

# DISTRIBUTION IN MARINE FISHERIES OF MARKED CHINOOK SALMON FROM THE COLUMBIA RIVER HATCHERY PROGRAM, 1963-66

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## Abstract

Preliminary data from the hatchery evaluation program of Columbia River system hatcheries were analyzed to determine the distribution of marked fall chinook salmon from different sources in the marine fisheries. Estimated catches of marked fish in 1963-66 from the 1961-64 broods were tabulated by type of fishery and port or zone of recovery.

Differences in distribution from north to south were detected between fish from different hatcheries and ocean ages. Only Kalama River fish demonstrably reached Alaskan waters, but fish from nearly all hatcheries were found as far south as northern California. The relative contributions of marked fish from different hatcheries to the marine fisheries varied considerably.

Specific differences among hatcheries in availability of fish to ocean sport and troll fisheries also were detected for ports between Newport, Oregon, and Neah Bay, Washington. Apparent intraseasonal movements of Spring Creek and Kalama River fish during 1964 and 1965 agreed in some respects, but not in others, with the known schedules of their return to the Columbia River.

## Introduction

Annual releases since 1950 of fall chinook salmon (*Oncorhynchus tshawytscha* Walbaum) from 19 hatcheries along the lower 180 miles of the Columbia River and its tributaries have averaged about 70 million fish. No estimates of their economic value were available, however, until the recent finding that the 1961 brood, which cost \$832,000 to rear, was worth \$1.9 million to commercial and sport fishermen in 1963-66 (Worlund, Wahle, and Zimmer, 1969).

This preliminary estimate emerged from a study of the 31 million fingerlings of the 1961-64 broods that were marked and released at 12 stations to assess the bioeconomic contribution of Columbia River hatcheries to the North American catch of chinook salmon. Sampling for marked fish began in certain fisheries off Oregon and Washington during 1963, was expanded during 1964 from California to Alaska, and was continued through 1969 except in Alaska (Figure 1).

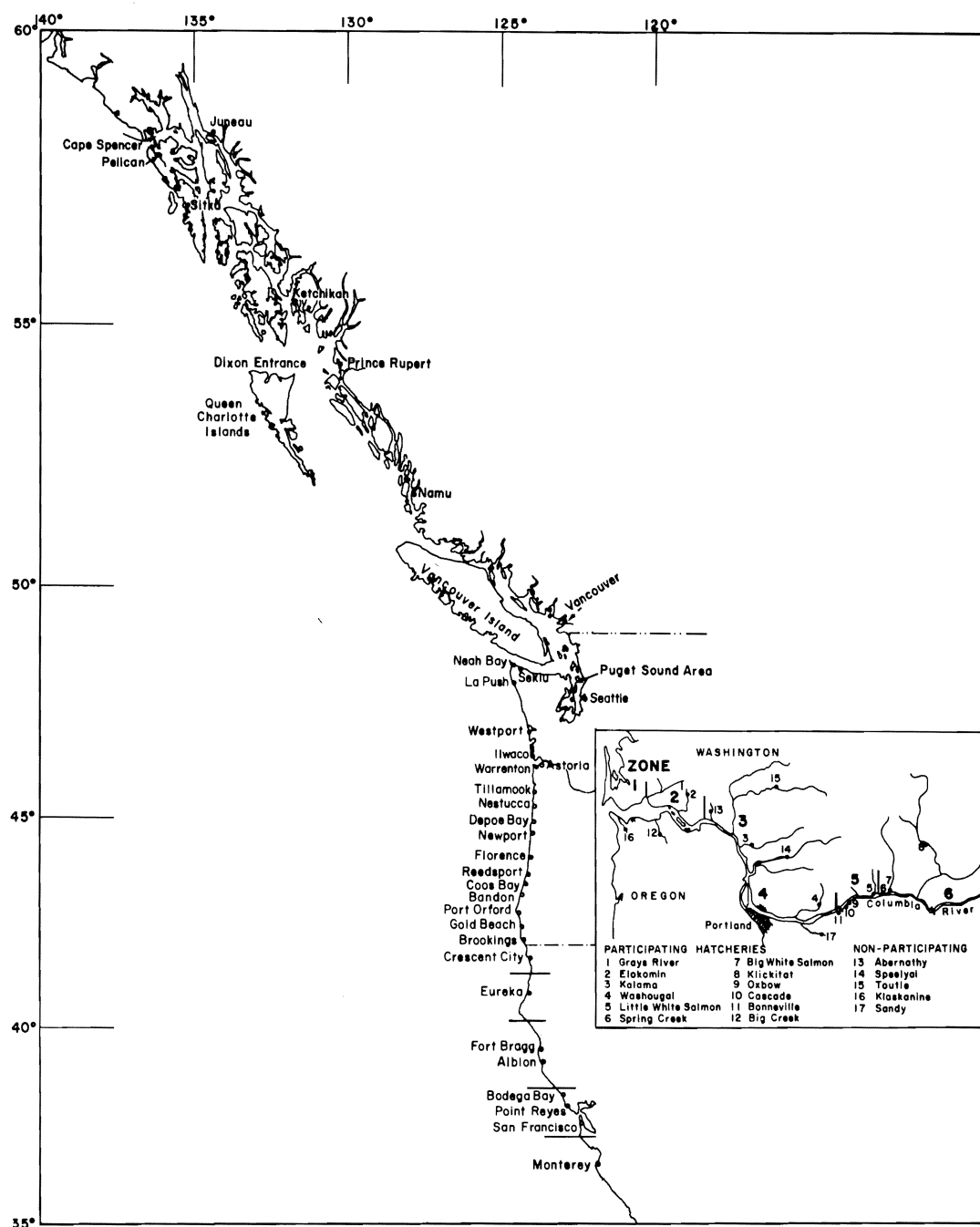
The experimental design of the evaluation program (Worlund *et al.*, 1969) involved releases from 12 hatcheries (the "hatchery complex") with a common, brood-specific mark. In addition, fish with hatchery-specific marks were released from each brood from four of the stations with the

restriction that releases from Kalama River and Spring Creek hatcheries (Figure 1) be identifiable by brood year during the recovery phase. These two hatchery-specific marks provided continuing comparisons for the 1961-64 broods. Different marks were released from each brood at two other hatcheries and provided brood-specific comparisons with Spring Creek, Kalama River, and the hatchery complex.

Cleaver (1969) investigated the effects of ocean fishing on hatchery stocks of fall chinook salmon, both historically and on the basis of data from the evaluation program for the 1961 brood. He estimated hatchery-specific differences in potential yield from computed rates of ocean growth and mortality, but also considered variations in marine distribution. Marked fish were recovered from California to Alaska, but mainly off Washington and British Columbia; only fish from Kalama River hatcheries were shown conclusively to range as far north as Alaska.

The present report compares individual hatcheries and the hatchery complex with respect to availability of marked fish from the 1961-64 broods, as sampled in marine fisheries during 1963-66. First, annual centers of abundance are inferred even though exploitation rates are unknown and may vary regionally. Preliminary comparisons

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**Figure 1. Sampling areas in marine fisheries and release locations (inset) for the Columbia River hatchery evaluation program.**

are next made between offshore troll and inshore sport fisheries which operate from the same ports in Oregon and Washington. Finally, intraseasonal movements during 1964 and 1965 are examined for the 1961 brood.

### Description of Source Data

The estimated catch of marked hatchery chinook in ocean fisheries during 1963-66, as determined from the evaluation program, is shown in Tables 1-4 by port or zone of landing for the 1961-64 broods (Bureau of Commercial Fisheries, 1964-68).

Worlund *et al.* (1969) analyzed observations and experiments regarding fin regeneration in relation to the occurrence of complete and partial marks in the fisheries and hatcheries. They reported negligible occurrence of naturally missing fins in hatchery releases (only 156 in over 30 million fish examined during marking of the 1961-64 broods). The following results also were reported for marked fish held in salt-water ponds for periods of up to 34 months after marking: (1) no regeneration of the adipose fin; (2) partial regeneration of the ventral fin in substantial portions (to 47%) of the fish held in each group; and (3) complete regeneration of the maxillary bone in 7-12% of the fish held from the 1961-62 broods (only the tip removed), and in 1-3% of the fish held from the 1963-64 broods (about half the bone removed). The authors concluded that maxillary regeneration explained most of the adipose-ventral and adipose-only marks recovered, but that maxillary regeneration or naturally missing ventral fins explained most ventral-only marks recovered.

On this basis, fish with adipose-only marks were assigned in Tables 1-4 to the hatchery complex. Fish with ventral-only marks, while indicated in the tables to complete the record through 1966 by port of landing, were considered to be only of "possible" hatchery origin and were excluded from all other marks ("known" and "probable"). Actual analysis, therefore, is

based on estimated recoveries in the last column of each of Tables 1-4 (i.e., "Total less ventral-only").

### North-South Distribution

The distribution of marked hatchery fish in the commercial and sports fisheries cannot be given quantitatively from estimated annual catches (Tables 1-4). One reason is that the fisheries take hatchery (and native) stocks selectively with respect to time, size, and area; for instance, recruitment begins about 1 year after survivors of a released group of fish reach the estuary, and is mainly in the sport fisheries, which have lower legal size limits than troll fisheries.<sup>①</sup> Another reason is that fishing intensity and rate of exploitation were not measured for the various fisheries along the coast for the years in question. Yet appropriate analysis of the data in Tables 1-4 yields useful comparisons among hatcheries.

