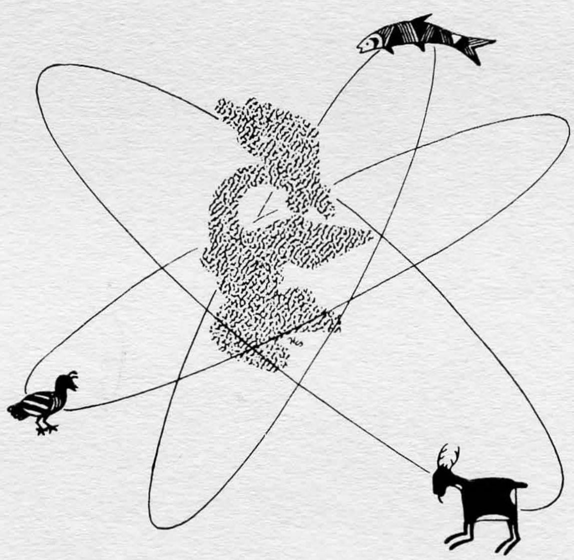
Massey

PROGRESS MEMORANDUM, FISHERIES
NUMBER 5
1971



RESEARCH DIVISION

Oregon State Game Commission

THE BIOLOGY OF THE WINTER STEELHEAD OF THE WILLAMETTE RIVER, OREGON

J. B. Massey

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by

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Oregon State Game Commission

September 1971

INTRODUCTION

On their return up the Columbia River in 1806, Lewis and Clark noted a large river, called the Multnomah, which entered from the south near the present site of Portland, Oregon. They theorized that this river and its wide valley might extend as far south as the Gulf of California. Although the size of its drainage basin was considerably overestimated, the Willamette River, as it is now called, still is one of the largest northerly-flowing rivers in the United States and is the largest river in the country entirely within one state.

There have been many changes in the Willamette and its basin since the time of Lewis and Clark. One of the more recent of these is the manipulation of the fish fauna of the river. The Fish Commission of Oregon (FCO) has embarked on an ambitious 10-year program to enhance the fishery resources of the river. Already coho and fall chinook salmon and summer steelhead have been introduced into various Willamette River tributaries and the existing runs of spring chinook salmon and winter steelhead have been increased. In addition, the Oregon State Game Commission (OGC) has also begun a program to establish summer-run steelhead in the Willamette system. Other studies have been made of the changes in the populations of salmon (Pearson, et al., 1967; Collins, 1969b). This paper deals only with the native winter steelhead, Salmo gairdneri gairdneri.

Historically, the major obstruction limiting the distribution of steelhead in the Willamette basin has been Willamette Falls at Oregon City (Figure 1). The falls, approximately 45 feet high depending on river water levels, was apparently a complete barrier to anadromous fish passage during lower flows. The winter steelhead, however, passed through the river during the rainy season and was able to negotiate the falls at certain flows (Collins, 1968). Only during the last year have improvements in the fish ladders at the falls allowed continuous year-round passage.

Even though winter steelhead had access above Willamette Falls, the species failed to become firmly established in many apparently suitable river systems like the Middle Fork, McKenzie, Marys, Luckiamute, Yamhill and Tualatin rivers. The Fish Commission estimates that over 50 percent of the potential for natural production is unutilized by winter steelhead. Largely because the native steelhead had such a late and short migration period, the Fish and Game Commissions introduced adults of other stocks of winter steelhead from coastal and lower Columbia River streams. Objectives beginning in 1964 were to enhance the size of the run and at the same time to develop an early run of steelhead above Willamette Falls (Collins, 1969a). Offspring were due to return from the ocean at the same time that improvements in fish passage were completed in recent years. The newer ladders pass

