BIOLOGICAL INVESTIGATIONS OF THE FISHERY RESOURCES OF TRINITY RIVER, CALIF.

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Explanatory Note

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Fishery Research Biologists

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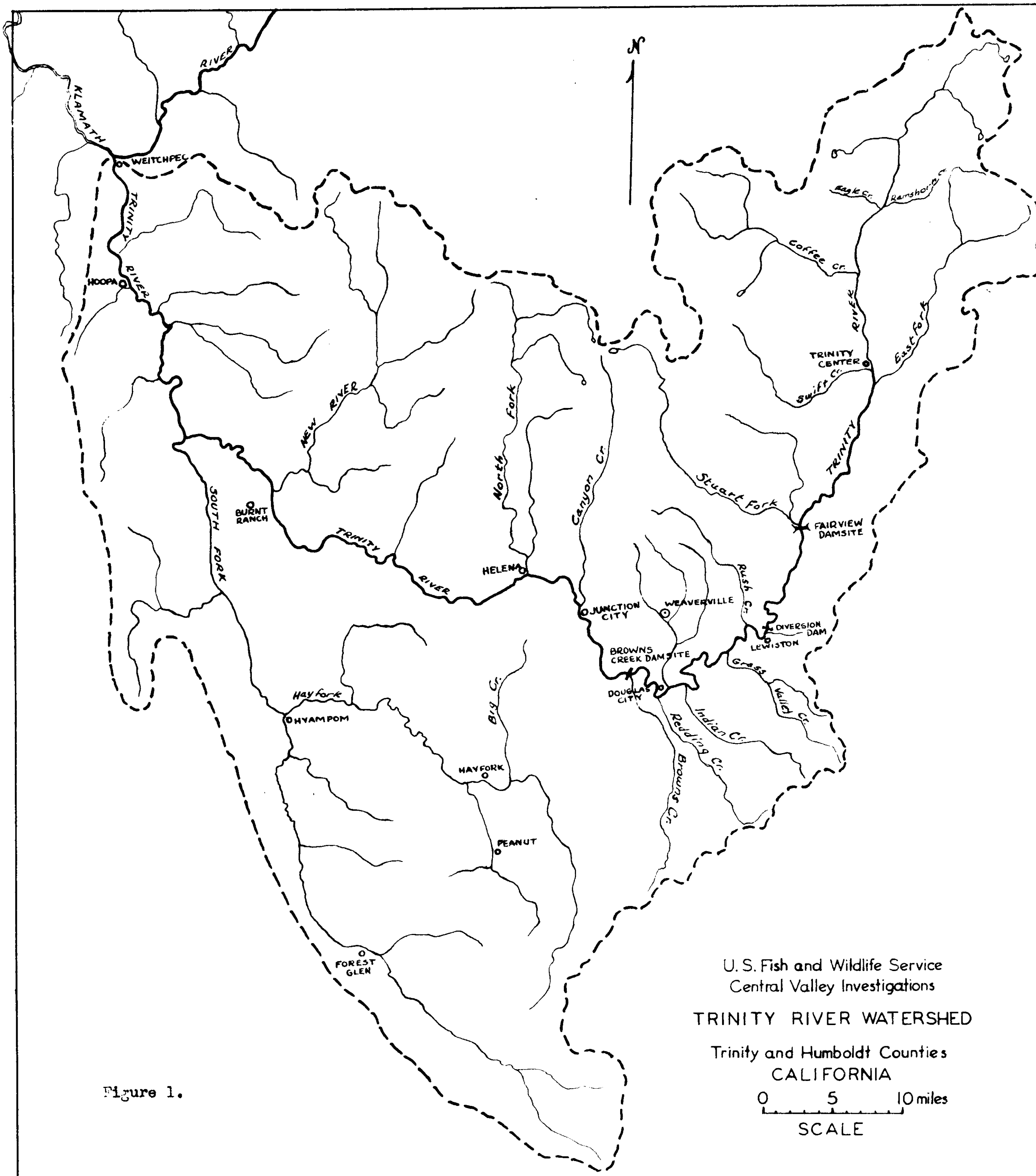
INTRODUCTION

Demands for additional water supplies for irrigation and production of hydroelectric power in the Central Valley and adjacent areas in California, focused attention on the upper Trinity River drainage as a possible source of supply. Plans to divert Trinity River water into Sacramento Valley from that area were formulated and published in 1931 as a part of the California State Water Plan. These plans were further studied and refined by the U. S. Bureau of Reclamation and U. S. Army Corps of Engineers and by 1941, their realization seemed certain. It was apparent that diversion of Trinity River water would seriously affect the fishery resources that are dependent upon the upper river, particularly king salmon and steelhead trout. In order to determine the magnitude and biological characteristics of these resources and to design management plans and procedures for their protection, the U. S. Fish and Wildlife Service conducted a comprehensive survey and study of the entire problem. Major features of the study involved determination of (1) the size and composition of fish population, (2) the characteristics of the seaward migration of young salmon and steelhead trout, (3) the extent and utilization of spawning grovels, (4) the physical characteristics of the drainage, (5) existing biological conditional, and (6) possible means of controlling the fishery and its environmental factors.

Work was first started in the fall of 1942 when a temporary fish counting weir was constructed on the Trinity River a few hundred yards below the river bridge at Lewiston (see map) and approximately 105 miles upstream from the river's mouth. Studies of some of the biological and physical conditions of the stream were also started during November of 1942. The temporary fish counting weir was replaced with a removable structure in late 1943. Because of wartime impediments, uninterrupted studies of the Trinity River fishery covered a period of only two years. As a result, it is impossible to make positive and final conclusions. This report, therefore, is an interim report with most findings and conclusions subject to possible revision pending further investigational findings.

Trinity River, largest of the Klamath River tributaries, rises in the Scott Mountains at the northern end of Trinity County, California. It courses south and west through Trinity County, then north to its confluence with the Klamath River in Humboldt County. The less canyonous portions of the river bed abound with broad gravel riffles and provide excellent spawning grounds for king salmon. Numerous small tributaries and the upper part of the main stream furnish adequate spawning ground for large numbers of anadromous and resident trout. Like many of the rivers in the northern California, its run-off pattern consists of extremes in flood and in drought. During summer, its flow is extremely low. In winter and spring, it rages destructively when in flood and discharges much of its annual run-off.

The Trinity and its parent stream, the Klamath, have been fishing grounds for Indian tribes for ages. Well established trade routes from the interior to the sea passed through or terminated in the Klamath and Trinity country where a lively commerce in shells and dried fish existed. Thousands of king salmon, silver salmon, and steelhead trout were caught by the Indians living in Klamath and Hoopa territory (Hewes, 1942). These Indians were highly skilled in fishing. They constructed fish weirs of logs, poles, and brush across the rivers and speared or netted the upstream migrant salmon, trout, and even lampreys. These weirs remained in the streams as virtually impassable barriers until the first rains of autumn replenished river flow sufficiently to wash them away. Year after year the weirs were installed according to strict ritual and procedures (Snyder, 1924). In modern times most of the fish weirs have disappeared. 0ne is usually built each summer at Hoopa on the lower Trinity River and below it the Indians seine, spear, or operate gill nets. Salmon and steelhead are dried, smoked, canned in the Reservation cannery, or used fresh. The Indians



N
KLAMATH
RIVER
WEITCHPEC
TRINITY
RIVER
HOOPA
NEW RIVER
North Fork
Canyon Cr.
Eagle Cr.
Ramshorn Cr.
Coffee Cr.
RIVER
TRINITY CENTER
Swift Cr.
East Fork
TRINITY
Stuart Fork
FAIRVIEW DAMSITE
SOUTH FORK
BURNT RANCH
TRINITY
RIVER
HELENA
JUNCTION CITY
WEAVERVILLE
Rush Cr.
DIVERSION DAM
LEWISTON
BROWNS CREEK DAMSITE
DOUGLAS CITY
Grass Valley Cr.
Indian Cr.
Redding Cr.
Browns Cr.
Hayfork
HYAMPOM
Big Cr.
HAYFORK
PEANUT
FOREST GLEN
U. S. Fish and Wildlife Service
Central Valley Investigations
TRINITY RIVER WATERSHED
Trinity and Humboldt Counties
CALIFORNIA
0 5 10 miles
SCALE

Figure 1.

practice conservation of a sort, part of the migrating salmon are allowed to pass the weir through gates installed for that purpose.

Trinity River has long been famous as a gold-bearing stream. In early times, some rather large communities occupied its banks and most of the presently existing towns are remnants of these settlements which degenerated following exhaustion of the major placer and hard-rock gold deposits. Extensive gravel deposits above North Fork have been dredged for gold. Great spoil piles of barren gravel constitute the immediate stream bank for mile upon monotonous mile. The original character of the stream and its adjacent flats has been seriously altered. Some isolated dredge operations still go on in the drainage and, at times, the stream bears great quantities of silt in much the same manner it did for 75 years or more following the discovery of gold.

A vigorous commercial fishery on Klamath River began shortly after gold-mining started. The early fishing efforts were for local supplies and usually concentrated on the riffles of the river and its tributaries. Canneries began operating on the Klamath estuary prior to 1892 and reached a high state of development by 1912 (Snyder, 1931). Over-fishing and possibly mining soon made noticeable changes in the abundance of king salmon. Early records given by Snyder indicate a historical peak in the Klamath River commercial fishery occurred in 1912 when over 1,384,000 pounds of fish were packed from a catch of approximately 141,000 salmon. Records for that year are incomplete and consist of estimates applied to portions of unreported packs. The 1915 pack is recorded more completely; about 1,232,229 pounds of salmon were packed from a catch approximating 72,357 king salmon.

Essential features of the Trinity development plan consist of an earth-fill storage dam about 352 feet high, built in the vicinity of Fairview Quartz Mill (see map); a diversion dam about 110 feet high located just above the town of Lewiston, California; and a series of tunnels, power plants, and canals leading from the diversion dam to the Sacramento River above Keswick Dam. A second plan contemplates construction of a storage dam near Browns Creek, some 6 miles below Douglas City. Water from this reservoir would be pumped to the diversion tunnel above Lewiston. The point of diversion from the Trinity River at Lewiston is about 1300 feet above the Sacramento River.

Dams at the Fairview and Browns Creek sites would be high barriers insurmountable by present type of fish ladders. Reservoirs formed by these dams would be very long, extensive, and would cover much of the existing spawning grounds of anadromous fishes. These fishes might be lifted mechanically over the dams, but it is doubtful that their offspring would pass through the reservoirs, find the river outlets, and proceed downstream without suffering material losses. Most of the water would flow into the diversion tunnel and with it the majority of the young salmon and trout produced upstream.

Almost without exception, Trinity River salmon migrating above the South Fork spawn in the 72 miles of river between the North Fork and Ramshorn Creek. In addition to the main river, three tributaries are used by spawning salmon. A dam at the Lewiston site would cut off 35 miles of the main river and all of Stuart Fork, the most important spawning tributary. The salmon would be blocked from approximately 50 percent of their natural spawning grounds in the upper Trinity. A dam at the Browns Creek site would cut off the remaining two spawning tributaries and 59 miles of the main river spawning area. This dam would eliminate some 82 percent of the natural salmon spawning area.

Appreciation is expressed for the help given by the State of California Division of Fish and Game and by many persons who were connected with the work from time to time. Among these were Dr. Paul R. Needham, who directed the project until the end of 1944, Harry A. Hanson, George Warner, Owen Vivian, William B. Davenport, Millard Coots, Donald Drake, S. N. McKinsey, Norman Mattoon and many

residents of Lewiston who assisted with work on the project. Much of the information included has been generously supplied by the U. S. Bureau of Reclamation U. S. Engineers, U. S. Forest Service, and the U. S. Geological Survey. The Indian Agency at Hoopa, on the lower Trinity River, also cooperated.

This investigation was supported by funds transferred to the Fish and Wildlife Service by the Bureau of Reclamation. It was considered a vital part of the pre-project engineering and exploratory work conducted by the Bureau of Reclamation. The study was terminated in August 1946, when the Bureau of Reclamation ceased active work on the Trinity River diversion project.

PHYSICAL CHARACTERISTICS OF TRINITY RIVER

Trinity River is approximately 159 miles long and drains a semiwilderness area of approximately 2,900 square miles. It is divided into five more or less distinct sections which have a direct bearing on the utilization of the stream by spawning and juvenile anadromous fishes. The uppermost 18 miles of the river from its source to Ramshorn Creek are precipitous (gradient 222 ft./mile), the channel is narrow, gravel riffles are very limited, and the bottom is covered with large boulders. The 12 miles of river between Ramshorn Creek and Trinity Center traverse a broad valley into which many small tributary streams enter. The stream has a gradient of 58 feet per mile and meanders through wooded and pasture lands wherever gold dredges have left the original terrain. Its channel is broad and gravelly with large extensive riffles alternating with deep pools. From Trinity Center to North Fork, the gradient is less se-mere (15 ft/mile), water volumes are greater, and very extensive riffles characterize the channel. Most of the spawning grounds of salmon are located in this 60-mile section of stream. Between its North and South Forks the river passes through a rocky canyon 40 miles in length. Water flows are concentrated and made turbulent and exceedingly rapid by the narrow confines which typify this canyon. Gradients are more severe (23 ft./mile) and volumes of flow, in relation to channel capacity, are relatively great. The Trinity between South Fork and its confluence with Klamath River meanders (gradient 12 ft. mile) the length of beautiful Hoopa Valley (29 miles) and is characterized by broad gravel riffles alternating with large, deep pools.

Run-off and Flow

The run-off characteristics of Trinity River are quite similar to those encountered in most California streams. The great bulk of the annual run-off occurs in winter, while summer flows are quite low (figure 2 Table 1). At Lewiston gauging station the extremes of flow between winter and summer are represented by a high flow of 40,300 second-feet recorded on February 28, 1940, and a low flow of 23 second-feet recorded on July 30, 1924 (U. S. Geological Survey data). The average annual run-off is 1,106,454 acre-feet as measured at Lewiston, and 3,811,520 acre-feet at Hoopa, about 10 miles above the mouth.

The run-off pattern of Trinity River at Lewiston varies widely from year to year, although the seasonal wet-dry cycles occur during corresponding periods each year. The volume of annual run-off Prom the drainage above Lewiston had a range of approximately 250,000 to 2,500,000 acre-feet, with a mean of 1,106,454 acre-feet, during the years 1912 through 1945.

TABLE NO. 1

AVERAGE DAILY FLOW II CUBIC FEET PER SECOND

TRINITY RIVER AT LEWISTON WATER YEARS 1928-1942

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,647	1,655	3,945	3,435	3,863	2,608	1,017	248	132	137	376	609
2	'1,626	2,045	3,249	3,259	3,799	2,607	991	240	1%	158	334	1,341
3	1,400	2,436	2,714	3,206	3,694	2,549	953	232	141	179	343	1,347
4	1,437	2,779	2,526	3,539	3,583	2,592	893	223	135	179	394	733
S	1,171	2,354	2,475	3,217	3,435	2,676	857	215	134	163	392	599
6	1,018	2,929	2,268	2,933	3,443	2,635	821	207	133	15s	336	522
7	1,028	2,747	2,124	3,017	3, 447	2,600	790	201	128	160	310	489
8	1,085	2,692	2,134	3,071	3,575	2,425	749	198	126	1%	296	481
9	1,166	2,377	2,308	2,982	3,873	2,334	724	194	127	151	536	766
	1,175	2,243	2,346	2,917	3,905	2,303	638	185	127	[illegible]0693	510 189	2,174 128
	1,450	2,263	2,277	2,993	4,048	2,346					506	2,893
12	1,191	2,005	2,803	3,032	4,283	2,296	605	182	128	144	388	1,696
13	1,259	1,842	2,770	3,529	4,342	2,201	678	177	131	I44	374	1,343
14	1,659	1,720	2,427	5,805	4,359	2,107	561	171	130	163	476	2,260
15	1,940	1,526	2,305	3,953	4,126	2,309	515	167	134	17s	813	1,859
	1,464	1,546	2,693	3,723	3,973	2,468			130	163	655	2,383
17	1,281	1,524	2,431	3,428	3,718	1,981	499	161	127	156	663	1,407
18	1,181	1,492	2,629	3,454	3,490	1,799	464	166	124	153	555	1,478
19	1,277	1,503	2,751	3,541	3,187	1,659	439	161	125	149	708	1,365
20	1,167	1,601'	2,601	3,526	3,344	1,552	417	156	127	142	1,817	1,546
21	1,075	1,972	2,679	3,661	3,689	1,497	403	151	126	190	944	1,485
22	1,207	2,008	2,589	3,631	3,894	1,471	387	148	125	199	71s	1,261
23	1,579	1,735	2,508	3,699	3,819	1,444	372	144	121	194	1,078	1,174
24	1,723	1,697	2,420	3,677	3,931	1,358	347	141	119	186	715	1,273
2s	1,877	1,919	2,476	3,518	4,617	1,269	328	138	118	210	578	1,160
26	2,183	2,143	3,391	3,412	3,804	1,194	310	137	120	207	578	1,127
27	2,167	3,132	3,801	3,422	3,383	1,154	295	135	12s	219	506	1,237
28	1,671	4,779	3,767	3,565	5,166	1,125	287	134	134	204	s31	1,024
29	1,547	-----	3,639	3,767	2,967	1,088	275	134	137	267	654	988
30	1, 501	-----	4,122	3,840	2,821	1,066	265	135	137	256	738	1,072
31	1,474	-----	4,106	-----	2,674	-----	256	133	---	355	---	1,255
Mean	1,436.6	2,160.5	2,809.1.	3,425.0	3,679.0	1,957.1	557.3	173.1	129.2	179.7	593.9	1,301.1

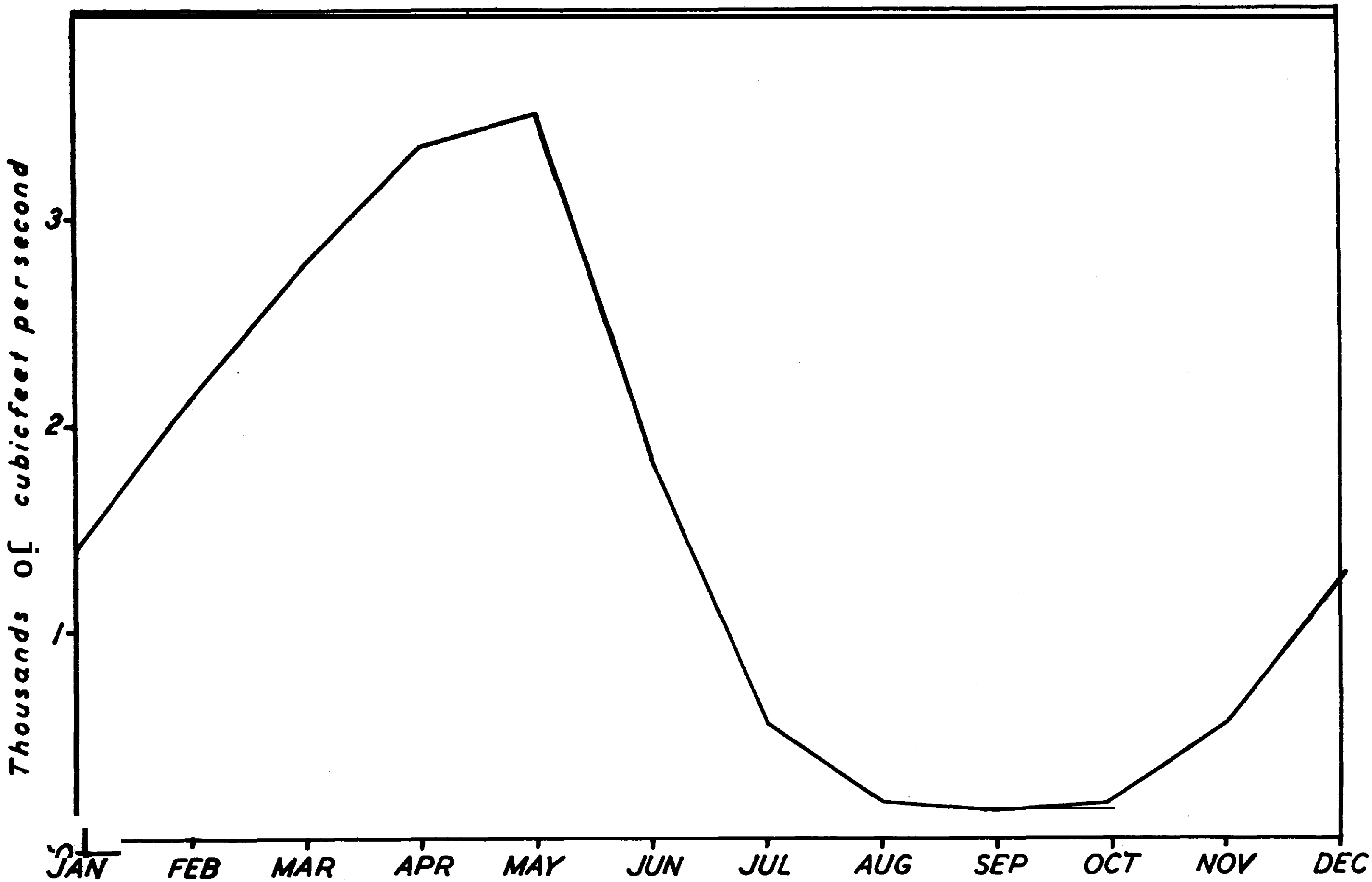


Figure 2. Average monthly flow of Trinity River at Lewiston during water years 1928-1942.

