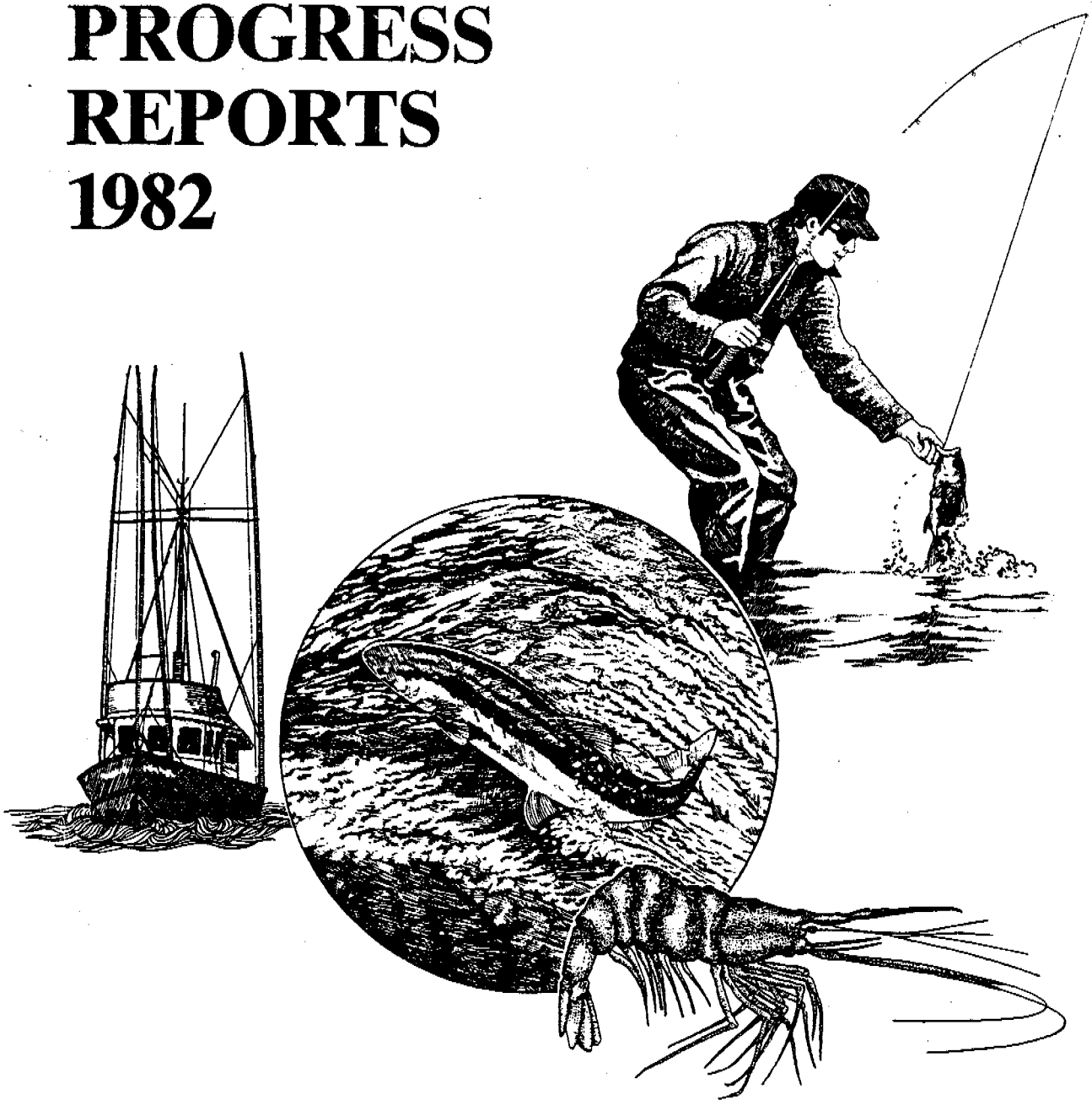
PROGRESS REPORTS 1982



FISH DIVISION

Oregon Department of Fish and Wildlife

Development and assessment of steelhead in the Willamette River basin

ANNUAL PROJECT REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Development and assessment of steelhead in the Willamette River basin.

CONTRACT NUMBER: F-117-R-2

JOB NUMBER: 1 through 5

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SUMMARY

(Job 1)

Objectives for FY 1982

The objective is to increase steelhead angling opportunities in the Willamette basin by developing steelhead fisheries in new areas.

Accomplishments in FY 1982

1. Skamania summer steelhead smolts were experimentally introduced into the Middle Fork of the Willamette River below Dexter Dam. Migration success and timing of these smolts were monitored at Willamette Falls and compared to similar smolt releases in the McKenzie River.

2. No work was done on the task to acclimate summer steelhead smolts in net pens above Foster Dam. Funds were used to offset increased costs in Jobs 2, 4, and 5.

Findings in FY 1981 and FY 1982

Steelhead released in the Middle Fork Willamette were captured in a significantly greater percentage at Willamette Falls than smolts released in the McKenzie River in both 1981 and 1982. The timing of smolts released into the Middle Fork Willamette and McKenzie River was comparable at Willamette Falls in both 1981 and 1982. However, in 1982 smolts were released in the Middle Fork Willamette on May 10 and 11 and peak movement occurred at Willamette Falls in late May while in 1981 they were released on April 13 and peak movement occurred in mid-May, 10 days earlier.

Management Implications

1. Data collected at Willamette Falls in 1981 and 1982 suggest that releases of Skamania summer steelhead in the Middle Fork Willamette will produce a greater percentage of adult return than releases in the McKenzie River.

2. Experimental releases in 1981 and 1982 indicate that a late April smolt release in the Middle Fork Willamette will produce an earlier smolt migration to Willamette Falls than an early May release. The lower Willamette may exceed 17°C (63°F) after the middle of May and these temperatures have been found to adversely affect survival and migration of steelhead smolts (Buchanan 1975). Therefore, we suggest a late April release for the Middle Fork Willamette.

