SURVEY OF THE COLUMBIA RIVER AND ITS TRIBUTARIES - Part IV

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Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating agencies and in processed form for economy and to avoid delay in publication.

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Albert M. Day, Director

Special Scientific Report - Fisheries

No. 37

SURVEY OF THE COLUMBIA RIVER AND ITS TRIBUTARIES

4. 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.

By

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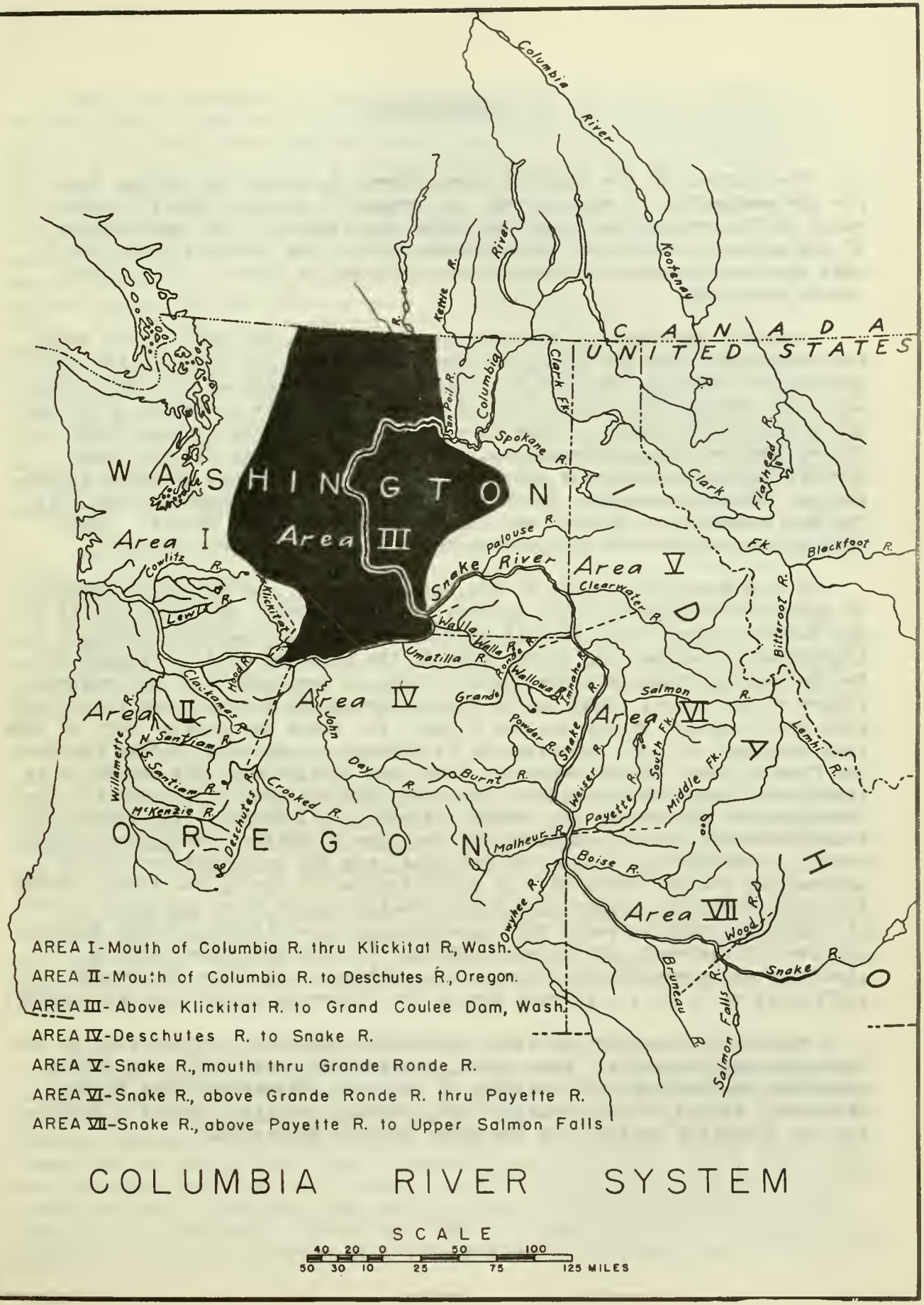

Figure 1.-- Columbia River System

INTRODUCTION

The purpose of the Columbia River Stream Survey is to provide data for the evaluation of each stream, or portion of stream, from the standpoint of its present and potential value in relation to the maintenance of the salmon resources of the Columbia River. The Columbia River watershed has been divided into several survey areas or units. This report covers Area III.

Area III includes all tributaries entering the Columbia on the north and west sides from the Klickitat River to Grand Coulee Dam, and the few tributaries entering from the east and south sides between the Snake River and Grand Coulee Dam. Also included in this report is a section in which are given brief accounts of the more important tributaries above Grand Coulee Dam that formerly supported runs of salmon. Area III has been divided into three separate sub-areas to cover the several sizeable stream systems that are present. These sub-areas are: (1) the Yakima River, (2) the Wenatchee-Entiat Rivers, and (3) the Methow-Okanogan Rivers. Other tributaries are covered in upstream order in Part 1 of this report.

All of Area III is east of the Cascade summit, and the major streams of this area originate on the eastern Cascade slopes. The great height of the Cascade range, which in this section is generally between 5,000 and 10,000 feet in elevation, causes most of the moisture that is brought by the prevailing winds from the Pacific Ocean to precipitate on the western slopes of the range. Only during the winter months is there any considerable precipitation on the eastern slopes, and since the greater part of this area lies east of the foothills, it is largely a semi-arid plateau section. The flow of water in the larger streams that originate in the mountains is fairly well sustained throughout the year, but the smaller streams are intermittent or dry during the summer and early fall months. The amount of winter snowfall in the mountains and the type of weather during the spring months, particularly in late May and June, are the principal factors in determining whether there will be sufficient water during the summer months to supply diversion demands and still provide stream flows adequate to permit migratory fish to reach their spawning grounds without serious delays enroute. In general, if the month of June is cool and there is much cloudy or rainy weather the snow melt is delayed, and there is usually sufficient water in the streams during the following summer and fall months.

The forest cover of the area, principally conifers, is confined to the mountains and foothills. Sage brush, grasses and other small vegetative forms are the only natural covering of the vast plateau sections of the watershed, except for the usual willow, poplar, and alder thickets bordering the immediate vicinity of the water courses themselves.

The first white men in the area were the fur trappers, traders, and voyagers of 1805 who did not settle or change the original conditions in the area other than to remove the fur-bearing animal population. The first white settlers utilized this area largely for stock grazing, the country then being considered as naturally too arid for large crop production. One of the first reported attempts to irrigate in this area was by an Indian named Kamiakin, who diverted water from Ahtanum Creek in 1852 to grow a vegetable garden. In 1872 a white man, Jospeh Scannon, dug a canal from the Naches River to the original site of the city of Yakima at Union Gap. The first orchard was planted in 1870. A large number of settlers entered the area in the last three decades of the 19th century, and many irrigation diversions were made. In 1881 the Konewock (Kennewick) Canal was dug, and was later enlarged until by 1891 it had been developed into a great canal system. In 1884 the Northern Pacific Railroad entered the Yakima Valley, and thereafter agriculture, utilizing irrigation, expanded rapidly until today the valley is covered with net-works of canals, both large and small. The Wenatchee, Methow, Okanogan and other valley areas were similarly developed, with fruit production being one of the main industries.

Virtually all of the streams in this area supported large runs of silver, chinook, and blueback salmon as well as steelhead trout prior to the settlement of the area by white men. With the development of the region and the construction of dams and unscreened irrigation diversions, there was a steady diminution in the abundance level of the runs. The dams impeded and in some instances completely blocked the upstream passage of adult fish, and countless thousands of fingerlings were lost down the irrigation ditches as they were migrating to the ocean.

As late as 1936, the stream survey parties found only 8 diversions screened out of 40 examined on the main Yakima River. This lack of screens was typical of all irrigation canals in the area. Since then the Washington State Fisheries Department, aided in part by the Works Progress Administration, has undertaken an effective screening program. The Fish and Wildlife Service has screened government constructed diversions.

Another problem in conserving the salmon of this area is raised by the fishing activities of the Indians, who spear, net and snag many of the fish concentrated in the shallow waters below dams and fish ladder entrances, as at the Richland, Prosser, Sunnyside, and Wapato dams on the Yakima River.

Under the treaty of 1855, which is still in effect, the Indians are allowed "the exclusive right of taking fish in all streams running through or bordering on said reservations ..... as also the right of taking fish at all usual and accustomed places". It is therefore impossible at present to prevent Indians from taking fish in the lower main Yakima and other streams where they border or are in the reservations. White men, on the other hand, are forbidden by State law to take salmon or food fish in "Any and all waters within one mile below any rack, dam or other artifical obstruction, either temporary or permanent, across any river or stream, except as otherwise provided". A full agreement with renegotiation of treaties must be made with

the Indians to provide for satisfactory spawning escapement if in the future any of the streams in or bordering on the various reservations in this area, and particularly those of the Yakima River system, are to be restocked and rehabilitated for salmon and steelhead.

Despite the fact that a part of the spawning grounds in Area III has been made inaccessible by high dams, river flows have been diminished by the diversion of irrigation water, that there are still many unscreened irrigation ditches, and that the abundance level of the runs is far below the former level, Area III is still an important salmon producing area.

At Priest Rapids, which are located approximately 396 miles up the Columbia River, the Pacific Power and Light Company operates a power plant. There is no barrier dam, the water being diverted by a small wing dam from above the rapids down a mile-long canal to the power house on the south bank. The maximum operating head is about 25 feet, and the usual diversion is 300 c.f.s. The plant operates two fixed bladed power wheels, one a Francis type, and the other a propeller type, at a speed of approximately 150 R.P.M. It is recommended that this canal be adequately screened and provided with a satisfactory by-pass channel.

There are now two dams on the main Columbia in this Area, and a third is under construction. The Rock Island Dam was built by the Puget Sound Power and Light Company and is located about 15 miles below the mouth of the Wenatchee River, and 452 miles above the mouth of the Columbia. It is a 22 to 33 foot barrier to migratory fish, but has 3 satisfactory fishways. It was started in 1929 and completed in 1934. The original construction provided for 8 more generators, each of 20,000 K.W. capacity, for future installation in addition to the units actually installed. However, even at this late date there has been no attempt to install and operate the additional units, in spite of recently threatened power shortages in the Pacific Northwest.

Fish counting stations have been operated at this dam during part of each year by the Fish and Wildlife Service to provide information on fish entering the section of the river above the Yakima River and below Grand Coulee Dam. These counts are given in the following table.

Examination of the Rock Island counts shows that there were relatively small runs of fish remaining in the Columbia above Rock Island in the few years prior to the building of Grand Coulee Dam, and that there had previously been poor years as well. It is also quite evident that there have been no great losses to the runs that can be attributed to the salvage operations and transferring of the stocks to hatcheries and streams below Grand Coulee after 1939 under the Grand Coulee Fish Salvage Program of the Fish and Wildlife Service. It is therefore desirable that a greater spawning escapement be provided so that these important stocks can be increased in the future, and may more fully utilize the large potential spawning and rearing capacity of this section.

Table 1. FISH COUNTS AT ROCK ISLAND DAM 1/

YEAR	CHINOOK SPRING	CHINOOK SUMMER	CHINOOK TOTAL	STEELHEAD SPRING	STEELHEAD FALL	STEELHEAD TOTAL	BLUEBACK TOTAL	TOTAL ALL SPECIES
1933	--	5,668	5,668	--	1,055	1,055	40,737	47,460
1934	619	6,482	7,101	202	381	583	2,227	9,911
1935	2,555	13,755	16,310	1,030	4,382	5,412	14,013	35,735
1936	2,186	5,210	7,396	1,256	1,113	2,369	16,501	26,266
1937	519	4,614	5,133	424	1,790	2,214	15,087	22,434
1938	1,592	4,211	5,803	1,393	1,007	2,400	17,123	25,326
1939	4,256	6,950	11,206	1,383	4,044	5,427	19,591	36,224
1940	4,328	5,164	9,492	1,199	4,351	5,550	26,894	41,936
1941	1,610	961	2,571	1,970	1,591	3,561	949	7,081
1942	1,359	5,455	6,814	532	3,054	3,586	16,282	26,682
1943	7,374	3,771	11,145	658	1,591	2,249	17,665	31,059
1944	1,498	1,877	3,375	464	865	1,329	4,932	9,636
1945	2,376	3,320	5,696	143	978	1,121	7,142	13,959
1946	4,144	5,848	9,992	294	1,467	1,761	45,029	56,782
1947	8,181	3,585	11,766	575	1,540	2,115	79,834	93,715
1948*	1,839	5,256	7,095	387	1,952	2,339	84,627	94,061
1949	4,234	--	--	653	--	--	--	--
TOTAL	48,870	82,127	126,563	12,563	31,161	43,071	408,633	578,267
AVERAGE	3,042	5,133	7,910	785	1,948	2,692	25,540	36,142

* No counts made during the first 3 weeks in June 1948 due to severe flood. The arbitrary date selected to separate the spring and summer runs was July 9. A few silvers have also been counted (226 in 1947).

Grand Coulee Dam is located approximately 63 miles above the mouth of the Okanogan River and approximately 595 river miles above the mouth of the Columbia. It first blocked fish in 1939 and water first spilled over its top in 1944. Its forebay height of 290 to 325 feet above tailwater provides a complete barrier to

fish. Although it would probably have been possible to trap the adult fish below the dam and release them above it, there are no means known at present to provide for collecting and passing the downstream migrating fingerlings from above the dam without almost certain death to all. Therefore, from 1939 to 1943 all adult salmon were trapped at Rock Island Dam and placed in the Wenatchee, Entiat, Methow and Okanogan Rivers, which enter the main Columbia below Grand Coulee Dam. 1/ Later, part of the runs were taken to hatcheries constructed on these streams. Marked fish experiments and field observations have subsequently vindicated the belief that, with few exceptions, the offspring of these transplanted fish have returned to the foster streams into which they had been transferred. Most of these runs now show increases. In order to protect the runs until they could become well established, the Washington State Department of Fisheries made it unlawful to take food fish or salmon in any of the tributaries of the Columbia River above Rock Island Dam, and the State Game Department prohibited the taking of steelhead over 16 inches in length in the Wenatchee, Entiat and Methow Rivers.

The McNary or Umatilla Dam, which is now under construction, is located just above the Umatilla Rapids in the Columbia River at approximately 292 miles above its mouth and 91 miles above Celilo Falls, and will be an 87 foot high barrier to fish. While it will be provided with fish ladders, its effect on fish is difficult to predict, for two or three barriers may have an accumulative adverse effect on fish that is considerably greater than two or three times the observed adverse effect of a single dam or barrier of similar height and type. It is therefore desirable that no further dam building will be undertaken on the main traveled routes of fish in the Columbia River System until the irrigation and power facilities at present installations and at sites above Grand Coulee Dam are fully developed and utilized.

There are several more dams which are being considered by the construction agencies for the main Columbia in this Area. The Dalles Dam would be located just above the city of The Dalles, Oregon, would be about 88 feet in height, and would flood out Celilo Falls. The John Day Dam would be located just below the mouth of the John Day River, and would be approximately 50 feet high. The Arlington Dam would be located just above the town of Arlington, Oregon, and would be 48 feet high. These three dams are expected to be provided with fishways if they are constructed. A new dam is proposed at Priest Rapids, and the latest announced plans suggest a 200 foot high multiple-purpose dam at this site. As this dam will be too high for existing types of fishways, and will therefore be a complete barrier to all fish, it will eliminate all of the known production areas for blueback salmon

1/ A Report upon the Grand Coulee Fish-Maintenance Project 1939-1947 by F. F. Fish and M. G. Hanavan, Fish and Wildlife Service, Special Scientific Report No. 55 (processed).

in the Columbia, and nullify all of the results of the Grand Coulee fish salvage programs. There are no known suitable lakes and spawning areas for blueback below Priest Rapids and the high quality spring and early summer run stocks of salmon produced above this site are much needed in the economy of the Columbia River commercial fishery.

The Rocky Reach Dam, which would be located a few miles above Wenatchee, would be 65 feet high, and the Chelan Dam to be located just above the mouth of the Chelan River would be approximately 92 feet high. These dams have all been proposed and if built would seriously interfere with salmon now spawning above the Wenatchee River and below Grand Coulee Dam.

The Foster Creek or Chief Joseph Dam, as proposed will be 172 feet high, and will be located approximately 51 miles below Coulee Dam. Since its location is above the mouth of the Okanogan River and it will therefore have no effect on the present runs of fish, those interested in salmon conservation on the Columbia have been unanimous in asking that this dam be built before any of the others proposed.

There are fair runs of spring chinook salmon into the Area III streams with Nason Creek, the Entiat and Methow rivers receiving the largest number of fish. There are larger runs of summer chinook and small runs of fall chinook into all of the main streams and onto spawning grounds in the main Columbia as well. Although it was known that Indians formerly took salmon at spawning areas in the vicinity of White Bluffs, and that as early as 1875 salmon were reported to spawn on the gravelly beaches of the main river the extent of the utilization of the main Columbia by spawning salmon was not definitely realized until M. G. Hanavan of the Fish and Wildlife Service made an aerial survey in late October and early November 1946, and counted nearly 1,000 spawning areas in use between the Snake and Okanogan River confluences. Silver salmon formerly ran into several tributaries and were even taken commercially near the mouths of the Snake and Yakima Rivers, but there are presently only very small runs into the Yakima and Wenatchee Rivers. Large blueback runs into the Yakima system have been exterminated, and the Wenatchee and Okanogan River Systems produce nearly all of the fish of this species now remaining in the entire Columbia River system. Steelhead trout runs were once very large, but are now greatly diminished in size.

Practically all of the accessible streams in Area III have been surveyed. From these surveys it is conservatively estimated that there are spawning areas available for approximately 800,000 salmon in the tributaries and for at least 300,000 salmon in the main river between Celilo Falls and Grand Coulee Dam. Spawning area for approximately 200,000 additional salmon could be provided if sustained summer flows were possible in the tributaries, and removal of minor obstructions would make spawning areas available for over 25,000 more.

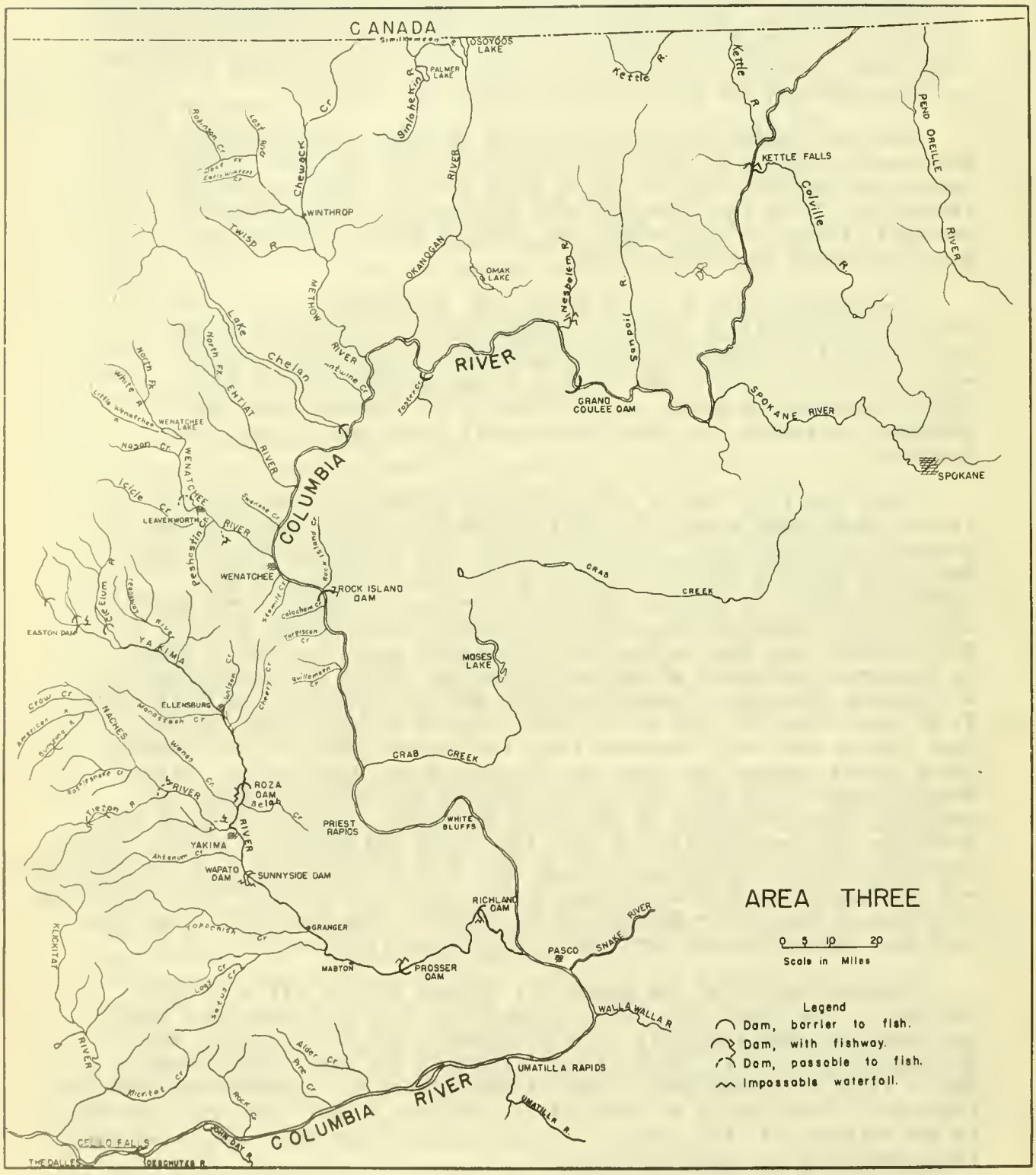

Figure 2.-- Area Three

The early stream survey findings in this area undoubtedly prompted much of the screening programs that have been undertaken in the past 10 years. The Grand Coulee Fish-Maintenance Program (Fish and Hanavan, 1949) showed that the area can be utilized. It therefore would appear that--if the next few years show that additional fish losses at McNary Dam are not too excessive--the fishery resources of this area should be considered as one of the several important economic factors in any plan for the complete development of the entire area.

Unless otherwise indicated, all field data presented were obtained on the dates given for each account. All temperatures are listed in degrees Farenheit. Due to the fact that there have been one or often several changes in ownership for many of the farms and smaller irrigation ditches, it is impossible to bring the change of names for all ditches up to date, but in many cases the original names and common names are still in use, and these were secured by the stream survey parties in the field.

Members of the stream survey parties who made observations on which the following account is based, and the dates on which the surveys were made are given in connection with the treatment of each stream. For convenience there is given here a complete list of all of these men who were engaged in the survey of Area III: C. H. Baltzo; C. J. D. Brown; R. E. Burrows; F. G. Bryant; L. R. Christy; L. E. Fulton; H. A. Gangmark; M. G. Hanavan; F. W. Jobes; L. N. Kolloen; M. C. Lobell; M. K. Morton; Z. E. Parkhurst; R. W. Peterson; R. F. Shuman; A. J. Suomela; and R. T. Whiteleather. Information on certain stream conditions were also furnished by R. J. Holcomb, K. G. Weber and G. A. Holland, formerly fieldmen on the Yakima River system; Mr. A. A. Gentry, Fisheries Management Technician at the Leavenworth Station; and P. A. Zimmer, formerly field biologist of the Grand Coulee Fish Salvage Project. Mr. A. W. Haslam, formerly Fish Screen Supervisor of the Washington State Fisheries Department who assisted the author in rechecking the diversions and screens of the Yakima River system in 1944 also furnished certain observations.

COLUMBIA RIVER STREAM SURVEY

PART 1

Area III, Exclusive of Sub-Areas

Introduction

There are few tributaries of any size in Area III other than the five major streams which are covered in the Sub-Area reports. A single exception is the Chelan River which is too steep for fish to ascend for any distance. The reason for the lack of streams in this area is, of course, the small amount of precipitation in the Columbia Plateau east of the Cascade Range.

In addition to the streams mentioned in this survey report there are approximately 25 creeks in the area which are direct tributaries of the Columbia River. For the most part these have steep gradients, and none of them has a year-round flow. For these reasons they are of no value to salmon.

The streams mentioned in this section of the report are of little value to migratory fish, owing to their small size.

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The Survey

Main Columbia River.-- (October-November, 1946; Barnaby and Hanavan.) The main stem of the Columbia River, within the confines of Area III, is in addition to being a migration route of anadromous fish, a relatively important spawning area. A careful evaluation of the area by the usual methods is not possible owing to the size of the river. However aerial surveys have shown that chinook salmon do utilize suitable gravels throughout the 210 mile reach of the river from the mouth of the Snake River to the confluence of the Okanogan River. It is probable that some spawning also occurs in the main stem of the river downstream from the confluence of the Snake River, but turbid water from the Snake River made observations impossible during the period of the survey.

1. Rock Creek.

2. Pine Creek.

3. Alder Creek.-- (April 21, 1937; Hanavan and Lobell.) These creeks are from 20 to 30 miles in length, and were flowing from 15 to 20 c.f.s. at the time of the survey. The stream gradients were relatively steep, but there were a few good spawning areas in some sections. They are populated by a few steelhead and native trout.

4. Yakima River.-- (See Part 2)

5. Crab Creek.-- (Inspected June 30, 1937; Baltzo and Jobes.) Crab Creek originates at Big Springs at the foot of a 200 foot ridge southeast of Ephrata, Washington and flows south for several miles to enter the upper end of Moses Lake. From Mosses Lake it continues south and flows into Goose Lake reservoir. From the reservoir it flows south and west some 50 miles to empty into the Columbia River near Beverly, Washington, approximately 422 miles above the mouth of the Columbia and 30 miles below Rock Island Dam.

There is another water course originating east of Davenport, Washinton and flowing south and west thru a series of small lakes into Crab Lake near Wilson Creek, Washington that is also shown on maps as Crab Creek, but is more commonly referred to as "upper" Crab Creek. Some maps even show drainage from Crab Lake into Soap Lake, which is located 7 miles northeast of Ephrata, and is highly alkaline since it has no outlet. There is no surface connection between this "upper" Crab Creek drainage and the "lower" Crab Creek drainage, although many persons believe that underground seepage from the former probably supplies the springs that feed "lower" Crab Creek.