The distribution among sampled fisheries of all marked fish caught each year from every hatchery source is given in Table 5 from the 1961-64 broods. The estimated total catch of Spring Creek marks (Ad-LV-RM and Ad-LV) of the 1961 brood during 1963, for example, was  $(0 + 4) + (46 + 39) + (43 + 24) + (0 + 4) = (89 + 71) = 160$  (Table 1). These catches, shown in Table 5, were distributed as follows: 4, or 2%, in the Oregon sport fishery; 85, or 53%, in the sport fishery off the mouth of the Columbia River; 67, or 42%, in the Washington ocean sport fishery north of Ilwaco; and 4, or 2%, in the Washington troll fishery. The annual contri-

<sup>①</sup> D. D. Worlund (personal communication) notes that data from the evaluation program might be used to make forecasts of the contribution from a specific hatchery at relatively low cost. If the total catch (at all ages in all fisheries) of marked fish from one hatchery (say Spring Creek) is highly correlated in the 1961-64 broods with the partial catch of marked fish at age .1 in sport landings at one port (say Ilwaco), then part of the future releases at that hatchery could be marked and sport landings at that port monitored rather inexpensively as a basis for prediction.

**Table 1. Estimated catch in marine fisheries during 1963-66 of 1961-brood chinook salmon with known, probable, and possible hatchery marks**

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Elo- komin		Oxbow			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- RM	Ad	Ad- LV- RM	Ad- LV	Ad- RV- RM	Ad- RV	LV- RM	LV	RV- RM	RV		
1963	Oregon, sport	Reedsport .....	0	0	0	4	0	0	0	0	0	0	4	4
	Columbia River mouth, sport	Warrenton-Ilwaco .....	201	99	46	39	3	0	0	0	7	4	399	395
	Washington, Ocean sport	Neah Bay .....	73	5	0	5	0	0	0	0	0	6	89	83
		LaPush .....	22	35	8	0	0	0	0	0	0	0	65	65
		Westport .....	79	57	35	19	14	4	0	12	4	0	224	212
		Total .....	174	97	43	24	14	4	0	12	4	6	378	360
	Washington, troll	LaPush- Westport .....	0	3	0	4	0	0	0	0	0	0	7	7
	All	All .....	375	199	89	71	17	4	0	12	11	10	788	766
1964	California, troll	Crescent City .....	0	0	3	2	2	0	0	0	0	0	7	7
		Eureka .....	2	0	0	8	0	0	7	0	0	0	17	17
		Ft. Bragg .....	21	0	6	0	0	0	0	0	0	0	27	27
		San Francisco .....	0	0	6	0	0	0	0	0	0	0	6	6
		Total .....	23	0	15	10	2	0	7	0	0	0	57	57
	Oregon, sport	Depoe Bay .....	3	0	0	2	0	0	0	0	15	0	20	20
		Newport .....	49	10	5	16	0	0	0	5	3	3	91	83
		Florence .....	4	27	0	0	0	0	0	0	0	0	31	31
		Reedsport .....	10	49	0	26	0	0	0	6	0	0	91	85
		Coos Bay .....	3	7	0	0	0	0	3	0	0	0	13	13
		Brookings .....	3	0	0	0	0	0	0	0	0	2	5	3
		Total .....	72	93	5	44	0	0	3	11	18	5	251	235

Table 1. Continued

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Elo- komin		Oxbow			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- RM	Ad	Ad- LV- RM	Ad- LV	Ad- RV- RM	Ad- RV	LV- RM	LV	RV- RM	RV		
1964	Oregon, troll	Astoria .....	229	10	40	0	6	0	5	3	0	3	296	290
		Tillamook .....	4	1	0	0	2	0	0	0	0	0	7	7
		Nestucca .....	1	0	0	0	0	0	0	0	0	0	1	1
		Depoe Bay .....	3	1	1	0	0	0	0	0	1	0	6	6
		Newport .....	24	27	8	1	6	0	3	0	2	0	71	71
		Florence .....	39	0	15	0	0	0	0	4	4	1	63	58
		Reedsport .....	10	0	0	0	0	0	0	0	0	0	10	10
		Coos Bay .....	13	5	6	5	3	2	1	5	7	13	60	42
		Bandon .....	1	0	2	2	0	1	0	1	1	3	11	7
		Port Orford .....	0	1	0	0	1	0	0	0	1	1	4	3
		Brookings .....	0	0	1	0	0	0	0	0	4	0	5	5
	Total .....	324	45	73	8	18	3	9	13	20	21	534	500	
	Columbia River mouth, sport	Warrenton-Ilwaco .....	86	37	25	20	6	4	0	5	8	6	197	186
	Washington, ocean sport	Seki .....	540	28	114	12	18	0	0	0	17	0	729	729
Neah Bay .....		201	38	27	20	9	0	0	9	0	9	313	295	
LaPush .....		26	8	3	5	0	0	0	0	0	0	42	42	
Westport .....		828	113	185	20	41	0	8	41	18	37	1,291	1,213	
		Total .....	1,595	187	329	57	68	0	8	50	35	46	2,375	2,279
	Washington, troll	Neah Bay .....	861	149	208	64	74	0	12	22	17	11	1,418	1,385
LaPush .....		565	78	262	121	14	7	4	11	4	0	1,066	1,055	
Westport .....		1,424	121	312	26	30	10	27	14	29	11	2,004	1,979	
Ilwaco .....		386	49	87	4	14	0	2	17	8	7	574	550	
		Total .....	3,236	397	869	215	132	17	45	64	58	29	5,062	4,969
	Washington, gill net	Neah Bay- Clallam Bay .....	5	0	0	0	0	0	0	0	0	0	5	5

1965	British Columbia, gill net	Zone 42 .....	4	4	0	0	0	0	0	0	0	0	8	8
	British Columbia, purse seine	Zone 40 .....	2	4	0	0	0	0	0	0	0	0	6	6
	British Columbia, troll	Alaska area .....	0	2	0	0	0	0	0	0	0	0	2	2
		Zone 43 .....	80	37	0	2	29	9	0	8	0	14	179	157
		Zone 42 .....	48	23	6	0	18	0	0	9	0	13	117	95
		Zone 40 .....	3,972	496	761	72	373	12	28	43	8	32	5,797	5,722
		Total .....	4,100	558	767	74	420	21	28	60	8	59	6,095	5,976
	Southeastern Alaska, commercial	Zone 11 .....	0	0	0	0	5	0	0	0	0	0	5	5
		Zone 13 .....	0	0	0	0	0	0	0	2	0	0	2	0
		Zone 14 .....	0	2	0	0	0	0	0	2	0	0	4	2
		Total .....	0	2	0	0	5	0	0	4	0	0	11	7
	All	All .....	9,447	1,327	2,083	428	651	45	100	207	147	166	14,601	14,228
1965	California, sport	Eureka .....	0	0	0	0	0	0	0	0	2	0	2	2
	California, troll	Crescent City .....	0	0	0	0	0	0	0	8	0	17	25	0
		Eureka .....	0	0	0	0	0	0	0	0	0	22	22	0
		Ft. Bragg .....	0	4	0	0	0	0	0	13	0	27	44	4
		San Francisco .....	0	0	0	0	0	0	0	0	0	5	5	0
		Total .....	0	4	0	0	0	0	0	21	0	71	96	4
	Oregon, sport	Depoe Bay .....	2	0	0	0	0	0	0	0	0	0	2	2
		Reedsport .....	24	16	0	4	0	0	0	0	4	5	52	48
		Gold Beach .....	0	0	0	0	0	0	0	0	0	2	2	0
		Brookings .....	0	0	0	0	0	0	0	0	0	2	2	0
		Total .....	26	16	0	4	0	0	0	0	4	9	58	50
	Oregon, troll	Astoria .....	0	3	4	2	0	0	0	2	0	0	11	9
		Tillamook .....	0	0	12	0	0	0	0	0	0	0	12	12
		Newport .....	7	4	0	0	0	0	3	1	2	0	17	16
		Florence .....	2	0	0	2	0	0	0	0	0	0	4	4
		Reedsport .....	0	2	0	0	0	0	0	0	0	0	2	2
		Coos Bay .....	0	0	0	0	3	0	0	0	0	0	3	3
		Brookings .....	1	3	0	0	1	0	0	2	0	1	8	5
		Total .....	10	12	16	4	4	0	3	5	2	1	57	51

Table 1. Continued

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Elo- komin		Oxbow			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- RM	Ad	Ad- LV- RM	Ad- LV	Ad- RV- RM	Ad- RV	LV- RM	LV	RV- RM	RV		
1965	Columbia River mouth, sport	Warrenton-Ilwaco .....	93	26	8	21	21	8	0	14	0	0	191	177
	Washington, ocean sport	Sekiu .....	48	7	11	0	13	0	0	6	0	0	85	79
		Neah Bay .....	32	6	6	0	13	0	7	0	0	0	64	64
		LaPush .....	9	0	0	0	0	0	0	0	0	0	9	9
		Westport .....	234	65	27	24	25	20	8	7	0	21	431	403
		Total .....	323	78	44	24	51	20	15	13	0	21	589	555
	Washington, troll	Neah Bay .....	145	5	9	0	28	4	0	4	0	9	204	191
		LaPush .....	78	23	27	0	13	0	0	11	0	0	152	141
		Westport .....	201	22	40	0	68	2	5	7	9	5	359	347
		Ilwaco .....	23	4	0	4	9	12	0	0	0	0	52	52
		Total .....	447	54	76	4	118	18	5	22	9	14	767	731
	Washington, gill net	Grays Harbor .....	8	5	2	0	4	2	0	0	0	0	21	21
	British Columbia, gill net	Zone 42 .....	23	0	0	0	0	0	0	0	0	0	23	23
	British Columbia, troll	Alaska area .....	0	2	0	0	0	0	0	0	0	0	2	2
		Zone 43 .....	71	33	0	0	35	8	0	3	0	0	150	147
		Zone 42 .....	47	59	0	0	59	0	0	0	2	7	174	167
		Zone 41 .....	113	0	0	0	0	0	0	0	0	5	118	113
		Zone 40 .....	1,617	276	140	24	361	17	7	43	14	39	2,538	2,456
		Total .....	1,848	370	140	24	455	25	7	46	16	51	2,982	2,885