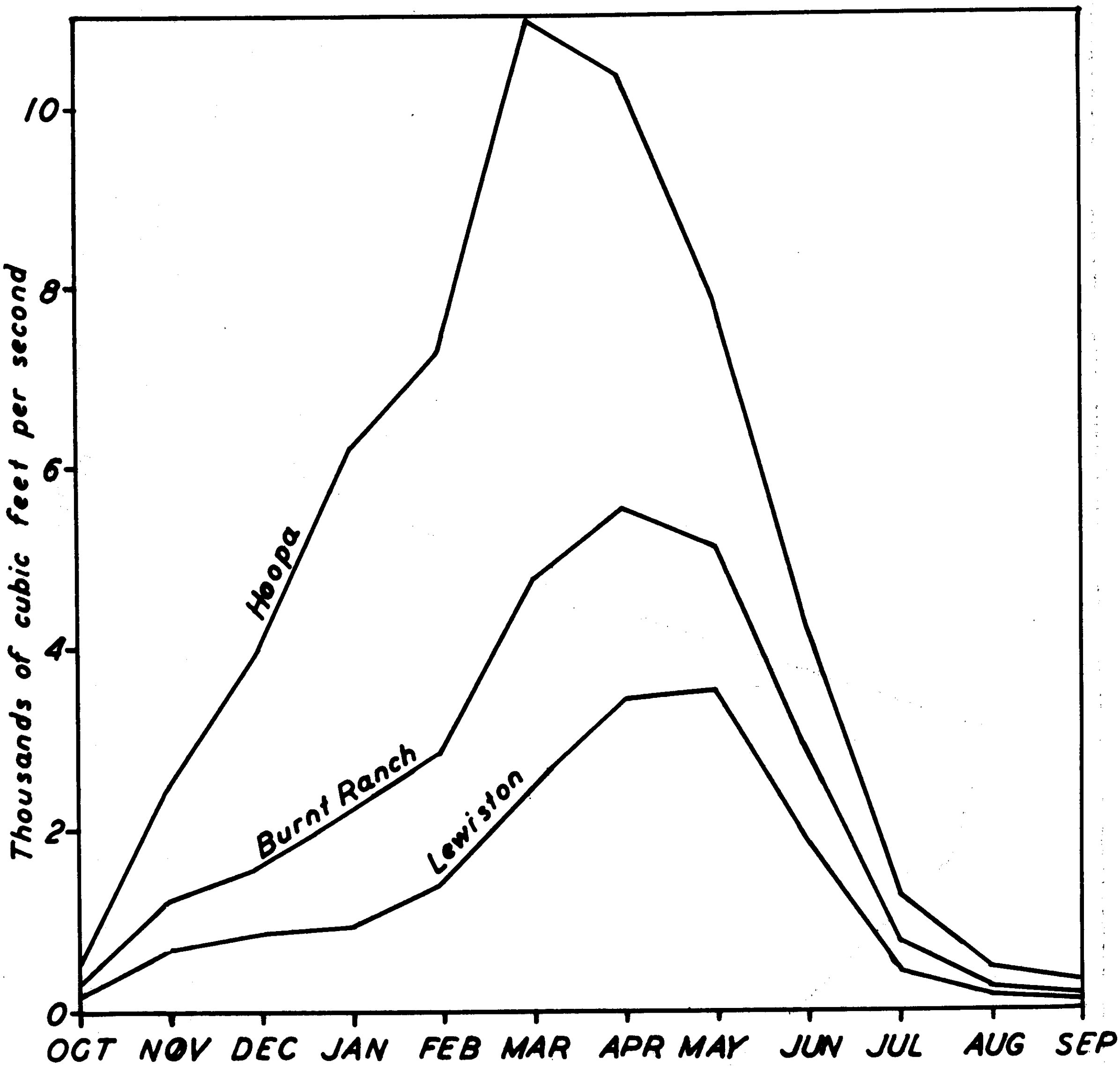


Figure 3. Average monthly discharge of Trinity River at three points in the drainage. Water years 1932-1939.

The general run-off pattern over the entire Trinity drainage varies somewhat from that recorded at Lewiston. The spring run-off peak at Burnt Ranch occurs a month earlier than the peak at Lewiston (Figure 3). Inflow from many small tributaries which drain an area with little snow accumulation contributes most of the earlier run-off at that point. River flow at Hoopa, including the inflow from New River and the extensive South Fork drainage, reaches a spring run-off peak in March, two months earlier than the peak at Lewiston.

River Temperatures

River temperatures at Lewiston were recorded daily from November 1942 through July 1946 (Tables 2-5 and Figure 4). Temperatures were taken with a hand thermometer three times each day, at 8 a.m., 12 noon, and at 5 p.m., until January 1945. Following that date, continuous temperatures were recorded by a thermograph. During most of the year, the river reached its maximum temperature at about 5 p.m., and its minimum at 8 a.m.; consequently, temperatures taken by hand thermometer at these hours closely approximate the extremes. Average daily temperatures after January 1945 were computed from thermograph records by taking the mean of temperature readings at two-hour intervals during a 24-hour period.

Trinity River is warmest during July and August when spring and summer salmon are holding over in the main river. The maximum water temperatures and dates of occurrence for years of record are as follows: 78°F., on August 13, 1943; 81°F., on July 24 and 27, 1944; and 83°F., on July 27, 1945. Temperature records were not complete enough in 1946 to show the highest temperature with certainty, but a high of 80.5°F., was reached on July 22, 1946. The maximum temperature recorded for 1943 may not be the true peak temperature for that year, as it was taken from partial records made during August and September. A temperature of 80°F., or higher was recorded on 9 days during the summer of 1944 and 27 days during the summer of 1945. As a result of experience gained at Deer Creek Station on Sacramento River, California (Moffett, 1949), 80° is considered lethal or near lethal for king salmon. The same species is able to survive when surface temperatures are above 80°F in Trinity River by remaining in the cooler waters of deep holes along the river. In August 1944, water at depths over 8 feet in one of these large holes was 7°F cooler than surface water.

The daily temperature range is of interest when considering the effect of maxima as lethal agents. To illustrate this range in Trinity River during summer, the hourly record for July 27, 1945, is presented:

12:00midnight	74.0	8:00am	70.5		
1:00am	73.5	9:00am	71.5	5:00pm	83.0
2:00am	72.5	10:00am	73.5	6:00pm	82.5
3:00am	72.0	11:00am	75.0	7:00pm	81.5
4:00am	71.5	12:00noon	77.0	8:00pm	80.5
5:00am	71.0	1:00pm	79.0	9:00pm	79.0
6:00am	70.5	2:00pm	81.0	10:00pm	77.5
7:00am	70.0	3:00pm	82.5	11:00pm	76.5
		4:00pm	83.0	12:00midnight	75.0

During 7 hours of the day, water temperatures were above 80°F., while during 11 hours, temperatures were below 75°F. Between 9 a.m. and 4 p.m., the river temperature rose 11.5 degrees, and between 6 p.m. and midnight it fell 7.5 degrees.

On July 4, 1945, a recording thermometer was installed at Junction City, some 28 miles down river from Lewiston, to determine the warming effect of hot summer weather on the river between these two points. The maximum, minimum, and average daily water temperatures recorded at this station are given in Tables 6 and 7. A maximum temperature of 85°F was recorded at that station on July 27, 1945, the same day the peak temperature of 83°F., was recorded at Lewiston. The hottest days of the summer were July 26 and 27, when a maximum air temperature of 108°F., was recorded at Lewiston on both days. The river temperature reached or exceeded 80°F., on 32 days in the summer months at Junction City. During July and August, maximum water temperatures at Junction City were one or two degrees higher than Lewiston water temperatures for the corresponding day. Temperature records at Junction City during 1946 were too incomplete for analysis.

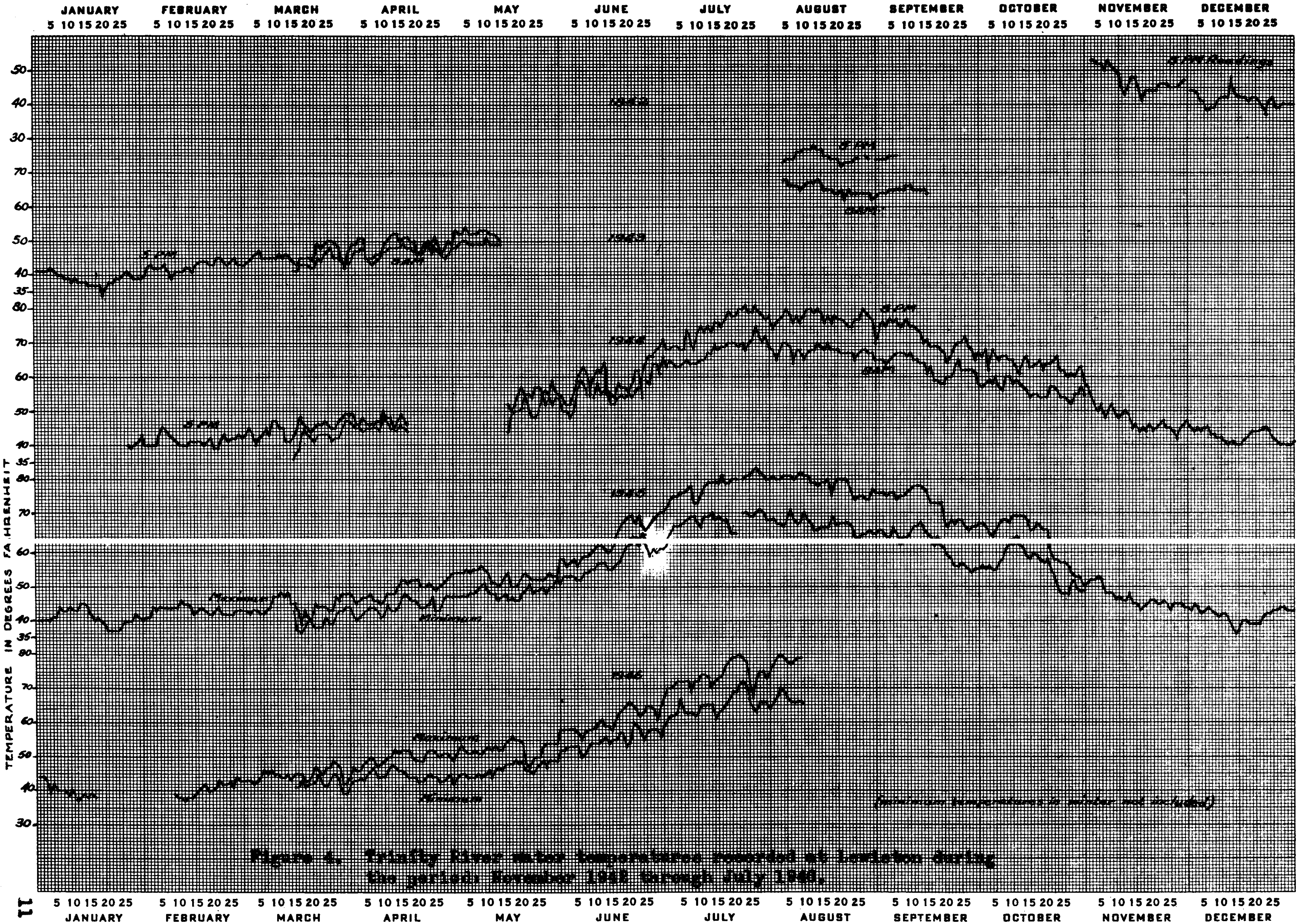


Figure 4. Trinity River water temperatures recorded at Lewiston during the period: November 1942 through July 1946.

TABLE NO. 2

DAILY RIVER TEMPERATURE, TRINITY RIVER AT LEWISTON

	1942				1943													
	Nov.		Dec		Jan		Feb		Mar.		Apr.		May		Aug.		Sept.	
Day	8am	5pm	8am	5pm	8am	5pm	8am	5pm	8am	5pm	8am	5pm	8am	5pm	8am	5pm	8am	5pm
1				44	41	41	39	40	42	43	45	49	48	53			64	74
2	53	53	43	44	41	41	40	42	43	44	47	49	49	52			64	74
3	53	53	42	43	41	41	42	43	44	45	47	51	50	52			64	74
4	53	52	41	41	41	41	42	42	45	46	48	51	50	54	68	73	65	75
5	52	52	36	41	41	42	42	42	45	47	45	45	49	52	68	74	65	75
6	47	50	36	38	41	41	42	42	45	45	44	45	49	52	66	74	65	75
7	51	53	37	39	39	40	42	43	45	45	43	45	49	52	66	74	65	
8	49	51	38	39	39	40	43	41	44	45	44	46	49	53	66	76	65	
9	49	50	39	41	38	39	39	39	45	45	45	46	49	53	65	76	66	
10	47	49	41	42	38	39	40	41	45	45	47	48	51	53	66	77	66	
11	44	45	41	42	37	38	41	41	45	46	47	50	49	52	67	77	65	
12	44	43	41	42	37	39	41	41	45	45	48	51	49	52	67	77	65	
13	45	45	41	48	38	38	41	42	46	46	48	52	49	51	67	78	65	
14	47	48	41	43	37	38	40	42	44	45	48	52	49	50	68	77	65	
15	47	48	41	42	37	38	40	41	41	44	48	50			67	77	64	
16	46	44	41	42	37	37	40	43	41	43	49	51			65	75		
17	40	41	41	42	37	37	42	44	43	45	48	51			65	75		
18	43	44	41	41	36	37	42	44	43	45	48	50			65	74		
19	43	44	40	42	37	37	43	44	43	45	47	50			64	74		
20	43	44	41	42	35	34	42	43	42	45	46	46			64	74		
21	44	44	41	41	34	36	43	43	42	44	46	47			65	72		
22	45	46	40	39	38	38	43	45	45	49	47	49			62	73		
23	46	46	38	37	37	38	44	45	44	48	49	50			65	73		
24	46	46	40	41	39	39	43	44	46	49	46	49			64	73		
25	46	45	42	42	39	39	40	43	47	50	48	51			64	74		
26	45	45	38	39	40	40	41	44	48	50	47	49			64	74		
27	45	45	39	39	41	41	44	45	45	49	46	46			64			
28	45	46	39	40	40	40	42	43	45	48	45	48			64	75		
29	46	47			40	39			44	45	46	50			64	74		
30	47		40	40	39	39			42	42	48	49			62			
31			40	40	39	39			43	47					63	74		
Av.	46.6	47.1	40.0	41.2	38.5	38.9	41.2	42.6	44.1	45.8	46.7	48.9	49.2	52.2	65.2	74.8	64.9	74.5

TABLE NO. 3
1944 DAILY RIVER TEMPERATURE, TRINITY RIVER AT LEWISTON

Day	Jan. 8am	Jan. 5pm	Feb. 8am	Feb. 5pm	Mar. 8am	Mar. 5pm	Apr. 8am	Apr. 5pm	May 8am	May 5pm	June 8am	June 5pm	July 8am	July 5pm	Aug. 8am	Aug. 5pm	Sept. 8am	Sept. 5pm	Oct. 8am	Oct. 5pm	Nov. 8am	Nov. 5pm	Dec. 8am	Dec. 5pm
1			40	40	39	43					50	54	63	68	68	74	65	75	57	66	53	57	44	45
2			40	40	39	45	46	49			50	52	65	68	65	76	65	76	58	68	52	54	41	44
3			40	40	40	43	45	46			48	52	64	69	68	77	64	75	59	62	51	52	41	45
4			40	40	39	40	45	46			50	55	63	69	70	78	65	77	58	68	49	50	42	44
5			40	43	39	42	44	48			55	59	63	68	70	80	66	76	60	66	50	62	43	4s
6			43	45	40	43	45	46			59	61	64	68	69	78	67	77	57	65	50	48	43	45
7			43	44	41	45	45	46			58	63	65	74	64	76	67	75	56	66	48	50	43	43
8			43	43	40	43	45	47			55	61	64	70	68	78	67	75	60	66	SO	52	42	43
9			40	42	45	47	44	47			55	55	64	68	68	76	66	77	60	65	47	49	41	42
10			40	41	43	47	48	50			54	60	64	73	65	78	67	75	58	65	48	48	40	42
11			39	40	40	45	47	48			58	62	65	75	67	80	65	75	59	63	47	49	40	41
12			38	40	40	45	45	48			55	62	65	73	68	80	65	74	58	61	48	50	39	40
13			37	40	39	41	4s	45			56	64	67	75	68	79	64	73	57	65	47	49	37	41
14			38	41	37	41	44	47			55	56	67	73	70	60	64	70	56	66	46	45	38	40
15			38	41	36	43	46	49			52	55	70	76	69	79	61	71	54	63	45	46	38	40
16			37	41	38	45	45	48	44	52	52	S4	68	76	68	76	63	69	55	63	42	44	39	40
17			37	41	41	48	44	46	48	50	54	58	69	75	70	78	59	69	55	64	42	45	40	42
18			37	40	45	46			50	52	55	57	69	77	68	76	59	69	54	65	43	44	41	43
19			38	41	43	45			SO	55	54	57	70	79	68	78	58	68	54	62	43	46	42	44
20			37	42	42	44			51	57	55	S6	70	78	68	77	58	67	54	64	42	44	42	44
21			39	39	41	45			56	55	54	58	70	78	67	77	60	64	57	64	42	45	43	44
22			36	39	43	46			51	55	56	62	69	80	67	76	60	66	57	65	43	46	44	45
23			37	42	43	46			48	54	57	62	70	80	67	75	62	69	56	66	45	47	45	45
24			39	43	43	47			48	57	56	54	68	81	67	75	65	70	54	62	44	45	44	44
25			39	41	43	46			SO	57	59	64	70	79	65	77	62	70	54	62	42	45	42	42
26			36	42	41	45			SS	55	58	66	71	79	67	77	62	72	53	60	43	44	40	41
27		40	37	42	42	45			52	56	64	66	75	81	68	80	62	69	52	61	40	42	40	40
28	37	39	39	43	42	47			54	55	64	68	72	79	68	79	62	68	55	60	44	45	40	40
29	39	40	40	42	44	48			52	59	61	69	70	78	67	78	61	65	55	62	44	46	39	40
30	40	41			47	49			54	56	66	71	72	77	67	77	58	67	57	63	46	47	39	40
31	40	43			47	49			54	55			69	78	65	70			5s	59			39	41
Av.	39.0	40.6	38.9	41.3	41.4	45.0	45.1	47.2	51.1	55.0	55.8	59.8	67.6	74.9	67.5	77.3	63.0	71.4	56.3	63.8	45.9	47.5	41.0	42.4

TABLE NO. 4

1945 DAILY RIVER TEMPERTURE, TRINITY RIVER AT LEWISTION

Day	January Max.	January Av.	January Min.	February Max.	February Av.	February Min.	March Max.	March Av.	March Min.	April Max.	April Av.	April Min.	May Max.	May Av.	May Min.	June Max.	June Av.	June Min.
1	40	----	39*	41	----	39*	43	40.8	40	47	44.2	42	54	51.2	47	58	56.0	53
2	40	----	39*	41	----	39*	42	40.5	39	45	43.2	40	54	51.3	47	56	55.4	53
3	40	----	39*	44	----	41*	4 3	40.8	40	46	44.1	41	54	51.4	47	57	55.3	53
4	40	----	39*	43	----	42*	43	40.6	39	47	44.9	42	55	51.6	47	58	55.6	53
5	41	----	40*	44	----	42*	42	40.2	38	47	44.6	43	54	51.6	48	56	54.4	52
6	41	----	41*	44	42.5	41	42	40.4	39	48	45.9	44	55	62.2	48	58	55.2	52
7	44	----	43*	44	43.2	43	43	41.4	40	46	45.2	44	55	S2.6	49	59	56.4	54
8	43	41.9	41	44	43.4	43	44	42.6	42	46	44.4	43	56	53.5	50	59 --	56.8	54
9	43	41.7	41	44	43.1	42	47	43.8	42	45	43.3	41	55	52.5	51	60	57.6	55
10	44	42.9	42	44	43.3	42	47	45.4	43	46	44.6	42	54	51.8	49	61	58.3	55
11	43	42.2	41	46	44.8	43	48	45.5	44	48	46.3	45	51	so.2	48	62	59.5	57
12	43	41.9	41	45	43.7	42	47	45.9	45	48	45.6	43	51	- -	48*	62	59.8	57
13	45	44.0	43	45	44.4	43	48	45.6	44	48	45.6	43	SO	- - -	46*	61	59.0	57
14	46	44.2	44	44	42.8	42	4s	44.6	44	SO	46.9	44	51	- -	47*	60	57.6	55
15	44	42.4	42	42	41.2	39	46	44.1	43	62	49.4	47	53	SO.8	48	61	58.0	55
16	42	41.1	40	43	41.4	40	43	40.7	37	62	SO.7	48	54	50.0	46	63	59.5	56
17	40	38.0	38	44	43.2	42	39	37.1	36	61	49.0	47	SO	48.4	47	65	61.3	57
18	41	39.1	38	43	42.1	40	43	39.9	38	52	49.5	46	So	48.3	46	67	63.4	59
19	40	39.6	38	42	40.4	38	41	40.8	40	62	49.6	48	51	48.6	46	68	65.1	61
20	39	37.7	36	42	40.5	39	40	39.8	39	62	49.2	4s	53	so.7	48	69	65.6	62
21	37	35.5	35	43	40.9	39	45	41.0	38	so	47.9	44	54	61.7	49	69	66.0	63
22	37	35'0	34	44	42.4	41	44	41.7	38	SO	47.6	44	53	52.4	51	67	65.2	63
23	37	35.0	34	42	41.4	40	44	40.6	38	Sl	48.1	4s	62	SO.7	48	69	66.1	62
24	37	35.3	34	42	40.7	39	44	42.2	41	60	49.0	47	52	so.5	49	66	65.3	64
25	38	36.6	36	42	40.3	39	43	41.2	39	49	45.7	43	52	SO.8	49	65	63.2	62
26	40	37.3	36	42	40.6	39	43	40.0	39	so	46.2	43	52	51.2	50	66	62.7	59
27	40	37.4	36	43	40.6	40	47	44.4	42	51	48.7	46	53	50.9	48	68	64.9	61
28	40	37.0	35	43	40.9	39	46	44.6	43	52	50.0	47	54	52.1	50	69	64.8	60
29	42	39.1	37				48	46.0	43	53	50.1	47	53	51.6	50	70	66.0	61
30	41	40.6	40				48	46.3	44	54	50.9	47	63	52.6	52	70	66.3	61
31	40	39.7	39				48	46.6	44				68	54.1	51			
Av.	41	39.8	39	43	41.9	41	44	42.5	41	49	46.8	44	53	50.7	48	63	60.4	58

*Readings taken with hand thermometer.