(Job 2)

Objective for FY 1982

The objective is to determine the migration timing and hatchery:wild ratios of adult Big Creek stock and Willamette stock winter steelhead above Willamette Falls.

Accomplishments in FY 1982

1. A shunt and a Denil steeppass were installed at Willamette Falls and scale samples were taken from 264 captured winter steelhead adults.

2. Captured steelhead were tagged with a Floy anchor tag to determine upstream movement.

3. All Big Creek stock hatchery smolts released and 68% of the Willamette stock hatchery smolts released in 1982 were fin marked to better define hatchery:wild ratios for adults returning in 1983-85.

Findings in FY 1982

1. We found that 80% of the early returning (December to mid-February) and 15% of the late returning (mid-February to May) winter steelhead sampled were of hatchery origin. The first fin marked adult from a release of Willamette stock smolts was captured on February 18.

2. Of the 264 tagged winter steelhead, 24 were recaptured in the Willamette basin and returned to department personnel. Three of these recaptured fish were adults that had not spawned yet were recaptured below Willamette Falls.

Management Implications

1. One year of study at Willamette Falls suggests that a major portion of the Willamette winter steelhead runs are wild fish. Until more years of hatchery:wild ratio data are gathered, we believe the early returning Big Creek stock should be managed as 80:20, hatchery:wild and the late returning Willamette stock should be managed as 15:85, hatchery:wild.

2. Winter steelhead counts at Willamette Falls may be inflated due to fish ascending the falls before returning to the Clackamas River or recycling of upriver steelhead at the falls.

(Job 3)

Objectives for FY 1982

The objective is to determine natural or artifical factors which may be contributing to population fluctuations of steelhead.

Accomplishments in FY 1982

No work was done on this job in FY 1982.

(Job 4)

Objective for FY 1982

The objective is to improve the percentage of adult return from hatchery releases of Skamania, Big Creek, and Willamette stocks. Our objective in 1982 is to provide managers with improved size at release guidelines that will produce adult returns of at least 2.5% of smolt release.

Accomplishments in FY 1982

1. Groups of small (<18 cm fork length), medium (18 to <20 cm) and large (>20 cm) Skamania summer steelhead smolts were marked and released below Foster Dam. Timing and relative success of their freshwater migration was monitored at Lebanon Dam and Willamette Falls.

2. Skamania steelhead adults returning from a 1980 size of release experiment were captured at the Foster Dam trap and date, fin mark, length, and sex recorded.

Findings in FY 1982

1. There was a highly significant difference in percentage of capture between the medium and small smolt groups at Lebanon Dam and Willamette Falls. There was no significant difference between the medium and large smolt groups in percentage captured at Lebanon Dam or Willamette Falls. Peak migration of the large smolts at Willamette Falls was three weeks after release while peak migration of the medium size group was slightly later, 3 to 4 weeks after release. Significant portions of the small smolt group were captured 3-8 weeks after release.

2. The 1-salt and 2-salt adult returns from the 1980 size at release experiment showed that large smolts (>20 cm) produced 12.6 times more adults than small smolts (<18 cm) and 2.2 times more adults than medium smolts (18 to <20cm).

Management Implications

1. A minimum fork length of 18 cm is a useful guideline to increase the percentage of adult return of Skamania summer steelhead in the Willamette basin.

2. Adult return data for Skamania steelhead indicate that a larger smolt release size produces a larger percentage of adult return.

(Job 5)

Objective for FY 1982

The objective is to determine the best stocks of summer and winter steelhead for use in the Willamette system.

Accomplishments in FY 1982

1. Skamania summer steelhead smolts from adults returning to the McKenzie and South Santiam rivers in 1981 were released into the McKenzie River. Their relative percentage migration and timing were compared at Willamette Falls.

2. Resistance of reciprocal crosses of Umpqua x Skamania and Siletz x Skamania summer steelhead to Ceratomyxa shasta was determined.

3. Big Creek and Willamette winter steelhead smolts were released into the Molalla River and their relative percentage migration and timing were compared at Willamette Falls.

Findings in FY 1982

McKenzie Broodstock Development

Data collected at Willamette Falls suggests that there is no significant difference in percentage migration or timing at the falls between smolts resulting from brood collected at McKenzie and South Santiam rivers.

C. shasta Resistant Strains

Nearly all Umpqua and Siletz fish died from C. shasta by 105 and 98 days after initial exposure for group 1 and group 2, respectively, whereas very few of the Skamania fish died. All of the hybrid groups survived at intermediate levels. There was no difference in percentage survival between reciprocal (male and female) crosses of the same exposure and stocks. However, differences between exposures and between stock groups were significant. No mortalities collected during the 131 days after January 13, 1982 were infected with C. shasta.

Big Creek Stock

No significant difference in percentage migration or timing at Willamette Falls was found between Big Creek and Willamette winter steelhead smolts released into the Molalla River.

Management Implications

1. No alternate steelhead stocks for use in the Willamette River system have been identified at this time.

2. Big Creek and Willamette winter steelhead smolts released into the Molalla will produce an equal percentage of adult return. However, we need to determine adult fishery timing and contribution before final recommendations are made.

