Monitoring of Downstream Fish Passage at Cougar Dam in the South Fork McKenzie River, Oregon 1998-00

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INTRODUCTION

Cougar Dam, constructed by the U.S. Army Corps of Engineers in 1963, is located 42 miles east of Eugene, Oregon on the South Fork McKenzie River 4.4 miles upstream of its confluence with the mainstem McKenzie River. The dam is a rock-fill embankment 1,500 feet long and 452 feet high. The regulating outlet (RO) and penstock opening are in the intake structure located in the west abutment. The elevations of the RO and turbine intakes are 1485 and 1426 respectively. At full pool the reservoir is 6.5 miles long, 0.7 miles wide, has a surface area of 1,280 acres and stores 207,759 acre-feet of water.

Following construction, fish passage at Cougar Dam was evaluated during a 4-year program conducted by the Fish Commission of Oregon. In 1966 (after 2 years of study) it became evident that passing adult and juvenile chinook salmon (*Oncorhynchus tshawytscha*) at Cougar Dam was not feasible with existing facilities. A decision was made by the steering committee to abandon downstream migrant fish passage facilities, discontinue passing salmon at Cougar, and to artificially propagate salmon destined for the upper river in mitigation. After 1967, adult salmon passage at Cougar Dam was discontinued.

In 1993, Oregon Department of Fish and Wildlife (ODFW) began placing adult chinook salmon that were excess to hatchery operations at McKenzie and Willamette Hatchery above Cougar Dam in an attempt to restore some of the biological contributions salmon made to the ecology of the South Fork McKenzie River prior to Cougar Dam construction (Table 1). Contributions included increased nutrient input to the ecosystem and an additional food source for predators, including bull trout. In addition, the progeny of these adult salmon provided a landlocked chinook fishery in the reservoir and ODFW was able to discontinue annual releases of juvenile salmon reared in ODFW hatcheries (1996). ODFW assumed most of the salmon attempting to leave the reservoir would be killed by various means upon passage through the turbines or regulating outlet. Between 1994-97, ODFW field observations provided circumstantial evidence that some juvenile chinook were surviving passage through the dam. In 1998, we began monitoring juvenile chinook migration out of the reservoir to determine the number, size, age, and mortality rate of fish passing through the turbines and regulating outlet of Cougar Dam. This effort was cooperatively agreed to and funded by the U.S. Army Corps of Engineers and ODFW.

Table 1. The number of spring chinook adults released into the South Fork McKenzie River above Cougar Reservoir, 1993-99.

Year	McKenzie Stock	Willamette Stock	Total
1993	56		56
1994			0
1995			0
1996	122	172	294
1997	200	838	1,038
1998	318		318
1999	549		549

METHODS

During, the first field season we fished two 2.44 m (8 ft.) rotary screw downstream migrant traps from 11 November 1998 to 8 March 1999. One trap was placed in the thalweg of the turbine channel approximately 200 m downstream of the turbine outlet. The second trap was located in the regulating outlet channel approximately 100 m below the stilling basin. The second field season we fished the turbine channel only from 03 October 1999 - 01 February 2000. Captured live fish and mortalities were counted, measured, and released. We calculated trapping efficiency for live and dead juvenile chinook by marking a known number of fish captured in the screw trap (upper and lower caudal fin clip respectively), releasing them above the trap, and dividing the number of recaptured fish by the number of fish released. We did not calculate trapping efficiency of dead juvenile chinook in 1998-99.

RESULTS

We fished a rotary screw trap in the turbine and regulating outlet channel below Cougar Dam during two field seasons. Juvenile chinook salmon were abundant and accounted for 91% of the fish captured (Table 2). Peak catches of chinook occurred in mid-December and late January and coincided with low average pool elevations in Cougar Reservoir during 1998-99 (Figure 1).

Table 2. Date, species, number, and location of fish captured in two rotary screw traps below Cougar Dam during two field seasons.