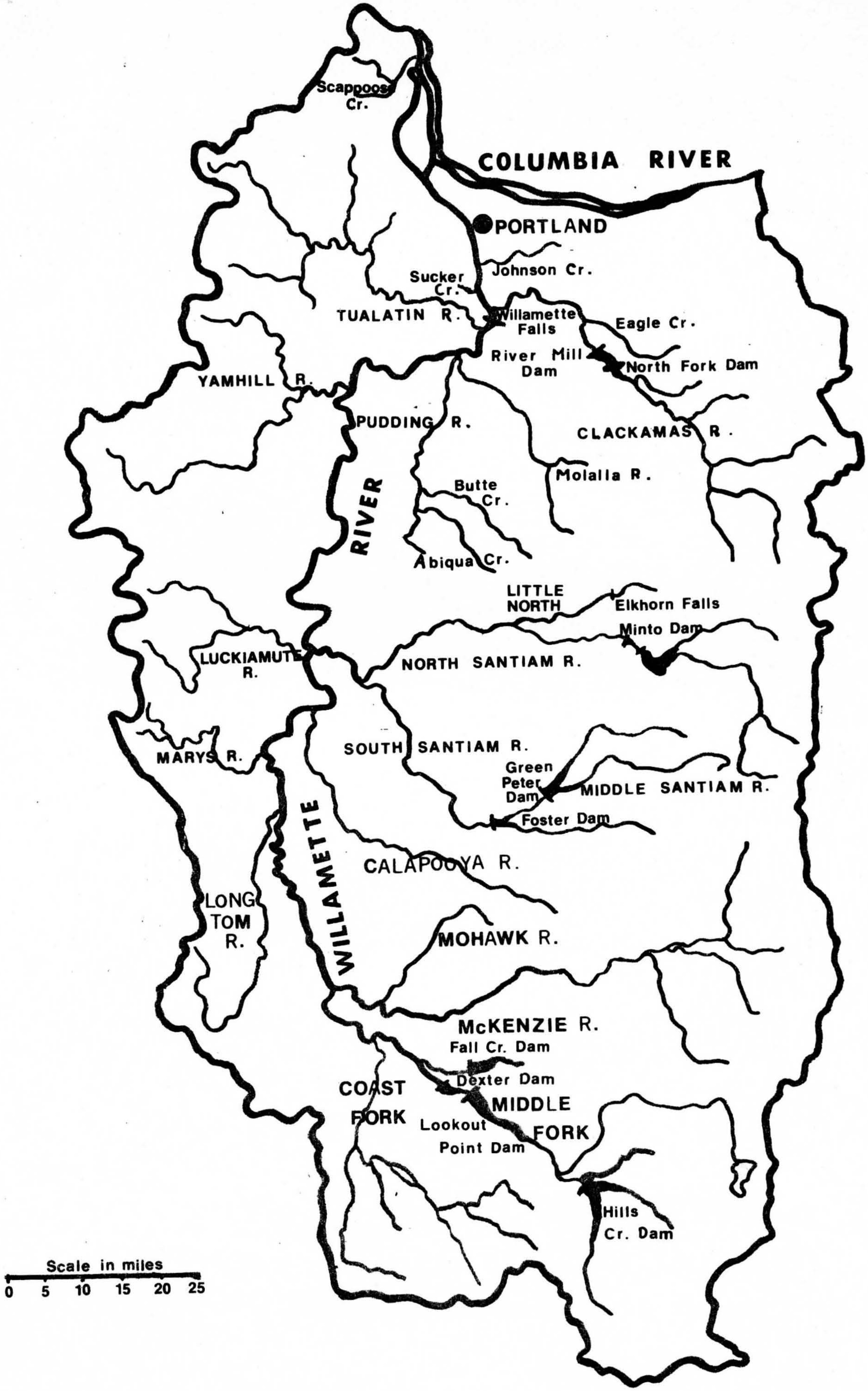

FIGURE 1. The Willamette River system, Oregon.

fish throughout the year while the older ladder was passable only duriing moderate flows (Collins, 1969a). In the 1970-71 season, the winter steelhead run was larger and earlier than any on record. Because of the two concurrent developments, it is no longer possible to identify the migration time of the native Willamette steelhead trout passing Willamette Falls. We do not know if the earlier fish are really the progeny of the introduced early-run adults or if they are native fish which in years past could not pass the falls until later in the season. Similarly, it is not clear if the increased numbers of fish passing the falls are due to successful reproduction by exotic steelhead in streams which previously had no run or to improved fish passage and more complete counts. The situation will undoubtedly become more confused as more introductions and fish passage improvements are made.

Another potential problem for native fish is posed by the introduction of exotic summer steelhead. Since substantial populations of no more than one form of rainbow trout (resident rainbow, winter or summer steelhead) apparently exist in any stream in the Willamette system, it is possible that if summer steelhead become established they will compete harmfully with the winter fish. An understanding of the biology of the native fish is necessary before additional introductions are made so that resource agencies may assess such competitive effects or other new developments. Only the general life history of the native steelhead will be discussed. No attempt will be made to summarize introductions of either native or exotic hatchery fish during recent years. Such has already been done (Collins and Korn, 1968; Collins, 1969b).

TIME OF UPSTREAM MIGRATION

Most of the data on the timing of the adult spawning run of steelhead in the Willamette has been collected at fish ladders bypassing various falls and dams. This information seems especially questionable since such ladders often have a tendency to delay or perhaps discourage fish passage altogether.

This may be the case in the Clackamas River, which is the major tributary of the main stem below Willamette Falls. Gunsolus and Eicher (1970) found that in 1950-64 the movement of "winter run" steelhead past the North Fork Project dams began in mid-April and extended up to the end of May or early June. The bulk of the run occurred during a three-week period in late April and early May. The estimated monthly catches of Clackamas River steelhead for 1956-69, however, would indicate that the peak abundance of steelhead was around the beginning of the year (Table 1, summarized by R. O. Koski, OGC). Hutchison and Aney (1964) reported that steelhead adults were in the Clackamas and main Willamette rivers all year.

