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# A Winter Steelhead Tagging Program on The Columbia River

Lawrence Korn



FISH COMMISSION OF OREGON  
Portland, Oregon  
Contribution No. 26  
August 1961

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# A WINTER STEELHEAD TAGGING PROGRAM ON THE COLUMBIA RIVER

Lawrence Korn<sup>①</sup>

## ABSTRACT

The Oregon Fish Commission and Washington Department of Fisheries conducted a cooperative winter steelhead trout (*Salmo gairdneri*) tagging program on the Columbia River during the winters of 1954-55 and 1955-56. Objectives of the program were: (1) to obtain information on the timing of the various segments of the run; (2) to obtain a population estimate; (3) to measure the sport and commercial fishing mortality; and (4) to compare Petersen disc and spaghetti tube tags. Drift and set gill nets were used to capture the fish. The total numbers tagged were 837 in 1954-55 and 3,362 in 1955-56. Mortalities due to gill netting and seals amounted to 343 fish. The principal sources of tag recoveries were the sport fishery, tagging gear, commercial fishery, fishways, and hatcheries. A total of 145 and 632 tags, respectively, were recovered from the two winters of the investigation, or 17.3 and 18.8 per cent. Chi-square tests showed a significant difference between the recovery ratios of Petersen disc and spaghetti tube tags from the commercial gill-net fishery and tagging gear. No difference was indicated in the recovery ratios from the tributary sport fisheries or hatcheries and fishways. The gill nets appeared to exhibit a 2:1 selectivity for Petersen tags. Steelhead were present in the lower Columbia River throughout the winter months, with the largest numbers taken during March in both years. Numbers of tagged steelhead remained or milled in the Columbia River up to 20 days and occasionally a month or more prior to entering the tributaries. The major winter steelhead streams, such as the Cowlitz, Willamette, Sandy, and Lewis Rivers, received recoveries from almost all months of tagging, but the Willamette River was characteristic in that the bulk of recoveries were from the March tagging. The Cowlitz River received a larger proportion of November-February fish. The other rivers showed no particular trend although March was the best month for most streams. The population of winter steelhead entering the Columbia River during 1955-56 was estimated at 217,400 with 95 per cent confidence limits of 172,700 to 279,900. The commercial fishery was calculated to have taken between 3 and 5 per cent of the run and the sport fishery 13 to 21 per cent.

## INTRODUCTION

A cooperative winter steelhead trout (*Salmo gairdneri*) tagging program on the lower Columbia River was initiated in December 1954 by the Washington Department of Fisheries and the Oregon Fish Commission. The program extended over two winters, 1954-55 and 1955-56. Several species other than steelhead were tagged, the principal ones being chinook salmon (*Oncorhynchus tshawytscha*) and white sturgeon (*Acipenser transmontanus*). This paper will deal solely with the steelhead phase of the tagging program.

Winter steelhead enter the Columbia River throughout the period November-April and spawn during the same season. Relatively small numbers of early summer steelhead also appear in the Columbia during the latter part of this period and enter a few of the same tributaries but

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do not spawn until the winter and spring of the following year. Virtually all tributaries below Bonneville Dam, 145 miles upstream from the mouth of the Columbia, and a few between Bonneville and The Dalles Dams, support winter steelhead runs. The Bonneville counts indicate that the number of winter steelhead passing the dam is small compared with known runs entering the tributaries below the dam. The major winter-steelhead-producing tributaries in the Columbia River are depicted in Figure 1.

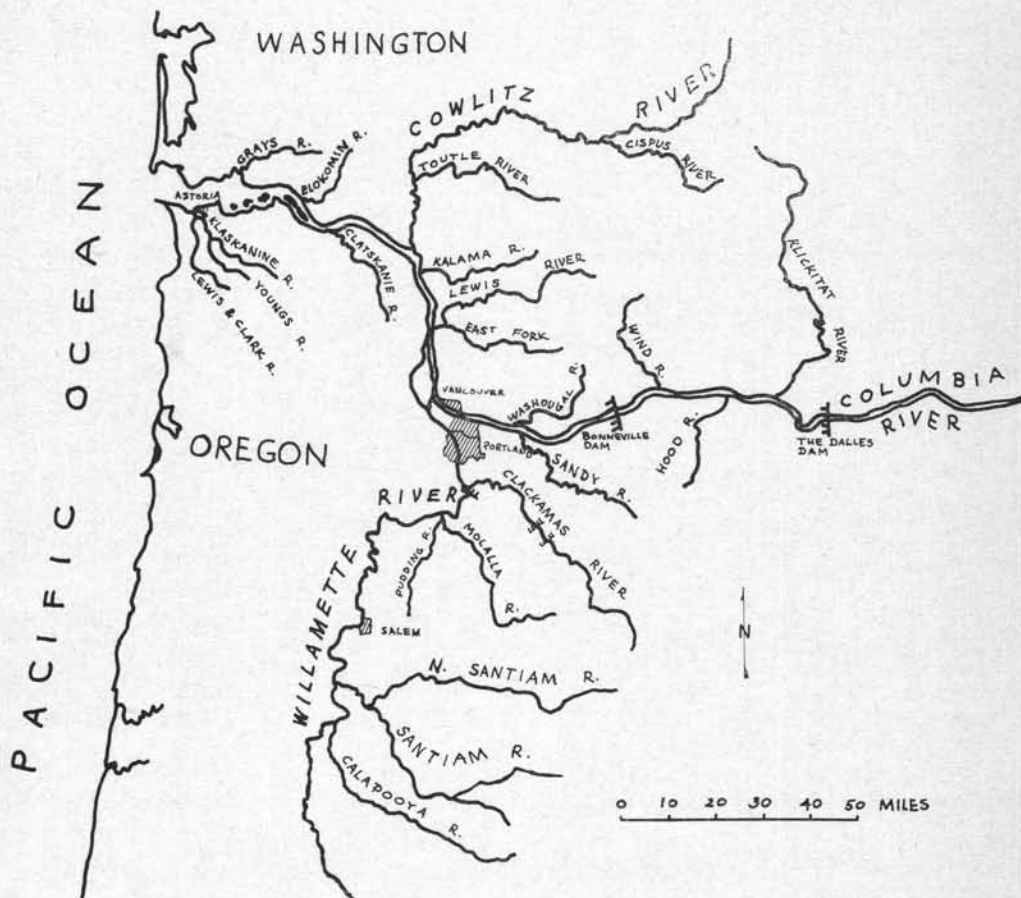


FIGURE 1. MAJOR WINTER-STEELHEAD-PRODUCING TRIBUTARIES OF THE COLUMBIA RIVER. SOME, BUT NOT ALL, MINOR STREAMS ARE ALSO SHOWN.

The basic reasons for inaugurating the tagging program were: (1) a general lack of knowledge of winter steelhead runs; and (2) the conflict between sport and commercial fishing interests on the Columbia, emphasizing the need for basic information pertaining to management of this resource.

The primary objective of the tagging program was to determine the timing through the lower Columbia River of the various tributary runs of winter steelhead. Secondary objectives included an estimate of the



population and the percentages of the total run caught by the commercial and sport fisheries. A comparison of Petersen disc and spaghetti tube tags was planned for the second year.

In addition to the cooperative Columbia River tagging program, separate tagging studies were launched simultaneously on two winter steelhead tributaries, the Grays River in Washington and Sandy River in Oregon. The Washington Department of Fisheries carried out the Grays River study and has reported its data in a separate report (Wendler, Rothfus, Ward, and Jewell, 1956). The Oregon Fish Commission study on the Sandy was not successful as the fyke nets used did not catch sufficient numbers of steelhead for tagging.

## TAGGING

### Methods of Capture

Gill nets were chosen for capturing steelhead for tagging because substantial numbers could be taken in them during the winter months and they are relatively inexpensive to operate compared to other gear. The major disadvantage is that the fish become enmeshed in the web, causing fin mutilation, gill damage, and invariably loss of mucous and scales. Some die as a direct result of being caught in the net while others may become easy prey for seals.

The use of traps and seines was considered during the early planning of the project but soon rejected due to the expense and the fact that they are not as effective as gill nets in the muddy water common in the Columbia River during the winter.

It was decided that the two agencies should have separate tagging crews, and each would seek out a fishing area in the lower Columbia River and develop its own methods for catching steelhead. Experienced commercial gill netters were hired by each department to do the fishing.

During the 1954-55 winter season, the Oregon and Washington tagging crews used both diver and floater drift gill nets (a diver net is weighted so it will drift along the bottom of the river while a floater drifts at the surface). The Oregon Fish Commission also used set gill nets to a limited extent.

In the 1955-56 winter season the tagging crews of the two departments successfully used both drift and set gill nets. Table 1 shows the numbers of steelhead caught for tagging, by gear, by both crews combined. Total number of steelhead tagged was 4,199 (837 in 1954-55 and 3,362 in 1955-56).

Experience with both types of gear showed set nets were better than drift nets for tagging purposes for the following reasons: (1) when they were fished for comparable periods in the second year, more fish were caught in set nets than drift nets; (2) during certain winter periods seals killed many fish caught in drift nets but not in set nets; and (3) the fishermen could observe steelhead striking the set nets and immediately remove them without pulling the entire net into the boat. The latter practice was more difficult with drift nets and as a result the general condition of set-net-caught fish was better than those caught in drift nets.

TABLE 1.—WINTER STEELHEAD TAGGING BY MONTH AND GEAR,  
1954-55 AND 1955-56.

