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MEMORANDUM FOR: F/NWR5 – Ritchie Graves

FROM: F/NWC3 – Scott Hecht

SUBJECT: Preliminary survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2024

This memorandum summarizes conditions in the Snake and Columbia Rivers and preliminary estimates of survival of PIT-tagged juvenile salmonids passing through reservoirs and dams during the 2024 spring outmigration. We also provide preliminary estimates of the proportion of Snake River smolts that were collected at Snake River dams and transported in 2024. Our complete detailed analyses and report for the spring migration will follow this memo at a later date. As in past years, possible revisions to the PIT-tag database could result in differences in estimates of survival, likely no more than 3% or 4%. In particular, we will revise estimates when data becomes available from PIT-tag recoveries from estuary bird colonies in fall 2024.

Summary of Research

The tagging program at Lower Granite Dam operated at normal capacity in 2024. A total of 5,749 wild yearling Chinook, 6,390 wild steelhead, and 19,454 hatchery steelhead were tagged for release into the tailrace of Lower Granite Dam. In addition, NOAA Fisheries tagged fish as juveniles in tributaries upstream of Lower Granite Dam. The Columbia River estuary trawl operated as normal in 2024, with both the traditional open cod-end net trawl and the flexible hose trawl detection systems being operated.

Survival estimates provided in this memorandum were derived from data from fish PIT tagged by or for NOAA Fisheries, as described above, along with fish PIT tagged by other agencies within the Columbia River Basin. For technical reasons, the statistical

model for survival estimation can produce estimates that exceed 100%. When this occurs, we report the actual estimate, but for practical purposes these estimates should be interpreted as representing true survival probabilities that are less than or equal to 100%.

Detection data for survival estimation are provided by PIT-tagged fish that remain in the river; fish that are transported provide data up until their transportation site. Estimates are assumed to apply to non-tagged fish that remain in the river in the run at large. We do not present estimates that integrate survival estimates for in-river and transported fish.

We have estimated survival probabilities for migrating PIT-tagged salmonids since 1993. In this memo, we compare 2024 estimates in various river segments to averages over periods of years. Estimates are not available for every reach in every year. Unless otherwise noted, when we refer to a long-term average for a particular river segment, the average is across all years for which estimates are available.

We performed statistical tests to compare pairs of survival estimates between years or stocks or to compare an estimate to its estimated long-term mean. For each of these comparisons, we calculated the difference between survival estimates and used the estimated variances of the estimates to calculate a variance of the difference. Resulting variances were then used to calculate z-statistics, which we compared to a standard normal distribution to obtain two-sided p-values. We reported p-values for differences that were statistically significant at the $\alpha = 0.05$ level.

Considerably fewer wild smolts were tagged at Lower Granite in 2024 than in years prior to 2020, for both Chinook and steelhead (Table 1). Increasing spill levels at Lower Granite also resulted in a reduction in the number of fish that entered the juvenile bypass system to be detected. Moreover, the spill levels maintained in 2024 resulted in more fish passing via spillbays that are not monitored for PIT tags. The number of smolts detected in the bypass system was the second lowest on record, and the number detected in the spillway was the lowest since spillway detection began in 2020.

As a result of these low detection and tagging rates, the combined sample size of fish available for survival estimation

from Lower Granite Dam was well below average in 2024 for both hatchery and wild stocks of Chinook and steelhead (Table 1).

An even more consequential limiting factor for survival estimation in 2024 was low detection probabilities at dams downstream of Lower Granite Dam. A combination of high rates of spill with low flow resulted in extremely low rates of bypass-system passage, which equate to low probabilities of detection. Detection rates in 2024 were close to the lowest on record at nearly all dams (Figure 1). Also, as described above, the detection rate also dropped at Lower Granite dam relative to 2020-2023.

Low detection rates resulted in imprecise survival estimates for most reaches. They also necessitated use of different methodology for survival estimates between McNary Dam and Bonneville Dam than we used through 2019. Previously, our method for estimates in the lower Columbia River was to create weekly cohorts of fish detected at McNary Dam. However, in the last four years, too few fish were detected at McNary Dam for that method. Instead, the biweekly cohorts of fish detected or tagged at Lower Granite Dam which were used for survival estimation in the Snake River were also used in the lower Columbia.

To estimate survival through reaches that terminate at Bonneville Dam requires data from smolts detected after they pass Bonneville Dam ("post-Bonneville" data). For years through 2019, our preferred source of such data was the Columbia River estuary trawl. However, in 2020 the trawl was not operated, and we used alternate data sources, including both sites where live fish were detected and recoveries of tags deposited in various sites by predaceous birds. In 2021 the trawl resumed, and since then we have used trawl data in combination with the additional sources.

At this time in 2024, available sources of post-Bonneville data are the estuary trawl (both matrix trawl and towed flexible antenna), detections from a number of automated detector systems installed at Pile Dikes 5, 6, 7, and 8, and detections of fish that ascend the adult fish ladders at Bonneville Dam not long after passing the dam in the downstream direction. This last category is almost all Chinook salmon; precocious males that are known as "mini-jacks."

In the upcoming months, various avian colonies in the Columbia basin will be surveyed for PIT tags and the records of scanned

tags deposited on the colonies will be uploaded to the PTAGIS database. For our 2024 final report we will use data from estuary (post-Bonneville) avian sites for survival estimation. We continue to evaluate the use of data from interior avian sites (upstream of Bonneville Dam), and may use those data if doing so improves the quality of estimates. Data from avian recoveries was not available in time for use for this memo.