The fish passing the North Fork Project likely are native steelhead which enter in March, while the large number of fish caught earlier below River Mill Dam are hatchery fish (E. Weiss, FCO, personal communication). Thus the data for the Clackamas in Table 1 are biased by the good returns of early-returning hatchery stock to Eagle Creek Hatchery in 1968-69 (Weiss, pers. comm; see section on exploitation). When the data for 1968 and 1969 are eliminated from the totals in Table 1, the remainder shows that there were between 4,335 and 4,997 fish caught in each month from December to April. Although peak months for 1956-67 were still January and December with 4,997 and 4,956 fish respectively, the April catch was just behind with 4,893 steelhead.

The timing of passage past Willamette Falls would appear to have been biased toward a late run. In 1966 and 1967, Collins (1968) found that although counting began in in February, only small numbers of steelhead passed the falls prior to April 5 and 6 peaks. He also noted that the fishway was impassable in January and late March because of high flows. Based on Fish Commission counts at Willamette Falls from 1957 to 1966, 76.6 percent of upstream movement occurred in April with 9.5 percent in March and 7.3 percent

TABLE 1. Estimated total sport catch of winter steelhead for 1956-69, by month, for the Willamette River and several tributaries.

Stream	MONTH AND NUMBER OF FISH												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
Calapooya R.	31	31	191	584	459	32	4	7	13	4	27	91	1,474
Clackamas R.	7,582	6,887	6,150	5,807	1,101	434	186	308	213	438	1,321	7,136	37,563
Johnson Cr. *	381	476	144	39	3					7	35	135	1,220
McKenzie R.	47	54	22	9	57	205	15	6	6	5	9	30	465
Molalla R.	39	116	273	1,038	789	12	15	19			10	17	2,328
Santiam R.	303	272	871	3,562	3,190	453	118	50	47	40	208	370	9,484
Scappoose Cr.	326	433	273	46	10	3	6			17	41	295	1,450
Sucker Cr. *	195	287	61	35	6		22	10		7	25	124	772
Willamette R.	2,841	3,482	3,948	6,491	1,386	210	410	256	177	335	445	1,618	21,599
TOTAL:	11,745	12,038	11,933	17,611	7,001	1,349	776	656	456	853	2,121	9,816	76,365

* Data for 1958-69 only

in May (Thompson, et al., 1966) but, in 1968 Collins (1969a) found that peak movement by the falls was in late February immediately after the installation of the new cul-de-sac ladder, with only a small peak in April. He felt that possibly the normal April peak was absent because most of the run passed by in February.

Another reason could be that the disastrous flood of winter, 1964, greatly reduced the naturally produced year-class of steelhead for that year. Since the most common life cycle of Willamette River steelhead consists of two years in both fresh and salt water (see section on age and growth), the late (March-April) run of wild fish may have been greatly reduced in 1968. If so, then the 1968 counts were mainly early hatchery fish introduced above Willamette Falls.

Korn (1961) tagged steelhead upon entrance from the ocean and then studied subsequent recoveries. He found that the preponderance of Willamette River sport tag recoveries came from fish tagged (in the mouth of the Columbia) in March and April, with only a small proportion of the tags from December through February. This would indicate that the Willamette run consisted mostly of "late-winter" fish which moved rapidly upstream and probably were not held up a great deal at Willamette Falls. Undoubtedly, however, many of these tag recoveries came