Moses Lake is 15 miles long, one mile wide and supports a population of carp, bass, suckers, cyprinids and trout. At the time of the inspection, irrigation ditches were allowed to take a total of 40 c.f.s. from upper Crab Creek, 33 c.f.s. from Moses Lake and 144 c.f.s from lower Crab Creek. Three irrigation companies had the right to store excess water

in Moses Lake above elevation 1,038 feet. One company had the right to store 1,312 acre feet of surplus water from lower Crab Creek in Goose Lake Reservoir. Due to this irrigation use, lower Crab Creek has an intermittent flow. It therefore is not used at present by salmon and steelhead.

6. Quilomene Creek.

7. Tekison Creek.

8. Tarpiscan Creek.

9. Colockum Creek.

10. Stemilt Creek.

11. Squilchuck Creek.-- (April 22, 1937; Jobes and Baltzo.) All of these creeks have intermittent flows due to the diversion of water for irrigation purposes. None of them is of any value for anadromous fish.

12. Wenatchee River. (see Part 3)

13. Entiat River. (see Part 3)

14. Chelan River.-- (Inspected June 5, 1935; Suomela and Jobes.) The Chelan River flows from Lake Chelan and enters the Columbia River 503 miles above the mouth of the latter. It is only 4 miles long, but in that distance it drops 390 feet in a deep, narrow, canyon. Due to the steep gradient and the fact that its flow is intermittent owing to the diversion of water to a power plant, it is of no value for anadromous fish.

15. Antoine Creek.--(June and October 1936, and April and May, 1937, by Jobes and Baltzo.) Tributary to the Columbia 2 1/2 miles below Azwell, Washington, this small stream has a constant flow in the upper wooded reaches, but its entire flow is diverted for irrigation near its mouth, and when observed it was dry for at least 1 mile upstream.

16. Methow River.-- (see Part 4)

17. Swamp Creek.-- (July 16, 1937; Jobes and Baltzo.) This creek enters the Columbia between the Methow and Okanogan Rivers. It is over 12 miles long, but is intermittent and has so small a flow that there is not even enough water to adequately irrigate the land near its mouth on Brewster Flats.

18. Okanogan River.-- (see Part 4)

19. Foster Creek.-- (July 18, 1937; Jobes and Baltzo.) Foster Creek enters the Columbia River near Bridgeport, Washington, approximately 555 miles above the mouth of the Columbia and 9 miles above the confluence

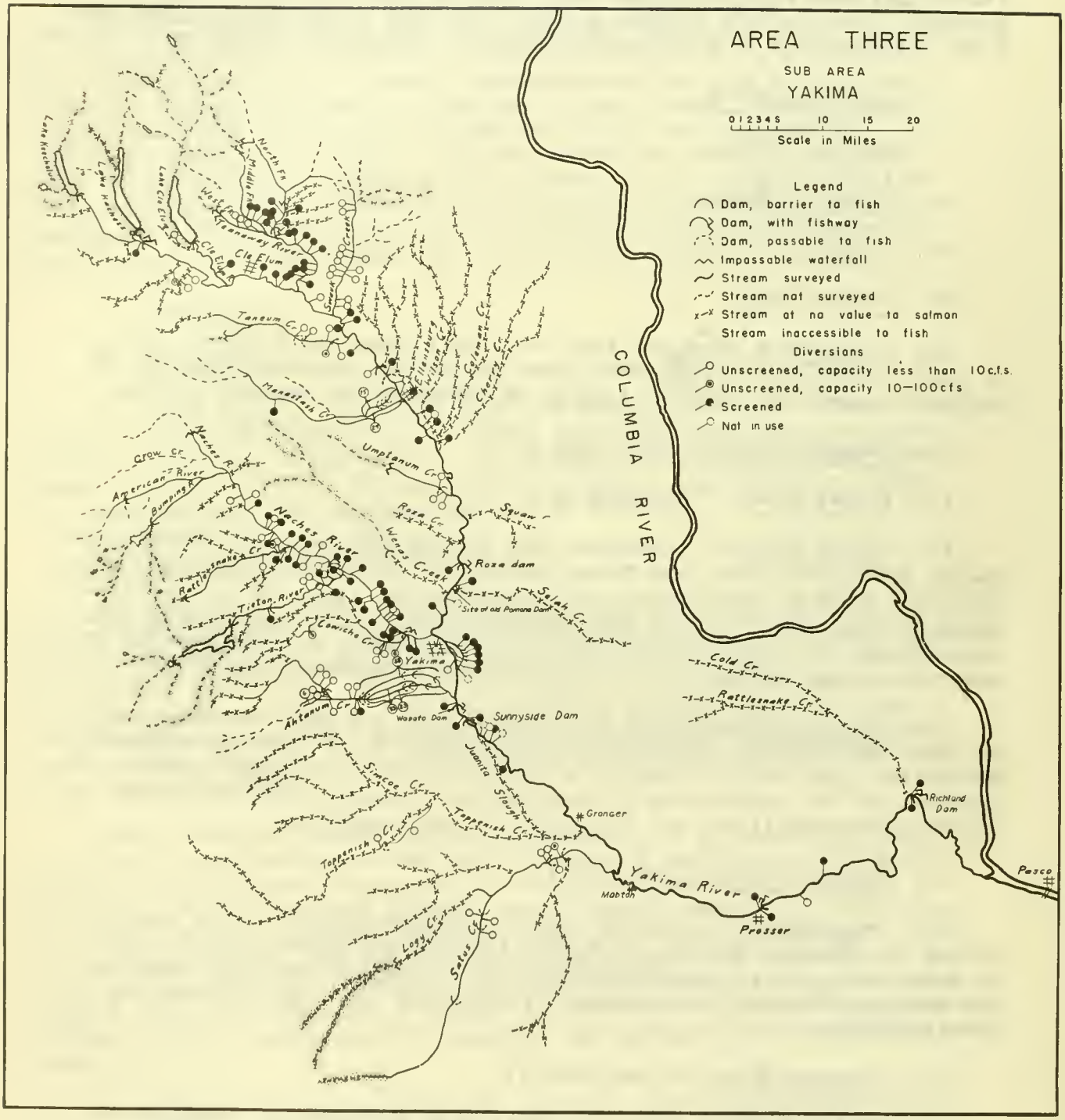

Figure 3.-- Sub-Area Yakima River System

Figure 4.-- Irrigation ditches from the Yakima River crossing the Terrace Heights Wasteway of the Roza Canal near Yakima, Washington. Crossing from top to bottom are: Roza Canal; Selah - Moxee Canal; Highway bridge; Ray Slavin Branch of the Moxee Ditch; Middy Branch of the Moxee Ditch; Union Gap Ditch.

of the Okanogan River. It is over 10 miles long and has three forks above the lower 2 miles. During the summer all of the stream flow is diverted, leaving the lower water course dry. This creek is of no value for anadromous fish.

20. Nespelem River.-- (April 26, 1937; Jobes and Baltzo.) This stream joins the Columbia approximately 15 miles below Grand Coulee Dam. It is 25 miles long and flows through a narrow canyon in a rugged hilly area. The watershed is typically arid, and the gradient is moderate to steep. During the spring high-water period the Columbia River backs up into the Nespelem for over 300 yards. The stream flow was measured at 38 c.f.s There is an 8 foot falls 2,100 yards above the mouth that is passable to fish only with considerable difficulty. There is an impassable 15 foot high falls 50 yards above, and the survey was concluded at a 55 foot falls located 250 yards farther up stream. Two steelhead were seen below the falls, but no salmon runs are reported. There is little spawning area below the falls, and the stream is of little value as a fish producer.

PART 2

YAKIMA RIVER SYSTEM

Introduction

The Yakima River is one of the largest tributaries of the Columbia River. Its drainage area is 5,000 square miles. Prior to the settlement and development of the Yakima Valley this river system was unquestionably a tremendous fish producer, owing to the extensive spawning and rearing areas for chinook, silver, and blueback salmon as well as steelhead trout.

The construction of irrigation dams made large sections of spawning area inaccessible and resulted in the extermination of the blueback salmon populations. The extensive diversions of water for irrigation resulted in such serious losses of downstream migrating fingerlings that the abundance level of the runs decreased to only a fraction of their former size. In addition to the losses of fingerlings down unscreened diversions there was a loss of both seaward migrants and adults as a result of low flows caused by the diversion of water.

Within the past two decades all of the major and many of the minor diversions have been screened, and some attempt has been made to provide increased flows through release of stored water during critical periods of fish migration. Because of this screening program put into effect by the State and Federal fishery agencies, the Yakima is still an important fish producer, and has considerable potential value.

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4. Yakima River.-- (Surveyed at various times, 1936-1947; Hanavan, Baltzo, Whiteleather, Parkhurst, Morton, Bryant, Fulton, and Gangmark).

The Yakima River originates at Lake Keechelus on the east side of Snoqualamie Pass in the Cascade mountains, at an elevation of 2,460 feet. It flows 198 miles to join the Columbia River approximately 335 miles above the mouth of the latter and 10 miles above the confluence of the Snake River. The main river has a total bottom area of over 22,000,000 square yards, of which only 6 percent was large rubble, 36 percent was mud and sand, and the remaining 58 percent or approximately 13,000,000 square yards was medium and small rubble. The gradient is slight, averaging only 11 feet per mile. The river flow is regulated by several reservoirs. Water storage is started in the impoundments at the conclusion of the irrigation season, usually in October. In 1943, the flow at Kiona, 29 miles above the mouth of the Yakima, varied from 1,300 c.f.s. in mid October to 13,200 c.f.s. in mid April. The maximum recorded discharge at this point was 71,100 c.f.s. on December 23, 1933, and the minimum was 105 c.f.s. on September 11, 1906.

In the lower 29 miles, from the river mouth to Kiona, Washington there are excellent riffles and good pools. Most salmon have a tendency to ascend farther upstream and this area is seldom used except by a few fall-run fish. Summer temperatures are often high in this section of the Yakima, frequently reaching 80° F.

In the next 16 miles from Kiona to Prosser Dam the river flows through a narrow valley. Here the current is fairly swift and there is little spawning area.

From Prosser up to the city of Yakima, Washington, a distance of 50 miles, the valley is wide and fairly flat. The gradient is low, the current is slight, the water is deep, (particularly below Granger) and the bottom is usually covered with silt and algae. There are few spawning riffles in this reach of the river that are satisfactory for salmon, and during the summer months the water is often too warm for salmon to tolerate for any length of time.

For most of the 40 mile distance between Yakima and Ellensburg the river is in a deep canyon where the current is fast. There are only a few good spawning riffles in this section.

The 47 mile reach from Ellensburg to Easton Dam contains the best and most frequently used spawning areas of the entire river. The temperatures are satisfactory, and there are good spawning riffles.

The construction of Roza Dam (see page 24) enabled counts on the escapement to the upper Yakima to be made after 1940. The counts on spring chinook at this dam for each of the years from 1940 to 1947 inclusive were as follows: 1011, 239, 521, 689, 242, 447, 989 and

2,645. These counts were usually made between mid May and late July, and represent the greater majority of but not all of the fish that pass above the dam. The peak of the spring chinook run is reached in June. In 1944 and 1947 observations were also made on the fall runs passing over the dam, and counts of 51 chinook and 774 silver salmon were obtained in 1944, and 29 chinook and 1943 silver salmon in 1947. The peak of the silver salmon run was reached in early October, the largest daily count in 1947 being 144 fish on October 4th.

The main hazard to fish life in this upper section is the reduction in river flow, owing to storage of water in the reservoirs, during the fall and winter months. This can, of course, seriously interfere with any existing spawning activities of salmon, and frequently results in the loss of eggs already deposited.

Some spawning area is present above Easton Dam, but is virtually unused by anadromous fish. Although the dam is provided with a fish ladder, it has a relatively high gradient and several other faults and consequently very few fish ascend the ladder. Easton Dam is in effect, therefore the upstream limit of anadromous fish migration in the Yakima River.

The individual dams and diversions on the main Yakima are discussed briefly in the following paragraphs.

Richland or Horn Rapids Diversion Dam is located 18 miles upstream from the mouth of the Yakima River. It is of timber construction, 600 feet in length, and drops in 4 steps, each approximately 15 to 18 inches in height, with 4 to 6 foot wide aprons between the drops. These aprons prevent fish from jumping over the dam during low waters periods when there is very little flow, but fish can easily pass over the structure during periods of high water. In recent years two fish ladders have been built, one near the center and one at the north end of the dam.

Flash boards are used occasionally during the irrigation season, and on at least one occasion even the fish ladders were found to have been boarded up, a practice that should not be permitted in the future.

Columbia or Kennewick Ditch takes off at the south end of the Richland Dam. This irrigation canal has a capacity of 325 c.f.s., and was screened in 1938.

Richland Ditch takes off at the north end of the Richland Dam, and has a capacity of 300 c.f.s. It was screened in 1938.

Kiona Ditch takes off on the north bank of the Yakima River 38 miles upstream. It has a capacity of 40 c.f.s., and was screened at a point 1 mile below the head of the ditch in 1938. The screen by-pass leads to a slough-like side channel on the main river.

Gibbon Station Diversion Ditch takes off on the south bank approximately 40 miles upstream.

Prosser Power Dam is located 45 miles up the Yakima River. It is built of concrete, is 768 feet long, 8 feet high, and spills onto a rock ledge that is crossed by many small shallow channels in which Indians fish for salmon during low water periods. A central three step fish ladder built in 1930 by the Washington State Department of Fisheries is effective at higher water levels but has a poor approach through shallow ledge rock channels that makes it less effective at low water stages.

A new ladder, very much needed, has been considered and should be located at the head of the deepest channels near the south bank.

Prosser Power Canal takes off at the north end of Prosser Dam. It has a capacity of 1,150 c.f.s. and leads to a powerhouse located about a mile below the headgates. The water from the powerhouse is returned directly to the river. The Bureau of Reclamation acquired this property, including the dam, from a former power company and rebuilt the head gate structure in 1932. The power generated is used to pump water from the Columbia ditch onto 4,268 acres of Kennewick project, with surplus power being sold to a private power company. The ditch is adequately protected by a battery of huge rotary screens, located a few hundred yards below the head of the ditch, operated by the Fish and Wildlife Service. An underground by-pass returns fish to the river.

Kirkwood Ditch takes off on the south bank 79 miles upstream. It is in the Yakima Indian Reservation and has not been used during the past few years.

Snipes and Allen Ditch takes off on the north bank 83 miles upstream, has a capacity of 35 c.f.s., and was screened in 1938.

Flint Ditch takes off about 500 feet above the Snipes and Allen Ditch on the north bank. It has a small pumping station and is protected by a panel screen.

Sunnyside Dam located approximately 88 miles above the mouth of the Yakima River and 5 miles below Union Gap, Washington, was built in 1906-1907 by the Bureau of Reclamation. It is a concrete structure 500 feet long and 8 feet high, equipped with three fishways, one at each side and one at the center. At the present time only the center fishway is operated. The Yakima Indian Reservation borders the west bank of the stream in this area, and the Indians fish for salmon and steelhead immediately below the dam.

Sunnyside Canal takes off on the east bank at the Sunnyside Dam. It has a capacity of 1,250 c.f.s. and runs for 60 miles down the east side of the Yakima Valley. For over 20 years this diversion was unprotected and it is probable that during this time more fish entered this canal and perished than in any other diversion from the Yakima River.

In 1929 and 1930 electric fish screens were installed at the head of the ditch. In 1935 a battery of eight rotary screens was installed. In 1939 these were rebuilt and improved with two more units being added, making the present battery of ten rotary screens which successfully prevents the loss of the downstream migrants.

Old Indian or Old Reservation Canal takes off on the west bank of a side channel in the Yakima River approximately one-half mile above the Sunnyside Dam. It is reported to carry about 200 c.f.s during the irrigation season, and a small flow is maintained during the rest of the year to water stock on the Yakima Indian Reservation. The diversion was apparently unprotected prior to 1930 when an experimental electric fish screen was installed at the head of the canal. This was later replaced by a 1/2" spaced bar screen, which provides some protection to fish.

The Wapato Diversion Dams are located approximately 91 miles up the Yakima, and were built in 1917. There is a 9 foot high concrete dam across the east channel, and another dam across a west side channel, both being flanked by long earth dikes. In 1930 a ladder was built in the center of the east-channel dam. A second ladder was later constructed at the west end of the same dam, but it appears to lack attraction for fish. The dam across the east channel is not equipped with a fishway. The Yakima Indian Reservation borders the river in this area and Indians fish for salmon and steelhead below these dams.

Wapato Canal of the U. S. Indian Irrigation Service takes off from the west bank above the west channel dam, and has a capacity of 2,000 c.f.s. It was unscreened prior to 1929 when an electric fish screen was installed. In 1939 the present battery of ten rotary screens was installed at a point one-half mile below the take-off.

Richartz Ditch takes off on the east bank approximately 98 miles upstream, between the Moxee and the Yakima highway bridges. It is equipped with a rotary drum screen.

Union Gap Ditch takes off from a side channel 99 miles upstream and less than a mile above the Yakima highway bridge. It has a capacity of 71 c.f.s and has a new rotary screen located a short distance below the take-off, with a by-pass for fish emptying directly into the Terrace Heights Wasteway of the Roza Canal.

Moxee Ditch takes off immediately above the Union Gap Ditch and has a capacity of at least 24 c.f.s A headgate and a rotary drum screen are located a short distance below the take-off before the ditch crosses the Terrace Heights Wasteway. The canal below the screens is usually referred to as the Ray Slavin Branch, and runs for several miles down the valley to irrigate farms in the vicinity of Moxee, Washington. Two short by-pass channels from the Moxee Ditch, one from in front of the headgates and the other from in front of the rotary screen, join immediately and form the Middy Branch of the Moxee Canal. This is now protected by a new rotary screen located a few yards below, with a fish by-pass leading directly into the Terrace Heights Wasteway. The Middy Branch crosses the Terrace Heights Wasteway and supplies the Hubbard, Granger, Bott #1 and the Normandin ditches, and then empties any remaining water into the Richartz Ditch at a point just above the rotary screens in the latter canal.

Cascade Lumber Company Ditch takes off on the west bank below the Fourth Avenue bridge in the city of Yakima. It leads to two mill ponds, from which a channel returns the water to the river. This ditch or flume is not being used at present, the water for the mill now being supplied by a branch of the Old Union Ditch from the Naches River.

Taylor Ditch takes off on the west bank approximately 2 miles above the town of Selah, Washington and has a capacity of 27 c.f.s A rock wing dam shunts water into the ditch, which was screened in 1938.

Pomona Dam of which only remnants are left, is located approximately 106 miles above the mouth of the Yakima River and midway between the mouths of Wenas and Selah Creeks. This dam was built so long ago that it is difficult to obtain data on it. The structure is now owned by the Cascade Lumber Company of Yakima, Washington, who report that they bought it from the Yakima Boom Company in 1919. They further state that the dam was evidently built to store water which was used to float logs down the Yakima River to the saw mills. The dam has not been in use for over 30 years. Older residents along the river have stated that this dam together with the Sunnyside Dam (before it was laddered) were important factors in the early decrease in the numbers of fish in the Yakima River because both structures blocked part of the runs from their former spawning grounds for many years.

Selah-Moxee Canal takes off on the east bank approximately 108 miles upstream. It has a capacity of 140 c.f.s and was screened in 1938.

Roza Dam located approximately 115 miles upstream is one of the more recent structures on the Yakima River, having been built in 1940 by the Bureau of Reclamation. It is a concrete structure having a crest length of 220 feet and a drop of over 20 feet. A fish ladder is located at the east end of the dam.

Roza Canal takes off at the west end of Roza Dam and has a capacity of over 2,200 c.f.s It is fully equipped with a battery of six rotary drum screens at the upper end of the canal.

Stein-McLeod Ditch takes off on the east side 133 miles upstream, and is supplied with water by a diesel operated pump. The intake is protected by a panel screen.

The Stone-McGaff Ditch System takes off from a small side channel 135 1/2 miles upstream. The ditch loops for about one-half mile and is joined by a drainage ditch before it returns to the river. The five lateral diversions are equipped with screens which force fish to continue on through the main ditch back to the river.

The Damon Mill Ditch originally took off from above a log wing dam on the west bank of the river 136 1/2 miles upstream. It had a capacity of 12 c.f.s., and passed through a conduit under a dyke and supplied several small irrigation ditches, as well as the mill. Several years ago the mill was torn down, the dam was removed, and the ditches are now supplied by a new intake located one-half mile downstream. The intake and the small laterals are unscreened.

The Grinrod-Doughty Ditch takes off on the east bank 137 1/2 miles upstream and above the lower Ellensburg Bridge. It has a capacity of 34 c.f.s., and was screened in 1938.

The Reed Ditch takes off on the north bank 140 miles upstream and above a wing dam that is sometimes extended entirely across the stream. Its capacity is 5 c.f.s., and it has been screened.

The Ellensburg Power Canal take-off is located about 144 miles upstream, and has a capacity of 612 c.f.s. Screens have been made for the canal, but have not been installed.

The Ellensburg Dam is located 144 miles upstream. It is a concrete structure having a 4 foot drop onto an apron. Provision is made for the use of flash boards during low water periods, at which times the dam is impassable to fish.

The Old Town Irrigation Canal take-off is located at the north end of the Ellensburg Dam, and normally diverts 174 c.f.s. A short distance below the intake the canal branches to supply the Olson Irrigation Canal. Both canals were screened in 1939.

The Mills Power Dam is located 146 1/2 miles up the Yakima River. The dam is built of planks laid at a 45 degree angle to the stream bed and has a drop of 2 1/2 feet. It is reported to be a possible barrier during low water periods.

The Mills Power Canal takes off on the south bank of the river above the dam. It has a capacity of 112 c.f.s, and is not screened.

The Westside Irrigation Company Canal takes off on the south bank 148 1/2 miles upstream, and has a capacity of 112 c.f.s. Itwas screened in 1938.

The Ellison Ditch takes off near the Westside Canal, and has a capacity of 20 c.f.s. It was screened in 1938.

The Garrison Ditch takes off above a wing dam on the north bank of a side channel 150 miles upstream. It was diverting 37 c.f.s. when examined, and was screened in 1941.

The Cascade Canal takes off on the north bank 152 miles upstream, and has a capacity of 140 c.f.s. Itwas screened in 1938.

The Swauk Creek Irrigation Ditch takes off on the north bank 158 miles upstream, and is supplied by a 25 foot high paddle-wheel dipper or noria. Since noria dip downstream they seldom capture fish, and therefore the canal does not require screening.

The O'Conner Ditch takes off above a log and brush wing dam on the north bank of a side channel 162 miles upstream, and has a capacity of 15 c.f.s It has been screened.

The Frazer Ditch takes off a short distance above the O'Connor Ditch, and diverts about 6 c.f.s It is screened.

The Younger or CleElum Town Ditch takes off on the north bank 164 miles upstream and diverts approximately 15 c.f.s. It has been screened in the past few years.

The Easton Dam is located just above the town of Easton, Washington, and approximately 186 miles above the mouth of the Yakima River. It is a concrete structure built in 1929 and has a crest length of 248 feet and a drop of about 60 feet. It has a 20 pool fish ladder on the north side that is reported to be kept in operation only during the irrigation season. During the winter months such discharge as is permitted is from two apertures at the base of the dam, and the dam is then a barrier to fish. The fish ladder is steep and not a particularly good one, the pools being small for salmon passage. The drops between the pools are high, requiring fish to jump from one pool to another, and fish occasionally have observed to jump completely out of the ladder. This fishway should be rebuilt so that it will operate effectively. A few salmon have been seen above the dam by survey parties, and fish have been reported passing the dam on several occasions.

The Kittitas Diversion Canal more popularly known as the High Line Canal, takes off at the south end of the Easton Dam but later crosses the Yakima River in the vicinity of Horlick, Washington. It diverted 500 c.f.s in 1929, 1,080 c.f.s. in 1936, and over 1,300 c.f.s after 1937. Its total length is 76 miles. It is protected by a stationary one-half inch spaced bar screened at the intake.

The Lake Keechelus High Control Dam is located 198 miles above the mouth of the Yakima River, and approximately 12 miles above Easton Dam. It is a rock faced, earth and gravel fill dam, 70 feet high, with a crest length of 6,500 feet. Water from above the dam is normally spilled through a conduit or tunnel 12 feet wide, and hence the dam is impassable to fish. There were originally two small lakes at this site that were accessible to fish and supported a blueback population. Storage first began above a crib dam in 1906, and above the present dam in 1914, although the reservoir was not completely filled until 1920. Because of the great fluctuation in the water level, sometimes over 60 feet, a fish ladder over this dam has not been considered practical.

Tributaries of the Yakima River are discussed in upstream order in the following accounts:

4A. Satus Creek.-- (November 16 to 19, 1935; Shuman and Whiteleather.) This stream originates in the Horse Heaven Hills and flows northeast for 50 miles to join the Yakima River near Mabton, Washington, 60 miles upstream. The lower 41 miles were surveyed. The entire stream is in the Yakima Indian Reservation, and the Bureau of Indian Affairs records list a minimum flow in the fall of 22 to 27 c.f.s, and a maximum spring flow of 348 c.f.s. The mid-section of the stream is often quite shallow in the

summer months. The gradient is slight in the lower 37 miles, but the remainder of the stream is fairly steep. The water temperature was 35° to 46° F., but summer temperatures are reported to be high. It had 7 unscreened irrigation diversions and 5 dams, as follows:

An Indian Service concrete dam 9 1/2 miles upstream has a drop of 14 inches. This dam is usually passable to fish.

The Indian Service Irrigation Canal takes off at the north end of the dam and has a capacity of 110 c.f.s. It is not screened at present.

The Shearer Irrigation Canal takes off on the south bank 11 miles upstream and above a brush dam that was not considered a barrier at the time it was inspected. The canal has a capacity of 10 c.f.s., is unscreened, and is reported to be used only during water periods.

A small, unscreened, irrigation ditch 4 feet wide takes off on the north bank 12 1/2 miles upstream but was not in use when inspected.

An unscreened irrigation ditch 6 feet wide takes off on the north bank 13 miles upstream above a 2 foot high log and rock dam. The passability of the dam is questionable at low water stages.

A similar unscreened ditch takes off on the north bank 26 1/2 miles upstream, above a low rock diversion dam.

The Satus Stock Ranch Irrigation Ditch takes off above a rock wing dam on the south bank 27 miles upstream. It is 10 feet wide and unscreened.

An unscreened irrigation ditch 6 feet wide takes off from the south bank 30 miles upstream. It is supplied by a rock diversion dam 2 1/2 feet high that is believed to be a low water barrier.

A log and rock debris slide 4 to 5 feet high and 100 feet long 40 1/2 miles upstream is believed to be a low water barrier.