The automated PIT-tag detectors on pile dikes are an area of active research and expansion. The detector arrays on Pile Dikes 5 and 6 were expanded in 2024 relative to previous years, and the detector on Pile Dike 8 was relocated to a nearby structure as a trial.

As a whole, the pile dike detection systems were very successful in 2024. Among stocks included in this memo, a total of 4,548 unique juvenile spring/summer Chinook and 1,600 juvenile steelhead were detected across all four pile dikes during the 2024 migration season, with the vast majority detected at pile dikes 5, 6, and 8. The pile dikes actually detected more Chinook smolts in total than were detected by the estuary trawl, and pile dike detections comprised approximately 47% and 27% of all detection information currently available for Chinook and steelhead that passed Bonneville Dam, respectively.

PIT-tagged yearling Chinook salmon have been released every year from 1993 through 2024 from each of seven Snake River Basin hatcheries Dworshak, Kooskia, Lookingglass/Imnaha Weir, Rapid River, McCall/Knox Bridge, Pahsimeroi (except 1996), and Sawtooth. Following hatchery practices instituted at these "index" hatcheries for the 1998 migration season, the annual mean estimated survival from release to Lower Granite Dam increased over that observed in 1993-1997, and has remained relatively stable ever since (Figure 2, Table 2). Mean survival in 2024 was 65.3%, which was very near the 2023 mean of 65.6% and the long-term mean (1998-2024) of 65.1%. Estimated survival from release to Lower Granite Dam was the highest on record for fish from Kooskia hatchery, but the lowest on record for fish from Lookingglass hatchery.

Downstream of Lower Granite Dam, mean estimated survival for Snake River yearling Chinook salmon (hatchery and wild combined) in 2024 was above average in the Lower Granite to Little Goose and Little Goose to Lower Monumental reaches but below average in the Lower Monumental to McNary reach (Table 3, Figure 3).

Estimated survival was below average in the McNary to John Day reach and above average in the John Day to Bonneville reach. However, most of these estimates were imprecise (Table 3, Figure 4).

Estimated survival was moderately below average for both the longer reach from Lower Granite to McNary and the combined reach from Lower Granite to Bonneville (Table 4). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam to McNary Dam in 2024 was 67.8% (95% CI: 64.5-71.1%). Mean estimated survival from McNary Dam to Bonneville Dam was 67.0% (54.8-79.2%). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam to Bonneville Dam was 46.0% (38.0-54.0%).

Estimated survival for hatchery and wild yearling Chinook salmon in the Lower Granite project (head of reservoir to tailrace) was 96.2% (95% CI: 76.2-116.2%), based on fish PIT tagged at and released from the Snake River trap. This estimate is above the long-term mean of 91.9% and is one of only two estimates above the long-term mean for this reach since 2018 (Table 3).

The combined yearling Chinook salmon survival estimate from the Snake River trap to Bonneville Dam tailrace was 44.3% (95% CI: 32.2-56.3%), which was moderately below the long-term mean of 48.1%, though the difference was not statistically significant (Table 4, $P = 0.53$).

For wild Snake River yearling Chinook, mean estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace was 66.0% (95% CI: 57.2-74.8%), and from McNary Dam tailrace to Bonneville Dam tailrace was 48.2% (36.4-60.0%). The survival estimate for the longer reach from Lower Granite tailrace to Bonneville tailrace was 31.8% (25.1-38.5%). This was far below the long-term mean of 46.8% and the difference was statistically significant ($P < 0.01$).

The number of Chinook tagged at the Snake River smolt trap has been consistently low in recent years. In 2024, the sample size of wild Chinook tagged at the Snake River smolt trap was only 254 fish in total. We estimated that survival from the Snake River trap to Lower Granite Dam tailrace for these fish was 100.8% (95% CI: 57.2-159.2%). These estimates resulted in a survival estimate for wild Chinook from the Snake River trap to Bonneville Dam tailrace of 34.4% (16.7-52.1%), which was well below the long-term mean of 44.1% but not statistically different from it

due to the imprecision of the estimate (P = 0.28). Both low detection rates and the small sample size of smolts tagged at the trap contributed to the poor precision of these estimates.

For Snake River steelhead (hatchery and wild combined), mean estimated survival in 2024 was close to average in the Lower Granite to Little Goose reach and above average in the two remaining component reaches of the Snake River, though the precision of these estimates was extremely poor (Table 5, Figure 3). Estimated survival was well below average in both the McNary to John Day and John Day to Bonneville reaches, though once again both estimates were imprecise (Table 5, Figure 4).

These estimates resulted in an above-average estimate of survival for the longer Lower Granite to McNary reach, but a below average estimate for the McNary to Bonneville reach. The estimate for the overall Lower Granite to Bonneville reach was below average (Table 6). Mean estimated survival for steelhead from Lower Granite Dam to McNary Dam in 2024 was 81.9% (95% CI: 66.8-97.0%). Mean estimated survival from McNary Dam to Bonneville Dam was 55.0% (45.2-64.8%). Mean estimated survival for steelhead from Lower Granite Dam to Bonneville Dam was 43.5% (36.1-51.0%), which was below the long-term mean (1997-2024) of 49.6%. While this estimate was the second lowest estimate for this reach since 2007, it was not significantly different from the long-term mean due to the poor precision of the estimate (P = 0.2).

