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Temporal and Spatial Distribution of Fall Chinook Salmon Spawning in Elk River
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ABSTRACT

Maturing fall chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), in Elk River have a protracted time of upstream migration and spawning. Most fish enter the river in October, November, and December, mature for about 40 days, and spawn mostly in December and January. Because of their timing, these fish probably deserve some special designation such as "late-run" fall chinook salmon. Spawners are found throughout the main river and tributaries in areas with suitable gravel. Most spawn in the main river below the hatchery and in Anvil and Rock creeks. Time of spawning appears to be a sensitive character which could be used to measure the effect of Elk River Hatchery on this particular stock of fish.

INTRODUCTION

Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), are divided into spring, summer, fall, and winter races based on the time of river entrance during spawning migrations (Galbreath 1966; Slater 1963). Some stocks enter their natal streams several months before spawning and migrate long distances upstream. Others enter the river shortly before spawning and make only a short migration. Fall chinook salmon on the south coast of Oregon are late-running, bright fish that are available to the sport fishery in the estuaries and lower rivers for an extended period prior to spawning.

The purpose of this report is to generally describe the temporal and spatial distribution of the population of fall chinook salmon spawning in Elk River. Time of spawning is one possible characteristic which could be used to measure the long-term effects of Elk River Hatchery on this stock of fish. Data for this report are based on extensive observations of the population from 1964 to 1976.
DESCRIPTION OF THE STUDY AREA

Elk River is located on the southern coast of Oregon 6 km north of Port Orford (Fig. 1). The river drains about 240 km² and extends inland about 55 km. The watershed is fairly narrow with short, steep tributaries draining the rugged terrain of the northern Klamath Mountains. Mean daily discharge varies annually from a low of about 1.5 m³/sec in late summer to a high of about 240 m³/sec in winter. Flow is influenced by rainfall and often fluctuates rapidly during the spawning season. Spawning areas with suitable gravel are available throughout the river, except for an 8-km section above the hatchery (Fig. 1), which is in a narrow canyon characterized by deep pools and exposed bedrock. The river is accessible to spawners upstream to the confluence of the North and South forks (49 km).

The estuary is small and has an extremely limited holding area for salmon migrating upstream in autumn. Within 200 m of the ocean beach, the river veers north and forms a 2-km estuary parallel to the ocean. The mouth of the estuary opens directly into the ocean surf and is narrow and unstable. Adult salmon are clearly visible if they enter the estuary at low tide. Most of the lower estuarine area is less than 0.5 m deep with only occasional pockets of slightly deeper water. An embayment of about 200 m in length and about 2 to 3 m deep usually develops in late summer where migrants can hold prior to upstream migration. The lower estuary is a favorite sport fishing area as are larger pools in the main river.

Elk River Hatchery was constructed in 1968 without facilities to direct migrating spawners into the hatchery. All fish that enter the fishway to the adult holding pond do so of their own volition. The hatchery program was started with native fall chinook salmon captured with dip nets in Anvil and
Fig. 1. Elk River showing location of the hatchery, canyon area, and prominent tributaries.
Rock creeks (Fig. 1). Few wild fish enter the hatchery, but large numbers of hatchery fish have returned to the fishway annually.

METHODS

Time of entrance into Elk River was determined from seining which commenced in the fall when the first fish were either observed or thought to be in the river. These fish were tagged to estimate the total population and obtain data on maturation time. The time between river entrance and spawning was determined from the date of tagging to date of recovery as dead fish on the spawning grounds.

Time and location of spawning was obtained from records of surveys throughout the river. Even though surveys of the spawning grounds were subject to seasonal and annual variations related to frequency of surveys, intervals between surveys, and water conditions, they were believed to be reflective of changes in spawning activity. Counts of adults and jacks, both live and dead, were combined in this report. Numbers observed for a given survey were converted to a percentage of the annual total to show seasonal trends. Additional information was obtained about time of migration and spawning from the hatchery egg-take records.

Distribution of spawners was determined from surveys in standard locations and random observations in other areas. The sport fishery provided general information on time of river entrance, holding location, and maturation time of fall chinook salmon.

RESULTS

Time of Migration

Maturing chinook salmon have occasionally been observed in Elk River during summer. In 1970 a hatchery jack was observed in the fishway at Elk
River Hatchery on June 16 and was subsequently captured a day later. On July 9, 1971, a wild adult male was removed from the junction box at the hatchery outlet. On July 14, 1972, a wild adult female entered the fishway, and on July 17, 1972, a hatchery jack was found fresh dead in the fishway at the hatchery. Two additional jacks were observed in the fishway, and two sightings of a live adult were noted in the pool below the hatchery during August 1972.

