FISH PASSAGE CENTER

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MEMORANDUM

TO: CBFWA Members Group

FROM: Michele DeHart

DATE: August 10, 2001

RE: Spring Migration 2001 in response to Request from Brian Allee

In response to a request from Brian Allee, CBFWA, the Fish Passage Center staff reviewed the 2001 passage data for spring migrants. This document presents the preliminary results of analysis of the 2001 spring migration of steelhead and chinook in the Snake and Columbia Rivers.

- Near record low run-off volume, energy deregulation, volatile wholesale power markets and BPA energy and financial emergencies combined to produce poor migration conditions for juvenile spring chinook.
- NMFS Biological Opinion flow targets were never met. Seasonal average flows for the spring period were 48.9 kcfs at Lower Granite, 126.3 kcfs at McNary and 76.7 kcfs at Priest Rapids compared to a Biological Opinion target flow of 85 kcfs at Lower Granite and 220 kcfs at McNary.
- Spill was eliminated from Snake River projects and only 600-megawatt months were spilled at Lower Columbia projects.
- River conditions this year produced the poorest survivals since PIT Tag survivals have been estimated (1993). Seasonal survival estimates from Lower Granite to McNary Dam for yearling chinook was estimated at 0.57 and for steelhead 0.16. Average survival for spring chinook in this reach from 1995 to 2000 was 0.72 and 0.70 for steelhead. Wild yearling chinook survival was lower than 2000 in this reach.
- Run timing was affected for both chinook and steelhead with the run beginning later than normal and of a shorter duration than normal.
- Travel times in 2001 were some of the lowest in the twenty years of travel time data, with travel times for spring chinook in the McNary to Bonneville reach doubling when compared to past years.
- The poor flow year was exacerbated by power peaking operations in the mid-Columbia where flows were highest on weekdays and decreased considerably on weekends

2001 Migration Conditions

Low river runoff volume and hydrosystem operation decisions affected the ability to implement the Biological Opinion measures for the 2001 juvenile salmon migration. The July Final Runoff Volume Forecast at The Dalles was 52% of average, and at Lower Granite Dam the volume was estimated at 47% of average. A power system emergency was declared by the Bonneville Power Administration based on concerns relative to power reliability and financial solvency. The declared emergency subsequently determined how the hydrosystem operated in 2001 relative to the provision of fish mitigation measures. Reservoir refill was prioritized in order to provide power and financial reserves for BPA. While flows would have been below the NMFS Biological Opinion levels, this reduction was further exacerbated by the system operation. The resulting spring flows and the Biological Opinion levels are presented in the following table:

Location	Spring Flow Target Kcfs	Actual Flows Kcfs
Lower Granite	85	48.9
McNary	220	126.3
Priest Rapids	135	76.7

In addition to average flows that were well below the Biological Opinion flow targets, flows were fluctuated on a daily and weekly basis to maximize power production and revenue. These daily and weekly variations likely had a deleterious impact on migration conditions.

Because flows in the Snake River were projected to be less than 85 Kcfs, spill was terminated at the Snake projects and transportation was maximized. Transportation was also implemented to collect 50% of the spring migrants at McNary Dam.

Spill normally would have occurred at fairly significant levels between May 1 and June 30 at the lower Columbia projects. However, in 2001 a much curtailed spill program equivalent to a total of 600 MW-months was implemented at The Dalles and Bonneville dams from May 16 to June 15, from May 25 to June 15 at John Day Dam and on alternate days between May 25 and June 15 at McNary Dam.

Figure 1. Daily average flow and spill at Lower Granite Dam compared to BiOp flow and spill targets.

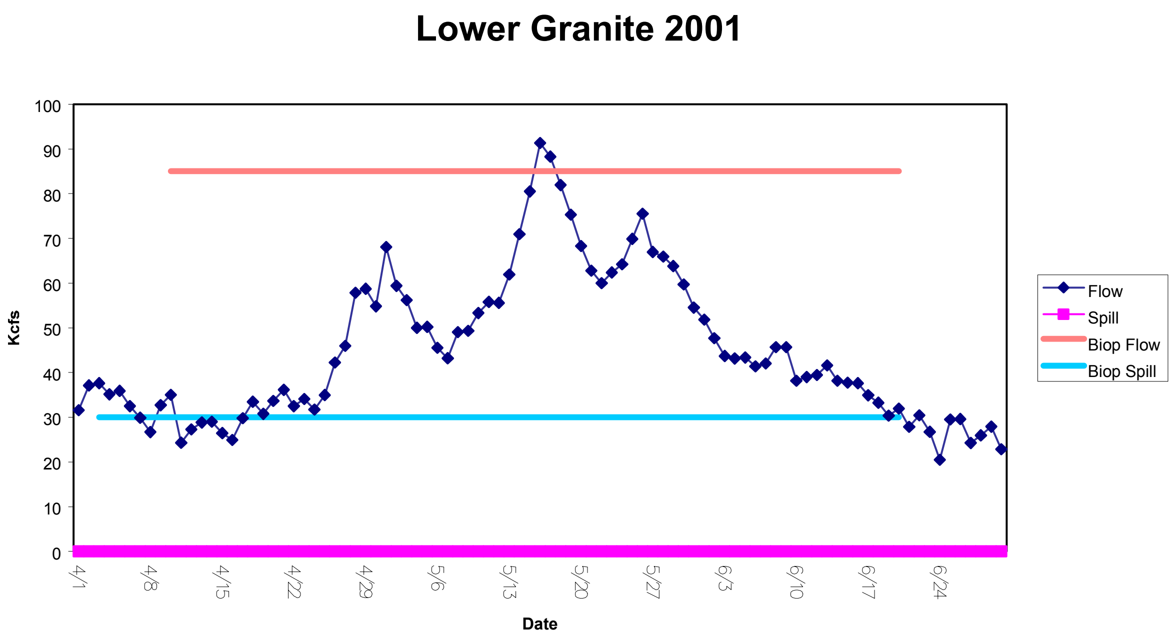


Figure 2. Daily average flow and spill at Little Goose Dam compared to BiOp flow and spill target.

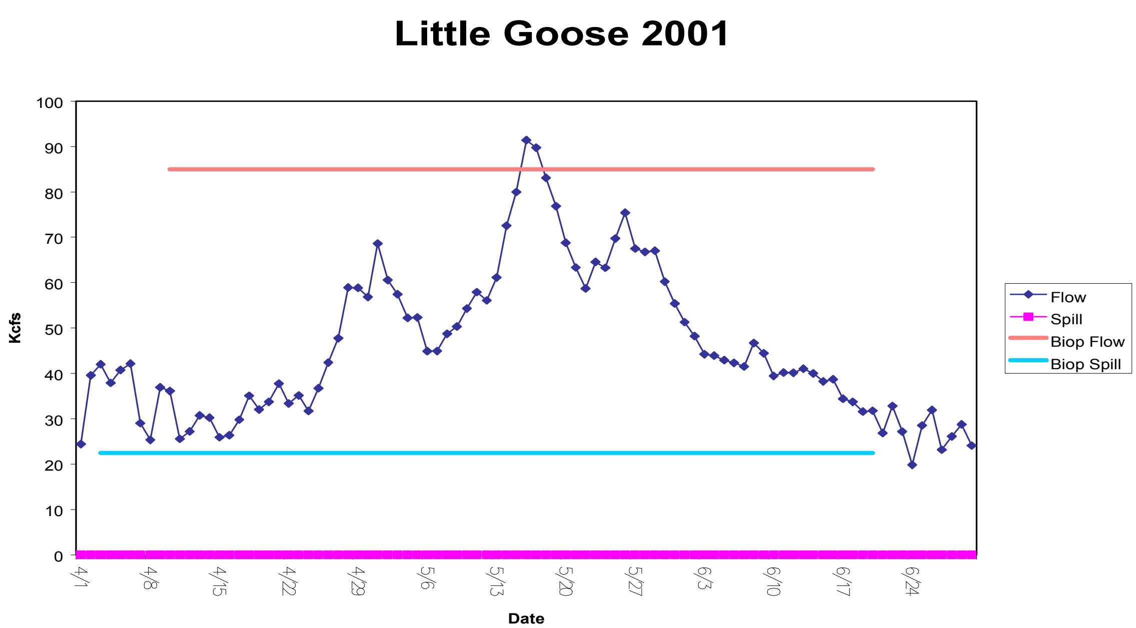


Figure 3. Daily average flow and spill at Lower Monumental Dam compared to BiOp flow and spill targets.

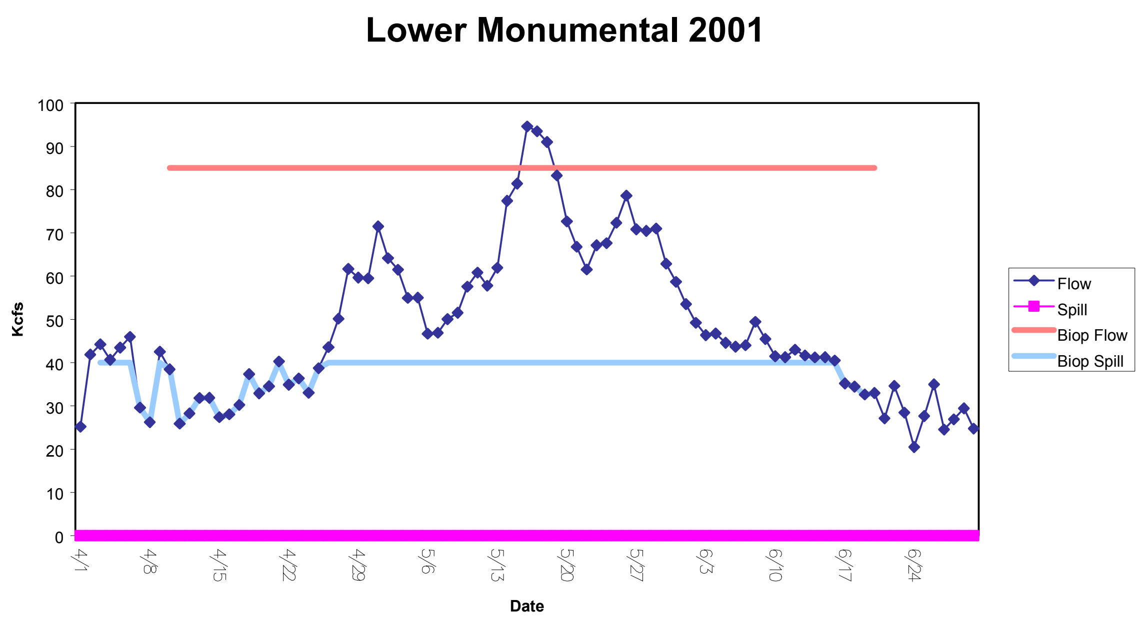


Figure 4. Daily average flow and spill at Ice Harbor Dam compared to BiOp flow and spill targets.