Month	1954-55 <sup>①</sup> Numbers Tagged			1955-56 <sup>②</sup> Numbers Tagged			
	Drift Nets	Set Nets	Total	Drift Nets	Set Nets	Unspecified <sup>③</sup>	Total
November .....	.....	.....	.....	41	0	0	41
December .....	33	.....	33	318	6	2	326
January .....	114	6	120	65	344	63	472
February .....	140	44	184	97	190	0	287
March .....	284	101	385	960	1,235	41	2,236
April .....	84	31	115	.....	.....	.....	.....
TOTAL .....	655	182	837	1,481	1,775	106	3,362

① Drift netting started December 2, 1954, Oregon set netting January 21, 1955. Several drift-net sites were used but only 2 set-net sites. The Washington crew did not set net during this winter.

② Drift netting began November 27, 1955; the Oregon crew began set netting on December 14, 1955 and Washington crew on February 2, 1956.

③ Fish caught by drift net and set net were held in a live box at Woody Island. They could not be separated at the time of tagging.

### Areas Fished

All of the tagging took place in the lower Columbia River from its mouth to the upper end of Puget Island, a distance of approximately 40 river miles (Figure 2). During the 1954-55 winter season, Oregon tagging crews fished several drift-net areas and two set-net sites directly off Astoria. The drifts were located either in or near the ship channel and the set-nets at the edge of Youngs Bay. The Washington crews concentrated their fishing efforts on Klondike and Chute Drifts, located off Harrington Point.

In the 1955-56 winter season the Washington crews again fished Klondike and Chute Drifts and a number of sites in the Skamokawa area several miles upstream. The Oregon crews fished near Woody Island between the two Washington fishing areas (Figures 2 and 3).

The first year's tagging off Astoria had certain advantages. Tagging sites were located downstream from most of the winter steelhead spawning tributaries; hence fish from all streams may have been available. The sites were at the lower extremity of the commercial fishery so the tagging gear should have had the first opportunity to catch steelhead entering the Columbia. There was lack of success in catching large numbers of steelhead off Astoria, however, possibly because the river is about 7 miles in width.

The main advantage of the Woody Island-Skamokawa area, used exclusively in the second year, was that fishing took place in a constricted part of the river, resulting in relatively large catches. A disadvantage was that it was located upstream from a number of steelhead-producing tributaries, the most important of which was Grays River. This situation may not have been serious since steelhead tend to mill in the main Columbia before entering the tributaries and several tags were eventually recovered in these downstream tributaries. Since the Woody Island-Skamokawa area has a concentrated commercial fishery during February, it was possible for tagged steelhead to be taken by the commercial fishery before becoming evenly distributed throughout the untaged population.

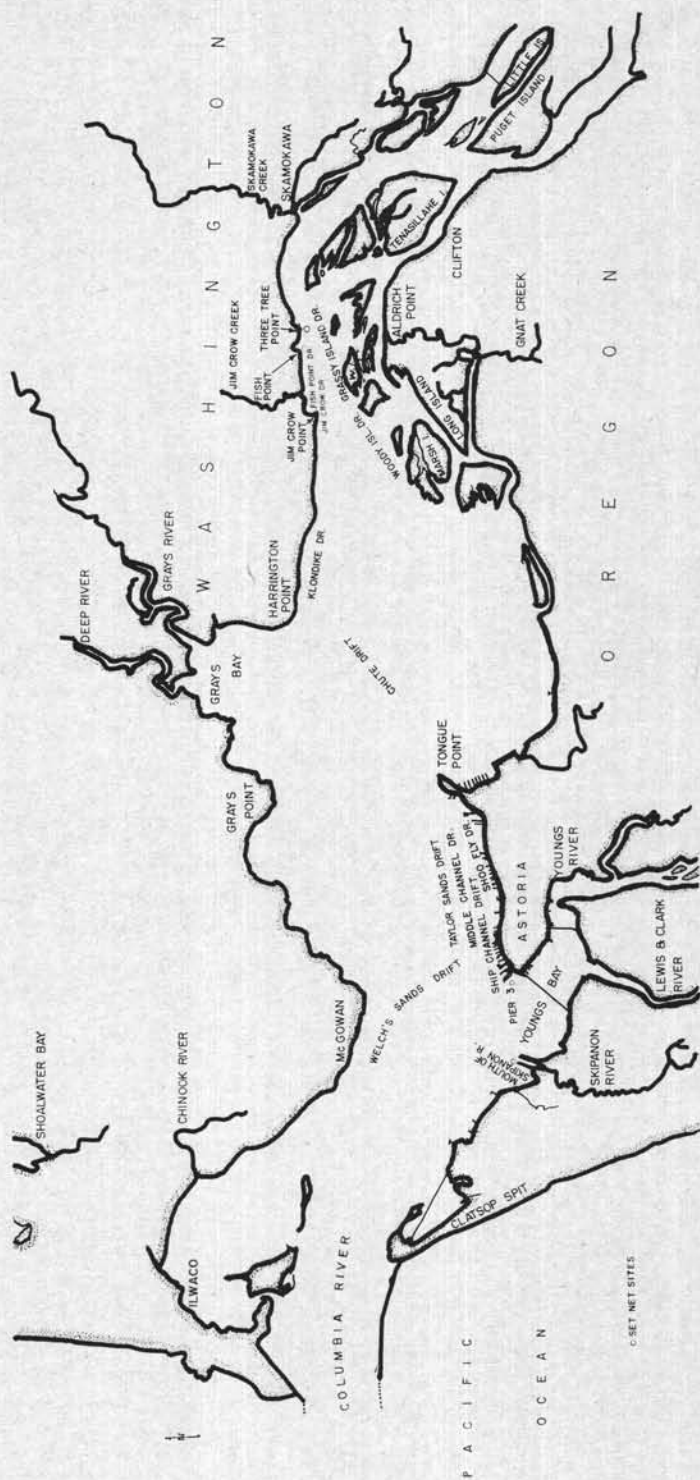
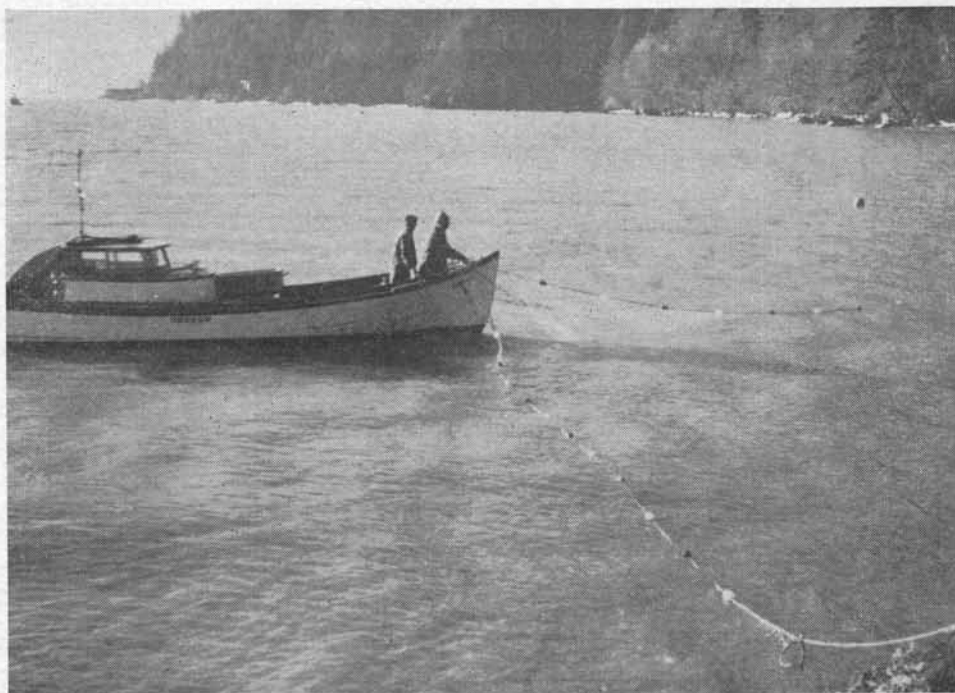


FIGURE 2. LOWER COLUMBIA RIVER TAGGING SITES, 1954-56.  
Scale: 1 inch equals 5 miles.





**FIGURE 3.** SET NETTING FOR WINTER STEELHEAD IN THE WOODY ISLAND AREA OF THE COLUMBIA RIVER.

### **Tagging Periods**

Tagging occurred in the first year from December 2, 1954 to April 25, 1955. Few steelhead were caught during December, largely due to inclement weather, although it was generally felt that large numbers of fish were present. After April 15, 1955, few steelhead were caught even though tagging continued for 10 days.

During the second winter, tagging occurred from November 27, 1955 to March 30, 1956. Fishing was generally good, with sporadic slack periods, particularly in cold weather. February weather was especially severe, resulting in curtailed fishing and fewer tagged steelhead. Commercial landings were also down. Good catches of steelhead were still being made when the tagging program ended on March 30.

### **Tagging Methods**

During the first year fish were tagged immediately after removal from the net. In the second year, the catch was frequently so large that taggers could not keep pace with the fish brought into the boat. As a result, the Oregon crews devised and installed in the fish locker of the gill-net boats a holding tank consisting of a large piece of canvas attached to a rectangular section of 1-inch pipe clamped to the top of the locker. The canvas hung from the pipe frame and conformed to the contour of the locker.

Operations were also facilitated in 1955-56 at Woody Island by the use

of a live box, made of a balsa wood ring from a Navy life raft and webbing from a fish trap. The box was placed in the Columbia at Woody Island. Steelhead caught by gill net for tagging would first be placed in the holding tank in the boat locker, and then transported to Woody Island and transferred to the live box there until it was convenient to tag them. This procedure saved time which could be devoted to fishing and also made tagging easier since fish could be tagged from land instead of a rocking boat. Use of the Woody Island live box was discontinued in March 1956 when large numbers of fish were caught on each drift and could not be accumulated in the boat locker due to the danger of crowding. They were tagged as quickly as possible and returned to the water.

During the winter of 1954-55 Petersen-type plastic disc tags were used by both departments. They were applied at the origin of the dorsal fin with soft-temper stainless steel pins. These pins bent too easily due to the soft temper. Consequently a hole was made in the back of the fish with a hypodermic needle so the pin could be inserted.