TABLE NO. 4 (Concluded)

1945 DAILY RIVER TEMPERATURE, TRINITY RIVER AT LEWISTON

	July			August			September			October			November			December		
Day	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.
1	72	67.8	62	81	73.8	68	76	70.8	65	67	61.8	56	51	49.9	49	43	43.3	43
2	74	69.6	64	80	73.5	67	76	70.7	64	66	61.5	55	52	50.9	50	45	44.2	43
3	75	70.5	66	80	73.3	67	75	69.6	63	64	60.4	56	52	51.1	50	44	43.6	42
4	75	70.6	66	81	73.6	66	76	70.2	63	63	59.7	55	53	51.3	50	42	40.5	39
5	76	71.3	66	81	74.6	68	76	71.1	66	65	60.8	55	52	50.2	48	43	42.2	41
6	76	71.8	67	81	75.4	71	74	69.3	64	67	62.3	57	48	46.6	44	44	43.3	42
7	77	72.6	68	80	73.9	68	75	68.7	62	68	63.7	58	48	45.2	44	43	42.8	42
8	78	73.3	69	81	73.8	67	75	69.4	63	68	65.0	61	48	45.6	44	42	41.8	41
9	73	71.0	69	82	74.9	68	76	70.0	63	67	64.5	62	46	44.8	44	41	40.5	40
10	73	69.6	67	81	75.2	70	77	71.1	64	69	65.5	62	47	45.1	44	42	41.1	40
11	76	71.3	66	81	74.3	68	78	72.3	66	69	65.7	63	46	45.2	44	42	41.1	40
12	78	73.2	69	79	73.0	67	78	72.3	66	69	65.3'	62	46	44.9	43	40	39.3	37
13	79	73.9	69	79	71.8	65	78	72.6	67	69	64.3	61	48	46.0	44	38	36.3	35
14	79	73.7	70	78	72.0	65	77	71.4	65	68	63.3	59	45	44.7	44	36	35.2	34
15	79	73.4	68	79	72.3	66	75	70.3	64	65	62.3	58	45	43.9	43	37	36.5	35
16	79	73.7	69	79	72.3	66	73	68.7	63	65	62.3	60	43	42.5	41	40	38.5	37
17	81	73.4	68	80	73.3	66	73	68.1	62	67	62.6	59	44	42.6	41	40	39.2	38
18	79	73.0	68	75	71.9	69	73	68.7	63	66	61.5	58	45	44.6	43	39	38.3	38
19	79	71.8	66	79	72.6	67	73	67.9	62	65	60.6	57	46	45.3	44	39	37.7	37
20	80	71.3	64	80	73.7	67	68	65.3	61	65	61.0	58	46	45.2	44	39	37.8	37
21	80	71.8	64	80	73.9	67	66	62.7	59	60	57.2	55	45	44.0	43	39	38.8	38
22		----	--	80	73.7	67	68	62.6	58	58	55.5	53	45	44.2	43	41	39.7	39
23	80	75.3	70	79	72.8	67	67	61.7	56	58	53.9	50	46	45.3	44	42	41.0	40
24	81	74.8	70	76	70.7	66	68	62.5	56	57	52.8	48	45	45.1	44	42	42.0	42
25	81	74.4	69	74	69.1	63	68	62.8	57	57	52.4	48	43	43.0	42	43	42.5	42
26	82	74.4	69	75	69.5	63	66	61.6	56	56	52.4	48	45	43.8	43	43	42.3	42
27	83	76.4	70	75	69.8	64	65	60.3	55	54	52.7	51	45	45.3	44	44	----	42*
28	82	76.2	71	74	69.3	64	66	60.6	54	53	52.7	52	45	44.4	43	44	----	43*
29	81	75.2	70	74	69.8	65	66	62.1	55	53	51.0	49	44	43.3	42	43	----	42*
30	80	73.8	68	77	70.4	64	67	61.5	55	--	----	--	44	43.3	42	43	----	42*
31	80	73.7	68	76	70.6	64	--	----	--	50	49.5	49	--	----	--	43	----	42*
Av.	78	72.9	68	79	72.5	67	72	66.8	61	63	59.4	56	47	45.4	44	42	40.7	40

*Readings taken with hand thermometer,

TABLE NO. 5
1946 DAILY RIVER TEMPERATURE, TRINITY RIVER AT LEWISTON

	January*		February			March			April			May			June			July			August		
Day	Max.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.
1	44	43				43	42.0	41	47	46.0	43	51	47.8	44	58	55.6	52	70	65.3	61	77	n.3	66
2	44	43				43	41.8	'40	46	45.2	43	53	49.5	45	58	56.1	53	70.	65.9	62	79	73.3	68
3	43	43				42	40.9	39	46	46.6	44	52	49.4	45	68	55.8	63	71	66.3	62	80	73.7	70
4	39	39				43	41.2	38	48	46.7	43	61	48.5	44	68	65.7	53	72	67.1	63	79	73.2	69
5	42	41				44	42.6	41	49	47.0	46	61	47.9	44	57	55.3	53	72	69.4	67	78	71.8	67
6	40	40				46	44.1	42	SO	47.9	46	52	48.7	44	55	55.3	50	72	67.7	63	77	70.8	66
7	40	39				45	44.Q	41	49	47.6	47	61	48.6	45	57	54.6	51	72	67.4	63	78	71.0	66
8	40	39				46	44.6	42	47	46.7	44	51	47.9	44	68	5S.7	53	69	66.1	63	79	71.5	66
9	39	38	39	36.0	35	45	43.9	41	48	45.8	44	52	48.8	45	58	66.0	54	72	66.9	62	79	71.8	66
10	40	39	38	36.6	35	46	43.6	42	49	46.7	44	63	49.8	46	59	56.1	54	72	67.9	63			•
11	--	39	36	35.6	34	44	42.8	40	so	48.8	46	52	49.0	44	60	57.4	54	74	69.2	66			
12	37	36	37	35.2	34	44	43.6	43	50	49.3	48	53	50.2	.46	61	68.0	55	74	69.8	65			
13	38	36	38	36.7	34	45	43.3	41	62	49.7	47	52	50.2	47	59	57.3	66	73	69.3	65			
14	39	37	38	36.3	35	43	41.5	39	61	49.2	46	62	49.7	46	59	56.8	64	70	67.2	65			
15	38	37	39	37.6	36	45	43.0	41	62	49.6	46	54	61.3	48	68	56.5	66	72	66.3	61			
16	39	38	40	38.4	37	45	43.3	41	62	49.4	45	55	51.6	48	61	57.9	66	73	67.7	63			
17	38	37	41	39.3	38	45	44.2	43	52	48.7	44	56	51.5	48	63	69.3	67	74	68.9	64			
18	--	38	42	40.2	38	43	42.2	41	50	47.2	44	56	52.7	49	64	60.4	57	76	70.3	65			
19			40	38.9	38	43	42.9	'42	49	46.8	44	56	62.0	40	65	61.7	53	78	71.9	67			
20			40	38.9	38	45	43.7	42	49	46.3	43	54	61.8	49	66	62.8	54	79	73.2	69			
21			41	40.0	39	47	44.8	43	49	46.7	43	48	47.7	46	65	62.7	60	79	73.7	69			
22			43	40.8	39	46	45.8	45	sl	47.8	44	47	46.7	46	64	61.6	59	80	76.0	71			
23			42	41.2	40	45	43.0	42	62	49.3	4S	49	47.6	45	62	69.5	67	79	74.0	72			
24			42	41.2	40	47	44.1	41	52	49.0	44	So	49.2	47	63	59.0	55	78	73.5	70			
26			43	41.3	40	47	45.6	43.	sl	48.4	44	50	49.6	48	65	60.8	57	72	69.5	67			
26			41	40.4	39	49	47.5	45	50	47.0	43	53	49.3	49	65	61.5	68	67	66.0	64			
27			44	42.2	41	48	46.9	45	51	47.5	43	54	50.5	47	64	61.5	58	73	68.0	63			
28			43	41.8	40	47	44.1	42	51	48.2	44	54	62.2	49	61	60.6	58	75	70.3	66			
29						42	40.1	39	so	47.6	45	54	52.2	49	65	60.6	56'	75	70.3	66			
30						42	41.2	39	49	45.8	42	54	52.7	49	68	63.6	69	73	69.0	66			
31						44	43.2	42				68	65.0	52				75	69.2	64			
Ave.-			40	39.0	38	45	43.4	42	SO	47.2	45	53	49.7	47	61	-68.2	66	74	69.4	65	78	72.8	67

*Readings taken **with** hand thermometer.

TABLE NO. 6

1945 DAILY RIVER TEMPERATURE, TRINITY RIVER AT JUNCTION CITY

Day	July Max.	July Av.	July Min.	August Max.	August Av.	August Min.	September Max.	September Av.	September Min.	October Max.	October Av.	October Min.	November Max.	November Av.	November Min.	December Max.	December Av.	December Min.
1	--	----	--	83	77.3	72	78	72.8	67	69	63.4	58	51	49.6	48	44	43.6	43
2	--	----	--	60	76.1	71	78	72.7	67	68	63.1	58	53	51.3	49	44	43.5	42
3	76	----	--	82	75.8	70	77	71.8	66	66	62.2	59	54	53.0	52	44	43.6	43
4	76	72.6	68	81	75.7	70	77	71.6	66	66	61.8	58	54	52.6	51	43	42.4	41
5	77	73.3	69	01	76.0	70	77	72.0	68	67	62.0	57	53	51.5	49	44	42.9	41
6	77	73.8	70	81	76.5	72	76	70.7	66	66	62.5	59	50	48.7	46	45	44.2	43
7	79	75.0	n	80	75.0	70	76	70.0	64	68	63.9	59	48	46.4	45	44	43.3	42
8	79	75.4	72	81	75.3	69	77	71.2	65	68	65.4	62	48	46.8	45	43	41.8	41
9	74	72.6	72	82	76.2	70	77	71.7	66	67	65.0	63	47	46.9	46	42	40.7	40
10	74	71.2	69	80	76.2	72	79	72.6	67	69	65.4	62	47	46.4	45	42	41.4	40
11	78	73.5	70	80	75.1	70	80	73.6	68	69	66.1	63	46	45.5	44	43	41.9	41
12	79	75.0	71	79	74.3	69	79	73.6	68	70	66.1	63	48	46.1	45	41	40.2	38
13	80	75.8	72	80	74.2	68	79	73.4	69	70	65.5	63	49	46.6	45	39	37.5	36
14	80	76.0	72	80	74.2	69	78	72.2	67	69	64.5	61	47	46.1	45	36	35.7	34
15	80	76.0	72	80	74.4	69	76	n.3	67	68	63.7	60	47	45.7	4s	37	36.2	35
16	80	75.6	72	79	74.0	68	75	70.4	66	65	63.0	61	45	44.2	44	38	37.7	37
17	79	75.2	71	81	75.3	69	76	70.0	65	67	63.0	61	45	43.9	43	40	38.9	38
38	80	75.3	71	75	73.5	71	76	70.5	66	67	62.2	59	45	44.4	43	40	38.0	38
19	78	74.1	70	79	73.8	69	75	69.7	65	66	61.7	58	47	46.1	45	39	38.0	37
20	78	73.6	69	80	74.6	69	71	67.1	64	66	61.8	59	47	46.0	45	38	38.1	38
21	78	73.6	69	81	75.3	70	66	63.8	61	60	58.4	56	46	45.1	44	40	39.3	38
22	79	74.3	70	81	75.3	70	69	63.8	60	60	56.5	53	46	45.2	44	40	40.0	40
23	80	75.0	70	79	74.0	69	68	63.4	59	58	54.4	51	47	46.5	45	41	40.5	40
24	80	75.3	71	76	72.0	68	70	64.2	59	58	53.5	50	47	46.1	45	42	41.8	41
25	81	75.4	70	76	70.8	66	70	64.8	60	57	53.0	49	45	43.6	43	43	42.4	42
26	83	76.7	71	76	71.0	66	69	64.1	59	56	52.5	49	45	44.0	43	42	42.3	42
27	85	78.5	73	76	n.4	66	66	62.1	58	53	52.2	51	46	45.4	44	44	42.7	42
28	84	78.9	74	75	71.0	66	67	61.4	56	53	52.2	51	46	45.2	44	46	44.8	44
29	82	77.6	73	77	71.5	67	68	62.5	57	53	52.5	52	44	43.5	42	45	44.3	44
30	82	76.3	70	78	72.3	67	68	63.0	58	52	49.5	48	45	43.7	43	44	43.4	43
31	82	77.1	71	78	72.7	67	mm	----	--	49	49.5	48	--	----	--	44	43.5	43
Average 8	79	75.1	71	79	74.1	69	74	68.9	64	63	60.0	57	48	46.4	45	42	41.0	40

TABLE NO. 7
1946 DAILY RIVER TEMPERATURE, TRINITY RIVER AT JUNCTION CITY

Day	January Max.	January Av.	January Min.	February Max.	February Av.	February Min.	May Max.	May Av.	May Min.	June Max.	June Av.	June Min.	July Max.	July Av.	July Min.
1	45	43.3	44	38	37.7	36	--	----	--	61	57.9	54	71	67.6	64
2	44	44.0	44	39	30.7	38	--	----	--	62	59.4	57	71	67.9	64
3	43	43.2	43	39	38.4	37	--	----	--	62	59.0	56	71	68.1	64
4	43	41.5	40	38	37.7	36	--	----	--	62	59.2	56	72	69.3	65
5	43	41.6	41	38	37.7	37	--	----	--	61	58.4	56	73	69.6	66
6	42	41.3	41	38	36.0	35	--	----	--	61	57.9	54	73	69.8	66
7	41	40.6	40	37	35.6	34	--	----	--	62	57.9	54	73	69.8	66
8	41	40.2	39	39	37.3	35	--	----	--	62	58.9	55	70	68.5	66
9	40	39.4	39	40	39.0	38	--	----	--	62	59.2	56	73	69.4	65
10	41	39.5	41	39	38.0	37	--	----	--	62	59.2	55	74	70.6	67
11	41	39.8	39	39	37.5	36	--	----	--	64	60.7	57	75	71.7	68
12	39	37.8	36	38	37.1	36	--	----	--	65	61.8	58	76	72.3	68
13	38	37.2	36	39	37.6	36	--	----	--	63	61.3	58	--	----	--
14	39	36.8	36	38	37.8	36	--	----	--	63	60.5	57	--	----	--
1s	39	37.9	36	39	38.8	38	--	----	--	62	60.0	57	--	----	--
16	39	38.0	37	--	----	--	--	----	--	64	60.7	57	--	----	--
17	39	38.0	37	--	----	--	--	----	--	66	62.6	58	--	----	--
18	39	38.0	36	--	----	--	--	----	--	67	63.9	60	--	----	--
19	38	37.8	37	--	----	--	--	----	--	69	65.3	61	--	----	--
20	39	38.8	37	--	----	--	--	----	--	70	66.6	62	--	----	--
21	39	38.8,	38	--	----	--	--	----	--	69	66.9	63	--	----	--
22	40	39.5	39		----	--	--	----	--	66	64.3	62	--	----	--
23	42	40.8	40	45	44.4	43	--	----	--	64	61.3	58	--	----	--
24	42	41.4	41	43	42.4	41	--	----	--	64	61.3	58	--	----	--
25	42	40.7	40	44	42.2	40	51	50.2	49	66	62.8	59	--	----	--
26	40	37.9	38	42	40.6	39	52	49.9	48	66	63.2	60	--	----	--
27	38	36.8	35	--	----	--	54	51.2	48	66	63.6	60	--	----	--
28	38	37.1	35	--	----	--	56	52.6	49	64	62.2	61	76	72.2	69
29	39	37.0	35	--	----	--	57	53.4	50	66	62.5	58	76	72.2	69
30	38	37.4	36	--	----	--	57	54.2	51	69	65.8	62	74	71.1	69
31	38	37.1	35	--	----	--	58	55.6	52	--	----	--	76	71.7	67
Averages	40	39.3	38	40	38.7	37	55	52.4	50	65	61.5	58	74	70.1	67

EXISTING BIOLOGICAL CONDITIONS

Non-game Fishes

The Klamath black dace, Rhinichtys osculus klamathensis (Evermann and Meek), and the fine-scaled River sucker, Catostomus rimiculus (Gilbert and Snyder), are the only coarse fish taken during this study which are known to spend their entire life cycle in the Trinity River. Both of these species occur commonly throughout the drainage.

The Klamath black dace is the most numerous and ubiquitous species found in the Trinity River. It inhabits all stream sections except the headwaters of some tributaries. The dace is a small fish in the Trinity; the largest individuals seldom exceed a fork-tail length of 3.1 inches (80 millimeters). During the summer low-water period, Klamath black dace are seen in very large numbers in pools along the river. They are almost inactive during the daytime when they rest in shallow water or in rubble on the river bottom, but they start receding at sunset and remain active until the nest morning. There seems to be no gregarious tendency during this active period. Observations of feeding activity indicate that dace are omnivorous. Most feeding takes place on the algal-covered bottom, but drifting food particles and floating insects are also taken. In winter months, dace are seldom seen in the open, although their appearance in fyke-net catches during this period indicates some nocturnal activity.

The Klamath black dace of Trinity River have been extensively reported on by Jhingran (1948). Much of the dace material collected during this investigation was placed at his disposal and is incorporated in his study.

Fine-scaled Klamath River suckers are as widely distributed in the river as are the dace, but they are much less abundant. They are most commonly found in deeper holes along the river and in tributaries with moderate gradients. It is common to see large schools feeding along the bottom of pool areas any time of the year. This fish apparently has little value in the Trinity River as a forage fish for large trout. Undoubtedly, juveniles enter the diet of native trout and steelhead but most small suckers are found in tributary streams where large trout do not occur.

Resident Game Fishes

The Trinity River investigation has revealed the presence of three resident Salmonidae: rainbow trout, Salmo gairdnerii (Richardson); brown trout, Salmo trutta (Linnaeus); and eastern brook trout, Salvelinus fontinalis (Mitchill); named in order of abundance.

Rainbow trout, the only native species, are distributed in fairly large numbers throughout the drainage, except in the upper extremities of some tributaries This species contributes the major portion of all game fish taken by sportsmen. The California Division of Fish and Game reports that approximately 7,750 anglers took an estimated 389,900 trout from the Trinity River in 1941. No observations have been made of rainbow trout spawning activities but ripe males have been taken during the steelhead spawning period (February - April) in Rusch Creek, a tributary, and it may be assumed that they spawn during that period.

Brown trout are also generally distributed but are fewer in number and more conspicuously absent from the upper extremities of the river and its tributaries than are the rainbow. There are known to be definite spawning migrations of adult brown trout in the Trinity. From June 29 through August 2, 1945, 39 brown trout passed through the gates of the Lewiston fish-counting weir. Six specimens taken for study had an average weight of 5.7 pounds and an average length of 23.4 inches Their sex products were further developed than those of steelhead, but less than salmon taken at the same time. Less conspicuous but larger migrations occur during November and December. Although these fish have not been observed spawning in the Trinity River during this study, local residents report having seen them spawning in the upper main stem and its tributaries from late December until early February.

Several young brown trout were usually taken in the fyke nets at Lewiston during the week following the first fall rain. A few young, near or in their second year, were taken through the remainder of the winter months. Fry of this species that had recently left the gravel were taken by fyke nets on very rare occasions in March and April. It is possible that the brown trout of Trinity River migrate to the sea as do representatives of the same species in Europe, although no direct evidence is yet available to demonstrate such movement. Scales from the specimens taken at Lewiston were so reabsorbed that positive age and growth determinations could not be made.

Rather limited populations of eastern brook trout occur in the colder waters of the upper extremities of the Trinity River and its tributaries. They are caught in fair numbers by sportsmen who frequent the higher, primitive areas. These fish do not attain a very: large size in the drainage, but their gaminess and limited distribution make them highly desirable to many sportsmen.

Anadromous Fishes

Four anadromous or sea-run fishes have been recognized in the Trinity River during the course of this investigation. These are the three-toothed lamprey, Entosphenus tridentatus (Gairdner), the king salmon, Oncorhynchus tschawytscha (Walbaum), the silver salmon, Oncorhynchus kisutch (Walbaum); and the steelhead trout, Salmo gairdnerii (Richardson).

King salmon

Commercial and sports fisheries

King salmon have long been sought by Indians, commercial fisher- and sportsmen as one of the most abundant and desirable of the Pacific salmons. The part played by the Trinity River in supplying the salmon fishery of California is not definitely known, but some idea of its contribution can be deduced from discussion of catch statistics. An average annual catch of 2,286,588 pounds of salmon has been taken commercially from waters of Humboldt and Del Norte Counties over a period of 28 years (Table 8). These counties lie north and south of the mouth of the Klamath River, and catches there certainly include a major portion of the contribution of the Klamath River. Salmon originating from other drainages appearing in these catches are assumed to be compensated for by Klamath River salmon taken north and south of these two counties. Trinity River contributes approximately one-third of the total Klamath drainage accessible to spawning salmon, and its contribution to the commercial fishery supported by the Klamath drainage is assumed to be proportional to its part of the drainage area involved. Based on these assumptions the annual catch of salmon from Trinity River would approximate 762,200 pounds.

An important sports fishery materially increases the value of the salmon production. It is difficult to even approximate the value of these fish to the sportsmen. Businesses and people benefiting from sport fishing are so greatly varied and widely distributed that a summation of values is impossible. The California Division of Fish and Game estimates that 1,385 anglers took 11,496 salmon from the Trinity River in 1941. Based on an average weight of 11 pounce per salmon this catch amounted to 126,456 pounds. The total production of the salmon fishery resource of the Trinity River is probably 890,000 pounds per year.

Characteristics of the seasonal runs

King salmon enter the Klamath River from the ocean in two well-defined runs, one in spring and another in fall. The spring run, once the largest run entering the riser, begins in late March, reaches a peak in May, and diminishes as to the vanishing point by the end of June. At present this run is very small, but Snyder (1931) cites a paper by R. D. Hume (undated) as authority for the assertion that in 1850 and even later the spring run was the most abundant. It was practically extinct in 1892, and no evidence of recovery was evident when Hume wrote his article which certainly appeared before the turn of the century. The summer run usually begins to enter Klamath estuary about the first of July. It increases gradually throughout that month, reaches a peak in August, declines steadily through September, and practically disappears by the beginning of winter. There appears to be little or no segregation of this latter run into summer and fall segments.

Adult king salmon migrate past Lewiston en route to their spawning grounds in what appear to be three seasonal groups: one in spring, one in summer, and one in fall. Each of these groups, excepting possibly the spring run, is distinct and divisions between them are well defined (Figure 5 and Table 9). The spring migration passes Lewiston during June and July, the summer migration during August and September, and the fall migration during October and November.

TABLE NO. 8 COMMERCIAL SALMON CATCH --DEL NORTE AND HUMBOLDT COUNTIES

Year	Weight of catch in pounds
1916	1,980,953
1917	1,521,378
1918	1,234,653
1919	1,468,162
1920	1,307,568
1921	1,212,879
1922	2,006,822
1923	1,990,235
1924	2,193,688
1925	3,795,062
1926	2,825,650
1927	1,856,451
1928	1,211,600
1929	1,520,624
1930	2,387,507
1931	3,813,300
1932	3,047,400
1933	3,340,678
1934	2,769,304
1935	3,499,610
1936	2,347,116
1937	3,375,560
1938	1,438,23D
1939	1,675,116
1940	3,369,492
1941	2,413,368
1942	2,255,862
1943	2,176,182
TOTAL	64,024,450

*From California Division of Fish and Game published commercial catch records.