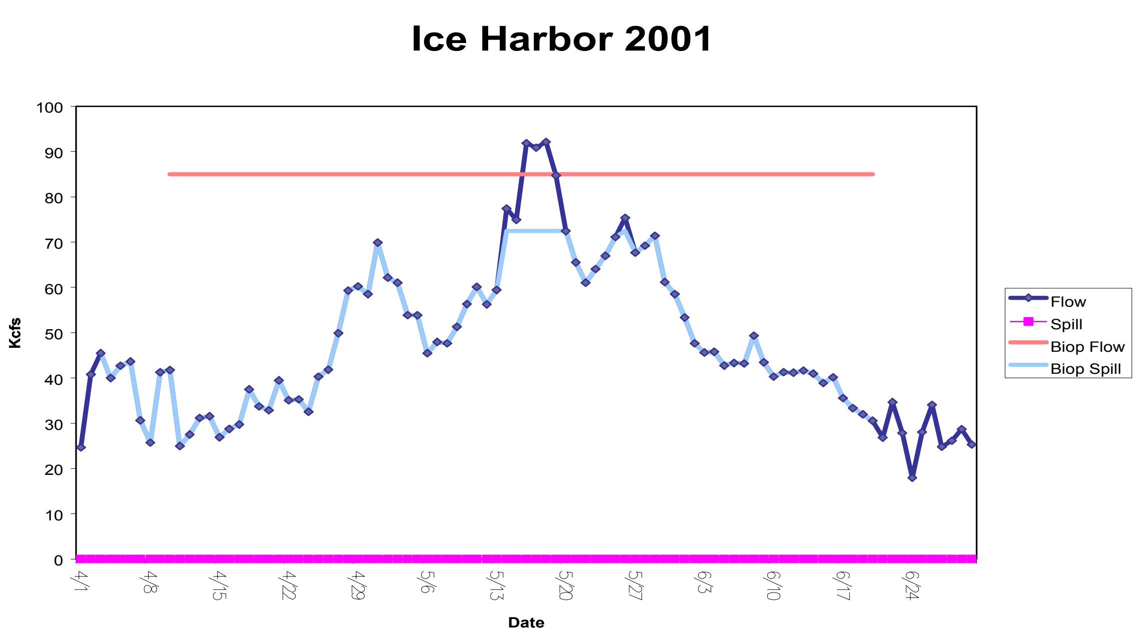


Figure 5. Daily average flow and spill at McNary Dam compared to BiOp flow and spill targets.

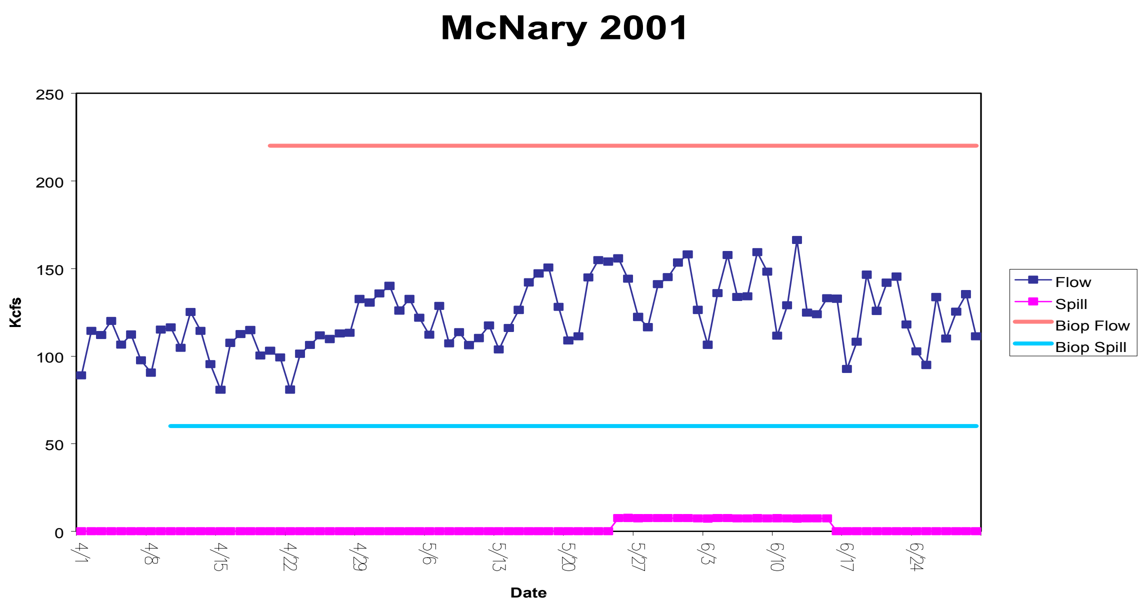


Figure 6. Daily average flow and spill at John Day Dam compared to BiOp flow and spill targets.

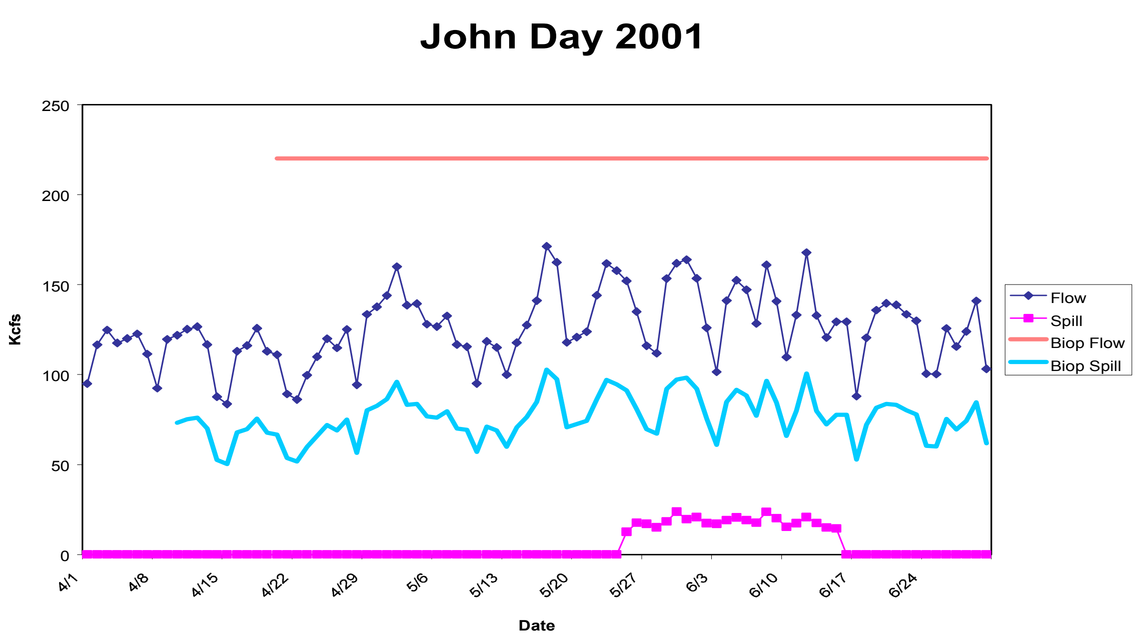


Figure 7. Daily average flow and spill at The Dalles Bonneville Dam compared to BiOp flow and spill targets.

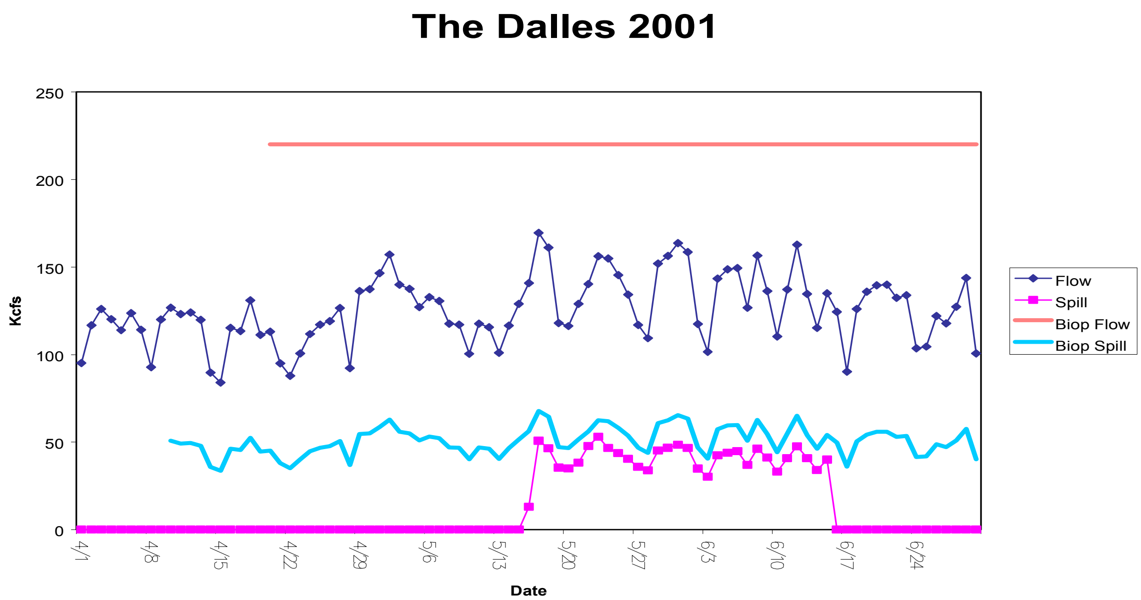
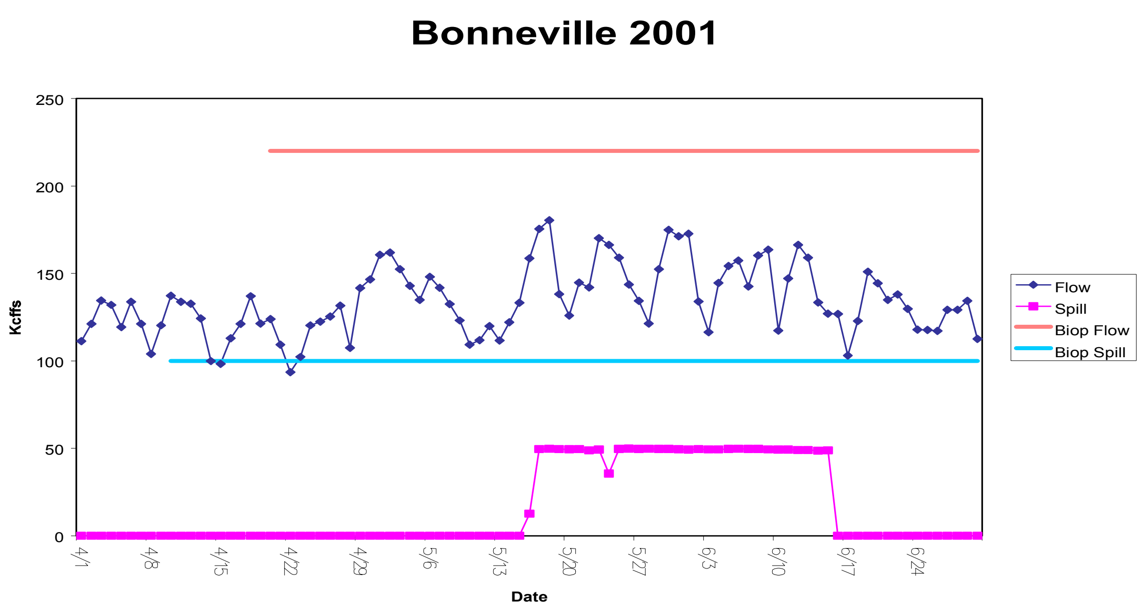


Figure 8. Daily average flow and spill at Bonneville Dam compared to BiOp flow and spill targets.



Survival

We estimated survivals of yearling spring/summer chinook and steelhead, in the reach from Lower Granite tailwater to McNary Dam tailwater, using fish that were PIT-tagged above Lower Granite and subsequently detected at Lower Granite Dam. Fish were grouped in weekly blocks based on date of detection at Lower Granite Dam. Where the sample size of PIT-tagged fish were large enough and standard error of estimates were low enough to generate estimates with reasonable confidence intervals (due in part to recapture probability that was, due to lack of spill, high this season) those estimates were developed and are reported in the graphs and tables below.

Weekly survival estimates for yearling spring\summer chinook were below 60% (about 10% to 15% below normal) in April and declined from mid-May through the remainder of the migration. Estimates of survival by the end of May were lower than 20%. Estimates for both hatchery and wild chinook were very similar. For steelhead survivals began near 20% and declined to less than 10% for hatchery fish, while the wild steelhead seemed to fair only slightly better with survivals that stayed near 20%.

Weighted average seasonal survivals for yearling chinook and steelhead were calculated based on the proportion of fish migrating during each week. For yearling chinook, a season average survival of 0.57 was estimated, and for steelhead 0.16. These season survival estimates are well below the estimates reported for the previous 5 years for migrating juvenile salmonids in the lower Snake River (Table 1 and Figure 13). The steelhead estimate was far below any other seasonal estimate and probably represents both very low survival as well as residualism. In either case the survival of juvenile salmonids was severely impacted by the poor migration conditions in the spring of 2001.