	S.E. Alaska, gill net troll	Various .....	0	3	0	0	0	0	0	3	0	0	6	3
		Zones 1, 3, 4 .....	0	0	0	0	10	4	0	23	0	33	70	14
		Zones 5, 8 .....	0	0	0	0	0	0	0	3	0	0	3	0
		Zones 9-13 .....	7	5	0	0	0	12	0	3	0	0	27	24
		Zones 10-12, 15 .....	0	10	0	0	0	0	0	3	0	0	13	10
		Zones 14, 18, 22 .....	0	5	0	0	4	5	0	16	0	8	38	14
		Total .....	7	23	0	0	14	21	0	51	0	41	157	65
	All	All .....	2,785	588	286	81	667	94	30	172	33	208	4,944	4,564
1966	California, troll	Crescent City .....	0	0	0	0	0	0	0	0	0	3	3	0
		Eureka .....	6	0	0	0	0	0	0	0	0	0	6	6
		Total .....	6	0	0	0	0	0	0	0	0	3	9	6
	Columbia River mouth, sport	Warrenton-Ilwaco .....	22	5	0	0	5	0	0	0	0	0	32	32
	Washington, ocean sport	Sekiu .....	0	0	0	0	0	0	0	0	0	11	11	0
		Neah Bay .....	5	6	0	0	0	0	0	0	5	0	16	16
		Westport .....	40	4	0	0	0	4	0	0	4	0	52	52
		Total .....	45	10	0	0	0	4	0	0	9	11	79	68
	Washington, troll	Seattle .....	2	4	0	0	0	0	0	0	0	0	6	6
		Neah Bay .....	9	2	0	0	5	0	0	5	0	2	23	16
		LaPush .....	21	0	0	0	0	0	0	0	0	3	24	21
		Westport .....	9	2	0	0	2	0	3	0	0	0	16	16
		Total .....	41	8	0	0	7	0	3	5	0	5	69	59
	Washington, gill net	Willapa Hbr. ....	0	0	0	0	0	0	0	5	0	3	8	0
	Puget Sound, sport	Zone 11 .....	0	0	0	0	0	0	0	0	0	64	64	0
	British Columbia, gill net	Zone 42 .....	0	0	0	0	0	0	0	36	0	24	60	0
	British Columbia, troll	Zone 43 .....	12	12	0	0	0	0	0	3	0	8	35	24
		Zone 42 .....	48	21	0	0	7	4	6	9	6	29	130	92
		Zone 41 .....	1	0	0	0	0	0	0	0	0	0	1	1
		Zone 40 .....	174	35	5	0	82	2	0	15	0	16	329	298
		Total .....	235	68	5	0	89	6	6	27	6	53	495	415
	Southeastern Alaska, troll	Zones 14, 16, 18, 22 .....	0	2	0	0	4	0	0	15	0	2	23	6
	All	All .....	349	93	5	0	105	10	9	88	15	165	839	586
1963- 1966	All	All .....	12,956	2,207	2,463	580	1,440	153	139	479	206	549	21,172	20,144



**Table 2. Estimated catch in marine fisheries during 1964-66 of 1962-brood chinook salmon with known, probable, and possible hatchery marks**

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Grays		Cascade			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- LM	Ad	Ad- LV- LM	Ad- LV	Ad- RV- LM	Ad- RV	LV- LM	LV	RV- LM	RV		
1964	Oregon, sport	Newport .....	0	3	0	0	0	0	0	0	0	0	3	3
	Oregon, troll	Astoria .....	2	0	0	0	0	0	0	0	0	0	2	2
	Columbia River mouth, sport	Warrenton-Ilwaco .....	83	21	4	4	0	0	0	0	0	0	112	112
	Washington, ocean sport	Sekiu .....	0	9	0	12	0	0	0	0	0	0	21	21
		LaPush .....	3	0	0	0	0	0	0	0	0	0	3	3
		Westport .....	77	5	10	4	0	0	0	3	0	3	102	96
		Total .....	80	14	10	16	0	0	0	3	0	3	126	120
	Washington, troll	Neah Bay .....	3	0	0	0	0	0	0	0	0	0	3	3
		Westport .....	5	0	0	0	0	0	0	0	0	0	5	5
		Total .....	8	0	0	0	0	0	0	0	0	0	8	8
	British Columbia, troll	Zone 40 .....	51	8	0	0	0	0	0	0	0	0	59	59
	All	All .....	224	46	14	20	0	0	0	3	0	3	310	304
1965	California, sport	Eureka .....	0	5	0	0	0	0	0	0	2	2	9	7
		Ft. Bragg .....	0	3	0	0	0	0	0	0	0	0	3	3
		Total .....	0	8	0	0	0	0	0	0	2	2	12	10
	California, troll	Crescent City .....	0	3	0	0	0	0	0	3	0	0	6	3
		Eureka .....	0	6	0	0	0	0	6	0	0	5	17	12
		Ft. Bragg .....	6	53	0	0	0	0	0	8	0	12	79	59
		San Francisco .....	0	5	0	0	0	0	0	0	0	21	26	5
		Total .....	6	67	0	0	0	0	6	11	0	38	128	79

Oregon, sport	Depoe Bay .....	0	2	0	0	0	0	0	0	0	0	2	2
	Newport .....	0	7	0	0	0	4	0	0	0	0	11	11
	Florence .....	0	4	0	0	0	0	0	0	0	4	8	4
	Reedsport .....	12	8	0	0	0	0	0	0	0	0	20	20
	Coos Bay .....	0	0	2	0	0	0	0	0	0	7	9	2
	Total .....	12	21	2	0	0	4	0	0	0	11	50	39
Oregon, troll	Astoria .....	11	2	9	0	2	0	0	0	0	5	29	24
	Newport .....	8	8	0	0	0	2	2	0	0	4	24	20
	Florence .....	5	2	0	0	0	0	0	0	0	0	7	7
	Reedsport .....	0	2	0	0	0	0	0	0	0	0	2	2
	Coos Bay .....	0	0	0	0	0	0	0	6	0	0	6	0
	Brookings .....	1	4	0	0	0	0	0	3	0	3	11	5
	Total .....	25	18	9	0	2	2	2	9	0	12	79	58
Columbia River mouth, sport	Warrenton-Ilwaco .....	44	27	0	0	11	5	0	0	2	0	89	89
Washington, ocean sport	Seki .....	111	0	33	5	6	0	0	0	0	0	155	155
	Neah Bay .....	11	5	0	0	0	0	0	0	0	0	16	16
	LaPush .....	13	4	0	0	4	0	0	0	0	0	21	21
	Westport .....	280	131	85	17	24	26	0	8	8	11	590	571
	Total .....	415	140	118	22	34	26	0	8	8	11	782	763
Washington, troll	Neah Bay .....	149	24	26	0	4	0	0	0	3	29	235	206
	LaPush .....	119	48	0	12	0	6	0	0	0	12	197	185
	Westport .....	640	51	95	13	24	0	15	5	3	7	853	841
	Ilwaco .....	38	45	0	0	2	11	0	0	3	0	99	96
	Total .....	946	168	121	25	30	17	15	5	9	48	1,384	1,331
Washington, gill net	Grays Hbr. ....	27	0	4	0	0	0	0	0	0	0	31	31
Puget Sound, sport	Zone 6 .....	81	0	0	0	0	0	81	0	0	0	162	162
British Columbia, troll	Zone 43 .....	16	12	0	0	9	0	0	0	0	0	37	37
	Zone 42 .....	7	15	0	0	18	0	0	22	0	0	62	40
	Zone 41 .....	0	5	0	0	0	0	0	0	0	0	5	5
	Zone 40 .....	1,160	336	68	7	128	7	2	23	45	45	1,821	1,753
	Total .....	1,183	368	68	7	155	7	2	45	45	45	1,925	1,835

Table 2. Continued

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Grays		Cascade			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- LM	Ad	Ad- LV- LM	Ad- LV	Ad- RV- LM	Ad- RV	LV- LM	LV	RV- LM	RV		
1965	S.E. Alaska, gill net troll	Various .....	0	3	0	0	0	0	0	0	0	0	3	3
		Zones 10-12, 15 .....	0	5	0	0	0	0	0	0	0	0	5	5
		Zones 14, 18, 22 .....	0	1	0	0	0	0	0	0	0	0	1	1
		Total .....	0	9	0	0	0	0	0	0	0	0	9	9
	All	All .....	2,739	826	322	54	232	61	106	78	66	167	4,651	4,406
1966	California, sport	San Francisco .....	0	0	0	0	0	0	0	4	0	0	4	0
	California, troll	Eureka .....	0	0	0	0	0	0	0	0	0	6	6	0
	Oregon, sport	Reedsport .....	0	0	0	0	4	0	0	0	0	0	4	4
	Oregon, troll	Astoria .....	3	3	3	0	0	0	3	0	3	0	15	15
		Coos Bay .....	0	0	0	0	0	0	5	0	0	0	5	5
		Total .....	3	3	3	0	0	0	8	0	3	0	20	20
	Columbia River	Warrenton-Ilwaco .....	15	3	12	0	3	0	0	5	3	0	41	36
	Washington, ocean sport	Sekiu .....	37	8	0	0	0	0	0	11	0	11	67	45
		Neah Bay .....	10	5	0	0	0	0	0	0	6	0	21	21
		Westport .....	46	32	4	8	4	0	0	12	4	8	118	98
		Total .....	93	45	4	8	4	0	0	23	10	19	206	164
	Washington, troll	Seattle .....	2	11	8	0	2	0	0	0	0	0	23	23
		Neah Bay .....	49	10	8	0	6	0	0	2	2	2	79	75
		LaPush .....	25	0	8	0	0	0	0	6	0	0	39	33
		Westport .....	47	5	7	2	7	0	0	0	2	4	74	70
		Ilwaco .....	7	2	0	0	0	0	0	0	0	0	9	9
		Total .....	125	28	31	2	15	0	0	8	4	6	224	210

