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CONTRIBUTION OF COLUMBIA RIVER HATCHERIES TO HARVEST OF
1964 BROOD FALL CHINOOK SALMON (Oncorhynchus tshawytscha)

by

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1964 BROOD FALL CHINOOK SALMON (Oncorhynchus tshawytscha)

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ABSTRACT

A marking experiment was designed in which fall chinook salmon (Oncorhynchus tshawytscha) from 12 Columbia River hatcheries were marked in 4 consecutive years to estimate their contribution to the sport and commercial fisheries. The study was planned and executed by scientists of the Fisheries Research Board of Canada, U. S. Bureau of Sport Fisheries and Wildlife, National Marine Fisheries Service, and fishery agencies of the States of Alaska, Washington, Oregon and California.

Sampling for marked chinook salmon was conducted in most ocean fisheries from Avila Beach, California to Pelican, Alaska, as well as on the Columbia River. This report delineates and summarizes the estimated contribution of the total hatchery releases of the 1964 brood based on the returns for the 4.6 million marked fish released in the fourth year of the study. Estimates of the contributions of the 1961, 1962 and 1963 broods were published in 1969 and 1970.

The estimated catch of the 1964-brood fish that originated from the hatcheries under study was 262,643, or about 10.9 percent of the total catch of chinook salmon of that brood in the fisheries sampled. The estimated net value of this catch was \$1,862,750 in comparison with production costs of \$837,750. The benefit-to-cost ratio was 2.2:1.

The net value of the catch of fall chinook salmon of the 1964 brood that originated from all Columbia River hatcheries (including those not participating in the marking experiment) was estimated at \$2,103,963.

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INTRODUCTION

The U. S. Government has financed the Columbia River Fishery Development Program, a cooperative effort of the States of Oregon, Washington and Idaho, since its inception in 1949. The Columbia Fisheries Program Office, National Marine Fisheries Service, Portland, Oregon, administers the program. This project is designed to increase production of salmon (Oncorhynchus spp.) and steelhead trout (Salmo gairdneri) in the Columbia River as a countermeasure to the depletion of fishery resources through deterioration and loss of natural stream habitat.

A marking experiment was begun in 1962 by the Columbia Fisheries Program Office to estimate the contribution of hatchery-reared fall chinook salmon to commercial and sport fisheries of the Pacific Coast. The study was planned and initiated by the National Marine Fisheries Service. Personnel of the Fisheries Research Board of Canada, U. S. Bureau of Sport Fisheries and Wildlife, National Marine Fisheries Service, and fishery agencies of the States of Alaska, Washington, Oregon and California executed the study. The marking portion of the study began in 1962 with the 1961 brood and ended in 1965 with the 1964 brood. Sampling for these marked fall chinook salmon was started in 1963 and ended in 1969.

A detailed account of the experimental design, with methods and procedures used for marking the fish and estimating the contribution of the 1961 brood was presented by Worlund, Wahle and Zimmer (1969). Discussion of basic theory with essential formulas and supporting basic data tables will not be repeated in this report.

This report has been prepared with a format similar to the one that was developed by Worlund et al. That format was followed in the 1962 and 1963 brood fall chinook salmon reports (Rose and Arp, 1970; Arp, Rose and Olhausen, 1970). Appendix table 1 lists tables by number that are common to two or more of these reports. These tables contain data pertinent to the development of contribution estimates. Comparison of the tables will help to point out similarities and differences between the four broods of fish.

Twelve hatcheries were selected to participate in the marking program. These hatcheries produced about 90 percent of the fall chinook salmon propagated in hatchery facilities in the Columbia River system prior to the marking experiment and continued this production throughout the 4-year study. Six other hatcheries which also reared fall chinook salmon contributed to the experiment by supplying cost accounting and production data. Table 1 lists the participating and non-participating hatcheries included in the experiment.

Table 1.--Columbia River hatchery facilities contributing to
1964-brood fall chinook salmon

Hatchery	Agency ^{1/}
PARTICIPATING	
1) Grays River	WDF
2) Elokomin	WDF
3) Kalama Falls and Lower Kalama	WDF
4) Washougal	WDF
5) Little White Salmon	BSFW
6) Spring Creek	BSFW
7) Big White Salmon egg taking and rearing facilities	BSFW
8) Klickitat	WDF
9) OxBow	FCO
10) Cascade	FCO
11) Bonneville	FCO
12) Big Creek	FCO
NON-PARTICIPATING	
13) Abernathy	BSFW
14) Toutle	WDF
15) Sandy	FCO
16) Eagle Creek	BSFW
17) Gnat Creek	OGC
18) Klaskanine	FCO

^{1/} FCO--Fish Commission of Oregon
OGC--Oregon Game Commission
WDF--Washington Department of Fisheries
BSFW--Bureau of Sport Fisheries and Wildlife

MARKING

Approximately 10 percent of the juvenile chinook salmon at each of the 12 participating hatcheries were marked each year by removing the adipose fin and a portion of the right or left maxillary bone. A total of 21.3 million fish were marked with this mark. In addition to this common mark, 4 special marks were used each year to study variation within the 12 participating hatcheries. Two of these marks were allotted to Spring Creek and Kalama hatcheries, and the other two marks were rotated among 8 of the remaining hatcheries (i.e., two different hatcheries in each of the four years of marking). A total of 9.6 million fish were marked with the special marks. Marks used for the 1964 brood are listed in table 2.

Table 2.--Marks of Columbia River 1964-brood fall chinook salmon and ages in catches and escapements by sampling years (1966-69)

Mark	Release site	Year of sampling			
		1966	1967	1968	1969
		-----Year of life-----			
Ad-LM	12 hatcheries	2	3	4	5
Ad-LV-LM	Spring Creek	2	3	4	5
Ad-RV-LM	Kalama	2	3	4	5
LV-LM	Bonneville	2	3	4	5
RV-LM	Little White Salmon	2	3	4	5
Number of marks in catches and escapements.....		5	5	5	5

1/ Ad: Adipose; LV: left ventral; RV: right ventral;
LM: left maxillary.

RELEASE OF FISH

Table 3 shows estimated numbers of 1964-brood fall chinook salmon released for each mark type, the numbers of unmarked fish released, and ratios of marked to unmarked fish.