Figure 9. Reach survival estimates from LGR to MCN for hatchery spring/summer chinook.

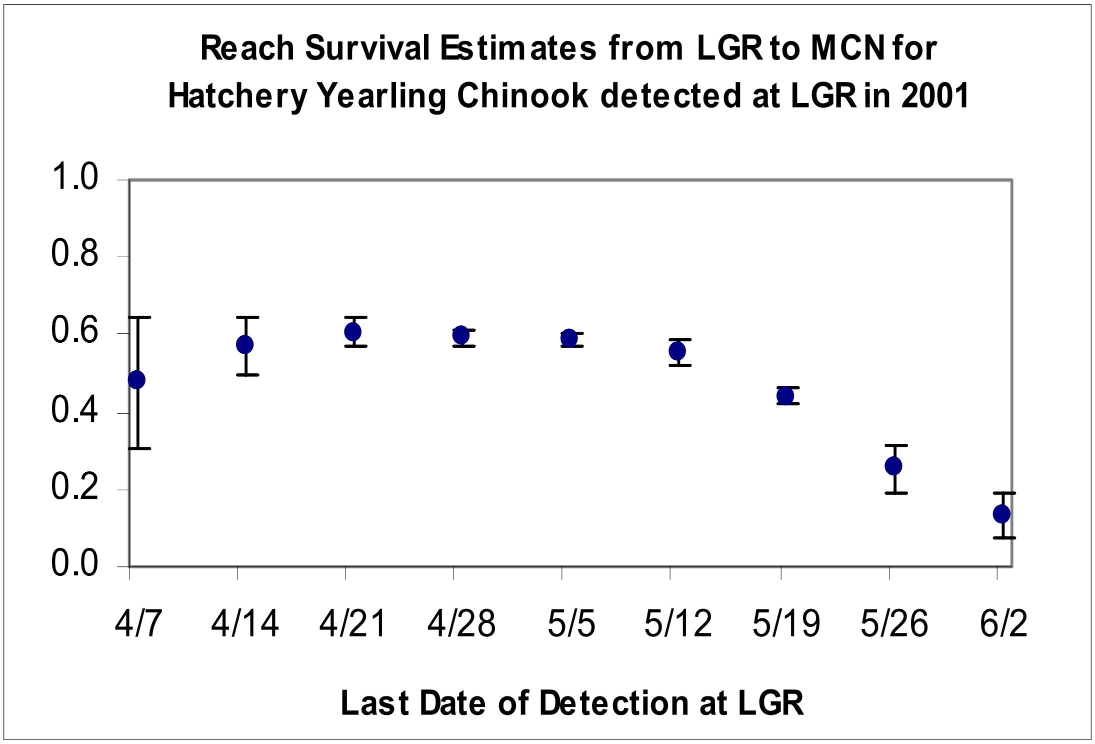


Figure 10. Reach survival estimates from LGR to MCN for hatchery steelhead.

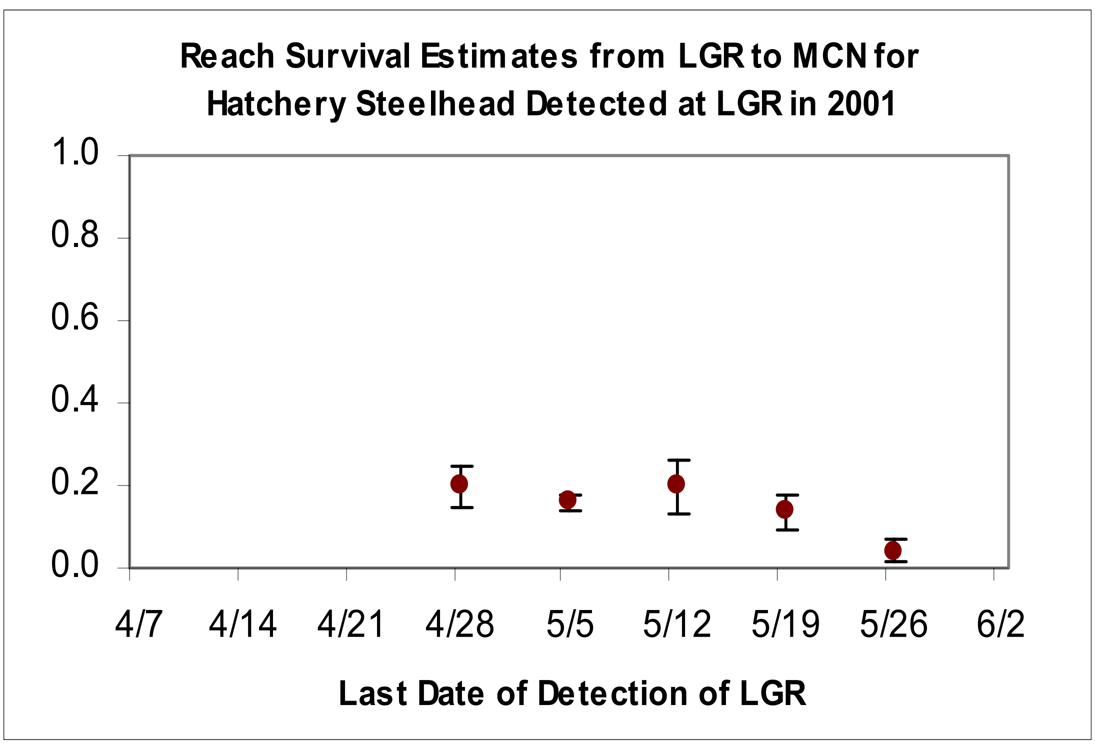


Figure 11. Reach survival estimates from LGR to MCN for wild spring/summer chinook.

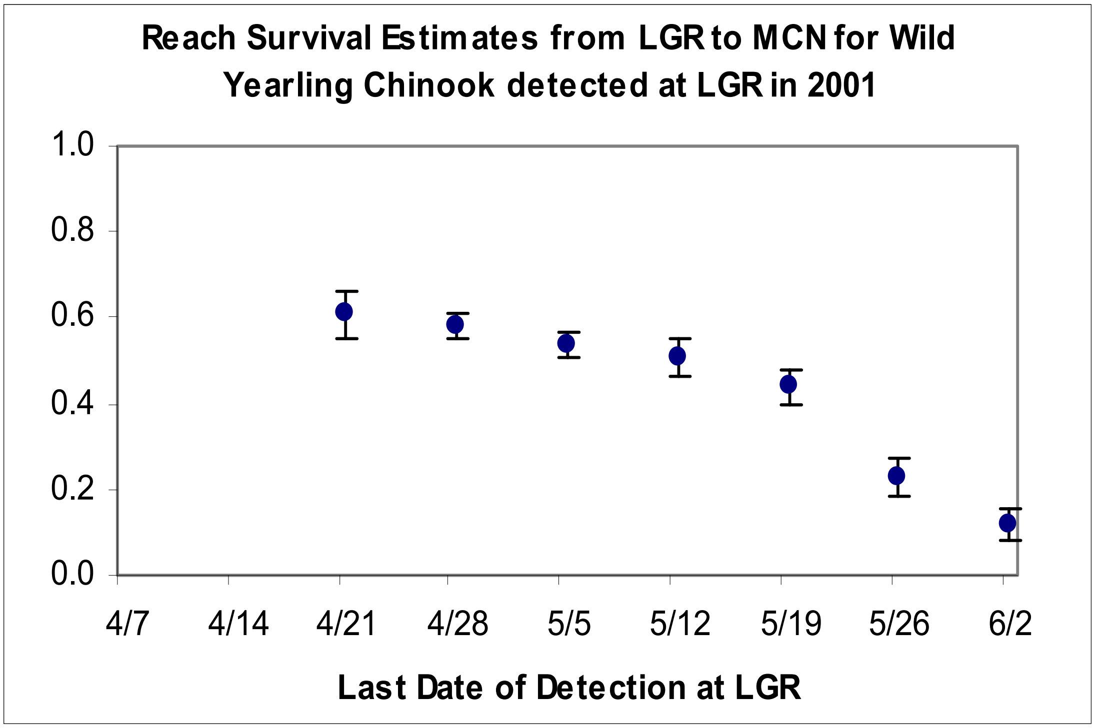


Figure 12. Reach survival estimates from LGR to MCN for wild steelhead.

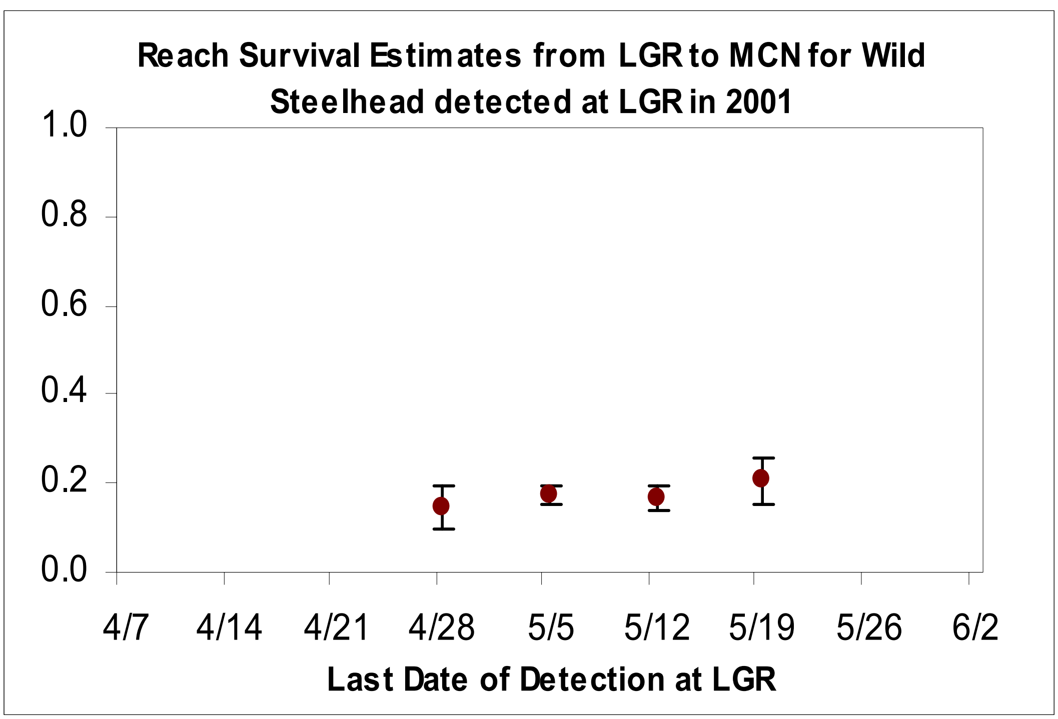


Table 1. Season survival estimates[a] for the reach Lower Granite tailwater to McNary tailwater.

Migration Year	Yearling Chinook	Steelhead
1995	0.72	0.74
1996	0.65	0.69
1997	0.65	0.73
1998	0.77	0.65
1999	0.79	0.69
2000	0.76[b]	
2000	0.74[c]	
2001	0.57[d]	0.16[d]

[a] Estimates from NMFS white paper "Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams" unless otherwise indicated.
[b] Estimate by Fish Passage Center includes only wild yearling chinook.
[c] Estimate by Fish Passage Center includes only hatchery yearling chinook from CSS study groups.
[d] Estimates by Fish Passage Center includes hatchery fish only (estimates for wild fish were similar see figures 9 to 12).

Figure 13. Season survival estimates for reach from Lower Granite tailwater to McNary tailwater.