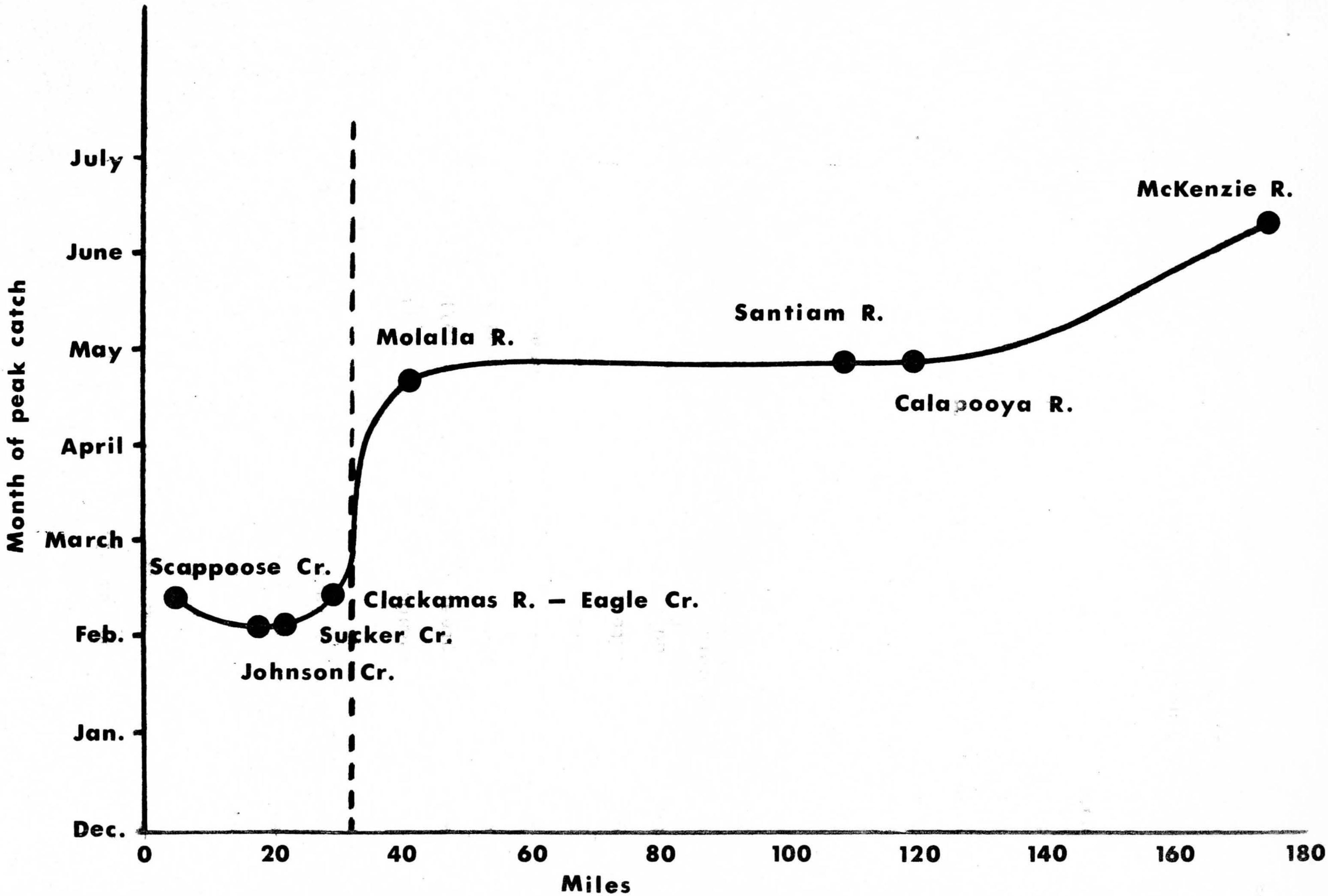

FIGURE 2. Comparison of the time of peak steelhead catches among various Willamette River tributaries, 1953-69. Mile "0" denotes Willamette confluence with Columbia; dashed line marks Willamette Falls.

from the lower Willamette where there is a heavy sport fishery for spring chinook salmon during mid-March through mid-May. This would tend to bias the tag returns towards steelhead tagged later in the season. Adult steelhead arrived at Minto Dam on the North Fork Santiam River only from May to mid-July (DeCew, 1969).

On the other hand, the monthly sport catch estimates for 1953-69 (presented in Table 1 and graphed in Figure 2) show that passage problems at Willamette Falls undoubtedly have held up, or at least exercised a strong natural selection on steelhead runs to the upper river. The catches in tributaries just below the falls peaked in February, while just above the falls the peak was in late April. Since significant numbers of steelhead were caught as early as December in streams below Willamette Falls, it appears that the genetic basis for an early run has always been present in some of the native fish.

SIZE AND DISTRIBUTION OF ADULT RUN

Table 2 (derived mainly from Table 2 of Collins, 1969a) gives partial counts of steelhead past Willamette Falls for 1950-71. Hutchison, et al., (1966b), who studied the numbers and distribution of steelhead redds in 1965-66 by major river system, estimated that most fish passing the falls were headed for the Molalla, Calapooya and Santiam rivers (Table 3).

TABLE 2. Estimated number of steelhead past Willamette Falls, 1950-71.

Year	Estimated Number of Fish
1950*	2,200
1951*	1,200
1952*	3,400
1953*	1,200
1954	5,200
1955	2,100
1956	3,800
1957	7,500
1958	5,500
1959	3,700
1960	2,200
1961	6,500
1962*	5,900
1963*	1,000
1964*	900
1965*	1,500
1966	14,700
1967	14,600
1968	6,400
1969	8,600
1970	4,700
1971	26,600

* Incomplete - see Collins (1969a)

TABLE 3. Estimated number of steelhead running in several Willamette River tributaries, 1965-66. /1

River	Estimated Number of Fish	Percentage of Estimated 13,910 fish past Willamette Falls
Coast Fork	21	0.2
Middle Fork	415	3.0
McKenzie	345	2.5
Santiam /2	8,261 /2	59.4
Molalla	4,454	32.0
Tualatin	414	3.0
Clackamas	5,499	

/1 See Hutchison, *et al.*, (1966b)
/2 Includes 1,000 *to* 2,000 Calapooya River fish.

The Coast Fork of the Willamette apparently had only a small sporadic run of steelhead (Thompson, et al., 1966). They did not occur naturally in the Middle Fork Willamette but were introduced from the North Santiam (DeCew, 1969; Fulton, 1970). The Middle Fork has the potential to produce a run of fish much greater than 400 but 80 percent of the basin's total miles of stream are closed to anadromous fish by dams. Hatcheries built by the Corps of Engineers as mitigation for the fish losses which were due to the effect of man-made structures apparently cannot replace the rearing capacity of the isolated streams (Thompson, et al., 1966). Counts of adult steelhead entering the Dexter holding ponds on the Middle Fork averaged 223 fish for 1957-66 (Hutchison, et al., 1966a). The ladder to these ponds is open only during the migration period of spring chinook, so these counts do not represent the entire run of steelhead, many of which spawn below Dexter Dam (E. Smith, FCO, pers. comm.)