In 1955-56, the Washington crew used only spaghetti-tube tags and the Oregon crew both spaghetti and Petersen tags. Whenever possible, the Oregon crew tagged fish alternately with the two types of tags. Occasionally the supply of spaghetti tags was exhausted and for certain periods Petersen tags only were used. The total number of tags put out by both crews was 1,643 Petersen and 1,719 spaghetti. Petersen tags were again applied at the origin of the dorsal fin, and hard-temper stainless steel pins were used satisfactorily. The hypodermic needle technique was not necessary.

Spaghetti tags were applied just below and slightly forward of the insertion of the dorsal fin. The spaghetti tag used by the Washington crew had a short plastic sheath with the necessary printing, but the Oregon tag had the inscription directly on the spaghetti. The tag was applied with a long, straight aluminum needle and a simple overhand knot was used to tie the ends. Figure 4 shows the tags used by each organization.

A small section of the dorsal lobe of the caudal fin was clipped on all salmonids tagged as an aid to biologists sampling the commercial catch, thus permitting them to identify readily fish from which the tag had been lost or removed.

### Summary of Tagging

Table 2 shows the numbers of each species tagged during the two winters. Steelhead numbered 4,199 while all species totalled 7,247.

**TABLE 2.—NUMBERS OF FISH TAGGED BY SPECIES, 1954-55 AND 1955-56.**

Winter of Tagging	Numbers Tagged							Total
	Steelhead	Chinook	Silvers	Chums	White Sturgeon	Green Sturgeon	Shad	
1954-55 .....	837	1,484	1	1	132	26	63	2,544
1955-56 .....	3,362	522	99	7	575	138	.....	4,703
Total ....	4,199	2,006	100	8	707	164	63	7,247

Figure 5 depicts the length-frequency distributions at tagging of all steelhead tagged and recovered.



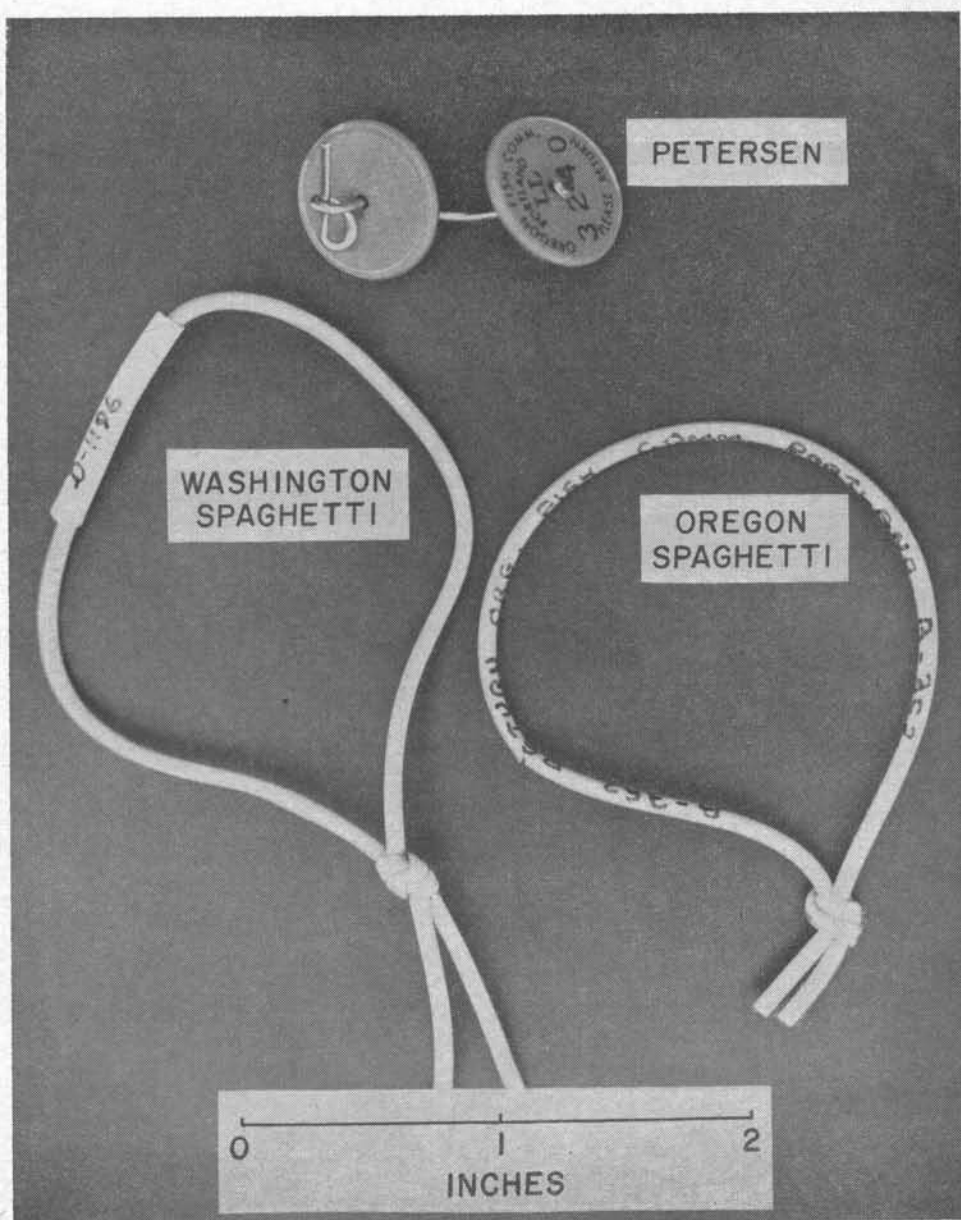


FIGURE 4. TYPES OF TAGS USED IN THE WINTER STEELHEAD TAGGING PROGRAM.

Tables 3 and 4 summarize tagging mortalities by “net kill” and “seal kill”. Mortalities due to net and seal kill amounted to 88 in the first and 255 in the second winter.

## RECOVERIES

### Recovery Methods

The principal means of obtaining tag recoveries were: (1) from commercial fishermen, voluntarily; (2) sampling of the commercial catch; (3) tagging crews; (4) sport fishermen, voluntarily; (5) sampling of the sport catch in Grays River by the Washington Department of Fisheries; and (6) from fishway traps and hatchery personnel.

Tagged steelhead appeared at the Toutle and Elokom River hatcheries of the Washington Department of Fisheries and Minto Holding Ponds on the North Santiam River and Big Creek Hatchery of the Oregon Fish

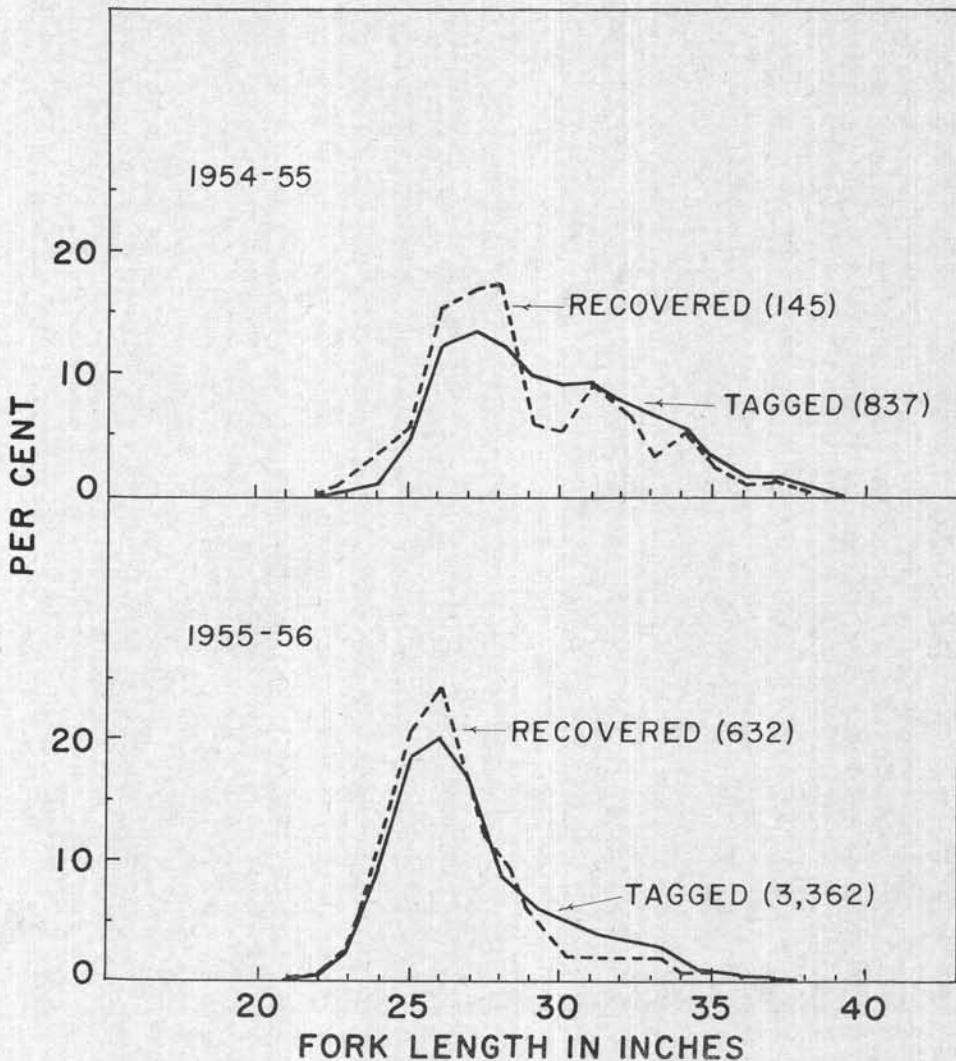


FIGURE 5. SIZE COMPOSITION AT TAGGING OF TAGGED AND RECOVERED WINTER STEELHEAD, 1954-56.