Estimated survival for hatchery and wild steelhead in the Lower Granite project (head of reservoir to tailrace) was 107.8% (95% CI: 86.8-128.7%) in 2024, based on fish PIT tagged at and released from the Snake River trap. This estimate was above the long-term mean of 95.0%, but the estimate was very imprecise. The overall steelhead survival estimate from the Snake River trap to Bonneville Dam tailrace was 46.9% (34.7-59.1%), which was very close to the long-term mean of 46.8% (Table 6).

For wild Snake River steelhead, mean estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace was well above average at 89.6% (95% CI: 41.2-138.0%), though the estimate was not statistically different from the long-term mean of 65.8% due to the extremely poor precision of the 2024 estimate (P = 0.32). Mean survival from McNary Dam tailrace to Bonneville Dam tailrace was estimated at 32.3% (13.3-51.3%), which was far below the long-term mean of 63.8% and the difference was statistically significant (P < 0.01).

Estimated survival for wild steelhead from Lower Granite Dam tailrace to Bonneville Dam tailrace was 29.0% (95% CI: 22.1-35.9%), which was far below the long-term mean of 42.8% and the difference was statistically significant ($P < 0.01$). The survival estimate from the Snake River trap to Lower Granite Dam tailrace was 91.3% (39.4-143.2%) in 2024, which was below the long-term mean of 94.8% but extremely imprecise. These estimates resulted in a survival estimate from the Snake River trap to Bonneville tailrace of 26.5% (10.2-42.8%), which was far below the long-term mean of 41.6%, but the difference was not statistically significant due to the poor precision of the estimate ($P = 0.07$).

For PIT-tagged hatchery yearling Chinook salmon originating from the upper Columbia River in 2024, estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 71.5% (95% CI: 60.7-84.3%; Table 7), which was below the long-term mean of 79.4%.

For PIT-tagged hatchery steelhead originating from the upper Columbia River in 2024, estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 62.9% (95% CI: 46.7-84.7%; Table 7). This estimate was well below the long-term mean of 76.2%, but the difference was not statistically significant due to the poor precision of the 2024 estimate ($P = 0.2$).

Estimated survival in 2024 of Snake River sockeye salmon (hatchery and wild combined) from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam was 27.9% (95% CI: 23.3-33.5%; Table 8). This estimate was well below the long-term mean of 40.4% and the difference was statistically significant ($P = 0.01$).

Due to the cessation of tagging at Rock Island Dam, we have shifted to reporting survival from the lower Wenatchee River screw trap for upper Columbia River sockeye (Table 8). Estimated survival in 2024 of Columbia River sockeye salmon (hatchery and wild combined) from the lower Wenatchee River screw trap to the tailrace of Bonneville Dam was 12.2% (5.7-26.0%; Table 8). This estimate was well below the long-term mean of 27.7% and the difference was statistically significant despite the poor precision of the estimate ($P = 0.04$).

Our preliminary estimates for 2024 of the percentage transported of non-tagged wild and hatchery spring-summer Chinook salmon

smolts from the Snake River Basin are 6.4% and 8.4%, respectively. For steelhead, the estimates are 5.5% and 6.2% for wild and hatchery smolts, respectively (Figure 5). These estimates represent the percentage of smolts that arrived at Lower Granite Dam that were subsequently transported, either from Lower Granite Dam or downstream from Little Goose or Lower Monumental Dam. Estimated percentages transported in 2024 were the lowest we have ever estimated for the "PIT-tag era" (since 1993).

Travel times for Chinook were quite short for much of 2024, and in both the first half of April and in the middle of May Chinook travel times were close to the shortest on record. In comparison, steelhead travel times in 2024 were not as notably short. Steelhead travel times were generally close to or slightly shorter than travel times observed in recent low-flow years (Figure 6). There was a noticeable increase in travel time for both species in late May which may be related to especially low flows observed at that time.

Discussion

Spill operations at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams in 2024 were continuous 24-hour spill to the cap of 125% dissolved gas saturation. Spill operations in 2024 at John Day, The Dalles, and Bonneville dams were constrained by structural and power demand limitations but were still as high as allowable within those constraints. These increased spill rates were the primary driver of low detection rates in 2024.

There is much interest in the potential benefits of increased spill to fish survival and travel time through the hydropower system. Unfortunately, the precision of the estimates of these metrics has suffered under the high spill operations due to marked decreases in detections of fish. This makes it difficult to assess whether the new operations provided benefits--or were detrimental for fish--especially when focusing on metrics in shorter river reaches.

Our estimates of survival were generally below average for most stocks in 2024, including combined hatchery and wild groups for both Snake River Chinook and steelhead in the Lower Granite to Bonneville reach. Our estimates of survival for the Lower Granite project (head of reservoir to tailrace) were above average in 2024 for combined hatchery and wild groups of Chinook and steelhead, but survival for the overall reach from the Snake River Trap to Bonneville was still below average for Chinook and only about equal to average for steelhead.

Despite the poor precision of many of our survival estimates, there were some cases where estimates were so far below the mean that the differences were statistically significant. Of note, the estimates were statistically below average for both wild Snake River Chinook and wild Snake River steelhead in the Lower Granite to Bonneville reach, and for both Snake River sockeye in the Lower Granite to Bonneville reach and upper Columbia River sockeye in the Wenatchee Trap to Bonneville reach.

Sample sizes of both wild and hatchery Chinook tagged at the Snake River smolt trap have declined substantially from past years. Only 254 wild Chinook and 162 wild steelhead were tagged at the trap in 2024, which may not be sufficient to represent the overall run of wild smolts.