	Nov. 11, 1998 - Mar. 08, 1999		Oct. 03, 1999- Feb. 01, 2000	
Species	Turbine	Regulating Outlet	Turbine	Regulating Outlet
Chinook	467	1,165	381	-
Rainbow	26	15	147	-
Dace	4	1	9	-
Whitefish	1	1	0	-
Sculpin	0	0	1	-

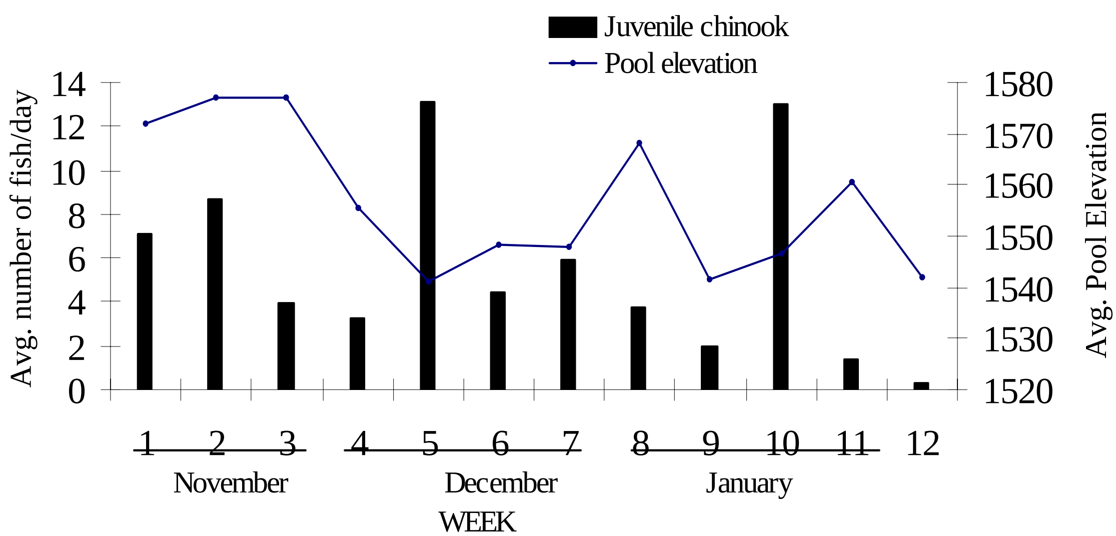

Figure 1. Average daily catch of juvenile chinook in the turbine trap below Cougar Dam and average pool elevation of Cougar Reservoir summarized weekly from November 11-February 03, 1998-99.

In 1998-99 we estimated that 14,000 juvenile spring chinook migrated through the regulating outlet and 1,477 - 3,924 migrated through the turbine outlet. In 1999-00 estimated spring chinook migration through the turbine outlet was 6,236. Estimated mortality of juvenile chinook and rainbow trout passing through the turbine and regulating outlet of Cougar Dam ranged from 7.1-44.9% (Table 3). Estimated mortality increased in the turbine channel from 7.1% to 18.1% during the second field season. Trap efficiency in the turbine channel during 1999-00 was 5.95% and 6.98% for live and dead fish respectively.

Table 3. Estimated mortality and trap efficiency for spring chinook and rainbow trout migrating through the turbine and regulating outlet of Cougar Dam during two field seasons.

	Estimated Mortality (%)			Estimated Trap Efficiency (%)		
	1998-99		1999-00	1998-99		1999-00
Species	Turbine	Regulating Outlet	Turbine	Turbine	Regulating Outlet	Turbine
Chinook	7.1	32.3	18.1	16.5	10.9	5.95[a], 6.98[b]
Rainbow	30.1	40	44.9	(n=200)	(n=29)	(n=185, 43)

a- estimated trap efficiency for live chs
b- estimated trap efficiency for dead chs

Length frequency histograms of spring chinook migrating through the turbine and regulating outlet indicate three size classes of fish (Figure 2) (Figure 3). Mean fork length of juvenile chinook migrating through the turbine outlet increased from 11 cm in 1998-99 to 13.4 cm in 1999-00. Mean fork length of juvenile chinook migrating through the regulating outlet in 1998-99 was 13.3 cm.