Puget Sound, sport	Zone 9 .....	0	0	0	0	0	0	32	8	8	8	32	32
	Zone 10 .....	0	0	0	0	0	0	0	54	0	0	54	0
	Zone 11 .....	0	0	0	0	0	0	0	64	0	0	64	0
	Total .....	0	0	0	0	0	0	32	118	0	0	150	32
British Columbia, gill net	Zone 42 .....	12	0	0	0	0	0	0	0	0	48	60	12
British Columbia, troll	Zone 43 .....	8	32	5	0	6	10	3	3	3	0	70	67
	Zone 42 .....	79	13	0	0	16	0	0	26	4	19	157	112
	Zone 41 .....	4	2	0	0	0	0	0	0	0	1	7	6
	Zone 40 .....	719	207	62	23	113	15	11	45	16	72	1,283	1,166
	Total .....	810	254	67	23	135	25	14	74	23	92	1,517	1,351
Southeastern Alaska, troll	Zones 9-13, 15 .....	0	0	0	0	0	0	0	16	0	16	32	0
	Zones 14, 16, 18, 22 .....	5	13	0	0	2	2	0	12	0	10	44	22
	Total .....	5	13	0	0	2	2	0	28	0	26	76	22
All	All .....	1,061	344	117	33	163	27	54	260	43	197	2,299	1,851
1964- 1966	All .....	4,024	1,216	453	107	395	88	160	341	109	367	7,260	6,561

**Table 3. Estimated catch in marine fisheries during 1965-66 of 1963-brood chinook salmon with known, probable, and possible hatchery marks**

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Klickitat		Big Creek			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- RM	Ad	Ad- LV- RM	Ad- LV	Ad- RV- RM	Ad- RV	LV- RM	LV	RV- RM	RV		
1965	California, troll	San Francisco .....	0	0	0	0	0	0	0	4	0	0	4	0
	Oregon, sport	Depoe Bay .....	0	0	0	0	0	2	0	0	0	0	2	2
	Oregon, troll	Astoria .....	4	0	0	0	0	0	0	0	0	0	4	4
	Columbia River mouth, sport	Warrenton-Ilwaco .....	242	63	55	16	21	3	15	20	33	21	489	448
	Washington, ocean sport	Sekiu .....	115	0	0	0	0	0	16	0	0	32	163	131
		Neah Bay .....	43	0	0	0	0	0	0	0	0	0	43	43
		LaPush .....	34	12	22	0	0	0	13	0	4	3	88	85
		Westport .....	130	32	27	0	0	0	32	0	19	28	268	240
		Total .....	322	44	49	0	0	0	61	0	23	63	562	499
	Washington, troll	Neah Bay .....	5	0	0	0	0	0	0	0	0	0	5	5
		LaPush .....	0	0	0	0	0	0	0	3	0	0	3	0
		Westport .....	0	0	0	0	0	0	3	0	0	0	3	3
		Total .....	5	0	0	0	0	0	3	3	0	0	11	8
	Puget Sound, sport	Zone 6 .....	562	0	0	0	81 <sup>①</sup>	0	0	0	0	0	643	643
		Zone 9 .....	63	0	0	0	0	0	32	0	0	0	95	95
		Zone 10 .....	0	0	0	0	0	33 <sup>①</sup>	0	0	0	0	33	33
		Total .....	625	0	0	0	81	33	32	0	0	0	771	771
	British Columbia, troll	Zone 42 .....	0	7	0	0	0	0	0	0	0	0	7	7
		Zone 40 .....	55	0	23	0	0	0	0	0	0	0	78	78
		Total .....	55	7	23	0	0	0	0	0	0	0	85	85
All	All	All .....	1,253	114	127	16	102	38	111	27	56	84	1,928	1,817

1966	California, sport	Ft. Bragg .....	0	0	4	0	0	0	0	0	0	0	4	4
		San Francisco .....	0	7	0	0	0	0	4	0	0	11	22	11
		Monterey .....	0	0	0	0	0	0	0	0	0	1	1	0
		Total .....	0	7	4	0	0	0	4	0	0	12	27	15
	California, troll	Eureka .....	2	13	0	0	0	0	0	11	0	0	26	15
		Ft. Bragg .....	10	20	0	0	0	0	0	9	0	2	41	30
		San Francisco .....	0	0	0	0	0	0	0	0	7	0	7	7
		Total .....	12	33	0	0	0	0	0	20	7	2	74	52
	Oregon, sport	Depoe Bay .....	14	9	3	0	0	0	3	0	0	0	29	29
		Newport .....	8	0	0	0	0	0	0	0	0	0	8	8
		Florence .....	6	0	0	0	0	0	0	0	3	0	9	9
		Reedsport .....	67	4	13	4	0	0	0	4	0	0	92	88
		Coos Bay .....	0	0	3	0	0	0	0	0	0	0	3	3
		Gold Beach .....	0	0	2	0	0	0	0	0	0	2	4	2
		Total .....	95	13	21	4	0	0	3	4	3	2	145	139
	Oregon, troll	Astoria .....	332	26	17	2	0	2	10	0	9	6	404	398
		Tillamook .....	47	0	0	0	0	0	0	0	0	0	47	47
		Nestucca .....	6	0	2	0	0	0	2	0	0	0	10	10
		Depoe Bay .....	15	8	0	0	0	0	0	0	0	0	23	23
		Newport .....	38	5	5	0	2	0	5	0	5	0	60	60
		Florence .....	8	0	0	0	0	0	0	16	11	0	35	19
		Coos Bay .....	13	3	2	0	1	0	6	0	5	5	35	30
		Brookings .....	0	0	0	0	2	0	2	1	0	0	5	4
		Total .....	459	42	26	2	5	2	25	17	30	11	619	591
	Columbia River mouth, sport	Warrenton-Ilwaco .....	1,183	171	168	12	78	12	63	8	65	21	1,781	1,752
	Washington, ocean sport	Sekiu .....	255	88	20	11	0	2	4	6	40	11	437	420
		Neah Bay .....	91	20	23	0	15	0	15	0	20	0	184	184
		LaPush .....	39	2	3	0	20	0	20	0	0	0	67	67
		Westport .....	1,085	161	158	12	58	12	63	8	55	21	1,633	1,604
		Total .....	1,470	271	204	23	76	14	102	14	115	32	2,321	2,275
	Washington, troll	Seattle .....	125	13	2	0	2	0	2	0	0	2	146	144
		Neah Bay .....	533	21	54	2	16	8	37	13	50	10	744	721
		LaPush .....	891	78	111	0	35	0	36	10	48	8	1,217	1,199
		Westport .....	809	47	136	4	30	0	55	16	41	15	1,153	1,122
		Ilwaco .....	867	16	71	1	12	0	35	6	11	0	1,019	1,013
		Total .....	3,225	175	374	7	95	8	165	45	150	35	4,279	4,199

Table 3. Continued

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Klickitat		Big Creek			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- RM	Ad	Ad- LV- RM	Ad- LV	Ad- RV- RM	Ad- RV	LV- RM	LV	RV- RM	RV		
1966	Washington, gill net	Willapa Hbr. ....	2	3	0	0	4	0	0	0	0	2	11	9
	Puget Sound, sport	Zone 6 .....	540	0	0	0	0	0	0	0	0	0	540	540
		Zone 7 .....	81	0	0	0	0	0	0	0	0	0	81	81
		Zone 8 .....	32	0	38	0	0	0	0	0	0	0	70	70
		Total .....	653	0	38	0	0	0	0	0	0	0	691	691
	British Columbia, troll	Zone 43 .....	26	9	0	0	9	3	0	10	0	3	60	47
		Zone 42 .....	58	7	0	0	22	0	55	7	9	9	167	151
		Zone 41 .....	1	16	0	0	0	0	0	25	0	0	42	17
		Zone 40 .....	4,498	402	530	27	190	17	194	59	18	92	6,027	5,876
		Total .....	4,583	434	530	27	221	20	249	101	27	104	6,296	6,091
	Southeastern Alaska, troll	Zones 1-4 .....	0	8	0	0	0	0	0	0	0	0	8	8
		Zones 9-13, 15 .....	0	0	0	0	0	0	0	0	0	16	16	0
		Zones 14, 16, 18, 22 .....	0	11	0	0	5	0	0	5	0	0	21	16
		Total .....	0	19	0	0	5	0	0	5	0	16	45	24
	All	All .....	11,682	1,168	1,365	75	484	56	611	214	397	237	16,289	15,838
1965- 1966	All	All .....	12,935	1,282	1,492	91	586	94	722	241	453	321	18,217	17,655

① Estimates of triple-only and double-only marks from the same origin in different zones were related to low mark sampling (1.4-3.0%) in this fishery.