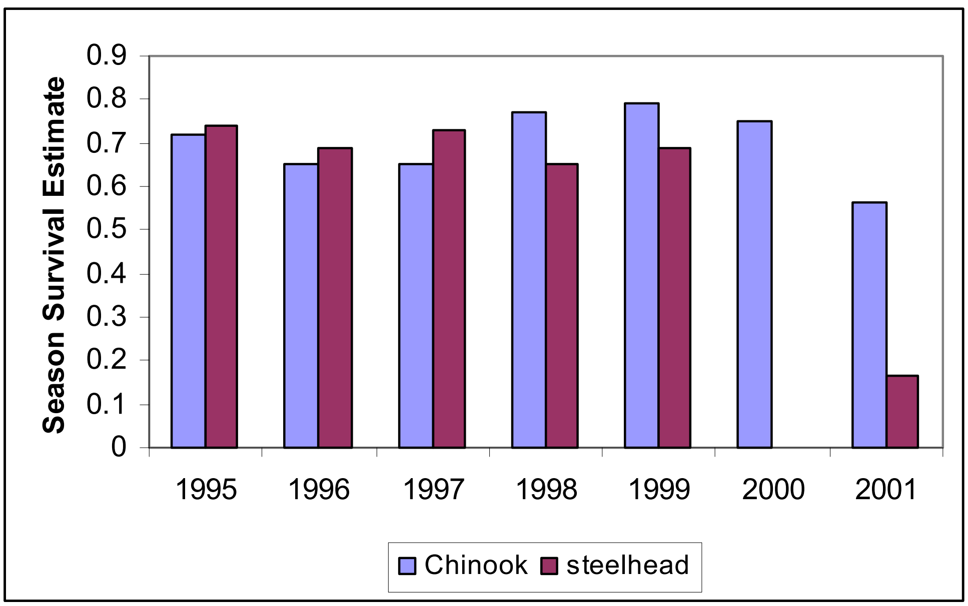


Figure 14. Weekly survival estimates of wild yearling chinook from Lower Granite to McNary dam relative 2001 vs 2000.

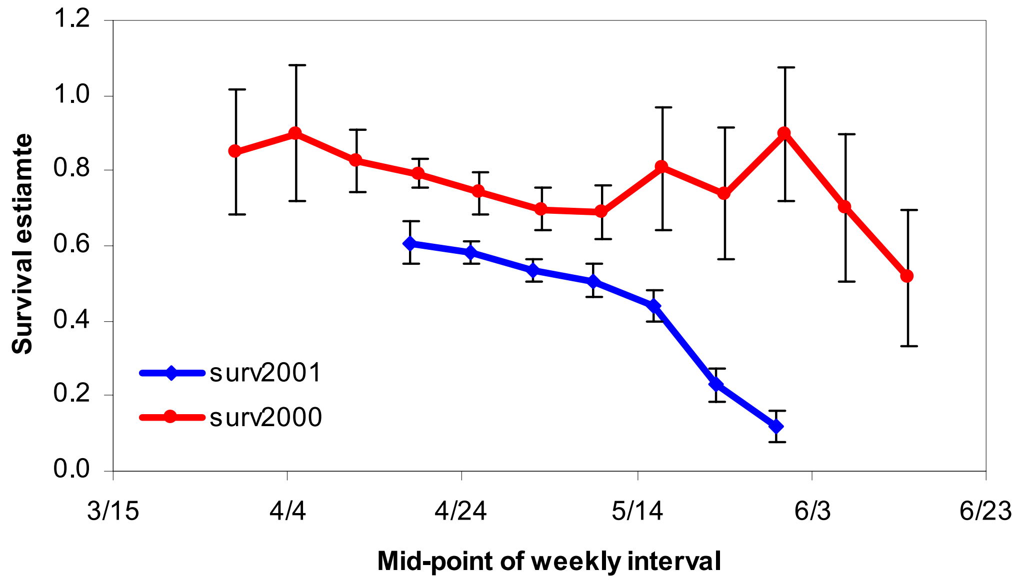
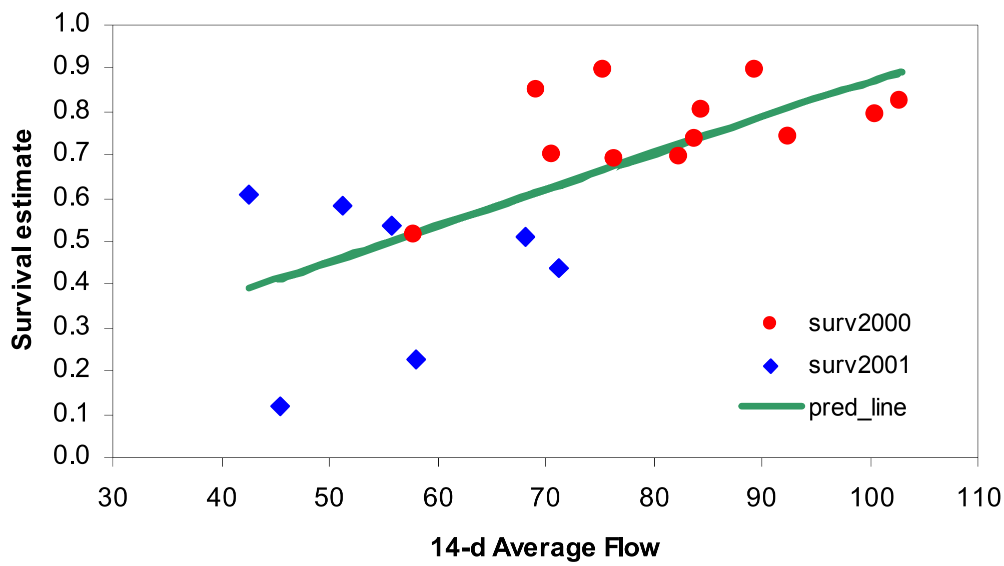


Figure 15. Weekly survival estimates of wild yearling chinook from Lower Granite to McNary Dam tailrace to 14-d average flows 2001 vs 2000.



Weekly survivals were plotted for wild yearling spring chinook through the reach from Lower Granite tailwater to McNary tailwater for the years 2000 and 2001 (Figure 14). The survival estimates in 2001 were significantly lower throughout the season when compared to 2000. For perspective, the 2000 wild yearling chinook season survival rate of 0.76 was near the average of 0.72, for the previous 5 years. In both 2000 and 2001, survivals were highest early in the migration and decreased toward the end of the migration. But in 2001 the late season survivals were obviously much lower than 2000.

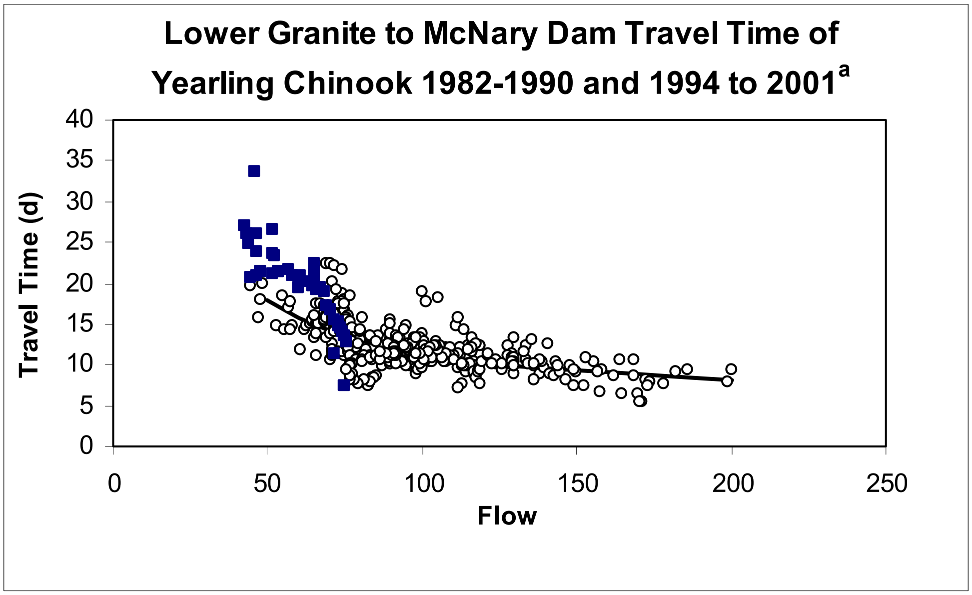
A comparison of survivals, to total discharge, using the same wild chinook data, showed an increase in survival with increasing flows (Figure 15). Flows in the lower Snake River in 2000 were considerably higher than those in 2001. At Lower Granite Dam in 2000, daily average discharge was 84 kcfs during the month of May, while for the same time period in 2001, flows averaged 64 kcfs. Weekly survivals were plotted against the 14-day average flows at Lower Granite Dam. Flows were averaged for the time-period beginning on the mid-date of the weekly survival block and extending for two weeks. The 14-d average was considered a representative index of the flow condition each survival block experienced as it passed through the reach. Based on this flow index, it was apparent that 2001 migrants generally experiencing much lower average flows than 2000 migrants, and that lower survivals in 2001, were strongly associated with these lower flows. Only the last weekly estimate for 2000 falls within the range of the 2001 survival estimates and that was during a period with the lowest flows in 2000 but similar to those seen at the peak of the 2001 migration.

Travel time

We calculated travel times for yearling spring\summer chinook and steelhead for two reaches: from Lower Granite to McNary Dam and from McNary to Bonneville Dam. We grouped migrants by date of detection at the upriver project and calculated travel times for all fish detected at the downriver project. We included all travel times between the 10% and 90% passage dates at the upriver project, where greater than 10 fish were observed. In most cases, for 2001, we had more than 50 fish per date, and on some dates over 1000 fish were used to calculate travel times. Travel times were plotted for 2001 versus data from the past several years for comparison.

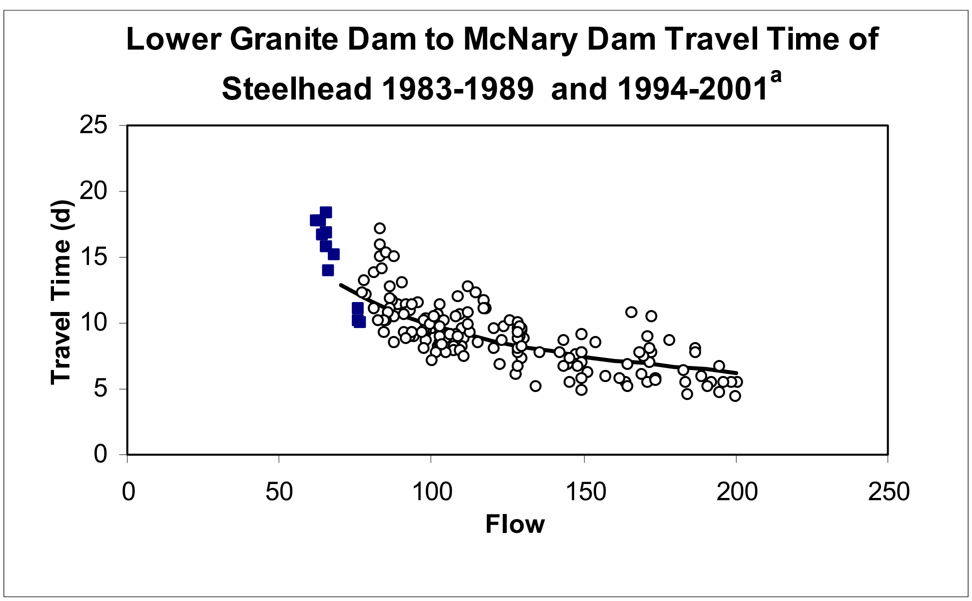
Travel times for the 2001 migration were among the longest seen for both yearling spring\summer chinook and steelhead in comparison to all other years we have been calculating these statistics for Columbia and Snake River fish (see figures 16 through 19). The unusually long travel times were especially noticeable in the Lower Columbia, where flows were near record lows. For yearling chinook over the years 1996 to 2000, travel time from McNary Dam to Bonneville Dam averaged 5.6 days (average and of median daily travel times) while for 2001 travel times average 10.8 days. For steelhead over the same reach the 1996 to 2000 average travel time was 5.0 days compared to an average of 10.0 for 2001.

Figure 16. Comparison of 2001 travel times of yearling spring/summer chinook from LGR to MCN to historic data.