BACKGROUND

The goal of this study is to assess and improve fishery benefits derived from steelhead stocks in the Willamette River basin. Defined fishery benefits include: (1) Produce adult returns of summer and winter steelhead so that run sizes and recreation days as suggested in the 1979 Willamette Basin Fish Management Plan and by the 1981 Willamette Basin Fisheries Coordination Group are satisfied. The updated run size objectives above Willamette Falls are 10,000 introduced Big Creek winter steelhead, 14,000 native Willamette winter steelhead and 15,000 introduced summer steelhead. (2) Maintain or increase the number of naturally produced "wild" adult steelhead in the upper Willamette. The term "wild" includes naturally produced fish from Skamania, Big Creek, and Willamette stocks. (3) Improve the survival of hatchery produced summer and winter steelhead smolts released above Willamette Falls to achieve an adult return of at least 2.5% of smolt release. The Willamette River basin above Willamette Falls with key locations discussed in this report is shown in Fig. 1. The objectives have been summarized in our proposal according to the following jobs. The major purpose of this report is to summarize our activities and accomplishments for each job in FY 1982.

Job 1. Increase Angling Opportunities

INTRODUCTION

Introductions of summer steelhead into the Willamette Basin have been quite successful. Releases of Skamania summer steelhead in the Clackamas River above the North Fork Dam have produced adult returns of over 5,500 fish. Releases of Skamania steelhead in the South Santiam, North Santiam, and McKenzie rivers have produced adult returns in excess of 15,000 fish over Willamette Falls. Additional tributary streams in the basin may support summer steelhead fisheries. An area with potential for increased angling opportunity is the Middle Fork of the Willamette River below Dexter Dam. This river reach has good water quality and flow, and is located near the Eugene-Springfield Metropolitan area.

METHODS

Groups of approximately 34,000 Skamania summer steelhead smolts were reared at Leaburg Hatchery and released into the McKenzie and Middle Fork Willamette rivers on May 10 and 11, 1982. A trap at Willamette Falls was used to capture migrating smolts and determine relative migration success and timing of downstream migration. The trap was described in Buchanan and Wade (1978). The trap was operated daily from April 19 through May 21 except for May 10 and every other day from May 23 to June 21. Trapping began at 1600 and continued 8 hours until 2400. Large numbers of fish prevented complete sampling on May 5, 7 to 9, 11 to 17, and 23, so we subsampled the catch and expanded proportionally for incomplete sampling hours. Numbers of fish on days not sampled were estimated as the average of the day before and the day after. Steelhead smolts caught were examined for fin marks, counted, and measured.

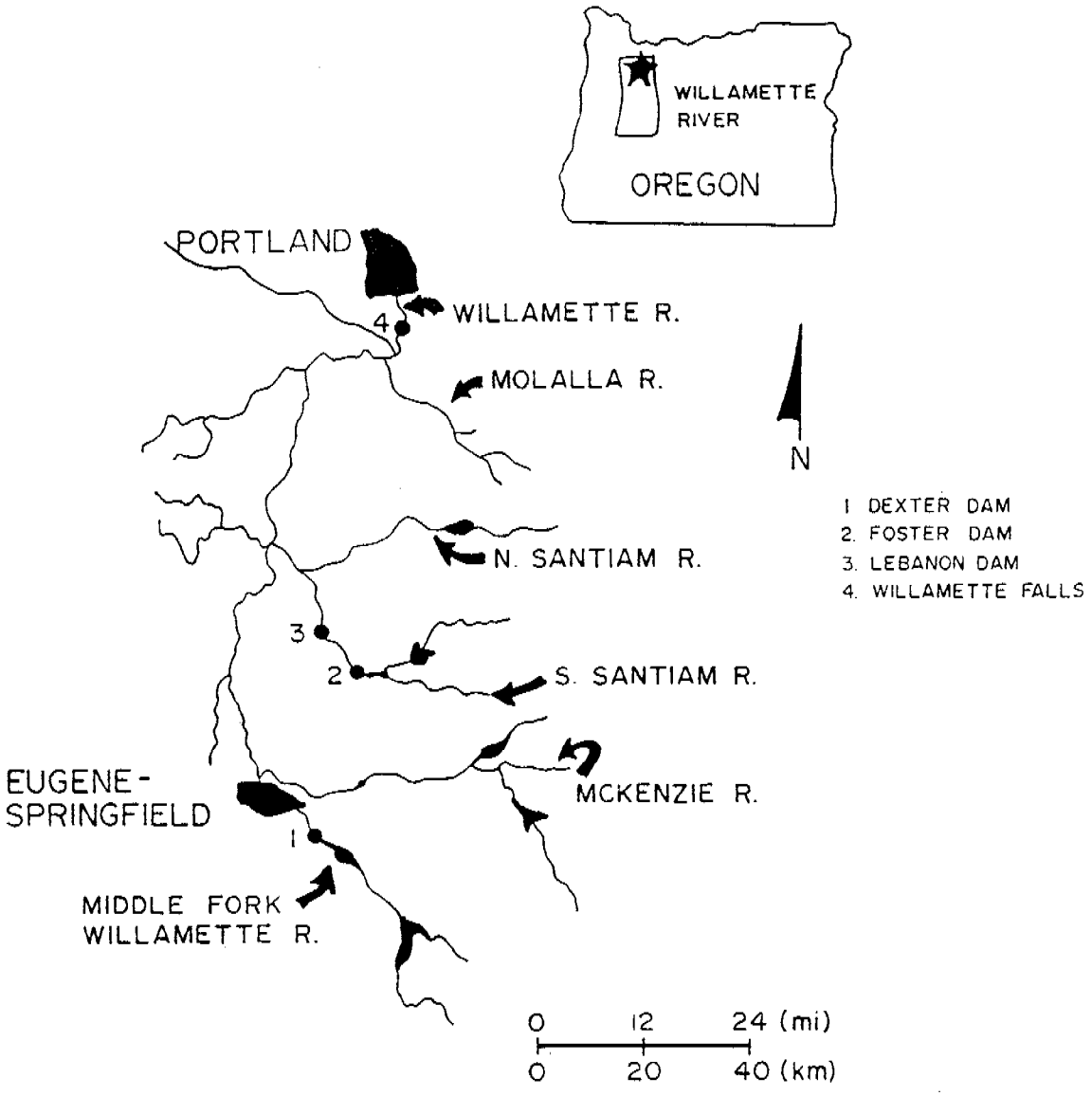

Fig. 1. The Willamette River system.

