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Contribution, Distribution of Catch, and Survival of 1970-Brood Fall Chinook Salmon from Elk River Hatchery
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Alan M. McGie

Oregon Department of Fish and Wildlife
Research and Development Section
Corvallis, Oregon

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ABSTRACT

Two groups of 1970-brood fall chinook salmon were liberated from Elk River Hatchery into Elk River in September 1971 to determine the contribution, distribution of catch, and survival. One group was released with a unique combination of marks and the second group was released with a single fin clip that was duplicated by other fisheries agencies. Estimated landings of uniquely marked adults totaled 3,966 fish spread over ages 2 to 5 and represented 4.1% of the smolts released. An estimated 45.0% of the catch was taken in the combined Oregon commercial and sport fisheries, primarily between Coos Bay and Brookings. The distribution of catch among fisheries was 74.6% ocean commercial, 3.1% ocean sport, and 22.3% Elk River sport. The total return to Elk River was 4.73% for uniquely marked fish compared with 3.79% for fish with a single fin mark, primarily because of differential returns of age-2 jacks. The total production (ocean catch plus escapement to Elk River) was 7.89% from smolts with unique marks. Total survival of spawners ranged from 3.04% to 3.83%. Exploitation rates (catch/catch plus escapement) by all fisheries combined were 0.52 including age-2 jacks and 0.63 for adults (> age 2) alone. Hatchery fish returns to Elk River from the 1970 brood outnumbered wild fish from this brood year by 4.4:1.

INTRODUCTION

Elk River Hatchery was constructed in 1968, 18 km above the mouth of Elk River on the southern Oregon coast (Figure 1). Various physical features of the hatchery were described by Reimers and Bender (1979). The primary purpose of the hatchery was to enhance the population of native fall chinook salmon, *Oncorhynchus tshawytscha*, harvested by sport and commercial fisheries in the ocean and by the sport fishery in the river. Prior to hatchery construction,
Figure 1. Elk River drainage showing location of the hatchery and major tributaries.
data were obtained on the life history of wild fall chinook salmon in Elk River as early as 1964 (Bender 1970b). The fall chinook salmon population was studied after 1968 to evaluate changes in the stocks of wild and hatchery fish in the system, and the contribution of hatchery fish to the offshore and river catches.

The first hatchery smolts liberated with a unique combination of marks (adipose-left maxillary) were from the 1969 brood (Reimers and Bender 1979). A second unique combination of marks, consisting of an adipose-right maxillary (Ad-RM), was applied to a group of 1970-brood smolts released from Elk River Hatchery. An additional group was also liberated with a left ventral (LV) fin clip. Single fin marks were duplicated on other chinook salmon stocks released by fisheries agencies. The uniquely marked smolts provided estimates of the contribution and distribution of catch to regional sport and commercial fisheries. Estimates of survival were obtained from both marked groups upon return to Elk River as jacks and adults and following exploitation by sport fishermen in Elk River.

The purpose of this report is to present the results of the marking experiments. Exploitation rates (catch/catch plus escapement) by sport and commercial fisheries are calculated for marked fall chinook salmon released in this study. Ancillary data are presented on the age and sex composition of returning fish. The results of this study are compared with published data on 1969-brood smolt releases from Elk River and other coastal and Columbia River stocks of chinook salmon. The work spanned the period from egg taking in 1970-71 through the anticipated return of age-6 fish in the 1976-77 spawning season.
DESCRIPTION OF BASIN

Elk River flows into the Pacific Ocean about 6 km north of Port Orford, Curry County, Oregon. The river drains about 240 sq km with mean daily discharge ranging from 1.5 cu m/s in summer to 240 cu m/s in winter (Reimers and Bender 1979). The river flows through a steep, narrow canyon in the upper reaches and a broader valley and surrounding pastureland in the lower reaches. The upper drainage is largely situated in the Siskiyou National Forest. The lower 3 km forms a shallow, transitory estuary inside the foredune before the river enters the ocean at the southern edge of Cape Blanco.