Table 3.--Estimated numbers and mark ratios of fall chinook salmon released from study hatcheries for 1964 brood year

Common mark	Origin	Marked	Unmarked	Ratio marked/unmarked	Special marks	Total release of marked and unmarked
Ad-LM	All hatcheries	4,638,237 ^{1/}	39,465,495 ^{2/}	0.1175	2,674,820 ^{3/}	46,778,552

Special mark	Origin	Marked	Unmarked	Ratio marked/unmarked
Ad-LV-LM	Spring Creek	600,953	5,278,009	0.1139
Ad-RV-LM	Kalama	319,412	2,829,900	0.1129
LV-LM	Bonneville	957,110	7,941,491	0.1205
RV-LM	Little White Salmon	797,345	6,736,013	0.1184
	Subtotal	2,674,820		

^{1/} Includes Ad-LM marked fish released from four hatcheries with special marks.

^{2/} Includes unmarked fish released from four hatcheries with special marks.

^{3/} From four hatcheries with special marks.

MARK SAMPLING AREA AND INTENSITY

Catches of chinook salmon in the fisheries that were sampled and numbers of fish that were examined each year for marks and age are given in table 4. Data are shown for 1966, 1967, 1968 and 1969. During this 4-year period, most of the chinook salmon fisheries were sampled from Avila Beach, California to Pelican, Alaska. Sampling was discontinued in Alaska during the 1968 and 1969 sampling seasons. The British Columbia sport fishery was not sampled for marked Columbia River hatchery fish during any part of the contribution studies.

During the 4 years of sampling, 18.4 percent of the total catch of 10.4 million fish was examined for marks and 1.1 percent was sampled for age. Mark sampling percentages for the 4 years were 21.3, 20.2, 18.0 and 14.3.

Table 4.--Catches of chinook salmon and number of fish examined for marks and age, 1966-69

Year	Catch of chinook salmon		Sampled for marks	Sampled for age
	1964 brood	Total catch		
1966.....	139,419	2,681,507	570,994	38,556
1967.....	1,261,947	2,560,266	518,351	27,407
1968.....	831,440	2,443,778	440,290	21,816
1969.....	173,058	2,705,275	386,601	30,302
Total...	2,405,864	10,390,826	1,916,236	118,081

1/ Catch data is only for fisheries that were sampled.

RECOVERIES OF MARKED FISH

Table 5 summarizes all marks of Columbia River hatchery origin (1964 brood) recovered in the fisheries. This includes partial or incomplete marks, designated in the data reports (1967-71) (see references) as possible or probable hatchery marks. A total of 4,862 marked fish was recovered during the 4 years of sampling. This compares with 9,578 recoveries for the 1961 brood, 2,748 for the 1962 brood and 7,476 for the 1963 brood. About 55 percent of the marked fish were taken as 3-year-olds in 1967 and about 38 percent in 1968 as 4-year-olds.

Kalama hatchery fish have shown a trend toward delay in mark recoveries in the four brood years studied. This trend was depicted most clearly in the 1964 brood, where 23 percent of the Kalama marks were recovered in 1967 and 62 percent in 1968.

Table 5.--Marked 1964-brood-year fall chinook salmon of possible Columbia River hatchery origin recovered in the fisheries, 1966-69^{1/}

Origin of mark	Mark	Year of capture				Total
		1966	1967	1968	1969	
All hatcheries.....	Ad-LM	115	1,626	1,035	48	2,824
	Ad	36	196	192	6	430
Spring Creek.....	Ad-LV-LM	51	614	329	7	1,001
	Ad-LV	17	55	39	2	113
Kalama.....	Ad-RV-LM	1	36	108	18	163
	Ad-RV	9	7	8	1	25
Bonneville.....	LV-LM	31	55	53	1	140
	LV	4	20	25	2	51
Little White Salmon	RV-LM	1	27	37	0	65
	RV	2	27	21	0	50
Total.....		267	2,663	1,847	85	4,862

^{1/} Includes partial or incomplete marks designated as possible or probable hatchery marks in the data reports (1968-71).

Distribution of recoveries for each year by region of capture and type of fishery is shown in table 6. Only full mark recoveries are listed.

Distribution of the total mark recoveries shows that the greatest numbers were taken in the northern part of the total sampling range. Recoveries for the 1961, 1962 and 1963 broods showed the same trend. Kalama hatchery fish, consistent with trends shown in the previous broods, ranged northward in greater numbers than fish from any of the other hatcheries. Seventy-one percent of the Kalama marks were recovered in the British Columbia troll fisheries compared with 51 percent for the nearest competitor, Little White Salmon hatchery, and a 40 percent average for all of the hatcheries.

Table 6.--Marked 1964-brood Columbia River chinook salmon recovered by year, region of capture, and type of fishery, 1966-69^{1/}

Origin and type of mark	Year	California		Oregon		Washington			Puget	British Columbia			S. E. Alaska		Columbia River		
		Sport	Com- mer- cial	Sport	Com- mer- cial	Sport	Commercial		Sport	Commercial			Commercial		Sport	Commercial	
							Troll	Gill net		Troll	Gill net	Purse seine	Troll	Gill net		Gill net	Dip net
-----Number of recoveries-----																	
All hatcheries (Ad-LM)	1966	0	0	16	0	85	2	0	1	4	0	0	0	(*)	0	6	1
	1967	0	0	41	103	218	604	11	4	412	2	0	0	(*)	0	226	0
	1968	1	0	7	26	44	99	10	0	419	0	0	(*)	(*)	0	425	4
	1969	0	0	0	0	1	1	0	0	10	0	0	(*)	(*)	0	35	1
Spring Creek (Ad-LV-LM)	1966	0	0	3	0	44	0	0	0	0	0	0	0	(*)	0	4	0
	1967	0	1	8	34	88	223	5	0	162	0	0	0	(*)	0	93	0
	1968	1	0	2	0	10	30	2	0	108	1	0	(*)	(*)	0	175	0
	1969	0	0	0	0	0	0	0	0	2	0	0	(*)	(*)	0	5	0
Kalama (Ad-RV-LM)	1966	0	0	0	0	1	0	0	0	0	0	0	0	(*)	0	0	0
	1967	0	0	2	1	6	13	0	0	14	0	0	0	(*)	0	0	0
	1968	0	0	1	0	3	13	0	0	77	0	0	(*)	(*)	2	12	0
	1969	0	0	0	0	0	1	0	0	7	0	0	(*)	(*)	0	10	0
Bonneville (LV-LM)	1966	0	1	9	1	9	3	0	0	7	1	0	0	(*)	0	0	0
	1967	0	2	0	7	10	20	0	0	15	0	0	0	(*)	0	1	0
	1968	0	1	0	2	4	5	0	1	34	0	0	(*)	(*)	0	6	0
	1969	0	0	0	0	0	0	0	0	1	0	0	(*)	(*)	0	0	0
Little White Salmon (RV-LM)	1966	0	0	0	0	0	0	0	0	1	0	0	0	(*)	0	0	0
	1967	0	0	0	3	5	12	0	0	6	0	0	0	(*)	0	1	0
	1968	0	2	0	0	3	5	0	0	24	0	0	(*)	(*)	0	3	0
	1969	0	0	0	0	0	0	0	0	0	0	0	(*)	(*)	0	0	0

*No sampling.