We used a chi-square contingency table to test differences between groups in ratios of the number of smolts observed and not observed at the capture sites.

RESULTS

Steelhead smolts released in the Middle Fork Willamette were captured in a significantly greater percentage at Willamette Falls than smolts released in the McKenzie River in both 1981 (X^2=8.46, d.f. = 1, $p \leq 0.01$) and 1982 (X^2=19.23, d.f. = 1, $p \leq 0.01$) (Table 1). Timing was comparable at Willamette Falls for the Middle Fork Willamette and McKenzie River release groups (Fig. 2).

Table 1. Relative migration success of Skamania summer steelhead smolts released in the Middle Fork Willamette and McKenzie rivers and captured at Willamette Falls in 1982.

Release location	Number of smolts released	Expanded number of smolts captured	Expanded percent of release captured
Middle Fork Willamette	33,990	1,589	4.7
McKenzie	34,840	1,399	4.0

DISCUSSION

Data collected at Willamette Falls in 1981 and 1982 suggests that releases of Skamania summer steelhead smolts in the Middle Fork Willamette will produce a greater percentage of adult return than releases in the McKenzie River. Adult catch data from punchcard estimates and a logbook program will document the development of this fishery.

Job 2. Adult Timing and Hatchery:Wild Ratios

INTRODUCTION

Accurate estimates of hatchery and wild production of introduced Big Creek and native Willamette winter steelhead above Willamette Falls are needed for the protection of spawning and rearing areas of wild fish and to assess the percentage of adults returning from hatchery releases. Each year approximately 175,000 Big Creek and 100,000 Willamette smolts are released above Willamette Falls. Accurate counts of winter steelhead returning to the river system have been made since 1971 but separation of stocks and hatchery:wild ratios have previously been only a guess (Table 2).

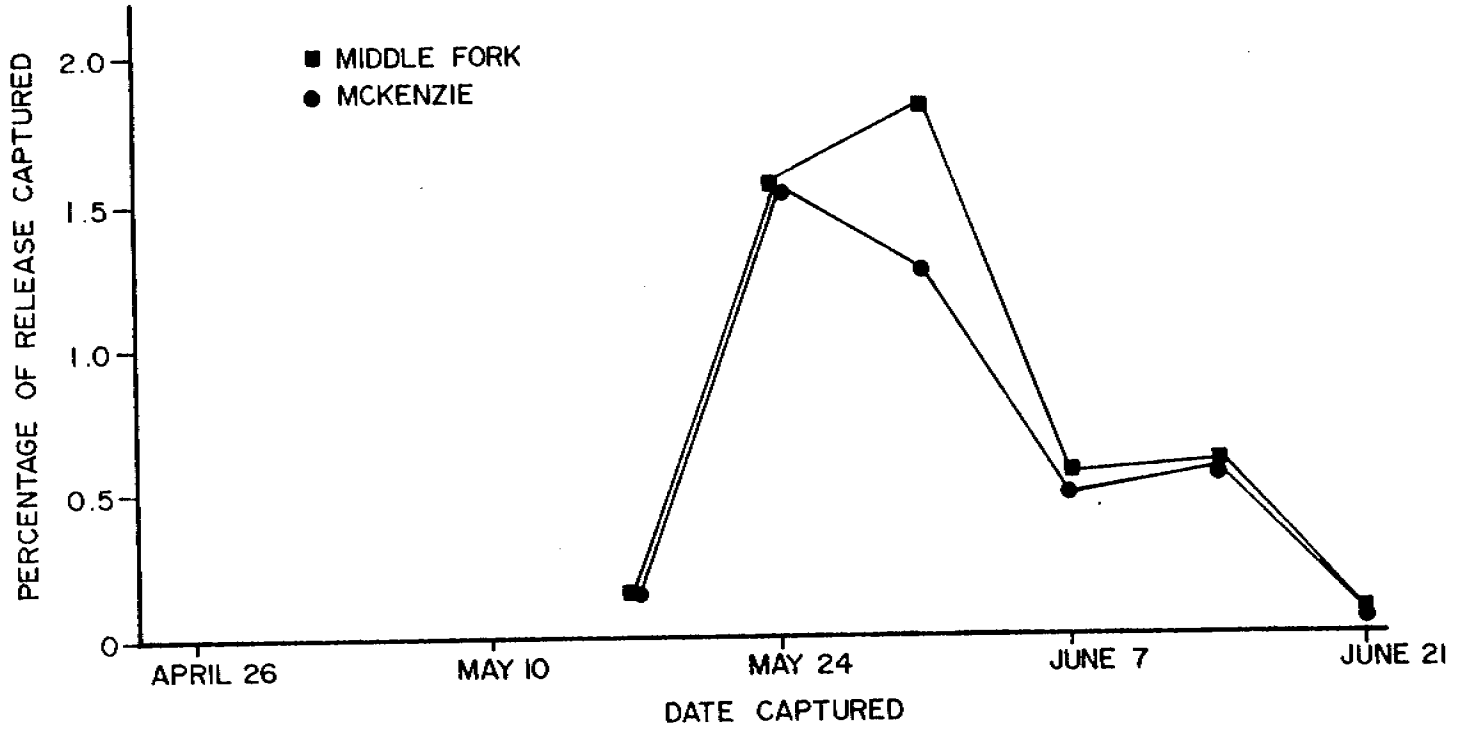

Fig. 2. Timing and rate of capture at Willamette Falls of Skamania steelhead smolts released into the Middle Fork Willamette and McKenzie rivers in 1982.