METHODS

Hatchery Procedures

The entire 1970-brood egg take was obtained from the wild stock in Elk River. The first return of hatchery adults at age 3 did not occur until 1971. The hatchery egg take was obtained from 40 females seined in Elk River between 26 October and 30 November 1970, 113 females dipnetted from Anvil Creek, and 27 females dipnetted in Rock Creek. The females were dipnetted from the creeks between 24 November 1970 and 2 January 1971. Females with green eggs were held at the hatchery until ripe.

Ripe females were killed, bled, and spawned into dry buckets. The eggs were fertilized with sperm from one or two males (age-2 jacks were discarded). Eggs from individual females were generally spawned into separate containers, although eggs from partially spawned fish were combined. Hatchery personnel spawned 174 females and collected 779,251 eggs.

Eggs spawned into individual containers were placed into separate Heath incubator trays at Elk River Hatchery. Live eggs were counted with a
revolving-disk counter at the eyed stage, and the count added to the previously recorded egg mortality to obtain fecundity. Anomalous alevins were discarded shortly before yolk absorption. Egg mortality totaled 6.3% and alevin mortality was 1.7%.

Hatchery personnel ponded 722,391 fry (average weight 0.53 g) between 8 March and 14 April 1971. The fry were placed in a screened-off section of each Burrows pond (Burrows and Chenoweth 1970), and fed mash-sized Oregon Moist Pellets (Hublou 1963). When the fish were large enough to accept larger pellets, the screens were removed and fish allowed to spread through the entire pond. No serious diseases were encountered, although enteric redmouth disease (Yersinia ruckeri) in the spring and an incidence of furunculosis (Bacterium salmonicida) when water warmed in midsummer were effectively controlled with sulfamethazine and oxytetracycline (TM 50) in medicated feed. Mortality during pond rearing was 5.1% including fin marking mortality.

One group was marked by clipping the adipose fin and right maxillary bone (Ad-RM) and a second group was given a single left ventral (LV) fin clip. The fish were marked between 1 and 25 June 1971. Mark quality was monitored during the marking operation. Observed mortalities of marked fish were subtracted from the number released into Elk River.

The 1970-brood smolts were liberated into Elk River on 7 September 1971, after about 5.5 months of rearing in the hatchery. The smolts were released earlier than scheduled (mid-October) when excavation for a new water system for the hatchery endangered the existing water supply. We released 97,568 smolts marked Ad-RM along with a simultaneous release of 171,757 smolts marked LV. Each marked group averaged 35.7 g at release. An additional 409,092 presmolts had been liberated in June 1971 (Reimers and Concannon 1977). The total mortality in the hatchery from egg take to release was 13.6%.
Mark Recoveries

Ocean Troll and Sport Fisheries

The ocean troll and sport fisheries were systematically canvassed by state agencies to estimate the number of marked fish landed in Washington, Oregon, and California using procedures presented by Worland et al. (1969). The estimated catches of marked 1970-brood fall chinook salmon liberated at Elk River Hatchery (Ad-RM) were obtained from published catch estimates from 1972 through 1976 (Fish Commission of Oregon 1974, 1975; Oregon Department of Fish and Wildlife 1976, 1977a, b). Since only incidental catch data were available for British Columbia fisheries in 1974 (Heizer and Beukema 1977) and for the Alaska troll fishery in 1974-75, I estimated the total catch in these fisheries based on data obtained from 1973-brood smolts released from Elk River Hatchery with coded-wire tags (McGie 1981; Oregon Department of Fish and Wildlife, unpublished data). Alaska and British Columbia fisheries accounted for 42% of the total ocean catch of the 1973-brood smolts. The total adjusted ocean catch of 1970-brood fall chinook salmon was obtained by dividing the combined Washington, Oregon, and California catch of Ad-RM-marked fish by 0.58. The calculated catch was apportioned between British Columbia and Alaska and by age groups within each of these areas based on the 1973-brood catch data.