**Table 4. Estimated catch in marine fisheries during 1966 of 1964-brood chinook salmon with known, probable, and possible hatchery marks**

Sampling year	Fishery	Port or zone of recovery	Hatchery and type of mark										Total esti- mated catch	Total less ventral- only
			Hatchery complex		Spring Creek		Kalama		Bonneville		Little White			
			Known	Prob.	Known	Prob.	Known	Prob.	Known	Poss.	Known	Poss.		
			Ad- LM	Ad	Ad- LV- LM	Ad- LV	Ad- RV- LM	Ad- RV	LV- LM	LV	RV- LM	RV		
1966	California, troll	San Francisco .....	0	0	0	0	0	0	5	0	0	0	5	5
	Oregon, sport	Depoe Bay .....	0	0	0	0	0	0	11	0	0	0	11	11
		Reedsport .....	4	0	0	0	0	0	13	0	0	0	17	17
		Coos Bay .....	0	0	0	0	0	0	3	0	0	0	3	3
		Total .....	4	0	0	0	0	0	27	0	0	0	31	31
	Oregon, troll	Coos Bay .....	0	0	0	0	0	0	7	0	0	0	7	7
	Columbia River mouth, sport	Warrenton-Ilwaco .....	343	72	132	108	0	0	20	23	0	0	698	675
	Washington, ocean sport	Sekiu .....	22	26	0	0	0	0	0	0	0	0	48	48
		Neah Bay .....	63	0	54	0	0	0	0	0	0	0	117	117
		Westport .....	170	24	69	8	4	34	29	0	0	4	342	338
		Total .....	255	50	123	8	4	34	29	0	0	4	507	503
	Washington, troll	Seattle .....	2	0	0	0	0	0	0	0	0	0	2	2
		Neah Bay .....	2	0	0	0	0	0	2	0	0	0	4	4
		LaPush .....	0	24	0	0	0	0	0	0	0	0	24	24
		Westport .....	4	0	0	0	0	0	3	0	0	0	7	7
		Total .....	8	24	0	0	0	0	5	0	0	0	37	37
	British Columbia, gill net	Zone 42 .....	0	0	0	0	0	0	12	0	0	0	12	12
	British Columbia, troll	Zone 43 .....	0	3	0	0	0	0	0	3	0	0	6	3
		Zone 42 .....	0	0	0	15	0	0	34	0	0	0	49	49
		Zone 41 .....	3	0	0	0	0	0	0	0	0	0	3	3
		Zone 40 .....	7	3	0	0	0	0	9	0	4	0	23	23
		Total .....	10	6	0	15	0	0	43	3	4	0	81	78
	All	All .....	620	152	255	131	4	34	148	26	4	4	1,378	1,348



**Table 5. Percentage catch of marked 1961-64-brood chinook salmon in marine fisheries from evaluation hatcheries during 1963-66 (read percentages across), and percentage contribution of each hatchery to annual catch of evaluation marks (read percentages down last column); (A dash (—) indicates no mark sampling and a plus (+) indicates less than 0.5%)**

Brood year	Recovery year	Age at recovery <sup>①</sup>	Hatchery	Location of fishery and type of gear												South-eastern Alaska	Contribution to total catch of marked fish
				California		Oregon		Washington				British Columbia		Commercial			
				Sport	Troll	Sport	Troll	Col. R. mouth sport	Ocean sport	Troll	Gill net	Puget Sound sport	Gill net		Purse seine		
1961	1963	.1	Complex .....	—	—	0	0	52	47	1	—	—	—	—	—	—	75%
			Spring Cr. ....	—	—	0	—	53	42	2	—	—	—	—	—	—	21%
			Kalama .....	—	—	2	0	14	86	0	—	—	—	—	—	—	3%
			Elokomin .....	—	—	0	0	0	0	0	—	—	—	—	—	—	0
			Oxbow .....	—	—	0	0	64	36	0	—	—	—	—	—	—	1%
			All .....	—	—	1%	0	52%	47%	1%	—	—	—	—	—	—	②
	1964	.2	Complex .....	0	+	2	3	1	17	34	+	—	+	+	43	+	76%
			Spring Cr. ....	0	1	2	3	2	15	43	0	—	0	0	33	0	18%
			Kalama .....	0	+	0	3	1	10	21	0	—	0	0	63	1	5%
			Elokomin .....	0	7	3	9	0	8	45	0	—	0	0	28	0	1%
			Oxbow .....	0	0	12	14	5	24	40	0	—	0	0	5	0	1%
			All .....	0	+	2%	4%	1%	16%	35%	+	—	+	+	42%	+	②
	1965	.3	Complex .....	0	+	1	1	4	12	15	+	0	1	0	66	1	74%
			Spring Cr. ....	0	0	1	5	8	19	22	+	0	0	0	45	0	8%
			Kalama .....	0	0	0	1	4	9	18	1	0	0	0	63	5	17%
			Elokomin .....	0	0	0	10	0	50	17	0	0	0	0	23	0	1%
			Oxbow .....	6	0	12	6	0	0	27	0	0	0	0	48	0	1%
			All .....	+	+	1%	1%	4%	12%	16%	+	0	1%	0	63%	1%	②
1966	.4	Complex .....	0	1	0	0	6	12	11	0	0	0	—	69	+	76%	
		Spring Cr. ....	0	0	0	0	0	0	0	0	0	0	—	100	0	1%	
		Kalama .....	0	0	0	0	0	4	6	0	0	0	—	86	4	19%	
		Elokomin .....	0	0	0	0	0	0	33	0	0	0	—	67	0	2%	
		Oxbow .....	0	0	0	0	0	60	0	0	0	0	—	40	0	3%	
		All .....	0	1%	0	0	5%	12%	10%	0	0	0	—	71%	1%	②	

1963- 1966	.1.4	Complex .....	0	+	1	3	5	17	27	+	0	+	+	47	+	75%
		Spring Cr. ....	0	1	2	3	5	17	38	+	0	0	0	33	0	15%
		Kalama .....	0	+	0	2	3	10	18	+	0	0	0	64	3	8%
		Elokomin .....	0	5	2	9	0	17	38	0	0	0	0	29	0	1%
		Oxbow .....	1	0	11	11	7	23	33	0	0	0	0	15	0	1%
		All .....	+	+	1%	3%	4%	16%	29%	+	0	+	+	46%	+	②
		Complex .....	0	0	1	1	39	35	3	0	—	0	0	22	0	89%
		Spring Cr. ....	0	0	0	0	24	76	0	0	—	0	0	0	0	11%
		Kalama .....	0	0	0	0	0	0	0	0	—	0	0	0	0	0
		Grays .....	0	0	0	0	0	0	0	0	—	0	0	0	0	0
1962	1964	Cascade .....	0	0	0	0	0	0	0	0	—	0	0	0	0	0
		All .....	0	0	1%	1%	37%	39%	3%	0	—	0	0	19%	0	②
		Complex .....	+	2	1	1	2	16	31	1	2	0	0	44	+	81%
		Spring Cr. ....	0	0	1	2	0	37	39	1	0	0	0	20	0	9%
		Kalama .....	0	0	1	1	5	20	16	0	0	0	0	55	0	7%
		Grays .....	0	6	0	2	0	0	14	0	76	0	0	2	0	2%
		Cascade .....	3	0	0	0	3	12	14	0	0	0	0	68	0	1%
		All .....	+	2%	1%	1%	2%	17%	30%	1%	4%	0	0	42%	+	②
		Complex .....	0	0	0	+	1	10	11	0	0	1	—	76	1	77%
		Spring Cr. ....	0	0	0	2	8	8	22	0	0	0	—	60	0	8%
1962	1965	Kalama .....	0	0	2	0	2	2	8	0	0	0	—	84	2	10%
		Grays .....	0	0	0	15	0	0	0	0	59	0	—	26	0	3%
		Cascade .....	0	0	0	7	7	23	9	0	0	0	—	53	0	2%
		All .....	0	0	+	1%	2%	9%	11%	0	2%	1%	—	74%	1%	②
		Complex .....	+	1	1	1	4	15	24	1	2	+	0	51	1	80%
		Spring Cr. ....	0	0	+	2	4	32	32	1	0	0	0	29	0	9%
		Kalama .....	0	0	2	1	4	13	13	0	0	0	0	67	1	7%
		Grays .....	0	4	0	6	0	0	9	0	71	0	0	10	0	2%
		Cascade .....	2	0	0	3	5	17	12	0	0	0	0	62	0	2%
		All .....	+	1%	1%	1%	4%	16%	24%	4%	3%	+	0	50%	+	②
1964- 1966	.1-3	Complex .....	0	0	0	+	22	27	+	0	46	0	0	5	0	75%
		Spring Cr. ....	0	0	0	0	50	34	0	0	0	0	0	16	0	8%
		Kalama .....	0	0	1	0	17	0	0	0	81	0	0	0	0	8%
		Klickitat .....	0	0	0	0	14	55	3	0	29	0	0	0	0	6%
		Big Creek .....	0	0	0	0	59	41	0	0	0	0	0	0	0	3%
		All .....	0	0	+	+	25%	27%	+	0	42%	0	0	5%	0	②
1963	1965	Complex .....	0	0	0	+	22	27	+	0	46	0	0	5	0	75%
		Spring Cr. ....	0	0	0	0	50	34	0	0	0	0	0	16	0	8%
		Kalama .....	0	0	1	0	17	0	0	0	81	0	0	0	0	8%
		Klickitat .....	0	0	0	0	14	55	3	0	29	0	0	0	0	6%
		Big Creek .....	0	0	0	0	59	41	0	0	0	0	0	0	0	3%
		All .....	0	0	+	+	25%	27%	+	0	42%	0	0	5%	0	②