TABLE 3.—STEELHEAD TAGGING MORTALITY, 1954-55.

	Drift Net						Set Net						Total Drift and Set Nets
	Dec.	Jan.	Feb.	Mar.	Apr.	Total	Dec.	Jan.	Feb.	Mar.	Apr.	Total	
<i>Oregon</i>													
Net Kill .....	0	0	6	17	9	32	0	0	7	9	1	17	49
Seal Kill .....	3	7	11	1	4	26	0	0	0	0	0	0	26
Total .....	3	7	17	18	13	58	0	0	7	9	1	17	75
<i>Washington</i>													
Net Kill .....	0	0	0	0	2	2	SET NETS NOT USED						2
Seal Kill .....	11	0	0	0	0	11	SET NETS NOT USED						11
Total .....	11	0	0	0	2	13	SET NETS NOT USED						13
<i>Oregon and Washington</i>													
Net Kill .....	0	0	6	17	11	34	0	0	7	9	1	17	51
Seal Kill .....	14	7	11	1	4	37	0	0	0	0	0	0	37
Total .....	14	7	17	18	15	71	0	0	7	9	1	17	88

TABLE 4.—STEELHEAD TAGGING MORTALITY, 1955-56.

	Drift Net						Set Net						Total Drift and Set Nets
	Nov.	Dec.	Jan.	Feb.	Mar.	Total	Nov.	Dec.	Jan.	Feb.	Mar.	Total	
Oregon													
Net Kill .....	8	33	4	0	16	61	0	1	12	6	81	100	161
Seal Kill .....	1	21	2	0	1	25	0	0	8	0	0	8	33
Unspecified .....	0	1	1	0	0	2	0	0	0	0	0	0	2
Total .....	9	55	7	0	17	88	0	1	20	6	81	108	196
Washington													
Net Kill .....	0	1	0	0	44	45	0	0	0	1	5	6	51
Seal Kill .....	0	1	7	0	0	8	0	0	0	0	0	0	8
Total .....	0	2	7	0	44	53	0	0	0	1	5	6	59
Oregon and Washington													
Net Kill .....	8	34	4	0	60	106	0	1	12	7	86	106	212
Seal Kill .....	1	22	9	0	1	33	0	0	8	0	0	8	41
Unspecified .....	0	1	1	0	0	2	0	0	0	0	0	0	2
Total .....	9	57	14	0	61	141	0	1	20	7	86	114	255

Commission. Tag recoveries were also obtained from Marmot Dam on the Sandy River, River Mill Dam on the Clackamas River, Powerdale Dam on Hood River, Warrenton Water Supply Dam on Lewis and Clark River, Number 5 Falls on Klickitat River, Sheppard Falls on Wind River, Gnat Creek weir, and Merwin Dam on the North Fork of the Lewis River.

Finally, some tags were returned by people who found them on dead fish (4 in 1954-55 and 3 in 1955-56).

### Summary of Recoveries

Tables 5 and 6 show the numbers of steelhead tagged and recovered during the two winters of tagging.

There was a total of 20 second year recoveries, 1 from 1954-55 tagging and 19 from 1955-56 tagging. The 1 recovery from the first year's tagging was made by the sport fishery; of the second year's tagging, 7 recoveries were from the sport fishery, 11 from the commercial fishery, and 1 from a fishway. These recoveries are not included in Tables 5 and 6.

### COMPARISON OF RECOVERIES BY TAG TYPES

Table 7 shows the numbers of steelhead tagged and recovered and per cent recovered by type of tag and source of recovery for 1955-56. The percentages recovered by the commercial fishery and tagging crews (who used gill nets exclusively) were greater for Petersen than spaghetti tags. However, the percentages recovered by the sport fishery and at dams and hatcheries were quite similar for the two types of tags.

Because of insufficient information, the November-December recoveries from the commercial fishery and tagging crews and November-February recoveries at dams and hatcheries are omitted from the following statistical tests and consequently are not included in Table 7. For this reason, the numbers tagged varies by source of recovery (see footnotes in tables). All recoveries within a time period, both from sampling and voluntary returns, were combined since it was felt that the chance of recovery by voluntary means was independent of tag type.

Chi-square tests comparing the number of recoveries of Oregon and Washington spaghetti tags (Li, 1957), shown in Table 8, suggest that there was no significant difference for any source of recovery. As a result, the Washington and Oregon spaghetti tag recoveries were combined for use in later tests.

Table 9 shows the results of chi-square tests comparing Petersen and spaghetti tag recoveries for each source of recovery (commercial fishery, sport fishery, dams and hatcheries, and tagging crews). In the case of the commercial fishery and tagging crews, there is a significant difference in recovery ratios for the two types of tags, indicating selectivity for Petersen tags. There was no significant difference in the sport fishery and at dams and hatcheries, and thus no apparent selectivity for either tag.

A second type of calculation was employed to obtain confidence limits for the ratio of percentage of Petersen tags to spaghetti tags recovered (Yates, 1953), shown in Table 10. If conditions affecting the recovery of the two types of tags were equal, a 1:1 ratio for the percentage of Petersen to spaghetti tags recovered would be expected. The results indicated, however, that the ratio was greater than 1:1 for the commercial-fishery and tagging-crew recoveries. The sport-fishery and dam and hatchery recoveries exhibited nearly a 1:1 ratio.



TABLE 5.—NUMBERS OF STEELHEAD TAGGED AND RECOVERED BY SOURCE AND MONTH OF TAGGING, 1954-55.

Month of Tagging	Numbers Tagged	Numbers Recovered											Per Cent Recovered	
		Sport Gear			Hatcheries							Misc.①		Total Recovered
		Wash. Trib.	Ore. Trib.	Main Columbia	Total	Ore.	Wash.	Fishways Ore.	Commercial Gill Net	Tagging Gear				
Dec. 1954	33	2	1	0	3	0	0	1	5	0	0	9	27.3	
Jan. 1955	120	7	1	3	11	0	0	1	12	3	0	27	22.5	
Feb. 1955	184	5	2	2	9	0	3	2	32	9	0	55	29.9	
Mar. 1955	385	8	7	4	19	1	1	4	3	6	5	39	10.1	
Apr. 1955	115	0	2	0	2	2	0	1	7	2	1	15	13.0	
Total	837	22	13	9	44	3	4	9	59	20	6	145②		
Per Cent Recovered		2.6	1.5	1.1	5.3	0.4	0.5	1.1	7.0	2.4	0.7	17.3		

① Tags recovered from dead fish found in streams and through undetermined methods.

② Total recoveries: Washington tributaries, 28; Oregon tributaries, 26; main Columbia, 91.

TABLE 6.—NUMBERS OF STEELHEAD TAGGED AND RECOVERED BY SOURCE AND MONTH OF TAGGING, 1955-56.

Numbers Recovered															
Month of Tagging	Numbers Tagged	Sport Gear			Hatcheries				Fishways		Commercial Gill Net	Tagging Gear	Misc.①	Total Recovered	Per Cent Recovered
		Wash. Trib.	Ore. Trib.	Main Columbia	Total	Ore.	Wash.	Ore.	Wash.						
Nov. 1955	41	3	2	0	5	0	0	1	0	3	0	1	10	24.4	
Dec. 1955	326	31	14	5	50	0	0	0	0	4	5	0	59	18.1	
Jan. 1956	472	35	3	0	38	2	0	1	0	45	20	6	112	23.7	
Feb. 1956	287	8	2	1	11	0	1	4	0	23	26	0	65	22.6	
Mar. 1956	2,236	85	68	12	165	12	13	25	1	17	140	13	386	17.3	
Total ..	3,362	162	89	18	269	14	14	31	1	92	191	20	632②	—	
Per Cent Recovered .....		4.8	2.6	0.5	8.0	0.4	0.4	0.9	0.03	2.7	5.7	0.6	18.8		

① Tags recovered from dead fish found in streams and through undetermined methods.

② Total recoveries: Washington tributaries, 189; Oregon tributaries, 142; Main Columbia, 301.



TABLE 7.—NUMBERS OF STEELHEAD TAGGED AND RECOVERED AND PER CENT RECOVERED BY TAG TYPE  
AND SOURCE OF RECOVERY, 1955-56.

	Commercial Fishery <sup>①</sup>			Taggers <sup>①</sup>			Sport Fishery <sup>②</sup>			Dams and Hatcheries <sup>③</sup>		
	Ore. P. ④	Ore. S. ⑤	Wash. S.	Ore. P.	Ore. S.	Wash. S.	Ore. P.	Ore. S.	Wash. S.	Ore. P.	Ore. S.	Wash. S.
Numbers of Steelhead Tagged ....	1,410	802	783	1,410	802	783	1,602	894	825	1,094	546	596
Numbers of Tags Recovered .....	57	15	13	104	32	36	123	68	58	27	18	11
Per Cent Recovered .....	4.0	1.9	1.7	7.4	4.0	4.6	7.7	7.6	7.0	2.5	3.3	1.8

① Excludes data from November-December tagging.

② Excludes data from November tagging.

③ Excludes data from November-February tagging.

④ Petersen tags.

⑤ Spaghetti tags.

TABLE 8.—RESULTS OF CHI-SQUARE TESTS COMPARING RECOVERIES OF OREGON SPAGHETTI AND WASHINGTON SPAGHETTI TAGS.

Source of Recovery	X <sup>2</sup> Value	Probability	Degrees of Freedom
Commercial Fishery .....	0.0984	>.70	1
Tagging Gear .....	0.3629	>.50	1
Sport Fishery .....	0.2083	>.50	1
Dams and Hatcheries .....	2.4120	>.10	1

TABLE 9.—RESULTS OF CHI-SQUARE TESTS COMPARING RECOVERIES OF OREGON PETERSEN AND OREGON AND WASHINGTON SPAGHETTI TAGS.