The McKenzie River system appears to be ideal for anadromous fish and supports a substantial run of spring chinook salmon. Nevertheless, most of the small run of winter steelhead which entered the system each year used the Mohawk River and only occasional strays have reached the upper McKenzie since 1956 (Willis, et al., 1960). Reasons for the phenomenon are not known. It might be competitive exclusion and perhaps the historical existence of a large population of resident rainbow trout or "redside" in the McKenzie could partially explain the absence of steelhead. Perhaps a more logical explanation is given by E. Wagner (FCO, pers. comm.). Since the drainage basins of the McKenzie and Middle Willamette have the highest elevation of any Willamette River tributaries, he feels that these streams are too cold (below 45°) for optimum or even minimal upstream movement of adult steelhead during the normal time of the spawning migration in the Willamette system. Mean monthly water temperatures in the McKenzie River are usually near or below 45° from November to May. By May, lower water levels at Willamette Falls could have prevented the passage of a later run of steelhead to these streams.

Although there are a number of dams on the upstream areas of the Santiam, it and the Molalla system are probably the only rivers in the Willamette basin which have produced winter steelhead at near capacity. Steelhead adults collected at Minto Dam on the North Fork Santiam averaged 1,000 in 1952-59 (Fulton, 1970). An electronic counter at Elkhorn Falls on the Little North Fork Santiam found an average of 120 steelhead passed yearly during 1959-64 (Thompson, et al., 1966). Table 4 gives the numbers of steelhead which passed Willamette Falls in 1967-70 and the number which arrived at the adult trap at Foster Dam on the South Santiam River. In 1970, almost one-third of the fish passing the falls were

TABLE 4. Estimated number of steelhead passing Willamette Falls and the number counted at Foster Dam, South Santiam River, 1967-70. *

Year	NUMBER OF FISH Willamette Falls	 Foster Dam	Percentage of fish past falls counted at Foster Dam
1967	14,600	2,731	18.7
1968	6,400	1,100	17.2
1969	8,596	1,417	16.5
1970	4,682	1,413	30.2

*From minutes of Corps Projects Steering Committee Meeting, May 28, 1970.

accounted for at Foster. Either this means that the counts at Willamette Falls were low or that the South and Middle Forks of the Santiam above Foster Dam produced a disproportionate number of winter steelhead from the upper Willamette system. Since the counts at Willamette Falls were made primarily for spring chinook salmon and only at favorable flows, it is possible that the counts were low. Although quantitative data taken previous to dam construction on the South Santiam are apparently lacking, and the full impact of these dams is not yet apparent, the information would also seem to indicate that dams with adequate up- and downstream passage facilities may not necessarily be harmful to steelhead runs.

Gunsolus and Eicher (1970) give annual counts of adult steelhead passing River Mill Dam, 1950-55, and North Fork Dam, 1957-64, on the Clackamas River. Complete counts varied from 556 to 4,365 and averaged 800 fish per year.

Small numbers of winter steelhead also ran into a number of other Willamette tributaries (Thompson, et al., 1966). Hutchison and Aney (1964) reported that less than 500 steelhead moved into the Tualatin River each year suggesting that poor summer rearing conditions could be the cause. An electronic fish counter at Bonnie Falls on Scappoose Creek near Portland reported 376 steelhead in the winter of 1956-57 and 264 in 1957-58 (Willis, et al., 1960). The same publication reported that several hundred steelhead were held up at a dam on Abiqua Creek on the Pudding River in 1952.

EXPLOITATION BY ANGLERS

Even though the native Willamette winter steelhead above Willamette Falls arrive too late to have the bright appearance desired by sportsmen and are only in the stream for a relatively short time before spawning, they are sought by anglers, although not as actively as in most other Oregon steelhead streams. Korn (1961) who estimated that sport fishermen took between 13 and 21 percent of the Columbia River winter steelhead run in 1955-56, noted that spent fish appeared to be particularly vulnerable in the Willamette system and their catch provided many tag recoveries from June through August.

Table 5 presents the sport catch of steelhead for 1953-69 estimated from punch card returns for various Willamette River tributaries. The final column is the total catch for the system revised because of bias resulting from nonresponse (Hicks and Calvin, 1964; Koski, 1970). Even though the estimates for most individual streams cannot be corrected because of small catch size, the actual catch for each year in a stream should roughly parallel the deviation shown for total catch (Koski, 1970) and the original estimates should

TABLE 5. Estimated sport catch of steelhead in the Willamette River and several tributaries, 1953-69.