Environmental conditions in 2024 resulted in a year with flow that was moderately below average and temperatures which were above average. Daily flow values were close to average or slightly above average for most of April, but dipped to below average in May and well below average in late May and early June. There was no large spring freshet in 2024, with only two small spikes in flow around 16 April and 14-19 May (Figure 7).

Mean water temperature at Little Goose Dam during the 2024 migration period was 12.0°C, which was well above the long-term mean (1993-2024) of 11.2°C and was the fourth warmest year in that time period. Daily temperature values were above average for essentially the entire migration season, averaging about one degree warmer than average for most of April but spiking to more than two degrees above average around 18 May. Daily water temperatures then fell to only slightly above average in early June (Figure 7).

Mean daily spill discharge at the Snake River dams during the 2024 migration was 58.9 kcfs, which was far above the 2006-2024 mean of 38.1 kcfs and was the second highest mean spill discharge on record. Daily spill discharge was consistently well above the long-term median for the whole season, and peaked around 16 April and again around 14-20 May, corresponding with peaks in daily flows (Figure 8).

Spill as a percentage of flow at Snake River dams averaged 74.8% in 2024, which was far and away the highest mean spill percent on record and dwarfed the long-term (2006-2024) mean of 42.0%. In 2020-2022 when flexible spill operations were instituted, a daily mean percentage spill of around 60-65% was typical. The move to 24-hour gas cap spill in 2024 resulted in increased spill rates, especially when flows were below average. Since flow was below average for most of the 2024 season, very high spill rates in excess of 75% were maintained through the whole season (Figure 8).

Daily mean percent dissolved gas saturation in 2024 at the Snake River dams was above average for the entire season (Figure 9). Daily levels of dissolved gas ranged between 118% and 120% saturation for most of April and between 120% and 122% for most of May, but briefly spiked to about 123% around 16 April, 14-20 May, and 4-8 June. Hourly values for 3 April through 15 June fluctuated between approximately 106% and 126% (data not shown).

During that time period, hourly dissolved gas percentage exceeded 120% for 75% of the total hours and exceeded 125% for 3% of the total hours at one or more of the three index dams in Figure 9.

Median smolt passage at Lower Granite Dam was early for Chinook salmon and much earlier than average for steelhead in 2024 (Figure 10). There was a substantial spike in Chinook passage in the middle of April, and peak passage for steelhead occurred at the same time. Peak Chinook passage occurred around 1 May, a few days earlier than the average peak timing in past years. In comparison, Steelhead passage was almost complete by 1 May, with only low numbers passing after that date. There was a peak in flow around 16 April which occurred at the same time as the notable peak in smolt passage in mid-April, but there was no similar peak in flow during the same time as the large peak in Chinook passage around 1 May (Figures 7 and 10).

We observed short travel times for juvenile Chinook for most of the 2024 season, particularly in comparison to other recent low-flow years. Flow in 2024 was moderately below average; however, Chinook travel times resembled those seen in high-flow years. Notably, during April of 2024 Chinook travel times were extremely short, among the shortest seen for that time period. In comparison, steelhead travel times were not especially short, and were more or less what would be expected for the intermediate flow conditions seen in 2024. The unusually short travel times observed for Chinook in 2024 may be related to the warmer than average water temperatures seen this spring, especially during April.

Our estimates of juvenile survival were below average for many stocks of salmonids in the Snake and Columbia Rivers in 2024. These below average survival estimates are perhaps not surprising, given that environmental conditions were generally indicative of low survival, including warm temperatures and slightly below-average flows. Survival estimates for wild stocks of Chinook and steelhead were notably further below average than the estimates for their hatchery conspecifics, a pattern which has been observed multiple times in recent years. The primary goal of the current management regime is to restore and rebuild wild stocks, and it may prove valuable to investigate whether the physical, biological, or management regime in the Columbia basin is having differential effects on wild versus hatchery smolts.

In any given year the percentage of a stock that is transported is largely determined by a combination of three factors: (1) migration timing, (2) the starting date of general smolt transportation, and (3) the percentage of smolts that enter the collection system during the general transportation period.

The overall proportion of smolts transported in 2024 was the lowest seen in the history of this project, slightly lower than the previous low in 2021 (Figure 5). Collection for transportation in 2024 began on 24 April at Lower Granite, Little Goose, and Lower Monumental Dams, the same start date as in 2019-2023.

The run in 2024 was substantially earlier than average for both Chinook and steelhead. We estimate that 83.8% of wild and 25.1% of hatchery Chinook salmon, and 42.4% of wild and 54.5% of hatchery steelhead passed prior to the start of transportation. These proportions are much higher than in any of the past five years. This indicates that run timing contributed greatly to reduced transportation rates in 2024, as a much smaller share of the population was potentially available to be transported once the general program began.

In 2024, the proportion of passing smolts collected after the start of transportation was far below average. We estimate that 18.7% of wild and 10.3% of hatchery Chinook and 8.8% of wild and 10.3% of hatchery steelhead that passed during transport operations were collected and transported. These collection rates are essentially tied with the very low rates in 2021 for being the lowest on record. The combination of high passage prior to the start of transport and extremely low collection rates resulted in the extremely low overall transportation rates we estimated for 2024.

Unfortunately for quantity and quality of data, a side effect of increased spill since 2006 has been a large drop in detection rates of smolts at most Snake and Columbia River dams (Figure 1). The exceptionally high spill since 2020 has resulted in exceptionally low detection rates in most years. Detection rates were generally close to the lowest ever in 2024, especially at Lower Monumental and John Day dams.