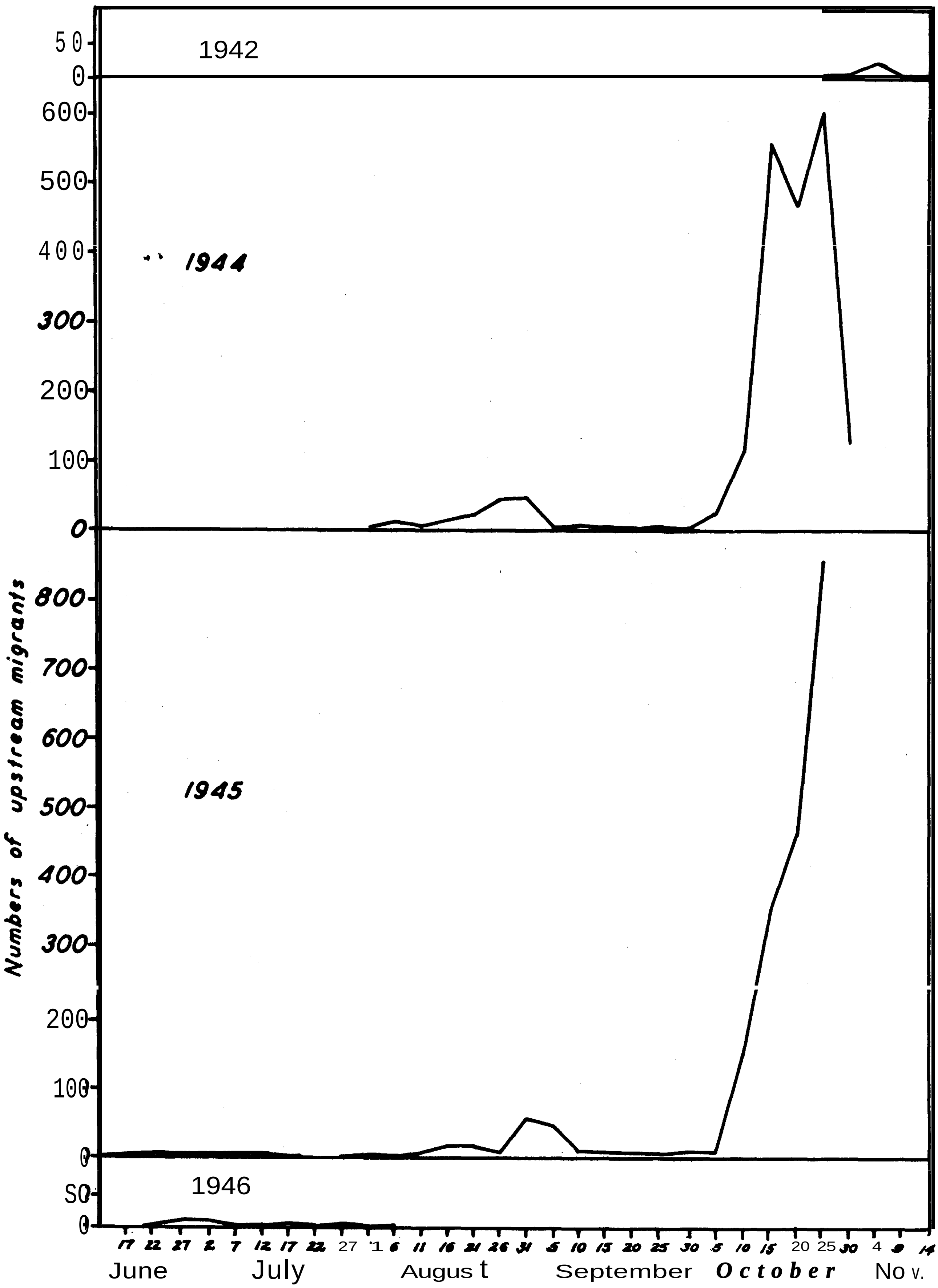


Figure 6. Numbers of adult king salmon passing through the Lewiston weir in 1942, 1944, 1945 and 1946, Trinity River.'

TABLE NO. 9
KING SALMON COUNTS
TRINITY RIVER AT LEWISTON

Day	1942 Oct.	1942 Nov.	1944 A,,.	1944 Sept.	1944 Oct.	1944 Nov.	1945 June	1945 July	1945 Aug.	1945 Sept.	1945 Oct.	1946 June	1946 July	1946 Aug.
1		5		8	14	1407		2	0	4	0		9	6
2		2		177	1	75		1	1	12	0		17	7
3		18		90	2	171		0	1	16	11		9	3
4		17	3	76	5			5	0	112	21		30	0
5		3	0	40	1			1	0	108	2		28	1
6		4	0	23	3		0	0	0	9	6		14	0
7		6	0	8	0		0	0	0	37	3		11	0
8		96	0	0	4		0	0	0	21	12		4	1
9		0	13	8	1		0	0	0	80	1		5	0
10		0	3	5	23		0	0	1	65	5		5	1
11		9	11	5	41		0	2	0	47	12		16	
12		4	23	1	55		0	2	0	22	13		6	
13		4	4	19	91		0	0	0	24	114		3	
14		4	5	8	85		0	0	0	4	255		4	
15		0	3	1	98		0	0	0	10	155		11	
16		0	6	4	151		0	1	12	0	75		6	
17		0	12	2	150		0	0	8	17	173		7	
18		12	2	4	359		0	0	3	9	205		4	
19		3	5	9	641		0	0	21	7	351	0	10	
20			3	6	700		0	0	35	17	478	0	12	
21			6	2	385		0	0	16	4	369	0	3	
22			25	1	711		2	0	6	0	348	0	6	
23			23	2	901		0	0	0	5	338	0	1	
24			14	0	461		0	0	3	3	374	0	2	
25			23	4	295		0	0	0	1	445	0	2	
26			34	1	399		0	0	23	9	385	0	2	
27			18	4	281		0	0	56	5	755	0	3	
28			22	0	259		3	0	10	7	536	2	3	
29	6		13	2	166		3	0	11	1	1170	2	8	
30	2		6	1	499		3	0	6	0		1	2	
31			13		689			0	4				7	
Totals	8	187	290	511	7471	1653	11	14	217	656	6612	5	250	19
Yearly totals		195				9925					7510			274

Counts of migrating adult salmon began early enough to include spring-run fish in 2 of the 2 1/2 years of observations June and July counts in 1945 totaled 25 fish. The total count for the same months, plus the first 10 days in August, amounted to 274 salmon in 1946. The run in 1946 was large enough to demonstrate trends and limits It began on June 28, increased rapidly to a peak on July 4, tapered off very gradually through July, and practically ceased by the 5th of August. The spring-run segment nearly failed in 1945. The weir at Lewiston began operations June 6, but the first salmon to pass it did not arrive until June 22. In the period June 28 through July 16, all but two of the 25 fish passed the weir. No other fish were counted until August 2.

Spring-run salmon are very deliberate in their migratory habitat. They travel fast and do not hesitate to fight any obstacle encountered. Their greatest movement through the counting weir took place during the two hours following sunset, although some migration continued day and night. They are in excellent condition, as is shown by their visceral fat, silvery bodies, and very red flesh. In some years this run is hardly noticeable in Trinity River because of its relatively small size and the fact that the salmon in it rarely strike at a fisherman's lure. Upon reaching deeper holes between Lewiston and Trinity Center, these fish stop migrating and remain in a semi-quiescent state until they spawn early in October.

The so-called summer run was much more numerous and distinct than the spring run in both 1944 and 1945. Weir operation began August 4, 1944, and on that date 3 fish passed the gates. Salmon arrived at the weir in erratic but gradually increasing numbers throughout the remainder of the month. The greatest daily count was made on September 2, after which the migration dwindled to practically nothing. The total number of salmon involved in this run was 801. In 1945 the summer run began passing the weir on August 16. It increased in the same erratic fashion as did the 1944 run until the greatest daily count was made on September 4. Unlike the 1944 migration, movement through the weir gates after the peak day were sustained until the middle of September before a marked reduction occurred. Migration virtually ceased by the end of September. The 1945 summer run consisted of 873 individuals.

The summer king salmon are slow and rather cautious in their migratory habitat. They are quite wary of any obstruction or disturbance and their greatest movement at Lewiston took place in the four hours following sunset. Little, if any, migratory movement was observed during daylight hours. Periodic fluctuations in daily counts of these fish appear to be related to changes in water temperature . At Lewiston, there were generally a peak count two days following a low river temperature. Fish of the summer migration are in fairly good condition. They have no visceral [at, but their flesh is quite red and firm. Few of these salmon will a bike a lure' however, they are quite noticeable in the larger holes along the river between North Fork and Trinity Center. It is possible that the summer run at Lewiston is a late or delayed portion of the spring run which, having stopped migrating early in the season, is forced to move upstream to escape high summer water temperature

Fall-run salmon reached Lewiston about October 1 in 1944 and once they began to arrive the number counted each day increased rapidly. After the initial surge "waves" of migrants passed through the counting gates until seasonally peak in daily count was reached November 1. This peak accompanied the first sustained rain and river flow increase of the season. A second storm and subsequent rise in river flow forged removal of the counting weir on November 3. The counted portion of the fall run of 1944 amounted to 8,124 fish. The fall run of 1945 reached Lewiston at about the same time in October as did the 1944 run. It also passed through the counting gates in successive "waves" which culminated in a peak daily count of the season on October 29. This peak count also coincided with the first sustained rainstorm of the season which continued in intensity and forced removal of the weir on October 30. Fall-run salmon counted in 1945 totaled 6,612 at the time operations ceased.

The fall migration is the largest and most noticeable. Many of these fish will take the fisherman's lure, and, as a result, they support a heavy sports fishery. Their flesh is quite pink and readily distinguishable from that of the fish in the two earlier migrations, which is almost white by the time the fall migration starts. These salmon can also be distinguished from fish of the two previous migrations because their gonads are not fully mature while the other fish have begun spawning. Since these fish mature later, many of them are able to enter smaller tributaries after the first fall freshets.

Obviously, the total annual number of adult salmon passing Lewiston was greater than the 9,925 counted in 1944 and the 7,510 in 1945. It is believed, however, that the number of salmon passing Lewiston was not much greater than 120 percent of the number counted. If such is assumed to be the case, then the 1944 run would have totaled about 12,000 and the 1945 run about 9,000.

Spawning and development

The first spawning activities of the spring and summer salmon are noticeable along the river between Grass Valley Creek and Stuart Fork during the first week of October. By the middle of that month, spawning fish can be seen on every suitable riffle in this area and scattered spawning occurs upriver to the East Fork and downstream to the North Fork. Spawning in this stretch of the river reaches a peak during the first two weeks of November when many of the fall-run fish are also depositing their eggs. During the course of the investigations, high water flow and turbidity prohibited observation of main river spawning after the first week of November, although spawning is known to occur long after that date. Salmon that had recently died following spawning, and a few living fish, have been seen as late as December 19 near Lewiston. Three freshly spent salmon were found dead near Lewiston in February 1946. Salmon start to spawn in the Trinity Center area during the first two weeks of November, and a peak in the spawning activity is reached during the last two weeks of that month. Spawning salmon have been observed as late as December 12 near Trinity Center.

King salmon fry begin to emerge from the river gravels during January. Undoubtedly, the first fry to appear are offspring of the spring and summer adult runs which spawn some four to six weeks ahead of the fall-run adults; however, no distinction between the hatching times of the separate runs can be detected from fyke-net catches after the emergence is well underway. The movement of salmon fry from their nests continues from January through May, as indicated by results summarized in Table 10. The appearance of undeveloped fry serves as a rough index to the emergence period, however, nets placed directly downstream from salmon nests took very few yolk sac specimens, which demonstrates that young, not fully developed as they leave the nest, are the exception rather than the rule.

Seaward migration

Seaward migration begins to intensify in March (Figure 6, Table 11), usually reaches a peak in May and June, continues until the first half of July, and practically ceases by the first of August. The main migration takes place during the spring run-off period and is only generally influenced by fluctuations in water flows or temperatures. Migration ceases in early summer as the river becomes low and its average temperature ranges into the seventies. The greatest numbers of migrants for each year of observation were taken in May of 1945 and 1944, April of 1945, and June of 1946.

Figures in Table 11 do not indicate the actual size of the seaward migration, and, therefore, the results obtained in one year cannot be compared directly with those of another. Quantitative evaluation of fyke-net catches as indices of the total number of migrants is very difficult. Too many variables, as location of the net, stage of water flow, current, debris, and other factors, change the fishing success each day. The only certain value of the fyke-net records is to show the periods of seaward migration and their relative intensity during different seasons of the year.

Young salmon were observed from a barge anchored in the middle of the river during a heavy migration on June 24, 1946, between 8 and 9 p.m. At that time, fry in great numbers could be seen drifting downstream

TABLE NO. 10
DEVELOPMENT STAGE OF KING SALMON CATCHES IN THE LEWISTON FYKE NET

Periods	1945 Yolk Sac	1945 Abdomen Open	1945 Abdomen Closed	1945 Total Catch	1946 Yolk Sac	1946 Abdomen Open	1946 Abdomen Closed	1946 Total Catch
Feb. 5-9				9	0	1	1	2
10-14				4	0	0	3	3
15-19				5	0	0	0	0
20-24				3	1	2	1	4
25-1				3	0	0	2	2
May 2-6				29	0	1	1	2
7-11	3	2	70	75	0	3	9	12
12-16	5	19	28	52	0	0	3	3
17-u	2	5	49	56	0	1	3	4
22-26	0	1	39	40	0	0	2	2
27-31	0	0	41	41	3	8	19	30
Apr. 1-5	0	2	77	79	0	2	10	12
6-10	0	1	70	71	0	6	21	27
11-15	0	2	216	218	0	3	71	74
16-20	1	4	165	170	0	4	15	19
21-25	0	0	15	15	0	1	38	39
26-30	0	0	8	8	0	3	67	70
May 1-5	0	0	7	7	0	1	104	105
6-10	0	0	12	12	0	0	16	16
11-15	0	0	20	20	0	0	10	10
16-20	0	0	16	16	0	0	17	17

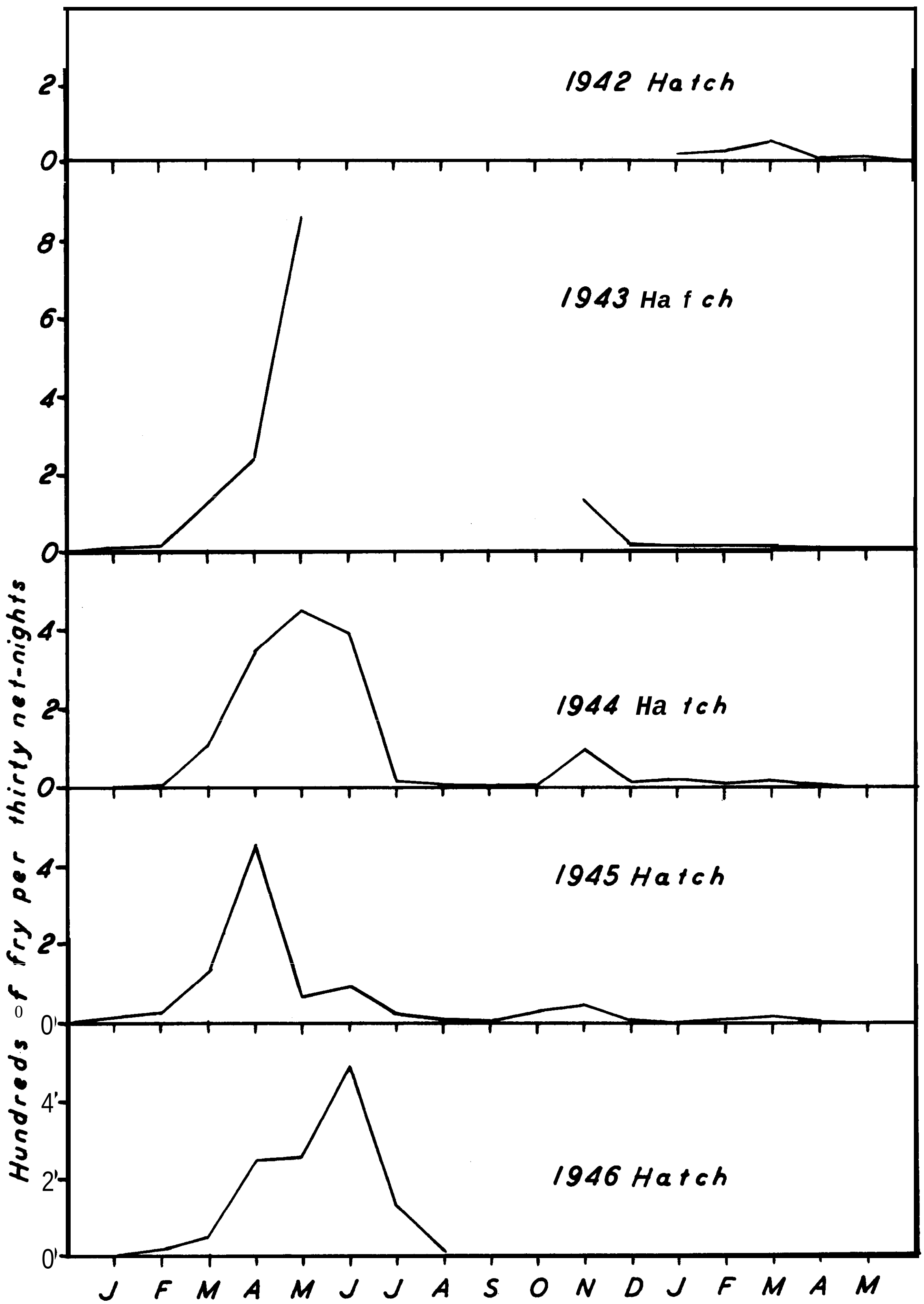


Figure 6. Seaward migration of young king salmon in Trinity River at Lewiston.

TABLE NO. 11

FYKE NET CATCHES OF YOUNG KING SALMON IN TRINITY RIVER AT LEWISTON

Length groups	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
								1942-43									
56 -60 mm.													1				
61 - 65													1	1			
66 - 70													2	3	2		
71 - 75													2	5	8		
76 - 80													3	7	10	1	
81 - 85													1	3	7	1	
86 - 90													3	2	8		
91 - 95													1	1	3		
96 -103														1	3		1
111-115																	1
Total fish													14	23	41	2	2
Net nights fished													22	22	22	21	13
Fish/30 net nights													19	31	56	3	5
Aver. length													76.9	78.0	81.9	80.5	ld5.5
Length groups								1943-44									
31 - 35 mm.			4	10	1												
36 - 40	1	7	85	96	22												
41 - 45			3	10	23												
46 - 50				16	73												
51 - 55				19	117												
56 - 60			1	11	95						2			1			
63 - 65				3	37								1		1		
66 - 70				3	6						4	4	1		1		
71 - 75					1						8	1	1	8			
76 - 80											7	lo	2	5	2		
81 - 85											5	S	3	8	3	1	
86 - 90											1	1	1	1	2		
91 - 95											1		1			I	
Total fish	1	7	93	168	375						28	19	10	23	9	2	
Net nights fished	22	22	22	21	13	0	2	44	0	0	9	27	25	S8	60	54	
Fish/SO net nights	1	9	127	240	865		0	0			127	21	12	12	4	1	
Awr. length	36	36	36.3	41.4	52.0	-	-	-	-	-	75.5	76.9	79.0	77.6	79.1	88	

1 net night equals 1 net fished from 5 p.m. to 8 a.m.

Fyke Net Catches of Young King Salmon in Trinity River at Lewiston (Table No. 11 continued)

Length groups	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
							1944-45										
31 - 35 mm.			39	97	15	2	1										
36 - 40		4	190	460	64	27	4										
41 - 45		1	2	41	133	126	4				1						
46 - 50			4	14	164	215	8				2						
51 - 55				11	87	197	2		2		9						
56 - 60				4	15	11s	4				12		1				
61 - 65					2	50	3	1			16	3	2	1			
66 - 70					5	18				1	2	3	8	3	3		
n - 75						7	1				1	3	13		11		
76 - 80						7					1	1	8	2	6	1	
81 - 85													2	1	1		
86 - 90						2						1					
91 - 95														1		1	
Total fish	0	5	235	627	485	766	27	1	2	1	44	11	34	8	21	2	
Net nights fished	25	58	60	54	32	58	60	62	60	33	14	30	41	54	62	39	
Fish/SO net nights	0	3	118	348	455	396	14	1	1	1	94	11	25	4	10	2	
Aver, length		39.0	37.4	38.2	46.3	51.6	49.7	63	53	68	59.3	70.7	72.6	74.9	74.2	85.5	
Length groups							1945-46										
26 - 30 mm.			3														
31 - 35	1	2	31	15		1											
36 - 40	6	9	213	141	9	3											
41 - 45	3	12	11	35	36	11	1										
46 - 50				7	35	27	3										
51 - 55					8	17	9	1		1	1						
56 - 60					1	23	3	1		3	3						
61 - 65						2	4			11	11						
66 - 70						1	1			2	9	I			1		
n - 75						3	1			1	8			1	5		
76 - 80						1	1	1			3					2	
81 - 85											1						
86 - 90																1	
Fish not meas.				365						5							
Total fish	10	23	258	563	89	89	23	3	0	23	36	3	0	1	6	3	
Net nights fished	41	54	62	39	37	29	30	28	3	13	25	31	12	21	31	30	
Fish/30 net nights	7	13	125	434	72	92	23	3	0	30	43	3	0	1	6	3	
Aver. length	39	39.4	37.5	38.9	45.5	52.2	56.9	63.0	-	62.7	67.5	69.7	-	73	69.7	81.3	

1 net night equals 1 net fished from 5 p.m. to 8 a.m.

Fyke Net Catches of Young King Salmon in Trinity River at Lewiston (Table No. 11 concluded)

Length groups	Jan.	Feb.	Nar,	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	feb.	Mar.	Apr.	May
							1946-47										
26 - 30			1														
31 - 35		2	13	10	3												
36 - 40		6	31	174	118	9											
41 - 45		3	7	53	9s	187	13										
46 - 50			1	2	34	183	30										
51 - 55				2	11	122	43	1									
56 - 60						17	23										
61 - 65						2	9										
66 - 70							3										
71 - 75						1	1										
76 - 80						1											
Not measured							5										
Total fish	0	10	53	241	261	472	127	1									
Net nights fished	12	21	31	30	30	29	31	9									
83 Fish/30 net nights	0	14	51	241	261	488	123	3									
Aver. length		38.5	37.4	39.1	67.6	48.2	52.9	53									

1 net night equals 1 net fished from 5 p.m. to 8 a.m.

with the current. They seemed to be evenly dispersed over the entire river with no tendency to travel in groups or schools and most of them were within a few inches of the surface. Few were seen at depths exceeding 18 inches, but all of them make some effort to stay headed upstream as they drifted with the current. In a 5-minute period, 47 were counted as they passed through an illuminated section of river 10 feet wide. Assuming that the migrants were evenly distributed across the 200-foot width of the river, they were moving peat this point at the rate of 188 per minute, or 11,280 per hour at that time.