^{1/} All sport fishing is by rod and reel. Commercial fishing is by trolling, unless otherwise noted.

Mark recoveries in the Columbia River gill net fishery followed the same general trend as the three previous broods. Fish with the common mark (Ad-LM) and the three special marks, excluding Kalama, were recovered in greatest numbers in 1967 and 1968 as 3- and 4-year-olds, the highest numbers being recovered in 1968. No Kalama marks were recovered in 1966 and 1967 and almost one-half the marks were recovered in 1969 as 5-year-olds. This suggests, as did the previous broods, that Kalama fish tend to mature later than the main body of Columbia River hatchery fish.

Marked fall chinook salmon of the 1964 brood recovered in hatchery escapements are presented in appendix table 2 and summarized in table 7. Tributary streams were sampled for spawning escapements in 1966, but no marked fish of the 1964 brood were found that year. Stream sampling was omitted in 1967, 1968 and 1969.

Most of the marked fish in the escapement and fisheries were recovered in 1967 and 1968 as 3- and 4-year-olds. In the escapement two-thirds of the total number of 3- and 4-year-old marked fall chinook were recovered in 1968 as 4-year-olds, while in the fisheries (table 5) almost two-thirds were taken in 1967 as 3-year-olds. Trends for recoveries in escapement and fisheries were similar for the 1962, 1963 and 1964 broods, while in the 1961 brood most of the marked fish were recovered as 3-year-olds in the escapement as well as in the fisheries.

ESTIMATED CATCHES OF MARKED FISH

Methods used in this report to estimate the total catch of fish for each mark in each stratum (fishery, port or capture area, and time period) are explained in the report for the 1961 brood. Estimated numbers of marked 1964-brood fish caught in the fisheries, returning to the hatcheries or escaping to the tributary streams are listed in table 8. These include fish which had a partial or incomplete mark (e.g., Ad only instead of Ad-LM or Ad-RV only instead of Ad-RV-LM). The number of Ad only marked fish recovered in the fisheries (1,740) is about 16 percent of the number with the full mark of Ad-LM. This compares with the three prior broods, as follows: 1961, 14 percent; 1962, 23 percent; and 1963, 9 percent.

Total numbers of partially marked fish, expressed in percentages proportionate to their corresponding full marks, are summarized in table 9. Percentages of partial marks are lower than they were in the 1961- and 1962-brood mark recoveries, but slightly higher than in the 1963 brood. The occurrence of EV (either ventral) only marks in proportion to the Ad-EV and Ad only marks was similar to but not as pronounced as for the three prior broods.

Table 7.--Recoveries of 1964-brood fall chinook salmon in the Columbia River escapement by type of mark, recovery location, and year of capture, 1966-69

Origin of mark	Mark	Recovery location ^{1/}											
		Study hatcheries				Other hatcheries				Tributary streams			
		1966	1967	1968	1969	1966	1967	1968	1969	1966	1967	1968	1969
		-----Number of recoveries-----											
All hatcheries.....	Ad-LM	57	193	392	65	0	0	2	0	0	(*)	(*)	(*)
	Ad	7	40	78	22	0	0	0	0	0	(*)	(*)	(*)
Spring Creek.....	Ad-LV-LM	20	78	103	3	0	0	0	0	0	(*)	(*)	(*)
	Ad-LV	1	10	13	0	0	0	0	0	0	(*)	(*)	(*)
Kalama.....	Ad-RV-LM	0	1	10	22	1	0	0	0	0	(*)	(*)	(*)
	Ad-RV	0	0	4	2	1	0	0	0	0	(*)	(*)	(*)
Bonneville.....	LV-LM	0	0	20	3	0	0	0	0	0	(*)	(*)	(*)
	LV	0	1	1	2	0	0	0	0	0	(*)	(*)	(*)
Little White Salmon	RV-LM	3	2	25	3	0	0	0	0	0	(*)	(*)	(*)
	RV	0	0	2	2	0	0	0	0	0	(*)	(*)	(*)
Total.....		88	325	648	124	2	0	2	0	0	(*)	(*)	(*)

*Not sampled.

^{1/} "Study hatcheries" include the 12 hatcheries participating in the marking program.

"Other hatcheries" include Abernathy, Speelyai and Toutle.

"Tributary streams" include those streams listed in appendix table

Table 8.--Estimated number of marked fall chinook salmon of 1964 brood in catches, tributary spawning populations, and hatchery returns by type of mark, region of recovery, type of fishery, and year of capture, 1966-69

Region	Fishery type	Study hatcheries												
		Ad-LM				Ad				Total				
		1966	1967	1968	1969	1966	1967	1968	1969	1966	1967	1968	1969	
-----Number of fish-----														
Ocean fisheries:														
	Southeastern Alaska....	Commercial...	0	0	*	*	0	0	*	*	0	0	*	*
	British Columbia.....	Commercial...	10	1,339	1,446	92	6	270	331	7	16	1,609	1,777	99
	Washington.....	Sport.....	483	1,506	249	0	112	175	126	0	595	1,681	375	0
		Commercial...	4	2,268	354	3	28	217	76	0	32	2,485	430	3
	Oregon.....	Sport.....	151	178	21	0	10	48	23	0	161	226	44	0
		Commercial...	0	436	149	0	0	72	41	0	0	508	190	0
II	California.....	Sport.....	0	0	1	0	0	0	0	0	0	0	1	0
		Commercial...	0	0	0	0	0	10	3	0	0	10	3	0
	Subtotal.....	(Sport.....	634	1,684	271	0	122	223	149	0	756	1,907	420	0
		(Commercial...	14	4,043	1,949	95	34	569	451	7	48	4,612	2,400	102
Freshwater fisheries:														
	Columbia River.....	Sport.....	0	0	0	0	0	0	0	0	0	0	0	0
		Commercial...	19	1,001	1,204	171	9	39	110	27	28	1,040	1,314	198
	Total.....	All fisheries	667	6,728	3,424	266	165	831	710	34	832	7,559	4,134	300
Columbia River escapement:														
	Study hatcheries.....		57	193	392	65	7	40	78	22	64	233	470	87
	Other hatcheries.....		0	0	2	0	0	0	0	0	0	0	2	0
	Tributary streams.....		0	*	*	*	0	*	*	*	0	*	*	*
	Total.....	Escapement...	57	193	394	65	7	40	78	22	64	233	472	87

*Not sampled.