The addition of a detector in the spillway at Lower Granite Dam offset low detection rates in the juvenile bypass system there: the total numbers of PIT-tagged fish detected at Lower Granite

Dam and known to be alive in the tailrace have been similar to past years, with a moderate drop in 2024 due to increased use of other spillbays. However, detection at downstream dams continues to occur only in juvenile bypass systems (with the exception of the corner collector at Bonneville Dam). Despite otherwise sufficient sample sizes of fish leaving Lower Granite Dam, most survival estimates to downstream dams in 2024 were extremely imprecise. This is especially true for wild stocks, which are of greatest concern.

In addition, low detection rates decrease "resolution" of the information, requiring pooling data into larger temporal groups. For example, two-week groupings were necessary for many survival estimates in 2024, when we prefer to use weekly and daily groups to better conform to the assumptions of the mark-recapture model. Quality of the data for wild stocks was so poor that we were forced to pool all data for the season into a single cohort for wild-only survival estimates.

The PIT tag is currently the primary tool for research and monitoring of Columbia basin salmon. Numerous agencies in the region have invested enormous amounts of resources into PIT tagging and analysis. The informational return on these investments is diminished when actions are taken that decrease detectability. If management priorities result in spill continuing at current levels, then the region would do well to find ways to compensate for the loss of PIT-tag detection in juvenile bypass systems.

The success of the new spillway detector at Lower Granite Dam continues to be very instructive. Because the current management goal is to pass as many juveniles via spill as possible, the spillway is the ideal location for expanded PIT-tag detection. Additionally, the continued success of the pile-dike detection systems is very encouraging. The technology and expertise developed for the pile dike detectors potentially has wide applicability throughout the basin. Similar detection systems could allow for expanded PIT-tag detection at locations such as the head of Lower Granite pool, which would be very valuable for survival estimation.

Increased detection rates will pay dividends on all of the other investments in PIT-tag research within the region, not merely this project. We believe that it should be a high priority to increase detection capabilities at other dams on the Snake and

Columbia rivers, especially McNary Dam and Bonneville Dam. We also believe it would be valuable to emphasize development of new and improving technologies that will boost our abilities to detect PIT-tagged fish at the dams and at new detection sites, especially downstream of Bonneville Dam.

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Table 1. Total number of PIT-tagged hatchery and wild yearling Chinook salmon and juvenile steelhead used for survival probability estimates from Lower Granite Dam, 2010-2024. Fish are categorized by location of detection or tagging. Only smolts returned to the river after detection or tagging are included.

	Smolt numbers at Lower Granite Dam (n)							
	Detected in spillway system		Detected in juvenile bypass system		Tagged in juvenile bypass system		Total	
Year	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
				Yearling Chinook salmon				
2010	-	-	35,402	12,411	47,902	17,008	83,304	29,419
2011	-	-	70,206	17,495	47	16,029	70,253	33,524
2012	-	-	51,282	12,831	46	16,749	51,328	29,580
2013	-	-	43,617	8,550	13	11,773	43,630	20,323
2014	-	-	69,152	15,502	76	17,917	69,228	33,419
2015	-	-	26,210	3,465	33	8,300	26,243	11,765
2016	-	-	87,431	11,964	85	22,145	87,516	34,109
2017	-	-	45,355	8,158	10	14,241	45,365	22,399
2018	-	-	54,989	9,409	0	11,823	54,989	21,232
2019	-	-	38,961	6,376	14	6,349	38,975	12,725
2020	60,290	5,344	14,106	2,295	0	0	74,396	7,639
2021	94,298	6,850	3,768	600	57	1,770	98,123	9,220
2022	81,920	9,088	23,047	3,995	57	6,285	105,024	19,368
2023	56,742	5,712	28,884	5,200	274	6,786	85,900	17,698
2024	44,037	5,180	3,671	1,303	5	5,749	47,713	12,232
Mean	**67,457**	**6,448**	**39,739**	**7,971**	**3,241**	**10,862**	**65,466**	**20,982**
				Steelhead				
2010	-	-	33,171	5,035	16,173	11,991	49,344	17,026
2011	-	-	60,961	5,350	22,011	18,001	82,972	23,351
2012	-	-	45,350	7,438	20,121	20,122	65,471	27,560
2013	-	-	29,420	5,400	17,380	7,457	46,800	12,857
2014	-	-	42,082	6,823	20,593	14,493	62,675	21,316
2015	-	-	14,626	1,578	25,278	17,065	39,904	18,643
2016	-	-	55,467	5,625	17,972	14,774	73,439	20,399
2017	-	-	42,253	3,619	22,049	18,422	64,302	22,041
2018	-	-	47,465	5,699	20,249	15,396	67,714	21,095
2019	-	-	47,919	4,249	20,888	14,758	68,807	19,007
2020	60,090	3,442	9,899	1,161	0	0	69,989	4,603
2021	83,846	7,173	4,756	476	18,120	4,854	106,722	12,503
2022	68,917	3,605	16,294	1,650	21,758	9,350	106,969	14,605
2023	54,613	2,424	26,465	2,052	19,092	13,738	100,170	18,214
2024	34,358	3,387	3,621	428	19,454	6,390	57,433	10,205
Mean	**60,365**	**4,007**	**31,983**	**3,773**	**18,743**	**12,454**	**70,847**	**17,562**

Table 2. Estimated survival and standard error (s.e.) for yearling **Chinook** salmon released at Snake River Basin and Upper Columbia River hatcheries to Lower Granite Dam tailrace (LGR) and McNary Dam tailrace (MCN), 2022 through 2024.