Source of Recovery	X <sup>2</sup> Value	Probability	Degrees of Freedom
Commercial Fishery .....	13.9252	<.01	1
Tagging Gear .....	12.9970	<.01	1
Sport Fishery .....	0.1307	>.70	1
Dams and Hatcheries .....	0.0147	>.90	1

TABLE 10.—RATIOS OF PER CENT PETERSEN TO SPAGHETTI TAGS RECOVERED AND CALCULATED CONFIDENCE LIMITS FOR THESE RATIOS.

Source of Recovery	Ratio of % Petersen to Spaghetti Tags Recovered	95% Confidence Limits for Ratio of Recoveries
Commercial Fishery .....	2.28:1	1.27—3.29
Tagging Crews .....	1.71:1	1.20—2.23
Sport Fishery .....	1.04:1	0.80—1.30
Dams and Hatcheries .....	0.97:1	0.47—1.46

The calculated confidence limits were large in all cases; those for the commercial fishery and tagging crews were above the 1:1 ratio but the lower limits approached this ratio. The upper limits were greater than 2 to 1. The confidence limits found for recoveries in the sport fishery and at hatcheries and dams straddled the 1:1 ratio and further indicated there was no selectivity in these two tag recovery sources.

The question arises, how could there be a 1:1 ratio in the tributary recoveries after the commercial fishery had already taken Petersen tags out of the population in a greater than 1:1 proportion? This situation is understandable, however, because only about 3 per cent of all the tags released were taken by the commercial fishery. This figure was obtained by a calculation of tagged to untagged data from sampling the commercial steelhead fishery in the Columbia River. This fishery did not take enough tags to cause an appreciable imbalance in the other recovery areas. Recoveries made by the tagging gear were returned to the river and many of these fish were later recaptured in the tributaries.

The results of all these tests suggest that the commercial fishery and tagging crews fished selectively on Petersen tags. The exact degree of selectivity is unknown but appears to be about 2:1. There is no indication of selectivity on either type of tag from recoveries in the sport fishery or at dams and hatcheries.

## TIMING AND MOVEMENT OF WINTER STEELHEAD RUNS THROUGH THE LOWER COLUMBIA RIVER

Studies were made to determine: (1) the abundance of steelhead in the lower Columbia as shown by the numbers of fish tagged by month; (2) the range of time individual steelhead remain in the main Columbia, according to recoveries by the commercial fishery and tagging gear; and (3) the period of time steelhead from specific tributaries are found in the main Columbia as indicated by sport fishing tag recoveries in the tributaries.

Tagged-to-untagged ratios were obtained from check points on five tributaries below Bonneville Dam during the 1955-56 winter season: the Washington Department of Fisheries hatchery racks on the Elokomín and Toutle Rivers (the Toutle River is a tributary of the Cowlitz River); the Oregon Fish Commission weir on Gnat Creek; Marmot Dam on the Sandy River; and Willamette Falls on the Willamette River. The Cowlitz, Sandy, and Willamette Rivers are among the major winter steelhead streams in the Columbia River system. Table 11 shows the numbers of steelhead sampled and tags counted at each of the tributary check points.

**TABLE 11.—NUMBERS OF TAGGED AND UNTAGGED STEELHEAD  
COUNTED AT TRIBUTARY CHECK POINTS, 1956.**

Tributary	Numbers Untagged	Numbers Tagged	Total	Per Cent Tagged
Elokomín River .....	106	4	110	3.6
Toutle River .....	365	10	375	2.7
Gnat Creek .....	261	3	264	1.1
Willamette River .....	1,875	22	1,897	1.2
Sandy River .....	2,176	34	2,210	1.5
Total .....	4,783	73	4,856	1.5

The percentage of tags found in the samples varied from 1.1 to 3.6 per cent of the total fish counted. The value of chi-square resulting from a test of these ratios has a probability greater than 5 per cent, indicating no significant difference in the tagged-to-untagged ratios from the areas sampled. As a result of this test, the assumption is made that the various tributary runs of winter steelhead were tagged at a similar rate as they traveled through the lower Columbia River. It was not possible to test the tagged-to-untagged ratios found in the tributary samples during 1954-55 due to the small number of tag recoveries.

The ratio of tags recovered in the tributary samples to the steelhead tagged was tested by period of tagging for both years of the program. This was done for all tributaries combined since individual streams did not have sufficient recoveries. The resultant chi-square value, having a probability greater than 10 per cent, indicated no significant difference in the tag recovery ratio by period of tagging. Sampling in the tributaries was therefore assumed to be proportional during the two years of the experiment.

Figure 6 summarizes the percentage of steelhead tagged by month for each of the two winters and indicates that steelhead were present in the lower Columbia River from November through April. The largest numbers of steelhead were present during March, with lesser numbers present during the months of December, January, February, and April. In the second year, tagging did not continue into April. The mortalities are not included in these figures but they would have small influence on these percentages. Competition with the commercial fishery undoubtedly affected the numbers of fish caught for tagging during February of both years. The first year's tagging is probably a better presentation of the progression of the run since tagging took place below the major fishery. The commercial fishery does not operate in March, when the largest numbers of steelhead appeared to be present.

The length of time winter steelhead spend in the main Columbia River is also of interest. Tables 12 and 13 show recoveries for both years by the tagging crews and commercial fishermen by 10-day periods of tagging and recovery. Most of the recoveries were made by the tagging crews during the 10-day period of tagging and the 10-day period following tagging, indicating that many steelhead remained in the tagging area up to 20 days. A few tags were recovered by the tagging crews after being out over a month.

Three commercial fishing seasons affected the winter steelhead runs: September 10–December 1, January 29–March 1, and April 30–May 27 for both winters. The February commercial fishery recovered many tags put out in January. Also, tags put out in early February were taken throughout the month. The commercial fishery recoveries indicate that tagged fish remained in the main Columbia up to a month or more. The May commercial fishery yielded a number of tags—20 per cent of the total commercial recoveries for each year. Many of these fish were known spawnouts, however, and not fish that had remained in the main Columbia after tagging.

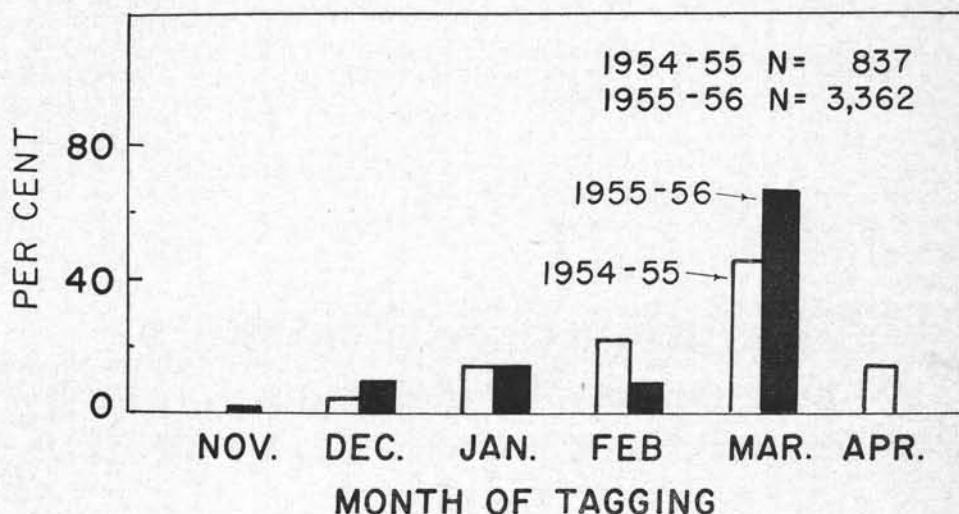


FIGURE 6. PERCENTAGE OF WINTER STEELHEAD TAGGED BY MONTH, 1954-55, AND 1955-56.



TABLE 12.—RECOVERIES BY TAGGING CREWS BY 10-DAY PERIODS, 1954-56<sup>①</sup>.

Tagging Period	Numbers Tagged	Numbers Recovered by Days Out					Total Recovered
		0-10	11-20	21-30	31-40	Over 50	
Nov. 27-Dec. 1 <sup>②</sup> .....	61 (0)	0	1	0	0	0	1
Dec. 2-11 .....	144 (5)	1	0	0	0	0	1
12-21 .....	150 (10)	0	0	1	0	0	1
22-31 .....	45 (18)	0	2	0	0	0	2
Jan. 1-10 .....	147 (32)	1 (1)	3	2	0	0	6 (1)
11-20 .....	174 (34)	1	2	1	0	1	6
21-30 .....	233 (54)	2 (2)	1	0	2	2	7 (2)
Jan. 31-Feb. 9 .....	99 (39)	2	0	1	1	0	4
Feb. 10-19 .....	146 (99)	10 (9)	4 (3)	1	0	0	15 (12)
20-29 .....	282 (64)	9 (2)	10 (1)	8 (2)	2 (1)	0	29 (6)
Mar. 1-10 .....	864 (149)	21 (1)	36 (1)	11	0	0	68 (2)
11-20 .....	1,058 (114)	21 (1)	31	0	0	0	52 (1)
21-30 <sup>③</sup> .....	681 (104)	17 (1)	1 (1)	0	0	0	18 (2)
Mar. 31-Apr. 9 .....	70 (70)	1 (1)	1 (1)	0	0	0	2 (2)
Apr. 10-19 .....	43 (43)	0	0	0	0	0	0
20-25 .....	2 (2)	0	0	0	0	0	0
Total .....	4,199 (837)	86 (18)	92 (7)	25 (2)	5 (1)	1	212 (28)

<sup>①</sup> Includes numbers tagged and recovered for both years; numbers tagged and recovered in 1954-55 in parenthesis included in totals.<sup>②</sup> 1954-55 tagging initiated December 2.<sup>③</sup> 1955-56 tagging ended March 30.