	RIVER AND NUMBER OF FISH											
Year	Cala-pooya	Clack-amas	Johnson Cr.	McKenzie	Molalla	Santiam	Scappoose Cr.	Sucker Cr.	Willamette	Total	Percent deviation*	Revised total*
1953	40	1,919		24	73	439	201		2,306	4,965		
1954	38	1,035		10	145	896	116		980	3,205		
1955	10	1,043		4	33	556	44		1,091	2,811	-16.2	2,356
1956	259	2,465		58	67	884	78		1,673	5,263	-14.2	4,516
1957	111	994		23	128	447	33		1,012	2,647	-11.0	2,356
1958	143	1,275	511	9	196	973	143	56	1,845	5,267	-15.4	4,456
1959	211	1,624	90	26	47	584	136	43	2,063	4,724	-17.3	3,907
1960	75	1,362	46	39	88	309	127	75	1,418	3,607	-15.7	3,041
1961	139	1,693	25	18	108	301	147	86	1,149	3,738	-16.3	3,129
1962	53	3,410	153	82	330	1,391	99	24	2,832	8,396	-16.0	7,053
1963	42	1,718	103	23	94	459	87	26	1,437	4,086	-15.6	3,449
1964	68	2,764	82	5	139	541	91	149	1,624	5,448	-17.9	4,473
1965	139	2,438	46	50	92	223	54	88	895	3,928	-16.7	3,272
1966	126	3,723	55	21	60	375	94	89	1,730	6,215	-17.3	5,140
1967	71	3,237	10	80	279	1,524	150	75	1,504	6,998	-18.1	5,731
1968	3	6,370	68	14	326	557	45	63	1,368	8,937	-17.7	7,355
1969	23	4,475	59	12	375	1,073	172		1,052	7,289	-17.2	6,035
MEAN	91	2,444	104	29	152	678	107	70	1,528	5,148	-16.2	4,418

* See text for explanation.

be adequate for showing trends. There was no trend with time in the total catch in any tributary except the Clackamas River. Between 1953 and 1969 the total Willamette catch, excluding the Clackamas, varied, apparently randomly, between 1,500 and 5,000 fish. The 1953 catch was several hundred fish greater than 1969 (Table 6). The above-falls catch accordingly varied very little from 1953 to 1969 (Table 6). The data also show that for the seventeen years, the catch above Willamette Falls comprised only one-third of the total catch for the system. Considering the small area of tributaries below the falls, it would seem that steelhead runs to upstream tributaries were minimal. Heavier fishing pressure below the falls, primarily for spring chinook, could have been partly responsible for the capture of two-thirds of the steelhead there.

The sport catch of winter steelhead in the Clackamas River increased substantially during the last decade (Table 6). For the years 1953 to 1969 it comprised an average of 47.5 percent of the total catch of the Willamette system, with the percentage increasing steadily to the present when a majority of the fish taken in the basin are caught in the Clackamas. The factors responsible for the heavy catch in the Clackamas are probably a combination of vulnerability to angling, increased hatchery runs, increased fishing pressure

TABLE 6. Comparison of the estimated catch of steelhead in the Clackamas River with other areas of the Willamette River, 1953-69.

Year	Total Willamette System	Estimated Catch Total Clackamas	Estimated Catch Remainder of System	Below* Falls	Above* Falls
1953	4,965	1,919	3,046	3,273	1,692
1954	3,205	1,035	2,170	1,641	1,564
1955	2,811	1,043	1,768	1,633	1,178
1956	5,263	2,465	2,798	3,380	1,883
1957	2,647	994	1,653	1,533	1,114
1958	5,267	1,275	3,992	2,908	2,359
1959	4,724	1,624	3,100	2,925	1,799
1960	3,607	1,362	2,245	2,319	1,288
1961	3,738	1,693	2,045	2,526	1,212
1962	8,396	3,410	4,986	5,102	3,294
1963	4,086	1,718	2,368	2,653	1,433
1964	5,448	2,764	2,684	3,898	1,550
1965	3,928	2,438	1,490	3,074	854
1966	6,215	3,723	2,492	4,826	1,389
1967	6,998	3,237	3,761	4,224	2,774
1968	8,937	6,370	2,567	7,230	1,707
1969	7,289	4,475	2,814	5,232	2,057
MEAN	5,148	2,444	2,704	3,434	1,714
Percent of Total Catch		47.5	52.5	66.7	33.3

*Assumes 50-50 distribution above and below falls of main stem Willamette River catch.

and the proximity of the river to the Portland metropolitan area.

Little is known about exploitation of juvenile steelhead by anglers in the Willamette system. Gunsolus and Eicher (1970) found that steelhead smolts were commonly caught in the North Fork Reservoir and that 16 percent of the catch consisted of wild steelhead and another 10 percent of hatchery steelhead. On the basis of these data and hooking mortality studies, they concluded that angling undoubtedly affected populations of steelhead. Certainly the late April opening day in the Willamette basin and the six-inch minimum size limit for trout allows a significant potential for harvest of juvenile steelhead by anglers. This is especially true on streams like the lower Clackamas River where angling pressure is very heavy at this time of year.