Table 8.--Estimated number of marked fall chinook salmon of 1964 brood in catches, tributary spawning populations, and hatchery returns by type of mark, region of recovery, type of fishery, and year of capture, 1966-69--Continued

Region	Fishery type	Spring Creek National Fish Hatchery												
		Ad-LV-LM				Ad-LV				Total				
		1966	1967	1968	1969	1966	1967	1968	1969	1966	1967	1968	1969	
-----Number of fish-----														
Ocean fisheries:														
	Southeastern Alaska....	Commercial...	0	0	*	*	0	0	*	*	0	0	*	*
	British Columbia.....	Commercial...	0	558	376	16	7	31	56	0	7	589	432	16
	Washington.....	Sport.....	226	553	66	0	18	28	4	10	244	581	70	10
		Commercial...	0	821	109	0	0	85	18	0	0	906	127	0
	Oregon.....	Sport.....	29	42	7	0	98	31	8	0	127	73	15	0
		Commercial...	0	82	0	0	0	16	12	0	0	98	12	0
	California.....	Sport.....	0	0	2	0	0	0	0	0	0	0	2	0
		Commercial...	0	3	0	0	0	5	0	0	0	8	0	0
	Subtotal.....	(Sport.....	255	595	75	0	116	59	12	10	371	654	87	10
		(Commercial...	0	1,464	485	16	7	137	86	0	7	1,601	571	16
Freshwater fisheries:														
	Columbia River.....	Sport.....	0	0	0	0	0	0	0	0	0	0	0	0
		Commercial...	13	404	473	18	2	43	31	6	15	447	504	24
	Total.....	All fisheries	268	2,463	1,033	34	125	239	129	16	393	2,702	1,162	50
Columbia River escapement:														
	Study hatcheries.....		20	78	103	3	1	10	13	0	21	88	116	3
	Other hatcheries.....		0	0	0	0	0	0	0	0	0	0	0	0
	Tributary streams.....		0	*	*	*	0	*	*	*	0	*	*	*
	Total.....	Escapement...	20	78	103	3	1	10	13	0	21	88	116	3

*Not sampled.

Table 8.--Estimated number of marked fall chinook salmon of 1964 brood in catches, tributary spawning populations, and hatchery returns by type of mark, region of recovery, type of fishery, and year of capture, 1966-69--Continued

Region	Fishery type	Kalama Falls State Salmon Hatchery											
		Ad-RV-LM				Ad-RV				Total			
		1966	1967	1968	1969	1966	1967	1968	1969	1966	1967	1968	1969
-----Number of fish-----													
Ocean fisheries:													
Southeastern Alaska,...	Commercial...	0	0	*	*	0	0	*	*	0	0	*	*
British Columbia,.....	Commercial...	0	45	469	57	0	0	9	7	0	45	478	64
Washington,.....	Sport.....	4	33	13	0	34	11	13	0	38	44	26	0
	Commercial...	0	57	37	5	0	8	0	0	0	65	37	5
Oregon,.....	Sport.....	0	6	10	0	0	0	0	0	0	6	10	0
	Commercial...	0	2	0	0	0	2	3	0	0	4	3	0
California,.....	Sport.....	0	0	0	0	0	0	0	0	0	0	0	0
	Commercial...	0	0	0	0	0	9	0	0	0	9	0	0
Subtotal,.....	(Sport.....	4	39	23	0	34	11	13	0	38	50	36	0
	(Commercial...	0	104	506	62	0	19	12	7	0	123	518	69
Freshwater fisheries:													
Columbia River,.....	Sport.....	0	0	17	0	0	0	0	0	0	0	17	0
	Commercial...	0	0	38	56	0	3	3	0	0	3	41	56
Total,.....	All fisheries	4	143	584	118	34	33	28	7	38	176	612	125
Columbia River escapement:													
Study hatcheries,.....		0	1	10	22	0	0	4	2	0	1	14	24
Other hatcheries,.....		1	0	0	0	1	0	0	0	2	0	0	0
Tributary streams,.....		0	*	*	*	0	*	*	*	0	*	*	*
Total,.....	Escapement...	1	1	10	22	1	0	4	2	2	1	14	24

*Not sampled.

Table 8.--Estimated number of marked fall chinook salmon of 1964 brood in catches, tributary spawning populations, and hatchery returns by type of mark, region of recovery, type of fishery, and year of capture, 1966-69--Continued

Region	Fishery type	Bonneville Salmon Hatchery											
		LV-LM				LV				Total			
		1966	1967	1968	1969	1966	1967	1968	1969	1966	1967	1968	1969
-----Number of fish-----													
Ocean fisheries:													
Southeastern Alaska....	Commercial...	0	0	*	*	0	17	*	*	0	17	*	*
British Columbia.....	Commercial...	38	36	117	7	3	13	62	13	41	49	179	20
Washington.....	Sport.....	39	58	87	0	3	12	8	0	42	70	95	0
	Commercial...	12	97	13	0	0	14	3	0	12	111	16	0
Oregon.....	Sport.....	37	0	0	0	20	5	0	0	57	5	0	0
	Commercial...	7	44	11	0	0	9	0	0	7	53	11	0
California.....	Sport.....	0	0	0	0	0	0	0	0	0	0	0	0
	Commercial...	5	16	5	0	0	13	7	0	5	29	12	0
Subtotal.....	(Sport.....	76	58	87	0	23	17	8	0	99	75	95	0
	(Commercial...	62	193	146	7	3	66	72	13	65	259	218	20
Freshwater fisheries:													
Columbia River.....	Sport.....	0	0	0	0	0	0	0	0	0	0	0	0
	Commercial...	0	4	16	0	0	0	8	0	0	4	24	0
Total.....	All fisheries	138	255	249	7	26	83	88	13	164	338	337	20
Columbia River escapement:													
Study hatcheries.....		0	0	20	3	0	1	1	2	0	1	21	5
Other hatcheries.....		0	0	0	0	0	0	0	0	0	0	0	0
Tributary streams.....		0	*	*	*	0	*	*	*	0	*	*	*
Total.....	Escapement...	0	0	20	3	0	1	1	2	0	1	21	5

*Not sampled.