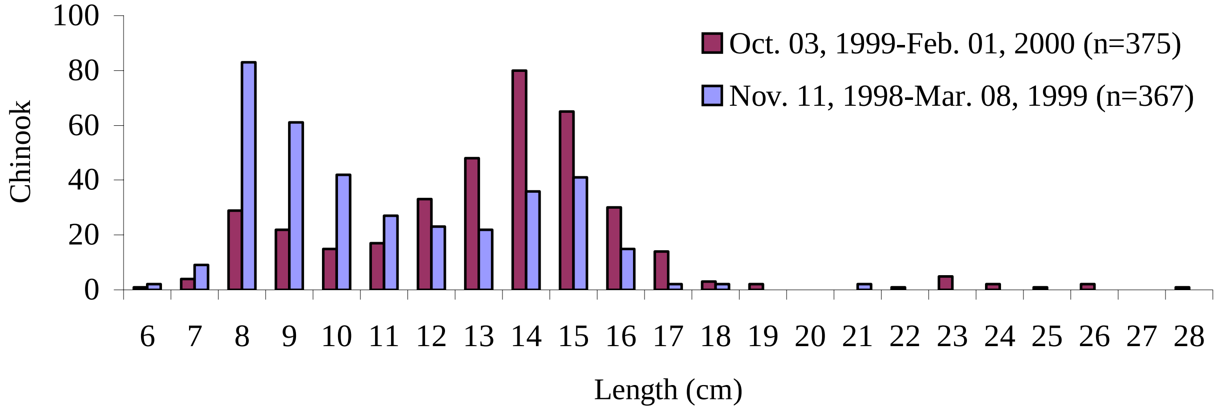

Figure 2. Length frequency histogram for juvenile spring chinook salmon captured in a rotary screw trap in the turbine outlet channel below Cougar Dam.

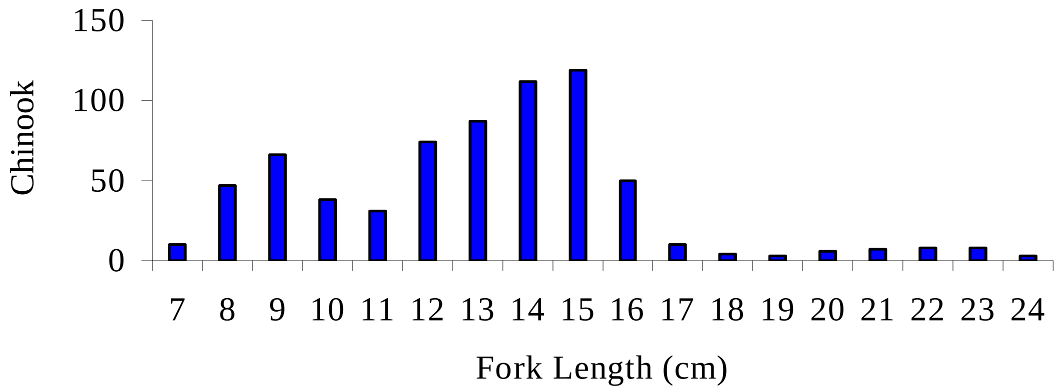

Figure 3. Length frequency histogram for 911 juvenile spring chinook captured in a rotary screw trap in the regulating outlet channel below Cougar Dam, November 1998 to February 1999.

Mortality increased significantly with size for spring chinook migrating through the turbine and regulating outlet channel ($p < 0.05$) (Figure 4) (Figure 5).

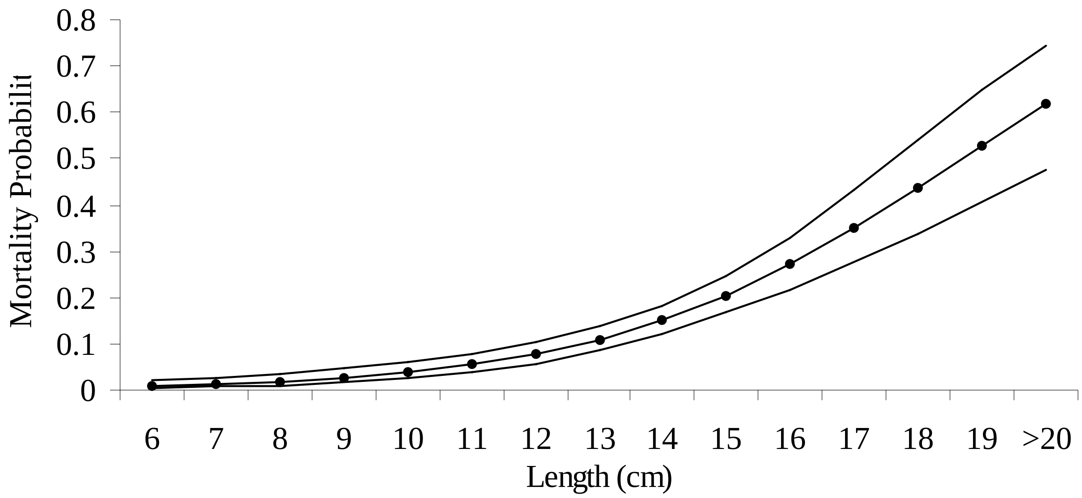

Figure 4. Logistic regression of mortality versus size for 742 juvenile chinook captured in a rotary screw trap in the turbine channel below Cougar Dam, 1998-00.