Table 2. Counts of adult winter steelhead at Willamette Falls, 1970-71 to 1981-82.

Run year	Willamette Falls Fishway		
	Early stock [a]	Late native stock [b]	Total
1970-71	8,016	18,314	26,330
1971-72	6,572	16,588	23,160
1972-73	6,239	11,511	17,750
1973-74	6,292	8,528	14,820
1974-75	3,096	3,034	6,130
1975-76	4,204	5,196	9,400
1976-77	5,323	8,277	13,600
1977-78	8,600	8,270	16,870
1978-79	2,835	5,865	8,700
1979-80	6,258	16,142	22,400
1980-81	2,662	9,038	11,700
1981-82	6,106	6,894	13,000

[a] *Steelhead passing from October 15 to February 15. These fish are primarily introduced Big Creek stock.*

[b] *Steelhead passing from February 15 to May 15. These fish are primarily native Willamette stock.*

METHODS

Adult winter steelhead were sampled at Willamette Falls from December 2, 1981 through April 9, 1982. Fish were captured using a shunt and Denil steeppass installed in the upper section of the cul-de-sac leg of the adult fishway. This capture method caused minimum disruption and allowed uninterrupted passage through the other three entrances of the fishway. Each captured fish was measured and examined for fin marks, dorsal fin stubbing, color, and spawning condition. A scale sample was taken and a numbered Floy anchor tag was inserted.

Big Creek fish were classified hatchery or wild origin based on subjective scale analsysis. Age 1+ smolts were classified as hatchery and age 2+ and 3+ smolts were classified as wild. Willamette winter steelhead were classified as hatchery or wild based on fin marks. All returning hatchery adults had been fin marked as smolts before their release.

All Big Creek smolts and 84,000 of the 124,000 Willamette smolts released above Willamette Falls in the spring of 1982 were fin marked to better define hatchery contribution and migration timing of adult winter steelhead stocks at Willamette Falls in 1983-84.

RESULTS

Of the 264 winter steelhead tagged, 24 were recaptured in the Willamette basin and returned to Department personnel (Table 3).

Table 3. Adult winter steelhead tagged at Willamette Falls and recaptured within the Willamette basin in 1981-82.

Recapture location	Date tagged	Date recaptured	Days between tagging and recapture
Below Willamette Falls			
1. Clackamas	12/17	01/20-30	34-44
2. Willamette	12/28	01/10	13
	01/13	02/06	24
	01/13	03/29	75 *a*
	02/04	04/11	66 *a*
Above Willamette Falls			
1. Tualatin-Gales Creek	01/13	01/31	18
	01/13	02/01	19
	01/13	02/12	30
	01/13	03/12	58
	01/25	02/17	23
	02/04	?	?
	02/18	03/10	20
	03/05	03/12	7
2. Molalla	01/12	02/06	25
	01/13	02/13	21
	01/13	?	?
	02/04	03/15	39
	02/18	03/06	16
3. Santiam	12/22	03/08	76
	03/05	04/14	40
	04/09	04/19	10
	04/09	04/21	12
	04/09	05/05	26
4. Fall Creek (upper Willamette)	?	04/07	?

a These fish were recaptured as kelts.

DISCUSSION

Adult sampling and tagging will continue at Willamette Falls in 1983 and 1984. Since some tagged fish were recovered below Willamette Falls we believe the total winter steelhead counts may be inflated. Further study may quantify this problem. Sampling in 1984 when marked Big Creek and Willamette adults are returning will more clearly define stock timing and hatchery:wild ratios at Willamette Falls.

Job 4. Improve Hatchery Returns

INTRODUCTION

Data from several years indicate that hatchery steelhead smolts less than 18 cm fork length, are not as successful as bigger smolts in migrating from the Willamette basin (Buchanan and Wade 1978; Buchanan et al. 1979; Buchanan 1980). We had not studied the survival of medium and large smolts to adult return. Studies done in FY 1982 were the second year of a scheduled 3 year release of marked small, medium, and large Skamania steelhead smolts.

METHODS

Smolt Studies

Skamania summer steelhead smolts were reared in three ponds at South Santiam Hatchery. Three weeks before release, smolts were separated into three size groups: small (<18 cm), medium (18 to <20 cm), and large (≥20 cm). We marked 4,858 small fish with a left ventral fin and 18,106 medium fish with a right maxillary mark. The large size group was subdivided into 18,577 right ventral and 19,766 left maxillary marked fish to measure differential survival caused by a fin mark.

After marking, the four groups were equally divided into two ponds to eliminate variability in rearing during the final 3 weeks before release. The length frequency of each group was measured prior to release.

Relative percentage of freshwater migration, timing and growth were measured at Lebanon Dam and Willamette Falls (see METHODS Job 1). Lebanon Dam is located 26 km (16 mi) below the Foster release site. Smolts were guided by a seine into an inclined plane trap in the north ladder of Lebanon Dam. The seine was tied to a steel cable stretching 52 m from the north ladder to a rock 30 m from shore. Posts were placed at intervals to hold the cork line above the water and the lead line was heavily anchored with railroad rails. The seine was 3.6 m deep and 38 mm square mesh. The inclined plane trap fished continuously from April 15 to June 18. Fish caught were identified by species, examined for marks, counted, measured to the nearest 0.1 cm fork length, and released.

Adult Studies

Adult summer steelhead from the 1980 release of small (<18 cm), medium (18 to <20 cm), and large (>20 cm) smolts returned to Foster Dam as 2-salt adults in 1982. These fish were captured at the Foster Dam trap and the date of capture, fin mark, length, and sex were recorded.