Table 8.--Estimated number of marked fall chinook salmon of 1964 brood in catches, tributary spawning populations, and hatchery returns by type of mark, region of recovery, type of fishery, and year of capture, 1966-69--Continued

		Little White Salmon National Fish Hatchery												
Region	Fishery type	RV-LM				RV				Total				
		1966	1967	1968	1969	1966	1967	1968	1969	1966	1967	1968	1969	
		-----Number of fish-----												
Ocean fisheries:														
	Southeastern Alaska....	Commercial...	0	0	*	*	0	41	*	*	0	41	*	*
	British Columbia.....	Commercial...	4	17	93	0	0	25	97	0	4	42	190	0
	Washington.....	Sport.....	0	38	31	0	68	68	11	0	68	106	42	0
		Commercial...	0	47	10	0	0	56	13	0	0	103	23	0
	Oregon.....	Sport.....	0	0	0	0	0	5	0	0	0	5	0	0
		Commercial...	0	7	0	0	0	1	0	0	0	8	0	0
	California.....	Sport.....	0	0	0	0	0	0	2	0	0	0	2	0
		Commercial...	0	0	14	0	0	0	0	0	0	0	14	0
	Subtotal.....	(Sport.....	0	38	31	0	68	73	13	0	68	111	44	0
		(Commercial...	4	71	117	0	0	123	110	0	4	194	227	0
Freshwater fisheries:														
	Columbia River.....	Sport.....	0	0	0	0	0	0	0	0	0	0	0	0
		Commercial...	0	5	8	0	0	3	2	0	0	8	10	0
	Total.....	All fisheries	4	114	156	0	68	199	125	0	72	313	281	0
Columbia River escapement:														
	Study hatcheries.....		3	2	25	3	0	0	2	2	3	2	27	5
	Other hatcheries.....		0	0	0	0	0	0	0	0	0	0	0	0
	Tributary streams.....		0	*	*	*	0	*	*	*	0	*	*	*
	Total.....	Escapement...	3	2	25	3	0	0	2	2	3	2	27	5

*Not sampled.

Table 9.--Recoveries of partially marked fish by region of capture, type of fishery, and type of mark, 1966-69

Region	Fishery type	Partial mark ^{1/}		
		Ad-EV ^{2/}	Ad	EV
-----Percent-----				
Ocean fisheries:				
Southeastern Alaska...	Commercial	0.0	0.0	0.0
British Columbia.....	Commercial	7.2	17.5	40.2
Washington.....	Sport.....	11.7	15.6	40.2
	Commercial	9.7	10.9	32.5
Oregon.....	Sport.....	59.3	18.8	44.8
	Commercial	29.7	16.2	12.7
California.....	Sport.....	0.0	0.0	0.0
	Commercial	82.4	100.0	33.3
Subtotal.....	All.....	12.8	15.2	39.7
Columbia River fisheries..	All.....	8.0	7.2	28.3
Columbia River escapement:				
Study hatcheries.....		11.2	17.2	12.5
Other hatcheries.....		50.0	0.0	0.0
Tributary streams.....		0.0	0.0	0.0
Subtotal.....		11.5	17.2	12.5

1/ Data in table are ratios (average for all years) of estimated numbers of partial marks to estimated sum of partial marks and corresponding complete marks expressed in percent.

2/ EV signifies "either ventral". Marks of same general type are combined.

In the ocean fisheries the percentage of Ad-EV marks is about one-third that of the EV only marks. The Ad-LV and Ad-RV partial marks are assumed to occur as a result of maxillary regeneration, because the chance of double fin marks occurring naturally is slight. The Ad only marks appear to occur in the same way, because the percentage of occurrence is so near that of the Ad-EV marks. But the percentage of EV only marks is over twice that of the Ad-EV; so less than one-half of these marks appear to have originated through maxillary regeneration. This seems to indicate that the origin of the rest of the EV only marks was not necessarily associated with the marking program of the Columbia River hatchery study.

Following the same procedure that was used in analysis of the 1961, 1962 and 1963 broods, estimated numbers of partially marked fish were combined with their corresponding full marks, except for the EV only marks. The estimated numbers of marked fall chinook salmon of Columbia River origin are summarized in table 10.

Table 10.--Estimated catch and escapement of marked fall chinook salmon of Columbia River hatchery origin by area of recovery, 1966-69

Recovery category	Type of mark				
	Ad-LM ^{1/}	Ad-LV-LM ^{1/} (Spring Creek)	Ad-RV-LM ^{1/} (Kalama)	LV-LM ^{2/} (Bonne- ville)	RV-LM ^{2/} (Little White)
	-----Number of fish-----				
Ocean fisheries	10,245	3,317	834	629	261
Columbia River fisheries	2,580	990	117	20	13
Total fisheries ^{3/} ...	12,825	4,309	951	654	274
Total escapement ^{3/} ..	856	228	41	23	33

1/ Includes partial marks.

2/ Full marks only.

3/ Does not include marked fish that spawned in streams in 1967, 1968 and 1969.

An estimated 12,825 Ad-LM marked fish of the 1964 brood released from the 12 study hatcheries were taken in the various fisheries between 1966 and 1969. This indicates that the catch of Ad-LM marked fish per 1,000 released was about 2.76. This compares with a catch of 3.62 Ad-RM marked fish per 1,000 released for the 1963 brood, 1.40 Ad-LM marked fish for the 1962 brood and 3.97 Ad-RM marked fish for the 1961 brood.

ESTIMATED CATCH OF 1964 BROOD HATCHERY FISH

The report for the 1961 brood listed six assumptions which were considered necessary to estimate the contributions of hatchery-reared fall chinook salmon to the fisheries. These assumptions are:

- 1) A marked fish is identifiable as a marked fish throughout its life.
- 2) All observed chinook salmon having the kind of mark used on the hatchery-reared fish are indeed hatchery fish.
- 3) Chinook salmon are correctly aged from scale examinations and information on size of fish and date of capture.
- 4) Marked and unmarked hatchery fish have the same survival rates and maturity schedules.
- 5) Marked and unmarked hatchery fish have the same ocean distribution and are equally vulnerable to the fisheries.
- 6) Either the ocean distribution and timing of migration of fish from each of the hatcheries are the same or the same proportion of each hatchery's production is marked.

Validity of the assumptions was tested in various ways and reasonably established for the 1961 brood, except for number 4. This assumption was tested by comparing the ratios of marked to unmarked fish at times of release and return. There was an increase in ratios with age. This seemed to indicate that marking caused a delaying effect on the age of maturity. Also, the marked to unmarked ratios at the time of return for all ages combined were smaller than for those at release. This indicates a lower total survival for marked fish. For example, the survival of 1961-brood Ad-RM marked fish, based on data for all study hatcheries, was 56.2 percent of that for the unmarked fish. The increase with age of the marked to unmarked ratios indicates that marking had some delaying effect on the age of maturity of the 1961 brood. The 1962 and 1963 broods showed trends similar to the 1961 brood in delayed maturity and increased mortality for the marked fish.

Data for the 1964 brood related to assumption 4 are shown in table 11. These data also point toward delayed maturity and increased mortality for marked fish. The proportions of marked fish fluctuated sharply for all study hatcheries and for Spring Creek between ages 2 and 3. The proportion of Kalama marked fish showed the most uniform increase with age and the selected hatcheries showed the largest increase with age.