SPAWNING AREAS

An outline and description of the spawning areas of steelhead in the Willamette River basin has been made by Fulton (1970). In general, of course, spawning occurred in the same streams listed in Tables 3 and 5 on adult runs and exploitation. Exceptions mentioned by Fulton are the main Willamette from the mouth of the Long Tom River to Eugene and Abiqua and Butte Creeks of the Pudding River system. In 1958, 427 steelhead redds were counted in the Calapooya River (Willis, et al., 1960). Pulford (1957) counted 623 steelhead redds in the Molalla River. Hutchison, et al., (1966b) counted the number of steelhead redds in several Willamette tributaries and used a steelhead per redd ratio of 1.9 to arrive at the spawning populations per stream in Table 3.

Hutchison, et al., (1966b) found that peak steelhead spawning occurred in April in eastward-flowing tributaries and in May in westward-flowing streams. Hutchison and Aney (1964) reported that some spawning occurred in March but according to DeCew (1969), steelhead spawned from May to mid-July on the upper North Santiam River.

At the North Fork project on the Clackamas River, Gunsolus and Eicher (1970) found that the number of spent steelhead passing downstream averaged 58 percent of the yearly upstream run for 1959-64. Weiss (FCO, pers. comm.) reports that the entrapment of steelhead kelts on the trash racks at Willamette Falls has been a perennial problem. Nevertheless, repeat spawners were probably rare in the Willamette system above the falls. DeCew (1969) did not find any repeat spawners among 105 North Santiam River steelhead.

SMOLT PRODUCTION

Like counts of adults, most estimates of smolt production have been made at falls and dams. Based on smolt counts of 17,694 to 38,929 for several year classes of steelhead, Gunsolus and Eicher (1970) calculated that the number of smolts passing downstream per parent at the North Fork project varied from 7 to 32 from 1958 to 1962. They also found that the percentage survival of steelhead from smolt to adult varied from 5.9 to 12.7 percent for upper Clackamas fish. Totals of 50,008, 54,310 and 26,408 downstream migrating steelhead passed the fish horn at Green Peter Dam, Middle Santiam River, in 1968-70 (From Minutes of Corps Projects Steering Committee Meeting, May 28, 1970).

Massey (1967a and 1967b) studied the passage of downstream migrant salmonids through the industrial complex at Willamette Falls. He estimated that from March 16 to July 20, 1966, a total of 137,000 coho salmon and steelhead passed the falls, of which approximately one-third were steelhead. He also found that steelhead moved downstream in the center of the river, a reason for so few being caught in traps near shore. Peak catches of steelhead occurred from noon to 3 p.m. with only minor movement from midnight to 3 a.m.

The seasonal downstream migration of Willamette River steelhead appeared to be normal for the species. DeCew (1969) stated that smolt migration was likely between the first of spring and the last of summer in the North Santiam River. He found an average of four scale circuli between the last freshwater annulus and the marine growth zone, and concluded that juveniles remained in freshwater past winter and into spring. Gunsolus and Eicher (1970) reported that steelhead juveniles moved through the collection system at the Clackamas River dam project almost entirely in the spring, with 82 percent of the total in May. In 1964-65, Massey (1967b) similarly found movement past Willamette Falls mainly from April to early July with the peak in May. In 1965-66, the period of migration was mainly late March to early July, with the peak in June (Massey, 1967b).

The size of winter steelhead smolts in the Willamette also was fairly typical for the species. DeCew (1969) found that the average length at the end of freshwater growth for the 1958 and 1959 broods of North Santiam fish was 7.2 inches. Thirty-six adult steelhead from the Middle Willamette averaged 9.1 inches when they moved to sea. Steelhead migrating downstream past Willamette Falls ranged from 3 to 14 inches. The most abundant size group was 6 to 8 inches and it comprised 69 percent of the total catch (Massey, 1967a and 1967b).

AGE AND GROWTH

Even though large numbers of adult steelhead have been counted past various dams and falls in the Willamette system, the early life history of only a few have been determined from their scales. DeCew (1969) aged 105 adult steelhead returning to the Minto Rack on the North Santiam. For fish captured in 1962, 91 percent had remained in freshwater for 2 years and 9 percent for 3 years. For the 1963 catch, the respective percentages were 88 and 12. DeCew (1969) also found that all of 36 Middle Willamette adults had been 2-year-old smolts.

Table 7 presents unpublished age and growth data of F. H. Sumner (OGC) for McKenzie and South Santiam River steelhead. For adults (first two entries in Table 7), all four of the McKenzie fish were 2-year-old smolts and returned to spawn after two years in the ocean. Eight of 26 (31 percent) of the Santiam adults had remained in freshwater for three years and the rest for only two years. Ten of 26 (39 percent) returned to spawn after three years at sea and the remainder after two years. One-half of the McKenzie fish and 69 percent of the Santiam fish showed plus growth, or intermediate growth between the slower freshwater growth zone and the first wide marine circulus. DeCew (1969) also noted that such transitional growth averaged 0.7 and 0.8 inch for North Santiam fish and 0.2

TABLE 7. Age and growth of winter steelhead from the Willamette River system, 1965-68. (Number of fish in parentheses)