RESULTS

Smolt Studies

There was a highly significant difference in percentage capture between the medium and small 1982 smolt groups at Lebanon Dam (X^2=7.45, d.f.=1, $P<0.01$) and Willamette Falls (X^2=51.07, d.f.=1, $P<0.01$) (Table 4). There was no significant difference between the medium and the pooled large smolt groups in percentage captured at Lebanon Dam or Willamette Falls. Migration of the large smolts peaked at Willamette Falls three weeks after release while the medium size group peaked slightly later, 3 to 4 weeks after release (Fig. 3). Significant portions of the small smolts were captured 3-8 weeks after release.

Adult Studies

The 1-salt and 2-salt adult returns from the 1980 size at release experiment showed that large smolts (≥20 cm) produced 12.6 times more adult than small smolts (<18 cm) and 2.2 times more adults than medium smolts (18 to <20 cm) (Table 5).

DISCUSSION

Smolt Studies

Both the 1980 and the 1982 releases of medium smolts were significantly more successful in percentage migration to Willamette Falls than the small smolts whereas no significant difference in percentage migration was found between the large and medium smolts. During both test years, downstream movement of smolts for the medium group was one week later and in the small group 2 to 4 weeks later than the large group (Fig. 3 and Buchanan 1980).

A greater percentage of the left maxillary marked large group was captured than the right ventrally marked large group at both Willamette Falls (X^2=17.90, d.f.=1, $P<0.01$) and Lebanon Dam (X^2=3.42, d.f.=1, $P<0.05$) (Table 5). It is questionable that fin marks would greatly affect survival less than 1 month after release. Another explanation may be differences in rearing density prior to the final 3 weeks of rearing. Fish to be marked were reared in 3 raceways, inadvertently, one at a "low" density and two at a "higher" density. A total of 37% of the LM fish were reared at a "high" density and 82% of the RV fish were reared at a "high" density. If low rearing densities promote higher survival rate of the smolts produced, it could be an explanation for the apparent higher survival rate of the LM fish. We plan to repeat a size of release experiment in spring 1983 which will incorporate fin marking and density experiments.

Adult Studies

Adult returns from the 1980 release of small, medium, and large smolts support the hypothesis that a minimum size threshold of 18 cm exists. Skamania smolts smaller than 18 cm tend not to migrate from the Willamette system. However, some 16 to 18 cm smolts may grow to 18 cm after release and begin downstream migration (Buchanan and Wade 1978; Buchanan et al. 1979; Buchanan 1980).

Table 4. Number and percentage of Skamania summer steelhead smolts fin marked by size group, released at Foster Dam, and captured at Lebanon Dam and Willamette Falls in spring 1982.

Test group	Number released	Number captured at Lebanon Dam	Percentage of release captured at Lebanon Dam	Expanded number captured at Willamette Falls	Percentage of release captured at Willamette Falls
Small group (<18 cm) LV fin mark	4,858	35	0.7	87	1.8
Medium group (18 to <20 cm) RM fin mark	18,106	213	1.2	706	3.9
Large group (≥20 cm) RV fin mark	18,577	190	1.0	660	3.6
Large group (≥20 cm) LM fin mark	19,716	241	1.2	867	4.4