Table 11.--Marked to unmarked ratios for hatchery returns of 1964-brood fall chinook salmon by type of mark and age of fish

Mark	Origin	Age (years)				
		2	3	4	5	All ages
		-----Marked/unmarked-----				
Ad-LM	All study hatcheries	0.301	0.033	0.054	0.114	0.046
Ad-RV-LM	Kalama	0	0.007	0.013	0.043	0.022
Ad-LV-LM	Spring Creek	0.149	0.022	0.048	0.333	0.029
Ad-LM	Selected hatcheries ^{1/}	0.033	0.042	0.068	0.483	0.053

^{1/} Cascade, OxBow, Little White Salmon and Spring Creek hatcheries.

Survival of marked fish relative to unmarked was significantly lower for the 1962 and 1963 broods than for the 1961 brood, and this trend continued in the 1964 brood. Survival for the Ad-LM marked fish based on data for all study hatcheries was $(0.046/0.1175) 100 = 39.1$ percent and for the four selected hatcheries $(0.053/0.1175) 100 = 45.1$ percent. Percentages for the 1961 brood were 56.2 and 60.4, for the 1962 brood 38.7 and 43.9, and for the 1963 brood 36.4 and 37.2.

Possible effects of straying on the survival of marked fish relative to unmarked were calculated using the same general formula that was used for the 1961 brood (Worlund et al.). Table 12 shows escapement recoveries and strays for Bonneville, Kalama, Spring Creek and Little White Salmon hatcheries. Percentages of marked fish straying from the four hatcheries were 8.7, 4.9, 9.6 and 21.2, respectively.

Calculations to find the probable number of nonhatchery fish that strayed into the four hatcheries between Bonneville and The Dalles dams (Spring Creek, Little White Salmon, OxBow and Cascade) are summarized in table 13. The number of nonhatchery strays is estimated to be 1,075. This number is used to adjust for the possible effects such strays would have on the calculated survival differential between marked and unmarked hatchery fish.

No definite information is available to explain the variation in mortality of marked fish in the four broods, but there are a number of separate observations that can be combined to postulate a plausible hypothesis.

Table 12.--Escapement recoveries of marked chinook salmon of 1964 brood by location of release and recovery and age at capture, 1966-69

Recovery location ^{2/}	Release location ^{1/}															
	Bonneville				Kalama				Spring Creek				Little White			
	Age				Age				Age				Age			
	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
	-----Number of fish-----															
Grays River.....																
Big Creek.....													1	0	0	0
Plympton.....																
Elokomin.....																
Abernathy.....																
Toutle.....																
Kalama.....					0	1	14	24								
East Lewis.....																
North Lewis.....					2	0	0	0								
Washougal.....																
Tanner Creek (Bonneville).....	0	0	18	3					0	6	8	0	0	0	2	0
Eagle Creek (Cascade).....	0	0	2	0					0	3	1	0	1	0	0	0
Herman Creek (OxBow).....									0	1	1	0				
Wind River.....																
Little White Salmon.....									0	1	1	0	1	2	22	1
Spring Creek.....									21	77	105	3	0	0	1	2
Big White Salmon.....																
Klickitat.....																
Total.....	0	0	20	3	2	1	14	24	21	88	116	3	3	2	25	3
Number of strays.....	0	0	2	0	2	0	0	0	0	11	11	0	2	0	3	2
Percentage of strays.....	0	0	10.0	0	100.0	0	0	0	0	12.5	9.5	0	66.7	0	12.0	66.7
Percentage of strays (all ages)	-----8.7-----				-----4.9-----				-----9.6-----				-----21.2-----			

1/ Bonneville: LV-LM; Kalama: Ad-RV-LM and Ad-RV; Spring Creek: Ad-LV-LM and Ad-LV; Little White: RV-LM.

2/ Recoveries in tributary streams were adjusted on the basis of the appropriate sampling ratios.

Table 13.--Estimated number of nonhatchery chinook salmon of 1964 brood spawned at four hatcheries^{1/} between Bonneville and The Dalles dams, 1966-69

Item	Year of run				Total
	1966	1967	1968	1969	
Count at Bonneville Dam ^{2/}	135,095	160,434	139,354	202,604	637,487
Count at The Dalles Dam ^{2/}	69,018	114,316	76,991	130,465	390,790
Hatchery returns ^{1/}	31,021	16,911	15,606	19,503	83,041
Catch ^{3/}	7,008	35,146	26,177	44,571	112,902
Bonneville count minus The Dalles count minus hatchery return minus catch	28,048	0 ^{4/}	20,580	8,065	50,754
Percent of 1964 brood ^{5/}	15.1	40.1	35.1	1.5	
Number of 1964 brood year not straying	4,235	0	7,224	121	11,580
Percent straying ^{6/}	8.7	12.4	8.5	0	
Estimated number of 1964-brood fish straying into four hatcheries ^{1/}	404	0	671	0	1,075

1/ Spring Creek, Little White Salmon, OxBow and Cascade hatcheries.

2/ Counts for period August 26 to September 30.

3/ Chinook salmon catch between Bonneville and The Dalles dams for period August 27 to September 30. Sport catch not included.

4/ The zero is used to indicate that there were no nonhatchery fish left in the Bonneville pool area to stray into the hatcheries. The remainder is actually a negative number (-5,939).

5/ Estimated age composition from fishery samples.

6/ Estimates from Spring Creek mark (Ad-LV-LM) and Kalama mark (Ad-RV-LM) combined, table 12.

Various observations and experiments have indicated that marked fish are definitely handicapped by the loss of a fin or maxillary bone. Conceivably, if a group of marked and unmarked fish experienced stress common to the group, mortalities would occur first among the marked fish. Hatchery fish of the 1962 brood were known to be of somewhat lower vitality than the other three broods, because of feed and disease problems. The added stress of marking could have been the deciding factor that increased the mortality of the 1962 brood as compared with the 1961 brood.

Mortalities for the 1963 and 1964 broods were also high compared with the 1961 brood. These mortalities may have been related quite directly to a mark-induced handicap. The maxillary marks for the 1961 and 1962 broods were made by removing only the tip of the maxillary bone, but this resulted in a relatively high occurrence of maxillary regeneration (Worlund, et al.). A major portion of the maxillary bone was removed for the 1963 and 1964 broods, in an attempt to inhibit regeneration. Maxillary regeneration was reduced but mortality apparently increased. There are indications that the loss of a maxillary bone is a serious handicap for marked fish. This would explain the high mortalities for relatively healthy broods of fish. This problem would be worth investigation in future studies with marked fish.