The stream bed in the lower 6 miles of Satus Creek consists mainly of mud and sand. The remainder of the stream possesses considerable spawning area, which is often inaccessible and unusable because of irrigation demands. Steelhead and salmon were reported to have run into this creek prior to 1910, but there are few, if any, at the present time.

With the exception of Logy Creek, none of the tributaries of Satus Creek have a sufficient flow in the fall months to provide for salmon runs.

4A-(1). Logy Creek.-- (May 1 to 4, 1937; Hanavan and Lobell.) This tributary enters Satus Creek 24 miles upstream and is 27 miles long. The lower 2.2 miles were surveyed, and the next 11 miles inspected. The observed flow was 18 to 20 c.f.s., but the creek is reported to be dry occasionally near its mouth during the late summer months. Otherwise there would be some suitable spawning area in the lower 3 1/2 miles. The remainder of the stream is fairly steep, and an impassable falls 15 feet high was found 14 miles upstream.

4B. Toppenish Creek.-- (Inspected April 29, 1937; Hanavan & Lobell.) This stream is approximately 60 miles long, entering the Yakima 68 miles upstream just below Granger, Washington. In the lower 25 miles, up to the confluence of Simcoe Creek, it flows through a flat swampy section where it serves as a drainage canal. In the next 10 miles, up to a dam 4 feet high the stream is diverted into many small channels for irrigation purposes. These channels have considerable good spawning area, but one or another of them are reported to be dry at intervals during the summer. The dam has a crest of 40 feet, and when inspected had a 6 inch flow of water over it, but during the summer irrigation period the entire flow is reported to be diverted into a large ditch at the dam. The remaining 25 miles of stream above the dam maintains a flow of water throughout the year, and has good spawning areas. A small run of steelhead is reported to enter the stream, and to pass over the dam during the period of high water. The stream is of little present value to salmon. Rainbow trout are reported to be numerous. The stream is entirely within the Indian Reservation, and Indians customarily take fish at the dam.

4C. Ahtanum Creek.-- (October 20 and November 8-13, 1935: Whiteleather and Shuman.) This creek joins the Yakima 94 miles upstream near Union Gap, Washington, and was surveyed for a distance of 21 1/2 miles to the confluence of the North and South Forks. The stream is bordered by the Yakima Indian Reservation on the south bank, and hence is subject to Indian fishing. The gradient is slight to moderate. The gradient in the lower 8 1/2 miles is slight, the bottom having a large amount of mud and sand with only occasional spawning riffles. There is a concrete dam 3 1/2 feet high 17 miles upstream that diverts water into an artificial side channel called Hatton Creek, and 1/4 mile farther upstream a second and similar dam diverts into another channel called Bachelor Creek. Water is shifted back and forth between these three channels, any of which may be dry or nearly so during the summer and fall months.

The main stream channel has 23 irrigation diversions, many of which have low earth, rock, or board dams, but no fishways, and are barriers at low water stages. The only diversion that is screened is the Indian Service Diversion Canal 18 1/2 miles upstream, which has a maximum capacity of 70 c.f.s., but is allowed to take only one-fourth the stream flow when the latter drops below 100 c.f.s. This canal was screened by the Bureau of Fisheries (predecessor of the Fish and Wildlife Service) in 1929.

The Hatton or Hollow Creek Channel is 10 miles long and returns to main Ahtanum Creek 7 1/2 miles above the mouth of the latter. It has 33 unscreened diversions and several low dams, one of which is located only 200 yards above the return to Ahtanum Creek and is a definite barrier to fish. Due to this barrier and to the fact that the regulated flow is so intermittent, none of the spawning area in this channel is of value.

The Bachelor Creek Channel is over 17 miles long and returns at a point 2.6 miles above the mouth of Ahtanum Creek. It has 38 unscreened diversions and several low diversion dams, one of which, located 2 miles upstream, is a low water barrier. The water fluctuation in this channel also makes it unusable to salmon.

Ahtanum Creek formerly had good runs of salmon and steelhead. The only fish still reported to enter the stream are a few chinook in the lower 2.6 miles below the Bachelor Creek channel during high water periods.

4C-(1). North Fork of Ahtanum Creek.-- (November 13 and 14, 1935 and September 30, 1936; Shuman and Whiteleather.) This stream is 20 miles long, the lower 13.2 miles having been surveyed. It is inaccessible and therefore of no value to anadromous fish. The flow from late July to the following winter is usually from 12 to 45 c.f.s. and during the spring runoff is usually from 125 to 275 c.f.s. The stream is sluggish in the lower 3 miles and flows in several channels on which there are occasional beaver dams. The remainder of the stream has many good riffles with suitable spawning area. There are 5 unscreened diversions, and a diversion dam 4 feet high 1 1/2 miles upstream is a low water barrier. Rainbow and cutthroat trout were reported.

4C-(2). South Fork of Ahtanum Creek.-- (November 14, 1935; Shuman and Whiteleather.) This stream is 13 miles long, 5.3 miles having been surveyed. It is inaccessible to anadromous fish. The usual flow is from 5 to 20 c.f.s. with about 90 c.f.s. during the spring runoff. The gradient is fairly uniform and there were many small riffles. There are 6 unscreened diversions, 2 being above small brush dams that are probably not barriers. Prior to 1900, salmon ascended at least the lower 2 miles of this stream, but none have been reported since then.

4D. Naches River.-- (July 16-23, 1935, and July-August, 1936; Hanavan, Whiteleather, and Burrows.) The Naches is the largest tributary of the Yakima River extending approximately 51 miles to the confluence of the North and South Forks. It joins the Yakima River 101 miles above the mouth at a point just above the City of Yakima, Washington. It was all surveyed. The gradient is moderate, the river having cut a deep valley from its headwaters on the slopes of Mt. Rainier. The stream flow now fluctuates less than formerly, as it is partially regulated by the Tieton and Bumping Lake reservoirs. The spring runoff, fed by melting snows on Mt. Rainier and the adjacent Cascade slopes, occurs between late March and mid June, the flow usually being between 1,000

to 2,200 c.f.s. From August until December, during the fall spawning period, the flow is generally between 75 and 500 c.f.s. During the period of low water in late summer the water temperature may exceed 70° F. except in the upper watershed.

In the lower 17 miles, below the Tieton River, the stream flows through a broad valley that is bordered by semi-arid slopes, except for the irrigated tracts. Here there is occasionally more than one channel, but the salmon usually pass over the available spawning grounds in preference for those in the cooler headwaters. The valley above is considerably narrower and is bordered by steep moderately wooded slopes. The mid-section of the river has many large, clear, deep resting pools, and riffle areas are frequent. There are extensive suitable spawning areas in the middle and upper sections, and the river formerly supported large runs. A few spring and summer chinook salmon and steelhead trout still enter the Naches and its upper tributaries to spawn.

The only natural obstruction to fish is an 8 foot cascade located 1 mile above the Crow Creek trail bridge, about 45 miles up the river. This is difficult for fish to pass during periods of low water. The main obstacles to fish are the shallow or dry sections encountered at the height of the irrigation season, flashboards and downstream aprons at several of the diversion dams, and superior attractions at one or two diversion returns.

The Old Union Irrigation Ditch takes off from the south bank 2 miles above the mouth of the Naches River. It is one of the first ditches built in the Yakima River system, has a capacity of 66 c.f.s., and was screened in 1938. In recent years it has been enlarged to furnish water to the Cascade Lumber Co. mill pond in Yakima, the surplus being by-passed directly to the Yakima River. It is therefore operated throughout the year, although the screens are taken out at the end of the irrigation season and remain out all winter.

The Fruitvale Diversion Ditch takes off from the south bank 3 miles upstream. It has a capacity of 110 c.f.s., and was screened 1/3 mile below the intake in 1938. A gravel and rock dam built along the side of the river leads water to the intake and also shunts most of the water of lower Cowiche Creek into this canal.

The Naches-Cowiche Irrigation Dam located 3 1/2 miles upstream is a low concrete dam with an initial drop of 3 feet onto a 15 foot wide apron, and a second drop of 2 or 3 feet to the river below. A fishway is present at the south end of the dam. Flashboards are usually used during the irrigation season, and have at times been placed across the upper end of the fishway as well. At such times the structure is a barrier to fish.

The Naches-Cowiche Irrigation Ditch takes off at the south end of the dam and has a capacity of 50 c.f.s. It was screened in 1938.

The Yakima Irrigation Canal takes off at the dam and runs to a concrete settling basin located beside the highway a short distance below. The outlet of the settling basin is screened with fine mesh panel screens, and the by-pass empties into lower Cowiche Creek. The ditch then runs to the City of Yakima.

The Schuller-Rodenback Ditch takes off from a side channel 5 1/2 miles upstream, has a capacity of 6 c.f.s. This ditch is screened.

The Chapman and Nelson Ditch takes off from a side channel 6 miles upstream, has a capacity of 32 c.f.s., and is screened.

The McCormick and Long Ditch takes off from above a piled rock wing dam on the north bank 6 1/2 miles upstream. It has a capacity of 4 1/2 c.f.s., and is unscreened. Due to its small size, there are probably few fish lost in it.

The White and Leach Ditch takes off from a side channel 7 1/2 miles upstream, has a capacity of 6 c.f.s., and is unscreened. The entire side channel flow is diverted into this ditch.

The Congdon Irrigation Ditch takes off from a side Channel one-fourth mile above the White and Leach Ditch and opposite the town of Naches, Washington. A 60 foot long wing dam on the main channel diverts water to the side channel, which is dammed at the ditch intake. This ditch has a capacity of 60 c.f.s., and has one of the first rotary screens ever to be installed in the state.

The Morrisey Ditch takes off from the north bank 8 miles upstream. It diverts 8 c.f.s., and is screened.

The Gleed Irrigation Ditch takes off from the north bank above a low concrete wing dam 8 1/2 miles upstream. It has a capacity of 78 c.f.s., and was screened in 1938.

The Scott Channel Diversions.--A rip-rap wing dam 9 1/2 miles upstream diverts water into an artifical side channel known as the Scott Channel. From this channel the following irrigation ditches take off: The Lower Scott, La Fortune, Upper Scott, Powell #1, Powell #2, and Basket Ford (sometimes known as the Naches Mill Ditch). Each of these ditches has a capacity of 16 to 27 c.f.s. They were screened in 1938.

The Kelley and Lowery Ditch takes off from the north bank nearly opposite the Scott Channel Diversion. It divides into two separate ditches, each having a capacity of 20 c.f.s. Both were screened in 1938.

The Foster-Naches Ditch takes off from the south bank 10 1/2 miles upstream and has a capacity of 9 c.f.s. This ditch is screened.

The Clark Ditch takes off from the north bank 11 miles upstream, has a capacity of 12 c.f.s, and was screened in 1938.

The Wapatox Power and Irrigation Canal takes off from the north bank 16 miles upstream, and is the largest and most important diversion on the Naches River. It has a capacity of 565 c.f.s., of which 300 c.f.s. is used for power and the rest for irrigation. A low loose rock dam usually diverts most of the river at this point, and should be provided with a definite passageway for fish, and a usable channel approach should be maintained below the dam.

The diversion was first protected by an electric screen installed by the Pacific Power and Light Company in 1930. A battery of rotary screens, located about one-fourth mile below the intake, was installed by 1938.

The canal runs for nearly 7 miles to two power plants. The power wheels are supplied by penstocks from the canal and operate with a head of approximately 100 feet.

The water from the power plant flows back into the Naches River at a point just above the Gleed Ditch take-off. Since the flow from this tailrace canal is usually considerably greater than the flow in the river at this point, it has a greater attraction to upstream migrating salmon and steelhead, which have been reported to ascend futiley to the power plant.

The Selah-Naches Canal takes off from the north bank of a side channel 17 miles upstream. It has a capacity of 136 c.f.s., and was screened in 1938. The Washington State Fisheries Department operates a fish trap in the screen by-pass to check on the downstream migration of fingerlings. At times of low water a low, rubble diversion dam is often constructed across the entire river to divert water into this canal.

The Yakima Water Works Dam located 18 miles upstream is composed of a series of concrete abutments 3 to 5 feet high that have a provision for the use of flashboards during low water periods. A fishway is present at the north end of the dam.

The Yakima Water Works Canal (Inspected March 15, 1944) takes off from the north bank some 20 feet above the dam. A small concrete wing extends diagonally downstream from just above the intake and serves to shunt debris away from the canal. Downstream migrating fish also are apparently shunted out into the stream and few fish make the reverse turn back into the canal mouth, but continue on either over the low dam or through the fishway. This is in effect a "Reverse Intake", and it is certainly less hazardous to fingerlings than the conventional type of diversion. The canal leads to a series of settling basins from which the water is filtered through the ground to be picked up by a perforated pipe gallery. Since it is impossible for fish to get into the water mains, the diversion does not need to be screened, as any fish

reaching the settling basins pass out through an overflow and drain pipe leading back to the river. The latter route could doubtless be improved as a fish passage, but only a few fish have ever been observed in the settling ponds.

The Krober Ditch takes off from the north bank 21 1/2 miles upstream near a steel bridge. It diverts 2-3 c.f.s. and is not screened.

The Meloy (or Melog) Ditch takes off from the south bank 22 miles upstream. It has a capacity of 4 c.f.s. and is not screened.

The Griffin Ditch takes off from the south bank 24 miles upstream. It has a capacity of 4 c.f.s. and was screened in 1938.

The Stevens or Scott-Stevens Ditch takes off from the north bank of a side channel 24 1/2 miles upstream. It has a capacity of 13 c.f.s., and is screened some distance below the intake. The by-pass is often blocked by beaver dams and trash, requiring frequent inspection and cleaning.

The Frederick and Hunting Ditch takes off from the north bank 25 miles upstream just above the bridge to the Rattlesnake Creek Guard Station. It diverts 7 c.f.s. and is screened 1/4 mile below the intake.

The Carmack and Parker Irrigation Ditch takes off from the south bank 25.8 miles upstream. It diverts 3 c.f.s., and is screened.

The Palmer Irrigation Ditch takes off from the north bank of a side channel 27 1/2 miles upstream. It diverts 2 1/2 c.f.c., and is screened.

The Lower Markel Irrigation Ditch takes off from the south bank 29 miles upstream, above an 80 foot long log wing dam. It diverts 11 c.f.s., and was screened in 1938.

The Upper Markel Irrigation Ditch takes off from the south bank 29 1/2 miles upstream. This is a small ditch, reported to be used only during high water stages, and is not screened.

The Lindsey Irrigation Ditch takes off from the north bank of a side channel 1/4 mile above the upper Markel Ditch, and just above a low, board dam. It has a capacity of 16 c.f.s, and is screened.

The Valentine Ditch takes off from the north bank 30 1/2 miles upstream. It diverts 2 c.f.s., and is not screened.

The Benton Ditch takes off from the north bank about 110 yards above the Valentine Ditch. It has a capacity of 3 c.f.s., and was screened in 1938.

The Emrich (or Emrie) Irrigation Ditch takes off from the north bank 34 miles upstream. It has a capacity of 4 c.f.s., and is screened.

The Anderson Ditch takes off from the north bank 36 miles upstream. It has a capacity of 6 c.f.s., and is screened. During periods of high water part of the flow of Gold Creek is also diverted through this ditch.

The Fontaine Ditch takes off from the south bank 37 miles upstream. It has a capacity of 3 c.f.s., and was not screened at the time of inspection.

4D-(1). Cowiche Creek.-- (August 1, 1936: Whiteleather.) Joins the Naches River 3.2 miles above the mouth of the latter, and extends for 7 miles to the confluence of the North and South Forks. The gradient is slight to moderate and silting now occurs on most of the spawning areas. The flow is so reduced by irrigation demands that the stream bed is often dry in places. The survey party found 9 unscreened diversions, each above a 1 to 3 foot high dam that diverted all or nearly all of the stream flow at that point. It is reported to have been a good trout stream, and steelhead utilized the stream before extensive irrigation was undertaken. In its present condition the creek has little or no value to migratory fish, and irrigation demands make any attempt at improving or restocking unfeasible. The lower 5 miles of the North Fork is usually dry in the summer, and part of its channel is utilized by the Tieton Canal. The South Fork has 5 unscreened irrigation diversions that utilize almost all of its water.

4D-(2). Tieton River.-- (July 11 to 13, 1935; Whiteleather and Burrows.) Joins the Naches River 16 1/2 miles above the mouth of the latter, and extends for 22 miles to the Tieton Reservoir (Rimrock Lake). It has been completely surveyed. Most of the water course is in a heavily forested, steep walled canyon. The gradient is consistently moderate, averaging 51 feet per mile. There are occasional good deep resting pools, and riffles are numerous but have a considerable portion of large rubble. Fair spawning areas are found throughout. The stream value is greatly reduced by the control of the stream flow at the Rimrock Dam. During flood and irrigation seasons, the discharge at the dam may be 1,000 to 2,000 c.f.s., although it is usually around 500 c.f.s. When water is being stored from November to April the flow is usually cut to less than 100 c.f.s. and may be below 10 c.f.s. at times. A few spring chinook and steelhead are reported still to utilize the stream, but they are only a small portion of the runs in former years. Kokanee have been stocked in Rimrock Lake (Tieton Reservoir), but often are killed or injured by passage over the spillway or through the tunnel outlet. Numbers of injured and fungused individuals were seen in the river by the survey party.

The following obstructions and diversions were found.

An irrigation ditch takes off from the south bank 1/4 mile upstream. It was diverting 12 1/2 c.f.s. at the time of inspection, and since has been reported to have been screened.

A small irrigation ditch takes off from the north bank 1/3 mile upstream, above a rock wing dam. It now is reported to have been screened.

An irrigation ditch takes off from the north bank 1.8 miles upstream and above a 40 foot long wing dam. It was diverting 1.7 c.f.s., and was unprotected.

An irrigation ditch takes off from the south bank 2 1/2 miles upstream, and was diverting 1 c.f.s. It has been screened.

An irrigation pipe (30") to a ditch takes off from the north bank 3.3 miles upstream, and was diverting 25 c.f.s. It has since been reported as screened.

An irrigation ditch takes off from the north channel 4 miles upstream, above a low rock diversion dam. It was diverting 1-2 c.f.s. and was not screened.

An irrigation ditch takes off from the north bank 5 1/2 miles upstream and was diverting 3 c.f.s. It was not screened at the time of inspection.

The Tieton Irrigation Dam located 14 miles upstream is built of concrete and has a 2 to 4 foot spill. It is not a barrier at normal water levels, but is a total block at low water periods. No fishway is provided.

The Tieton Irrigation Ditch takes off at the dam, and has a capacity of 320 c.f.s. It is also fed by diversions from Cowiche Creek. An electric screen was installed in the ditch in 1929. The Bureau of Fisheries later installed a battery of 4 drum type revolving screens.

The Rimrock Dam 22 miles upstream was completed in 1925, is 220 feet high (160 feet high from tunnel to spillway level), and is a total barrier to fish. It has a spillway, but most of the water is discharged through a tunnel 18 feet in diameter and having a capacity of 2,000 c.f.s., which is located near the base of the dam. The drop over the spill or the sudden pressure changes encountered in passing from the tunnel kills or injures most fish coming out of the Tieton Reservoir. It is therefore not practical to stock migratory fish above this dam.

The Clear Creek Reservoir Dam was completed in 1918 and is located 1/4 mile above the backwater of Tieton Reservoir, on the North Fork. The dam is 53 feet high from the outlet pipe to the crest.

4D-(2)a. Wildcat Creek 20 miles upstream is a good cold water feeder stream, discharging 20-30 c.f.s., but is also steep and full of difficult cascades. There is a small (1 or 2 c.f.s.) water supply intake 1 1/2 miles upstream. No fish except native tout are reported. All tributaries to the Tieton River entering above the Rimrock Dam are now inaccessible, and a large portion of the former spawning area has been lost, including the North and South Forks, each of which is 18 to 20 miles long.

4D-(3). Rattlesnake Creek.-- (July 30, 1935 and August 31 to September 3, 1936; Whiteleather, Burrows, and Hanavan.) Enters the Naches River 25 1/2 miles upstream and is 23 miles long, the lower 17.7 miles to Little Wildcat Creek having been surveyed. The stream extends through a rugged mountainous canyon, and has a fairly steep gradient. A flow of 93 c.f.s. was measured at a point 4 miles upstream. Logging operations on the lower watershed cause fast freshet rises and bank erosion. Good spawning riffles were found throughout, with the best spawning areas being in the lower 3 miles, and between 15 and 16 miles upstream. Resting pools are numerous, though not well protected. The water temperature was 52° -55°F in the lower portion and 42° -49°F. in the upper portion. Chinook salmon in small numbers are reported to enter the stream in the years when conditions are favorable for passage up the Yakima, and particularly over the Sunnyside Dam. Obstruction and diversions are as follows:

An irrigation diversion 1/4 mile upstream on the south bank diverted 4 c.f.s. It had a low rock diversion dam, and has since been screened.

An irrigation diversion 0.9 miles upstream on the north bank and above a log wing dam was diverting 3.6 c.f.s. and was unscreened.

An irrigation ditch 1.2 miles upstream on the north bank above a log wing dam was diverting 12.7 c.f.s., and was unscreened.

A small irrigation ditch 4.3 miles upstream on the south bank above a board wing dam is unscreened.

A cascade falls 16 1/2 miles upstream is only 8 feet high, but the water is spread out over so great a surface that it is too shallow for fish to pass during low water periods.

4D-(4). Bumping River.-- (July 25-27, 1935; Whiteleather and Burrows.) Enters the Naches 42 miles above the mouth and extends for a distance of 24 miles, of which the lower 16.3 miles to Bumping Lake is accessible to fish. An impassable storage dam at the outlet of the lake was the upper terminus of the survey. This dam is 45 feet high above the stream channel and spills through a 7 foot wide conduit into a deep pool below. It is believed that most fish can pass out of the lake into the stream without injury. The river is 50 to 70 feet wide, has a gradient of 53 feet per mile. The only obstruction below Bumping Lake Dam is a log jam 20 to 40 feet high located 13.7 miles upstream. This is passable at normal water stages by a side channel around the jam, but may be a barrier to fish at low water stages.

The river flow is controlled by the discharge at Bumping Lake Dam, and from April through August it is usually 100 to 600 c.f.s. From September through November it is generally 30 to 90 c.f.s. and from December through March it is quite variable, generally being between 3 and 190 c.f.s. (U.S.G.S. records taken at a station 1/4 mile below the dam). There is no cultivation in the valley, which has steep forested slopes. There are good spawning areas and good resting pools along the entire river below the dam. More good spawning areas are located in the main stream and tributaries above the dam, but are inaccessible at present. There were formerly good runs of spring

chinook salmon into the Bumping River, although the greater portion is said to have spawned in the American River, its largest tributary. A few chinooks were observed by the survey party in deep resting pools, but it was impossible to make an accurate count. Landlocked sockeye salmon (or Kokanee) have been planted in Bumping Lake, and rainbow, cutthroat, and Dolly Varden trout and whitefish were observed in the stream. The river is heavily fished and the present size of fish taken is reported to be much smaller than formerly.

4D-(4)a. The American River.-- (July 28-29, 1935 Whiteleather and Burrows.) Enters Bumping River 3 1/3 miles above the mouth of the latter, and extends for approximately 21 miles into the Mt. Rainier National Forest. The lower 18 miles were surveyed. The flow from March to July is usually 100 to 600 c.f.s., and from July to December it is 25 to 100 c.f.s. December and January flows are variable, but usually over 100 c.f.s., while the February flow is often below 100 c.f.s. The gradient averages 55 feet per mile, although in the lower 5 miles it is over 100 feet per mile and contains a preponderance of large rubble. Resting pools average 6 per mile, and are often deep and well protected. There are no dams or diversions in this stream. The river enters a narrow gorge 14 miles upstream, where it drops 100 feet in 400 yards in a series of cascades. At normal water levels these cascades do not form a complete barrier to fish, but at low water periods there is not sufficient flow over the rocks to permit fish passage. The entire stream has excellent spawning riffles, with the middle and upper sections being of the highest value. The American River was an excellent chinook salmon producer in the past, but there was only a fair run at the time of the survey, when the fish were observed in the deep resting pools. The stream is heavily fished and produces fair numbers of rainbow, cutthroat, and Dolly Varden trout.

4D-(4)a-i and ii. Cooper Creek.-- 9 miles upstream and Union Creek 11 miles upstream, are the chief tributaries of the American River. Although only 5 miles long they have well sustained spring flows of 35 to 40 c.f.s. Both have steep gradients, but contain some spawning areas near the mouths. Union Creek has a series of falls, 12 to 60 feet high, beginning 1/2 mile upstream.

None of the tributaries of the upper Naches (often called the Little Naches above the confluence of Bumping River) have been surveyed. Crow Creek, 4D-(5), entering 44 miles upstream is the largest, being over 16 miles long. It was inspected on May 5, 1937 when it had a flow of approximately 100 c.f.s., but was too turbid to survey. Quartz Creek, 4D-(6), entering on the opposite bank and flowing 40 c.f.s., was also too turbid.

4E. Moxee Creek.-- Entering the Yakima River near the Wenas Creek confluence was not surveyed, but has a small summer flow and is believed to be of no value for salmon, due to irrigation demands.

4F. Wenas Creek.-- (May 6, 1937; Jobes and Baltzo.) Wenas Creek enters the Yakima 106 miles upstream is approximately 30 miles long, and had a flow of 25 to 30 c.f.s. The stream is often dry

during the summer when it is almost entirely used for irrigation, there being several channels for this purpose. A reservoir control dam 60 feet high located 12 miles upstream is a total barrier to fish. This stream formerly supported good salmon and steelhead runs. There are now no runs reported in this creek and there is little chance for stream improvements.

4G. Umptanum Creek.-- (July 1, 1936; Shuman and Kolloen.) Enters the Yakima 121 miles upstream. It is 16 miles long, the lower 7.6 miles having been surveyed to an impassable 35 foot falls. About 1/2 mile upstream an irrigation ditch diverts during high water stages. At a point 3/4 mile up a wing dam diverts all of the flow into an unscreened ditch during periods of low water, and the stream was dry for 150 yards below the dam. Another dam 1/2 mile farther upstream diverts water into an open irrigation ditch during the spring high water period. The stream has a small summer flow and fairly high water temperatures. There is some spawning area present, but most of it is inaccessible and of little possible value because of the dams and diversions. A good run of silver salmon was formerly reported in this stream before the Pomona Dam was built on the Yakima, but there have been no runs of migratory fish in recent years.