	2022		2023		2024[a]	
Hatchery	Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)
Dworshak	0.911 (0.015)	0.538 (0.084)	0.819 (0.011)	0.500 (0.035)	0.656 (0.020)	0.433 (0.033)
Kooskia	0.748 (0.034)	---	0.806 (0.025)	0.479 (0.096)	0.830 (0.061)	0.508 (0.107)
Lookingglass (Catherine Cr.)	0.530 (0.016)	0.277 (0.050)	0.587 (0.010)	0.530 (0.067)	0.424 (0.019)	0.382 (0.076)
Lookingglass (Grande Ronde)	0.491 (0.046)	---	0.347 (0.028)	0.282 (0.148)	0.472 (0.077)	---
Lookingglass (Imnaha Weir)	0.639 (0.024)	0.432 (0.182)	0.555 (0.009)	0.326 (0.039)	0.480 (0.024)	0.311 (0.041)
Lookingglass (Lostine River)	0.460 (0.042)	---	0.457 (0.015)	0.244 (0.044)	---	---
McCall (Johnson Cr.)	0.611 (0.062)	---	0.539 (0.032)	0.402 (0.181)	0.424 (0.056)	0.283 (0.145)
McCall (Knox Bridge)	0.732 (0.012)	0.448 (0.059)	0.660 (0.006)	0.441 (0.030)	0.686 (0.015)	0.568 (0.052)
Pahsimeroi	0.468 (0.012)	0.357 (0.095)	0.670 (0.052)	0.304 (0.151)	0.639 (0.029)	0.426 (0.054)
Rapid River	0.737 (0.010)	0.553 (0.096)	0.497 (0.005)	0.369 (0.042)	0.722 (0.017)	0.449 (0.031)
Sawtooth	0.706 (0.018)	0.355 (0.083)	0.582 (0.009)	0.400 (0.052)	0.558 (0.025)	0.305 (0.041)
Entiat	---	0.480 (0.078)	---	0.499 (0.066)	---	0.598 (0.127)
Winthrop	---	0.948 (0.460)	---	0.423 (0.066)	---	0.529 (0.119)
Leavenworth	---	0.525 (0.124)	---	0.520 (0.037)	---	0.482 (0.055)

a. Estimates are preliminary and subject to change.

Table 3. Annual weighted means of survival probability estimates for yearling **Chinook** salmon (hatchery and wild combined), 1993–2024. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam. Simple arithmetic means across all available years are given.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.828 (0.013)	0.854 (0.012)	NA	NA	NA	NA	NA	NA
1994	0.935 (0.023)	0.830 (0.009)	0.847 (0.010)	NA	NA	NA	NA	NA
1995	0.905 (0.010)	0.882 (0.004)	0.925 (0.008)	0.876 (0.038)	0.936	NA	NA	NA
1996	0.977 (0.025)	0.926 (0.006)	0.929 (0.011)	0.756 (0.033)	0.870	NA	NA	NA
1997	NA	0.942 (0.018)	0.894 (0.042)	0.798 (0.091)	0.893	NA	NA	NA
1998	0.924 (0.011)	0.991 (0.006)	0.853 (0.009)	0.915 (0.011)	0.957	0.822 (0.033)	NA	NA
1999	0.940 (0.009)	0.949 (0.002)	0.925 (0.004)	0.904 (0.007)	0.951	0.853 (0.027)	0.814 (0.065)	0.902
2000	0.929 (0.014)	0.938 (0.006)	0.887 (0.009)	0.928 (0.016)	0.963	0.898 (0.054)	0.684 (0.128)	0.827
2001	0.954 (0.015)	0.945 (0.004)	0.830 (0.006)	0.708 (0.007)	0.841	0.758 (0.024)	0.645 (0.034)	0.803
2002	0.953 (0.022)	0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.915	0.907 (0.014)	0.840 (0.079)	0.917
2003	0.993 (0.023)	0.946 (0.005)	0.916 (0.011)	0.904 (0.017)	0.951	0.893 (0.017)	0.818 (0.036)	0.904
2004	0.893 (0.009)	0.923 (0.004)	0.875 (0.012)	0.818 (0.018)	0.904	0.809 (0.028)	0.735 (0.092)	0.857
2005	0.919 (0.015)	0.919 (0.003)	0.886 (0.006)	0.903 (0.010)	0.950	0.772 (0.029)	1.028 (0.132)	1.014
2006	0.952 (0.011)	0.923 (0.003)	0.934 (0.004)	0.887 (0.008)	0.942	0.881 (0.020)	0.944 (0.030)	0.972
2007	0.943 (0.028)	0.938 (0.006)	0.957 (0.010)	0.876 (0.012)	0.936	0.920 (0.016)	0.824 (0.043)	0.908
2008	0.992 (0.018)	0.939 (0.006)	0.950 (0.011)	0.878 (0.016)	0.937	1.073 (0.058)	0.558 (0.082)	0.750
2009	0.958 (0.010)	0.940 (0.006)	0.982 (0.009)	0.855 (0.011)	0.925	0.866 (0.042)	0.821 (0.043)	0.906
2010	0.968 (0.040)	0.962 (0.011)	0.973 (0.019)	0.851 (0.017)	0.922	0.947 (0.021)	0.780 (0.039)	0.883
2011	0.943 (0.009)	0.919 (0.007)	0.966 (0.007)	0.845 (0.012)	0.919	0.893 (0.026)	0.766 (0.080)	0.875
2012	0.928 (0.012)	0.907 (0.009)	0.939 (0.010)	0.937 (0.016)	0.968	0.915 (0.023)	0.866 (0.058)	0.931
2013	0.845 (0.031)	0.922 (0.012)	0.983 (0.014)	0.904 (0.022)	0.951	0.931 (0.054)	0.823 (0.036)	0.907
2014	0.905 (0.015)	0.947 (0.005)	0.919 (0.010)	0.894 (0.017)	0.946	0.912 (0.053)	0.752 (0.104)	0.867
2015	0.909 (0.103)	0.928 (0.031)	0.960 (0.057)	0.785 (0.032)	0.886	0.724 (0.069)	0.937 (0.160)	0.968
2016	0.936 (0.015)	0.956 (0.006)	0.912 (0.010)	0.872 (0.013)	0.934	0.796 (0.039)	0.871 (0.047)	0.933