Total returns of marked (Ad-LM and Ad only) and unmarked hatchery fish to the four hatcheries are listed in appendix table 2. The returns were 588 marked and 11,003 unmarked fish. Adjusting for the estimated non-hatchery strays, the total number of unmarked fish would be 11,003 minus 1,075 = 9,928 fish. Using the adjusted figure, the marked to unmarked ratio would be $588/9928 = 0.059$. Expressed in percent, the survival of marked fish relative to unmarked would be $(0.059/0.1175) 100 = 50.4$ percent.

The calculations established a range of survival values of marked fish relative to unmarked, with a median of 44.8 percent. Based on this median, the estimated total catch of 1964-brood hatchery fish is presented in table 14. The estimated catch of 262,371 fish comprised about 10.9 percent of the total catch of 1964-brood fall chinook salmon in the fisheries sampled.

Salmon carcasses that remain at the hatcheries after removal of spawn are used in several ways. These include sale to commercial processors and donation to various institutions and groups. These fish have been omitted from the catch estimates because they were not taken in the fisheries. They are included in the final estimate of the total harvest value of the 1964-brood fall chinook salmon that originated in Columbia River hatcheries.

Table 14.--Estimated catch of hatchery fall chinook salmon of 1964 brood by type of fishery and year of capture, 1966-69

Fishery type	Year of catch				Total
	1966	1967	1968	1969	
	-----Number of fish-----				
Ocean sport	15,603	38,934	8,640	10	63,187
Ocean commercial	1,033	94,214	49,345	2,132	146,724
Columbia River sport	0	0	17	0	17
Columbia River commercial	575	21,256	26,845	4,039	52,715
Total	17,211	154,404	84,847	6,181	262,643

ESTIMATED VALUE OF CATCH FOR 1964-BROOD HATCHERY FISH

The cost of producing fish released from the 12 hatcheries was estimated from 1965 fiscal year costs at individual hatcheries. Costs were apportioned between the brood year-species groups at each hatchery on the basis of estimated relative man-hours expended and relative size of each group. At each hatchery costs were divided into three categories:

- 1) Amortized and discounted capital investment
- 2) Fish food and drugs
- 3) Operational costs other than food

Capital investment in the hatcheries was amortized over 50 years (2 percent per annum) and was also charged a simple interest rate of 5 percent per annum, which amounts to 7 percent of the total capital investment chargeable to each year's operation. This 7 percent was then apportioned among the broods and species present by using the percentage of time spent caring for each group of fish. Cost of fish food and drugs during the fiscal year was apportioned according to the pounds of each brood year-species group produced. Operational cost other than food and drugs was apportioned in the same manner as capital investment. Total cost of production of 1964-brood fall chinook at the 12 study hatcheries was calculated to be \$837,750.

For commercially caught fish, the economic value was determined from estimated landings and average prices paid to fishermen in 1966-69. We treated this as a net economic value for the same reasons as presented in the report for the 1961 brood.

Estimation of net value for the catch of hatchery chinook salmon by sport fishermen was made from an accepted net value per fish of \$8.87.^{4/}

Calculation of total net value of the commercial and sport catch of fall chinook salmon that originated from the hatcheries under study is shown in table 15. The net value is estimated to be \$1,820,750.

The economic value of salmon carcasses was determined from the average price paid by commercial processors. Donations to various institutions and groups were valued at the same price. The estimated value of these fish is \$42,000; so the total harvest value of fall chinook salmon originating from the hatcheries under study is estimated to be \$1,862,750.

The benefit-to-cost ratio is obtained from the ratio \$1,862,750/\$837,750, and is estimated as 2.2:1.

We assumed that the 6.2 million fish released from 6 other hatcheries not included in the study contributed to the fisheries in the same proportion as the 46.8 million from the study hatcheries. Based on this assumption, the estimated contribution of the 6 hatcheries is 34,795 fish, with a net value of \$241,213.

Based on the preceding estimates, the total value of the harvest of 1964-brood fall chinook salmon originating from all the Columbia River hatcheries is an estimated \$2,103,963.

SUMMARY

- 1) During the 4 years of marking at 12 hatcheries, 21.3 million fish (10 percent of the total production of 213 million) were marked with an adipose-maxillary mark. An additional 9.6 million were identified with special marks unique to a hatchery.
- 2) The 1964-brood release of 46.8 million fish included 4.6 million marked with a "common mark" (Ad-IM). Fish with marks unique to a hatchery were released from Spring Creek, Kalama, Bonneville and Little White Salmon hatcheries.
- 3) During the 4 years of mark sampling, which included 1964-brood fish (1966-69), an average of 18.4 percent of the chinook salmon catch was examined for marked fish.

^{4/} U.S. Department of the Interior, Bureau of Commercial Fisheries, Division of Economics, 1966. An economic evaluation of Columbia River anadromous fish programs. 52 pp. (Processed.)

- 4) Sampling for marked fish was conducted in most chinook fisheries, with a few exceptions, from Avila Beach, California to Pelican, Alaska. During the years indicated, there was no sampling in the following fisheries: 1966, British Columbia purse seine and southeast Alaska gill net; 1967, southeast Alaska gill net; 1968 and 1969, southeast Alaska troll and gill net.
- 5) A total of 4,862 marked fish from the 1964 brood of possible Columbia River hatchery origin were recovered during the 4 years. The majority, 2,663, were recovered as age-3 fish in 1967.
- 6) Although marked fish were recovered in the ocean fisheries over the entire range of sampling, most were recovered from landings made north of the Columbia River mouth (Washington and west coast of Vancouver Island fisheries).
- 7) Seventy-one percent of the Kalama marks were recovered in the British Columbia troll fisheries compared with 51 percent for Little White Salmon hatchery and a 40 percent average for all the hatcheries.
- 8) An estimated total of 12,825 marked (Ad-LM) fish that originated from the 12 study hatcheries was caught. An additional 856 escaped the fisheries and returned to spawn.
- 9) The catch ratio of Ad-LM marked fish from all 12 hatcheries in terms of numbers released was 2.76 per 1,000.
- 10) By assuming that marked and unmarked hatchery fish have the same ocean distribution, and that relative survival of marked fish was 44.8 percent of the survival of unmarked fish, it was estimated that the total catch of hatchery fish (marked and unmarked) was 262,643.
- 11) The estimated catch of hatchery fish, 262,643, comprised about 10.9 percent of the total catch of 1964-brood fall chinook salmon in the fisheries sampled.
- 12) The estimated cost of rearing the fall chinook salmon of the 1964 brood released from the study hatcheries was \$837,750. The estimated harvest value of these fish was \$1,862,750. The benefit-to-cost ratio, therefore, was 2.2:1.
- 13) The estimated total value of the harvest of fall chinook salmon of 1964 brood that originated from all Columbia River hatcheries (including 6 hatcheries not participating in the marking experiment) was \$2,103,963.