4H. Wilson Creek.-- (April 20, 1936; Whiteleather and Shuman.) This creek now enters the Yakima 131 miles upstream. There were formerely two or three tributaries to the Yakima in this area, but they were diverted for irrigation purposes, and are now part of the Wilson Creek system. This creek now receives water from the Colockum ridge flume, from the ditched channels of Naneum, Cherry, and Coleman Creeks, and from the Tjossem Mill ditch near the mouth of the stream. The upper parts of the creeks have clear water and support small trout populations, but salmon and steelhead have not been known to enter the system for many years, and it is so thoroughly utilized for irrigation purposes that it is of no possible value for anadromous fish.

4I. Manastash Creek.-- (June 24 to 28, 1936; Shuman and Kolloen.) Enters the Yakima River opposite Ellensburg, Washington. It extends for 29 miles to the forks, the lower 23 miles having been surveyed. The stream splits into two channels 5 miles above the mouth. The south channel again splits into two channels, which empty into the Yakima about a mile apart. The gradient is slight in the channels on the flat Yakima Valley bottom, but increases upstream. The lower 11 miles of this creek have been taken over almost entirely for irrigation purposes, there being 44 unscreened irrigation diversions present. Nearly half of these ditches have diversion dams of one type or another, although few would be barriers to fish if there were good sustained stream flows. In the upper 10 miles surveyed there were some fine spawning riffles, occasional pools, and good cover. Three low falls were found, but they would not interfere with fish except at very low water stages. Beaver dams have ponded several

areas and some would interfere with fish passage. The two forks are reported to maintain a good flow of cool water, and are supplied by two small mountain lakes. Trout fishing is very good in the upper Manastash and its tributaries. There is spawning area for a large number of salmon and steelhead in this creek and its upper branches, all of which is now inaccessible due to irrigation facilities on the lower courses.

4J. Taneum Creek.-- (July 20, 1936; Shuman and Kollosn.) Enters the Yakima approximately 148 miles above the mouth. The main stem extends for 12 miles to the confluence of the north and south forks, and was completely surveyed. The lower 4 miles of the course is through cultivated valley lands and the remainder is in a steep, rocky canyon. There are some good spawning areas but these are now mostly inaccessible and of little value to anadromous fish because of irrigation demands and numerous low dams. Before the completion of the Taneum Canal in 1910 the stream supported a good run of silver salmom, but no runs have occurred for many years. Diversions and obstructions are as follows:

An irrigation ditch takes off from a brush wing dam on the south bank 1 1/2 miles upstream. It was diverting only 2 c.f.s. when inspected, but has a much greater capacity, and is unscreened.

A concrete dam 2 miles upstream has a spillway 3 feet high, with provision for the use of 2 foot flashboards. It diverts all water from the stream at times.

The Taneum Ditch takes off at the south end of the dam, and was diverting 85 c.f.s. at the time of observation.

The Lom Thompson Ditch takes off from the north bank 2 1/2 miles upstream. It was unscreened, but was not in operation at the time of observation.

A small flume takes off 5.2 miles upstream. It is unscreened and is located above a log dam 1 1/2 feet high.

A ditch 3 feet wide takes off on the north bank approximately 6 1/2 miles upstream, above a log dam 1 foot high. It is unscreened.

4J-(1). North Fork of Taneum Creek.-- (August 3, 1936; Whiteleather and Jobes.) This stream is 11.3 miles long, the lower 5 miles having been surveyed. It flows in a narrow wooded mountain valley, has a moderate gradient and good spawning areas in the section surveyed. Farther upstream the gradient is steeper and there is a greater amount of large rubble in the stream bed. There are no obstructions or diversions except a log jam 3 1/2 miles upstream that may be a barrier at low water. The stream has native trout, but salmon and steelhead runs never have been reported. The observed flow was 8 c.f.s.

4J-(2). South Fork of Taneum Creek.-- (June 22, 1936; Shuman and Kolloen.) This stream is 9 miles long, of which the lower 3 miles were surveyed. Its flow was 17 c.f.s., but it is reported to become nearly dry in late summer. A 25 foot falls 3 1/2 miles upstream is a total barrier. There is spawning area for a few fish in the lower 3 miles, but no runs are reported.

4K. Swauk Creek.-- (July 17 and 18, 1936; Shuman and Peterson.) Enters the Yakima 153 miles upstream. It is 20 miles long, of which 13.6 miles were surveyed. The observed flow was 9 c.f.s., but the lower section becomes dry during the irrigation season. The upper portion of the stream has the best spawning areas. There were twelve small unscreened irrigation ditches diverting a total of 18 c.f.s. at the time of observation, but having considerably larger total capacity. Eleven of the diversions had dams that would hinder the upstream migration of fish but would not be complete barriers except at very low water stages. There are no runs of salmon remaining in Swauk Creek. All tributaries except Iron Creek are dry or nearly so in summer and of no value to salmon.

4K-(1). Iron Creek.-- (July 19, 1936; Shuman and Kolloen.) This 3 mile tributary to upper Swauk Creek was surveyed for 1.2 miles. It is small, having a flow of only 8 c.f.s. at the time of observation, but has some excellent spawning areas. The stream cannot be reached by migratory fish at the present time, but steelhead were reported in it prior to 1915, and native trout are present in fair numbers.

4L. Teanaway River.-- (July 2 to 5, 1936; Shuman and Peterson.) Enters the Yakima approximately 159 miles above the mouth and extends for 11 1/2 miles through a small cultivated valley to the confluence of the Middle and West Forks. The stream was completely surveyed. The gradient is slight, and the discharge becomes very low in the fall. There were 9 irrigation ditches diverting a total of 66 c.f.s. at the time of observation. All of the ditches have been screened. Three low dams were found, none over 3 feet in height, but since each diverts the total stream flow during the irrigation period, they are low water barriers to fish. It was reported that good runs of salmon occurred prior to 1904. From 1905 until 1916 logging companies were blasting in the stream channels and driving logs down the river, which may have contributed to the destruction of the salmon run.

4L-(1). North Fork of the Teanaway River.-- (July 3, and 12-14, 1936; Shuman and Kolloen.) This stream is over 17 miles long, of which the lower 14 miles were survyed. The lower 2 miles of the stream is in a small cultivated valley, but the remainder is in increasingly rugged country, and the upper 2 miles surveyed were too steep and rough to be of value to salmon. The flow was 26 c.f.s. at a point 9 miles upstream. A low dam 1/4 mile upstream diverts the entire flow during periods of low water. Three other low dams were also present. Several log jams and beaver dams may

also interfere with fish migration, and a 5 foot falls 6 1/2 miles upstream is a low water barrier. The survey party found 6 diversions below the falls, each taking 7-13 c.f.s., but these have been screened in recent years.

Good salmon runs were reported prior to the 1905-1916 period, but few fish have been seen since then, and there are no runs reported in recent years. There are good resting pools and spawning areas sufficient for several thousand salmon if this stream and the main Teanaway could be kept passable for migratory fish.

4L-(1)a. Stafford Creek.-- (July 15, 1936; Shuman and Kolloen.) Enters the north fork of the Teanaway stream, 7 miles upstream, is 7 miles long, and the lower 2.7 miles were surveyed to the mouth of Bear Creek. The flow was 21 c.f.s. at the time of observation. The gradient is moderate up to Bear Creek, but is steep above. There is sufficient spawning area for several hundred fish, and salmon were reported to ascend as far as Bear Creek prior to 1916, but there have been no runs in recent years. Bear Creek, a tributary, is 3 1/2 miles long and was surveyed for 1/2 mile to an impassable 20 foot falls and log jam. It had a flow of 8 c.f.s. and spawning area for a few fish below the falls.

4L-(2). Middle Fork of the Teanaway River.-- (July 5-7, 1936; Shuman and Peterson.) Extends for a distance of 15 miles, of which the lower 11 1/2 miles were surveyed. The discharge at the mouth was 16 c.f.s. at the time of observation. The lower 4 1/2 miles is in a cultivated valley where the gradient is moderate and there are good spawning riffles. The gradient increases above, and suitable gravel is confined to small, scattered areas. There were four unscreened irrigation diversions, the lower three having wing dams, and the upper diversions having a log and rock dam that has no spill during low water periods and is therefore a barrier to fish. No salmon runs have been reported since 1916.

4L-(3). West Fork of the Teanaway River.-- (July 5, 1936; Shuman and Kolloen.) This stream is 13 1/2 miles long, the lower 8.7 miles having been surveyed. In the lower 6 miles the stream is about 30 feet wide, is shallow, has a moderate gradient, and a considerable amount of suitable spawning area. Above this point the gradient is steeper and the rubble larger. An impassable 15 foot falls was encountered 7.3 miles upstream and at the upper end of the survey a rock-slide also was believed to be impassable. There were three small unscreened irrigation ditches in the lower 3 miles. One ditch had a low wing dam, and another had a low rock and board dam. Several log jams were believed to be difficult for the passage of fish. No salmon runs have been reported for many years. Stream improvements for the passage of salmon are not warranted because of irrigation demands on the main Teanaway. None of the tributaries of the West Fork had a flow of over 5 c.f.s.

4M. CleElum River.-- (July 25-26, 1941; Weber and Holland.) Joins the Yakima River 169 miles above the mouth. The river is 33 miles long, of which the lower 8 miles up to the impassable CleElum Lake Reservoir Dam were surveyed.

The flow below the reservoir dam is under regulation, and is greatly reduced after the end of the irrigation season in mid October. During the winter impoundment period the discharge is seldom more than 20 to 30 c.f.s. From April to October the discharge is often 600 to 2,000 c.f.s. The stream section below the reservoir is of little value to fish because of the fluctuations in reservoir discharge. A low rubble dam about 1 1/2 miles below the reservoir supplies domestic water for the town of CleElum, the diversion being protected by a panel screen.

The 135 foot high reservoir dam was completed by the U. S. Bureau of Reclamation in 1933 for irrigation purposes. It is improbable that a fishway ever will be built over this dam, and for this reason the river and its tributaries above the reservoir were not surveyed in detail, although it is known that the natural lake on the site of the present reservoir and additional lake and stream spawning areas farther upstream formerly supported good runs of blueback and chinook salmon and steelhead trout. Landlocked bluebacks or kokanee still are present, together with good populations of rainbow, cutthroat, and Dolly Varden trout.

4M-(1). Domerie Creek.-- The only tributary of the CleElm River below the reservoir dam. Most of its flow is diverted 2 miles upstream for the water supply of the town of Roslyn, and the stream is therefore of no value to salmon.

4M-(2). Cooper River.-- Enters the CleElum River 20 miles above the mouth, and extends for a distance of 9 miles. It is inaccessible to anadromous fish because of the impassable ClemElum reservoir dam, and therefore was not surveyed.

4M-(3). Waptus River.-- Enters the CleElum River 22 miles above the mouth, and extends for a distance of 9 miles to Waptus Lake. It is inaccessible to anadromous fish because of the impassable CleElum reservoir dam, and therefore was not surveyed.

4N. Big Creek.-- (February 19, 1935; Shuman.) Enters the Yakima 178 miles upstream, and extends for 10 miles. It is used extensively for irrigation, there being 11 water rights allowing a total diversion of 26.4 c.f.s. On May 6, 1937, its flow was 40 c.f.s. and on July 3, 1937, it was estimated at 10 c.f.s. The lower 2 miles of the stream below the diversions are usually dry during the summer, but a few steelhead trout still ascend the creek during the spring high water period.

4-O. Silver Creek.-- March 6, 1937; Baltzo and Jobes.) Enters the Yakima about one mile below Easton Dam, and is 7 miles long. The discharge was 6 c.f.s. at the time of inspection, but during the greater part of the year the lower portion of the course is practically dry, rendering the stream of no value to migratory fish.

4P. Kachess River.-- (March 20, 1935; Shuman and Whiteleather.) Joins the Yakima less than 1 mile above Easton Dam. It was surveyed for 1 1/2 miles to the impassable storage dam at the outlet of Kachess Lake. There was originally a natural lake at this site, and a crib dam was installed at its outlet in 1905. This was replaced in 1911 by a 63 foot, rock-faced, earth-fill dam built by the Bureau of Reclamation. A good run of blueback salmon entered the lake until blocked by construction of the dam. There are still large sized landlocked blueback or kokanee, ling, cutthroat, and rainbow trout in the lake. Runs of salmon and steelhead no longer enter the stream. The tributaries above the dam were not surveyed because the great fluctuation of the reservoir level makes it improbable that a fishway will be built. The discharge is now completely regulated. It is usually 200 to 1,500 c.f.s. from April to October, and nearly dry during the rest of the year while water is being impounded.

4Q. Cabin Creek.-- (April 19, 1937; Jobes and Baltzo.) Enters the Yakima about 3 miles above Easton Dam, and extends for 14 miles. It had a flow of 50 c.f.s. during the spring run-off, but it is quite low in the fall. The water supply for the town of Easton is diverted from this stream, and the lower 2 miles has been channeled for flood control. The stream therefore has little value to salmon and no runs are reported.

TABLE OF OBSTRUCTIONS AND DIVERSIONS 1/

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Yakima River	Richland or Horn Rapids Dam	5-6		2 ladders
	Columbia or Kennewick Ditch		325	Screened
	Richland Ditch		300	Rotary Screens
	Kiona Ditch		40	Rotary Screens
	Gibbon Station Ditch		?	None
	Prosser Power Dam	8		Poor ladder
	Prosser Power Canal,		1,150	Rotary screens
	Prosser Flour Mill Canal		125-220	Rotary screens
	Kirkwood Ditch		?	?
	Snipes & Allen Ditch		35	Rotary screens
	Flint Ditch		Varied	Panel screen
	Piety Flat Ditch		?	?
	Hardison Ditch		?	?
	Sunnyside Diversion Dam	8		3 fishways
	Sunnyside Canal		1,250	Rotary screens
	Old Indian or Old Reservation Canal		Usually 200	Slat grill & screen
	Wapato Diversion Dams	6-8		2 ladders
	Wapato Canal		1,000	Rotary screens
	Blue Slough Canal System		Varied	All laterals screened
	Union Gap Ditch		71	Rotary screens
	Moxee Ditch		24	Rotary screens

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Yakima River (Cont'd.)	Cascade Lumber Co. Ditch		?	?
	Taylor Ditch		27	Rotary screen
	Gilson Power Ditch			Not in use
	Pomona Dam	5-6		Not in use
	Selah-Moxee Canal		140	Rotary screens
	Roza Dam	20		2 ladders
	Roza Canal		2,200	Rotary screens
	Stein-McLeod Ditch		?	Panel screen
	Stone-McGaff Ditch system		?	Laterals screened
	Tjossem Grist Mill Canal		146	Rotary screens
	Damon Mill Ditch		12	None
	Grinrod-Doughty Ditch		34	Rotary screens
	Reed Ditch		5	Screened
	Ellensburg Power Canal		612	See text
	Ellensburg Water Co. Dam	4-6		None
	Ellensburg Water Co. Canal and Olson Canal		174	Rotary screens
	Mills Power Dam	2-3		None
	Mills Power Canal		112	None
	Westside Irrigation Co. Canal		112	Rotary screens

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Yakima River (Cont'd.)	Ellison Ditch		20	Rotary screen
	Garrison Ditch		37	Screened
	Cascade Ditch		140	Rotary screens
	Swauk Creek		Small	None
	O'Connor Ditch		15	Screened
	Frazer Ditch		6	Screened
	Younger or CleElum Town Ditch		15	Screened
	Easton Dam	40		1 ladder
	Kittitas or High Line Canal		over 1,300	Bar screen
	Keechelus Lake Control Dam	70		None

1/ This list does not include minor cascades, low falls, log and brush jams, etc., that do not interfere with passage of migratory fish. The listed height of falls and dams is the approximate height that fish would have to jump to clear the obstruction at normal water levels; i.e. the distance from tailwater to the crest of the obstruction. Small irrigation pumps are usually screened and are not listed in the table of diversions.

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in o.f.s.	Existing Protective Devices
Satus Creek	Indian Service Dam and Irrigation Canal	1-2	110	None
	Shearer Irrigation Canal		10	None
	Irrigation Ditch		Small	None
	Irrigation Dam and Ditch	2	6 ft. wide	None
	Irrigation Dam and Ditch	2	Small	None
	Satus Stock Ranch Ditch		10 ft. wide	None
	Irrigation Dam and Ditch	$2\frac{1}{2}$	6 ft. wide	None
	Rock and Debris Slide	4-5		None
Logy Creek	Falls	15		None
Toppenish Creek	Several Irrigation Channels		varied	None
	Irrigation Dam and Ditch	4	Total in season	None
Ahtanum Creek	Main Channel; 11 dams and 23 diversions	1-3	1-70 varied	Only 1 screened
	Hatton or Hollow Creek Dam and Channel; Several low dams and 33 diversions	$3\frac{1}{2}$	Varied	None
	Bachelor Creek Dam and Channel; Several low dams and 38	3-4	Varied	None

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
North Fork Ahtanum Creek	4 Irrigation Diversions; several beaver dams	2-4	?	None
	Irrigation Dam and Ditch	4	?	None
South Fork Ahtanum Creek	6 Irrigation Diversions		Varied	None
Naches River	Old Union Ditch		66	Rotary screens
	Fruitvale Diversion Ditch		110	Rotary screens
	Naches-Cowiche Diversion Dam	5-6		Fishway
	Naches-Cowiche Irrigation Ditch		50	Rotary screen
	Yakima Irrigation Canal		?	Panel screens
	Schuller-Rodenback Ditch		6	Rotary screen
	Chapman and Nelson Ditch		32	Screened
	McCormick & Long Ditch		4-5	None
	White and Leach Ditch		6	None
	Congdon (or Condon) Ditch		60	Rotary screen
	Morrisey Ditch		8	Screened
	Gleed Irrigation Ditch		78	Rotary screen

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Naches River (Cont'd.)	Scott Channel Diversions (6)		16-27 ea.	Screened
	Kelley and Lowery Ditch		40	Screened
	Foster-Naches Ditch		9	Screened
	Clark Ditch		12	Screened
	Wapatox Dam	2-4		None
	Wapatox Power and Irrigation Canal		565	Rotary Screens
	Selah-Naches Canal		136	Rotary Screens
	Yakima Water Co.Dam	3-5		Fishway
	Yakima Water Co. Canal		?	Ground filters
	Feohter and Janeck Ditch		2	None
	Krober Ditch		3	None
	Meloy (or Melog) Ditch		4	None
	Griffin Ditch		4	Screened
	Stevens (or Soott-Stevens) Ditch		13	Screened
	Frederick & Hunting Ditch		7	Screened

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Naches River (Cont'd.)	Carmack & Parker Ditch		3	Screened
	Palmer Ditch		3	Screened
	Lower Markel Ditch		11	Screened
	Upper Markel Ditch		?	None
	Lindsay Ditch		16	Screened
	Valentine Ditch		2	None
	Benton Ditch		3	Screened
	Emrich (or Emrie) Ditch		4	Screened
	Anderson Ditch		6	None
	Fontaine Ditch		3	Screened
	Cascade	8		None
Cowiche Creek	9 Irrigation ditches and dams	1-3	Varied	None
North Fork Cowiche Creek	Partly used for Tieton Canal		Varied	None
South Fork Cowiche Creek	5 Irrigation dams and diversions	1-3	Varied	None
South Fork Cowiche Creek	5 Irrigation dams and diversions	1-3	Varied	None
Tieton River	Irrigation Ditch		$12\frac{1}{2}$	Screened
	Irrigation Ditch		2	Screened
	Irrigation Ditch		1-5	None

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Tieton River (Cont'd)	Irrigation Ditch		1-5	Screened
	Irrigation pipe and ditch		25	Screened
	Irrigation dam and ditch	2	2	None
	Irrigation ditch		3	None
	Tieton Irrigation Canal Dam	2-4		None
	Tieton Irrigation Canal		320	Rotary screens
	Rimrock Dam (Storage)	160		None
Wildcat Creek	Many cascades; water supply diversion	2-10	1-2	None
North Fork Tieton River	Clear Creek Reservoir Dam	53		None
Rattlesnake Creek	Irrigation diversion and dam	low	4	Screened
	Irrigation diversion		3.6	None
	Irrigation ditch		12.7	None
	Irrigation ditch		2-3	None
	Cascading falls	8		None
Rock Creek	Falls	4		None
Gold Creek	Many cascades and falls			None
Bumping River	Log jam	20-40		None
	Bumping Lake Reservoir Dam	45		None

TABLE OF OBSTRUCTIC AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
American River	Beaver dams	1-5		None
	Cascade series	2-6		None
Union Creek	Series of falls	12-60		None
Wenas Creek	Irrigation diversions		Nearly all	None
	Reservoir and control dam	60		None
Umptanum Creek	3 Irrigation dams and ditches	1-3	Nearly all	None
	Falls	35		None
Wilson-Cherry Creek System	Many irrigation dams and ditches			None
Manastash Creek	44 Irrigation ditches and several dams	1-4	varied	None
	3 cascade falls, and several beaver dams	1-4		None
Taneum Creek	Irrigation ditch		2-20	None
	Taneum diversion dam	3-5		None
	Taneum ditch		85	None
	Lom Thompson ditch		?	None
	Irrigation dam and flume	1-2	small	None
	Irrigation dam and ditch	1	?	None

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
North Fork Taneum Creek	Log jam	4-6		None
South Fork Taneum Cr.	Falls	25		None
Swauk Creek	12 Irrigation diversions, 11 with dams; beaver dams	1-4	18 (total)	None
Teanaway River	9 Irrigation diversions and 3 irrigation dams	3	66 (total)	Screened
North Fork Teanaway River	4 Irrigation dams and 6 irrigation diversions	1-3	7-13 ea.	Screened
	2 Log jams; beaver dams	2-6		None
	Falls	5		None
Bear Creek	4 Log jams; falls	6;20		None
De Roux Creek	Falls	6		None
Middle Fork Teanaway River	4 Irrigation diversions and 1 dam	2-4	4-12 ea.	None
West Fork Teanway River	3 Irrigation ditches 1 dam	3	12 (total)	None
	Several log jams; 2 falls	6-15		None
CleElum River	CleElum Water Co.dam and diversion	2-3	varied	Panel screen
	CleElum Lake and reservoir dam	135		None

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Domerie Creek	Roslyn Water supply dam and diversion	Low	Varied	None
Little Creek	Irrigation diversions		All	None
Big Creek	11 Water rights		26.4 (total)	None
Kachess River	Kachess reservoir and control dam	63		None
Cabin Creek	Easton water supply dam and diversion	?	Varied	None

Interior—Duplicating Section, Washington, D. C.
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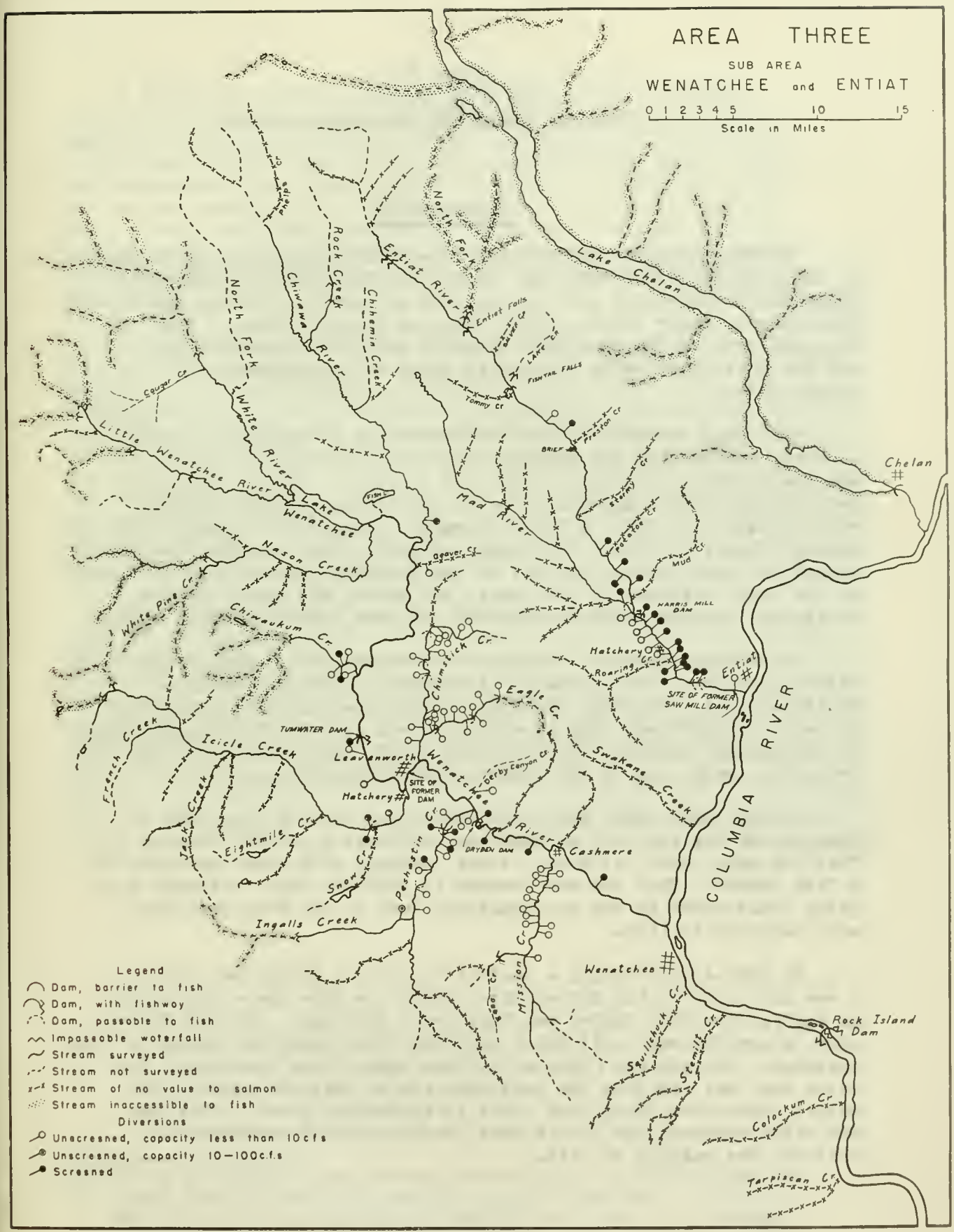

Figure 5.-- Sub-Area Wenatchee and Entiat River Systems

PART 3

SUB-AREA WENATCHEE AND ENTIAT RIVERS

Introduction

The Wenatchee and Entiat Rivers have their sources high in one of the most rugged sections of the Cascade Range near Glacier Peak (altitude 10,436 feet) and run parallel courses in a southeasterly direction to their junction with the main Columbia River. The drainage area of the Wenatchee River is over 1,000 square miles and the drainage area of the Entiat River is approximately 500 square miles.