In the warm summer months when relatively no downstream movement is evidenced by fyke-net returns, young salmon are commonly seen at all points along the river in the vicinity of Lewiston. Their presence is most conspicuous in the early morning when they can be observed Jumping from the water in quiet, shallow areas along the river's edge. Throughout the day they apparently seek seclusion in the rocks on the river bottom. Several hundred young salmon congregated at a small subsurface spring near Lewiston on days when the water temperature rose above 75°F. Any tendency toward downstream movement in their activities is so alight that it escapee detection. The seaward migration is resumed immediately following the first fall rains when water temperatures approximate those recorded in April, May, and June. This migration of young entering their second year of life usually starts in October or November and continues until march and April of the following year, as shown in Figure 6.

The rate of growth of seaward migrant salmon is difficult to ascertain from samples taken at a fixed location. It would be possible only if certain population segments could be followed downstream and sampled periodically. Sampling at a fixed location actually provides a single set of data on a different population group each day. It is interesting to note, however, that as the season of downstream migration progresses, the average length of migrants taken increases uniformly and may be indicative of the rate of growth (Table 11). Although samples taken in February are too small for reliable statistical treatment, salmon of the year captured during that month in three of the four seasons were larger than migrants caught in March of the same years. The average length of February migrants in 1944 and 1945 was greater than similar average lengths obtained in both March and April. This tendency is presumably indicative of the difference in time of emergence between progeny of spring or summer-run adults and progeny of fall-run parent salmon.

The difference in average lengths of seaward migrants was: 15 mm. (0.59 inches) between March and Nay of 1943; 15 mm. (0.69 inches) between March and June of 1944; 15 mm. (O.59 inches) between March and June of 1945; and 16 mm. (0.63 inches) between March and July of 1946. Salmon taken in November were greater in average length by 17 mm. (0.67 inches) in 1943, 22mm. (0.83 inches) in 1944, and 30mm. (1.18 inches) in 1945, than migrants of the same brood year netted in March. Occasional specimens, captured by the fyke nets in March of the year following their hatching, average 82mm. (3.23 inches) in length in 1943, 79mm. (3.11 inches) in 1944, 75mm. (2.95 inches) in 1945, and 73mm. (2.87 inches) in 1946. These lengths are probably less than the averages which could be obtained from series of samples collected by means other than fyke nets; fish larger than 70mm (2.76 inches) in length are able to avoid capture in most stationary fyke nets.

Sex ratios of adults

The matter of sex ratios in a given population of migrating adult king salmon has been the subject of considerable research effort. Apparently, the consensus of opinion to date favors the concept of equal numbers of males and females in the original stock with inequalities resulting almost entirely from the early maturation and migration of a certain portion of the males of any given year class. Snyder (1931, p. 103) established a sex ratio of 1 female to 1.07 males from 9,439 salmon taken in the commercial ocean catch off Monterey, California, during the years 1919-21. The ratio for the individual years varied only slightly, being 1:1.10 in 1919; 1:1.02 in 1920; and 1:1.05 in 1921. From these results, he maintains that sea fishing does not discriminate in any great measure against either sex. It is also fairly obvious that the sex ratio in the sea is 1:1 as would be expected. Determinations of the sex of salmon fingerlings sampled at

Lewiston indicate a ratio approximating equality. The sex ratio of 166 young salmon taken during 1943 was 1 female to 1.05 males, and a sample of 116 taken during 1945 revealed a ratio of 1:0.97. These samples were composed of fish ranging from 50 to 100 mm. (1.97-3.94 inches) in length.

Sex ratios established from observations on migrating adult populations are quite certainly affected by the type of fishing which the migration has had to pass. Gill-net fisheries are especially selective since most of the mesh sizes are fixed by law for the protection of the smaller sized fish in the run. Snyder (1924) reporting sex determinations made on a sample of 340 king salmon taken at Hoopa in late September 1920, found 260 males all less than 25 inches long, 47 males greater than 25 inches in length, and 33 females. These fish were taken from Trinity River below the Indian fishing weir and probably represented a fair cross section of the migrant population after it had passed the gill-net fishery at the mouth of Klamath River. The sex ratio derived from this sample is 1 female to 9.3 males. The preponderance of males far exceeds anything observed at Lewiston or Trinity Center during this study and is also an indication of the depletion which selective fishing gear can exert on a population despite presumably adequate escapement provisions made by law. In a later study, Snyder (1931, p. 36) found that females predominated in the gill-not catches at the mouth of Klamath River. During the years 1919-1923, inclusive, 63.2 percent of the catch consisted of females. His records are based on catches from nets that allowed the escapement of small fish, and, as he states, do not represent a true cross section of the salmon population. Snyder points out that a greater number of large males was taken in the fishery during the latter part of the season, but very seldom exceeded the number of females. He also noted an increase in the size *of* the fish as the fishing season progressed.

After closure of the Klamath River to commercial fishing in 1933, the migrant adult population of salmon in Trinity River must have returned to its original composition as regards sex ratios. Results obtained during this study would certainly be more representative than those of Snyder. In the vicinity of Lewiston, a sample of 33 fish consisted of 1 female to 1.91 males in 1942; a sample of 90 fish consisted of 1 female to 2.33 males in 1944; and a sample of 116 fish consisted of 1 female to 2.66 males in 1945 (Table 12). The ratio for all years of record at Lewiston is 1 female to 2.4 males. At Trinity Center, some 26 miles upstream from Lewiston, a sample of 548 fish examined in 1945 consisted of 1 female to 0.85 males, almost the reverse of the ratios found at Lewiston.

The difference in the sex ratios of fish sampled in these two areas may be influenced to some extent by the Indian gill-net fishery at Hoopa. The summer and early fall runs of salmon that a pawn near Lewiston must pass nets that would take out many of the larger fish resulting in a greater proportion of small precocious males in the upstream migration. It has been observed on other streams such as the Sacramento River, that the sex ratio may change from year to year. Some investigators aver that a preponderance of males, especially grilse, presages a large migration at maturity of the brood from which the grilse were derived.

Since the spring and summer salmon tend to spawn near Lewiston, and those migrating later utilized the area near Trinity Center, the two areas might be considered unrelated with respect to the composition of their spawning populations. The ratio of the fish spawning in one area is not necessarily related to that of the spawning population in the other. In order to arrive at the sex ratio of all salmon migrating up the Trinity River above North Fork, the sex composition of both of these populations must be considered. An average sex ratio determined from salmon taken at the center of each area should evaluate both populations equally and should be representative for the total spawning population. The sex ratio derived in this manner is 1 female to 1.63 males.

Measurements of the total length of salmon sexed in the Trinity Center area indicate that females there are larger than those spawning near Lewiston (Table 12, Figure 7). The mode or greatest number of females of the same length in the Lewiston sample was 29 inches and in the Trinity Center sample it was 31 inches. In the Trinity Center area 54 percent of the females measured 31 inches or longer, and near Lewiston only 18 percent were in the same category. The mean total length of females at Trinity Center was 30.3 inches and

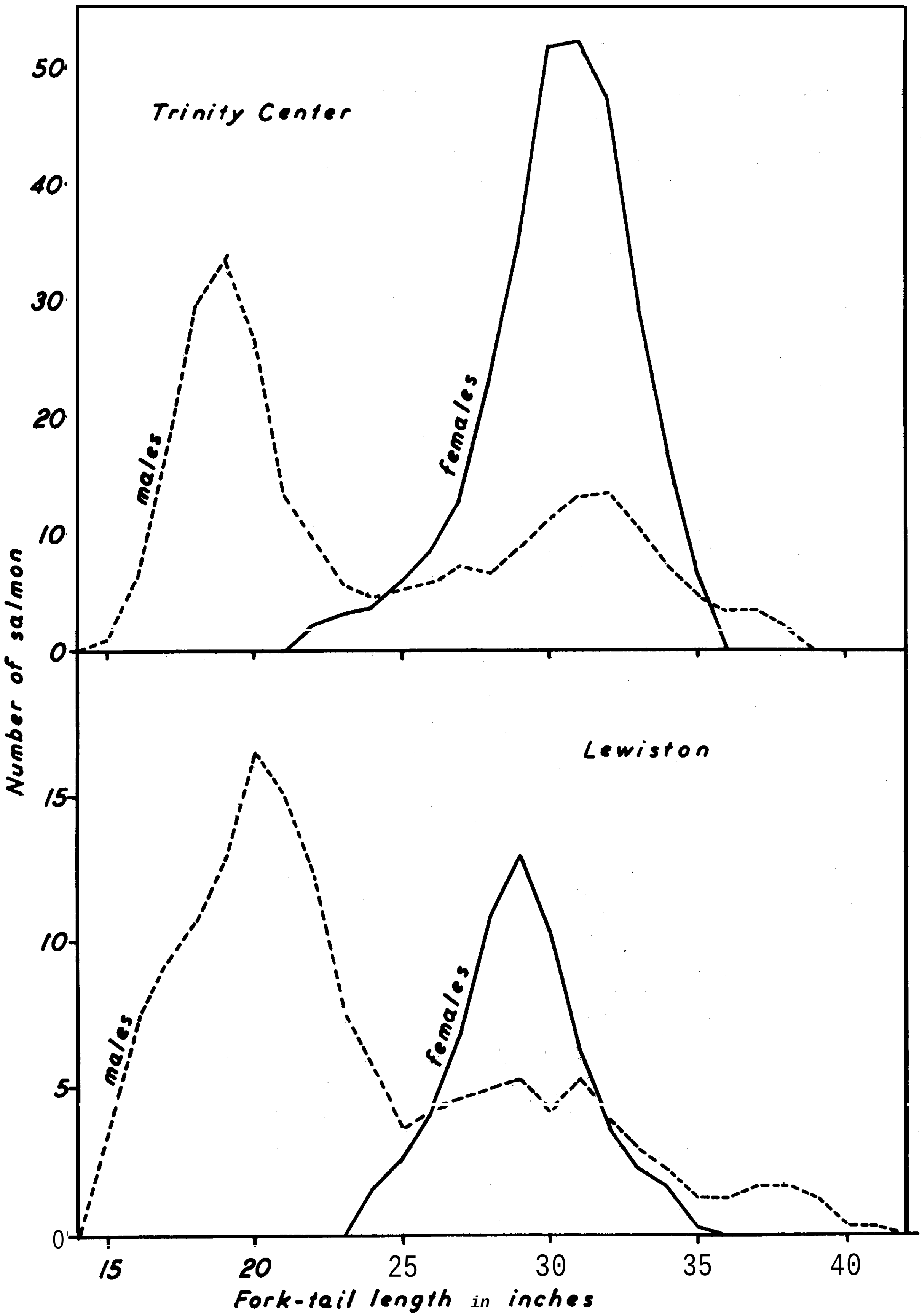


Figure 7. Length-frequency distribution of male and female king salmon from two different motions of Trinity River.

TABLE NO. 12
SPENT KING SALMON - TRINITY RIVER

Total Length Inches	Lewiston 1942 Female	Lewiston 1942 Male	Lewiston 1944 Female	Lewiston 1944 Male	Lewiston 1945 Female	Lewiston 1945 Male	Total 1942-1945 Female	Total 1942-1945 Male	Trinity Ctr. 1945 Female	Trinity Ctr. 1945 Male
15						1		1		1
16		7		2		1		10		2
17		4		3		4		11		15
18		1		3		3		7		33
19				2		12		14		39
20		1		6		11		18		28
21		1		10		7		18		14
22		1		7		4		12	2	8
23				4		3		7	4	6
24	1			4			1	4	3	3
25	2			4	2	2	4	6	3	4
26	2			1	1		3	1	11	8
27		2	3		3	4	6	6	11	5
28	2		5	4	5	3	12	7	16	8
29	2		6	1	7	1	15	2	41	6
30	1		7	3	4	4	12	7	46	12
31		1	2		2	3	4	4	68	15
32	1	1	1	3	1	1	3	5	42	12
33			2	1	2	2	4	3	31	13
34						1		1	16	6
35		1	1	2			1	3	3	3
36										5
37		1						1		2
38				2		2		4		3
39										
40										
41				1				1		
Not meas.					2	8	2	8		
Totals	11	21	27	63	29	77	67	161	297	251
Sex ratio	1:1.91		1:2.33		1~2.66		1:2.40		1:0.85	
Grilse (24" or less)	71%		65%		67%		59%		41%	
Females (31" or over)	9%		22%		19%		18%		54%	
Average length							28.9"	23.3"	30.3"	24.0"

TABLE NO, 13

FECUNDITY OF FEMALE KING SALMON - TRINITY RIVER

1942

	Number of eggs	Total length (in.)	Weight (lbs.)
	3,231	31	15
	3,132	28	11
	3,263	35	20
	3,409	26	8
	3,719	33	18
	2.341	25	8
Mean	3,182		
Range	2,341-3,719		

1944

	Number of eggs	Total length (in.)	weight (lbs.)
	3,063	27.50	----
	3,492	30.25	13.5
	2,965	30.00	13.0
	2,862	29.50	11.0
	4,179	33.50	17.0
	2,659	31.50	----
	3,037	31.00	11.5
	3,947	31.25	13.5
	3.222	31.00	16.0
	3,145	33.00	16.5
	3,259	31.00	13.0
	3.750	29.00	13.0
	3.340	27.00	11.0
	3,748	27.00	10.0
	3.664	30.00	11.0
	3,505	27.00	8.5
	3.052	32.00	16.0
	3,249	28.00	11.0
	3,640	32.50	12.0
	3,403	33.00	11.0
	3,922	34.50	18.0
	3,210	25.00	18.0
	4.354	25.50	---
	3,750	33.50	16.0
	4,180	33.00	14.5
	3,233	30.50	11.0
	3,015	27.00	9.0
	2.357	26.00	7.8
	3.154	-----	----
	3,480	-----	----
Mean	3,394		
Range	2,357-4,354		

1945

	Number of eggs	Total length (in.)	Weight (lbs.)
	3,659	32.25	16.7
	4,421	35.00	18.0
	3,229	15.00	8.6
	3,225	29.00	11.9
	3,178	25.75	8.0
	3,720	26.75	8.5
	3,103	29.00	11.6
	4,332	34.50	19.5
	3,353	31.00	13.3
	2,743	28.00	9.5
	2,982	32.00	13.0
	4,182	28.75	10.5
	3.224	33.00	13.0
	3,298	31.50	13.6
	31626	34.00	16.6
	3,462	32.00	12.3
	4,409	35.00	17.3
	3,409	33.00	14.6
	4,207	34.00	16.6
	3,665	29.00	10.8
	2,960	26.50	7.7
	3,491	38.50	12.0
	3,105	29.50	11.4
	3,187	30.00	10.0
	3,561	29.00	9.1
	3,658	29.50	9.8
	3,762	33.50	14.5
	4,764	34.50	15.6
	3,381	29.00	11.5
	3,505	29.00	10.3
	31997	32.00	13.0
	3.499	29.00	11.2
	2,961	29.00	12.0
	3,870	29.50	12.6
	4,052	33.00	15.6
Mean	3,576		
Range	2,793-4,764		

that of females at Lewiston was 28.9 inches. The difference between these means is 1.4 inches and tests for validity of this difference show a high degree of significance (2.3 times the square root of the sum of the squares of the standard errors of the means). The difference in the size of the male fish of the two areas is not significant. Males averaged 24.0 inches in length at Trinity Center and 23.5 inches at Lewiston. Near Lewiston 59 percent of the males were grilse, as compared with 41 percent at Trinity Center.

Eggs contained in the ovaries of 70 female salmon were counted during the course of the investigation. (Table 13). Individual counts ranged from 2,341 to 4,764 and average 3,466. The correlation between egg content and weight of females is not very well marked although the two characteristics are certainly closely related. Snyder (1931, p. 13) reports counts from salmon taken in the Klamath River that compare favorably with these figures. He derived a mean of 3,760 eggs between extremes of 1,718 and 4,977. These counts closely approximate the average number of eggs in female king salmon from the Rogue River, which is believed to be about 3,000, and stands in sharp contrast to the 7,000 plus eggs carried by salmon in the Sacramento River. Part of this difference can be attributed to differences in average weights between females of the two races.

The weights of king salmon in the vicinity of Lewiston were determined from samples collected at the counting weir and along the river at various points. Weights of salmon in the spawning area are of little value in considering the problems of yield to commercial or sports fisheries but they are of biological interest. The average weight of 70 females collected during the 1944 and 1946 migrations was 13 pounds, while that of 61 males was 9.6 pounds. Average weights of salmon caught by commercial netters at t he mouth of Klamath River as determined by Snyder (1931) were :15.3 pounds in 1917 legal 16.6 pounds in 1919. These weights did not include many of the grilse entering the river and may be somewhat high averages for the entire run. If this discrepancy is disregarded, and if the Trinity River races are similar to all others in the Klamath drainage, then the effort expended in migrations upstream to Lewiston requires between 4.6 and 5.9 pounds of, body weight.

Silver Salmon

Silver salmon enter the lower Trinity River to spawn. They are not known to migrate above the mouth of the South Fork at the present time, and there are no definite indications that they have ever migrated upriver as far as Lewiston. Residents of Hyampom on the South Fork clearly describe a silver salmon migration to that area during one year when unusually early fall rains occurred. Silver salmon are known to be present in the Hoopa Valley during October.

Steelhead Trout

Steelhead trout using Trinity River spawning grounds are of little importance to the California commercial fishery, but they are outstanding as sports fish. Anglers seeking the thrill of catching these large gamey fish contribute to a sizable tourist population along the river in the fall and winter months.

In the Trinity River, young steelhead start to emerge from the gravel late in April and a few begin moving downstream in May and June. This early movement reaches a peak in June and July (Figure 8 and Table 14) and subsides rapidly with decreasing river flow and increasing water temperatures. In some years, many adult steelhead utilize the main Trinity River at and above Lewiston as spawning ground. Whenever such spawning occurs, there is a post-hatching migration downstream of very small steelhead which are apparently not migrating seaward, but are drifting downstream to satisfactory holding areas in quiet water. Generally, tributary streams are used by the steelhead, and under such circumstances the large fyke-net catches of very young fish are materially reduced. Some downstream movement continues through the summer and generally increases during the fall and winter. The migration is practically complete about the time fry of the next generation are starting to leave their nests

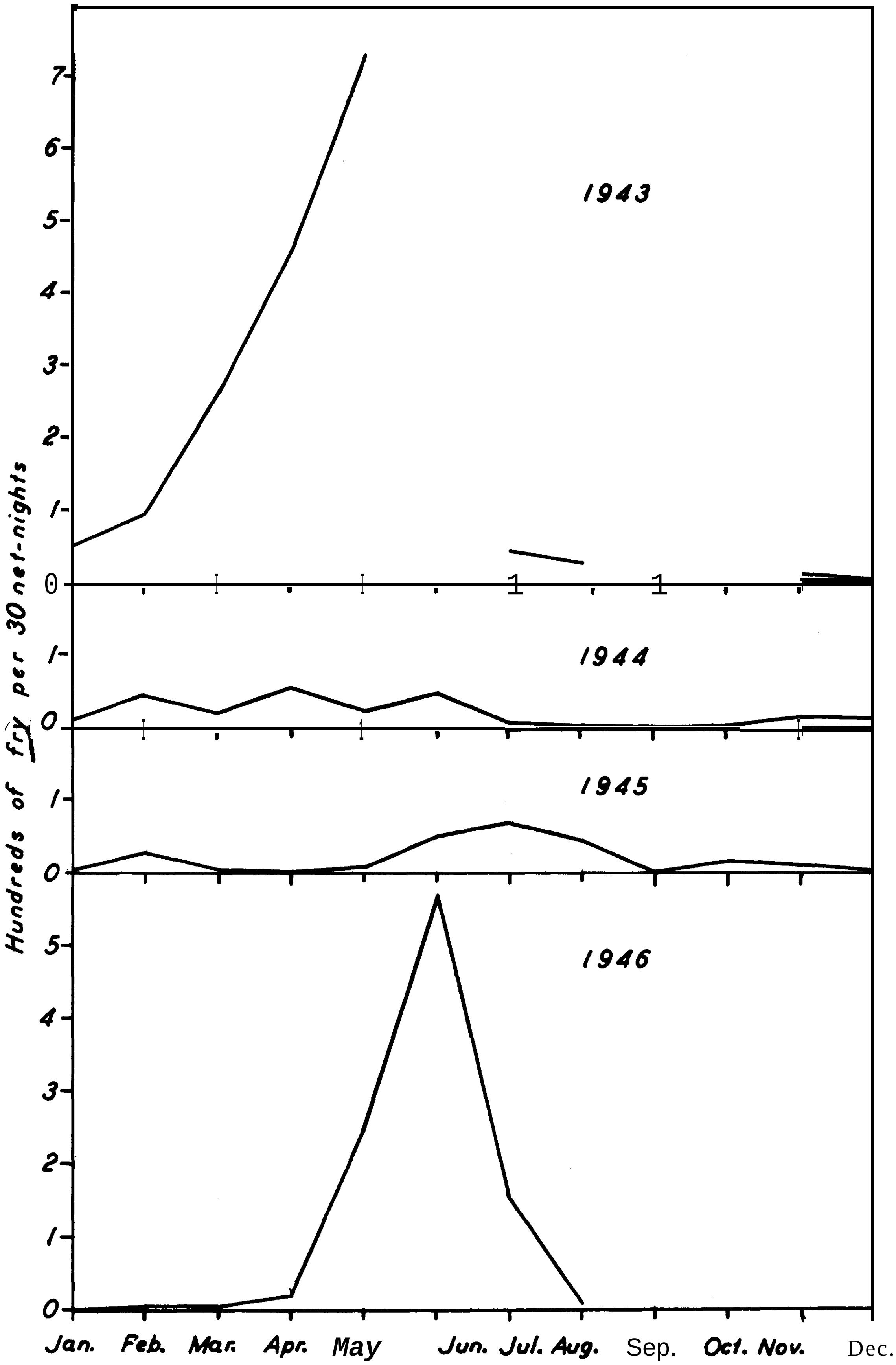


Figure 8. Downstream migration of steelhead trout in Trinity River at Lewiston.