	Date of capture	Number of fish	Fork length (inches)	BACK-CALCULATED LENGTH AT EACH ANNULUS: Fresh Water 1	2	3	4	Plus	Salt water or reservoir 1	2	3	4
									Salt Water			
McKenzie R.	May '66	4	27.1	3.9 (4)	7.5 (4)			0.7 (2)	20.8 (4)	27.1 (4)		
S. Santiam R.	March-May '66	26	28.8	3.7 (26)	5.6 (26)	7.7 (8)		1.3 (18)	19.3 (26)	27.1 (26)	31.0 (10)	
									Total Salt Water			
Willamette Falls	April-May '65	30	7.2	3.9 (30)	6.0 (29)	7.6 (12)		0.8 (20)	19.5 (30)	27.1 (30)	31.0 (10)	
Willamette Falls	March-June '66	62	7.1	3.5 (62)	5.5 (57)	7.4 (21)	12.1 (2)	1.2 (47)				
									Reservoir			
Foster Res.	April '68	9	7.7	3.4 (9)	5.7 (8)	7.6 (2)		0.8 (8)	9.3 (2)			
Green Peter Res.	April '68	16	9.1	3.0 (16)	5.2 (3)	7.2 (1)			8.5 (13)	11.4 (2)	12.0 (1)	
									Total Reservoir			
Total		147		3.6 (147)	5.7 (127)	7.5 (44)	12.1 (2)	1.1 (95)	8.6 (15)	11.4 (2)	12.0 (1)	

and 0.8 inch for Middle Willamette fish for two years. Plus growth is logical in the Willamette system because the smolts travel many miles to sea in the highly productive main stem.

Growth data from smolts collected by Massey (1967a and 1967b) at Willamette Falls (third and fourth entries) are also given in Table 7. The size of the fish at the end of the three freshwater years was similar to that of the adults. Six (6.5 percent) of the smolts migrated downstream after only one year in freshwater, 53 (57.6 percent) after two years, 31 (33.7 percent) after three years, and 2 after four years in the stream. Plus growth averaging approximately one inch was shown by 67 (73 percent) of the smolts passing Willamette Falls. This would indicate that some plus growth occurred in the tributaries and, perhaps, the upper main stem.

Wild steelhead captured in South Santiam reservoirs (last two entries in Table 7) showed stream growth similar to the previous groups. One of the Foster fish moved into the reservoir after only one year in the stream, six after two years, and two after three years but most (81 percent) of the fish captured in Green Peter Reservoir moved into the reservoir after only one year of stream residence. Surprisingly, growth of wild steelhead in the reservoirs was not much greater than in the stream. Unpublished data of F. H. Sumner indicates that growth of hatchery steelhead released in reservoirs on the Santiam and Middle Fork Willamette was only about one-half that of hatchery non-anadromous rainbow trout.

CONCLUSION

No attempt has been made to summarize data on introduced steelhead in the Willamette system. Little recent data (since 1968) was included since there is the possibility that it would include some fish from the exotic lower Columbia strains. Certainly, in the face of expanding introductions of winter and summer steelhead, the continued existence of the native late winter steelhead as a distinct stock above Willamette Falls is questionable.

There is evidence, however, that this late winter stock of steelhead has persisted in other lower Columbia rivers in spite of introductions of fish of other origins. For example, in the Sandy River, which enters the Columbia just a few miles above the Willamette, the yearly run of native steelhead past Marmot Dam has maintained itself at about 2,000 fish from 1955 to the present. During the same period, hatchery runs have been increased from zero in 1955 to 2,000 fish in 1965 (Massey, 1968).

Presently, the winter steelhead runs in streams with impassable high dams, such as the North Fork Santiam, are being maintained by hatchery releases. Such streams, of course, are no longer in their natural state. With the stream environment in the Willamette system being altered greatly by pollution, dams, and irrigation diversions, it may no longer be reasonable to assume that the native fish is still best adapted. Perhaps other strains of steelhead may be better suited to maintain or enhance the runs. For example, the success of a given stock of steelhead could now depend upon the timing of its migrations in relation to passage through new fish ladders and the present nitrogen problem in the Columbia River or to its adaptability to rearing in the reservoirs behind the high dams.

The complete elimination of the late winter stock, however, would be a tragedy, as is the extinction of any animal which has adapted and evolved in a given environment for thousands of years. The Oregon Fish and Game Commissions have tentatively set aside the Calapooya River as a sanctuary for the native Willamette steelhead. No introductions of other stocks of steelhead will be made in this river, which has no high dams and, except for logging, still remains in a relatively natural state in the upper areas where spawning and rearing take place. The necessity of maintaining this santuary is obvious. Future fishery developments could well show a now unknown or unappreciated need for this race of steelhead. Time alone will tell, and I hope that this summary may help in the determination and assessment of the ultimate fate of this adaptable fish.

ACKNOWLEDGMENTS

H. Campbell, R. E. Dimick, H. J. Rayner, E. Wagner, H. Wagner, and E. Weiss all criticized the manuscript and gave helpful suggestions. F. Sumner provided unpublished age and growth data. R. Aho prepared the figures.

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