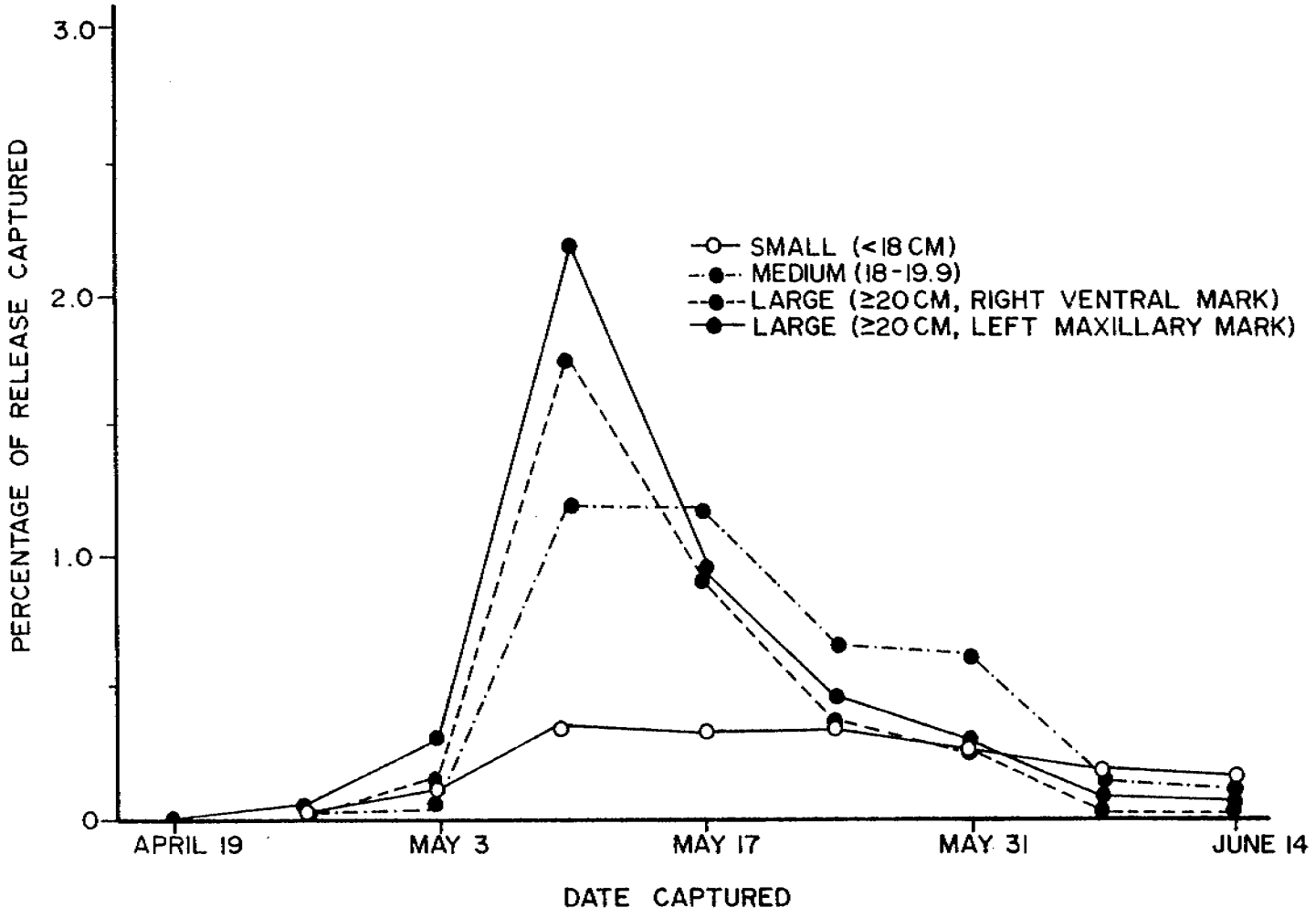

Fig. 3. Timing and rate of capture at Willamette Falls of small, medium and two large groups of Skamania smolts in spring 1982.

Table 5. Number and percentage of Skamania summer steelhead released as smolts at Foster Dam in spring 1980, captured near Lebanon Dam in spring 1980, and captured as adults returning to Foster Dam in 1981 and 1982.

Test group, mark	Number of smolts released	Number of smolts captured near Lebanon Dam in 1980.	Percentage of release captured near Lebanon Dam	Number of adults returning to Foster Dam in 1981	Number of adults returning to Foster Dam 1982	Percentage of release returning to Foster Dam
Small (<18 cm) RVLM fin mark	25,328	134	0.53	1	55	0.22
Medium (18 to <20 cm) RM fin mark	37,947	295	0.78	3	476	1.26
Large (≥20 cm) LM fin mark	27,271	207	0.76	17	737	2.76

Job 5. Determine Best Steelhead Stocks

INTRODUCTION

The Willamette winter steelhead is the only steelhead stock native to the system. The Skamania summer steelhead stock was introduced in the late 1960's. Although the Skamania stock is producing up to 8% returns to the Santiam River, returns to the McKenzie River have ranged from 0.2% to 2.0% of smolt release. Because all Skamania summer steelhead broodstock are collected at Foster Dam on the South Santiam River,the resulting smolts may not be well adapted to the environmental cues that initiate downstream migration in the McKenzie River. Broodstock obtained from Skamania adults returning to the McKenzie River may, through generations of natural selection, produce smolts better adapted to the McKenzie River.

Several summer steelhead stocks have been considered for introduction into the Willamette River system, and have been rejected for the following reasons: the Rogue stock has a half-pounder life history; the Clearwater and Deschutes stocks are carriers of IHN and IPN viruses; and the Siletz and Umpqua stocks, though believed to migrate early as smolts, are susceptible to Ceratomyxa shasta. C. shasta is a myxosporidian found in the Willamette River below Corvallis which causes death in susceptible fish. A hybrid fish resistant to C. shasta and with early migration characteristics may avoid other bacterial diseases which are present in the warm lower Willamette River.

A program to enhance winter steelhead production began in the mid-1960's when adults, fingerlings, and smolts from the early returning Big Creek stock were released above Willamette Falls. The success of this program is not known. Big Creek smolts have been released in the Molalla, Yamhill, and Tualatin systems but an evaluation has not been reported.

METHODS

McKenzie Broodstock Development

Groups of 34,000 Skamania smolts from the McKenzie River broodstock and South Santiam River broodstock were reared at the Leaburg Hatchery. Both groups were fin marked and released into the McKenzie River on May 10-11, 1982. Relative percentage migration and timing were determined at Willamette Falls (see METHODS - Job 1).

C. shasta Resistant Strains

Groups of reciprocal crosses of Umpqua x Skamania and Siletz x Skamania along with control groups of Umpqua, Siletz, and Skamania stock fish from the 1981 brood year were reared at the Corvallis Research Lab. The first test group was exposed to C. shasta in a 1.5 m^3 livebox in the Willamette River at Corvallis (river km 212, mi 132) at 15-16°C from September 30, 1981 to October 7, 1981. The second test group was exposed in the same location from October 7 to 15 at 12-14°C.

After exposure, the fish were held in pathogen-free well water at 12°C in 0.9 m circular tanks at the Smith Farm facilities, Oregon State University.

The fish were fed Oregon Moist Pellet with 3% oxytetracycline added to prevent bacterial infection. Mortalities were collected daily for 235 days and frozen or examined fresh. Fish were considered infected by C. shasta if a smear of intestinal fluid examined microscopically (400x) contained spores.

Big Creek Stock

Marked groups of Big Creek and Willamette smolts were reared at Gnat Creek Hatchery. Both groups were released into the Molalla River on April 22 and 26, 1982. Relative percentage migration and timing were compared at Willamette Falls (See METHODS Job 1). Earlier studies have shown that Skamania summer steelhead and Willamette winter steelhead less than 18 cm in fork length and precocious males tend not to smolt and migrate downstream (Buchanan and Wade 1978; Buchanan et al. 1980). These "low-migrators" could bias estimates of movement and success to Willamette Falls. We subtracted precocious males and smolts less than 18 cm from both the number released and captured at Willamette Falls. These adjusted numbers are reported in the results.

RESULTS

McKenzie Broodstock Development

Data collected at Willamette Falls suggests that there is no significant difference between the broodstock groups in percentage migration or timing at the falls (Table 6, Fig. 4).

Table 6. A comparison of two broodstocks of Skamania summer steelhead released into the McKenzie River and captured at Willamette Falls in spring 1982.