The upper portions of the watersheds are in rugged, forested country, and many of the tributaries in this section are steep and inaccessible because of falls and cascades. Winter snows are heavy in the forest area, and few of the streams in this section ever go naturally dry. A few of them are clouded with glacial silt during run-off periods. This upper section grades rapidly into the semi-arid, open country typical of the Columbia plateau region. Many of the lower tributaries are nearly dry during the summer months, irrigation demands now rendering most of them inaccessible to salmon.

There were formerly good runs of steelhead trout and chinook salmon into both river systems. Blueback salmon ran into Lake Wenatchee, and a good run of silver salmon spawned in the Wenatchee system. All of these runs were greatly reduced during the early part of the present century, primarily due to the unscreened diversion of irrigation water and to the construction of small dams.

An old lumber mill dam in the Wenatchee River at the town of Leavenworth was reported to have been at least a partial barrier to fish for many years, although it was equipped with some semblance of a fish ladder. This dam was removed in 1933 or 1934. Fishways were later constructed at the two remaining dams on the Wenatchee that were barriers to fish.

In 1898 a dam forming a partial barrier to salmon was built at a saw mill site on the Entiat River about one mile above the mouth. An ineffective fish ladder was built over this dam. Shortly thereafter a new dam was built which entirely obstructed the passage of fish upstream. Indians are reported to have taken large numbers of fish below the dam. In 1904 the last good run of chinooks entered the Entiat, depletion being very rapid in succeeding years. This dam was later removed, but others were installed which continued to obstruct the passage of fish.

A power dam 4 feet in height was constructed by the Puget Sound Power and Light Company on the Entiat about 3 miles above the mouth. This dam formed a barrier because of the diversion of a major part of the flow to the power plant one mile downstream, the intervening river channel being impassable at low water stages. The dam was provided with a fishway in 1939. The production of power at this point was abandoned in 1938, but the canal is still used to supply irrigation water, and an excessive amount of water is diverted from the river merely to be returned unused farther downstream.

Another dam in the Entiat, known as the Kellogg Mill Dam, was built in 1913 at a point a little over 3 miles above the mouth. This dam was 8 feet high, and was a barrier to fish except at flood stages. The mill burned in 1917, but the dam continued to bar the passage of fish until an opening was blasted through the structure by sportsmen in 1932. This dam later was completely washed out.

The Harris Mill Dam, formerly located 11 miles up the Entiat, was constructed in 1930. This dam, 13 1/2 feet high, was provided with an ineffective fishway in 1931. A better fishway was constructed in 1939. The entire structure was washed out in the flood of 1948.

Most of the diversions were screened, beginning about the year 1930, so that toward the end of the decade many of the former hazards to the migration of fish had been partially or totally removed. As a result of these stream improvements the productive capacity of these two rivers was somewhat improved and they, together with the Methow and Okanogan Rivers, were selected as the streams to receive the stocks of fish blocked by Grand Coulee Dam. This transplantation program took place during the period 1939-1943. 1/

1/ Fish, Frederic F. and Hanavan, Mitchell G. A Report upon the Grand Coulee Fish-Maintenance Project, 1939-1947. - Fish and Wildlife Service, Special Scientific Report No. 55, November 1948, p.1-63.

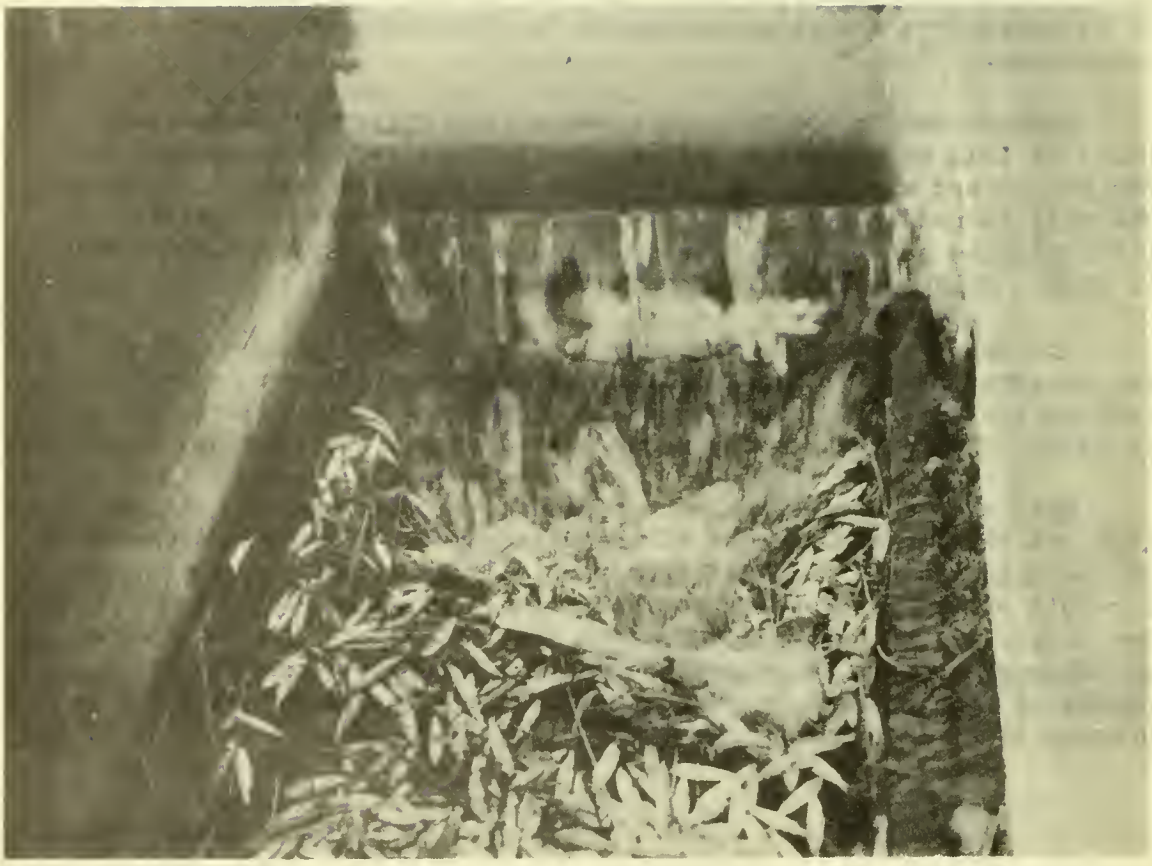

Figure 6.-- Dead chinook fingerlings in a Wenatchee River unscreened irrigation diversion ditch on July 14, 1940. Over 1,800 dead fingerlings were found in this ditch on the above date. A properly constructed and operated screen would have prevented this loss.

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12. Wenatchee River.-- (Surveyed at various times 1935 - 1947, by Suomela, Brown, Christy, Shuman, Whiteleather, Burrows, and members of the Grand Coulee fish maintenance project.) Enters the Columbia River at Wenatchee, Washington, and extends for 55 miles to Lake Wenatchee. The river is 200-350 feet wide near the mouth, and about 150 feet wide below the lake. It is mainly fed by rains and melting snow on the high mountains. The discharge in winter and spring is usually between 1,100 and 7,700 c.f.s., and in summer and fall it is 500-3,000 c.f.s., generally nearer the lower figure.

The gradient is moderate (62 feet per mile) throughout most of the course. The steepest and roughest section begins just above the town of Leavenworth, and extends for about 10 miles through Tumwater Canyon. A second section in which the stream bed is composed mainly of large rubble and bedrock with little spawning area is found in the 5 miles below the village of Plain, or about 9 miles below Lake Wenatchee. With the exception of these two sections, good spawning areas occur all along the course, with the best riffles in the upper 9 miles below the outlet of the lake. There is more than 700,000 square yards of suitable spawning area in the main stream, and over 400,000 square yards additional in the tributaries.

A fair run of spring chinook salmon reaches the Tumwater Dam in June and proceed to the upper major tributaries, although a few spawn in the main Wenatchee. It has been observed that in the years when mountain snow storage is heavy and the discharge is high that the chinook salmon go farther upstream and into the upper tributaries, while in low water years more are observed spawning in the middle and lower sections of the main river. The run of spring chinook spawns for the most part in August. There is also a summer run of larger chinook that enter the Wenatchee between July and September. These fish often have considerable difficulty in passing the Dryden and Tumwater Dams, and in some years the majority are forced to spawn in that portion of the river below Tumwater Dam. The summer chinook spawn mainly during September and October.

A large run of silver salmon formerly utilized the Wenatchee River for spawning purposes but they were virtually exterminated many years ago due to the previously mentioned barriers and diversions. They were reported to have entered the river during the period September - November with the peak of the run in October. Only a few silver salmon now migrate above Rock Island Dam, on the main Columbia River, the greatest recent count being 226 fish in 1947. The majority of the silvers passing Rock Island spawn in the Wenatchee River.

Virtually all of the bluebacks passing Rock Island Dam spawn in the Wenatchee and Okanogan River watersheds, these two rivers at present being the major producing areas of blueback salmon in the entire Columbia system. A part of the spawning run is taken for

artificial propagation by the Leavenworth hatchery of the Fish and Wildlife Service and the majority of the resulting fingerlings are liberated into Wenatchee Lake to aid in maintaining and increasing the abundance of this valuable species.

The Wenatchee supports a good run of steelhead trout which spawn in the spring in the upper section of the river and its tributaries. Cutthroat, Dolly Varden, rainbow trout, whitefish, and kokanee are also present and are extensively fished in the Wenatchee River watershed. Obstructions and diversions on the Wenatchee River are as follows:

The Gunn Irrigation Dam and Diversion is located 6 miles upstream. The dam is built of concrete, has a drop of 1 1/2 feet, and is on the north channel of the river at this point. The diversion has a capacity of 40 c.f.s. and was screened in 1938.

The Jones-Shotwell Ditch 12 miles upstream has a capacity of 25 c.f.s. It was provided with a rotary screen in 1938.

The Pine Flats Irrigation Ditch 16 1/2 miles upstream diverts 4 c.f.s. and is screened.

The Dryden Dam formerly owned by the Puget Sound Power and Light Company and the Wenatchee Reclamation District, and now operated by a Public Utility District, is located 17 miles upstream and has always been a serious obstruction to the upstream passage of anadromous fish.

There are three sections of this dam; an "upper dam" extending about two-thirds the way across the river, a concrete wall extending downstream about 100 yards, and a "lower dam" continuing to the opposite shore. The "upper dam" is about five feet high while the "lower dam" is approximately eight feet high. Both dams are constructed of wooden timbers and have wide downstream aprons. Both dams were equipped with small wood fishways. The fishway at the "upper dam" was replaced with a concrete pool-type fishway in 1947. The fishway at the "lower" dam has been virtually out of operation for a number of years. The situation at Dryden is aggravated insofar as the passage of fish is concerned owing to the diversion of water at this dam for power and irrigation purposes. The power plant is nearly a mile downstream from the dam so that the intervening reach of the river is nearly dry at low water flows, and fish have difficulty in ascending the river at such times.

The Dryden Power and Highland Canal takes off at the north end of the dam, and has a capacity of 1,375 c.f.s. A power house located nearly a mile below the intake returns a large portion of the water to the river, and the remainder is carried by the Highland Canal to the Wenatchee Reclamation District.

Figure 7.-- A rotary drum screen in a diversion ditch on the Wenatchee River. A by-pass provides passage for the fingerlings from in front of the drum screen back to the river.

When the Wenatchee River was first surveyed in 1935 the only protective device in the Dryden Ditch was an ineffective electric fish screen. Shortly thereafter, a battery of 7 rotary screens was installed in the canal a short distance above the power plant.

The Leavenworth Hatchery Diversion Canal was constructed in 1940 one mile above the town of Leavenworth. It has no dam, the water being diverted directly from the side of the stream channel. The hatchery intake from this canal is screened, and any fish in the canal can continue on through to lower Icicle Creek and thence into the Wenatchee River.

The Tumwater Power Plant of the Puget Sound Power and Light Company is located about 28 miles upstream, in Tumwater Canyon. The power diversion, originating at the dam 2 miles farther upstream, and amounting to a maximum of 550 c.f.s., operates a low speed turbine and is returned through the tailrace to the river at this point. The flow in the intervening river channel becomes very low at certain water stages, and at such times this section is a definite hazard and a partial barrier to the upstream migration of fish.

The Tumwater Power Dam of the Puget Sound Power and Light Company has a drop of about 15 feet onto a wide downstream apron. Passage for fish is provided by means of a multiple entrance ladder on the north side of the dam. Frequent fluctuations in the water level above the dam occur because of the slight storage capacity and irregular power demands. This in turn requires frequent adjustment of the flow in the fishway during the periods of upstream migration. The power diversion is screened at the intake.

12A. Mission Creek.-- (June 26, 1935; Suomela and Shuman, June 6, 1936; Burrows and Whiteleather.) Enters the Wenatchee River about 12 1/2 miles upstream, at Cashmere, Washington. The stream is 19 miles long, and the lower 17 miles were surveyed. The gradient is slight to moderate and there is only a small percentage of large rubble. The lower half of the stream has been straightened and dredged, and some portions provided with cribbing along the banks for protection and drainage during severe spring freshets; this process has eliminated pools and most marginal vegetation through the narrow, farmed valley. The lower 5 miles were polluted with household and barnyard sewage and garbage. In spite of this poor condition a few steelhead manage to ascend in May when the creek is high. There were 13 unscreened irrigation diversions and 3 low dams, two of them temporary. These diversions take the entire flow during the irrigation season and the stream usually is almost dry and therefore inaccessible a short distance above its mouth during the summer and fall months; it is therefore of no value to salmon.

12A-(1). Sand Creek.-- (June 28, 1935; Suomela and Shuman.) This tributary of upper Mission Creek extends through a narrow, forested valley for a distance of 8 miles, of which the lower 3 miles were surveyed. The stream bed contains a large amount of sand which greatly reduces the amount of suitable spawning area. A log jam 1/4 mile above the mouth and a falls 2 1/4 miles upstream were both barriers to fish at low water. The stream appears to be accessible and of value only to a few spring run steelhead trout.

12A-(2). East Fork of Mission Creek.-- (June 28-29, 1935, Suomela and Shuman.) Extends for 6 1/2 miles, of which the lower 2 1/2 miles were surveyed. The numerous beaver dams forming low water barriers as well as the large percent of mud and sand in the stream bed limit the available spawning area. The stream is of no present value to salmon. A small run of steelhead trout is able to ascend during the spring freshets.

12B. Peshastin Creek.-- (October 13-14, 1935; Burrows, Whiteleather, and Shuman.) Enters the Wenatchee River about 21 miles above the mouth, and approximately 2 miles above Dryden Dam. The stream extends for 18 miles, of which the lower 15 miles were surveyed. The watershed covers a rugged forested, mountainous area, and the stream gradient is fairly steep, with numerous cascades and low falls. However, there are some small, scattered spawning areas. The value of the stream for fish has been greatly reduced by irrigation use. Three low dams located 2, 2 1/2, and 6 miles upstream are barriers during the irrigation season. There were seven wing dams and nine irrigation diversions in use, of which five since have been screened. Chinook fingerlings were observed in 1944, and in 1945 a few spring chinooks were seen spawning. Fair runs of steelhead trout also were observed in 1944 and 1945. However, in 1946 and 1947 no salmon or steelhead were found.

12B-(1). Ingalls Creek.-- (July 27, 1936; Suomela and Jobes.) Enters Peshastin Creek 8 miles above the mouth. It is 14 miles long, of which 6 1/2 miles were surveyed up to an impassable 40 foot falls. The stream gradient is steep, being over 200 feet per mile, and the stream is mainly a series of cascades in a narrow, steep-sided, rocky canyon. Spawning area is confined to small, scattered patches that might accommodate only a few fish. There is a low dam 3/4 mile upstream with a diversion of 28 c.f.s. to a small electric power plant. No salmon are reported, and steelhead are seldom seen, although cutthroat trout and Dolly Varden are taken by fishermen.

12C. Chumstick Creek.-- (June 25-26, 1935; Whiteleather and Burrows.) Enters the Wenatchee River 24 miles above the mouth, just below the town of Leavenworth, Washington. The stream is 13 miles long, of which 11 miles were surveyed. The gradient is moderate, and there is a large amount of sand in the stream bed. The only good spawning area occurs in the lower 2 miles, which could accommodate several hundred salmon spawners. There were thirteen unscreened

irrigation diversions, three with dams that were considered barriers during low water periods. The first dam is located about 3 miles upstream. At times during the summer the entire flow is diverted and the stream bed is nearly dry. A few steelhead trout were reported to enter the stream in May, and a few chinook salmon enter after the fall rains in October, spawning in the lower 1/2 mile. The stream is of little present or potential value to migratory fish.

12C-(1). Engle Creek.-- (June 26, 1935; Whiteleather and Burrows.) Enters Chumstick Creek and extends for a distance of 9 miles, of which 6 miles were surveyed. The stream is similar to Chumstick Creek, particularly in being sandy and brushy. Spawning area for a few fish exists in the lower 1/2 mile, but there is little above. A total of 11 irrigation diversions, all unscreened at the time of inspection, leave the stream dry in places during most summers, and render it of little possible value to migratory fish. A small dam 3/4 mile upstream is a barrier to fish at low water stages. Normal stream flows are controlled by the impassable 15 foot Parkins Dam located 6 miles above the mouth. A few chinook salmon formerly spawned in the lower section, but none have been observed in recent years. A few steelhead trout were reported, and native trout are taken in the upper section. The stream is of little possible value to anadromous fish.

12D. Icicle Creek.-- (September 27 - October 7, 1935; Whiteleather, Burrows, and Shuman.) Enters the Wenatchee River at Leavenworth, Washington, and extends for 26 miles to its source in three small lakes high in the Cascade Mountains. The lower 24 miles were surveyed to an impassable series of 5 to 15 foot falls. The stream is 40-60 feet wide and discharges 90-300 c.f.s. during the summer and fall months and 2,700-3,200 c.f.s. during the spring run-off season. The lower 2 miles have a slight gradient and contain the best spawning area. The gradient jumps to 176 feet per mile in a rugged canyon above, but becomes moderate again farther upstream.

The Leavenworth Hatchery of the Fish and Wildlife Service was built in 1940 on Icicle Creek at a point about 2 1/2 miles above the mouth. This hatchery handles part of the transplanted runs that formerly passed above the Grand Coulee damsite. No salmon are allowed to pass above the hatchery racks, although small runs of chinook and blueback salmon, believed to consist mainly of hatchery stock, have been observed spawning below the hatchery. A few silver salmon and fair runs of steelhead trout, chinook, and blueback salmon run up to the hatchery.

There is a diversion from Icicle Creek available as part of the hatchery water supply. Other water supplies, particularly from Snow Lake and from deep wells relieve the hatchery from dependence upon the Icicle Creek diversion.

The Cascade Orchards irrigation diversion is located about 4 miles above the mouth. It has a capacity of 7 1/2 c.f.s., and was screened in 1938.

The Icicle irrigation and water supply dam is located about 5 miles above the mouth. It is a concrete structure with a drop of 2 1/2-4 feet, and is usually a barrier during the irrigation season. The Icicle irrigation ditch intake on the south end of the dam has a capacity of 110 c.f.s. It was screened in 1938. The town of Leavenworth water supply intake is located at the north end of the dam, and also is screened.

12E. Chiwaukum Creek.-- (October 15, 1935; Burrows.) This tributary enters the Wenatchee River 38 miles upstream. It is over 11 miles long, and was surveyed for 4 1/2 miles to a series of impassable falls having a total drop of nearly 250 feet. It had a flow of 25 c.f.s. at the time of observation and is in a narrow, forested, valley that is not over 1/4 mile wide at any point except at the mouth. The gradient is steep, being 100 to 150 feet per mile; large rubble predominates, and there is suitable spawning for only a few hundred fish. There are five diversions; three being unscreened irrigation diversions, one a screened diversion to a state trout hatchery, and the other a screened diversion to a C.C.C. camp that is no longer in use. No salmon runs were reported, and rainbow and cutthroat trout, formerly abundant, were considerably depleted. A few steelhead trout are reported to enter. The South Fork, the only tributary of size, enters above the falls and is therefore inaccessible.

12F. Beaver Creek.-- (July 13, 1937; Baltzo.) This small creek enters the Wenatchee approximately 48 miles upstream. It is 5 miles long, and is quite brushy. It had a flow of 4 c.f.s., but is largely used for local irrigation, and becomes almost dry later in the summer. It is of no value to salmon.

12G. Chiwawa River.-- (October 1, 9, and 10, 1935; Whiteleather, Burrows, and Shuman.) Enters the Wenatchee approximately 50 miles upstream, extends for 27 miles, and was completely surveyed. Its headwaters are fed by small glaciers near the Cascade summit, and during the spring and early summer the stream is clouded by glacial silt, clearing in the fall. The summer and fall discharge is usually 100-150 c.f.s. The spring run-off in April, May and June, fed by heavy snow melt, occasionally reaches a peak of 2,400 c.f.s. The gradient is moderate throughout, and the current is usually fairly fast. The water temperature was 45-51°F. There is a considerable amount of spawning area, estimated to exceed 100,000 square yards. No salmon were found at the time of the survey, and it was reported that there had not been any run into the Chiwawa for at least 20 years previously, although it had been a favorite salmon fishing stream of the Indians in the early days. After the start of the transplantation of a portion of the up-river runs into the Wenatchee River system in connection with the Grand Coulee Dam project, beginning in 1939, stream observers each year found a few chinook salmon ascending the Chiwawa to spawn. It is hoped that the run may be reestablished. The stream supports a good resident trout population. The only diversion on the stream is located 3 1/2 miles above the mouth, and has a capacity of 40 c.f.s. for irrigation.

Only two of the several tributaries were found to be of possible value to salmon, the others being either too small or too steep and rough.

12G-(1). Chickamin Creek.-- (July 14, 1937; Jobes.) Enters the Chiwawa River 12 miles above the mouth. It is 8 miles long, of which the lower 2 miles were surveyed. The creek was 20 feet wide and had a flow of 61 c.f.s. The lower mile on the Chiwawa valley bottom has a moderate gradient and good spawning riffles between adequate resting pools. The gradient increases rapidly above; most of the stream course being in a steep canyon, and bordered by dense brush, with spawning area confined to small patches. The discharge becomes low in the fall, but the lower section is usually passable to fish. Three log jams in the lower 3 miles may be barriers at low water. Chickamin Creek could support a small run near its mouth, but no migratory fish have been known to enter it in recent years.

12G-(1)a. Marble Creek.-- Entering Chickamin Creek about 1 mile above the mouth, is steep and has only a small amount of spawning area near its mouth. It was 8 feet wide and had a flow of 15 c.f.s.

12G-(2). Rock Creek.-- (July 14, 1937; Baltzo.) Enters the Chiwawa River about 17 miles above the mouth. The stream is 12 miles long, of which the lower 5 miles were surveyed. The discharge was 64 c.f.s., somewhat greater than the normal flow. The lower mile, in the flat Chiwawa Valley, has a moderate gradient and contains all of the good spawning area in the stream, amounting to an estimated 14,000 square yards. Above this section the stream is in a steep, narrow, forested valley and has an average gradient of more than 200 feet per mile. It is almost a continuous succession of clear, cold, tumbling cascades. Salmon could not ascend very far above the lower mile, and no runs were reported. Trout have been planted, and the lower part of the stream is heavily fished.

12H. Fish Lake Stream and Fish Lake.-- Fish Lake Stream enters the Wenatchee River 2 miles downstream from Lake Wenatchee. It extends for 1 mile to Fish Lake. The gradient is slight to moderate, and the flow is normally 5-10 c.f.s., although the stream may become dry in late summer. Numerous beaver dams prevent the migration of fish up or down the outlet stream.

Fish Lake is approximately 1 1/2 miles long and 1 mile wide. The greatest depth is about 50 feet, but there are large marginal areas of shallow water. The bottom is composed mainly of mud, with one or two small gravel banks. The lake is fed by several large springs with short inlets, and by melting snows from the adjacent mountain slopes. The fish population includes perch, largemouth bass, several cottoids, squawfish, and a few kamloops trout. Neither the stream nor the lake is of value to anadromous fish.

Figure 8.-- Excellent spawning riffles for salmon and steelhead trout in Nason Creek, a tributary of the upper Wenatchee River.

12I. Nason Creek.-- (Surveyed at various times 1935-1947; Whiteleather, Shuman, and members of the Grand Coulee fish maintenance project.) Enters the Wenatchee River just below Lake Wenatchee. The stream is 25 miles long, of which the lower 23 miles were surveyed. The discharge ranges from less than 50 c.f.s. during the late fall and winter months to 3,000 c.f.s. at maximum flood stage. The normal midsummer flow is 100-150 c.f.s. The gradient is slight to moderate in the lower half of the course, with numerous good spawning riffles and adequate, well-protected resting pools. It is estimated that there is approximately 100,000 square yards of suitable spawning area in the lower 15 miles. Gaynor Falls, located 15 miles upstream, is 12 feet high. This falls is a barrier to salmon, and it is doubtful if it is passable to steelhead trout at high water stages.

There once were large runs of chinook and silver salmon and steelhead trout into Nason Creek, but the salmon were practically exterminated and the steelhead greatly reduced for many years. Between the years 1939 and 1944 the Grand Coulee fish maintenance project maintained a weir just above the mouth, and transplanted adult chinook salmon and steelhead from Rock Island Dam on the main Columbia River into the stream. These fish spawned successfully for the most part, and a small run of spring chinook salmon has been reestablished. The steelhead are more difficult to observe because of their migration during the high water period, but a few returning adults have been seen below Gaynor Falls.

12I-(1). Whitepine Creek.-- (Surveyed at various times, 1936-1947; Whiteleather and members of Grand Coulee fish maintenance project.) Enters Nason Creek 14 miles above the mouth. The stream is 8 1/2 miles long, of which the lower 2 miles were surveyed. The discharge ranges from 15 to 50 c.f.s. A short distance above the mouth the course extends through a narrow, steep-walled canyon. A falls 18-20 feet high located 1 1/2 miles upstream is an impassable barrier to the upstream migration of fish. The gradient is steep, and spawning areas are small and scattered. The stream below the falls could accommodate only a small number of salmon. A few of the adult chinook salmon and steelhead transferred into Nason Creek were observed to work their way up this stream as far as the falls. Rainbow trout are numerous, but of small size.

12J. Lake Wenatchee.-- This lake, located at the head of the Wenatchee River, is 5 miles long and about 1 mile wide. The bottom is largely covered with glacial silt, with little good spawning area. The depth for the most part is 150-200 feet, there being few shallow areas. The shores are mostly rocky and wooded, although there is a swamp area bordering the head of the lake between the mouths of the Little Wenatchee and White Rivers. Lake Wenatchee is important in that it is one of the few remaining accessible rearing areas for blueback salmon in the Columbia River system.