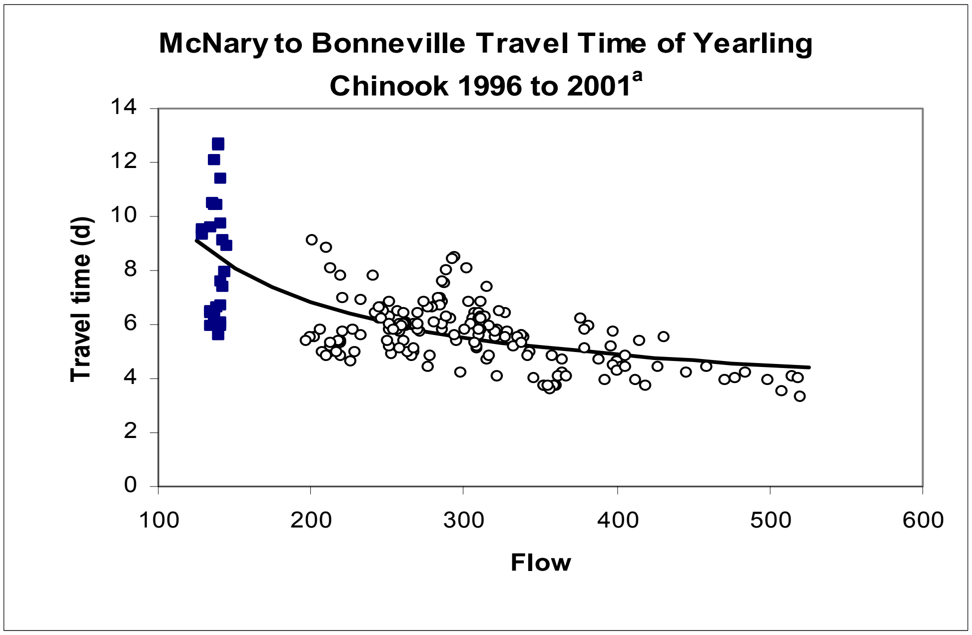
[a] 2001 data shown as solid squares.

Figure 17. Comparison of 2001 travel times of steelhead from LGR to MCN to historic data.



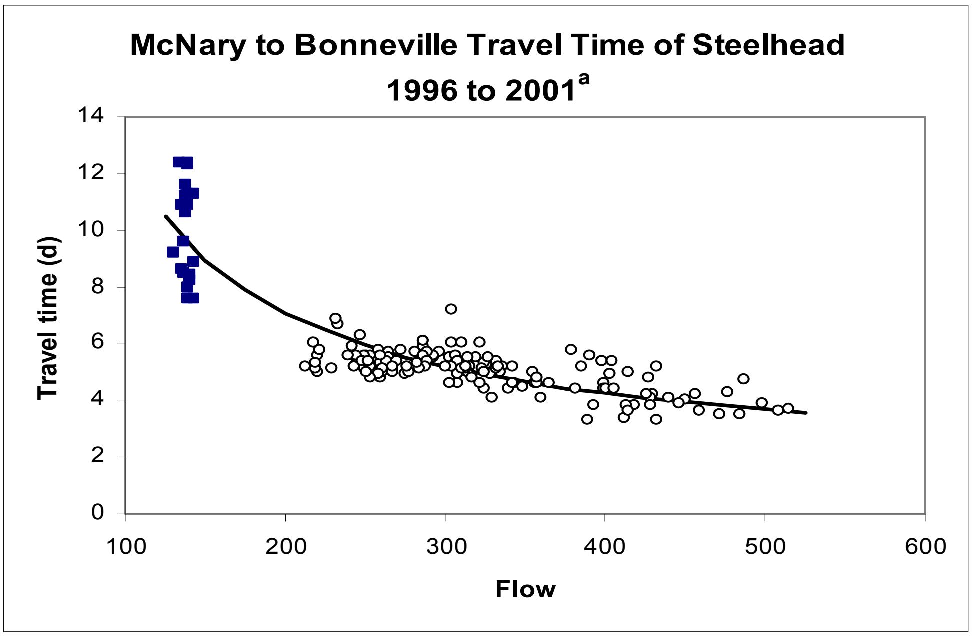
[a] 2001 data shown as solid squares.

Figure 18. Comparison of 2001 travel times of yearling spring/summer chinook from MCN to BON to historic data.



[a] 2001 data shown as solid squares.

Figure 19. Comparison of 2001 travel times of steelhead from MCN to BON to historic data.



[a] 2001 data shown as solid squares.

Migration Timing

The time period of the spring outmigration past Lower Granite Dam this season was not greatly different when compared to historic timing. However, for both yearling spring\summer chinook and steelhead, the run began later than normal and was of shorter duration when comparing 10% and 90% passage dates to historic averages (Tables 2 and 3). This suggests that the migration was slow to develop due to low flows and that survival to Lower Granite was lower, so that the migration ended earlier despite slower travel times. This truncation of passage is likely due to increased mortality in the case of chinook, while it may well be due to both mortality and residualism in steelhead.

Table 2. Migration Timing of yearling spring/summer chinook at Lower Granite Dam.

	10% Passage	**50% Passage**	**90% Passage**	**Days for mid-80% passage**
Avg 1985 to 2000	4/18	5/1	5/19	31
2001	4/26	5/5	5/18	22
Difference	+8	+4	-1	-9

Table 3. Migration Timing of steelhead at Lower Granite Dam.

	10% Passage	**50% Passage**	**90% Passage**	**Days for mid-80% passage**
Avg 1985 to 2000	4/26	5/9	5/28	32
2001	4/29	5/10	5/26	27
Difference	+3	+1	-2	-5

In the middle of the spring outmigration there was a large drop in daily flows (from 68 kcfs on 5/1 down to 43 kcfs on 5/7). This drop in flows was accompanied by a drop in daily passage index of yearling spring/summer chinook from a peak of 155,000 on 5/1 to 18,000 on 5/8 and for steelhead a peak of 346,000 on 5/2 down to 60,000 on 5/8. The flows then increased to 90 kcfs on 5/17 and coincident with this there was a second peak in the chinook passage index at 141,000 on 5/15 and a similar peak for steelhead at 388,000 on 5/18 (Figures 20 and 21). The drop in flows had the apparent effect of delaying the migration at a time when passage was peaking in the lower Snake River.

Figure 20. Passage timing of yearling chinook versus flows at Lower Granite Dam.

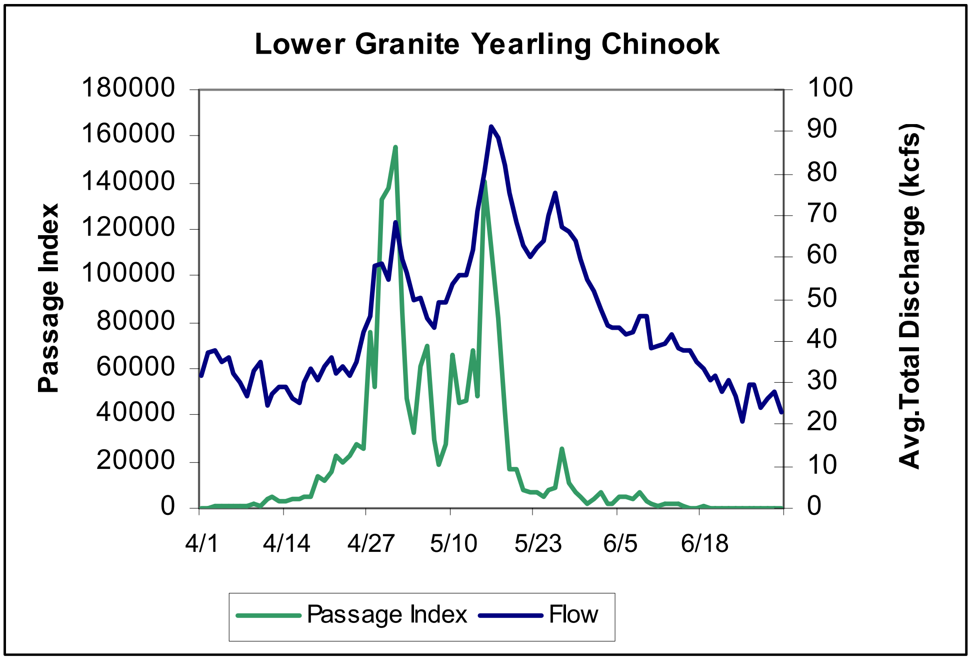
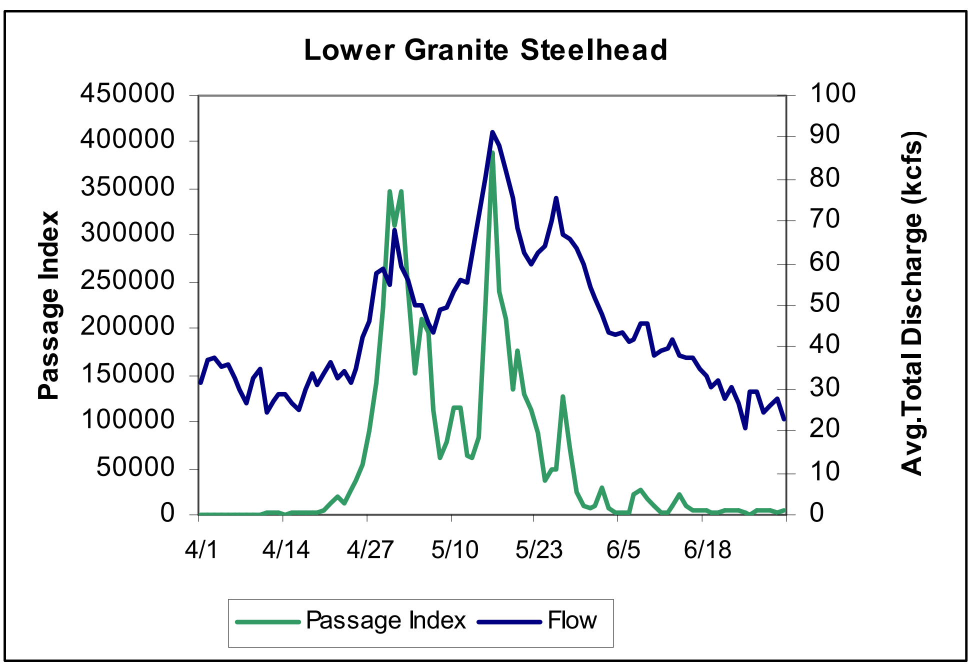


Figure 21. Passage timing of steelhead versus flows at Lower Granite Dam.



We generated seasonal total collections of migrants past Lower Granite, McNary, Rock Island, and Bonneville dams. In most cases we based the season total projected passage index upon NMFS estimates of total collection at those sites for each species. We then fitted the historic cumulative run-timing curves to these expected totals by adjusting cumulative daily proportions to an expected final total. The plots then provide an historic timing curve fitted to the magnitude of this year's expected outmigration. We then plot daily indices, in season, against the historic curve to be able to compare this season's migration timing and magnitude to both historic timing and projected magnitude (see Figures 22 and 23). Caution should be used in comparing actual in-season passage indices to preseason projections, since there can be some difficulty in determining the exact size of a run and subsequent collection past a particular dam any given year. However, the comparison can be quite useful for comparing timing and to some degree the magnitude of the run.

As indicated by the 10% and 90% passage dates described in table 2, at Lower Granite Dam the yearling spring/summer chinook migration began more slowly than historic average. In the cumulative graph (Figure 22), the 2001 data (in these plots the red line) appears below the historic curve and outside the 95% confidence interval; an indication that the spring migration began late at this site. The steelhead show a similar pattern (Figure 23) with the run beginning later than historic timing. Also, both graphs show a steep ascending portion that indicates large numbers passing each day during the height of the migration. In both chinook and steelhead this is interrupted by a period where the slope of the curve flattens out. The changes in slope coincide with decreasing numbers of fish passing the dam at a time period of low flows that occurred in the middle of the migration (this was discussed earlier in run-timing portion of document. For comparison see figures 20 and 21). The lowest flows occurred near May 8 coinciding with the change in slope of the cumulative curves.