Table 3. Continued.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
2017	NA	0.916 (0.009)	0.908 (0.013)	0.912 (0.024)	0.956	0.720 (0.041)	0.871 (0.200)	0.933
2018	0.880 (0.022)	0.942 (0.013)	0.917 (0.019)	0.877 (0.036)	0.936	0.770 (0.074)	0.743 (0.100)	0.862
2019	0.785 (0.027)	0.874 (0.015)	0.953 (0.027)	0.792 (0.032)	0.890	1.015 (0.088)	0.798 (0.111)	0.893
2020	0.848 (0.058)	0.811 (0.039)	1.171 (0.128)	0.847 (0.095)	0.920	0.862 (0.039)[b]	0.865 (0.060)[b]	0.930[b]
2021	0.867 (0.108)	0.806 (0.067)	1.136 (0.127)	0.854 (0.146)	0.924	0.960 (0.077)[b]	0.796 (0.096)[b]	0.892[b]
2022	0.963 (0.072)	0.823 (0.035)	1.014 (0.059)	0.869 (0.138)	0.932	0.806 (0.087)[b]	0.892 (0.077)[b]	0.944[b]
2023	0.876 (0.037)	0.921 (0.013)	0.995 (0.048)	0.701 (0.034)	0.837	0.894 (0.079)[b]	0.852 (0.082)[b]	0.923[b]
2024[a]	0.962 (0.102)	0.950 (0.037)	1.042 (0.222)	0.789 (0.148)	0.888	0.674 (0.107)[b]	0.941 (0.047)[b]	0.970[b]
Mean	**0.920 (0.009)**	**0.916 (0.008)**	**0.947 (0.013)**	**0.852 (0.011)**	**0.923 (0.006)**	**0.862 (0.018)**	**0.818 (0.019)**	**0.903 (0.011)**

a. Estimates are preliminary and subject to change.
b. Estimates for 2020-2024 in the reaches between McNary Dam and Bonneville Dam used a different method than in prior years.

Table 4. Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River yearling **Chinook** salmon (hatchery and wild combined), 1993–2024. Standard errors in parentheses. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; MCN–McNary Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR-MCN	MCN-BON	LGR–BON	Trap–BON
1993	0.828 (0.013)	NA	NA	NA	NA
1994	0.935 (0.023)	NA	NA	NA	NA
1995	0.905 (0.010)	0.715 (0.031)	NA	NA	NA
1996	0.977 (0.025)	0.648 (0.026)	NA	NA	NA
1997	NA	0.653 (0.072)	NA	NA	NA
1998	0.924 (0.011)	0.770 (0.009)	NA	NA	NA
1999	0.940 (0.009)	0.792 (0.006)	0.704 (0.058)	0.557 (0.046)	0.524 (0.043)
2000	0.929 (0.014)	0.760 (0.012)	0.640 (0.122)	0.486 (0.093)	0.452 (0.087)
2001	0.954 (0.015)	0.556 (0.009)	0.501 (0.027)	0.279 (0.016)	0.266 (0.016)
2002	0.953 (0.022)	0.757 (0.009)	0.763 (0.079)	0.578 (0.060)	0.551 (0.059)
2003	0.993 (0.023)	0.731 (0.010)	0.728 (0.030)	0.532 (0.023)	0.528 (0.026)
2004	0.893 (0.009)	0.666 (0.011)	0.594 (0.074)	0.395 (0.050)	0.353 (0.045)
2005	0.919 (0.015)	0.732 (0.009)	0.788 (0.093)	0.577 (0.068)	0.530 (0.063)
2006	0.952 (0.011)	0.764 (0.007)	0.842 (0.021)	0.643 (0.017)	0.612 (0.018)
2007	0.943 (0.028)	0.783 (0.006)	0.763 (0.044)	0.597 (0.035)	0.563 (0.037)
2008	0.992 (0.018)	0.782 (0.011)	0.594 (0.066)	0.465 (0.052)	0.460 (0.052)
2009	0.958 (0.010)	0.787 (0.007)	0.705 (0.031)	0.555 (0.025)	0.531 (0.025)
2010	0.968 (0.040)	0.772 (0.012)	0.738 (0.039)	0.569 (0.032)	0.551 (0.038)
2011	0.943 (0.009)	0.746 (0.010)	0.687 (0.065)	0.513 (0.049)	0.483 (0.046)
2012	0.928 (0.012)	0.790 (0.016)	0.802 (0.051)	0.634 (0.042)	0.588 (0.040)
2013	0.845 (0.031)	0.781 (0.016)	0.796 (0.064)	0.622 (0.052)	0.525 (0.048)
2014	0.905 (0.015)	0.768 (0.015)	0.715 (0.107)	0.549 (0.083)	0.497 (0.075)
2015	0.909 (0.103)	0.727 (0.033)	0.629 (0.043)	0.457 (0.038)	0.415 (0.058)
2016	0.936 (0.015)	0.752 (0.011)	0.672 (0.060)	0.505 (0.046)	0.473 (0.043)

Table 4. Continued.