The Grand Coulee fish maintenance project of the Fish and Wildlife Service transferred adult blueback salmon from the Rock Island traps into Lake Wenatchee from the year 1939 to 1943, the largest yearly transfer being 13,000 fish in 1943. These fish spawned mainly in the Little Wenatchee and White Rivers, with a few dropping down to spawn on the first few riffles below the lake outlet. Observations made in 1942 and 1943 showed no spawning activity along the lake shore. However, in September 1947, 46 spawning bluebacks and 10 redds were found on a small gravel area in the lake. A few chinook salmon were placed in the lake in 1939, most of these spawning at the outlet, with a few observed in White River. No more chinook were placed in the lake until 1943, when 900 were planted to determine the feasability of using the lake as a natural holding area. The majority of these fish spawned in the 3 miles below the falls on White River, a few spawned at the lake outlet, and one or two were observed in the Little Wenatchee River.

The lake always has had a large population of landlocked blueback salmon, known as "kokanee", "silver trout", or "little redfish". Kokanee are naturally distributed over much of the Columbia River watershed. Since kokanee furnish good sport fishing, they have been stocked in many lakes in recent years, and the state takes eggs annually from the Little Wenatchee River for this purpose. Kokanee are observed to concentrate their spawning activities lower in the Little Wenatchee River than do the blueback, and usually complete their spawning a week or so earlier than the blueback. Since there are still spawning areas in both the Little Wenatchee and White Rivers that are not being used there is little reason to believe that the blueback have interfered with the kokanee spawning.

12J-(1). Little Wenatchee River.-- (Surveyed at various times, 1935-1947; Burrows, Whiteleather, Shuman, and members of Grand Coulee fish maintenance project.) Enters the upper end of Lake Wenatchee through a small swamp and extends for more than 20 miles. The lower 15 miles were surveyed up to an impassable 30 foot falls. In the lower section the river is normally 50-60 feet wide. A discharge measurement of 40 c.f.s. was taken in September at low water stage. However, the flow at other seasons is much higher. The gradient is slight in the lower 1/2 mile, and the stream bed is heavily silted. In the next 3 1/2 miles upstream deep, sluggish, resting pool areas alternate with excellent shallow spawning riffles. Above the lower 2 miles the course extends through a rocky gorge, with a coniferous forest covering most of the mountainous watershed. Good spawning riffle and resting pool areas alternate in this section. A series of falls 4 to 20 feet in height is located 6 miles above the mouth. At this point the stream drops approximately 100 feet in a distance of 120 yards, and the cascades and falls are believed to constitute practically a total barrier to the upstream passage of fish. No

anadromous fish have been reported above this point. There is more than 100,000 square yards of suitable spawning area in this lower 6 miles. The amount of spawning area decreases steadily above the falls as the gradient increases. There is an impassable falls 30 feet high located 15 miles above the mouth.

The Little Wenatchee River is valuable as a spawning area for blueback salmon. A small remnant of the large early-day blueback run into the Wenatchee system has persisted in the Little Wenatchee River. The largest run in the two decades before the Grand Coulee transplantation project was begun amounted to 412 observed spawners in the year 1935. This run was greatly augmented by the transfer of the up-river runs in the period 1939-1943. Traps were installed near the mouth of the stream in 1942 and eggs were taken from about half of the 1,500 blueback spawners for artificial hatching and rearing at the Leavenworth hatchery of the Fish and Wildlife Service. This operation since has been an annual procedure, a portion of the run being allowed to spawn naturally. In 1948 a total of 4,255 blueback were taken for hatchery purposes, 1,945 spawning fish were counted above the racks, and 500-1,000 were estimated to have spawned below. Kokanee also spawn in the lower section of the river. A few chinook salmon and steelhead trout have been observed, as well as a small resident trout population.

None of the tributaries to the Little Wenatchee River are of much possible value to salmon.

Rainy Creek, entering 7 1/2 miles above the mouth and above the lower falls is passable, but is almost a continuous series of low cascades, and therefore lacks spawning area. All other tributaries are so steep that salmon could ascend them only for very short distances.

12J.(2). White River.-- (Surveyed at various times, 1935-1947; Burrows, Whiteleather, Shuman, and members of the Grand Coulee project and North Pacific staffs.)

Enters Lake Wenatchee through a swamp area about 1/2 mile north of the mouth of the Little Wenatchee River. The stream is 27 miles long, of which the lower 13 miles were surveyed up to an impassable 25 foot falls. The surrounding foothills and valley slopes of the watershed are heavily covered by conifer forests. The stream channel is about 100 feet wide in the lower section, and the discharge ranges from less than 100 c.f.s. to more than 1,000 c.f.s., normally being somewhat greater than that of the Little Wenatchee. In the lower 2 miles of swamp area the stream bed is covered with a thick layer of glacial silt. In the next 8 miles to the confluence with the North Fork the gradient gradually increases, and there are extensive spawning areas especially suited to blueback salmon because of the fine pea gravel. Above the North Fork the spawning rubble is larger and the gradient becomes steeper. However, some

good spawning areas continue to occur in the next 2 miles to the mouth of Cougar Creek. From Cougar Creek to the impassable 25 foot falls, a distance of about 1 mile, the rubble is too large for the most part to be considered good spawning area. It is estimated that there are more than 120,000 square yards of suitable spawning area below the falls. During the spring and early summer and even for short periods during the fall spawning period the river becomes turbid with glacial silt.

Large runs of blueback and chinook salmon entered the White River in the early days, but were depleted to a few hundred fish by the year 1935. Since 1939 most of the chinooks and a good share of the bluebacks that were trapped at Rock Island Dam on the main Columbia River and liberated in Lake Wenatchee have spawned in the White River. The chinooks spawn mainly in the three mile section from one mile below the North Fork up to the mouth of Cougar Creek, while the blueback spawn in larger numbers on the riffles below the North Fork, where the gravel is smaller. In the year 1946 the blueback spawning ground count was 2,063 live spawners on redds, 410 dead spawned-out, and 1,182 redds. In 1947 the count was 5,787 bluebacks and 1,656 redds. In 1948 it was estimated that nearly 10,000 bluebacks spawned in White River.

With the exceptions of the North Fork and Cougar Creek all the tributaries are too small, steep, or inaccessible, and of little possible value to salmon.

12J-(2)a. North Fork of White River.-- (Surveyed at various times, 1942-1945, Zimmer; and 1947-1948, Fulton and Gangmark.) Enters White River about 11 miles above the mouth. The stream is over 15 miles long, of which the lower 4 miles up to an 8 foot falls were surveyed. It is 20-30 feet wide in the lower section, and the discharge usually ranges from 50 to 100 c.f.s. The North Fork is somewhat larger than main White River at their confluence, and carries most of the glacial silt into White River, the main stream usually being clear above the confluence. The lower 2 miles exhibit excellent spawning riffles with large amounts of the small pea gravel particularly suitable for blueback spawning. The gradient and the percent of large rubble in the stream bed increase in the next 2 miles until the stream forms a nearly continuous series of cascades. The 8 foot falls located 4 miles above the mouth is believed to be a barrier to salmon.

It is estimated that the lower 4 miles could accommodate at least 2,500 pairs of blueback salmon. Bluebacks were observed spawning in scattered groups in this section in 1942 and 1943, and in 1948 3,400 blueback salmon were counted in one day in the lower 2 miles. No chinook salmon were found in the North Fork. The stream supports a good population of native cutthroat trout.

The outlet stream from Twin Lakes enters the North Fork 1 1/2 miles above the mouth, but is steep and inaccessible to salmon.

12J-(2)b. Cougar Creek.-- (Inspected at various times, summers of 1942 and 1943; Zimmer.) Enters White River 12 miles above the mouth, or 1 mile below the impassable White River falls. The stream is 5 miles long, and is 30 feet wide near the mouth. The gradient is fairly steep, and the stream bed is composed mainly of large rubble. No salmon have been found in it. A resident population of native trout has been reported, as well as a run of Dolly Varden ascending from Lake Wenatchee to spawn.

13. Entiat River.-- (Surveyed at various times, 1935-1947; Shuman, Whiteleather, and members of the Grand Coulee fish maintenance project.) Enters the Columbia River 15 miles above Wenatchee, Washington, or approximately 483 miles above the mouth. The stream is 52 miles long, of which 42 miles were surveyed. The discharge ranges from less than 100 c.f.s. to an occasional spring flood stage of 4,000 c.f.s. During the fall spawning period the discharge is usually 100-200 c.f.s. The gradient is moderate in the lower 28 miles, with spawning areas and resting pools well distributed throughout this portion of the course. The section of the river from 12 to 23 miles upstream contains the best spawning area. Here the gradient is 25-40 feet per mile, and there is a succession of wide, shallow riffles with ideal spawning conditions. It is estimated that there is more than 200,000 square yards of suitable spawning area in the lower 28 miles.

The former large runs of chinook salmon that entered the Entiat in the early days had been practically exterminated by the year 1925, due principally to the construction of small dams and the diversion of water. The former good steelhead trout run also has been greatly depleted. In the years 1939 and 1940 a portion of the Columbia River runs of adult chinook and steelhead were transferred to the Entiat in connection with the Grand Coulee Dam fish maintenance project. In the year 1941 the Entiat hatchery of the Fish and Wildlife Service was constructed at Packwood Springs, approximately 7 miles above the mouth. The combination of artificial propagation and natural spawning is gradually building up the runs of both chinook salmon and steelhead trout; the number of chinook spawners taken at the hatchery having increased from 85 in 1941 to 1,047 in 1947. The streams also supports a good population of rainbow trout.

The dams that formerly obstructed the passage of migratory fish have been removed or provided with fishways in recent years. There are at least nineteen irrigation diversions on the Entiat, of which eighteen have been provided with fish screens, thus greatly increasing the fishery production value of the stream.

Fish Tail Falls, located about 28 miles above the mouth, is one of a series of low falls and cascades which appears to be a barrier to the upstream passage of fish during low water stages, particularly since no salmon have been observed above this point. The gradient and the amount of large rubble in the stream bed increased above Fish Tail Falls; consequently this upper section is of little possible value to salmon, although a few steelhead trout may ascend at high water stages.

Entiat Falls, approximately 33 miles above the mouth, is 10 feet high and a barrier to fish. Several additional falls 8-10 in height are located farther upstream.

The only important tributary to the Entiat is Mad River.

13A. Mad River.-- (Surveyed at various times, 1935-1947; Shuman, Whiteleather, and members of the Grand Coulee fish maintenance project.) Enters the Entiat River 11 miles above the mouth. The stream is 25 miles long, of which 23 miles were surveyed. The stream channel is 30-40 feet wide near the mouth, and the discharge ranges from 15 c.f.s. to several hundred c.f.s. With the exception of the lower 1/2 mile, the gradient is steep, being 270-315 feet per mile in some sections. The stream bed is composed mainly of large rubble, and spawning areas are small and scattered. Despite the turbulent nature of Mad River, it was considered by local sportsmen to have been the principal steelhead trout producer in the Entiat River system. This run has been greatly depleted for many years. There are no reports of a run of salmon into Mad River. The stream still supports a large population of small rainbow trout.

Passage of migratory fish into Mad River was greatly restricted for many years by the Harris mill dam on the main Entiat just below the confluence of the two streams, as well as by other obstructions on the lower main Entiat River. However, steelhead are reported to have passed over the Harris mill dam at high water stages when the flood gates were opened.

A low log dam about 2/3 mile upstream supplies an unscreened irrigation diversion ditch carrying 6 1/2 c.f.s.

A plank dam 3 feet high located about 1 mile above the mouth supplies a screened pipe line 12 inches in diameter leading to the Harris lumber mill dam. Both of these dams are obstruction to fish at low water stages.

All of the tributaries to Mad River are too small and too steep to be of possible value to salmon.

13B. North Fork of Entiat River.-- (Surveyed at various times, 1935-1947; Shuman, Whiteleather, and members of the Grand Coulee fish maintenance project.) Enters the Entiat about 34 miles above the mouth, above Entiat Falls, and extends through a deep narrow canyon for a distance of about 10 miles. It is a typical steep, turbulent mountain stream having a large amount of bedrock and boulders and little possible spawning area in the stream bed. It is 12-15 feet wide near the mouth and has an average discharge of about 30 c.f.s. The stream is blocked 600 yards above the mouth by three falls 10, 18, and 30 feet high. The North Fork is of no value to salmon, and only of slight possible value to steelhead. The stream section above the falls supports a good resident trout population.

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Wenatchee River	Gunn Irrigation Dam and Ditch	1½	40	Rotary screen
	Jones-Shotwell Ditch		25	Rotary screen
	Pine Flats Irrigation Ditch		4	Rotary screens
	Dryden Dam	5½-8½		2 fishways
	Dryden Power and Highland Canal		1,375	Rotary screens
	Leavenworth Fish Hatchery Canal		Varied	Screened
	Tumwater Power Dam and Diversion	23	Varied	Fish ladder and screen
Mission Creek	13 Irrigation ditches and 3 dams	1-3	Entire flow	None
Sand Creek	Log jam; falls	7-6		None
East Fork, Mission Creek	Several beaver dams	2-4		None
Peshastin Creek	Numerous cascades and low falls	2-6		None
	12 Irrigation ditches; 3 dams	3-5	Entire flow	5 ditches screened
Ingalls Creek	Farm light plant dam and diversion	2-4	28	None
	Falls	40		None

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Derby Canyon Creek	Irrigation diversion		All	None
Chumstick Creek	13 Irrigation ditches; 3 dams	2-4	Entire flow	None
Eagle Creek	11 Irrigation diversions; dam	4	All	None
	Parkins Storage Dam	15		None
Icicle Creek	Cascade Orchards Irrigation Pipe		18	Screened
	Icicle Cr. Irrigation and Water Supply Dam	$2\frac{1}{2}$-4		None
	Icicle Irrigation Ditch		110	Screened
	Leavenworth Water Supply Pipe		Varied	Screened
	Series of falls	5-15 ea.		None
Chiwaukum Creek	5 Diversions, 3 for Irrigation		Varied	2 screened
	Series of falls	250		None
Beaver Creek	Irrigation diversion	—	Entire flow	None
Chiwawa River	Wenatchee Park, Land and Irrigation Co. Ditch	—	40	Screened
Chickamin Creek	3 log jams	5-8		None

TABLE OF OBSTRUCTIONS AND DIVERSIONS

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Nason Creek	Beaver dams and log jams	3;8		None
	Gaynor falls	12		None
Whitepine Creek	Falls	18-20		None
Little Wenatchee River	Series of falls	4-20		None
	Falls	30		None
White River	Falls	25		None
Entiat River	19 Irrigation ditches		3-20	18 now reported to be screened
	P.S.P.& L. Co. Power Dam and Diversion	4	145	Fishway
	Fish Tail Falls (Series)	5-8 ea.		None
	Entiat Falls	10		None
	2 falls	8;9		None
Mad River	Moe Irrigation Ditch and Dam	1-2	6½	None
	Dam and Diversion to Harris Mill	3		Screened
	Falls	6		None
North Fork Entiat R.	Series of 3 falls	10,18,30		None

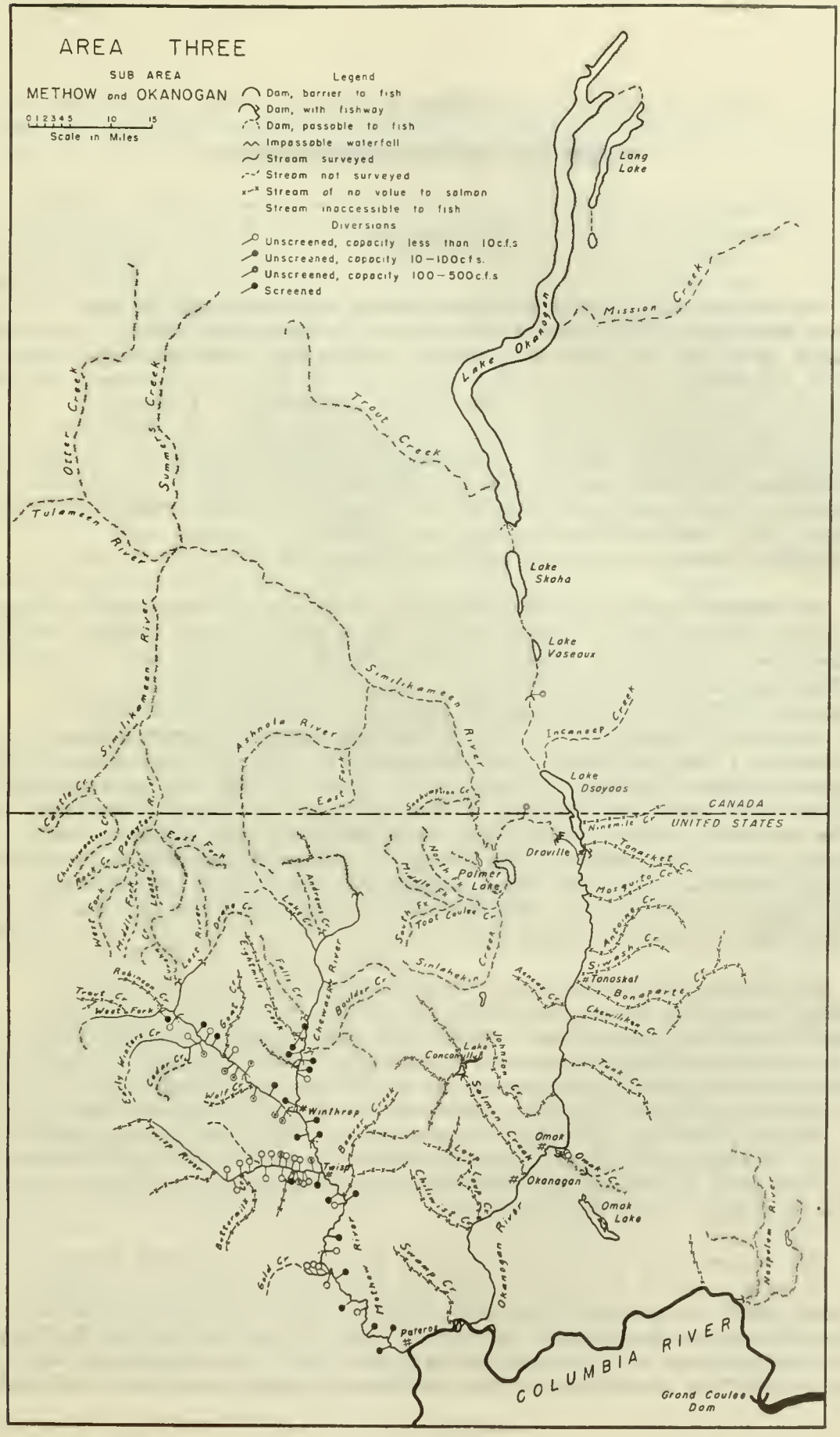

Figure 9.-- Sub-area Methow and Okanogan River Systems

PART 4

METHOW AND OKANOGAN RIVER SYSTEMS

Introduction

The Methow River has its source on the eastern slope of the Cascade Mountains, and flows southeast to discharge into the Columbia River at the town of Pateros, Washington. The drainage area of the Methow is about 1,700 square miles, and includes an extremely rugged, mountainous area in the headwaters. A large part of the watershed is semi-arid, open, hilly country. The fertile valley lands require irrigation for the best crop production. Melting snow in the high headwaters section maintains a good sustained flow in the upper part of the river. However, the lower main stream and its tributaries become very low in late summer because of irrigation demands.

The Methow River formerly supported large runs of chinook and silver salmon and steelhead trout. From 1899 through 1914 a hatchery was operated at Twisp by the State of Washington and the Okanogan Country Game Comission. This hatchery collected as many as 2,000,000 silver salmon eggs and about 70,000 chinook eggs annually. However, in 1915 the Washington Water Power Company constructed a dam at Pateros near the mouth of the river which was not provided with fishways of any kind. Since the dam was impassable, no fish could reach the hatchery. Therefore, it was moved downstream to the damsite. Silver salmon eggs were taken at this new location, although in smaller numbers than previously, and in addition 2 to 4 million steelhead eggs were taken annually. Practically no chinook salmon eggs were handled by the hatchery during this time, as the run had been virtually exterminated.

Egg taking was discontinued at this location in 1921. Several attempts were made during the period 1926-1931 to introduce chinook salmon from other hatcheries. These fish were nearly all late fall-run salmon taken from tributaries relatively near the mouth of the Columbia, and apparently there was no return to the Methow River from these plantings. By 1930, when the power dam at Pateros had been removed, the run of silver salmon had all but disappeared, and the run of steelhead was very small. At the time of the first stream survey in 1935, a few spring chinook salmon were seen in the main Methow and some of its tributaries.

The causes for the almost complete disappearance of the large runs of salmon which formerly inhabited this river system are obvious: The many open irrigation diversions resulted in the death of thousands of young migrants annually, a fact which was pointed out by the Washington State Commissioner of Fisheries as early as 1902. The diversion dams, which were often impassable during low water stages, seriously hindered

fish migration. The construction of the impassable power dam near the mouth of the river in 1915 was the final blow in reducing all of the runs to a negligible quantity.

Prior to the inception of the Grand Coulee fish maintenance project some of the diversions in the Methow watershed had been screened, and the power dam had been removed. The Methow was not included in the project fisheries transplantation program until 1941, as the screening program was still under way. However, in 1941 a program of annual liberations of artificially propagated chinook salmon and steelhead trout was begun in the Methow River.

The main stem of the river furnishes fair fishing for Dolly Varden, rainbow, and cutthroat trout, and is rather heavily fished by sportsmen. Chubs, suckers, whitefish, and squawfish are abundant in most of the stream.

Although the water of the Methow River is used extensively for irrigation, it still is an important, usable stream, both as a spawning and rearing area and as a migration route between the Columbia River and the numerous tributaries of the Methow River system.

The Okanogan River has its source in Canada, in Lake Okanogan, and flows south through Lakes Skaha, Vaseaux, and Osoyoos. Lake Okanogan is about 65 miles long and from 1 to 4 miles wide. Lake Skaha is about 8 miles long and 1 to 2 miles wide, while Lake Vaseaux is only about 3 miles long. The lowest lake in the series, Osoyoos, is about 8 miles long. The International Boundary divides Lake Osoyoos into two approximately equal parts, the lower half being in the United States. From Lake Osoyoos the Okanogan River flows about 80 miles south to discharge into the Columbia River near Brewster, Washington. Most of the broad Okanogan Valley, both in the United States and Canada is cultivated.

The Okanogan was an important Indian fishing ground until fairly recent times. As late as 1931 the natives built brush fishing weirs across the lower part of the river near Monse, Washington, trapping practically all adult salmon going upstream. This type of fishing, however, was not carried on continuously in the Okanogan. In the upper section of the river, in Canada, large numbers of bluebacks were taken by the natives on the spawning grounds. The great depletion of the large early-day runs of both chinook and blueback salmon must be attributed mainly to a combination of over-exploitation by the commercial fishery in the lower Columbia and the destructive Indian fishery.

A counting weir was operated at the Oroville mill dam from 1935 to 1937, inclusive, for the purpose of ascertaining the number of salmon that migrated beyond that point to spawn. The resultant count was 264 bluebacks in 1935, 895 in 1936, and 2,162 in 1937.

No significant number of chinooks passed the weir during any of these years, and it is doubtful that a large number of this species ever passed through Lake Osoyoos and spawned above it.

From 1939 to 1943 inclusive, any anadromous fish which might have entered the Okanogan were trapped at Rock Island Dam. Many of the bluebacks were hauled by tank truck to Lake Osoyoos, but the chinooks were all placed in other stream systems. This was in accordance with the program of the Grand Coulee Fish Maintenance Project necessitated by the construction of Grand Coulee Dam.

Because of the high water temperature and the slight gradient there are a large number and variety of rough fish in the river below Lake Osoyoos. Squawfish (Ptychocheilus oregonensis), carp (Cyprinus carpio), bream (Richardsonius balteatus), large-mouth black bass (Aplites salmoides), and several species of suckers, chubs, whitefish, and catfish are all found in varying abundance in the stream.

Lake Osoyoos also has a number of resident fishes. Large-mouth black bass, yellow perch (Perca flavescens), ling (Lota maculosa), kokanee or silver trout (Oncorhynchus nerka kennerlyi), and carp are all common. Some kamloops trout (Salmo gairdnerii kamloops) are taken in this lake, but they are not abundant.

In the stream sections between the various lakes in the Canadian portion of the river system there appear to be few resident fish except carp and suckers. Trout are not abundant in the main stream.

Lake Okanogan contains kamloops trout, kokanee or silver trout, Rocky Mountain and eastern whitefish, and a great variety of rough fish such as squawfish, carp, and suckers. Lakes Skaha and Vaseaux also have kamloops trout and landlocked bluebacks, as well as rough and spiny rayed fish.

At the present time the Okanogan River has the greatest available, and potentially available habitat for blueback salmon in the entire Columbia River System. Blueback now utilize Lake Osoyoos and some 8 miles of the river immediately above the lake for rearing and spawning area. The construction of fishways at the Lake Vaseaux diversion dam and at certain falls upstream would make available considerably more area for the natural propagation of this species.

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16. Methow River.-- (November - December, 1934, August 13-24, 1935, and March 16-17, 1938. Burrows, Christy, Hanavan, Kolloen, Shuman, Suomela, and Whiteleather.) Enters the Columbia River at the town of Pateros, Washington. The main stream is approximately 71 1/2 miles long, and was completely surveyed.

The discharge varies considerably, due to irrigation use. Gaging-station records for the water-year 1943-44 taken at Twisp, about 39 river-miles above the mouth, show discharges ranging from a maximum of 5,240 c.f.s. in May to a minimum of 145 c.f.s. in September. The water temperature in August ranges from 58°F. down to 47°F., becoming colder upstream. The gradient is moderate, about 22 feet per mile over the entire course. About half of the stream bed is composed of medium and small rubble, and in general the bottom conditions for spawning salmon are excellent.

There are two diversion dams on the main Methow River that are sometimes impassable to migrating fish during times of low flow. These are the Bolinger dam about 12 miles above the mouth, and the Methow Valley Canal Company irrigation diversion dam about 43 miles above the mouth.

In addition to these, there are three other dams that have been of the same nature in the past, but now are passable. The lowermost of these is the Parkinson irrigation dam, located about 24 miles above the mouth. A section of this dam has been washed out and it is not expected to be replaced.

The second is the Foghorn irrigation and power dam about 49 miles above the mouth. A fishway was installed at this dam in 1942.

The third is the Little Wetzel irrigation diversion dam located about 54 miles above the mouth. This dam has been partially washed out.