Table 15.--Estimated value of the catch of fall chinook salmon of 1964 brood released from twelve study hatcheries, by type of fishery

Fishery	Age	Fish	Sample size		Average weight ^{1/}		Total weight		Value per unit catch ^{2/}	Total value
			Number	Number of fish	Lbs.	Kg.	Lbs.	Kg.	Dollars	Dollars
Sport.....	All	63,204	-----	-----	-----	-----	-----	8.870 ^{3/}	560,619	
Ocean commercial.....	2	1,033	71 ^{4/}	5.93	2.69	6,126	2,779	.400	2,450	
	3	94,214	561	9.40	4.26	885,612	401,352	.470	416,238	
	4	49,345	129	12.15	5.51	599,542	271,891	.735	440,663	
	5	2,132	80 ^{5/}	20.78	9.43	44,303	20,105	.800	35,442	
	Columbia River commercial	2	575	8	5.39	2.40	3,099	1,380	.352	1,091
	3	21,256	199	17.50	7.94	371,980	168,773	.347	129,077	
	4	26,845	340	22.43	10.17	602,133	273,014	.326	196,295	
	5	4,039	39	27.50	12.47	111,072	50,366	.350	38,875	
Total.....		262,643	2,623,867	1,820,750	

^{1/} Weights for ocean commercial fisheries are dressed weights, and those for Columbia River fisheries are round weights. Original weights were in pounds for Ad-LM and Ad marked fish.

^{2/} Entries for commercial fisheries (dollars per pound) are based on prices paid for Washington State troll landings, obtained from Dale Ward, Washington Department of Fisheries (personal communication).

^{3/} U.S. Department of the Interior, Bureau of Commercial Fisheries, Division of Economics, 1966. An economic evaluation of Columbia River anadromous fish programs. 52 pp. (Processed.)

^{4/} Weights are for unmarked fish. Insufficient sample of marked fish.

^{5/} Weights are for Ad-LM, Ad, and unmarked fish.

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Appendix Table 1.--Key to tables common to evaluation reports
for 1961-, 1962-, 1963- and 1964-brood
fall chinook salmon

Table number			
Brood year 1964	Brood year 1963	Brood year 1962	Brood year 1961
1	1	--	--
2	2	--	2
3	3	1	4
4	4	2	6
5	5	3	7
6	6	4	8
7	7	5	9
8	8	6	10
9	9	7	12
10	10	8	13
11	11	10	14
12	12	11	15
13	13	12	16
14	14	13	17
15	15	14	20

Appendix Table 2.--Marked and unmarked returns of fall chinook salmon of 1964 brood year to Columbia River hatcheries and tributary streams--Continued

Recovery location	Group	Year of return			
		1966	1967	1968	1969
-----Number of fish-----					
Hatcheries--Continued					
Spring Creek.....	Unmarked	1,413	3,437	2,202	9
	Ad-LM	38	129	172	8
	Ad	5	27	44	10
	Ad-LV-LM	20	67	92	3
	Ad-LV	1	10	13	0
	LV	0	0	1	0
	RV-LM	0	0	1	2
	RV	0	0	0	1
OxBow.....	Unmarked	118	310	137	7
	Ad-LM	8	5	7	0
	Ad	0	2	0	0
	Ad-LV-LM	0	1	1	0
	LV	0	1	0	0
Klickitat.....	Unmarked	0	64	22	0
	Ad-LM	0	0	1	0
Toutle.....	Unmarked	228	1,111	1,150	210
Abernathy.....	Unmarked	273	615	384	5
	Ad-LM	0	0	2	0
Speelyai.....	Unmarked	410	5	0	0
	Ad-RV-LM	1	0	0	0
	Ad-RV	1	0	0	0
Tributary streams:					
Grays River.....	Unmarked	0	(*)	(*)	(*)
Big Creek.....	Unmarked	14	(*)	(*)	(*)
Kalama.....	Unmarked	48	(*)	(*)	(*)
Washougal.....	Unmarked	0	(*)	(*)	(*)
Little White Salmon.....	Unmarked	5	(*)	(*)	(*)
Big White Salmon.....	Unmarked	60	(*)	(*)	(*)
Klickitat.....	Unmarked	157	(*)	(*)	(*)
East Fork Lewis.....	Unmarked	1,034	(*)	(*)	(*)
Wind River.....	Unmarked	0	(*)	(*)	(*)
Plympton.....	Unmarked	8	(*)	(*)	(*)
Elokomin.....	Unmarked	68	(*)	(*)	(*)

*Not sampled.

**No fall chinook salmon collected for spawning.

Appendix Table 2.--Marked and unmarked returns of fall chinook salmon of 1964 brood year to Columbia River hatcheries and tributary streams

Recovery location	Group	Year of return			
		1966	1967	1968	1969
-----Number of fish-----					
Hatcheries:					
Grays River.....	Unmarked	13	(**)	80	5
	Ad-LM	0	(**)	6	0
Big Creek.....	Unmarked	52	826	387	5
	Ad-LM	1	5	13	6
	Ad	0	0	2	1
	RV-LM	1	0	0	0
Elokomin.....	Unmarked	72	571	262	7
	Ad-LM	0	3	20	0
	Ad	0	0	2	0
Kalama.....	Unmarked	27	138	1,044	557
	Ad-LM	0	4	18	24
	Ad	0	0	7	5
	Ad-RV-LM	0	1	10	22
	Ad-RV	0	0	4	2
	RV	0	0	0	1
Washougal.....	Unmarked	6	(**)	(**)	(**)
	Ad-LM	1	(**)	(**)	(**)
Bonneville.....	Unmarked	134	609	2,508	126
	Ad-LM	4	12	90	21
	Ad	0	5	14	1
	Ad-LV-LM	0	6	8	0
	LV-LM	0	0	18	3
	LV	0	0	0	2
	RV-LM	0	0	2	0
	RV	0	0	1	0
	Little White Salmon.....	Unmarked	62	448	927
Ad-LM	1	12	34	4	
Ad	2	3	5	4	
Ad-LV-LM	0	1	1	0	
RV-LM	1	2	22	1	
RV	0	0	1	0	
Cascade.....	Unmarked	181	617	1,091	19
	Ad-LM	4	23	31	2
	Ad	0	3	4	1
	Ad-LV-LM	0	3	1	0
	LV-LM	0	0	2	0
	RV-LM	1	0	0	0