TABLE NO. 14
STEELHEAD TROUT FYKE NET CATCHES- TRINITY RIVER AT LEWISTON

Total length (mm.)	1943 J	F	M	A	M	J	J	A	S	O	N	D	1944 J	F	M	A	M	J	J	A	S	O	N	D
21- 25																	1	11						
26- 30																	9	56						
31- 35																	4	14	1					1
36- 40																		2	5	1				
45	2	1										1		1	1				5			1		2
46- 50	4	3	3	1									2	2	2				1				3	2
51- 55	3	5	5	2	1			3						10	3	11		1		2			1	4
56- 60	5	4	10	10	6		1	2						8	3	4			1	2			1	3
61- 65	6	8	21	21	16						1		1	10	5	17		1					1	
66- 70	5	10	41	58	40									13	6	11	4	1					1	
71- 75	4	22	38	74	72						1		1	8	5	19	3						1	1
76- 80	7	10	38	71	78								2	8	3	17	2							1
81- 85	2	3	19	38	46								3	7	1	10	2							
86- 90	1	2	8	24	28							2		4	1	2	1	1						
91- 95		1	8	12	18									5	6	4	3							
96-100		1	1	9	7								2	4	1	1		1						
101-105			1		4			1						1	1	2								
106-110			1	2	1			2						2	1									
111-115								1																
116-120								1						1										
121-125				1				5					1	1	2	3		1						
126-130								5			1													1
131-135								4																
136-140				1				2																
141-145							1	5							1									
146-150								3								1								
151-155								2			1													
Over 155							1	4					1					1						
Totals	39	70	194	324	317	0	3	40	0	0	4	3	13	85	42	102	29	90	13	5	0	1	8	15
Net nights fished	22	22	22	21	13	0	2	44	0	0	9	27	25	58	60	54	32.5	58	60.	62	60	33	14	30
Fish/30 net nights	53	95	265	463	732	0	45	27	0	0	13	3	16	44	21	57	27	47	7	2	0	1	17	15

TABLE NO. 14 (Concluded)
STEELHEAD TROUT FYKE NET CATCHES - TRINITY RIVER AT LEWISTON

Total	1945												1946							
length(mm.)	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
21- 25						1										1	2		1	
26- 30					5	12	2										208	4 3	42	
31- 35						10	14										34	98	48	
36- 40			1		1	9	23	4		1	1							7	34	1
41- 45	1					7	12	11		1	1					1		3	20	
46- 50		5	1			9	13	11		4	1	1				2		1	7	
51- 55	2	11					2	5			2	1							4	
56- 60		8	3				1	2		1	1	1				1				
61- 65	1	9	1							1		1		1		3				
66- 70	3	5	3	1	1		1	2			2					4				
71- 75	1	3	3		1						1				1	6	1			
76- 80		2		1			1	1								1	1	1		
81- 85		1			1											1			1	1
86- 90							1													
91- 95					1			3												
96-100		2																		
101-105																				
106-110																			2	
111-115								2												
116-120		1	1			1														
121-125		2																	1	
126-130		1																		
131-135																				
136-140																				
141-145								1												
146-150																				
151-155						1														
Over 155																				
Total	8	50	13	2	10	50	70	42	0	8	9	4	0	1	1	20	246	549	160	2
Net nights fished	41	54	62	39	37	29	30	28	3	13	25	31	12	21	31	30	30	29	31	9
Fish/30 net nights	6	28	6	2	8	52	70	45	0	18	11	4	0	1	1	20	246	568	155	7

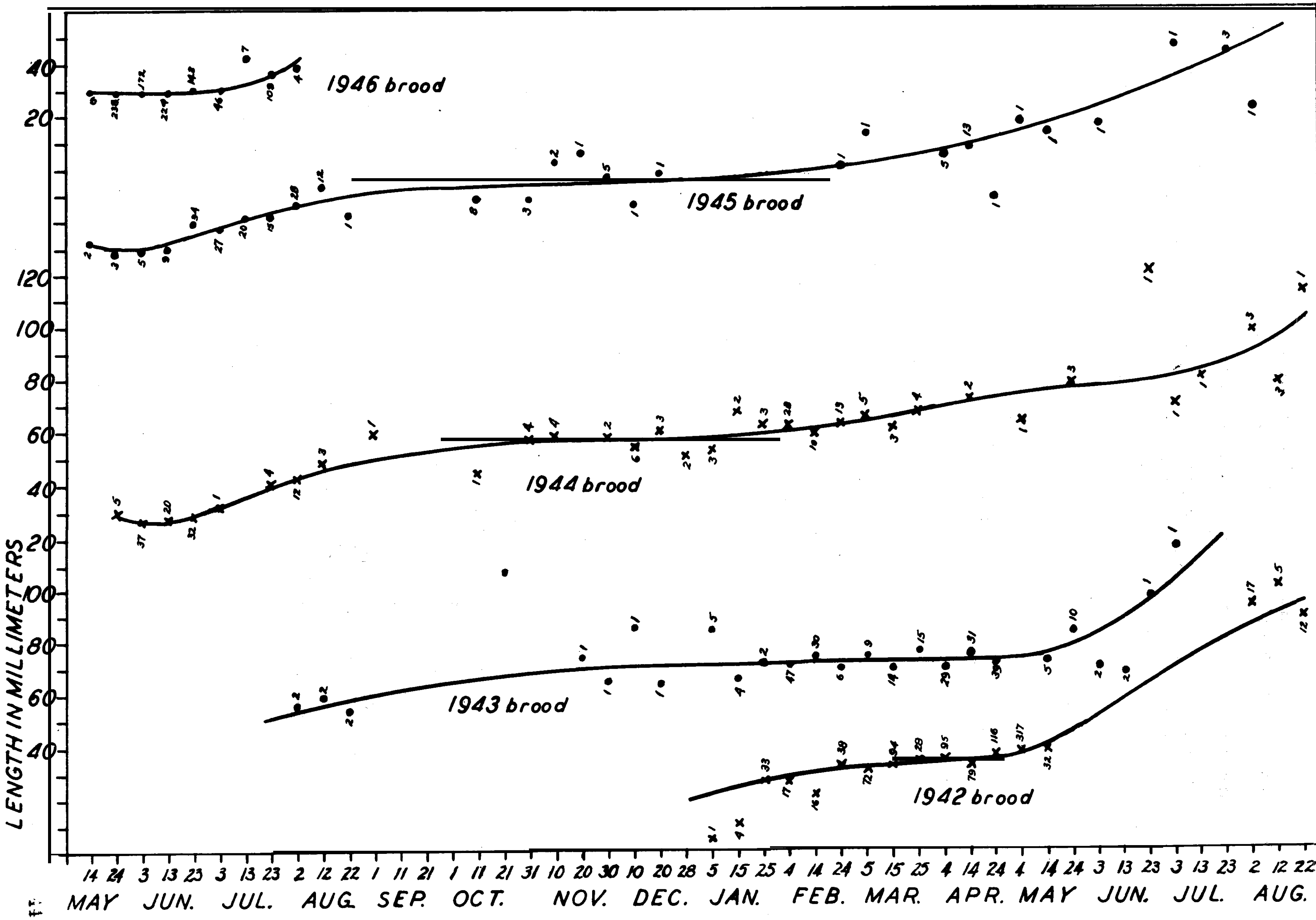


Figure 9. Average lengths of steelhead trout young taken in fyke nets from Trinity River at Lewiston, arranged according to brood years and time of capture.

Early freshwater growth of the steelhead in Trinity River is reflected to a certain degree by the length frequency distributions of fish taken by fyke nets. Catches were grouped into 10-day periods, and lengths of the fish were grouped at 3 millimeter (0.118 inch) intervals. Idealized growth curves for each season have been fitted by inspection on the basis of mean lengths for each period as they applied to brood years (Figure 9). Generally, no difficulty in separating the fish of each brood year was experienced. Because the hatching period of the steelhead in Trinity River extends over about 5 months, from March through July, length frequency distributions are especially broad. However, enough scales of young steelhead have been examined to substantiate the separations of year broods through the first 18 months of life. The time of annulus formation is uniform regardless of the time of hatching, and annuls would, therefore, appear on the scales after 6 months to 1 year of life, depending on when the fish began independent existence. Growth rates established in this manner are probably low. Larger fish were usually missed by the fyke nets. Beyond the arbitrary limit of 80 millimeters (3.15 inches), the samples are inadequate.

The step-like character of the growth curves expresses the length of growing seasons in Trinity River at and above Lewiston. Apparently, growth is quite rapid after emergence of fry from the gravels. This acceleration slows to a virtual standstill by September, and average lengths are almost constant throughout the winter. Increases in length begin in spring (March to May, depending on the year) and presumably continue until the following September, although catches of older steelhead are insufficient to determine the time of growth cessation in the second year of life.

The greatest number of downstream migrating steelhead, as determined by fyke netting, move shortly before or somewhat after the end of the first year of life. However, many migrant steelhead must be larger than those sampled by the fyke nets, as scale studies of adults show that many individuals remain in the stream two or three years before reaching the ocean. It is likely that young steelhead leave the Lewiston area as yearlings and spend a year or more completing their migration to the sea. Certainly the composition of migrants passing Lewiston is not necessarily the same as that of migrants entering the Klamath River or the ocean. During extended winter dry periods when the river is low and clear, groups of several hundred steelhead trout 6 to 8 inches in length can be seen slowly drifting downstream. The size of these fish would indicate that they were in their second or third year of life. These schools migrate down the center of the river hovering close to the bottom, thus eluding the fyke nets which, because of excessive current in midstream, were fished near the bank.

Prior to or during the seaward movement, steelhead trout become large enough to add materially to the fish population available to anglers. (There is no size limit in California.) The magnitude of the contribution to the sports fishery is not known, but it is assumed to be considerable.

Steelhead remain in the ocean from one to three years before making their first upstream migration to spawn. Many of them do not die following spawning but return to the ocean. Before completing their life history, steelhead may spawn three or four times, repeating this migratory procedure each year after maturity.

In 1945, the first group of steelhead migrating up the Trinity River reached Lewiston on June 10. This run continued until July 12 and totaled 41 fish (Table 15). A similar migration started on June 30. 1946, and continued until July 25, totaling 21 fish. These counts of migrating fish are minimal. Many smaller steelhead in the migration were able to pass through the pickets on the weir and were not counted. No counts were made early in 1944, but upstream migrant steelhead were caught by sportsmen during the first part of July. Adult steelhead are common in the deep holes along the river below North Fork in summer These fish start moving upstream along with fresh run steelhead during October. Counts of steelhead through the Lewiston weir in the first 3 days of November 1944 amounted to 456 fish. The weir was removed November 4. In 1945, a run of 170 steelhead was counted in the period October 1 to 29. The counting weir was removed from the river on the latter date. Steelhead continue their spawning migration up the Trinity until sometime in March. Attempts to count the migrants have failed as they move during storm periods when it is usually necessary to remove the counting weir.

Steelhead trout enter the larger tributaries such as North Fork, Browns Creek, and Stuart Fork following the first fall rain. Smaller tributaries are entered during the first rain in February after which these streams maintain a flow sufficient to insure adequate spawning conditions Spawning begins in the upper Trinity River drainage during the last part of February and reaches a peak in the last two weeks of March and the first two weeks of April. Some scattered spawning continues until the first week of June. All observations of spawning activity were made in tributary streams where steelhead were contained to small areas and could be easily seen. Most nests in tributary streams located in gravel pockets between large boulders. However, the few larger riffle areas available were so heavily utilized that individual nests could not be distinguished. Considerable spawning takes place in the main Trinity during the spring run-off period when ails-laden water obscures their activities This main river spawning has never been observed directly. It is evidenced by the many nests which are exposed as waters recede following the run-off period. The identity of those nests was proven through recovery of dead steelhead eggs from one nest exposed in shallow water.

Usually, fry have hatched and escaped from the gravel before such examinations can be made. Steelhead nests in the main river are most commonly found in gravel areas along the edge of the stream and in long, comparatively shallow pools with flat bottoms. Some of these nests are possibly those of the lamprey, which spawns during the same period and under similar conditions

Directly following spawning, adult steelhead start a return migration to the ocean. This downstream movement which probably starts some time in March continues to pass Lewiston throughout the month of June and into July. From June 6 through July 6, 1945, 195 of these migrants were counted through the gates of the Lewiston weir (Table 15). The weir was not in operation in 1948 during the corresponding period, thus only seven migrants were counted between June 20 and July 22, 1946.

TABLE NO. 15
ADULT STEELHEAD MIGRATIONS
TRINITY RIVER AT THE LEWISTON WEIR

Day	1944 Upstream Migration	1945 Downstream Migration		1945 Upstream Migration				1946 Downstream Migration		1946 Upstream Migration	
	Nov.	June	July	June	July	Sept.	Oct.	June	July	June	July
1	95	-	0	-	0	0	0	-	0	-	0
2	97	-	0	-	1	0	1	-	1	-	0
3	264	-	0	-	2	0	0	-	0	-	0
4	-	-	0	-	0	0	0	-	0	-	0
5	-	-	0	-	0	0	0	-	0	-	0
6	-	17	1	0	0	0	0	-	2	-	0
7	-	22	0	0	0	0	0	-	0	-	0
8	-	14	0	0	0	0	1	-	0	-	1
9	-	25	0	0	0	0	0	-	0	-	0
10	-	34	0	1	0	0	0	-	0	-	0
11	-	17	0	6	0	0	1	-	0	-	1
12	-	19	0	2	1	0	0	-	0	-	4
13	-	9	0	4	0	1	0	-	0	-	1
14	-	9	0	0	0	0	11	-	0	-	0
15	-	4	0	2	0	0	23	-	0	-	1
16	-	7	0	4	0	0	1	-	0	-	0
17	-	0	0	1	0	0	4	-	0	-	1
18	-	0	0	0	0	0	2	-	0	-	0
19	-	9	0	3	0	0	1	-	0	-	3
20	-	2	0	3	0	0	0	0	0	0	0
21	-	0	0	3	0	0	0	0	0	0	0
22	-	0	0	0	0	0	12	0	1	0	1
23	-	3	0	0	0	0	5	0	0	0	0
24	-	0	0	0	0	0	17	0	0	0	1
25	-	0	0	0	0	0	9	2	0	0	4
26	-	3	0	0	0	0	2	1	0	0	0
27	-	0	0	1	0	0	1	0	0	0	0
28	-	0	0	1	0	0	6	0	0	0	0
29	-	0	0	0	0	0	73	0	0	0	0
30	-	0	0	6	0	0	-	0	0	3	0
31	-	-	0	-	0	-	-	-	0	-	0
Totals	456	194	1	37	4	1	170	3	4	3	18
Annual totals	456		195				212		7		21

The spent steelhead passing Lewiston during June and July in their seaward migration are generally in very poor condition. Most individuals are badly spotted with fungus growth and heavily infested with nematode parasites. Many badly fungused individuals died and drifted downstream against the Lewiston weir. Approximately 80 percent of these dead steelhead were males, which indicates that they suffer the highest mortality in spawning. A few of the spent steelhead enter the sports fishery during May, the first month of the fishing season. Most of these fish are taken in the Trinity Center area near the upper end of the drainage where the flow is generally low enough to permit fishing in the main river during the first part of the season.

Pacific Lamprey

Least important of the anadromous fishes of the Trinity River as a commercial or game species is the Pacific or three-toothed lamprey. Hoopa Indians trap the lampreys for food (Snyder, 1924, p. 164), but otherwise they have no apparent economic importance.

The adult lampreys migrate up the Trinity River in small numbers throughout the summer. Occasional migrations took place during July, August, and September in 1944 and 1945. Migrations occurred at night and were infrequent, lasting only one or two nights with intervals of several weeks between movements. Lamprey migrants were not numerous and seldom could more than one be seen at a time. The upstream movement seemed to be very deliberate, and there appeared to be no tendency to pause, veer off, or delay as the migrants passed between picket openings of the Lewiston weir and through the illuminated section of water above the weir. Larger upstream migrations undoubtedly take place during the winter months.

Spawning lampreys are seen in the tributaries of the Trinity River during April and May. Lampreys presumably spawn in the main river during these months, but their activity is obscured by roiled waters of the spring run-off. Some lamprey are observed in nesting areas of the main river during June, and receding water during the same month exposes many other nests completed earlier. Lamprey nests are located in gravel along the river bottom where the current is not excessively swift. In tributaries, nests are most frequently located in gravel above riffles or in riffle areas with moderate current.

Following spawning, the lampreys drift downstream and die. Many spent lampreys were taken during May and June in fyke nets used to capture seaward migrant salmon. In June and July of 1945 and 1946, dead lampreys lodged against the pickets of the Lewiston weir and other live individuals were observed feebly working their way through the pickets.

After hatching, the young lampreys remain in a larval stage for a period of about four years. Larval lampreys can be found buried in sandy areas along the Trinity River at all times of the year. The downstream migration of lamprey ammocoetes starts during the first fall after hatching, at which time the smallest individuals are only 16 to 20 mm. (0.63 - 0.79 inch) long. These lampreys of the first age group are too small to be retained by the 1/4-inch mesh fyke nets used to sample downstream migrants of this and other species. Therefore, the downstream migration of the first age group could only be detected by successive poisonings of ponds along the river's edge that were overflowed during fall floods and then isolated by receding waters. These ponds were poisoned with rotenone preceding flood periods to be certain that they were devoid of all fish life. Following high-water periods and isolation from the river, they were again poisoned to obtain fish that had migrated during the flood. In poisoned ponds lampreys would emerge from the sand, swim around in frenzied distress, and usually die in shallow water where they were easily collected. Several thousand ammocoetes representing all age classes were collected from each of several sand bottom ponds 20 to 40 feet in width and length following each flood period. It is very likely that downstream movement of ammocoete stages is a passive movement. As silt beds in which these larvae live are destroyed or moved by high water, the relatively helpless lamprey larvae are carried to new locations downstream.

Fyke nets retained most young lampreys measuring 90 mm. (3.54 inches) or longer. Ammocoetes appeared in fyke-net catches throughout the year, but larger catches were made during and following flood periods. Eyed lampreys are also taken in fyke nets throughout the year. The relative absence of eyed young in samples taken by poisoning would indicate that they make a continuous and deliberate movement toward the ocean.

SALMON SPAWNING-BED SURVEYS

Following a preliminary survey in 1944, two surveys were conducted during the summer of 1945 to determine as nearly as possible the spawning capacity of the Trinity River between the proposed Lewiston dam site and North Fork at different flows.

Nest Measurements

During the 1945 spawning period, 20 completed nests were measured (Table 16). These measurements included the entire area of gravel disturbed by the spawning fish. Nest digging activities are somewhat erratic, and salmon usually disturb a margin of gravel on each aide of the nest that is not actually a part of it. There is also an area at the downstream end of the nest which is covered by loose gravel carried down by the current during nest digging and an area at the upper end where gravel is loosened by the fish to cover the last eggs laid. Nest measurements shown in Table 16 may be reduced by about 45 square feet to compensate for these unused but disturbed areas (1-foot margin on sides and lower end of nests and 2-foot margin at the head), making an average nest area of about 63 square feet, equal to the nest size (9' x 7') established by rough measurements in 1944.

Methods

Individual salmon nesting sites were counted and recorded for each riffle. An area of suitable spawning gravel, 9 by ? feet in extent, measured lengthwise with the current, was considered as one nesting site. Major criteria used to define suitable nesting gravel were: (1) depth of water (0.5 - 1.5 feet), (2) size of gravel (1 - 5 inches in diameter), (3) its location on the riffle, and (4) estimated current velocity. Application of these criteria to individual riffles was conditioned by combinations of many influences. Greater water velocities enable successful spawning in the areas where gravels are large. With lesser current velocity, these areas are not suitable. Under certain circumstances, water deeper than 0.5 - 1.5 feet is certainly used. Some riffles consist of suitable gravel, current velocities are satisfactory, and water depths are within the range stated, but the entire riffle may be compacted and cemented so that it cannot be used by spawning salmon. Broad standards of estimate were set for these surveys. However, much of the accuracy achieved necessarily depended on the experience and judgment of personnel.

On riffles with scattered patches of suitable gravel between large boulders, each individual nest site was picked out and counted. The area of riffles with larger rocks scattered throughout suitable spawning gravel was determined and reduced by a correction factor. The correction factor we found by counting the individual nesting sites on an average cross section of the riffle and comparing the count with the number possible if the entire riffle were suitable gravel. On riffles with greatly varying gravel types, two or more such corrections were made as the riffle changed in character. The areas of riffles composed entirely of suitable gravel were divided into 9 by 7 foot sections. The number of sections was considered to be the spawning capacity.

TABLE NO. 16
MEASUREMENTS OF COMPLETED KING SALMON NESTS
ON RIFFLE ABOVE LEWISTON BRIDGE
OCTOBER 26, 1945

Size in ft.		Area in sq. ft.
11 x 7		77
12 x 7		84
13 x 7		91
14 x 6		84
14 x 7		98
14 x 7		98
14 x 7		98
14 x 7		98
14 x 8		112
14 x 8		112
14 x 8		112
15 x 7		105
15 x 7		105
15 x 7		105
15 x 8		120
15 x 8		120
15 x 10		150
16 x 7		112
18 x 6		108
18 x 10		180
	Total	2,169

Average:

Length	14.5 ft.
Width	7.45 ft.
Area	108.45 sq. ft.

Results of Surveys

The first 1945 spawning bed survey was started in July when the river was flowing 350 cubic feet per second at the Lewiston gauge. The survey was completed 10 days later when the flow at Lewiston was 250 cubic feet per second. Slight corrections were made to compensate for variable flows so that the entire survey would show as nearly as possible the number of nests at a flow of 300 cubic feet per second.

The second spawning bed survey was conducted during the middle of September when the river discharge at Lewiston was 100 cubic feet per second. Results of these surveys are presented in Table 17, which gives the number of nests counted and the comparative efficiency of water and riffle usage for spawning at the two flows, expressed in nests per cubic foot per second per mile of stream.

In areas where there are broad riffles of fine gravel, the efficiency of water and riffle usage increases with increased water flow. This is particularly true of the stretch of river between Grass Valley Creek and Douglas City (Figure 10) where many broad, shallow riffles are converted to good spawning sites by increased flows. Just the opposite is true of narrow riffles where the spawning efficiency is reduced by increased flow.

Swifter current and deeper water over gravel on this type of riffle renders it unsuitable for spawning purposes. Examples of this condition can be found between Lewiston and Rush Creek, and between Douglas City and Browns Creek.