Despite these anomalous returns of migrants in the summer, the main spawning migration of fall chinook salmon in Elk River occurs in autumn. Tagging records from the years 1970-76 indicated some differences in timing between the runs of jacks and adults (Fig. 2). Usually the first jack was caught at an earlier date than the first adult, but in some years the first of each was captured on the same day. Mean date for the first capture of a jack was October 1 and for an adult was October 6. While jacks appeared in the river earlier than adults, no substantial differences in time of entry between fish of wild and hatchery origin were apparent.

Tagging records indicated that peak upstream migration of jacks usually occurred during the period October 11 through October 31 (Fig. 2). Catches of jacks declined rapidly after early November, but a few were taken through the end of December each year. Migration of adults exhibited a bimodal frequency distribution with time (Fig. 2). The earlier and higher of the two peaks occurred from about November 1 through 10, and the secondary peak occurred during the period December 1 through 10.

Tagging effort was terminated each year during late December or early January. This effort included the peak of entrance of fall chinook salmon into Elk River, but failed to include the full range of the spawning migration. A few fish entered the hatchery fishway in January and February each year.
Fig. 2. Percentage of capture by week ending date for jack and adult fall chinook salmon caught during tagging operations in Elk River estuary, 1970-76. The dashed line connects points averaged by 10-day intervals.
with external marine parasites (sea lice) attached, indicating recent entry into fresh water.

Time of Spawning

The earliest spawning activity by chinook salmon in Elk River probably commences in early November. On November 10, 1969, a redd occupied by a pair of chinook was observed below the mouth of Anvil Creek. However, little spawning activity was observed before the last week of November. Egg-take records for the years 1968-71, when wild fish were being captured for the hatchery egg supply, showed that the earliest egg take came on November 25 in 1970. In recent years, first spawning of hatchery fish returning to the hatchery occurred as early as November 19 in 1975, and as late as December 3 in 1974.

Counts of chinook in Rock and Anvil creeks in 1973-74, 1974-75, and 1975-76 showed a mean time of spawning on December 28 with a standard deviation of 22 days. The distribution had an early plateau of spawning activity near December 15, and a later, higher peak of activity near January 15 (Fig. 3). Validity of the peaks or waves of spawning activity was substantiated by comparison with tagging data which revealed that adult males averaged 46 days and adult females averaged 45 days between time of tagging in the estuary and time of recovery as dead fish on the spawning grounds (Fig. 4). Each peak of spawning (Fig. 3) was preceded by about 40 days by a corresponding peak time of entry into the river (Fig. 2).

Jacks lived about 2 weeks longer than adults, averaging 62 days from tagging to recovery as dead fish. However, peak of entry into the river was about 2 weeks earlier for the jacks, indicating that calendar time of death was about the same for jacks and adults.
Fig. 3. Time of spawning of fall chinook salmon in Elk River based on combining surveys in Anvil and Rock creeks for 3 years, 1973-1975. (Solid trend line connects points averaged by 10-day intervals.)
Fig. 4. Range, mean, and standard deviation of the mean days between time of tagging in the estuary and recovery as dead fish on the spawning grounds for fall chinook salmon in Elk River, 1970-1976.
Spawning activity by chinook salmon decreased rapidly in Elk River after mid-January, but some spawners were observed through the end of March. On March 16, 1970, a female was observed digging a redd in Anvil Creek. A live female was observed in Anvil Creek on March 30, 1971. One fresh dead female was observed during a survey of Anvil Creek on March 29, 1974, and two live females were observed in Anvil Creek during a subsequent survey on April 2, 1974. A live female observed in Elk River just below the mouth of Anvil Creek on April 4, 1973, was the latest documented observation of a spawner in Elk River. All very late spawners were females.

A test of statistical sensitivity was conducted for time of spawning. Data from only 3 years of spawning surveys in Anvil and Rock creeks could be used for the analysis. In other years the surveys were not used because they were too infrequent through the season, not all live and dead fish were counted, or the egg taking operation for the hatchery disrupted the spawning populations.