TABLE 13.—RECOVERIES BY COMMERCIAL FISHERMEN BY 10-DAY PERIODS, 1954-56<sup>①</sup>.

Tagging Period	Numbers Tagged	Recoveries by Period							Total Recovered
		Nov. 27- Dec. 1	Jan. 29-30	Jan. 31- Feb. 9	Feb. 10-19	Feb. 20- Mar. 1	Apr. 30- May 9	May 10-19	After May
Nov. 27-Dec. 1 <sup>②</sup>	61 (0)	3	0	0	0	0	0	0	3
Dec. 2-11	144 (5)	...	0	1	0	1	0	0	2
12-21	150 (10)	...	1 (1)	1	1	0	0	0	3 (1)
22-31	45 (18)	...	0	0	1 (1)	1 (1)	0	0	2 (2)
Jan. 1-10	147 (32)	...	0	2 (1)	2	0	0	0	4 (1)
11-20	174 (34)	...	2	7 (1)	1	3	0	0	13 (1)
21-30	233 (54)	...	2 (1)	8 (4)	13 (4)	10 (1)	0	0	33 (10)
Jan. 31-Feb. 9	99 (39)	...	...	1	4 (2)	5 (1)	0	0	10 (3)
Feb. 10-19	146 (99)	...	...	...	11 (11)	6 (4)	0	0	17 (15)
20-29	282 (64)	...	...	...	...	23 (5)	1 (1)	0	24 (6)
Mar. 1-10	864 (149)	...	...	...	...	...	2 (1)	3	5 (1)
11-20	1,058 (114)	...	...	...	...	...	1	2	3
21-30 <sup>③</sup>	681 (104)	...	...	...	...	...	8 (1)	5 (1)	13 (2)
Mar. 31-Apr. 9	70 (70)	...	...	...	...	...	1 (1)	1 (1)	2 (2)
Apr. 10-19	43 (43)	...	...	...	...	...	3 (3)	0	4 (4)
20-25	2 (2)	...	...	...	...	...	0	0	0
Total	4,199 (837)	3	5 (2)	20 (6)	33 (18)	49 (12)	16 (7)	11 (2)	1 (1) 138 (48)

<sup>①</sup> Includes numbers tagged and recovered for both years; numbers tagged and recovered in 1954-55 in parenthesis included in totals.<sup>②</sup> 1954-55 tagging initiated December 2.<sup>③</sup> 1955-56 tagging ended March 30.

Tag recoveries from the tagging crews and commercial fishery indicate that some winter steelhead exhibit a tendency to remain in the estuary prior to moving upstream and entering the tributaries. This behavior, termed milling or to-and-fro movement, is characteristic of some other salmonid populations that have been tagged in estuarine waters (Verhoeven, 1952 and Wendler, 1959). The possible effects of catching and tagging should not be overlooked, however, and this may be a factor in such behavior. As mentioned before, numbers of steelhead were retaken at the tagging sites during the same 10-day period as tagged or the 10-day period following and an occasional one up to a month or more after tagging. It is not possible to estimate from the tagging data the numbers of steelhead remaining in the lower Columbia River or the length of time involved. During the second year of the experiment 24 tagged steelhead were recaptured in Grays River; all of them were tagged in the Columbia River 3 to 9 miles upstream from the mouth of this tributary. Two obvious possibilities explain this behavior: (1) steelhead were hesitant to enter the tributaries immediately and deliberately milled in the Columbia River for a period of time, or (2) the fish had difficulty finding the mouth of the tributary for which they were bound, and moved back and forth in the main river while searching for their spawning stream. In either case, some milling in the main Columbia prior to entering a tributary is indicated.

A summary of the tag recoveries in the individual tributaries from all sources, by month of tagging, is shown in Tables 14 and 15. It is apparent from these tables that steelhead travel through the lower Columbia on their way to such major winter-steelhead-producing tributaries as the Cowlitz, Willamette, and Sandy Rivers throughout the winter months. Too few tag recoveries were received from the smaller tributaries to

TABLE 14.—RECOVERIES IN INDIVIDUAL TRIBUTARIES BY MONTH OF TAGGING, 1954-55<sup>①</sup>.

Tributaries	Recoveries by Month of Tagging					Total
	Dec.	Jan.	Feb.	Mar.	Apr.	
Grays River .....	0	0	0	1	0	1
Elokomin River .....	0	0	1	0	0	1
Cowlitz River .....	2	4	7	6	0	19
Kalama River .....	0	1	0	1	0	2
Lewis River .....	0	2	0	2	0	4
Willamette River .....	0	2	2	10	4	18
Sandy River .....	2	1	0	1	1	5
Washougal River .....	0	0	0	1	0	1
Hood River .....	0	0	2	2	0	1
Klickitat River .....	1	0	0	1	0	2
Total Tributary Recoveries ....	5	10	12	25	5	57
Numbers Tagged .....	33	120	184	385	115	837
Per Cent Recovered .....	15.2	8.3	6.5	6.5	4.3	6.8

① Both sport and non-sport recoveries are included.

TABLE 15.—RECOVERIES IN INDIVIDUAL TRIBUTARIES BY MONTH OF TAGGING, 1955-56<sup>①</sup>.

Tributaries	Recoveries by Month of Tagging					Total
	Nov.	Dec.	Jan.	Feb.	Mar.	
Lewis and Clark River .....	0	0	0	0	1	1
Grays River .....	1	0	4	1	18	24
Ferris Creek .....	0	0	1	0	0	1
Big Creek .....	0	0	2	0	0	2
Gnat Creek .....	0	0	3	0	0	3
Skamokawa Creek .....	0	0	0	0	1	1
Elokomin River .....	0	1	9	1	5	16
Clatskanie River .....	0	0	0	1	0	1
Abernathy Creek .....	0	0	0	0	1	1
Germany Creek .....	0	0	1	0	0	1
Cowlitz River .....	2	22	21	7	43	95
Kalama River .....	0	0	0	0	11	11
Lewis River .....	0	6	3	0	20	29
Salmon Creek .....	1	1	0	0	0	2
Willamette River .....	0	5	1	0	66	72
Sandy River .....	3	9	1	4	36	53
Washougal River .....	0	1	0	0	6	7
Wind River .....	0	0	0	0	1	1
Hood River .....	0	0	1	1	7	9
Klickitat River .....	0	0	0	0	2	2
Total Tributary Recoveries ....	7	45	47	15	218	332
Numbers Tagged .....	41	327	472	287	2,235	3,362
Per Cent Recovered .....	17.1	13.8	10.0	5.2	9.8	9.9

① Both sport and non-sport recoveries are included.

estimate adequately the period of time these fish were present in the lower Columbia. Some differences in sport fishing seasons between streams affected the occurrence of tag recoveries. The Oregon tributaries below St. Helens were closed to angling on February 28 but the tributaries above St. Helens remained open until June 30. There were also a number of mid-winter closures on the Washington tributaries that usually involved spawning areas. In general, the major steelhead streams remained open through the period of expected tag recoveries.

Figure 7 depicts the sport recoveries by per cent, by month of tagging, for the Cowlitz, Willamette, Sandy, and Lewis Rivers for the two years of the program. Only the Cowlitz and Willamette Rivers had sufficient recoveries for comparative purposes during the first year. The most obvious difference is between the Willamette River and other large winter steelhead streams. The preponderance of Willamette River sport tag recoveries came from tagging in March and April 1955 and March 1956, with a small proportion of the tags from the period December-February for both years (no tagging in April 1956). The Cowlitz River received equally large per-

centages of its recoveries from January and February tagging in the first year, and the largest percentage of its recoveries from March tagging in the second year. However, the total recoveries from November-February 1955-56 tagging was greater than from March 1956. The Sandy River