Table 5. Continued

Brood year	Recov- ery year	Age at recov- ery <sup>①</sup>	Hatchery	Location of fishery and type of gear													South- eastern Alaska	Contri- bution to total catch of marked fish
				California		Oregon		Washington				British Columbia						
				Sport	Troll	Sport	Troll	Col. R. mouth sport	Ocean sport	Troll	Gill net	Puget Sound sport	Gill net	Purse seine	Troll	Commer- cial		
1963	1966	.2	Complex .....	+	+	1	4	11	14	26	+	5	0	—	39	+	81%	
			Spring Cr. ....	+	0	2	2	13	16	26	0	3	0	—	39	0	9%	
			Kalama .....	0	0	0	1	17	17	19	1	0	0	—	45	1	3%	
			Klickitat .....	1	0	+	4	10	17	27	0	0	0	—	41	0	4%	
			Big Creek .....	0	2	1	8	16	29	38	0	0	0	—	7	0	3%	
			All .....	+	+	1%	4%	11%	14%	27%	+	4%	0	—	38%	+	②	
	1965- 1966	.1-2	Complex .....	+	+	1	4	12	15	24	+	9	0	0	36	+	81%	
			Spring Cr. ....	+	0	2	2	16	17	24	0	2	0	0	37	0	9%	
			Kalama .....	0	0	+	1	17	13	15	1	17	0	0	35	1	4%	
			Klickitat .....	1	0	+	3	11	23	23	0	4	0	0	34	0	4%	
			Big Creek .....	0	2	1	7	22	30	33	0	0	0	0	6	0	3%	
			All .....	+	+	1%	3%	12%	16%	24%	+	8%	0	0	35%	+	③	
	1964	1966	.1	Complex .....	0	0	+	0	54	40	4	0	0	0	—	2	0	57%
				Spring Cr. ....	0	0	0	0	62	34	0	0	0	0	—	4	0	29%
				Kalama .....	0	0	0	0	0	100	0	0	0	0	—	0	0	3%
				Bonneville ....	0	3	18	5	14	20	3	8	0	0	—	29	0	11%
				Little White ...	0	0	0	0	0	0	0	0	0	0	—	100	0	+
				All .....	0	+	2%	1%	50%	37%	3%	1%	0	0	—	6%	0	③

① Age designations follow the Koo (1962) system. No fresh-water annuli were laid down on the scales because the smolts were fingerlings; an Arabic numeral preceded by a dot gives the number of winters at sea.

② Individual entries in each row and in this column were rounded to the nearest whole percentage and therefore do not add to exactly 100 in all cases; the actual range for all sums is 98-101.

bution of marked fish from each hatchery to the total annual catch of fish with evaluation marks is in the last column of Table 5. Fish from Spring Creek thus accounted for 21% (160/766 from Table 1) of all evaluation marks caught in 1963 from the 1961 brood.

Coastwide differences in exploitation rate biased the relative availability (percentages along each row) of marked fish from any single source. The relative location of centers of abundance can be inferred for fish from various hatcheries, however, from comparisons of the ratios of percentages in Table 5. A ratio of 3:1 (Hatchery A: Hatchery B) under any column but the last means that three times as many marked fish from Hatchery A were caught in the sampled fishery than from Hatchery B.

An example of this reasoning follows for the Kalama:Spring Creek ratios at age .3 from the 1965 sampling. From south to north, with one or both elements nonzero, these were: 0:1, 1:5, 4:8, 9:19, 18:22, 1:+, 63:45, and 5:0. Marked fish from each hatchery were assumed to be (1) large enough from age .2 onward for nonselective retention and detection in all sampled fisheries where present, and (2) caught in proportion to their relative abundance within each fishery no matter how exploitation rates varied among fisheries. The geographic sequence of ratios indicates that for all marked fish at large from each hatchery, those from Spring Creek predominated south of the central or north coast of Washington, and those from Kalama farther north off Vancouver Island. The inference is that Kalama fish were concentrated farther north.

Further inferences from Table 5 follow for each brood. Centers of abundance are distinguished from ranges of distribution. Incomplete recruitment, mentioned previously, prevents valid statements for age .1, but the data were included to complete the available record.

#### 1961 Brood

At age .2 in 1964, when most—if not all—survivors were larger than the minimum legal size (26 inches total length), Kalama

fish evidently ranged as far south as fish from other hatcheries, but the British Columbia troll fishery accounted for most (63%) of the Kalama releases. They were centered farthest north and, along with fish with the general or Ad-RM mark, (some released at Kalama) were found in Alaskan waters. Chinook from Elokomin and particularly Oxbow stations (28% and 5%, respectively, in the British Columbia troll fishery) were concentrated farthest south and contributed least to the total catch of marked fish. Centers of relative abundance of fish from the hatchery complex and Spring Creek were probably off the north coast of Washington and in between those from other hatcheries.

At age .3 in 1965, Kalama fish again were centered farther north (off Vancouver Island) than those from Spring Creek, Elokomin, and Oxbow; they were distributed much like fish from the hatchery complex and ranged as far as Alaska, but apparently not to California. Oxbow and Spring Creek chinook may have been found at least as far north as the Strait of Juan de Fuca, but only Oxbow fish were recovered off California. Elokomin fish evidently were centered off the southern coast of Washington. Elokomin and Oxbow hatcheries again contributed least (1% each) to the total. Kalama contributed much more than to the Spring Creek catch (17 and 8%) than at age .2 (5 and 18%). This contribution partially reflects the higher proportion of Spring Creek and Kalama fish which matured at age .2 (Cleaver, 1969).

Small numbers (Table 1) may well have distorted the data on distribution at age .4 in 1966.<sup>①</sup> Kalama fish were still centered

<sup>①</sup> This problem is to be anticipated in future analyses of the hatchery evaluation data. Anything less than complete examination for marks in all marine landings south of Washington and north of Vancouver Island, where most of the hatchery fish were caught (Tables 1-4), implies a higher chance of "O" recoveries from broods (or hatcheries) with lower survival and a distorted picture of the range of distribution. Cleaver (1969) noted much higher survival for the 1961 than 1962 brood. Nearly 8 million marked fish were released from each brood; Tables 1-2 show respective catches of 14,228 and 4,406 at the dominant age of capture in marine fisheries (.2).

northward and off Alaska. Their contribution was much greater than that of Spring Creek (19 and 17%), even at age .3; the difference again reflects the higher average age at maturity of Kalama fish.

For the 1961 brood as a whole, then, Oxbow fish were centered farthest south, Kalama fish farthest north, and only they are known to have ranged as far as southeastern Alaska. Elokomin and Spring Creek releases were intermediate, but those from Spring Creek, particularly at age .3, tended to be farther north. Fish from all identifiable hatcheries and from the complex were in California waters at some time during their lives but only Oxbow fish unquestionably entered the California sport fishery.

#### **1962 Brood**

At age .2 Kalama fish again were farther north than Spring Creek fish, but only the hatchery complex was represented off Alaska. Although Cascade Hatchery releases may have been centered nearly as far north as Kalama fish, they also ranged south to California. Fish from Grays River entered the Puget Sound sport catch.<sup>①</sup>

By age .3 in 1966, some Kalama fish had migrated to Alaska where the hatchery complex was again represented. Centers of abundance from all hatcheries but Cascade apparently had shifted northward since age .2. Kalama contributed about the same percentage of total marks as Spring Creek at age .2 (total range for both years and hatcheries was 7-10%); this figure contrasted sharply with Kalama's higher relative contribution at age .3 in the 1961 brood (17% compared with 8% for Spring Creek). Grays River and Cascade each contributed only 2% during the 3 years of sampling.

<sup>①</sup> About 2% of the Puget Sound sport catch was examined for marks, and only during 1965 and 1966. The small sample precluded inferences on relative distribution, but the presence of marked fish in the Puget Sound sport catch from various hatcheries is summarized as follows (Tables 2-4): 1962 brood, from Grays River at ages .2 and .3; 1963 brood, from Kalama and Klickitat at age .1 and Spring Creek at age .2; and 1964 brood, from Bonneville at age .1.

#### **1963 and 1964 Broods**

Few data are available for the 1963 and 1964 broods. Kalama and hatchery complex fish from the 1963 brood again appeared in Alaskan waters at age .2. The centers for the complex, Kalama, Spring Creek, and Klickitat were similar but only Kalama chinook were not recovered south of Oregon. Big Creek fish were concentrated farthest south, probably off southern Washington. The similarity in distribution between Kalama and Spring Creek fish contrasted with the more northerly location for Kalama fish in the 1961 and 1962 broods.

Incomplete recruitment again prevented comparisons at age .1. Of special interest in the 1964 brood, however, are (1) the rather high relative contribution of Bonneville Hatchery releases (11%), and (2) the fact that Spring Creek contributed much more (29%) than in the 1963 and 1962 broods (8 and 11%, respectively). See also Tables 1-4 regarding hatchery-specific marks in the Puget Sound sport catch.

#### **North-South Distribution Summary**

The foregoing inferences on north-south distribution of hatchery releases substantiate two general findings by Cleaver (1969): (1) fish from different sources were widely distributed at the same age, and (2) the distribution of fish from a given hatchery varied with age.

To the extent that fishing intensity was similar among areas in different years, marked fish from the 1961 and 1962 broods (except from Cascade hatchery) evidently were farther north at age .3 than at age .2. Only fish from Kalama and the hatchery complex (some released at Kalama) were recovered in Alaskan waters. Additional inferences on distribution by age, brood, and hatchery source are shown in Table 5.

#### **Offshore-Inshore Distribution**

Knowledge of offshore-inshore distribution also may be needed to understand and predict the contribution of hatcheries to the fisheries. Marked fish from two or more

hatchery sources were recovered from troll and sport landings in California, Oregon, and Washington (Tables 1-4). Anglers typically fished closer inshore than did trollers off ports where both types of catches were landed. For ports between Newport, Oregon, and Neah Bay, Washington, the hypothesis that availability to offshore (troll) and inshore (sport) fisheries is independent of hatchery source was tested for ages .2 and .3 in the 1961-63 broods when sample sizes permitted. Unknown differences in exploitation rates and known differences in mark sampling ratios occurred between the two types of fisheries landed at each port, hence estimated catches of marked fish rather than unadjusted recoveries were compared.<sup>①</sup>

The hypothesis that availability of marked fish to offshore and inshore fisheries is independent of hatchery source was rejected in 9 of 14 tests (Table 6). Relative availability evidently depended in general on which hatcheries had released the fish.