The data in Fig. 3 were grouped by year to calculate a mean time of spawning for Anvil and Rock creeks combined. The data were then weighted by the number of surveys in each year and a new overall mean time of spawning, standard deviation, and coefficient of variation were calculated as source information for the test of sensitivity (Table 1).

Area of Spawning

Spawning chinook salmon were found in most suitable areas along the river (Fig. 5). Although spawners can migrate upstream as far as the confluence of the north and south forks, most fish spawned below the canyon (Fig. 1). In 1967 fairly large numbers of fish spawned throughout the upper river.
Table 1. Calculation of statistical sensitivity for mean time of spawning of fall chinook salmon in Elk River using 3 years of data in Anvil and Rock creeks combined.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean date of spawning</th>
<th>Number of surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Julian date</td>
<td>Calendar date</td>
</tr>
<tr>
<td>1973-74</td>
<td>363.7</td>
<td>Dec. 30</td>
</tr>
<tr>
<td>1974-75</td>
<td>367.3</td>
<td>Jan. 2</td>
</tr>
<tr>
<td>1975-76</td>
<td>351.3</td>
<td>Dec. 17</td>
</tr>
</tbody>
</table>

\[ \bar{x} = 362.2 \text{ (Dec. 28)} \]
\[ \text{S.D.} = 6.17 \]
\[ n = 3 \text{ years (involving 61 surveys in two streams)} \]
\[ \text{C.V.} = 1.7\% \]

Part B Sensitivity calculation

\[
d = \sqrt{(\text{C.V.}^2 \left( \frac{n_1 + n_2}{n_1 \cdot n_2} \right) (t_\alpha + t_\beta)}
\]
\[
d = \sqrt{(1.7\%)^2 \left( \frac{3 + 3}{3 \cdot 3} \right) (2.776 + 1.533)}
\]
\[ d = 6.0\% \]
\[ d = +21.7 \text{ days of the mean; or Dec. 6 and Jan. 19} \]

where: \( d \) = level of difference necessary to be statistically significant with known probabilities of Type I and Type II errors

\[ \text{C.V.} = \frac{\text{S.D.}}{\bar{x}} \times 100 \]
\[ n_1 = \text{number of years of pre-data} \]
\[ n_2 = \text{number of years of post-data} \]
\[ t_\alpha = \text{t-value for the probability of Type I error at .05 (two-tailed)} \]
\[ t_\beta = \text{t-value for the probability of Type II error at .10 (one-tailed)} \]
\[ \text{d.f.} = (n_1 + n_2) - 2 \]
Fig. 5. Distribution of spawning fall chinook salmon in Elk River.
In other years only a few fish were found in upstream areas and they were mostly early spawners.

Tributaries were not used under low-flow conditions, but during freshets contained many spawners. Anvil and Rock creeks were heavily used despite their small size. Bald Mountain Creek, the largest tributary, was consistently used but did not have large numbers of spawning chinook.

Under drought conditions in 1976, the distribution of spawners changed greatly from previous years. Most spawning in 1976-77 was in the lower river from just above tidewater to the hatchery.

DISCUSSION

Based on observations of their time of migration and spawning, this population probably deserves some special designation as "late-run" fall chinook salmon. They do not fit the traditional definition of fall chinook salmon as known from the Columbia River (Anon. 1974).

Fall chinook salmon in Elk River were found in the lower river probably partly by choice and partly by fish passage problems. Except for 1967, there were relatively few fish in the upper river. Passage problems in the canyon occurred in most years because of difficult jumps at low water and high velocity during freshets. Presumably, initial freshets with medium flows allowed reasonable opportunities for migration through the canyon.

In most years the timing and distribution of spawners in Elk River below the canyon appeared to be adequate to seed the natural rearing areas of the lower river with juveniles. Because of the apparent availability of unseeded spawning and rearing areas above the canyon, the upstream population has been augmented by hauling excess spawners from the hatchery to the mouths of Butler and Blackberry creeks. The benefit of this program will be determined
by monitoring juvenile populations and their possible contribution to an increased run of wild spawners in future years.

Our computations of sensitivity indicate that mean time of spawning in Anvil and Rock creeks would need to be earlier than December 6 or later than January 19 to be statistically different from the current mean of December 28. Since these dates are well within the current variability in time of spawning, such a change seems biologically possible and could result from selection of early or late spawners in the hatchery program. Distribution and timing of spawning in Elk River will be monitored in the future to determine if changes occur.

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LITERATURE CITED