Figure 22. Cumulative passage index graph for yearling spring/summer chinook at Lower Granite Dam.

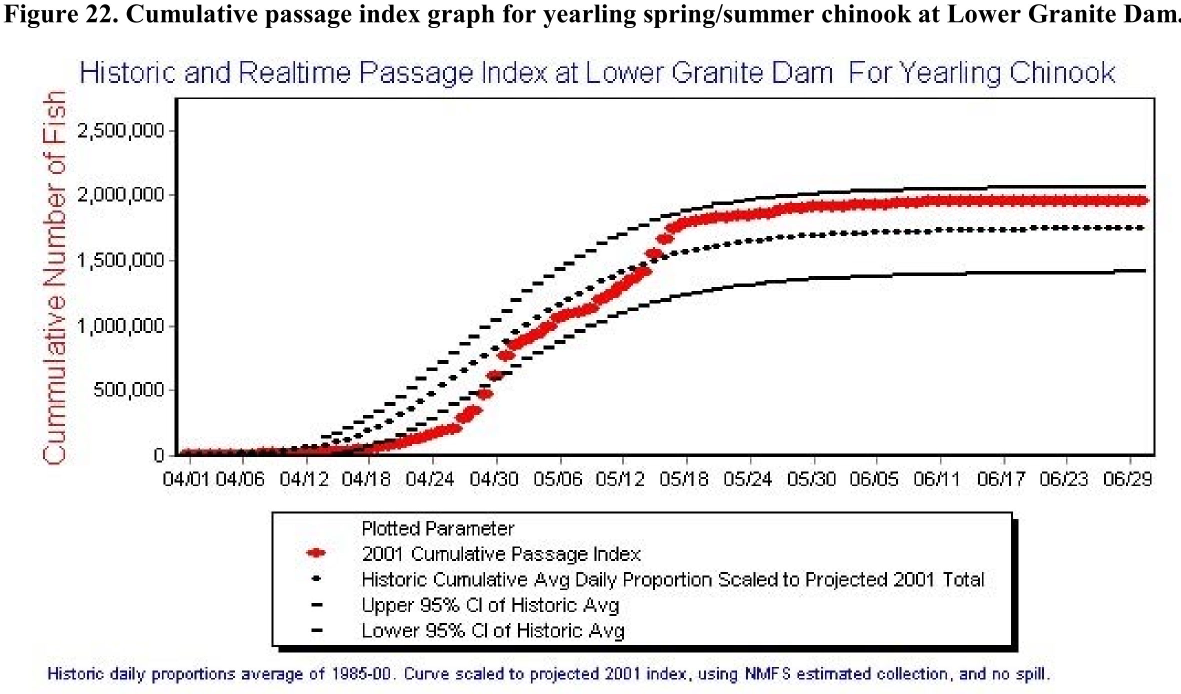
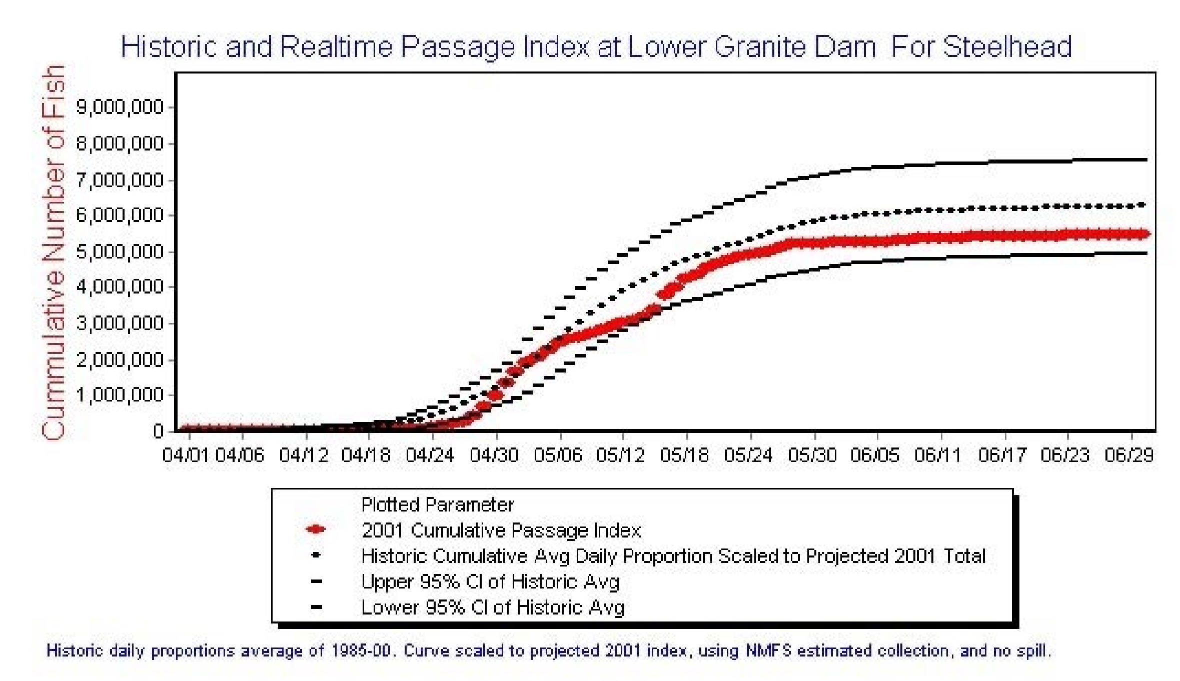


Figure 23. Cumulative passage index graph for steelhead at Lower Granite Dam.



The timing of passage for spring migrants at McNary was more delayed compared to the average historic dates for yearling chinook (Table 4). The chinook run began 18 days later than the historic average as fish appeared to be held up by low flows. Daily average flows averaged 107 kcfs at McNary in April of 2001 and 123 kcfs in May compared to 252 kcfs in April of 2000 and 256 in May. The delayed timing of the yearling chinook outmigration shows up quite distinctly in the cumulative passage plot (Figure 26). A spike in flows over 150 kcfs around 5/23 coincided with increased numbers of chinook passing the project (Figure 24). The

Table 4. Migration Timing of yearling spring/summer chinook at McNary Dam.

	10% Passage	50% Passage	90% Passage	Days for mid-80% passage
Avg 1985 to 2000	4/23	5/11	5/27	34
2001	5/11	5/26	6/7	27
Difference	+18	+15	+11	-7

Table 5. Migration Timing of steelhead at McNary Dam.

	10% Passage	50% Passage	90% Passage	Days for mid-80% passage
Avg 1985 to 2000	4/27	5/15	6/1	35
2001	4/27	5/22	6/9	43
Difference	0	+7	+8	+8

Figure 24. Passage timing of yearling chinook versus flows at McNary Dam.

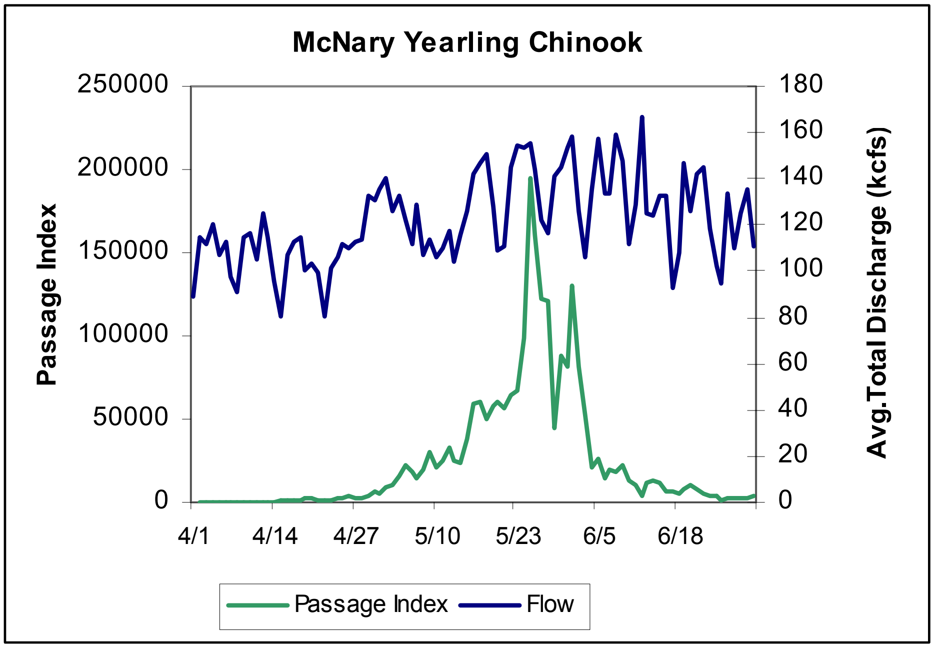
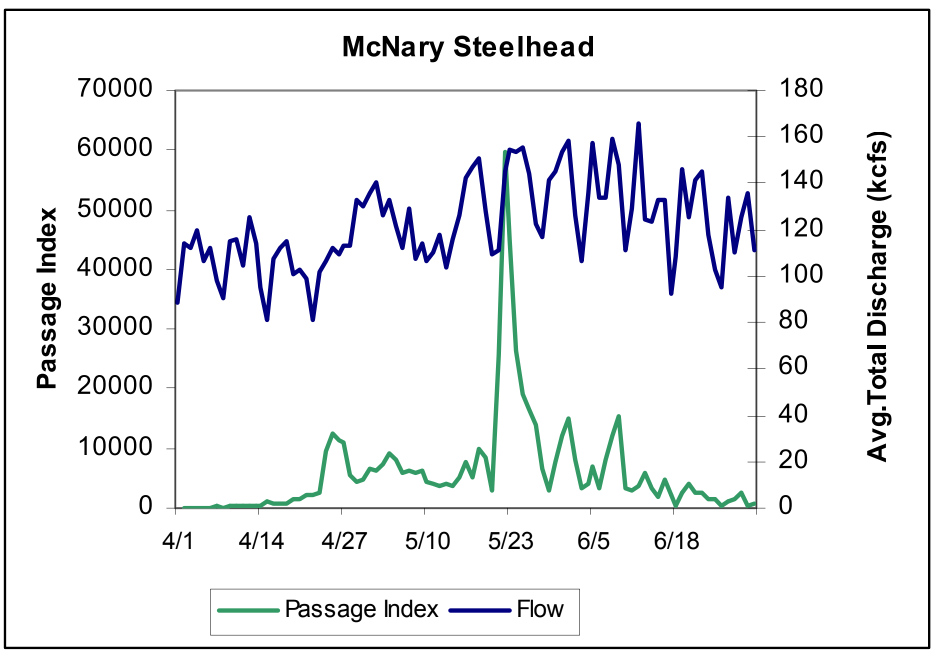


Figure 25. Passage timing of steelhead versus flows at McNary Dam.



high passage numbers (average 106,000/day) continued until the first week of June. But flows declined during this time period and then dropped to 106 kcfs on June 3. From that date on the numbers passing declined. For both steelhead and chinook the timing of the 90% passage was more than a week later than average. But the steelhead migration never reached the numbers we projected for total cumulative passage. Although the 10% passage date was the same as historic dates, the 50% and 90% passage dates were later than historic averages, indicating that the run was more protracted than historic average. Considering travel times we calculated for steelhead in the lower Columbia it is likely that this extended passage timing was due to slower rates of migration.

Figure 26. Cumulative passage index graph for yearling chinook at McNary Dam.