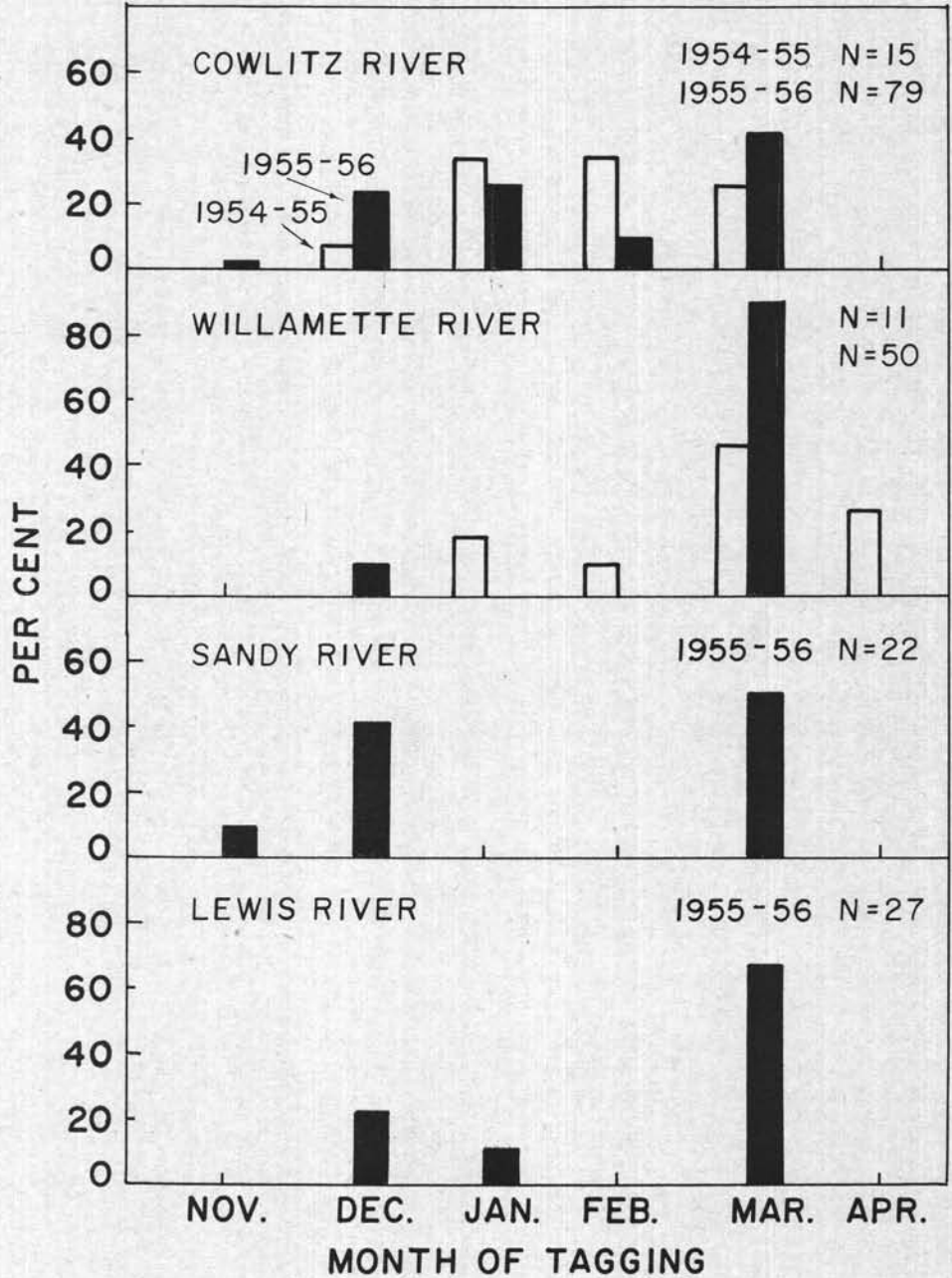


FIGURE 7. SPORT RECOVERIES IN MAJOR TRIBUTARIES BY MONTH OF TAGGING, 1954-55 AND 1955-56.



showed no particular trend since there were similar proportions of November-December and March tags recovered. March was the best individual month and none were recovered in the sport fishery from January or February tagging. The Lewis River received the largest proportion of its tag recoveries from the March tagging and smaller proportions from December and January.

It should be emphasized that these conclusions regarding timing do not necessarily pertain to the entire runs but to that portion entering the tributary sport catches. The tagging program indicates that the largest numbers of winter steelhead pass through the lower Columbia River during the period March-April (Figure 6). The sport tag recoveries, however, do not suggest that these fish were in all tributaries in proportion to their apparent abundance in the main Columbia River. A possible explanation may be that the later runs of fish are not subjected to the sport fishery for the period of time or intensity experienced by the earlier runs. This may be due to various closures in the spring to protect spawning fish and to anglers interest shifting to spring chinook salmon and trout at that time. The result may be a de-emphasis on the March-April steelhead in the sport catch from all tributaries.

Tables 16 and 17 present the total tributary recoveries, both sport and non-sport, by month of tagging and month of recovery for the two years of the program. The majority of the non-sport recoveries were made at fishways and hatcheries. Small numbers were taken by experimental fyke nets and set nets, and found dead in the streams. Tributaries having over a dozen recoveries were listed individually and all those having less were combined. The following remarks will deal mainly with the 1955-56 recoveries since they are more comprehensive than those for 1954-55.

It is apparent that tags from a particular month of tagging were recovered during the same month and several months thereafter. As an example, tags put out in December were recovered in the Cowlitz River from December through April; in the Lewis River from January through April; the Willamette River during January, February, April and June-August; and the Sandy River from December through April.

It is interesting to note that of the tags put out from November through February 1955-56 only two were recovered by sport fishermen after April. March tags, on the other hand, were recovered in March, April, May, and June-August. The lack of tag recoveries after April from November through February tagging may be due to the following causes: (1) the fewer tags put out in this period (one-third of the total as opposed to two-thirds in March); or (2) many of the earlier fish may either have moved upstream out of the sport fishing area or spawned and left the streams.

The recovery of tags during the period June-August, particularly by the sport fishery, may be deemed unusual since this period is considered to be after steelhead spawning. However, the majority of tags from this recovery period were taken in the Willamette River where spawned-out steelhead appear to be particularly vulnerable. Many of these tag recoveries were from known spawnouts. Most of the recoveries from fishways and hatcheries were made in April and May.



TABLE 16.—RECOVERIES IN THE TRIBUTARIES BY MONTH OF TAGGING AND MONTH OF RECOVERY, 1954-55<sup>①</sup>.

Recovery Stream	Month of Tagging	Nos. Tagged	Month of Recovery							Total <sup>②</sup>
			Dec.	Jan.	Feb.	Mar.	Apr.	May	June-Aug.	
Cowlitz and Tribs.	Dec.	33	0	0	2	0	0	0	0	2
	Jan.	120	...	1	3	0	0	0	0	4
	Feb.	184	...	...	1	1	1	3 (1)	0	6 (2)
	Mar.	385	...	...	...	1	2	3 (2)	0	6 (2)
	Apr.	115	...	...	...	...	0	0	0	0
	Total	837	0	1	6	2	3 (1)	6 (3)	0	18 (4)
Willamette and Tribs.	Dec.	33	0	0	0	0	0	0	0	0
	Jan.	120	...	0	0	0	0	1	0	1
	Feb.	184	...	...	0	0	1	0	1 (1)	2 (1)
	Mar.	385	...	...	...	0	5	2 (1)	3 (3)	10 (4)
	Apr.	115	...	...	...	...	0	4 (2)	0	4 (2)
	Total	837	0	0	0	0	6	7 (3)	4 (4)	17 (7)
All Others	Dec.	33	0	0	0	1	1	1 (1)	0	3 (1)
	Jan.	120	...	0	2	1	0	1 (1)	0	4 (1)
	Feb.	184	...	...	0	0	1	2 (1)	0	3 (1)
	Mar.	385	...	...	...	2	3	2 (2)	1	8 (2)
	Apr.	115	...	...	...	...	0	0	1 (1)	1 (1)
	Total	837	0	0	2	4	5	6 (5)	2 (1)	19 (6)

<sup>①</sup> Includes sport and non-sport recoveries; non-sport recoveries in parentheses included in totals.

<sup>②</sup> Some totals do not agree with those in Table 14 due to unknown date of recovery for certain tags.

TABLE 17.—RECOVERIES IN THE TRIBUTARIES BY MONTH OF TAGGING AND MONTH OF RECOVERY, 1955-56.

Recovery Stream	Month of Tagging	Nos. Tagged	Month of Recovery						Total
			Dec.	Jan.	Feb.	Mar.	Apr.	May	
Grays	Nov.	41	1 (1)	0	0	0	0	0	1 (1)
	Dec.	326	0	0	0	0	0	0	0
	Jan.	472	...	1	3 (1)	0	0	0	4 (1)
	Feb.	287	...	...	0	1	0	0	1
	Mar.	2,236	...	...	...	11 (4)	7 (1)	0	18 (5)
Total			1 (1)	1	3 (1)	12 (4)	7 (1)	0	24 (7)
Elokomin	Nov.	41	0	0	0	0	0	0	0
	Dec.	326	0	0	1	0	0	0	1
	Jan.	472	...	1	5	3	0	0	9
	Feb.	287	...	...	0	0	1 (1)	0	1 (1)
	Mar.	2,236	...	...	...	2	2 (1)	1 (1)	5 (2)
Total			0	1	6	5	3 (2)	1 (1)	16 (3)
Cowlitz and Tribs.	Nov.	41	1	1	0	0	0	0	2
	Dec.	326	4	10	5	2	1	0	22
	Jan.	472	...	3	10 (1)	4	2	0	19 (1)
	Feb.	287	...	...	1	5	1	0	7
	Mar.	2,236	...	...	...	15 (1)	21 (7)	4 (3)	40 (11)
Total			5	14	16 (1)	26 (1)	25 (7)	4 (3)	90 (12)
Lewis	Nov.	41	0	0	0	0	0	0	0
	Dec.	326	0	2	1	2	1	0	6
	Jan.	472	...	0	0	2	1	0	3
	Feb.	287	...	...	0	0	0	0	0
	Mar.	2,236	...	...	...	1	12	4 (1)	18 (2)
Total			0	2	1	5	14	4 (1)	27 (2)

TABLE 17—Continued.

Recovery Stream	Month of Tagging	Nos. Tagged	Month of Recovery								Total②
			Dec.	Jan.	Feb.	Mar.	Apr.	May	June-Aug.		
Willamette and Tribs.	Nov.	41	0	0	0	0	0	0	0	0	
	Dec.	326	0	1	1	0	2	0	1	5	
	Jan.	472	...	0	0	0	0	1 (1)	0	1 (1)	
	Feb.	287	...	...	0	0	0	0	0	0	
	Mar.	2,236	...	...	...	2	27 (1)	24 (12)	12 (3)	65 (16)	
Total		3,362	0	1	1	2	29 (1)	25 (13)	13 (3)	71 (17)	
Sandy	Nov.	41	1	1	0	0	1 (1)	0	0	3 (1)	
	Dec.	326	1	2	3	1	2	0	0	9	
	Jan.	472	...	0	0	0	0	1 (1)	0	1 (1)	
	Feb.	287	...	...	0	0	0	4 (4)	0	4 (4)	
	Mar.	2,236	...	...	...	3	12 (6)	19 (18)	1 (1)	35 (25)	
Total		3,362	2	3	3	4	15 (7)	24 (23)	1 (1)	52 (31)	
All Others	Nov.	41	0	1	0	0	0	0	0	1	
	Dec.	326	0	1	1	0	0	0	0	2	
	Jan.	472	...	1	2 (1)	4 (4)	0	1	0	8 (5)	
	Feb.	287	...	...	1	0	1	0	0	2	
	Mar.	2,236	...	...	...	1	11 (1)	11 (1)	5 (1)	28 (3)	
Total		3,362	0	3	4 (1)	5 (4)	12 (1)	12 (1)	5 (1)	41 (8)	

① Includes sport and non-sport recoveries; non-sport recoveries in parentheses included in totals.