The ocean troll salmon fishery was extended during November and December 1974 near the mouth of Elk River to harvest surplus hatchery fall chinook salmon returning to the river. Fishing was permitted in a small zone between Cape Blanco and Humbug Mountain and offshore 5.5 km. A similar season extension was granted to sports fishermen during December 1974. The season extensions were retained in 1975 and 1976, except the ocean fishery closed on 30 November in 1976. The 1976 extended sport and commercial seasons were subsequently
shortened when a drought hampered the upstream migration of adults. The season extensions were beyond the general season closures on 31 October for ocean salmon fisheries and 30 November for the river sport fishery for salmon.

Over the 5 years of sampling (1972-76) when age-2 through age-6 fall chinook salmon were presumably present offshore, 1.99 million chinook salmon were examined for marks at Pacific coast ports, representing 17.0% of the total catch of the fisheries sampled. Annual mark sampling rates ranged from 13.9% in 1972 to 18.4% in 1974.

Elk River Sport Catch

Sport catch estimates of marked fall chinook salmon were obtained from creel surveys in Elk River (Bender 1973, 1975; Bender and McGie 1978). The sport fishery was sampled each year beginning with the 1972 season.

Survival Estimates

The annual escapement of marked fall chinook salmon to Elk River was obtained by mark-recapture techniques. Adult salmon were seined in the estuary or lower river, tagged with a numbered, Petersen disk tag, and released at the capture site. When seining was difficult because of high streamflows, gill nets were fished at night in the lower 6 km of the river to capture additional fish for tagging.

Fish were generally tagged between 22 September and 29 December; although the tagging period varied each year depending upon river conditions. Fish were examined at the hatchery and on the spawning grounds to obtain tagged:untagged ratios. Carcass recoveries were generally complete by 10 to 22 February each season. Population estimates were computed from Bailey's modification of Petersen's single census model (Ricker 1975).
The percentages of each marked group (Ad-RM and LV) that returned as jacks and as adults were compared by computing a normal deviate \( z \), derived from the normal approximation to the binomial distribution corrected for continuity (Snedecor and Cochran 1967).

RESULTS

Contribution

The estimated catch of marked (Ad-RM) 1970-brood fall chinook salmon from Elk River Hatchery was 3,366 fish including 2,958 harvested in ocean commercial fisheries, 125 harvested in ocean sport fisheries, and 883 harvested in the Elk River sport fishery. The total catch represents 4.1% of the marked smolts released.

Distribution of Catch

Distribution of catch is illustrated in Figure 2. Although marked fish were landed from Monterey, California, to southeastern Alaska, the largest harvest occurred in the British Columbia ocean commercial fisheries. The sport fishery in Elk River harvested nearly as many fish as the combined ocean sport and commercial fisheries in Oregon. The combined Oregon troll and sport fisheries, including the sport catch in Elk River, composed nearly half of the total recorded landings. Commercial fishermen harvested 74.6% of the catch compared with a harvest of 3.1% in ocean sport fisheries.

Trollers landed the largest share of the Oregon commercial catch (82%) at south coast ports between Coos Bay and Brookings. The extended troll season in November and December off the mouth of Elk River increased the number taken in Oregon fisheries. Approximately 80 chinook salmon marked Ad-RM were harvested
Figure 2. Percentage catch of marked, 1970-brood fall chinook salmon from Elk River by area and fishery, 1972-76. Based on an expanded estimate of 3,966 fish.
in the extended troll fishery in 1974 and 9 were landed in 1975. The fish landed in the extended season represented 26% of the catch of 4-year-old and 18% of the catch of 5-year-old chinook salmon marked Ad-RM in the Oregon troll fishery.

Age-3 fall chinook salmon was the most important age group in the ocean commercial and sport fisheries, and age-2 jacks dominated the sport catch in Elk River (Figure 3). The percentage of age-4 fish in the ocean commercial catch was nearly twice that found in the ocean sport and Elk River sport catches. Few age-5 fall chinook salmon were harvested in any of the fisheries, and age-6 fish were absent in the catch.