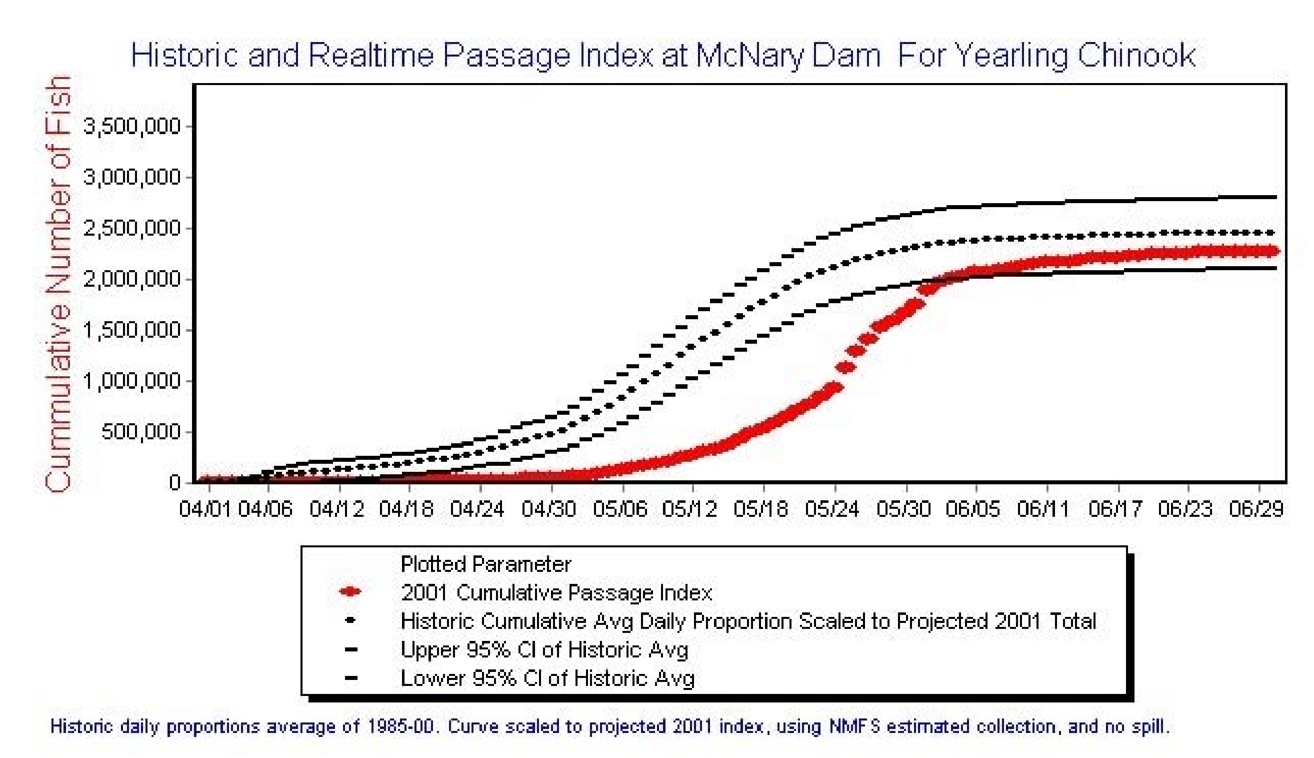
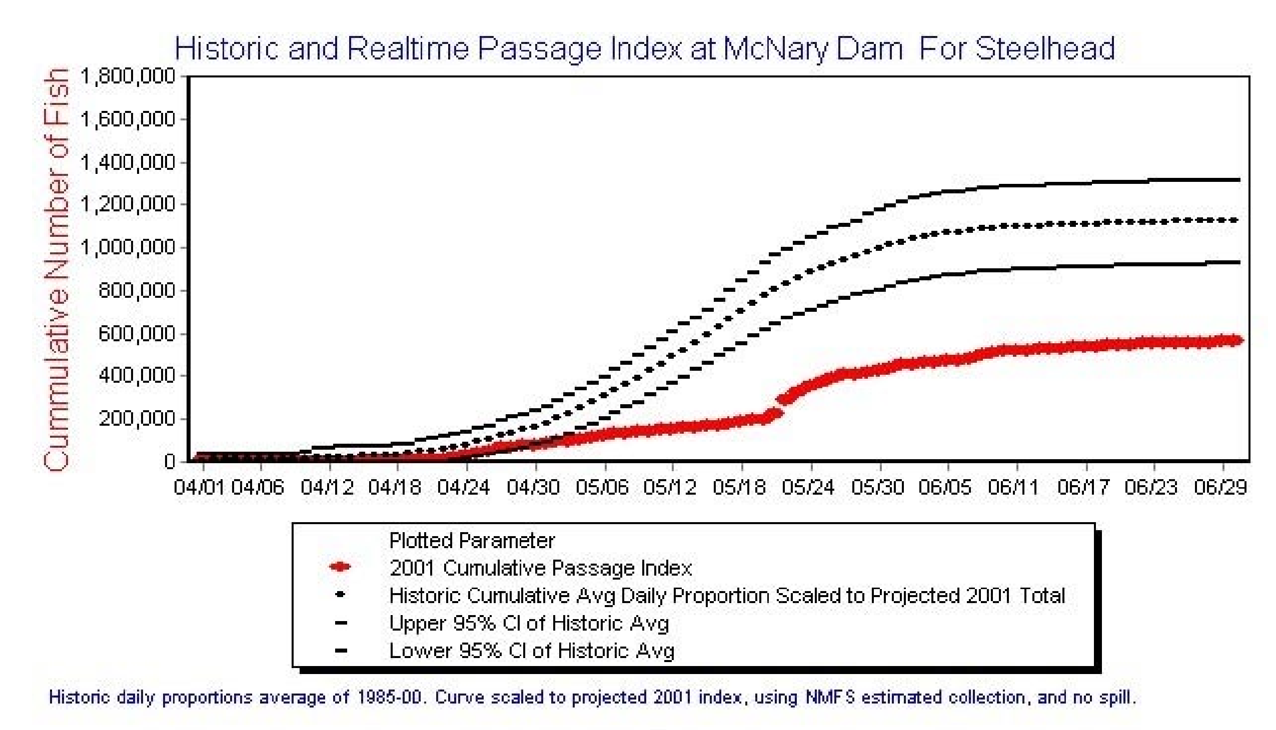


Figure 27. Cumulative passage index graph for steelhead at McNary Dam.



At Bonneville the Spring migration was later than historic passage (Tables 6 and 7). For both yearling chinook and steelhead the 10% passage date was 6 days later than average, and the 90% passage date was 10 d later. The lateness of passage timing at Bonneville Dam not surprising given the late timing of the migration at up-river projects. Also, this late timing may be explained in part, by the doubling of average travel times in 2001 for both chinook and steelhead versus historic travel times in the reach from McNary Dam to Bonneville Dam.

Table 6. Migration Timing of yearling spring/summer chinook at Bonneville Dam.

	10% Passage	50% Passage	90% Passage	Days for mid-80% passage
Avg 1985 to 2000	4/20	5/6	5/27	37
2001	4/26	5/19	6/6	41
Difference	+6	+13	+10	+4

Table 7. Migration Timing of steelhead at Bonneville Dam.

	10% Passage	50% Passage	90% Passage	Days for mid-80% passage
Avg 1985 to 2000	4/28	5/17	5/31	33
2001	5/4	5/19	6/10	37
Difference	+6	+2	+10	+4

While it is clear low flow contributed to increase travel times, flows in the lower Columbia also fluctuated widely over short periods of time. For example flows went from 162 on 5/2 to 109 on 5/10, then to 180 on 5/18 then down to 125 on 5/20 and back to 170 on 5/23; these fluctuations represent a change of 30 to 40% in total river flow. While these sorts of fluctuations might be expected to occur throughout the season, over such a short time period, it is questionable what effects these might have on migrating smolts. It is evident from weekly peaks in passage indices that steelhead were more affected by this type of flow fluctuation than chinook (compare Figure 28 to Figure 29).

Figure 28. Passage timing of yearling chinook versus flows at Bonneville Dam.

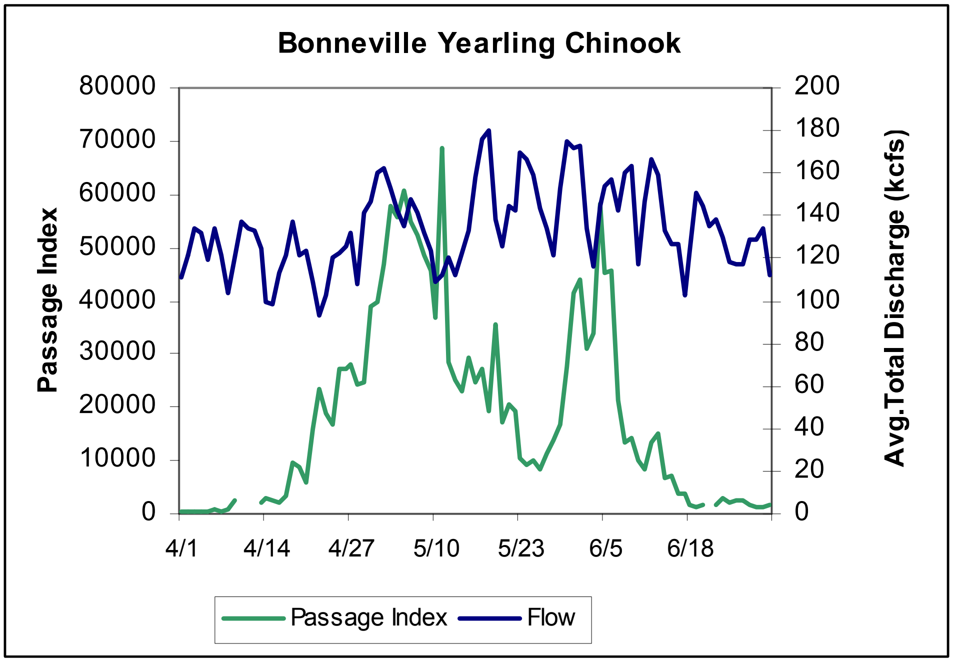


Figure 29. Passage timing of steelhead versus flows at Bonneville Dam.

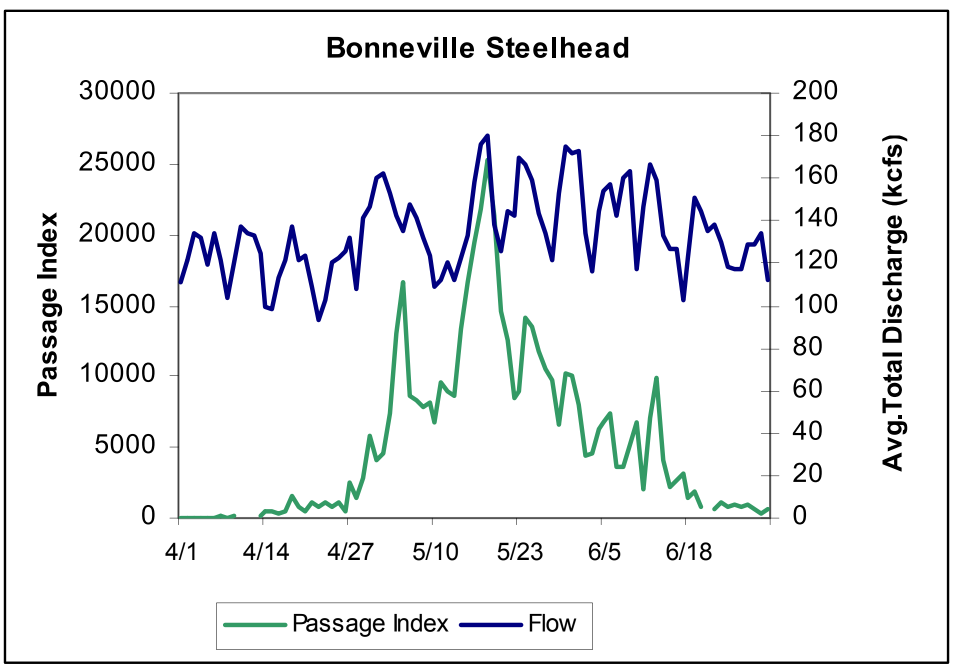


Figure 30. Cumulative passage index graph for yearling chinook at Bonneville Dam.