② Some totals do not agree with those in Table 15 due to unknown date of recovery for certain tags.

## POPULATION ESTIMATE

The tagging data were used to estimate the number of winter steelhead which entered the Columbia River during the period 1955-56. The estimate was based on the apparent homogeneity of tagged-to-untagged ratios from check points in five tributaries (Table 11): Elokomin and Toutle Rivers in Washington; and Gnat Creek, and Willamette and Sandy Rivers in Oregon. Data for the 1954-55 winter season were inadequate for this purpose.

The 1955-56 tag recovery ratios in the tributary samples were also tested for homogeneity by period of tagging. Recoveries from all tributary check points had to be combined due to relatively small numbers in each stream. The ratio of numbers of tags recovered to numbers of steelhead tagged for the January-February period was then compared with the same data for March. (The tagging period November-December was not included since it yielded only one tag return.) The difference between the proportions tested failed to produce a value of chi-square significant at the 5 per cent level. Thus the observed differences in recovery ratios between January-February and March tags can be attributed to sampling variation.

With respect to the five tributaries where enumerations could be obtained, it can be said that, in the aggregate, the number of recoveries varied directly with the number of tags released between January and March, when 88 per cent of the winter's total was tagged. Also, based on examination of tagged-to-untagged ratios, similar proportions of steelhead were tagged from each of the five tributaries having check points.

The method used to estimate the size of the 1955-56 winter steelhead run (November 27-March 30) in the Columbia River is that of Chapman (1952). Based on values of:  $t = 3,362$  = number of steelhead tagged,

$s = 73$  = number of tagged fish recovered at check points,

$n = 4,783$  = number of steelhead counted at check points,

the estimate of population is given by:

$$N = \frac{n(t+1)}{s+1} - 1 = \frac{4,783(3,362+1)}{73+1} - 1 = 217,367 \sim 217,400.$$

The calculation of confidence limits around this estimate follows the Poisson distribution recommended for use where the tag ratio in the population is low (Chapman, 1948). The 95 per cent confidence limits are 172,700-279,900.

Possible sources of error in the population estimate are tag loss and mortality due to tagging. The fish without tags counted at the check points could not be examined for tag scars or clipped caudal fins and as a result tag loss was not measured.

Results of the Oregon Fish Commission tagging at Gnat Creek weir provides some information on the loss of tags by steelhead. During the



1955-56 winter season, adult steelhead on their way upstream to the spawning area were tagged at the weir with both Petersen and spaghetti tags. Of 165 steelhead which returned downstream to the weir after spawning, only 10 (6 per cent) had lost their tags (Kruse, 1961). This experiment was repeated during the 1956-57 winter, when only 5 tags (4 per cent) were lost from 122 tagged steelhead counted downstream. Statistical tests indicate there was no significant difference between the loss of the two types of tags. The tagged fish recovered at Gnat Creek migrated shorter distances than most of the tagged fish recovered in the Columbia River tagging program; however, the majority of Columbia River steelhead had only to migrate from the point of tagging to the point of recapture in the tributaries whereas Gnat Creek fish were subjected to the rigors of spawning. The Gnat Creek study suggests that tag loss in the Columbia River program may not have been important in influencing the population estimate.

It was impossible to measure the mortality resulting from gill netting and tagging and the population estimate does not compensate for any such mortality.

## COMMERCIAL AND SPORT FISHING MORTALITY

The steelhead population estimate for the 1955-56 winter season permits calculation of commercial and sport fishing mortality rates for the same period, expressed as a range by taking the commercial and sport catches and calculating the percentage of each of the upper and lower limit of the population estimate.

The February 1956 commercial fishery landed approximately 8,100 steelhead (Oregon Fish Commission and Washington Department of Fisheries statistics). The confidence limits calculated for the population estimate in the Columbia River were 172,700-279,900. Commercial fishing mortality, therefore, was between 3 and 5 per cent of the total estimated steelhead run entering the Columbia River for the period November 27, 1955-March 30, 1956. A total of 3,091 winter steelhead was also landed during the commercial fishing season in November 1955. Since tagging began near the end of November, these fish were excluded from the population estimate. The mortality percentage consequently also excludes the November catch.

The 1955-56 Oregon and Washington winter steelhead sport catch presented in Table 18 (Oregon Game Commission, 1957, and Washington Department of Game, 1957) indicates that 37,145 fish were taken by anglers. The Washington figures are for the period December 1955-April 1956 and Oregon figures for the calendar year 1956. In the Oregon data November-December 1956 catches were substituted for the November-December 1955 figures—an unavoidable situation. The error involved should be negligible. The winter steelhead sport catch of 37,145 fish was between 13 and 21 per cent of the estimated Columbia River winter steelhead run, and the total commercial and sport fishing mortality constituted 16 to 26 per cent of the run.

TABLE 18.—ESTIMATED COLUMBIA RIVER WINTER STEELHEAD  
SPORT CATCH, 1955-56.

Washington <sup>①</sup>		Oregon <sup>②</sup>	
Stream	Estimated Catch	Stream	Estimated Catch
Abernathy Creek .....	76	Big Creek .....	757
Chinook River .....	16	Calapooya River .....	38
Cispus River .....	72	Clackamas River .....	2,465
Columbia River .....	2,288	Clatskanie River .....	336
Coweeman River .....	252	Gnat Creek .....	17
Cowlitz River .....	11,148	Klaskanine River .....	84
Deep River .....	12	Lewis and Clark River .....	183
Elokomin River .....	600	McKenzie River .....	58
Germany Creek .....	172	Molalla River .....	67
Grays River .....	1,208	Sandy River .....	5,272
Hamilton Creek .....	148	Santiam River .....	884
Kalama River .....	1,384	Scappoose Creek .....	78
Lewis River .....	0	Willamette River .....	1,673
East Fork Lewis River .....	2,608	Youngs River .....	17
North Fork Lewis River .....	180		
Mill Creek .....	16		
Salmon Creek .....	184		
Skamokawa Creek .....	84		
Tilton River .....	308		
Toutle River .....	3,224		
Washougal River .....	1,236		
Total .....	25,216	Total .....	11,929
Total Catch .....		37,145	

① From Washington Department of Game Bulletin, 1957. Washington figures for December 1955-April 1956.

② From Oregon State Game Commission, 1957. Oregon figures for calendar year 1956.

## SUMMARY

The Oregon Fish Commission and Washington Department of Fisheries carried out a cooperative winter steelhead trout tagging program on the lower Columbia River during the winters of 1954-55 and 1955-56.

The objectives of the investigation included: (1) determination of the timing of the various segments of the run, (2) population estimate, (3) determination of percentages of the winter steelhead run caught by the commercial and sport fisheries, and (4) a comparison of Petersen and spaghetti tags.

Both drift and set gill nets were used to capture steelhead for tagging. Commercial fishermen were employed to do the fishing.

During the first year of the program, tagging took place directly off Astoria and Harrington Point; in the second year, from Harrington Point upstream to the Skamokawa area. The tagging periods were December 2, 1954-April 25, 1955 and November 27, 1955-March 30, 1956.

Petersen tags only were used by both agencies during the first winter; the Washington Department of Fisheries used spaghetti tags and the Oregon Fish Commission both Petersen and spaghetti tags during the second winter.

A total of 837 steelhead was tagged during the first winter and 3,362 during the second winter. Eighty-eight steelhead mortalities due to netting and seal bites were recorded during the first winter and 255 steelhead were found dead in the nets during the second winter.

The principal sources of tag recoveries were the sport fishery, tagging gear, commercial fishery, fishways at dams and falls, and hatcheries. Total recoveries during the two winters of tagging were 145 and 632, respectively, or 17.3 and 18.8 per cent of the fish tagged.

Chi-square tests indicated a significant difference between the recovery ratios of Petersen and spaghetti tags from the commercial fishery and tagging crews. The gill nets appeared to exhibit a 2:1 selectivity for Petersen tags. No difference was found in the recovery ratios of Petersen and spaghetti tags from the tributary sport recoveries or at hatcheries and fishways.

The tagging study indicated that steelhead were present in the lower Columbia River throughout the winter months in each year, but in the greatest numbers during March.

Tag recoveries from the tagging crews suggest that numbers of winter steelhead remain or mill in the Columbia River up to 20 days and occasionally a month or more prior to entering the tributaries. Commercial fishery recoveries also were out up to a month or more.

The recovery of 24 tagged steelhead in Grays River in 1955-56 is regarded as corroborative evidence that steelhead mill in the main Columbia River since all these fish were tagged in the Columbia upstream from the mouth of Grays River.

Recoveries from the tributaries indicate that steelhead are traveling through the lower Columbia River on their way to the major winter steelhead-producing tributaries, such as the Willamette, Cowlitz, and Sandy Rivers, throughout the winter months.

Sport recoveries indicate that the largest proportion of the Willamette River sport catch came from steelhead moving through the lower Columbia during March and April in the first year and March in the second year. By contrast, the largest proportion of Cowlitz River recoveries were from fish tagged in December through February in both years. The Sandy and Lewis River recoveries showed no particular trend although March was the best month for both streams.

The winter steelhead population estimate in the lower Columbia for the period November 27, 1955-March 30, 1956 was 217,400 with 95 per cent confidence limits of 172,700-279,900.

The Columbia River commercial fishery was calculated to have taken between 3 and 5 per cent of the total estimated winter steelhead run during the 1955-56 season and sport fishermen between 13 and 21 per cent.

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