Broodstock	Number of smolts released	Expanded number of smolts captured	Expanded percent of release captured
McKenzie-Skamania	34,153	1,455	4.3
South Santiam-Skamania	34,840	1,399	4.0

C. shasta Resistant Strains

There was no difference in percentage survival between reciprocal (male and female) crosses of the same exposure and stocks (Table 7). However, there were significant differences between exposures (X^2=116.46, d.f.= 1, $P<0.01$) and between stock groups (X^2=28.86, d.f.=1, $P<0.01$). All of the hybrid groups survived at intermediate levels.

Big Creek Stock

No significant difference in percentage migration or timing at Willamette Falls was found between Big Creek and Willamette Winter steelhead smolts released into the Molalla River (Table 8, Fig. 5).

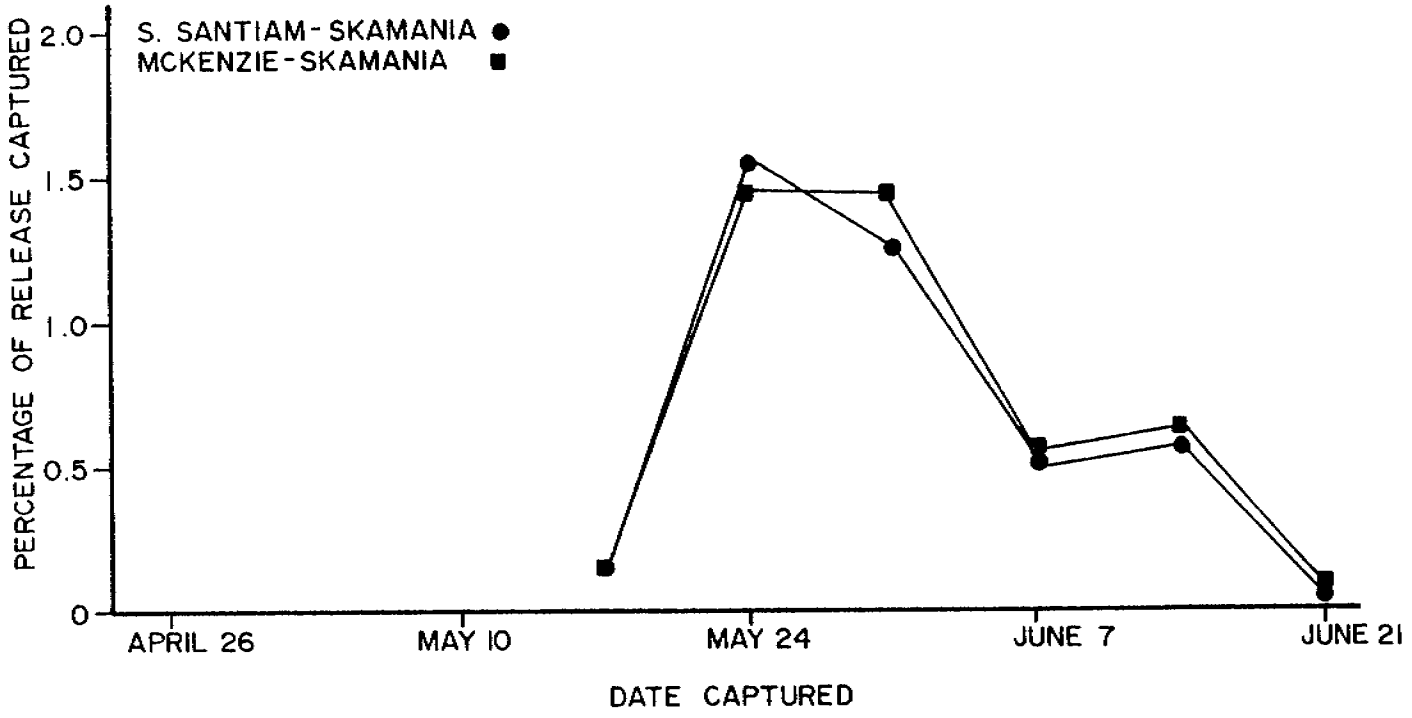

Fig. 4. Timing and rate of capture at Willamette Falls of smolts from two Skamania broodstocks released into the McKenzie River in spring 1982.

Table 7. Deaths of three stocks of summer steelhead and their reciprocal crosses due to *Ceratomyxa shasta*. The fish were exposed to Willamette River water near Corvallis from September 30 to October 7, 1981 (exposure 1) and October 7 to 14, 1981 (exposure 2).

Stock crosses (male x female)	Exposure 1			Exposure 2		
	Number of fish exposed	Number of deaths due to C. shasta	Percentage of deaths due to C. shasta	Number of fish exposed	Number of deaths due C. shasta	Percentage of deaths due to C. shasta
Skamania x Skamania	73	2	3	101	0	0
Umpqua x Umpqua	88	87	99	97	95	98
Siletz x Siletz	96	93	97	88	85	97
Umpqua x Skamania	77	38	49	85	9	11
Skamania x Umpqua	101	41	41	94	9	10
Siletz x Skamania	94	63	67	101	21	21
Skamania x Siletz	95	65	68	95	29	30

infectivity of C. shasta (Johnson 1975). Flow increased from an average of 13,370 cfs at Salem during the first exposure to 19,790 cfs during the second exposure while water temperature in the live box decreased from 15-16°C during the first exposure to 12-14°C during the second exposure. We believe resistance to C. shasta is a threshold trait that can be selected for. Natural selection for resistant individuals may be the mechanism by which resistant stocks were created (Johnson 1975, Zinn et al. 1975, Buchanan et al. 1983). We plan to spawn the fish that have survived two C. shasta challenges and produce an F_2 generation which we will test for susceptibility to C. shasta.

Big Creek Stock

During the 1984 run year, the Northwest Region will evaluate fishery timing of returning adult Big Creek and Willamette winter steelhead in the Molalla River.

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