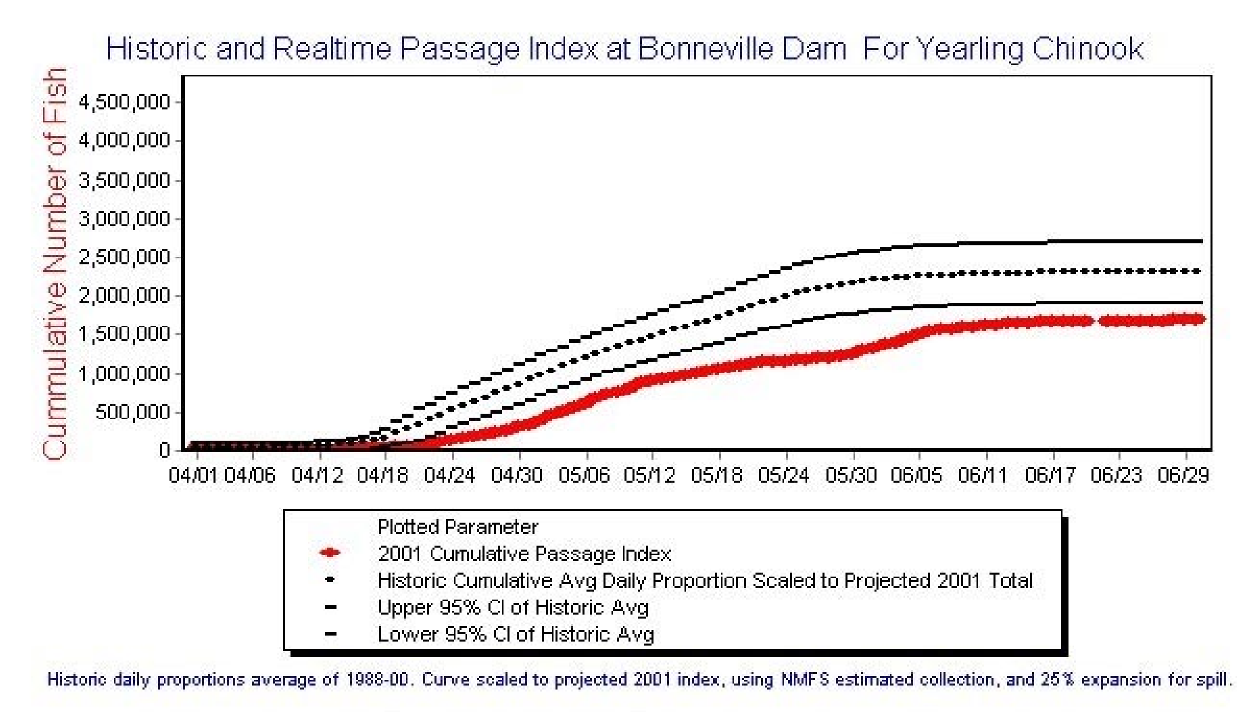
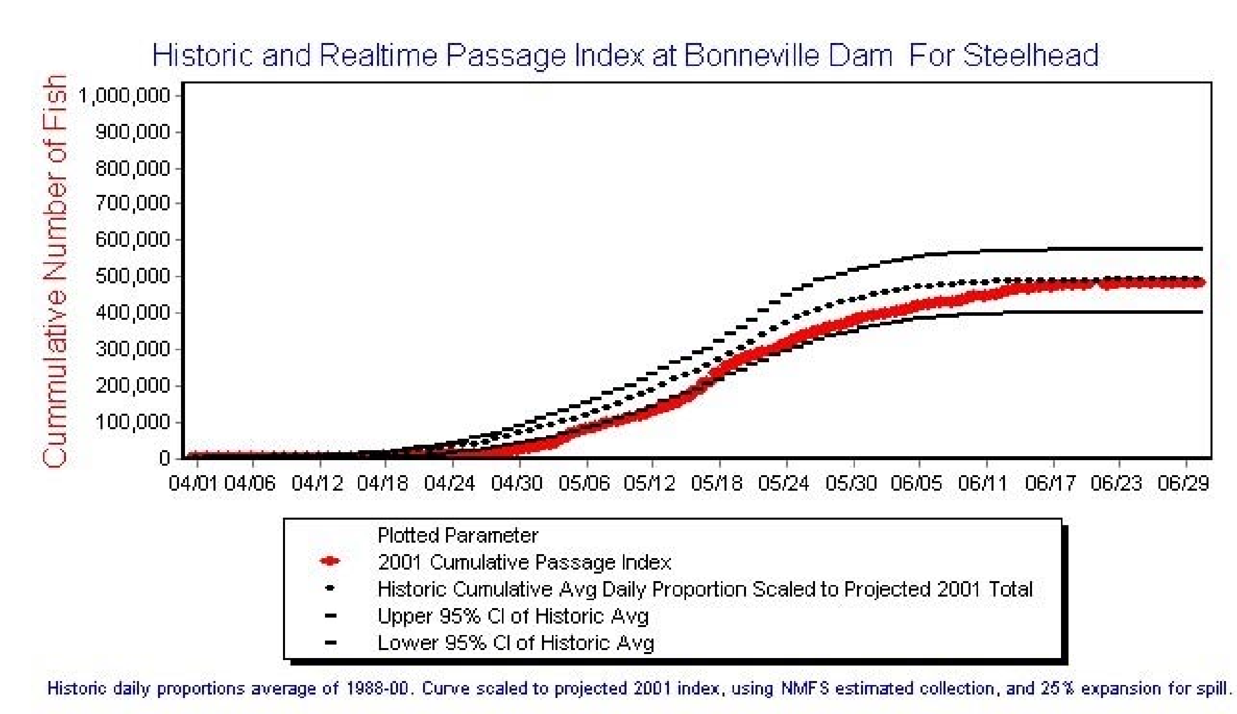


Figure 31. Cumulative passage index graph for yearling chinook at Bonneville Dam.



The mid-Columbia out-migration was shaped by the cyclic peaking of flows that followed the artificial weekly cycle of power needs. Flows out of Grand Coulee followed a weekly pattern, with low flows on Saturday and Sunday, and higher flows Monday through Friday. At Rock Island Dam passage timing of yearling chinook was earlier than historic 10%-90% passage dates.

Table 8. Migration Timing of yearling spring/summer chinook at Rock Island Dam.

	10% Passage	50% Passage	90% Passage	Days for mid-80% passage
Avg 1985 to 2000	4/23	5/12	6/1	39
2001	4/20	5/5	5/30	40
Difference	-3	-7	-2	+1

Table 9. Migration Timing of steelhead at Rock Island Dam.

	10% Passage	50% Passage	90% Passage	Days for mid-80% passage
Avg 1985 to 2000	5/2	5/15	6/1	30
2001	5/11	5/26	6/16	36
Difference	+9	+11	+15	+6

But in the case of yearling chinook the run never seemed to get started despite the sudden spike in the passage index of 867 on 4/20 that coincided with flows that had risen from 35 kcfs on 4/15 to 75 on 4/17 (Figure 32). The higher flows lasted only until 4/20; on 4/21 flows dropped to 43 kcfs and the passage index also began dropping reaching a nadir of 85 on 4/24. Again flows pushed upward cycling up to a high of 77 on 4/24 again fish passage responded and the index reached another peak of 295 on 4/26. This cycling of flow and passage index peaks occurred several times during the spring (Figures 32 and 33). Steelhead passage indices showed similar, but more pronounced weekly spikes during the peak of their migration past Rock Island Dam (Figure 33).

Figure 32. Passage timing of yearling chinook versus flows at Rock Island Dam.

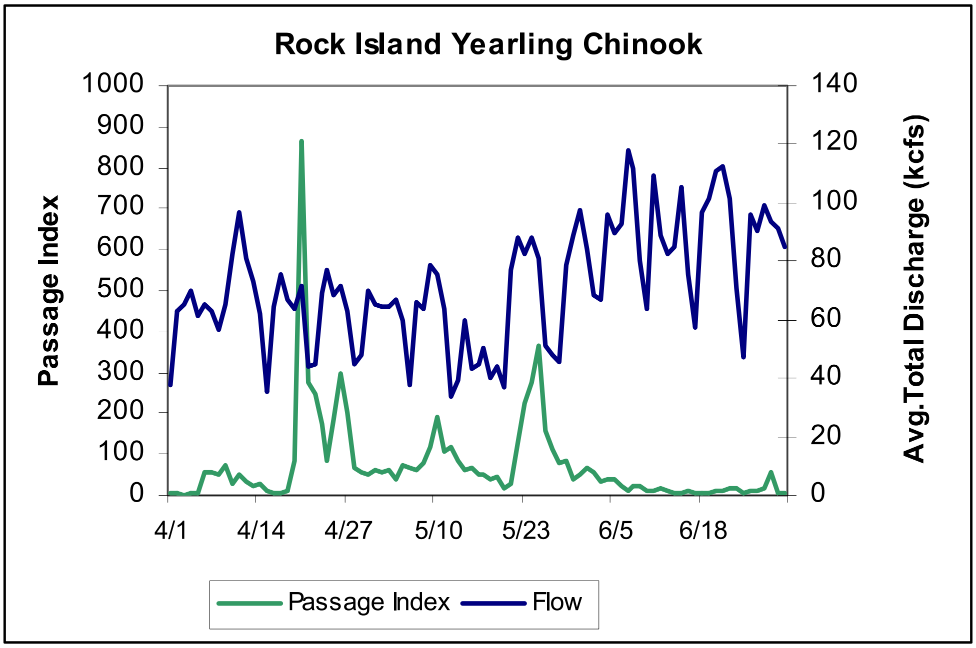
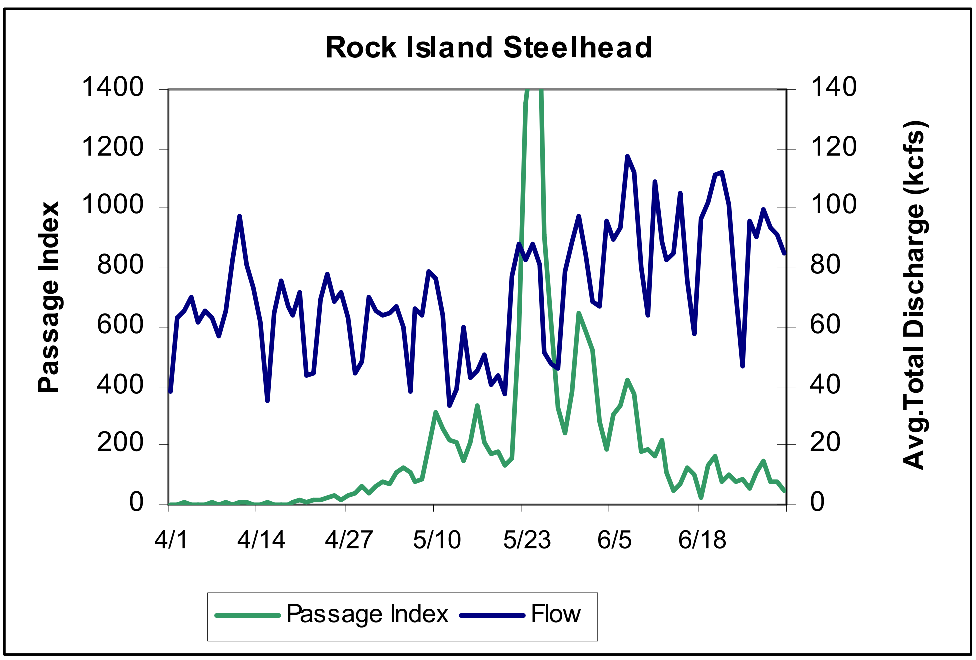


Figure 33. Passage timing of steelhead versus flows at Rock Island Dam.



Conclusions

Near record low flows produced poor migration conditions for juvenile salmonids this spring. NMFS flow targets were never met and the spill program was implemented at a fraction of BiOp levels. The combination of low spill and low flows resulted in very poor survivals and travel times for juvenile migrants.

Survival estimates for the reach from Lower Granite Dam to McNary Dam were the lowest since estimation using PIT-tags was begun, in 1993. Travel times for chinook and steelhead were longer than most historic values for the Snake River; and in the lower Columbia travel times doubled the historic average.