Migration Rates of Yearling Chinook Salmon in Relation to Flows and Impoundments in the Columbia and Snake Rivers

HOWARD L. RAYMOND

Bureau of Commercial Fisheries, 2725 Montlake Boulevard East, Seattle, Washington 98102

ABSTRACT

Migration rates of yearling chinook salmon (*Oncorhynchus tshawytscha*) through free-flowing and impounded stretches of the Snake and Columbia Rivers were compared during periods of low and moderate river discharge. Generally, the rate of migration was directly related to the water flows; it was 21 km/day at the low river discharge (Columbia—4,248 m^3/sec; Snake—1,416 m^3/sec), and 37 km/day during moderate river discharge (Columbia—8,495 m^3/sec; Snake—2,265 m^3/sec). Migration rates through most free-flowing and impounded stretches of the Snake and Columbia Rivers were similar with the one exception that in McNary Reservoir (Columbia River) fish moved only about one-third as fast as elsewhere.

Marked yearling chinook salmon from the Salmon River took 32 days to travel the 669 km to Bonneville Dam during the low river discharge in 1966. New impoundments may more than double the travel time now required during low river flows.

INTRODUCTION

The Columbia River has been almost completely transformed from a free-flowing stream to a series of impoundments behind lowhead dams. Similar changes will soon occur on its largest tributary, the Snake River, which is a significant producer of spring and summer-run chinook salmon (*Oncorhynchus tshawytscha*). Juveniles from these runs of salmon must now pass downstream to the sea as yearlings through the impoundments above Ice Harbor Dam on the Snake River and above McNary, The Dalles, and Bonneville Dams on the Columbia River. In the near future these fish will be required to negotiate an additional three to five impoundments on the Snake River and one large impoundment above John Day Dam on the Columbia River before they reach the sea (Figure 1).

For several years, information has been accumulated on the movement and survival of juvenile salmon, in relation to the changing environment in the Columbia Basin. These data revealed that most of the fish presently pass downstream in midspring before the peak river flows in June. Fishery managers are interested in the potential effects of additional impoundments and regulations of flow on movement and survival.

This paper provides estimates of the rate of migration of yearling chinook salmon through impounded and free-flowing sections of the Columbia and Snake Rivers during low and moderate flows. Yearling chinook salmon 90 mm to 130 mm long were studied because they migrate in substantial numbers during both low and moderate river flows; approximately 90%[1] are from the Snake River. The paper also points to the delay in migration that could result from new impoundments.

STUDY AREAS AND MIGRATION RATE CALCULATIONS

Study areas, including free-flowing and impounded sections of the Snake and Columbia Rivers are shown in Figure 1. Table 1 contains data relevant to these study areas.

Migration rates were determined by mark and recapture of specimens. From the beginning of the migration in early April until the end of May 1966, young fish were collected in either scoop traps (in the Salmon River about 84 km above its confluence with the Snake River) or dipnets (specially designed to recover fish from gatewells of turbine intakes at Ice Harbor, McNary, The Dalles, and Bonneville Dams). Methods of collecting, marking, and releasing fish from gatewells was described by Bentley and Raymond (1968). Water temperatures, generally, ranged from near 10 C in early April to 13 C by late May.

[1] Based on collections of chinook salmon from turbine intake gatewells at Priest Rapids Dam and Ice Harbor Dam, 1965–67. Bur. Comm. Fish., unpublished.

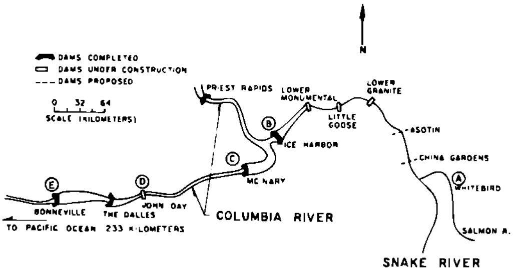

FIGURE 1.—Sites at which marked yearling chinook salmon were released (A, B, C, and D) and recovered (B, C, D, and E) in 1966 to study rates of downstream movement.

Fish were marked with a harmless thermal brand (Groves and Novotny, 1965) and released immediately downstream from sites A through C (Figure 1). Marked fish released at the John Day damsite (D) were obtained from the gatewells of The Dalles Dam and transported to the release site. Fish were not marked at Bonneville Dam (E). Separate marks identified all fish in each weekly release group by release site.

Average time of passage through a specified section of river was determined, for a given group, by subtracting the median date of recovery from the median date of release. The use of the median averted distortion in measurement of central tendency, to which the mean is sensitive. Because fish could not be collected at John Day damsite, migration rates for the 122-km stretch of river from McNary Dam to the John Day damsite were calculated by subtracting the median passage time between the John Day damsite and Bonneville Dam from the median passage time between McNary and Bonneville Dams.

In 1966 enough marked chinook yearlings were recovered to compare migration rates, through separate river sections, of three weekly release groups that had migrated in April, during a low river discharge, with three groups that had migrated in May, during a moderate river discharge. It was assumed that seasonal differences between April and May, in themselves, had no effect on migration rates. This assumption is reasonable, because (1) migration rates of yearling chinook and water flows measured in April 1965 were similar to the migration rates and water flows recorded in May 1966, described later, and (2) the groups of marked yearling chinook salmon compared were of the same size, age, and racial origin.