### Seasonal Comparisons for the 1961 Brood

Movements in the marine fisheries during a given season should reflect migration routes and maturity schedules of fish released from different hatcheries. Small samples and lack of information on fishing intensity by time and area typically limit the inferences from marking and tagging studies, but data from the 1961 brood warrant a trial comparison of seasonal movements of Spring Creek and Kalama fish during 1964 and 1965.

Most recoveries were off the mouth of the Columbia River and northward (Table 1). Estimated ocean catches of these marked fish during successive 14-day periods (longer at the start and end of the season) were combined into successive 28-day periods to increase the sample size. The results

by time period and major ocean age in each of five areas, converted to percentages are shown in Table 7 and Figure 2.<sup>①</sup>

Fish from both hatcheries were widely dispersed and apparently similarly distributed at the start of the 1964 season (age .2). However, larger proportions of Spring Creek than Kalama fish were found in landings toward the Columbia River as the season progressed to August 23. A substantial portion of the Kalama fish either moved north of Vancouver Island or became available to the fisheries during July. The residue of immature fish from both hatcheries was also distributed similarly by September 20. At age .3, some Kalama chinook were north of Vancouver Island near the start of the season (Table 7), but July was again the main month of northerly migration or recruitment in the northern area. Substantial southerly movement was detectable only during August for Spring Creek fish and during August and September for Kalama fish.

The data in Figure 2 and Table 7, when compared with return schedules in Table 8, are consistent in some respects and puzzling in others. Southerly movement of Spring Creek fish at age .2 (Figure 2) agreed with their slightly higher returns to the Columbia at age .2 than at age .3 (Table 8, bottom). Yet it failed to substantiate the theory that fall chinook salmon move slowly northward during the summer (Cleaver, 1969; Van Hyning, 1968). Also, the relatively few age .2 fish (12%) found near the Columbia, and the high percentage (47%) discovered near Cape Flattery during the recovery period ending August 23, 1964 (Table 7) does not agree with the idea that most Spring Creek fish slowly move south during the summer of predominant maturity. The rapid return of these fish during August at age .3 (Figure 2), however, agreed with return schedules (Table 8, top). Nearly half the available Kalama fish, on the other hand, remained off Vancouver Island in September at age .3

<sup>①</sup> For the Columbia River mouth, sport landings of marked fish at Warrenton, Oregon, and Ilwaco, Washington, were compared with troll landings of marked fish at Astoria, Oregon, and Ilwaco, Washington.

<sup>①</sup> Only catches exceeding 50 fish in any period were used in graphing percentages except for 33 Kalama fish at the start of the 1964 season.

**Table 6. Tests of the hypothesis that availability of marked chinook salmon to offshore (troll) and inshore (sport) fisheries is independent of hatchery source**

Brood year	Recovery Year	Ocean age at recovery	Recovery port	Hatchery source	Estimated troll catch <sup>①</sup> (No.)	Estimated sport catch <sup>①</sup> (No.)	Total (No.)	Chi-square	Result at 5% level
1961	1964	.2	Newport	Complex .....	51	59	110	-----	-----
				Spring Cr. ....	9	21	30	-----	-----
				Total .....	60	80	140	2.58	Accept
1961	1964	.2	Astoria, Warrenton and Ilwaco	Complex .....	574	123	697	-----	-----
				Spring Cr. ....	186	45	231	-----	-----
				Kalama .....	20	10	30	-----	-----
				Oxbow .....	8	8	16	-----	-----
				Total .....	788	186	974	14.80	Reject
1961	1964	.2	Westport	Complex .....	1,555	941	2,496	-----	-----
				Spring Cr. ....	338	205	543	-----	-----
				Kalama .....	14	41	55	-----	-----
				Oxbow .....	8	18	26	-----	-----
				Total .....	1,915	1,205	3,120	41.27	Reject
1961	1964	.2	LaPush	Complex .....	643	34	677	-----	-----
				Spring Cr. ....	383	8	391	-----	-----
				Total .....	1,026	42	1,068	5.80	Reject
1961	1964	.2	Neah Bay	Complex .....	1,010	239	1,249	-----	-----
				Spring Cr. ....	272	49	321	-----	-----
				Kalama .....	74	9	83	-----	-----
				Total .....	1,356	297	1,653	5.60	Accept
1961	1965	.3	Astoria, Warrenton and Ilwaco	Complex .....	30	119	149	-----	-----
				Spring Cr. ....	10	29	39	-----	-----
				Kalama .....	21	29	50	-----	-----
				Total .....	61	177	238	9.39	Reject
1961	1965	.3	Westport	Complex .....	223	299	522	-----	-----
				Spring Cr. ....	40	51	91	-----	-----
				Kalama .....	70	45	115	-----	-----
				Elokomin .....	5	8	13	-----	-----
				Total .....	238	403	741	12.92	Reject

1962	1965	.2	Astoria, Warrenton and Ilwaco	Complex .....	96	71	167	-----	-----
				Kalama .....	15	16	31	-----	-----
				Total .....	111	87	198	17.80	Reject
1962	1965	.2	Westport	Complex .....	691	411	1,102	-----	-----
				Spring Cr. ....	108	102	210	-----	-----
				Kalama .....	24	50	74	-----	-----
				Cascade .....	3	8	11	-----	-----
				Total .....	826	571	1,397	37.43	Reject
1962	1966	.3	Westport	Complex .....	52	78	130	-----	-----
				Spring Cr. ....	9	12	21	-----	-----
				Kalama .....	7	4	11	-----	-----
				Total .....	68	94	162	2.33	Accept
1963	1966	.2	Astoria, Warrenton and Ilwaco	Complex .....	1,241	1,354	2,595	-----	-----
				Spring Cr. ....	91	180	271	-----	-----
				Kalama .....	14	80	94	-----	-----
				Klickitat .....	45	63	108	-----	-----
				Big Creek .....	20	65	85	-----	-----
				Total .....	1,411	1,742	3,153	73.37	Reject
1963	1966	.2	Westport	Complex .....	883	1,246	2,129	-----	-----
				Spring Cr. ....	140	170	310	-----	-----
				Kalama .....	30	70	100	-----	-----
				Klickitat .....	55	63	118	-----	-----
				Big Creek .....	41	55	96	-----	-----
				Total .....	1,149	1,604	2,753	8.41	Accept
1963	1966	.2	LaPush	Complex .....	969	41	1,010	-----	-----
				Spring Cr. ....	111	3	114	-----	-----
				Total .....	1,080	44	1,124	0.56	Accept
1963	1966	.2	Neah Bay	Complex .....	554	111	665	-----	-----
				Spring Cr. ....	56	23	79	-----	-----
				Kalama .....	24	15	39	-----	-----
				Klickitat .....	37	15	52	-----	-----
				Big Creek .....	50	20	70	-----	-----
				Total .....	721	184	905	22.37	Reject

① Of the 96 expected values involved in the 14 independent tests, all exceeded 3.0 and all but 4 exceeded 5.0.



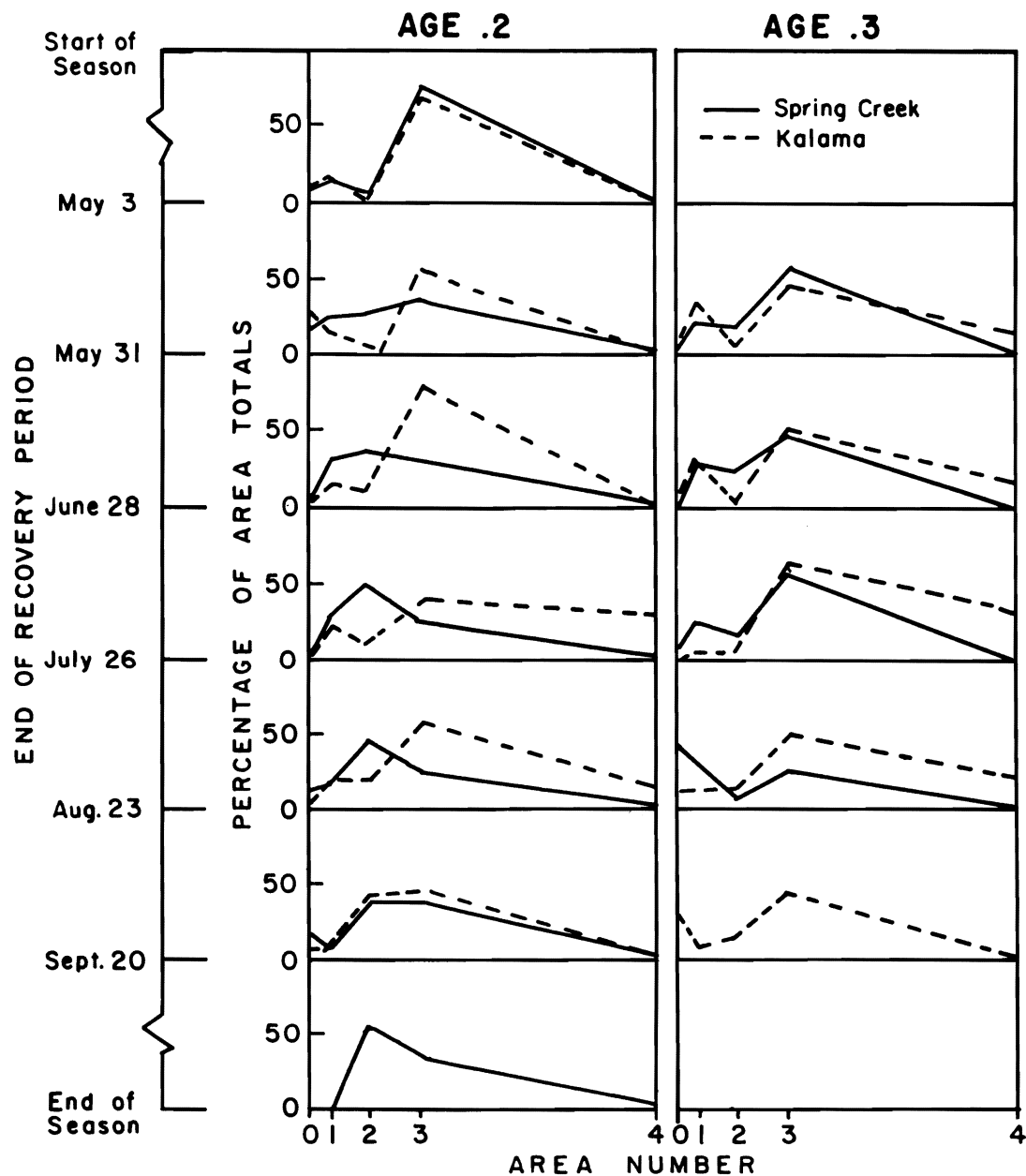
**Table 7. Estimated catch and relative occurrence, by time and area during 1964 and 1965, of marked 1961-brood chinook salmon from Spring Creek and Kalama hatcheries in sampled marine fisheries from the Columbia River and northward; (A plus (+) indicates less than 0.5%)**