Few age-3 adults contributed to the sport catch in Elk River compared with age-4 adults. The relatively large catch of marked chinook salmon at age 4 compared with age 3 was influenced by two factors. Sport fishing in Elk River in 1973 when returns from this brood were age 3 was severely curtailed by heavy rainfall and high stream flows after 5 November when most adults entered the river (Bender 1975). Conversely, the catch in 1974 when returns were age 4 was enhanced by the extra month of sport fishing granted in Elk River (Bender and McGie 1978).

Sport catch estimates of LV-marked fall chinook salmon in Elk River were 701 age 2, 40 age 3, 326 age 4, and 226 age 5 from the 1970 brood. Catch estimates by ocean fisheries were not reported because landings of chinook salmon with single marks were not routinely tallied at the ports.

Survival

I estimated 4,619 fall chinook salmon marked Ad-RM and 6,509 marked LV returned to Elk River between 1972 and 1976, representing 4.73% and 3.79%, respectively, of the smolts released (Table 1). The number of jacks that
Figure 3. Percentage age distribution of marked, 1970-brood fall chinook salmon in the catch in each of three fisheries. Expanded catch estimates were 2,958 in the ocean commercial, 125 in the ocean sport, and 883 in the Elk River sport fisheries.
returned at age 2 was the primary reason the survival estimates of the two marked groups differed. I estimated that 2.40% of those marked Ad-RM returned at age 2 compared with a return of 1.39% of the smolts marked LV. For adults, 2.33% marked Ad-RM returned compared with a return of 2.40% marked LV. A test of the null hypothesis that the proportionate return was independent of the mark applied was rejected for age-2 jacks ($P < 0.05$), but was not rejected for the combined return of age 3 to 6 adults ($P = 0.25$). The survival rates among comparable age groups of adults followed the same temporal pattern (Table 1).

Table 1. Estimated return to Elk River (percentage of release) of two marked groups of fall chinook salmon, 1972-77.

<table>
<thead>
<tr>
<th>Spawning year</th>
<th>Age</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ad-RM</td>
</tr>
<tr>
<td>1972-73</td>
<td>2</td>
<td>2.40</td>
</tr>
<tr>
<td>1973-74</td>
<td>3</td>
<td>0.98</td>
</tr>
<tr>
<td>1974-75</td>
<td>4</td>
<td>1.11</td>
</tr>
<tr>
<td>1975-76</td>
<td>5</td>
<td>0.24</td>
</tr>
<tr>
<td>1976-77</td>
<td>6</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4.73</td>
</tr>
</tbody>
</table>

The total production (ocean catch plus return) of fish marked Ad-RM was 7.89% based on catch estimates of 3,083 fish in the ocean and return of 4,619 jacks and adults to Elk River. The sport fishery in Elk River harvested 19.1% of the fish marked Ad-RM and 19.9% of the fish marked LV that returned to Elk River. The survival rate of spawners (jacks and adults) following the harvest in the Elk River sport fishery was 3.83% for fish marked Ad-RM and 3.04% for fish marked LV.

**Exploitation**

The exploitation rate of fish marked Ad-RM was 51.5% including jacks for all fisheries combined. The catch:escapement (C:E) ratio was 1.06:1. For
adults alone, the exploitation rate was 63.3% (C:E = 1.72:1). Using the C:E estimate of 1.72:1 for adults marked Ad-RM, I estimated that the group marked LV contributed 7,100 adults to the sport and commercial fisheries.

**Age Composition**

The largest proportion of each group of hatchery and wild fall chinook salmon returned to Elk River at age 2 (Figure 4). About half of those marked Ad-RM returned as jacks. Among adults, the largest return occurred at age 4 for hatchery and wild stocks. No age-6 adults were recorded among hatchery fish marked Ad-RM. Although the hatchery and wild stocks displayed similar patterns in age at maturity, the wild stock tended to return at older ages than the hatchery stock.