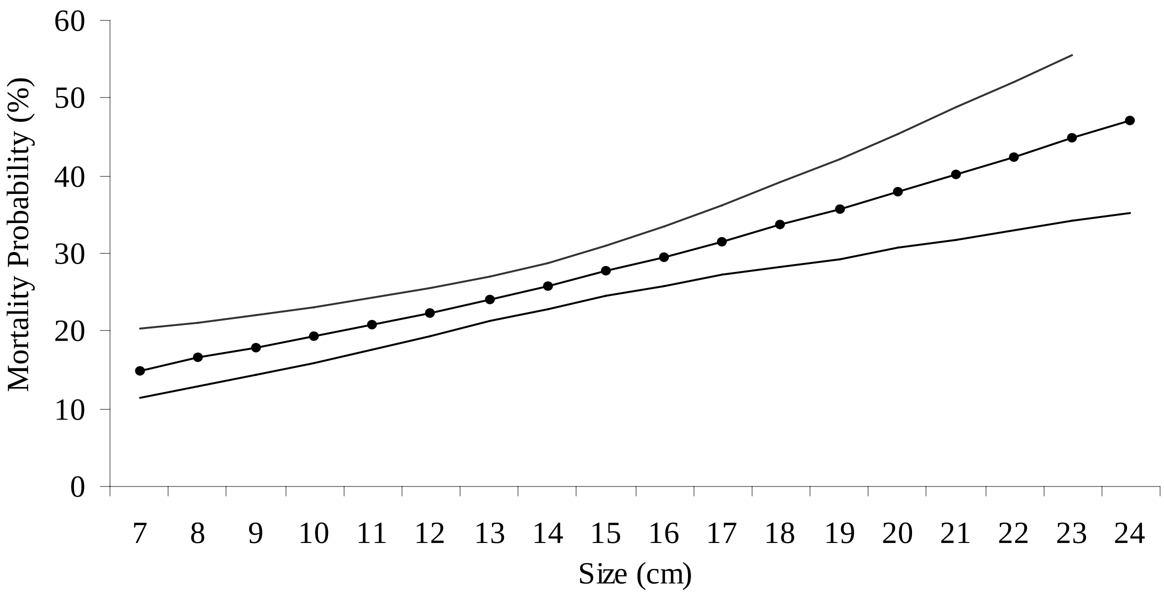

Figure 5. Logistic regression of mortality versus size for 911 juvenile chinook captured in a rotary screw trap below Cougar Dam, 1998-99.

DISCUSSION

Juvenile chinook were abundant and accounted for 91% of the fish captured during two field seasons of trapping below Cougar Dam. Migration out of the reservoir through the turbine was fairly consistent over the 12 week sampling period (1998-99) with the exception of two peaks seen in the second week of December and third week of January. Changes in flow through the turbine can not account for the increase in migration observed during those weeks, however, the peak migrations coincide with low average pool heights. These migrations may have occurred because the depth of the penstock opening is shallower during weeks with low average pool heights.

During the 1998-99 field season, approximately 80% of the chinook migrated out the regulating outlet, presumably, because the opening is shallower than the penstock opening. The number of juvenile spring chinook trapped migrating through the turbine outlet decreased during the second field season while the estimated number of juvenile chinook increased. This increased estimate was the result of lower trap efficiency during 1999-00 (5.95%) in comparison to 1998-99 (16.5%).

We estimated mortality associated with turbine and regulating outlet passage at 7.1% and 32.3% respectively (1998-99). We do not know why mortality for fish using the regulating outlet is higher than for fish migrating through the turbine. We observed an increase in mortality in the turbine trap during the second field season (7.1% to 18.1%). This increased mortality can be partly explained by a two centimeter increase in mean fork length and the strong positive relationship that exists between length and mortality. Logistic regression analysis of length versus mortality indicates that mortality increases with size. The relationship was stronger in the turbine channel and mortality may be over 50% for fish >20 centimeters in length.

Length frequency histograms indicate three size classes of fish, however, we do not know the age structure of the population. Scales were collected, but analysis has not been completed. We believe that juveniles that rear predominantly in the river attain a smaller size than those that rear in the reservoir.

Future researchers should employ methods that 1) increase trap efficiency to improve mortality estimates for chinook salmon migrating through the turbine and regulating outlet of Cougar Dam, 2) determine why mortality is higher for fish passing through the regulating outlet than the turbine outlet and 3) identify methods for improving downstream fish passage at Cougar Dam.