At the time of the original survey in August, 1935, there were 26 irrigation diversions on the main Methow with flows ranging from 1/2 to 80 c.f.s. and withdrawing a total flow of more than 500 c.f.s. None of these ditches were screened at the time of the survey, but the Washington State Fisheries Department has since succeeded in screening all of the important diversions.

At present the main Methow River supports a fair spring run of steelhead trout and small spring and summer runs of chinook salmon. The stream is suitable for these races of fish, and with the aid of artificial propagation the size of the runs has been increased. In 1946 the Winthrop hatchery trapped 1,074 chinooks. This is in addition to a large number of chinooks that spawned in the river.

16A. Gold Creek.-- (April 30, 1937, Jobes and Baltzo.) Gold Creek enters the Methow River approximately 20 miles above the mouth. The main stream is about 8 miles long, of which the lower 3 1/4 miles were surveyed, up to the confluence of the middle fork. The stream was about 25 feet wide at the mouth, and was discharging about 40 c.f.s. at the time of the survey. The water temperature was 50°F. at the mouth and 48°F. at the upper terminus of the survey. The gradient in the section surveyed is fairly steep, amounting to about 158 feet per mile. There are numerous good resting pools, but few shallow riffle areas. About half of the stream bed in this section is composed of medium and small rubble, and amounts to about 25,000 square yards of this type bottom. However, because of the steep gradient and numerous boulders, much of this is not suitable for spawning salmon.

There are three beaver dams in this section which might be impassable at low water stages.

There are four irrigation diversions in the section surveyed. Proceeding upstream, the first of these is found 1,015 yards above the mouth. The ditch is 5 feet wide and 4 feet deep, with no headgates. A low temporary diversion dam is not a barrier to fish. No water was being withdrawn at the time of the survey, but it was reported that for a period of several weeks beginning in August the diversion takes the entire stream flow at that point.

The next diversion is located 1,515 yards above the mouth. This ditch is about 4 1/2 feet wide and 2 1/2 feet deep. At the time of observation the diversion was 7 inches deep. There is no dam at this diversion.

The third diversion occurs 3,490 yards above the mouth. This ditch is 5 feet wide and 10 inches deep. The diversion was 2 1/2 inches deep. The remains of a temporary wing dam at this point would not hinder migratory fish.

The fourth diversion was found 4,120 yards above the mouth. This is a small wooden flume 9 1/2 inches wide and 8 inches deep. A small temporary dam in connection with this diversion was not regarded as a barrier.

There were no fish protective devices in connection with any of these diversions.

It was reported by local residents that salmon and steelhead have never entered Gold Creek. However, the stream supports a resident trout population.

Because of the diversion of the entire stream flow for irrigation during late summer and early fall, and also because of the steep gradient, Gold Creek was considered to be of no present or potential value to migratory fish.

16B. Twisp River.-- (August, 1935; Suomela and Shuman.) The Twisp River enters the Methow River at the town of Twisp, 38 river miles above the mouth. The stream is about 27 miles long and was completely surveyed. It is 40-70 feet wide in its lower portion, and at the time of the survey its discharge was about 90 c.f.s. at the confluence with the Methow. The water temperature ranged from 60.5°F. at the mouth to 47.5°F. near the headwaters. The stream gradient is moderate for the lower 24 miles, ranging from 33 feet to 62 feet per mile. The upper 3 miles has a steep gradient of about 190 feet per mile. There is an adequate number of large resting pools and sufficient shallow riffles to accommodate large runs of salmon and steelhead. Good spawning areas occur practically throughout the entire length of the stream, with the best spawning areas in the central portion. The stream bed contains about 65 percent of medium and small rubble, amounting to about 380,000 square yards of this type of bottom. A large part of this was considered suitable for spawning salmon.

There are no obstructions in the stream, and migratory fish are able to ascend practically to the headwaters during most of the year. However, during late summer and early fall, when the stream has a small flow and water is being used for irrigation, the Airy ditch, located about 1/2 mile above the mouth, takes the entire flow. This situation limits the use of the stream to the early runs of steelhead trout and chinook salmon.

There were 18 irrigation diversions on the Twisp River at the time of the survey. Three were not in use, and two of these appeared to be abandoned. The aggregate withdrawal in August, 1935, was 115 c.f.s. The principal diversions are the Airy ditch, 18 c.f.s., the North Side ditch, 15 c.f.s., the Methow Valley Canal, 50 c.f.s., and the Burke-Layman ditch, 23 c.f.s. Most of the major water diversions now are screened.

The history of migratory fish in the Twisp River is much like that of the remainder of the Methow System. In the early years great numbers of salmon utilized the spawning area in this stream and its tributaries. However, the many dams and formerly unscreened diversions in both the Twisp and the main Methow Rivers have caused such unfavorable conditions that the only populations of migratory fish still using the stream when the runs were intercepted at Rock Island Dam in 1939 were a few early run spring chinook salmon and still lesser numbers of steelhead trout. The stream is capable of supporting runs of several thousand salmon and steelhead. Rainbow trout are fairly numerous, although small, and Dolly Vardens are common, especially in the headwaters.

16B-(1). War Creek.-- (May, 1937, Jobes and Baltzo.) War Creek enters the Twisp River about 15 miles above the mouth, and is the largest tributary. The gradient is steep, and the stream

bed is composed mainly of large rubble and boulders. Cascades occur through a large part of its course, and impossible falls are located about a mile above the mouth. The stream maintains a considerable flow throughout the year. However, because of the steep gradient, impassable falls, and lack of suitable spawning area it was considered of little value to migratory fish.

16C. Chewack River.-- (August 11-16, 1935; Whiteleather, Shuman, and Burrows.) The Chewack River enters the Methow at Winthrop, approximately 48 river miles above the mouth. The stream is about 40 miles long, of which the lower 38 miles were surveyed. The stream is passable to salmon in the lower 32 1/2 miles, up to Chewack Falls. In the lower section the stream was 40-70 feet wide, and at the upper terminus of the survey it was about 20 feet wide. The discharge at the mouth was about 100 c.f.s, and in the middle section, above all diversions, the flow was about 200 c.f.s. The flow diminished rapidly in the upper section, and was reduced to 7 c.f.s. at the upper end of the survey. The water temperature ranged from 58°F at the mouth to 48°F in the upper section. The stream gradient in the lower 8 miles is 28 feet per mile. It was estimated that the average gradient in the lower 30 miles was 42 feet per mile, and in the upper 7 1/2 miles surveyed about 200 feet per mile. There are numerous excellent salmon spawning areas well distributed throughout the course. Resting pools are few in the lower section, but are large and deep. Pools are smaller and more numerous in the middle and upper sections.

The Fulton irrigation diversion dam, located approximately 3/4 mile above the mouth, is about 3 feet high and has an apron extending 8 feet downstream. It is a barrier to migratory fish at low water stages.

The Chewack irrigation diversion dam, located about 7 miles above the mouth, is only 2 feet high, but is difficult for fish to pass during the low water stages.

At the time of the survey there were five irrigation diversions on the stream. The total amount of water diverted was about 150 c.f.s. None of these were screened at the time of the survey, but all of the large permanent diversions later were screened by the Washington State Department of Fisheries.

The past history of this stream in regard to migratory fish is the same as that of the rest of the Methow system. It was reported that the Chewack was an excellent producing area for chinook salmon in the early days and supported large runs of that species. A run of steelhead trout persisted until the runs were intercepted at Rock Island on the main Columbia River in 1939. The former dams and unscreened diversions on the main Methow River played a major part in the depletion of these runs.

Rainbow, cutthroat, Dolly Vardens, and Rocky Mountain Whitefish are taken in the lower and middle sections of the river. Only rainbow trout are taken above Chewack Falls.

The Chewack River is extremely well suited for the production of early running varieties of chinook salmon and steelhead trout.

16C-(1). Big Boulder Creek.-- (April 29, 1937, Jobes and Baltzo.) Big Boulder Creek enters the Chewack River approximately 8 miles above the mouth. The stream is about 13 miles long, of which about 1 mile was surveyed up to an impassable falls 20 feet in height. The stream was 27 feet wide at the mouth, and was discharging about 14 c.f.s. on the date of observation. The water temperature was 47°F. at the mouth. The gradient is fairly steep; estimated to be about 125 feet in the mile surveyed. The possible spawning area is confined to small scattered patches, and the stream does not appear attractive as a salmon spawning area. More than half of the stream bed is composed of large rubble.

No salmon or steelheads were found or reported. The stream is of little possible value to migratory fish.

16C-(2). Eightmile Creek.-- (April 29, 1937, Jobes and Baltzo.) Eightmile Creek enters the Chewack River approximately 10 1/2 miles above the mouth. The stream is about 17 miles long. In the lower 1/2 mile it flows through a relatively flat valley, and the stream bed in this section contains some spawning area. The stream was about 15 feet wide and discharging about 15 c.f.s. at the time of observation. This was probably a minimum flow, since the spring run-off had not started. Two impassable beaver dams were found within 500 yards of the mouth. An extremely steep canyon begins about 1/2 mile above the mouth and extends for about 2 miles. A dam 3 feet in height is located at the lower end of the canyon. Two diversions occur near this point, one just above and one just below the dam. The lower ditch provides water for a U.S. Forest Service Guard Station, and is provided with a fish screen. Several impassable beaver dams were also found in the canyon. There is practically no suitable spawning area in the canyon, as the stream flows in steep cascades over bedrock and boulders. Above the canyon the gradient decreases, but beaver dams are numerous in the flat, upper meadows. No migratory fish were seen or reported, and the stream is of no significant importance as a potential salmon producer.

16C-(3). Twentymile Creek.-- (April 29, 1937, Jobes and Baltzo.) Twentymile Creek enters a small side-channel of the Chewack River approximately 19 miles above the mouth. Impassable beaver dams on this side-channel both above and below the mouth of Twentymile Creek render the latter stream entirely inaccessible to migratory fish. The stream is about 11 miles long. In the lower mile through the Chewack Valley the gradient is moderate to steep,

with a very limited amount of spawning area occurring between cascades. About 75 percent of the stream bed in this section consists of large rubble and boulders. Above this point the stream flows through a rocky gorge where the gradient is very steep, and there is no suitable spawning area. At the lower end of this gorge there is an impassable falls 25 feet high. The discharge near the mouth was estimated to be 10 c.f.s. The flow is fairly constant throughout the year, except for sudden spring freshets, which raise the water level several feet and flood the lower valley. The stream is of little potenital value as a salmon producer.

16C-(4). Lake Creek.-- (August 28-29, 1935, Whiteleather, Shuman, and Burrows.) Lake Creek enters the Chewack River approximately 23 miles above the mouth. The stream extends for about 6 miles to Black Lake. This lake is about 1 mile long and slightly less than 1/4 mile wide. The stream extends for about 8 miles above the upper end of Black Lake, and here is often called Upper Lake Creek. The stream was surveyed from its confluence with the Chewack to a point about 1 1/2 miles upstream from the lake, where it is blocked by a combination of a rock slide and log jam 4 feet high and 40 feet long forming a total barrier to migratory fish. Lake Creek was 24 feet wide near the mouth, and was discharging about 16 c.f.s. The water temperature was 52°F. at the mouth, 62°F. at the surface of the lake, and 45°F, in the stream just above the upper end of the lake. The gradient is fairly steep in the lower section, and was estimated to be about 80 feet per mile from the mouth to the lake. There are numerous cascades, some of which might be difficult for the passage of salmon. There is some possible spawning area in scattered patches between small pools and cascades. A storage dam 2 feet high at the outlet of the lake would be a barrier to migratory fish at low water stages.

The gradient in the surveyed section of Upper Lake Creek was estimated to be 25-30 feet per mile. This short section up to the impassable log and rock jam seemed to offer some good spawning area for salmon.

No salmon or steelheads were found anywhere in the stream, and it was reported that runs of these species never has been known to enter. The stream appears to be of no great potential importance to salmon.

16D. Wolf Creek.-- (May 1937; Jobes and Baltzo.) Wolf Creek enters the Methow River 2 1/2 miles above Winthrop, or approximately 50 1/2 miles above the mouth. It is a good size stream, about 13 miles long. In the lower part of its course it flows through the cultivated Methow Valley. Most of the flow is diverted through a flume into Patterson Lake. The normal water level of this lake has been raised 32 feet by a dam at the outlet in order to increase the storage capacity. Only enough water is allowed to pass the Patterson Lake diversion to comply with the irrigation rights of farms along the stream below that point. As a result the stream is entirely dry at its confluence with

the Methow River except during the spring run-off period usually occurring in May. For this reason the stream is of no value to migratory fish.

16E. Goat Creek.-- (May 4, 1937; Jobes and Baltzo.) Goat Creek enters the Methow River two miles below Mazama, or approximately 60 miles above the mouth. The stream is about 13 miles long. It was estimated to be discharging about 150 c.f.s. at the time of observation at the height of the spring run-off. In the lower section the gradient is moderate to steep, and the stream contains a fair amount of spawning area. There are several diversions for the irrigation of farms along the lower part of the course. These diversions take the entire flow during the summer and early fall. The stream was considered to be of no value to salmon under these conditions.

16F. Early Winters Creek.-- (September 6-8, 1935; Whiteleather, Shuman, and Burrows.) Early Winters Creek enters the Methow River approximately 64 miles above the mouth. The stream is about 18 miles long, of which the lower 11 1/2 miles were surveyed. It is readily accessible to migratory fish for a distance of 7 miles above the mouth. At this point there is a falls 20 feet high which is impassable except possibly to steelheads at high water stages. The stream was 20-30 feet wide in the lower section, and was discharging about 35 c.f.s. at the time of the survey. The water temperature ranged from 50°F. to 53°F. The gradient is fairly steep and was estimated to be about 120 feet per mile. The flow is almost continuously rapid, and small cascades are numerous. Spawning areas are extremely limited, the stream bed containing a large amount of boulders and large rubble. There are two irrigation diversions, both unscreened, in the lower part of the stream. One, the Early Winters irrigation ditch, was withdrawing about 25 c.f.s., and the other was taking about 2 1/2 c.f.s. No salmon or steelheads were seen or reported. However, it is a good size stream, and it is of some potential value, especially to steelhead trout.

16F-(1). Cedar Creek.-- (September 6, 1935; Whiteleather.) Cedar Creek enters Early Winters Creek approximately 5 miles above the mouth. The stream is about 7 1/2 miles long, of which the lower 2 miles surveyed up to a series of three impassable falls having heights of 20, 45, and 30 feet. The stream had an average width of 22 feet in the section surveyed, and rises 3-4 feet during the spring run-off. The water temperature ranged from 52°F. to 53°F. The gradient is very steep, and was estimated to be more than 350 feet per mile. The stream consists of an almost continuous series of steep cascades. The stream bed contains a large amount of medium and small rubble, but is almost entirely unsuitable for salmon spawning because of the steep gradient. No salmon or steelhead were seen or reported, and the stream was considered of little importance to migratory fish.

16G. Lost River.-- (August 15, 31, and September 1, 1935; Whiteleather, Shuman, and Burrows.) Lost River enters the Methow River approximately 70 miles above the mouth. The stream is about 22 miles long, of which the lower 7 miles were surveyed up to an impassable rock slide 20 feet high and extending completely across the river just above the confluence of Monument Creek. There is a high impassable falls near the confluence of Drake Creek approximately 12 miles above the mouth. Lost River was about 50 feet wide near the mouth, and was discharging about 120 c.f.s. on August 15, 1935. The water temperature ranged from 49°F. to 51°F. The gradient is moderate to steep, with numerous cascades. Good spawning areas are most extensive in the lower 4 miles, up to the confluence of Eureka Creek. Above this point the possible spawning areas are of poorer quality, the greater part of the stream bed being composed of large rubble.

Lost River was at one time heavily populated with chinook salmon. Indians from the surrounding regions formerly went there to obtain their winter supply of these fish. Local residents consider Lost River to have been next in importance to the Chewack River as a salmon producer. The unfavorable conditions formerly imposed on the lower Methow River, and especially the impassable power dam built at Pateros in 1915, resulted in the virtual extermination of the runs into Lost River. The stream is of great potential value in any fisheries rehabilitation program for the Methow system.

16G-(1) Eureka Creek.-- (September, 1935; Whiteleather, Shuman, and Burrows.) Eureka Creek enters Lost River approximately 4 miles above the mouth. It is a good size stream, about 14 miles long, and forks about 6 miles above the mouth. It was surveyed for a distance of only 3/4 miles, up to an impassable falls 35 feet high. The gradient is steep. It is not an important stream to migratory fish.

16H. Robinson Creek.-- (May 4, 1937; Jobes and Baltzo.) Robinson Creek joins the West Fork of the Methow to form the main Methow River approximately 71 1/2 miles above the mouth. It is about 8 miles long. At the time of observation, during the peak of the spring run-off, the stream was over its banks and discharging more than 200 c.f.s. It maintains a fair flow throughout the year. The gradient is steep over most of the course, with almost continuous cascades falling over predominantly large rubble. Suitable spawning area for salmon and steelheads is very limited, and the stream is of little potential value to migratory fish.

16I. West Fork, Methow River.-- (September 2-4, 1935; Suomela, Burrows, and Whiteleather.) The West Fork joins Robinson Creek to form the main Methow River approximately 71 1/2 miles above the mouth. The stream is about 17 miles long, of which 12 miles were surveyed. It is accessible for a distance of about 9 miles above the mouth, up to two falls 11 feet and 8 feet high that are impassable to migratory fish, with the possible exception of steelheads at high

water. About 1 mile upstream from the falls there is a log jam 20 feet high, which is completely filled in with sand and rocks so as form a total barrier to fish. There is one irrigation diversion located about 1/2 mile above the mouth. At the time of observation this ditch was withdrawing about 9 c.f.s., and was not screened. However, it is reported that it is now screened. The stream was 32 feet wide at the mouth and was discharging more than 40 c.f.s. at the time of observation. At the upper end of the survey the stream was only 12 feet wide and was flowing about 12 c.f.s. The water temperature ranged from 53°F. near the mouth to 47°F. in the upper section. The stream gradient is steep, being 150-250 feet per mile, and cascades are numerous. Good spawning area is very limited. It was reported by local residents that the West Fork had never supported significant runs of salmon or steelheads. The stream appeared to be of little potential value for the production of salmon. It is possibly of some value to steelhead trout.

18. Okanogan River.-- (December, 1934, Suomela and Christy; August, 1936, Hanavan and Whiteleather.) Enters the Columbia River near Brewster, Washington. The river extends for 80 miles to Lake Osoyoos, on the International Boundary, continuing upstream into Canada about 40 miles farther to its source in Lake Okanogan.

The river system within the United States was entirely surveyed, and permission was obtained for several fishery reconnaissance expeditions into Canada.

The discharge from the Okanogan varies considerably throughout the water-year. Records of the U. S. Geological Survey for the water-year 1943-44 taken at a point 5 1/2 miles south of Tonasket, Washington, or approximately 50 miles above the mouth, give a maximum discharge of 10,000 c.f.s. in June, and a minimum discharge of 225 c.f.s. in January.

The summer temperatures of the Okanogan River are extremely high, often reaching the high seventies below Lake Osoyoos.

The stream gradient is generally slight throughout the entire course. A considerable amount of water is taken from the river between the mouth and Lake Osoyoos, but it is all withdrawn by means of pumps. The intake of these pumps are all screened to keep out trash, and none of them are large. Therefore, it is believed that they do no damage to fish.

The Zosel mill dam, located at Oroville, is about 4 feet high. It recently has been provided with an improved fishway.

The diversion dam about 8 miles above Oliver, British Columbia, and below Lake Vaseaux is the present upper terminus of fish migrations. This dam is about 6 feet high, and is a total barrier to fish. It was reported that the dam once was provided with a fishway, which was

usually dry or otherwise impassable. It was reported that no significant number of bluebacks ever had been seen above the dam. The dam diverts about 170 c.f.s. of water into an unscreened canal for irrigation purposes.

Just below Lake Skaha there is a cascade-type falls about 30 feet high, which appears to be a barrier to fish. There is also a low impassable dam at the outlet of Lake Okanogan which has no fishway. The towns of Okanogan, Omak, Tonasket, and Oroville all discharge some raw sewage into the river.

Two species of salmon, blueback and chinook, inhabit this river system. There is also some evidence that steelhead trout utilize the lower portion of the river to a limited extent. The bluebacks ascend the river and, after ripening in Lake Osoyoos, spawn in the lake and in the lake section extending upstream to the impassable dam located about 8 miles above Oliver, British Columbia. The upper 20 miles of this 25 mile stream section consists almost entirely of excellent spawning riffles interspersed with resting pools.

Apparently Lake Osoyoos was originally one of the chief producers of blueback salmon in the Columbia River system. A number of plantings of adult blueback salmon and fingerlings have been made in Lake Osoyoos by the U. S. Fish and Wildlife Service. There have been good returns of several thousand adults from this program, and it appears that a good run has been reestablished. In recent years the runs of chinook salmon entering the Okanogan River have not been large. The chief chinook spawning areas are located in the lower 16 miles, up to the town of Malott, and for a distance of a few miles downstream from Lake Osoyoos. The former good runs of this species which entered the Okanogan in order to ascend such tributaries as Salmon Creek and Omak Creek have been exterminated, except for a few fish utilizing the lower Similkameen River.

18A. Chiliwist Creek.-- (August, 1936; Hanavan and Whiteleather.) Chiliwist Creek enters the Okanogan River approximately 14 1/2 miles above the mouth. It is a small stream, flowing through a deep ravine between barren hills in its lower reaches, and is entirely diverted for irrigation. Small springs maintain a meager flow in the lower 1/2 mile. The stream is of no possible value to salmon.

18B. Loup Loup Creek.-- (August, 1936; Hanavan and Whiteleather.) Loup Loup Creek enters the Okanogan River approximately 16 miles above the mouth. Its watershed consists for the most part of barren or sage covered hills, with some pine forest in the upper section. The flow is continuous only in the upper section, and was estimated to be about 10 c.f.s. on August 1, 1936. The entire flow is diverted for irrigation into the broad Okanogan Valley. There are two storage reservoirs, and the creek no longer joins the Okanogan River. The stream is of no present or potential value to anadromous fish.

18C. Salmon Creek.-- (August, 1936; Hanavan and Whiteleather.) Salmon Creek enters the Okanogan River approximately 25 miles above the mouth. The stream is about 25 miles long. The Conconully Reservoir Dam located about 16 miles above the mouth, is a total barrier to fish. This dam was completed by the Bureau of Reclamation in 1916. A similar, smaller dam is located on a tributary a short distance above the Conconully Dam. The purpose of these dams is to store water for use during the irrigation season, and to this end practically the entire flow is impounded. Only a small amount of "Wasted" water may reach the Okanogan River during exceptionally high run-off stages. During the irrigation season all the water released from the reservoirs is taken out by irrigation diversions. Therefore there is never any significant flow in the lower portion of the creek. This has resulted in the complete extermination of salmon and steelhead in the stream.

Before the completion of the irrigation project Salmon Creek supported a large run of chinook salmon, for a stream of its size. It was important to the Indians as a fishing place, and the natives dried many salmon there, but it is now of no further use to migratory fish.

18D. Omak Creek.-- (April 27, 1937; Baltzo and Jobes.) Omak Creek enters the Okanogan River approximately 31 1/2 miles above the mouth. The stream is about 25 miles long, of which the lower 3/4 mile was surveyed, up to an impassable mill dam 16 feet in height. The stream was 15 feet wide at the mouth, and was discharging 30 c.f.s. at the time of the survey. The water temperature was 55°F. at the mouth. The gradient is moderate, and was estimated to be 50-60 feet per mile. There were about 4,000 square yards of medium and small rubble constituting 52 percent of the stream bed in the section surveyed. A large part of this was considered to be suitable salmon spawning area. There are two irrigation ditches in the section surveyed. Neither of these is screened to prevent loss of fish. The ditches were not in use at the time of the survey, and the diversion dams were not barriers to fish. However, it was reported that in late summer the lowermost ditch, about 400 yards above the mouth, withdraws the entire flow remaining in the stream bed at that point, and the diversion dam at that time is a total barrier.

The stream section above the lumber mill dam contains little potential salmon spawning area. The St. Mary's Mission diversion dam is located at the lower end of a steep gorge about 5 miles above the lumber mill dam. This dam is 5 feet high, and is constructed on the crest of a bedrock slope or cascade having a drop of 12 feet. The upper steep cascade section through the rocky gorge is composed almost entirely of bedrock and large rubble, and is of no possible value to salmon.

Chinook salmon and steelhead trout were reported formerly to have spawned in small numbers up to the mill dam. These runs were necessarily included in the trapping of fish at Rock Island Dam

from 1939-1943 inclusive, and were transferred to other streams. There are no reports of salmon in Omak Creek in recent years. Fair trout fishing is reported in the upper section.

Because of the obstructions noted and the diversion of water for irrigation, Omak Creek is of little present or potential value to migratory fish.

18E. Bonaparte Creek.-- (August, 1936; Hanavan and Whiteleather.) Bonaparte Creek enters the Okanogan River approximately 55 1/2 miles above the mouth, at Tonasket, Washington. The stream extends for more than 25 miles to its source in Bonaparte Lake. The watershed is hilly, with barren sagebrush covered land and a few irrigated ranches in the lower section, and open pine forests along the upper reaches. The stream gradient is moderate. The earth banks have covered the stream bed with a large amount of mud and sand. Practically the entire flow is utilized for irrigation, and little water ever reaches the mouth of the stream. Bonaparte Creek is of no present or potential value to migratory fish.

18F. Similkameen River.-- (August 26, 1936; Hanavan and Whiteleather.) The Similkameen River enters the Okanogan River approximately 75 miles above the mouth, or 2 miles below Lake Osoyoos. It is the principal tributary to the Okanogan, the greater part of its course being in Canada. The stream was surveyed only for a distance of about 6 miles, up to a falls 15 feet high, which is at least a barrier at low water. There is an impassable power dam 65 feet high located 100 yards above the falls. The Similkameen is a large stream, its flow being almost three times as great as that of the Okanogan at their confluence. The stream was 210 feet wide at the mouth at the time of observation. Gaging-station records for the water-year 1943-44 taken at a station 12 miles above the mouth give a maximum flow of 9,510 c.f.s., in June, and a minimum flow of 250 c.f.s. in January. The mean yearly flow was 1,475 c.f.s. The summer water temperatures are high in the lower section, the temperature at the mouth on August 26, 1936 being 71°F. The stream gradient is moderate. The lower 1 1/2 miles up to the highway bridge contains a large amount of good spawning area, with excellent spawning riffles throughout. Above this point the river extends through a steep, rocky canyon for about 10 miles. In this section the stream consists mainly of large pools and cascades. The bottom consists chiefly of bedrock and large rubble, and there is little possible spawning area. Brief inspections of the stream in the valley section above the canyon showed extensive potential salmon spawning areas.