TABLE 1.—*Average migration rates of yearling chinook salmon through free-flowing and impounded sections of the Snake and Columbia Rivers during low and moderate river discharges[1]; data are based on three weekly release groups, each during low and moderate river discharge*

		Low river discharge					Moderate river discharge				
		Number of marked fish		Elapsed time (days)		Migration rate	Number of marked fish		Elapsed time (days)		Migration rate
Stretch of river and type of flow[2]	Distance (km)	Released	Recaptured	Average	Range	(km/day)	Released	Recaptured	Average	Range	(km/day)
Salmon River to Ice Harbor Dam (A–B) (nearly free flowing)	370	16,000	718	14	13–15	26	9,500	103	8	7–9	47
Ice Harbor Dam to McNary Dam (B–C) (impounded)	68	13,000	1,001	9	7–10	8	11,000	164	5	4–6	13
McNary Dam to John Day damsite (C–D) (free flowing)	122	36,400	702	5	5[3]	24	19,000	96	3	2–3	40
John Day damsite to Bonneville Dam (D–E) (impounded)	109	5,500	132	4	3–5	27	4,800	52	2	2[3]	55
Salmon River to Bonneville Dam (A–E) (based on sum of above)	669	—	—	32		21	—	—	18		37
Salmon River to Bonneville Dam (A–E) (based on recovery at Bonneville of fish released in Salmon River)	669	16,000	44	31	29–33	21	9,500	7	19	17–21	35

[1] Low river discharge: Snake 1,416 m^3/sec (Ice Harbor Dam); Columbia, 4,248 m^3/sec (McNary Dam); moderate river discharge: Snake 2,265 m^3/sec (Ice Harbor Dam); Columbia, 8,495 m^3/sec (McNary Dam).
[2] See Figure 1 for location of release and recovery sites.
[3] Average number of days between release and recovery was the same for all three replicates.

ESTIMATED MIGRATION RATES

Average migration rates were different during periods of different river discharges (Table 1). At moderate river discharges, the migration rate from the Salmon River to Bonneville Dam was 37 km/day, as compared with the 21 km/day estimated for the low river discharge. Yearling chinook salmon from the Salmon River migrated to Bonneville Dam in 18 days at the higher flow and in 32 days at the lower flow. Estimates based on a summation of recoveries in individual sections of the river agreed closely with those obtained from fish marked at the Salmon River and recovered at Bonneville Dam (Table 1).

The relation between river discharge and migration rate of juvenile salmon was also indicated by a pilot study conducted during April of 1965 to determine the practicability of a major mark and recovery program. Yearling chinook salmon and steelhead trout (*Salmo gairdnerii*) were collected and marked at Ice Harbor Dam and recovered at Bonneville Dam. Although the data could not be compared in detail with those for 1966, the recoveries from 10,000 marked fish released indicated rates of migration similar to those measured in May 1966. The average rate was 37 km/day, during water flows varying between 7,079 and 9,911 m^3/sec, compared to an average of 31 km/day at flows of 8,495 m^3/sec for this section of stream in May 1966.

Migration rates through most free-flowing and impounded stretches of the Snake and Columbia Rivers were similar with one exception; in McNary Reservoir (Columbia River) fish moved only about one-third as fast. This slower movement may have been caused by comparable reduction in water velocity through that section of river. Nelson, Perkins, and Haushild (1966) found that average velocities through McNary Reservoir were between 30 and 42% (depending on discharge) of the average velocity in the Columbia River below McNary Dam. Juvenile salmon from the Snake River may undergo a period of adjustment when they enter the mixture of the Columbia and Snake River waters, which could have accounted for the delay. More likely, however, velocity rather than change in water plays the dominant role in governing movement of fish in this area. In the following discussion on significance of delay, we have therefore assumed that the slowdown of fish through McNary Reservoir was caused by the reduction in water velocity.

SIGNIFICANCE OF DELAY

Although slower movement such as that observed in McNary Reservoir may not now affect the survival of yearling chinook salmon, the cumulative delay caused by a series of impoundments could affect their survival in the future. When John Day Dam, on the Columbia River, and the new dams on the Snake River are completed, the flow dynamics will be vastly changed. The impoundment above John Day Dam (3×10^9 m^3) will be nearly twice that above McNary Dam (1.6×10^9 m^3). Water velocity may be even slower in John Day Reservoir than in McNary Reservoir. The Snake River reservoirs will be smaller than those at McNary and John Day, but flow characteristics may be comparable to those in the larger reservoirs of the Columbia. Impoundments in the Snake River will be only one-third to one-fourth the size of the McNary Reservoir; the average discharge of the Snake River, however, is correspondingly only about one-third of that at McNary Dam, during most of the smolt migration (Table 1). As a result, water velocity in future Snake River impoundments could be comparable to the present velocity in McNary Reservoir.

Migration rates through McNary Reservoir in 1966 averaged 8 km/day during the low river discharge, about one third of the rate calculated through other stretches of river at that time (Table 1). If velocities in future impoundments approximate those in McNary Reservoir, the rate of migration through these impoundments will probably approximate the rate through McNary Reservoir. Yearling chinook required 32 days to migrate from Whitebird on the Salmon River to Bonneville Dam (during lower flows in 1966). If we assume that migration rates down the Snake River (when impounded) will approximate the present rate through McNary Reservoir during low river discharge, yearling chinook from the Salmon and Grande Ronde Rivers will require 36 additional days, or a total of 68 days, to reach Bonneville Dam.

LITERATURE CITED

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