			Number and percentage of area total during period ending—															
Source	Ocean age	Area <sup>①</sup>	May 3		May 31		June 28		July 26		Aug. 23		Sept. 20		End of season		Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Spring Creek	.2	Northern .....	0	0	2	+	4	1	2	+	0	0	0	0	0	0	8	+
		Vancouver Is. ....	193	73	167	34	213	30	97	23	62	25	68	39	33	37	833	35
		Cape Flattery .....	13	5	130	26	257	37	204	48	118	47	68	39	56	62	836	35
		Grays Harbor .....	33	13	120	24	214	31	118	28	41	16	7	4	0	0	543	23
		Columbia R. ....	25	9	77	16	7	1	4	1	29	12	33	18	1	1	176	7
		Total .....	264	100	496	100	695	100	425	100	250	100	176	100	90	100	2,396	100
Kalama	.2	Northern .....	0	0	0	0	0	0	30	29	26	14	0	0	0	0	56 <sup>②</sup>	8
		Vancouver Is. ....	23	70	30	56	82	79	39	37	105	55	74	47	32	100	385	57
		Cape Flattery .....	0	0	0	0	9	9	11	10	37	19	65	42	0	0	122	18
		Grays Harbor .....	6	18	8	15	13	12	25	24	18	10	11	7	0	0	81	12
		Columbia R. ....	4	12	16	29	0	0	0	0	4	2	6	4	0	0	30	5
		Total .....	33	100	54	100	104	100	105	100	190	100	156	100	32	100	674	100
Spring Creek	.3	Northern .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vancouver Is. ....	18	75	37	57	43	47	45	56	21	24	0	0	0	0	164	47
		Cape Flattery .....	4	17	12	18	21	23	12	15	4	5	0	0	0	0	53	16
		Grays Harbor .....	2	8	14	22	28	30	20	25	27	31	0	0	0	0	91	26
		Columbia R. ....	0	0	2	3	0	0	3	4	34	40	0	0	0	0	39	11
		Total .....	24	100	65	100	92	100	80	100	86	100	0	0	0	0	347	100
Kalama	.3	Northern .....	1	3	15	13	22	17	59	30	40	21	0	0	0	0	137	18
		Vancouver Is. ....	16	44	53	45	63	50	121	62	88	46	37	44	0	0	378	50
		Cape Flattery .....	19	53	8	7	3	2	6	3	21	11	14	16	0	0	71	10
		Grays Harbor .....	0	0	41	35	39	31	7	4	20	11	8	9	0	0	115	15
		Columbia R. ....	0	0	0	0	0	0	3	1	21	11	26	31	0	0	50	7
		Total .....	36	100	117	100	127	100	196	100	190	100	85	100	0	0	751	100

① Areas, coded in Figure 2, are defined as follows:

- Columbia River—Ilwaco, Astoria, and Warrenton troll and sport ..... "0"
- Grays Harbor—Westport troll and sport ..... "1"
- Cape Flattery—LaPush, Neah Bay, and Sekiu troll and sport ..... "2"
- Vancouver Island—B. C. troll, Zone 40 (west coast) ..... "3"
- Northern—B. C. troll, Zones 42-43, and Alaska troll ..... "4"

② Recovery dates were not available for an estimated catch of five more marked Kalama fish in the Alaskan fishery of 1964 (Table 1).



**Figure 2. Relative occurrence, by time and area, of marked 1961-brood chinook salmon from Spring Creek and Kalama, in sampled marine fisheries from the Columbia River northward during 1964 (age .2) and 1965 (age .3).** (Areas are numbered from "0" at the mouth of the Columbia, and are defined in a footnote in Table 7. Distances on the horizontal axis are roughly proportional to those between fisheries. Values are not plotted for time-area totals of less than 50 fish except for 33 estimated recoveries to May 3 for Kalama age .2 fish.)

during 1965 (Table 7), when 74% of all 1961 brood returns to the Columbia River were accounted for (Table 8, bottom).

Discrepancies between intraseasonal movements through the marine fisheries and schedules of return to the Columbia may be related to the conclusion from Table 6 that the relative availability to offshore and inshore fisheries depended generally on hatchery of origin. A more detailed explanation, however, must await further analyses. Because trollers from different ports fish to some extent in the same areas, sport catches might be analyzed separately or troll catches examined by fishing area instead of port of landing. A compilation of data by area of capture is in progress.<sup>①</sup>

### Summary and Conclusions

1. Preliminary comparisons of the distribution in marine fisheries of marked fall

<sup>①</sup> S. G. Wright, Washington Dept. of Fisheries, personal communication, March 1969.

chinook from various hatcheries were made from data of the Columbia River hatchery evaluation program. Estimated total recoveries of known, probable, and possible marks in the ocean fisheries during 1963-66 were as follows: 1961 brood—20,144; 1962 brood—6,561; 1963 brood—17,655; and 1964 brood—1,348. Sampling through 1966 was substantially complete for the 1961-62 broods, but incomplete for the 1963-64 broods. In addition to the fact that complete analysis must await tabulation of data through 1969 sampling, incomplete recruitment prevented drawing inferences on distribution for fish which had spent only one winter at sea. The available data are tabulated by port or zone of landing in the various fisheries (Tables 1-4).

2. Fall chinook salmon of the 1961 brood from hatcheries on the Kalama River were found in the ocean from Alaska to California by July 1964 (age .2). No other identifiable hatcheries were represented in

**Table 8. Return schedules of marked 1961-brood chinook salmon from Spring Creek and Kalama hatcheries for 1964 (age .2) and 1965 (age .3), and total returns for 1963-66 (ages .1-4). (A plus (+) indicates less than 0.5%)**

Item	Date	Year	Spring Creek		Kalama	
			Number of fish	Percentage of total	Number of fish	Percentage of total
Estimated catch by period (end dates given) in Zone 1 of Columbia River gill-net fishery	Aug. 1 .....	1964	3	1	0	0
	Aug. 8 .....		51	20	3	17
	Aug. 15 .....		127	50	3	17
	Aug. 22 .....		74	29	12	66
	Aug. 29 .....		0	0	0	0
	All .....		255	100	18	100
	July 31 .....	1965	2	+	0	0
	Aug. 7 .....		12	2	0	0
	Aug. 14 .....		49	10	22	7
	Aug. 21 .....		219	42	95	32
	Aug. 28 .....		235	46	155	53
	Sept. 18 .....		0	0	23	8
	All .....		517	100	295	100
Estimated return to the Columbia River	Total .....	1963	68	4	0	0
		1964	934	50	51	7
		1965	833	45	575	74
		1966	20	1	160	19
		All	1,855	100	786	100

Alaskan waters by this (or any) brood, although fish with the common mark of the hatchery complex (some released at Kalama) were recovered in this area. All hatcheries were represented southward from British Columbia to California at some time in the marine life of the 1961 brood, but only Oxbow fish were detected in the California sport fishery.

3. Hatchery fish from the following sources were found in the Puget Sound sport fishery sampled during 1965-66 but not 1963-64: 1962 brood, from Grays River at ages .2 and .3; 1963 brood, from Kalama and Klickitat at age .1 and Spring Creek at age .2; and 1964 brood, from Bonneville at age .1. The low fraction of landings (about 2%) sampled each year for marks in the Puget Sound sport fishery made it necessary to exclude this fishery in drawing inferences on relative distribution by origin.

4. Apparent centers of distribution for the 1961 brood (Kalama, Spring Creek, Elo-komin, Oxbow and the hatchery complex) were from Vancouver Island to the south coast of Washington. Except possibly for Cascade fish of the 1962 brood during 1965, Kalama fish apparently were centered farther north at all ages than those from any other hatchery in the 1961-63 broods.

5. Because of unknown differences in fishing intensity along the coast, it was not possible to determine that actual centers of distribution were identical to apparent centers as inferred from recovery data. To the extent that fishing intensity was similarly distributed in different years, fish were typically farther north at age .3 than at age .2.

6. Relative availability to offshore troll fisheries and inshore sport fisheries between Newport, Oregon, and Neah Bay, Washington, depended in general on hatchery of origin.

7. Apparent intraseasonal movements of the 1961 brood from Spring Creek and

Kalama were not wholly consistent with schedules of return to the hatcheries. In 1964 at age .2, immature Kalama fish either moved north of Vancouver Island during July or were already in northern waters. In 1965 at age .3, maturing Spring Creek fish rapidly moved south from Vancouver Island into the Columbia River during August.

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