Expressed in terms of nests per cubic foot per second per mile of stream the results of the two spawning-bed surveys indicate that at water flows between 100 and 300 cubic feet per second, there is a very slight decrease in water-use efficiency as flows become greater. Since the water-use efficiency varies only slightly, there would be little curve in a line projected to show water-flow in relation to nesting capacity The change in efficiency between these two points should be fairly constant because of the counteracting effects of variations in nesting capacity with changes in river flow on the two types of riffles (broad and narrow) already discussed

The curve shown in Figure 11 was derived by calculating a theoretical number of nests for each rate of water flow. In this calculation the number of nests was obtained by multiplying the number of miles of stream by the flow in cubic feet per second and also by an efficiency factor. This factor was computed by subtracting from the observed efficiency factor at 100 cubic feet per second the decrease in efficiency from 100 cubic feet per second to the rate of flow in question. The calculation is algebraically expressed in the following formulas:

$$N=MF[E_1-(E_1-E_2/n)(F-L/i)]$$

Where N is the number of the nests; M, the miles of stream; F, the river flow; E1, the water efficiency factor at the lowest flow measure; E2, the water efficiency factor at the highest flow measured; L, the lowest flow measured; n, the number of intervals used between the highest and lower flow; and i, the size of the interval in cubic feet per second.

Rains of short duration and variable intensity commonly occur during the peak of the spawning period, but temporarily increased flows caused by these rains cannot be considered in determining normal spawning flows. To eliminate errors that might result from these temporary fluctuations, only the minimum flows recorded at Lewiston during the peak spawning period (November 1-15) over a period of 18 years are considered (Table 18). The average minimum flow during this period is 235 cubic feet per second, but since the minimum flow is below this average in 11 of the 18 years, the median flow must also be less than average. Flows above 350 cubic feet per second might be eliminated as erratic since they result from unusual weather conditions and are widely separated in their occurrence. The average flow with these years excluded is 170 c.f.s. which is again greater than the minimum flows of more than half of the years involved. The median flow, therefore, is still less, or very near 150 cubic feet per second.

TABLE NO. 17
SALMON SPAWNING BED SURVEYS - 1945
TRINITY RIVER FROM LEWISTON DOWNSTREAM TO NORTH FORK

Area	Length of area in mi.	Number of Nests 300 cfs	Number of Nests 100 cfs	Nests/cfs/Mile 300 cfs	Nests/cfs/Mile 100 cfs
Lewiston Dam - Lewiston	2.0	731	228	1.22	1.14
Lewiston - Rush Creek	2.0	205	200	.34	1.00
Rush Creek - Grass Valley Cr.	3.5	670	199	.64	.57
Grass Valley Cr. - Lowden Dam	3.5	1,680	469	1.60	1.34
Lowden Dam - Douglas City	7.0	2,909	856	1.38	1.22
Douglas City - Browns Creek	5.5	811	850	.56	1.54
Browns Creek - Junction City	6.5	1,643	695	.84	1.07
Junction City - North Fork	7.0	1,248	423	.59	.60
	37.0	9,897	3,920	.89	1.06

TABLE NO. 18
MINIMUM AVERAGE DAILY FLOW OF TRINITY RIVER AT LEWISTON, NOVEMBER 1-15
DISTRIBUTION OF DAILY FLOW IN 50 C.F.S GROUPS

Year	Flow in c.f.s.	100-149	150-199	200-249	250-299	300-349	350-399	400-449	450-499	500-549
1927	234			X						
1928	186		X							
1929	116	X								
1930	111	X								
1931	138	X								
1932	103	X								
1933	147	X								
1934	405							X		
1935	163		X							
1936	127	X								
1937	195		X							
1938	394						X			
1939	120	X								
1940	500									X
1941	304					X				
1942	186		X							
1943	251				X					
1944	482								X	
Totals	4,162	7	4	1	1	1	1	1	1	1
Mean	231									

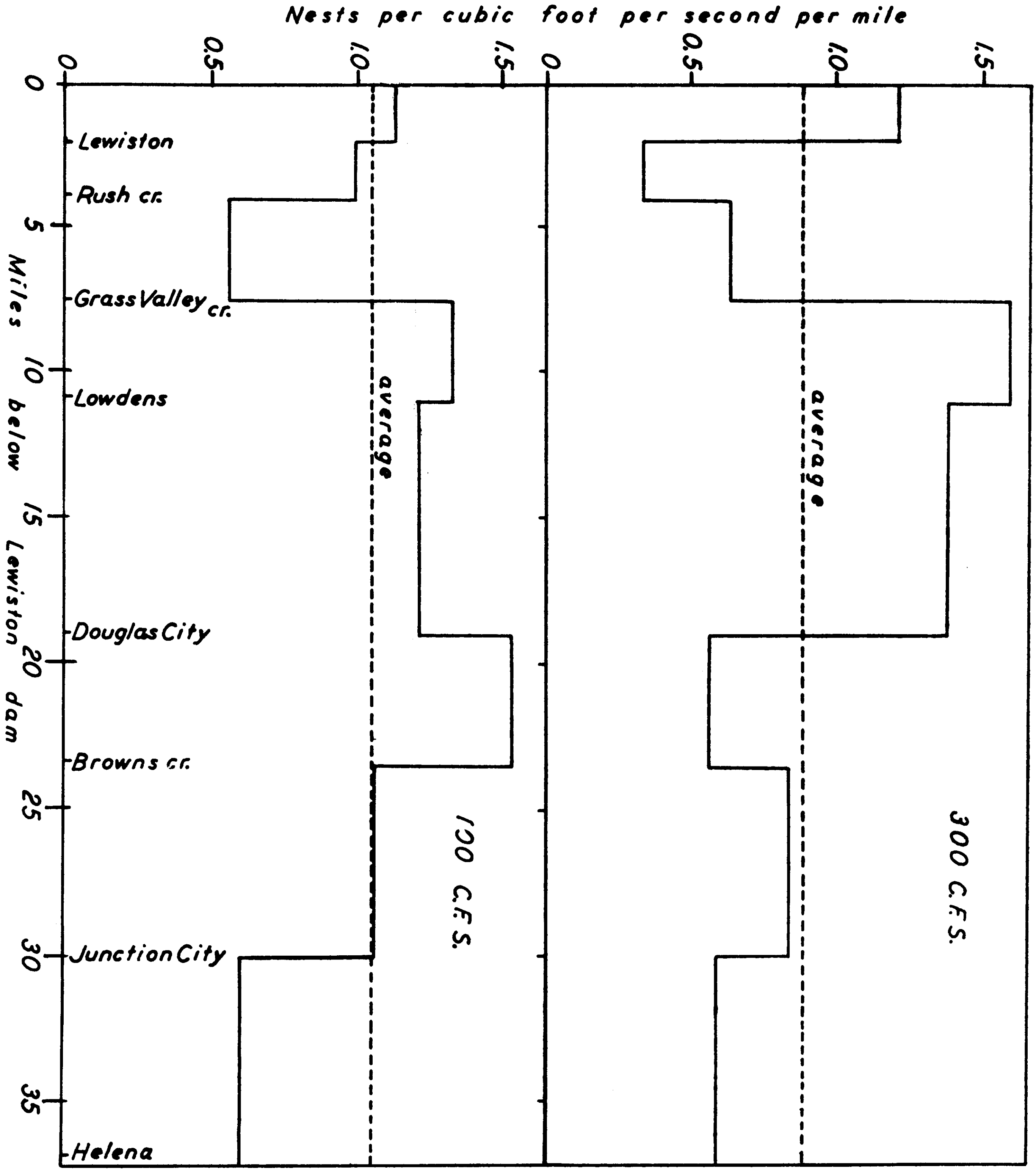


Figure 10. Number of salmon nests in Trinity River between Lewiston and North Fork as determined at two different river flows.

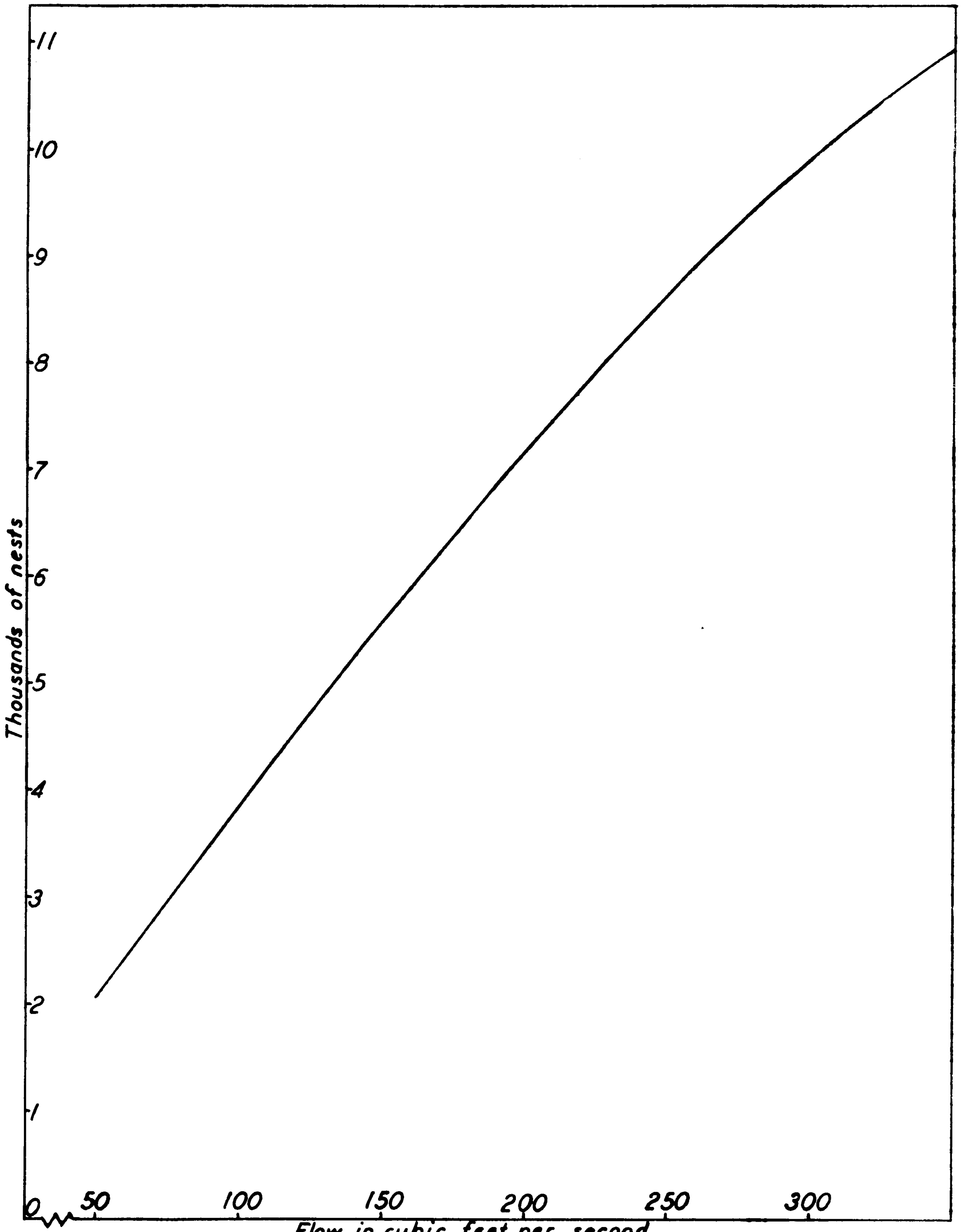


Figure 11. Number of salmon nests in Trinity River between Lewiston and North Fork, as related to a constant change in availability of gravel at various river flows.

Assuming that the Trinity River salmon population is at its maximum density under present conditions, and assuming that spawning space is the determining factor, then, at a median spawning flow of 150 cubic feet per second, 5,647 nests would be occupied in the river between Lewiston dam site and North Fork as determined by application of formula previously described

EFFECTS OF WATER DEVELOPMENT PLANS ON THE TRINITY RIVER FISHERY AND SUGGESTED MEANS FOR FISHERY PROTECTION

Resident game fishes will be least affected by the dam building program on the Trinity River. Movements of these fish are limited to short migrations up the tributaries where they spawn. This movement will not be interfered with by dam construction except in the case of the brown trout which appears to make extensive migrations. This species however, shows remarkable powers of adjusting itself to changing conditions and should adapt to any reasonable set of conditions which may result from dam construction.

Steelhead trout help to maintain the heavily fished resident rainbow trout population of the Trinity River. Proposed dams will block adult steelhead and will eliminate their construction to the sports fishery above these structures. The reservoir formed by the dams will support resident trout to an unknown degree, and will tend to offset partially the loss of the steelhead fishery now existing above the dam sites. Adult steelhead might be lifted over the dams so that their progeny could be added to the resident fish population. However, this addition to the resident population would be temporary. Losses of seaward migrants in diversion structures would very likely result in a net loss through such a program.

The effect of the dam construction program on dace and sucker populations cannot be stated at this time. The abundance of these species will undoubtedly be affected. Whether they increase or decrease in numbers will be determined only after the structures are built. If they increase or even maintain their present numbers, they might serve as an important source of food for the resident trout population.

Management plans for the anadromous species are necessarily based on three salient features of the water development plans: (1) It is certain that the dams would be too high for economical or practical construction of fish ladders over them; (2) as much as possible of the water developed by the proposed construction program would be diverted out of the Trinity River watershed; and (3) the location of the structures is highly important. A dam at the Lewiston site will cut off approximately 50 percent of the river used by king salmon for spawning and a greater percentage of the portion used by steelhead trout. A dam at the Browns Creek site would deprive these fish of nearly 82 percent of their spawning grounds.

General Principles of Operation

There are several general principles of operation which are considered essential in any of the management methods suggested. These principles have been established from experience with other projects and are incorporated herein to avoid many of the troubles encountered elsewhere.

1. The selected management procedure must be incorporated into plans of the water development program before any construction work is undertaken.

2. All fish should be allowed to pass upriver until the summer before the dams first act as barriers. By this time facilities for the conduct of any maintenance program adopted should be installed and operable.

3. Possible sources of stream pollution resulting from construction or its processes must be eliminated.

4. Releases at the dams should be made from the lowest possible level so that a minimum number of resident fish in the reservoirs will be drawn through turbines or turned into diversions. Releases at low levels in the dam will insure a supply of cold water to the stream below.

Maintenance Plans for Lewiston Dam

Three methods of maintaining the salmon blocked by the Lewiston Dam might be considered. First, additional spawning area might be developed by increasing the river flow above normal during tile spawning period. Second, suitable tributary streams might be developed into spawning areas. Third, fish hatcheries could be constructed. A satisfactory management plan may be found in one or a combination of these methods.

Development of Additional Spawning Grounds in the Main Stream

A plan for developing additional spawning areas by increasing the river flow is believed to be the least expensive, easiest to operate and least likely to prove unsatisfactory after it is placed into operation. The spawning bed surveys of 1945 showed conclusively that the spawning capacity varied directly with the river flow.

This method of increasing the spawning capacity of the river might be carried out in three general types of operation:

1. A minimum flow sufficient to accommodate the maximum population could be maintained throughout the year. A minimum flow would call for the least administration, supervision construction and maintenance of fish retaining and counting structures This method would be least hazardous for spawning fish, as it would guarantee adequate water at all times. The minimum flow required would be 300 cubic feet per second To maintain such a flow, 217,200 acre-feet of water would be needed and most of this water would be derived from storage. When spawning egg incubation and migration were not in progress, some of this water would not be necessary and its flow downstream might be construed as wastage. This plan has the greatest biological possibilities, but due to its relatively large water demand, it will probably be the least desirable to the constructing agency.

2. A fixed flow schedule could be established to accommodate the salmon life history and what is presumed to be the maximum spawning migration. A fixed flow schedule would prescribe water releases throughout the year designed to accommodate the life history phenomena of the salmon AS known at the present time (Figure 12). This schedule would not vary from year to year, but would remain the same regardless of the numbers of spawning salmon. It would require a minimum of administration and construction. Some maintenance and operation of fish retaining and counting structures would be necessary.

A fixed spawning flow of 300 cubic feet per second during November would make available the estimated 9,897 salmon nesting sites between Lewiston dam site and North Fork (Table 193. Approximately 5,600 of these nesting areas are normally occupied, and the additional 4,300 spawning areas available could accommodate '1,200 spawning salmon, using the established sex ratio of 1 female to 1.63 males. Adequate spawning area for the greatest number of salmon actually counted at Lewiston during 1944 and 1945 would result from this flow. However, observations in the fall of 1946 when no count was made, definitely indicate that a greater population of spawning salmon was present and may have been crowded under the conditions of this plan. The amount of crowding on spawning beds which can without reducing reproductive efficiency has not been determined, but certainly some could occur. Furthermore, it is almost certain that the spawning capacities fixed by survey are conservative.

Populations of spawning salmon are known to vary in number over very wide limits. Studies in California's Central Valley and elsewhere demonstrate variations between years and between cycles which exceed 500 percent. The provision of a slight margin is available nesting areas over the number necessary to accommodate salmon counted at Lewiston in 1944 is not adequate. It will not cover the probable maximum number of salmon which will return to the Trinity River in some years. A fixed release schedule for salmon has the added disadvantage of rigidity. It cannot be quickly or effectively changed when greater or lesser amounts of water and spawning grounds are needed for the proper safeguarding of spawning stock.

A fixed flow schedule such as the one proposed in Figure 12 requires a release of 120,500 acre-feet of water as measured at the Lewiston Bridge. The peak flow of 300 cubic feet per second would be maintained only during the period of heaviest spawning. After spawning is completed, the flow could be reduced to 200 cubic feet per second. Such a flow will cover all gravel in which eggs have been deposited. This flow should be maintained until the end of March when all but a very few of the young salmon have left their nests. The river flow should be not less than 150 cubic feet per second during April, May, and June, to adequately provide for steelhead spawning and hatching. The flow should not be less than 100 cubic feet per second from July 1 to October 15. The summer flow schedule (April through October 15) should insure the seaward migration of young salmon during April, May, and June, and the upstream adult migration from the end of June until the flow is increased to 200 cubic feet per second during the last 16 days of October to provide for the spring and summer runs that normally start spawning at that time.

The effect of this flow schedule on average river discharges below Lewiston is shown in Figure 13 and Table 20. The comparison presumes total diversion or storage of all other flow at Lewiston. The main river flows during summer are relatively unaffected. Flows during the steelhead spawning season are considerably reduced between Lewiston and Burnt Ranch and may make the river bed more suitable for the spawning of this species.

Fish-tight counting structures should be built near the Union Hill Pipe Crossing two miles below the Lowden dam site, and at a site to be selected between Douglas City and the mouth of Browns Creek. These barriers would divide the spawning grounds into three areas of nearly equal capacity and prevent a congestion of spawning fish in any one area. A trap and sturdier fish barrier should be installed at or near the present Lewiston weir to be used if it becomes necessary to transfer fish. The Lewiston barrier should be maintained as a means of preventing undesirable concentrations of fish immediately below the proposed Lewiston dam where practically no spawning grounds exist. It may be desirable, after further study, to locate the Lewiston barrier above the mouth of Deadwood Creek to allow use of this small stream by steelhead trout.

Fish barriers should consist of concrete dams 10 to 15 feet high, with long, shallow aprons. They should be equipped with high standard fish ladders adapted for ease in counting the fish passing over them. The ladders should also be fitted with effective closing devices. The barriers should be strong enough to withstand floods which might be anticipated following construction of the dams and should be located where spawning areas are restricted and where a minimum of gravel will be inundated by their forebays.

3. <u>The flow could be regulated to produce only the amount of spawning area needed each year, depending on the number of migrants</u>.-Regulation of the flow to approximate the needs of migratory fishes on an annual basis would require reservoir operation similar to that in type 2, but with variable spawning flows. Regulation of the spawning flow each year to meet needs of the particular salmon population would be more expensive to operate than other plans. It would call for the construction of an additional fish block and counting structure near the North Fork of Trinity River that would *of* necessity be sufficiently massive to withstand any floods that might our.

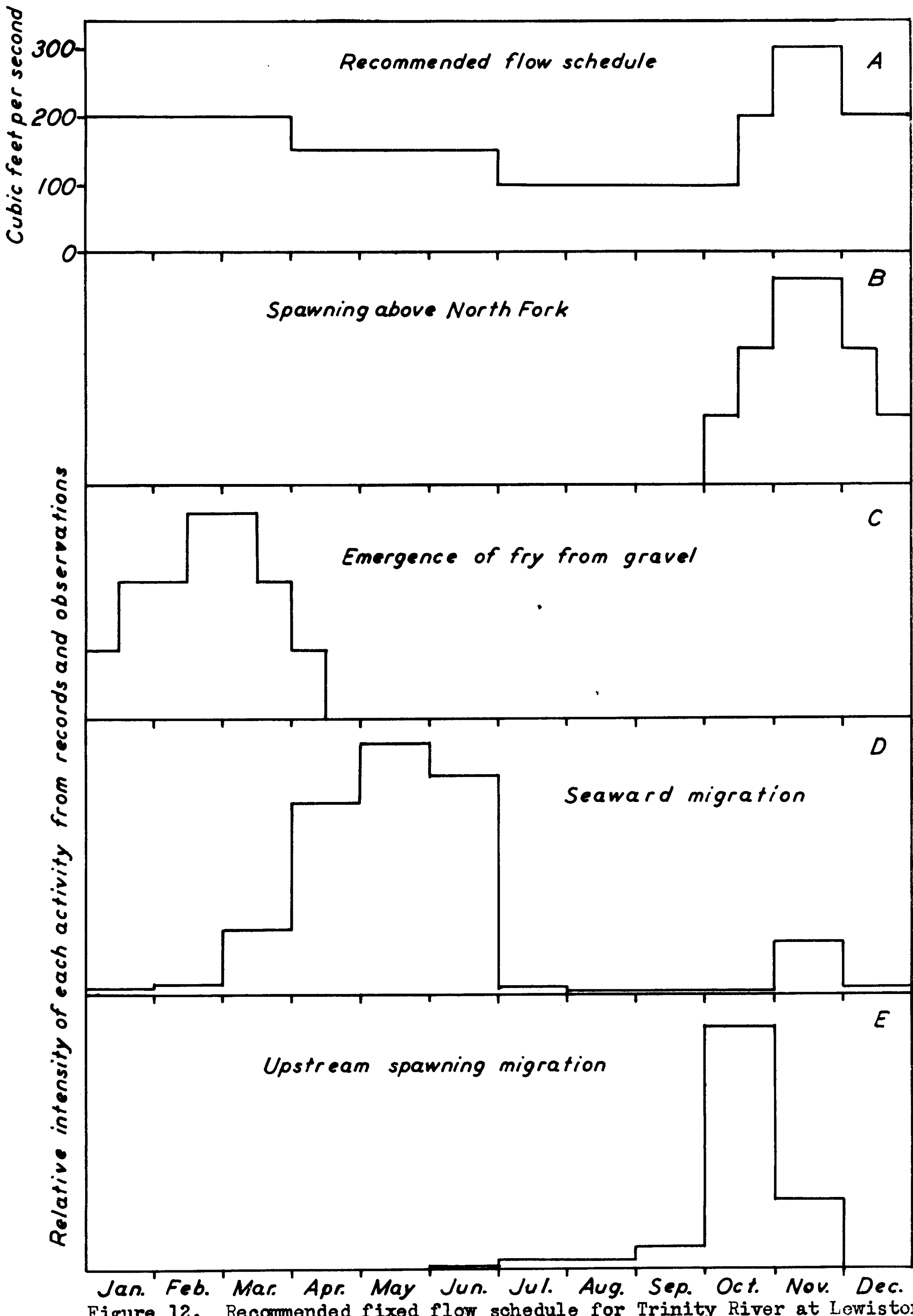


Figure 12. Recommended fixed flow schedule for Trinity River at Lewiston and its relation to the life history phenomena of king salmon in that stream.