**Sex Composition**

The sex composition of marked Ad-RM fall chinook salmon shifted from primarily males at ages 2 and 3 to predominately females at ages 4 and 5 (Table 2). For all age groups combined, the males comprised 87% and females 13% of the chinook sampled at Elk River Hatchery. Sex ratios of fall chinook salmon marked LV could not be calculated because an unknown number of older fish (ages 4 and 5) was hauled upstream to spawn.

Table 2. Sex composition (%) of 1970-brood hatchery fall chinook salmon marked Ad-RM sampled at Elk River Hatchery, 1972-76.

<table>
<thead>
<tr>
<th>Age</th>
<th>Sample size</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>611</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>417</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>26</td>
<td>74</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>13</td>
<td>87</td>
</tr>
</tbody>
</table>
Figure 4. Age composition of wild and hatchery fall chinook salmon from the 1970 brood year in Elk River. Run size estimates are 2,525 wild, 6,509 marked left ventral (LV), and 4,619 marked adipose-right maxillary (Ad-RM) for all ages combined.
DISCUSSION

The production (catch plus return to Elk River) of 1970-brood fall chinook smolts released at Elk River Hatchery was less than the production of smolts liberated from the 1969 brood year. Reimers and Bender (1979) reported 9.35% production from the 1969-brood release even though the Canadian and Alaskan fisheries were incompletely sampled. By applying correction factors for these fisheries similar to those used for the 1970 brood, I estimated the production of the 1969-brood was 11.78% compared with 7.89% for the 1970-brood smolts. These are comparable to or exceed estimates obtained from Umpqua River spring chinook salmon (Garrison and Rosentreter 1980) and Rogue River spring chinook salmon (Evenson et al. 1981). Estimates in these rivers have ranged from 2.77% to 11.31% for the most successful groups released from the 1972-75 brood years. The production of Elk River fall chinook salmon was similar to the average total percentage of 1967-, 1969-, and 1970-brood fall chinook salmon yearlings (38 g to 76 g average weight) liberated into the Sacramento River, California, (Sholes and Hallock 1979). These authors reported that catch plus escapement estimates ranged from 1.4% to 13.2% and averaged 7.5% of the smolts released for the three broods combined. Warner et al. (1961) reported that a group of fall chinook salmon yearlings (average weight 56 g) released from Nimbus Hatchery, American River, California, in 1957 contributed about 4% to the combined catch and escapement. In contrast, Wahle and Vreeland (1978) found an average 0.7% production from fall chinook salmon smolts (1961-64 brood years) released from Columbia River hatcheries at 6 to 8 cm, fork length. Based on these results, survival generally increased as a function of size at release (Reisenbichler et al. 1982). Elk River fall chinook smolts liberated in the fall at average weights of 36 to 57 g survived at rates 11 to 13 times larger than survival rates of Columbia River hatchery stocks released in the spring.
The catch:escapement (C:E) ratio of 1969-brood Elk River fall chinook salmon was 1.44:1 compared with 1.06:1 for the 1970 brood. For adults alone, these C:E estimates are 1.83:1 (1969 brood) and 1.72:1 (1970 brood) for all fisheries combined. These estimates indicate that Elk River fall chinook salmon were lightly exploited compared with exploitation of Columbia River stocks. Wahle and Vreeland (1978) calculated the average C:E ratio was 8.6:1 for all hatcheries and broods of fall chinook salmon combined in the Columbia River. This is partly a reflection of the additional harvest by gillnet fisheries in the Columbia River.

A relatively large percentage of Elk River fall chinook salmon were caught in Oregon fisheries in contrast to Columbia River hatchery stocks where about 5% were caught in Oregon and California ocean fisheries combined (Wahle and Vreeland 1978). The distribution of catch of Elk River fall chinook salmon differed from the nearby Rogue River spring chinook salmon. Evenson et al. (1981) reported that 82.2% of the 1975-brood Rogue spring chinook salmon were landed in California and 17.4% in Oregon with less than 1% landed north of Oregon.