There is one large water diversion in the canyon above the power dam. This ditch withdraws more than 100 c.f.s. for irrigation use in the Okanogan Valley near Oroville, and is unscreened.

The low wing dam in connection with the diversion would not be an obstruction in the event that this section is made accessible to migratory fish.

A large gold mine is located about 10 miles above the mouth of the Similkameen River. A catch-basin designed to hold the cyanide waste product has been long since filled, with a subsequent overflow directly into the river. It was reported that samples of river water taken as far as 9 miles downstream from the mine had been found to contain a cyanide compound. The effects of this waste product on fish in the stream have not been determined. However, Fish and Wildlive Service stream surveyors have recovered several dead salmon near the mouth of the stream which had not spawned and showed no signs of any external injuries.

The 6 mile stream section from the mouth to the falls and power plant supported a small run of chinook salmon prior to 1939, when trapping was begun at Rock Island Dam on the main Columbia River. Some blueback salmon also attempted formerly to ascend the Similkameen. In 1936 about 500 bluebacks were found in the stream, all of them having died without spawning. These fish may have been part of the run which normally ascends the Okanogan to spawn above Lake Osoyoos. A few steelhead trout have been observed in the lower section. Squawfish, suckers, whitefish, Columbia River chubs, and carp are abundant. The stream has been stocked several times below the dam with rainbow and eastern brook trout, by the Washington State Game Commission. Local sportsmen blame the numerous predatory species and the high summer temperatures for the poor results of these plantings. Since the cessation of the fish trapping at Rock Island Dam in 1943 a few chinooks and bluebacks again have entered the stream.

The Similkameen is of little present value in the production of salmon. However, it is of great potential value to chinook salmon and steelhead trout, and possibly of some potential value to blueback salmon. The utilization of the full salmon production capacity of the stream is primarily dependent on the providing of passage for fish over existing barriers, the screening of diversions and the elimination of pollution.

18F.(1). Sinlahekin River.-- (Not surveyed) The Sinlahekin River empties into Palmer Lake. The outlet from Palmer Lake is called Palmer Creek, and flows for 2 miles from the lake to its confluence with the Similkameen River at a point approximately 20 miles above the mouth of the latter stream.

Palmer Lake is about 5 miles long. It supports a population of landlocked blueback salmon called silver trout, and some eastern brook and rainbow trout, as well as rough fish. It has some potential value to salmon as a possible rearing area for bluebacks.

The Sinlahekin extends for approximately 27 miles above Palmer Lake. It loses the greater part of its flow to unscreened irrigation diversions during the summer months. It was reported that the upper part of the stream furnishes fair fishing for rainbow and eastern brook trout.

TABLE OF *OBSTRUCTIONS AND DIVERSIONS [1]

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Methow River	Bolinger diversion dam	3	10.5	Screen
	Methow Valley Canal Co. diversion dam	4½	81.5	Screen
Chewack River	Fulton dam and irrigation diversion	3	31.5	None
	Chewack dam and irrigation diversion	2	66.5	Screen
Early Winters Creek	Early Winters irrigation diversion		25	None
Lost River	Rock slide	20	--	None
West Fork, Methow River	Falls	11	--	None
	Falls	8	--	None
	Log jam	20	--	None

[1] This tabulation includes only those obstructions and diversions that would seriously interfere with runs of salmon and steelhead in the stream.

TABLE OF OBSTRUCTIONS AND DIVERSIONS 1/

Name of Stream	Name or Type of Obstruction or Diversion	Height in feet	Diversion in c.f.s.	Existing Protective Devices
Okanogan River	Zosel Mill Dam, Oroville, Wash.	4	None	Fishway
	Irrigation dam above Oliver, B.C.	6	170	None
	Cascades below Lake Skaha	30		None
	Dam below Lake Okanogan	Low		None
Salmon Creek	Conconully reservoir dam			None
	Irrigation diversions		Entire flow	None
Omak Creek	Two irrigation dams and diversions	3	Entire flow	None
	Lumber mill dam and diversion	16		None
	Mission dam and diversion	5		None
Similkameer River	Falls	15		None
	Power dam	65		None
	Irrigation diversion		100	None

The Sinlahekin is inaccessible to salmon at present. The upper part of the stream was not adequately examined, but may contain some potential spawning area.

PART 5

NOTES ON THE COLUMBIA RIVER AND ITS TRIBUTARIES

ABOVE GRAND COULEE DAM

The Columbia River enters the United States from Canada above Kettle Falls, and extends for some 300 miles nearly due north above the border, amid steep mountain ranges. It then loops back in a southerly direction for nearly another 200 miles to its point of origin in Columbia Lake. Since salmon are known to have ascended to within a few miles of this lake, and since the area developed more slowly than did the lower river areas, it is desirable to include a brief report on the upper main river and its history. Much of this information was obtained from W. D. Layman's "The Columbia River" and L. R. Freeman's "Down the Columbia", both of which deal with this upper section in some detail.

Salmon was a staple in the diet of the early settlers on the upper Columbia, and in later years, at least, many were bought from the Indians who had always taken fish for their own use and to trade with other tribes, particularly in the area around Kettle Falls.

Since boats have plied most of the river at one time or another since the days of the Voyageurs, and since salmon could, of course, go anywhere that boats could make their way, it is not surprising to find that they have ascended nearly the entire 1,300 miles of the Columbia. In 1881 Lieutenant Symons ran the 350 miles from just below Kettle Falls to the Snake on a Government survey party batteau. Captain McDermid later took the small sternwheel steamer "The Shoshone" down the same stretch from Kettle Falls. In December of 1865, Captain Lew White launched the boat "Forty Nine" at Colville, Washington and ascended the Columbia for 160 miles until he met ice at the head of the lower Arrow Lake. In the same year a party of 18 miners built a sailboat at Colville, Washington and with some portaging ascended the entire upper Columbia River to Columbia Lake, a trip of nearly 550 miles; hauled their boat across Canal Flats to the Kootenay River and descended that furious stream to Fort Steele on Wild Horse Creek. Before 1900 there were regular steamers on both the Kootenay and Arrow Lakes.

Grand Coulee Dam, at 595 miles above the mouth of the Columbia, ponded the river to form Roosevelt Lake, which extends almost to the Canadian boundary. From the damsite to Kettle Falls, a distance of 103 river miles, the river was formerly a fast-flowing stream for the

most part. Hells Gate, a basaltic construction barrier at river mile 616 had 3 main rapids, the upper being very fast, crooked and dangerous. A fair current existed in stretches between the smaller drops of Hawk Creek, French and Middle Rapids. Spokane Rapids at river mile 638 had a steep pitch but was straight, and Freeman went through it on a log raft at an estimated speed of 20 miles per hour in late October, 1920. Near Gerome Creek, 15 miles above, there was a current of about 3 miles per hour, and here he caught a 50-pound chinook salmon on a pike pole (the fish apparently had been weakened by spawning activities). At the San Poil Bar he saw Colville Reservation Indians fishing for salmon, the "crooked-nose dogs" (actually chinook) of the final run on October 24th. The river was broad and shallow for a few miles below Grand Rapids, (locally known as Rickey's Rapids) which were located 5 miles below Kettle Falls at river mile 692. Grand Rapids dropped 12 feet in 1,200 yards and was filled with hugh basaltic boulders, like pepper, making them very dangerous for any boat.

Kettle Falls at river mile 698 was in two parts, the lower fall dropping 10 feet in 1/4 mile as a tumbling cascade. The upper main fall was divided by a rocky island into two channels. The right or main channel had a vertical drop of 15 feet at low water, but the left channel looped around in a rapid with savage boils and whirls in an elbow called "the chandiere" by the Voyageurs. Early investigators report that salmon (chinook) formerly spawned in great numbers on gravel bars in the main river just below Kettle Falls, particularly toward the right side of the river. They were also reported to have spawned near the mouths of several tributaries in this area. (Gilbert and Everman, 1894) Mr. J. A. Meyers, a resident in the area between 1866 and 1894, is quoted as reporting that the salmon reached the falls in June, and in great numbers. The run continued until October, there having been a preliminary peak of the run in June (probably fish going through to the upper reaches of the river for the most part), with another later increase culminating in the appearance of the largest numbers of fish during the latter half of August. Prior to 1878, millions of fish were reported ascending the falls each year. A considerable decrease was noticeable after that date, although there were good runs in some years up to 1882. By 1894 the upper river runs were relatively small, although there were still thousands of fish. Salmon evidently got over the falls with some delay and effort during low water periods, but the earlier arrivals apparently reached the falls and passed them during the high-water period of the spring run-off. Indians had always netted fish at the falls, using large wicker jump-baskets that formerly took up to 300 fish in each of the two or three daily hauls or raises, and thousands of salmon were formerly used for winter food and for trade. The Falls has now been entirely flooded out by the backwaters of Grand Coulee Dam.

There were slack water stretches both above and below the "Little Dalles" some 20 miles above Kettle Falls and just below Northport. There the river "stood on edge" to race through two

channels, one less than 200 feet wide and the other 40 feet wide. The huge whirlpool found below where the two channels came together was one of the most violent on the entire Columbia, for it swallowed whole logs and trees which later appeared nearly a mile below rounded and scoured smooth.

Except for one or two shallow bars, there was deep, swift water for the next 30 miles to Rock Island Rapids, located 2 miles below Trail, B.C., which were similar to, but not quite as bad, as The Little Dalles. Freeman averaged 9 miles per hour in his boat for the 19 miles between Castlegar and Trail, B.C., there being a steamer channel between the gravel islands of China Bar. The latter may possibly have afforded spawning areas for salmon. Kootenay Rapids, just below Castlegar, were 1/2 mile of white water with a multitude of black rocks.

The Arrow Lakes occupy former deep, glaciated river valleys and together are about 100 miles in length and 2 1/2 to 3 miles wide. A narrow 16-mile long channel connects the two lakes, and steamers run from one end of the lakes to the other. The lake shores are often precipitous, although there are occasional bays and smooth shores on which dairy and fruit ranches are located, most of these being on the slightly less rugged, lower lake shores. The lower lake has moderately high mountains bordering it; the upper lake has the snowcapped mountain banks of the Monachee Range on the west, and the Slocan Group of the Selkirks on the east. The Selkirk Range has a greater snowfall than do the Rockies. At Glacier it averages 35 feet, and usually lies at least 4 to 8 feet deep from October to April. Therefore, although most of the streams have a plentiful supply of water throughout the year, they are often cloudy with glacial silt. It is evident that few of the cascading tributary streams in this mountainous section could be ascended for any distance by salmon. Blueback salmon are said formerly to have ascended to the Arrow Lakes region, but no data have been obtained as to any spawning areas that they may have used in this section.

The river is broad and there is no fast water in the 30 miles from upper Arrow Lake to the town of Revelstoke, but in the next 55 miles to Death Rapids and Goldstream confluence there are 3 very turbulent rapids. Revelstoke Canyon, at the lower end of this latter stretch, is a deep gorge, the walls being about 100 feet apart. The river in the canyon is at least 150 feet deep, and the current has a great velocity. Sand Slide Rapids at the head of the canyon is a fast rolling stretch of water. There are broader and quieter stretches of deep water between Rock Point, Priest and Death Rapids. The Canadian Priest Rapids are said to be the fastest on the main Columbia, with a current of over 20 miles per hour, but they are straight and the water is deep. Death Rapids are very rough, with rolling waves 12 to 15 feet high and abundant boils and whirlpools.

In the 40-odd miles from Death Rapids to Boat Encampment at the mouth of the Canoe River on the Big Bend, there are 3 more rapids. Rockslide Rapids just above Death Rapids are at the narrowest point on the whole Columbia below Windermere Lake, the river narrowing to 70 feet in width between nearly perpendicular rock walls, with a sharp bend at the foot of the chute. One mile above is Twelve Mile Rapids, which is white water but not as rough as those below. Gordon Rapids further up is a vicious tumble of wild, white water, but has a fast and comparatively clear back channel.

At the Big Bend, the Canoe River empties in a chocolate brown flood, and Wood River also discolors the Columbia. Above this point the Columbia has sparkling clear water, where it was translucent in the canyons below.

In the first 5 miles above the Canoe River, the Columbia is deep and swift, with a current of 8 to 12 miles per hour between boulder banks or cliffs in a timbered canyon. The next 16 miles have a fall of 260 feet in the long Kinbasket Rapids, a chain of small, successive rapids. Kinbasket Lake, at the head of the rapids, is 6 to 7 miles long and 1 to 2 miles wide. A slight current is noticeable, and a big eddy at the upper end collects all the drift of the upper river, just as did "Deadman's Eddy" just above Northport, Washington.

There is a drop of 64 feet in the 16 miles immediately above Kinbasket Lake followed by Surprise Rapids, which have a total drop of 100 feet in 3 1/2 miles. The upper cascades has the greatest fall, 21 feet in 750 feet. There is an 8 mile-an-hour current between this and the second cascade, 1/2 mile below, which has a drop of 15 feet in 1200 feet. At the third cascade there is a drop of 25 feet in 2500 feet, and the stream is choked with barely submerged rocks. A power dam has been proposed to be located below the rapids; it would back water to Beavermouth over 20 miles upstream.

Except for a big riffle known as Eight Mile Rapids, the Columbia generally flows quietly in a widening valley for the next 50 miles to Golden, B. C. In the 90 miles between Golden and the foot of Windermere Lake there is but 25 feet of fall, so that the winding river is hardly more than a series of lagoon-like stretches with a current of from 1 to 4 miles per hour. Lake Windermere is a wider basin on the plateau and is about 10 to 12 miles long. Several miles of faster river channel connect it with Columbia Lake which is similar to Windermere Lake. There is a smaller embayment above Columbia Lake known as Mud Lake, and the river above this is of small volume but is continuously fed by springs and seepage in the vicinity of Canal Flats. The entire area from Golden to Canal Flats is on a wide, nearly flat, saucer-shaped, mountain-bordered plateau, rather thinly settled by ranchers and farmers.

Professor Dawson, the eminent Canadian geologist, believes the section of the Columbia above the mouth of Blue River and Donald Canyon, located some 30 miles below Golden, B.C., was formerly united with the Kootenay River. A later, slight tilting of the earth's surface took place which was sufficient to change the drainage of Columbia Lake to the north and down the present Columbia's course, and form the present upper lagoon and lake section. The Kootenay, which is a sizeable stream at this point, now passes within a mile of the Columbia at Canal Flats, but goes in the opposite direction and at an elevation of only 9 feet higher than the Columbia. During high water periods, the Kootenay flooded into the Columbia on the flats and at such times in the past, salmon and other fish that had always been unable to ascend the falls in the lower Kootenay may possibly have entered and spread through the Kootenay from the upper Columbia River at Canal Flats. In the latter part of the 18th century, steamers ran from Golden through Columbia Lake and in 1888, a canal and locks were constructed to connect the Columbia and the Kootenay at Canal Flats. When the railroad came through the Rockies to Golden and up the Beaver River, it proved to be too much competition for boat traffic and regular steamer service was discontinued before 1910. The canal was destroyed by the great flood of 1894.

In spite of the difficulty that the many rapids on the upper Columbia presented to boat traffic, they probably were negotiated with much less difficulty for salmon or even other fish. The faster straight rapids were usually very deep, and in their depths the fish probably found many eddies and a variety of currents that aided them in passing such stretches. The rougher, more tortuous, rockstrewn rapids have even more eddies and cross currents that salmon can seek out and utilize, and there are no real falls above Kettle Falls that would necessitate jumping.

There is a paucity of references to Indian fishing between Arrow Lakes and the slack water below Golden, B.C. Had the salmon actually been held up at any point along this long section of the river, the Indians would seemingly have known it and gathered there to fish.

The more common Columbia River fish seem to be well distributed clear to Columbia Lake. Ling (Lota lota) and squawfish (Ptychocheilus oregonensis) are taken in Lake Windermere, and the usual trout are taken in neighboring streams.

Salmon spawning streams are probably lacking below Kinbasket Lake or Surprise Rapids due to the fact that nearly all of the stretch below is bordered by cliffs, steep canyon walls or directly by high steep mountain sides. Because of falls only the few larger streams could be ascended for any distance, and even these are swift, cold, snowfed streams that probably lack spawning areas. The plateau section above the Big Bend, therefore, would be one of the first extensive areas in the Canadian section of the Columbia

where salmon spawning could take place, and only a fairly early run of large, strong fish could be expected to survive the arduous, downstream fingerling and upstream adult journeys.

In order to determine whether or not salmon actually did ascend to the upper reaches of the Columbia beyond the Big Bend in British Columbia to spawn prior to the building of Grand Coulee Dam, an inquiry was made in 1936 through J. R. Townsend of Vancouver, B.C., who was an employee of the New England Fish Company in that city, and whose sister, Mrs. A. H. Soles, was a resident of Parsons, B.C., a small settlement above Golden. Mrs. Soles gathered information from "Most all of the residents in the area". She reported that since the main Columbia and most of its tributaries from the Arrow Lakes to Golden is muddy due to the quantities of glacial silt brought in from the snow and ice fields during the summer months, no one apparently sees or reports many salmon in that section of the river. Chinook salmon however still did (in 1936) ascend to spawn in the Columbia River above Golden, B.C. "They are first seen in the vicinity of the Salmon River, which is the first clear (spring fed) tributary above Golden." These fish usually appeared during the last week in August or the first week in September and immediately went onto the spawning beds. All of the salmon taken averaged nearly 40 pounds in weight even after this long journey of some 1,200 miles from the ocean, and 50 or 60 pound fish were frequently seen. 1/ The fish were taken illegally by spears and clubs for food by Indians and by some of the residents in the area, and had pink flesh and the big teeth of the mature spawning adult. Mrs. Soles states that there is a bridge at approximately 2 miles above the mouth of this stream (the Salmon River), and that "many have seen the river under the bridge packed tight with the salmon that were fighting their way up stream to spawn. After spawning, the shoals below the bridge were covered with dead fish." Another large "spawning bed" was reported by the residents in the main Columbia just below the settlement of Athalmer, which is approximately 20 miles above the Salmon River and just below the outlet of Windermere Lake. "Abnormally good years of heavy runs are reported, with some local residents stating that the runs were heaviest in the years when the water in the Columbia is highest." This may very well be true, because high water often enables a greater escapement to be made through the commercial and Indian fishery on the lower river, and may also have made passage easier at some of the many rapids in the river. These reports leave no doubt that salmon once ascended the entire Columbia River to spawn.

1/ The large size of these fish would indicate that they were probably at least 5 years of age, and their decendants, now relocated in tributaries just below Coulee Dam, may comprise a considerable portion of the larger fish that are taken by the lower river commercial fishery in July.

Tributaries to the Columbia River above Grand Coulee Dam

1. The San Poil River enters the Columbia at approximately 17 miles above the Grand Coulee Damsite, and 612 miles above the mouth of the Columbia River. The stream is approximately 75 miles long and formerly supported good runs of chinook salmon, the early settlers reporting the runs to have been huge in some years. A decline was evident around 1890, but Dr. W. H. Rich observed a good run in 1918 when he reported that the Indians were taking salmon near the town of Republic, Washington, some 60 miles above the mouth of the river. Mr. Jack Euchon, now of Astoria, Oregon, reports that he fished in the stream in the late 30's and that the stream was then very small during the summer months and few fish were reported in the stream at that time. L. A. Fulton and H. A. Gangmark report that kokanee now ascend this river at least 50 miles to spawn.

2. The Spokane River originates at Coeue d'Alene Lake in Idaho, and enters the Columbia at approximately 42 miles above the Grand Coulee Dam. Salmon formerly ascended to the impassable falls near Spokane, but never could ascend above this point or reach the Lake. Lyman shows pictures of the falls before and after their development for power, and states that the total fall in the Spokane River is 146 feet. Dr. Livingston Stone reports that salmon and steelhead ascended to the Little Spokane River, which enters at about 50 miles up the Spokane River, and were quite abundant in 1882 both there and in the vicinity of Spokane below the Falls. He found a large camp of Indians on the Little Spokane who were engaged in putting a trap of withes and poles across the river, and from them learned that large numbers of spawning salmon entered that stream about the first of September. A white man living in the neighborhood thought that on October 1, 1882, about 40,000 to 50,000 fish were dying at one time. Dr. Stone hired a man to check the runs in 1883, (a much poorer year) who estimated the Indian catch at about 2,000 fish. Cutthroat trout and whitefish were also reported as being abundant in this river system. Gilbert and Everman report that the Spokane River below the falls contained large spawning beds, and that large numbers of fish were present prior to 1882 but had declined since, until by 1894 the numbers were very few, although steelhead still occurred in considerable numbers. In 1899 the Monroe Street Dam, one of the oldest power dams in the Northwest, was built at Spokane Falls. In 1909 the Little Falls Dam was built at 27 miles above the mouth. This dam was 60 to 70 feet high, had no fishway, and totally blocked salmon runs from the main spawning areas above. The dam is owned by the Washington Water Power Company, which in the same year built the 60 foot Nine Mile Falls Dam some 19 miles farther upstream, and just above the mouth of the Little Spokane River. The impassable 175 foot Long Lake Dam was built in 1915 four miles above the Little Falls Dam. By 1918 the chinook, silver and steelhead runs had practically

disappeared from the river. Various residents have stated that there was also an extensive sport fishery on this river before the dams were built.

3. The Colville River enters the Columbia at river mile 694, 99 miles above Grand Coulee Dam and 3 1/2 miles below the Kettle Falls railroad bridge. It is approximately 40 miles in length. Salmon runs formerly ascended to Meyers Falls, located about 4 miles above the river mouth, but the 80 foot lower fall and the 26 foot upper fall presented an impassable barrier to fish. Nevertheless a great many salmon formerly spawned in the river below the falls prior to 1878, but were apparently scarce by 1890, both here and at Kettle Falls. The Meyers brothers reported to Gilbert and Everman in 1894 that they had been "almost unable to buy any salmon for their own table from the Indians for 3 years."

4. The Kettle River enters the Columbia at 701 miles up and 106 miles above Coulee Dam. It is over 160 miles long, and loops over the Canadian boundary twice below its point of origin in the lower Monashee Mountains of British Columbia. At approximately 25 miles above its mouth it is joined by a stream running out of Christina Lake in Canada, and this lake has in the past supported a small commercial fishery for landlocked blueback or "kokanee". A short distance above the confluence of the stream from Christina Lake there is a falls on which a dam has been built. It is not known whether salmon ever ascended above this falls, but spawning runs were reported in the lower river. Smelters are reported to have run slag into this river and killed off many fish at times, but a few persisted until the building of Grand Coulee Dam.

5. The Pend Oreille River is sometimes known as Clarks Fork, a name now usually applied only to the portion of the river above Pend Oreille Lake. This river enters the Columbia at river mile 739, 144 miles above Coulee Dam. At its confluence it forms the international boundary with Canada. It is over 100 miles from the Lake to the Columbia River, and Clarks Fork above the lake is over 250 miles long. The river originates near the head of the Missouri River in Montana. Salmon never have been able to reach the lake, because of a falls about 15 miles below the lake. Dr. Livingston Stone believed that approximately 20 miles above the mouth of the river, always blocked fish. Freeman states that this river comes tumbling down a sheer walled gorge in fall after fall, its spectacular last leap during the late October low water period being over a 10-foot ledge extending all the way across its 200-foot width. Runs of salmon were reported to have been heavy in some years, but declined after 1878, as did most of the upper Columbia River runs, although some fish were present until Grand Coulee Dam was built. Gilbert and Everman reported steelhead to be abundant at the mouth of this river in 1894.

6. The Kootenai (or Kootenay) River enters the Columbia at river mile 776, 3 miles below the Arrow Lakes. At approximately 50 miles above its mouth, at Nelson, B.C., the river has widened to form Kootenai Lake, whose 141,120 acres of clear, deep, cool water make it the largest lake in the Columbia River system. Above the lake the river loops back into Montana and then back into Canada to run northward some 200 miles further to its origin in the mountains and in so doing it passes within a mile of Columbia Lake at Canal Flats. Above Kootenay Lake, the river has a moderate gradient, and in 1894 Captain Jennings built a steamer, the North Star, at Jennings, Montana and sailed it up the wild Kootenai to Canal Flats, and went through the canal into Columbia Lake and into the Columbia River itself.

Unfortunately, the steep gradient of the lower 50 miles of the river below Nelson, B.C., prevented salmon from ascending this large river and lake system. In the lower section the river drops 350 feet in 28 miles of mostly white water. Gilbert and Everman (1894) report many cascades and turbulent rapids. They report that blueback salmon inhabit the waters of this region, but apparently refer to the small landlocked form which are seen in considerable numbers when they enter the streams to spawn in the fall. Lyman (1917) reports that Bonnington Falls at approximately 20 miles up is one of the noblest waterfalls on the entire Columbia River system, and it would seem that this series of cascades and falls would alone have stopped any ascent of salmon. A hydroelectric plant at this falls now supplies power to the towns of Trail and Nelson.

7. The Canoe River is the extreme north branch of the Columbia River, rising beyond latitude 53°, and entering the main Columbia at its extreme northern point at the "Big Bend." It is over 60 miles long, heading near the upper Fraser River. It obtained its name from the fact that it was known to the earliest traders and Voyageurs for the excellence of barks obtained on its banks for canoe building. Freeman (1921) describes it as being 40 yards wide at its mouth, and "flowing through a densely timbered valley in which the trees overhang the stream to such an extent as to almost shut it out from the light of heaven." Its waters were chocolate colored in the fall months and it is apparently quite swift, although trappers go down it in boats from its headwaters. Lyman describes it as a furious mountain stream, and it probably lacked spawning grounds for salmon.

8. Wood River (formerly Portage River) enters the Columbia from the east just above the Canoe River. It originates at the divide in the crest of the Rockies known as the "height of land" in a small lake. Within 30 yards of it is a second lake feeding the east-flowing Whirlpool River, a branch of the Athabaska. The Wood River flows through a tremendous cleft in the main range between lofty Mt. Brown and Mt. Hooker, and it was up this steep canyon that the early British fur traders passed to and from the upper Columbia. The water is said to be exceptionally cold, and salmon evidently did not use this swift stream to any extent.

Information is lacking on other streams, except that the Beaver River below Golden is a steep, white water stream, as is the frothing Wapta or Kicking Horse River entering at Golden. Any of the streams entering in the flatter plateau section above the end of the canyon at Surprise Rapids, that had a moderate gradient for some distance above its mouth, may have provided spawning areas for salmon, even as did the Salmon Creek described by Mrs. Soles.

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