TABLE NO. 19
FIXED SPAWNING FLOW SCHEDULE AS MEASURED AT LEWISTON GAGE

Month	c.f.s. at Lewiston	Acre-feet per day	Number of days	Acre-feet per month
January	200	396.7	31	12,298
February	200	396.7	28	11,108
March	200	396.7	31	12,298
April	150	297.5	30	8,926
May	150	297.5	31	9,223
June	150	297.5	30	8,926
July	100	198.3	31	6,149
August	100	198.3	31	6,149
September	100	198.3	30	5,951
October 1-15	100	198.3	15	2,975
16-31	200	396.7	16	6,347
November	300	595.0	30	17,852
December	200	396.7	31	12,298
			Total	120,500

TABLE NO. 20
AVERAGE MONTHLY FLOWS IN TRINITY RIVER
OCTOBER 1931 TO SEPTEMBER 1939

Month	Lewiston		Burnt Ranch			Hoopa		
	Present	Proposed*	Present	Less Lewiston	Proposed	Present	Less Lewiston	Proposed
	(Flows expressed in cubic feet per second)							
Oct.	181.8	151.6	301.0	119.2	270.8	532.8	351.0	502.6
Nov.	714.3	300.0	1256.9	542.6	842.6	2526.4	1812.1	2112.1
Dec.	897.6	200.0	1658.6	761.0	961.0	4010.6	3113.0	3313.0
Jan.	980.1	200.0	2267.6	1287.5	1487.5	6227.3	5247.2	5447.2
Feb.	1463.1	200.0	2929.7	1466.6	1666.6	7325.9	5862.8	6062.8
Mar.	2515.0	200.0	4762.0	2247.0	2447.0	10980.0	8465.0	8665.0
Apr.	3472.5	150.0	5567.8	2095.3	2245.3	10364.8	6892.3	7042.3
May	3554.4	150.0	5137.4	1583.0	1733.0	7970.3	4415.9	4565.9
June	1868.5	150.0	2825.6	957.1	1107.1	4198.5	2330.0	2480.0
July	438.3	100.0	777.0	338.7	438.7	1275.4	837.1	937.1
Aug.	142.1	100.0	246.0	103.9	203.9	462.5	320.4	420.4
Sept.	108.5	100.0	168.6	60.1	160.1	330.4	221.9	321.9

*Probable releases at Lewiston for fish needs.

The plan for each year would be based on counts by resident biologists of migrating salmon and steelhead made as they passed North Fork, which is presumably far enough to allow downstream flow schedule determination prior to the actual need. This system could be hazardous for the salmon, as their migration past North Fork may not be completed before the peak spawning period starts below Lewiston. Lake segments of the runs may not find sufficient gravel for their needs. Flow changes should be made at weekly intervals starting October 15, and the revisions should be determined by the cumulative counts obtained at the counting station near North Fork. The flow would be increased in accordance with the need for additional nesting capacity between Lewiston dam and North Fork as determined from Table 21. This plan would utilize both water flow and spawning areas most effectively.

Probable water requirements for this plan, had it been in operation during 1944 and 1945, are given in Table 22. The peak a pawning period would have required a release Or 280 cubic feet per second in 1944, and 250 in 1945. These flows are conservative as they only provide additional spawning area for the number of salmon actually counted at Lewiston, and do not provide for salmon passing Lewiston before and after the counting period. The a pawning flows given in Table 22 were determined by adding the number of nests needed for counted fish to the number of nests normally occupied in the spawning area (5,647). The spawning population passing Lewiston required 3,774 nests in 1944, and 2,856 in 1945. The flow producing the total number of nests was chosen to the nearest 10 cubic feet per second from Table 21.

The estimated 1946 requirement of 128,000 acre-feet of water for this plan (Table 22) is the amount needed for 15,000 salmon which are believed to have passed Lewis ton in 1946. The 1946 estimate was established from observations of concentration on spawning beds during that year compared with observed concentration in 1944 and 1945 when actual counts were made.

Because of the unreliability in flow of tributary streams immediately below Lewiston, required stream flows should be measured at Lewiston dam. As shown in Table 23, there is very little water entering the river between Lewiston and Lowden during the salmon nesting season (October-December). This yearly fall inflow is supplied almost entirely by periodic rains, and in dry years it would be negligible in its effect on salmon spawning conditions. It is, therefore, necessary to request a quantity of reservoir water for fishery management equal to the amount required by the plane discussed herein, to be certain of producing proper spawning conditions each year.

The studies that preceded the formulation of these management plans were during a period when no mining silt be introduced into the river in the major areas involved. These plans, it they are to be successful, can be placed in operation only under similar conditions. If a heavy load of mining silt wore allowed to enter those crowded spawning areas, the fishery might be seriously threatened. Regulated flows are far below those normally encountered following salmon spawning_ under natural conditions; thus silt could settle out rapidly, impact the gravel, and suffocate eggs and young fish. Therefore, stringent measures <u>must</u> be taken so that no mining silt will be introduced into the river during the salmon and steelhead spawning and hatching periods (October 1 through July 15).

Improvement of tributary streams

Four streams tributary to the Trinity River below the Lewis ton dam site might be developed for salmon and steelhead spawning. These are Rush Creek, Browns Creek, the South Fork of the Trinity River, and Hay Fork, a tributary to South Fork. Rush Creek and Browns Creek are available for salmon spawning only after rains increase their flow, and the South Fork spring and fall migrations of salmon each year. No salmon spawn in upper Hay Fork.

Each of those streams has been studied to determine the extent to which it might be developed for salmon spawning. Information obtained is not complete, but enough data have been gathered to a how relative

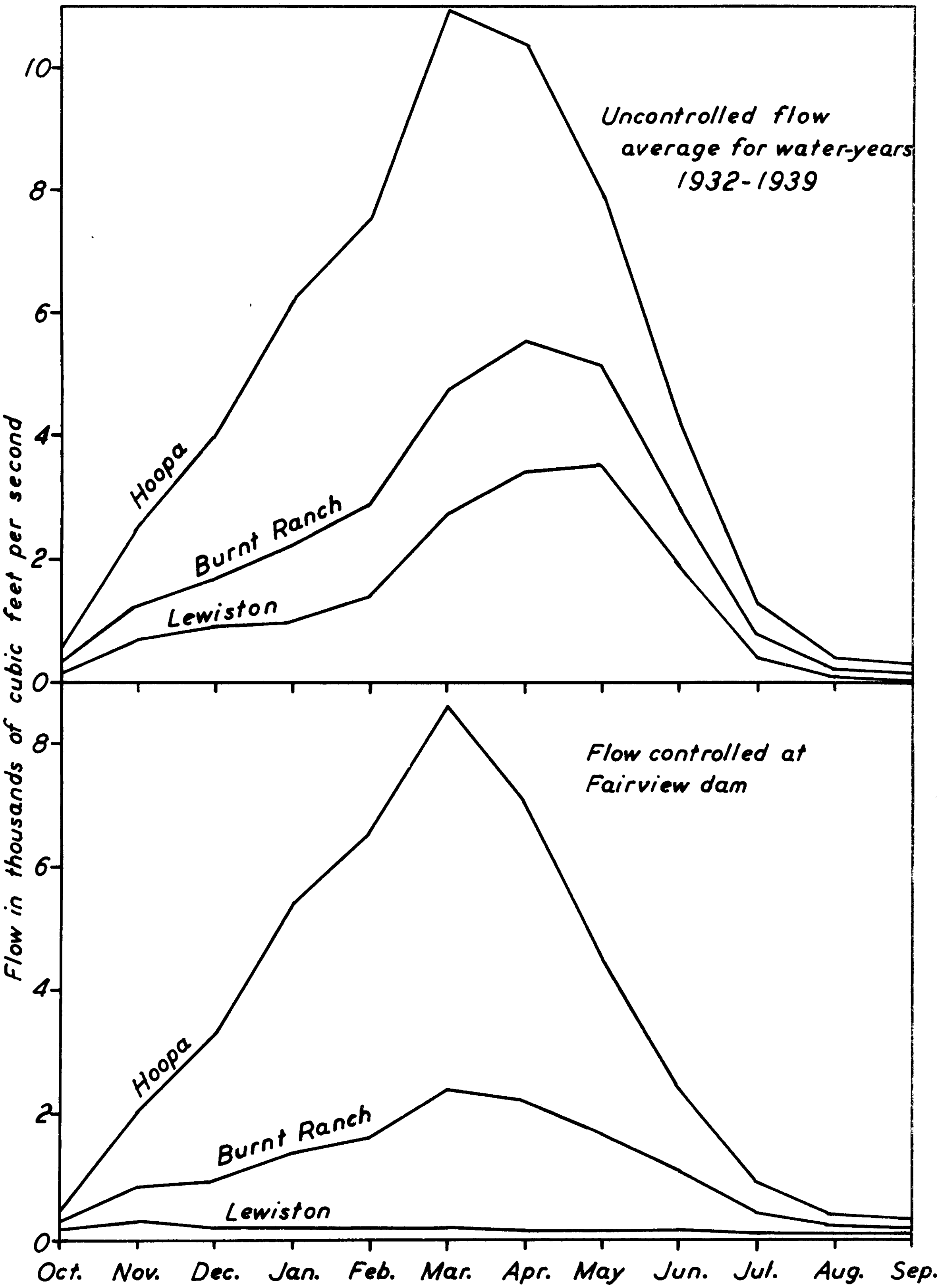


Figure 13. The effect of a fixed flow schedule for fish at Lewiston on the discharge of Trinity River at various points downstream.

TABLE NO. 21
KING SALMON SPAWNING NESTS, TRINITY RIVER

	Lewiston Dam Site to North Fork		Lewiston Dam Site to Grass Valley Creek		Grass Valley Creek to North Fork	
Flow c.f.s.	Nests/c.f.s. per Mile	Number of Nests	Nests/c.f.s. per Mile	Number of Nests	Nests/c.f.s. per Mile	Number of Nests
F	E	N	E	N	E	N
50	1.1014	2,038	.8666	324	1.1611	1,724
60	1.0930	2,426	.8604	387	1.1522	2,039
70	1.0846	2,809	.8543	449	1.1432	2,361
80	1.0762	3,186	.8482	507	1.1342	2,677
90	1.0679	3,556	.8421	568	1.1252	2,987
100 (F_1)	1.0595 (E_1)	3,920	.8360 (E_1)	627	1.1163 (E_1)	3,293
110	1.0511	4,278	.8299	685	1.1073	3,593
120	1.0426	4,629	.8238	741	1.0983	3,888
130	1.0343	4,975	.8176	797	1.0894	4,118
140	1.0259	5,314	.8116	852	1.0804	4,462
150	1.0175	5,647	.8054	906	1.0714	4,741
160	1.0091	5,974	.7993	959	1.0624	5,015
170	1.0007	6,294	.7932	1,011	1.0535	5,283
180	.9923	6,609	.7871	1,063	1.0445	5,546
190	.9839	6,917	.7810	1,113	1.0355	5,804
200	.9755	7,219	.7749	1,162	1.0266	6,057
210	.9671	7,514	.7687	1,211	1.0176	6,304
220	.9588	7,805	.7627	1,258	1.0086	6,546
230	.9504	8,088	.7566	1,305	.9996	6,782
240	.9420	8,365	.7504	1,351	.9907	7,014
250	.9336	8,636	.7443	1,396	.9817	7,240
260	.9252	8,900	.7382	1,439	.9727	7,461
270	.9168	9,159	.7321	1,483	.9638	7,677
280	.9084	9,411	.7260	1,525	.9548	7,887
290	.9000	9,657	.7199	1,566	.9458	8,091
300 (F_2)	.8916 (E_2)	9,897	.7138 (E_2)	1,606	.9368 (E_2)	8,291
310	.8832	10,130	.7077	1,645	.9279	8,486
320	.8748	10,358	.7016	1,684	.9189	8,674
330	.8664	10,579	.6954	1,721	.9099	8,858
340	.8581	10,795	.6893	1,758	.9009	9,036
350	.8450	10,943	.6832	1,793	.8920	9,210

E_1 or $E_2 = \frac{N \div M}{F}$

$$E = E_1 - \left[\left(\frac{E_1 - E_2}{n}\right)\left(\frac{F - F_1}{i}\right)\right]$$

$N = E \times F \times M$

E = Efficiency Rating.
E_1 = Efficiency Rating at low flow.
E_2 = Efficiency Rating at high flow.
n = Number of intervals between E_1 & E_2.
i = Size of interval in c.f.s.
F = Flow
F_1 = Flow at E_1 in c.f.s.
N = Number of nests.
M -= Miles of river.

TABLE NO. 22

PROBABLE WATER REQUIREMENTS FOR A CONTROLLED SPAWNING FLOW

Month	1944 Flow at Lewiston C.F.S.	1944 Flow at Lewiston A.F.	1945 Flow at Lewiston C.F.S.	1945 Flow at Lewiston A.F.	Probable Maximum Flow at Lewiston C.F.S.	Probable Maximum Flow at Lewiston A.F
January	187	11,498	167	10,264	213	13,971
February	187	10,386	167	9,275	213	11,830
March	187	11,498	167	10,264	213	13,971
April	150	8,926	150	8,926	150	8,926
May	150	9,223	150	9,223	150	9,223
June	150	8,926	150	8,926	150	8,926
July	100	6,149	100	6,149	100	6,149
August	100	6,149	100	6,149	100	6,149
September	100	5,951	100	5,951	100	5,951
October 1-15	100	2,975	100	2,975	100	2,975
16-31	187	5,935	167	5,300	213	6,760
November	280	16,661	250	14,876	320	19,042
December	187	11,498	167	10,264	213	13,971
Totals		115,775		108,542		127,844

TABLE NO. 23

ESTIMATED RUN-OFF

ON PORTION OF TRINITY RIVER DRAINAGE

FOR SALMON FISHERY STUDIES

Month	Average inflow Lewiston dam site to Lowden dam site 1917 to 1940, inclusive: Acre Feet	C.F.S.
January	3,430	56
February	5,870	106
March	7,500	122
April	10,010	168
May	10,120	165
June	4,750	80
July	1,220	20
August	430	7
September	370	6
October	620	10
November	2,360	40
December	3,430	56

U. S. Bureau of Reclamation data.

TABLE NO. 24
MINIMUM FLOWS REQUIRED
FOR DEVELOPMENT OF SPAWNING AREAS
IN TRIBUTARIES

Tributary	Nov.-April	April	May	June	July-Sept.	Oct.	Location
South Fork Trinity River:							
at Forest Glen	100	100	80	65	50	50	S13 T1S R7E HM (Forest Glen)
at Hyampom	200	100	100	100	100	150	S26 T3N R6E HM (Hyampom)
Hay Fork	100	100	60	20	10	70	S2 T30N R11W MDM (East Fork)
Browns Creek	65	40	30	20	10	50	S19 T31N R9W MDM (East Fork)
Rush Creek	45	35	25	15	5	40	S23 T34N R9W MDM (Below China Gulch)

SALMON SPAWNING CAPACITIES OF TRIBUTARIES

Tributary	Water flow		Number of Nests		Possible Increase	
	Present	Increased	Present	Increased	Nests	Salmon
South Fork	100 cfs	200 cfs	1,418	2,432	1,014	2,667
Hay Fork	20	100	0	1,300	1,300	3,419
Browns Creek	20	65	370	1,200	830	2,183
Rush Creek	15	45	211	632	421	1,107
					3,565	9,376

possibilities. It has not been possible to make spawning surveys of these streams during optimum flow conditions. Surveys have been conducted, however, to determine the general stream type, and nest counts have been made on Ruch Creek and parts of the South Fork at lower than optimum flow. With this information, the approximate nesting capacities of the tributaries at their optimum flows have been estimated. Using the nests per cubic foot per second per mile factors, established for portions of the Trinity River at the 100 cubic feet per second flow, nesting capacities were computed for comparable portions of the tributaries at their optimum flows (Table 24). Normal spawning flows for these streams were set up by evaluating statement made by people living along the streams and comparing this information with the few flow records that are available.

Improvement of these streams could probably make an additional 3,565 nests available for 9,376 spawning salmon. In order to make these nests available, additional water development on each stream is necessary. Rather large storage dams should be built in the upper portion of each stream drainage to provide a constant and adequate minimum flow during the entire year. Greater flows would be necessary when spawning occurs. It would be desirable to remove several obstructions which are barriers to fish migration during low water periods. Natural barriers obstruct fish movements into Hay Fork Valley. Artificial dams and diversions block from access miles of spawning area in Browns and Rush Creeks when water flows are low.

Two methods of developing salmon rune in these streams, after improvement, are possible (1) Salmon could be trapped at Lewiston or at other locations above the mouth of South Fork and hauled to the streams; (2) small runs now entering the streams or present in the main Trinity off their mouths could be left to take over the new spawning areas and develop natural runs to offset losses of salmon blocked by the Lewiston dam. Experience would dictate the latter course of action, although it may be very slow and gradual in developing. Transferring adult salmon is a costly process, not only in money, but also in fish. It is generally better to encourage a native seed stock to increase in abundance than to introduce a foreign race which may or may not adapt to the new situation. This attitude is especially applicable to the South Fork of Trinity River and its major tributary, Hay Fork. Some main stream salmon probably could be diverted into South Fork, Browns Creek and Rush Creek by constructing barriers on the main Trinity immediately above their respective mouths, but such construction would be costly and might result in serious disruption of the normal habits of the entire anadromous fish population. There are no means available whereby fish headed for the area above Lewiston can be segregated from those using the river below that point.

Perhaps the most serious obstacle in any plan to transfer salmon from one place to another in the Trinity River drainage is the almost utter lack of good roads. Tank trucks suitable for hauling adult salmon are very heavy and would operate in months when roads are wet and slippery. It is doubtful that any transfer program could be successful without major road construction and bridge strengthening projects preceding the actual truck operation.

Transfer of Trinity River salmon from the main stem to improved tributaries would now save any significant quantities of water for the project. Minimum flows ranging between 100 and 200 cubic feet per second would have to be released from the Lewiston dam to satisfy water users, to maintain the resident fish population in the river below, and to provide adequate spawning grounds for the salmon and steelhead populations which use the mainstream below Lewiston.

Artificial propagation

A third method of accommodating the salmon normally passing above the Lewiston dam site to spawn is artificial propagation. As yet, hatcheries have not proved themselves capable of maintaining large runs of king salmon. Therefore, this method cannot be recommended for the Trinity River at this time.

Adequate sources of water suited to hatchery operation are very scarce in the Trinity drainage below Lewiston. Many stream flows are cold enough, but they are insufficient in volume to supply a hatchery large enough to accommodate present runs of fish. Plenty of water of fair quality could be obtained from the reservoirs to be built. However, such an arrangement would require that a hatchery be located near the Lewiston dam site. The hatchery would need approximately 50 cubic feet per second of water for operation. In addition, sufficient water would have to be released to the river to bring salmon and steelhead to the hatchery. Quantities of water involved in this latter operation would exceed 100 cubic foot per second. Very little water would be saved to the project through artificial propagation.

Maintenance Plans for Browns Creek Dam

The construction of a dam at the Browns Creek site would cut off approximately 82 percent of the part of Trinity River used by salmon for spawning. Optimum development below Browns Creek could produce only 1,800 additional nests in the main river. Development of the South Fork and Hay Fork, which are the only suitable spawning tributaries below this dam site, would produce 2,300 additional salmon nests. Together, these additional nests in the river and tributaries would provide for only 10,700 of a possible 21,000[1] salmon that would normally spawn above the dam. The only method known that would take care of the remaining salmon that could neither spawn in the river nor in the tributaries would be to construct a 30-million egg hatchery utilizing water for the reservoir. Such a plan could not be recommended because of the very questionable outcome.

Steelhead Maintenance

Maintenance of the steelhead trout population would not present the serious problems inherent in the perpetuation of salmon if a dam is constructed at the Lewiston site. These fish are believed to spawn voluntarily in the lower reaches of the river during low water years and their nests are made during the spring run-off period. Much steelhead spawning takes place in tributaries in the main river below. Lewiston which are all carrying ample water to produce adequate available gravel during the steelhead spawning period.

To accommodate steelhead spawning in the river, a flow of 150 c.f. would be required during the steelhead spawning period. This is included in all flow schedules for salmon spawning that are suggested in this report. The inflow from tributaries in the upper portion of the spawning area below the Lewiston dam (Table 23) will make additional spawning area available in the main river for steelhead blocked by the dam. Tributary inflow peaks during the steelhead spawning season and should be fairly reliable from year to year. These tributaries are, at present, under-populated with spawning steelhead. If mining silt can be excluded from tributaries during the spawning and incubation period (February 15 through June 1S), they would be better suited to accommodate part of the steelhead held back by the Lewiston dam. Major steelhead spawning tributaries below Lewiston dam site are Rush Creek, Grass Valley Creek, Indian Creek, Redding Creek, Browns Creek, Canyon Creek, and the North Fork of the Trinity, including its East Fork.

Browns Creek dam would present a major problem in connection with steelhead spawning. Only two of the major spawning tributaries are below this dam, thus an unknown number of these fish would have to be diverted into the South Fork, or removed into a hatchery, or both. Neither possibility would seem feasible when it is considered that streams and hatchery facilities would have to be developed to a maximum for the salmon alone, and a project including steelhead salvage would involve operations of unprecedented proportions.

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[1] Determined by estimating the natural salmon population between Browns Creek and Lewiston, using the number of nests at the normal spawning flow (150 c.f.s.) in that area, and adding the maximum number of salmon counted at Lewiston.

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