The percentages of 1970-brood fall chinook returning to Elk River were 4.73% for Ad-RM marks and 3.79% for LV marks. Reimers and Bender (1979) reported that 5.79% of the 1969-brood smolt release returned to Elk River. The percentage return of 1970-brood smolts (35.7 g) released in early September was about 15 times larger than the return of 1970-brood fingerlings (9.7 g) liberated into Elk River in June (Reimers and Concannon 1977).

Jacks marked Ad-RM returned to Elk River at a higher rate than jacks marked LV, whereas, the return rate of adults was similar in each marked group. The Ad-RM and LV marks had no measurable differential effect on the survival of
adults returning to Elk River. There is no obvious biological reason for the differential return of jacks because smolts in each group were released from Elk River Hatchery at the same size and time. The similarity in the proportionate returns of adults in each marked group suggests that the different rates of return between jacks may have been the result of error in the estimates of age-2 fish. However, random variation within the marked groups must also be considered.

Survival rate of spawners following exploitation in the Elk River sport fishery was 3.83% and 3.04% for Ad-RM and LV marks, respectively, compared with 4.53% for 1969-brood fall chinook salmon. These survival rates are considerably larger than the average of 1.4% (0.4%) reported by Evenson et al. (1980) for the 1965-72 brood years of spring chinook salmon counted at Gold Ray Dam, Rogue River. The survival rates of spawners at Elk River were comparable with those of yearling hatchery fall chinook salmon released in the Sacramento River, California. Warner et al. (1961) reported that 3.56% returned to Nimbus Hatchery and the spawning grounds. Sholes and Hallock (1979) estimated that 1.2% to 1.4% of the yearlings released into the Feather River and at Rio Vista in the Sacramento River system survived to spawn.

The number of hatchery-reared adults that returned to Elk River Hatchery was small in comparison with those that remained in Elk River to spawn. Of the estimated 3,736 fall chinook salmon marked Ad-RM that escaped the river sport fishery, only 1,085 (29%) returned to the hatchery. The remaining hatchery fish spawned with wild fish in Elk River. An estimated 11,132 marked hatchery fish returned to Elk River from the spring and fall releases of 1970-brood chinook salmon. Returns of this magnitude may genetically "swamp" the wild stock spawning in Elk River. The return of hatchery fish from the 1970 brood was 4.4 times larger than from wild spawners (2,525), and many hatchery fish spawned in
the river (71% of those marked Ad-RM) rather than entering the hatchery. With stock size differences and straying rates this large, we need to assure that the hatchery population maintain as much biological variability as possible. The stocks should be monitored to determine if potential adverse changes in the stocks occur from hatchery influences (Reimers 1978).

The early success of Elk River Hatchery was largely the result of prior research on the general life history and requirements of stocks of fall chinook salmon on the south coast, use of indigenous wild stocks in the hatchery program, and adoption of a rearing program that simulated the natural life history of the stock (Bender 1970a; Reimers 1973, 1979). The success of Elk River Hatchery hinges on following these basic principles and conducting further research on fall chinook salmon stocks in the system as hatchery fish play a more dominant role in the future.

ACKNOWLEDGMENTS

The perseverance of the original Elk River Hatchery personnel--Reed White, Lyle Curtis, and Craig Smith--was instrumental in attaining the early goals of the hatchery program. In subsequent years, hatchery personnel under the supervision of Bill Gent cooperated in obtaining biological data from returning adults. Biological data on hatchery and wild fall chinook salmon in Elk River were collected and compiled by research personnel under the direction of Dr. Paul Reimers. The manuscript was reviewed by Arvo Riikula and Jay Nicholas. Wayne Burck provided editorial assistance. Mary Buckman helped with the statistical analysis.
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