Year	Trap–LGR	LGR-MCN	MCN-BON	LGR–BON	Trap–BON
2017	NA	0.743 (0.019)	0.643 (0.157)	0.478 (0.117)	NA
2018	0.880 (0.022)	0.733 (0.025)	0.590 (0.045)	0.432 (0.036)	0.381 (0.033)
2019	0.785 (0.027)	0.628 (0.027)	0.825 (0.060)	0.518 (0.044)	0.407 (0.037)
2020	0.848 (0.058)	0.766 (0.018)	0.733 (0.045)[b]	0.563 (0.039)	0.477 (0.046)
2021	0.867 (0.108)	0.730 (0.026)	0.746 (0.112)[b]	0.543 (0.085)	0.471 (0.094)
2022	0.963 (0.072)	0.709 (0.077)	0.689 (0.066)[b]	0.528 (0.022)	0.508 (0.044)
2023	0.876 (0.037)	0.627 (0.024)	0.751 (0.024)[b]	0.483 (0.031)	0.423 (0.033)
2024[a]	0.962 (0.102)	0.678 (0.017)	0.670 (0.062)[b]	0.460 (0.041)	0.443 (0.061)
Mean	**0.920 (0.009)**	**0.729 (0.011)**	**0.704 (0.016)**	**0.520 (0.016)**	**0.481 (0.016)**

a. Estimates are preliminary and subject to change.
b. Estimates for 2020-2024 in the reaches between McNary Dam and Bonneville Dam used a different method than in prior years.

Table 5. Annual weighted means of survival probability estimates for **steelhead** (hatchery and wild combined), 1993–2024. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam. Simple arithmetic means across all available years are given.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.905 (0.006)	NA	NA	NA	NA	NA	NA	NA
1994	0.794 (0.009)	0.844 (0.011)	0.892 (0.011)	NA	NA	NA	NA	NA
1995	0.945 (0.008)	0.899 (0.005)	0.962 (0.011)	0.858 (0.076)	0.926	NA	NA	NA
1996	0.951 (0.015)	0.938 (0.008)	0.951 (0.014)	0.791 (0.052)	0.889	NA	NA	NA
1997	0.964 (0.015)	0.966 (0.006)	0.902 (0.020)	0.834 (0.065)	0.913	NA	NA	NA
1998	0.924 (0.009)	0.930 (0.004)	0.889 (0.006)	0.797 (0.018)	0.893	0.831 (0.031)	0.935 (0.103)	0.967
1999	0.908 (0.011)	0.926 (0.004)	0.915 (0.006)	0.833 (0.011)	0.913	0.920 (0.033)	0.682 (0.039)	0.826
2000	0.964 (0.013)	0.901 (0.006)	0.904 (0.009)	0.842 (0.016)	0.918	0.851 (0.045)	0.754 (0.045)	0.868
2001	0.911 (0.007)	0.801 (0.010)	0.709 (0.008)	0.296 (0.010)	0.544	0.337 (0.025)	0.753 (0.063)	0.868
2002	0.895 (0.015)	0.882 (0.011)	0.882 (0.018)	0.652 (0.031)	0.807	0.844 (0.063)	0.612 (0.098)	0.782
2003	0.932 (0.015)	0.947 (0.005)	0.898 (0.012)	0.708 (0.018)	0.841	0.879 (0.032)	0.630 (0.066)	0.794
2004	0.948 (0.004)	0.860 (0.006)	0.820 (0.014)	0.519 (0.035)	0.720	0.465 (0.078)	NA	NA
2005	0.967 (0.004)	0.940 (0.004)	0.867 (0.009)	0.722 (0.023)	0.850	0.595 (0.040)	NA	NA
2006	0.920 (0.013)	0.956 (0.004)	0.911 (0.006)	0.808 (0.017)	0.899	0.795 (0.045)	0.813 (0.083)	0.902
2007	1.016 (0.026)	0.887 (0.009)	0.911 (0.022)	0.852 (0.030)	0.923	0.988 (0.098)	0.579 (0.059)	0.761
2008	0.995 (0.018)	0.935 (0.007)	0.961 (0.014)	0.776 (0.017)	0.881	0.950 (0.066)	0.742 (0.045)	0.861
2009	1.002 (0.011)	0.972 (0.005)	0.942 (0.008)	0.863 (0.014)	0.929	0.951 (0.026)	0.900 (0.079)	0.949
2010	1.017 (0.030)	0.965 (0.028)	0.984 (0.044)	0.876 (0.032)	0.936	0.931 (0.051)	0.840 (0.038)	0.917
2011	0.986 (0.017)	0.955 (0.004)	0.948 (0.010)	0.772 (0.014)	0.879	0.960 (0.043)	0.858 (0.051)	0.926
2012	1.001 (0.026)	0.959 (0.006)	0.914 (0.011)	0.811 (0.022)	0.901	0.814 (0.048)	1.021 (0.148)	1.010
2013	0.973 (0.032)	0.921 (0.020)	0.977 (0.020)	0.739 (0.031)	0.860	0.799 (0.025)	1.026 (0.154)	1.013
2014	1.018 (0.028)	0.953 (0.009)	0.947 (0.024)	0.836 (0.032)	0.914	1.082 (0.080)	0.982 (0.147)	0.991
2015	0.874 (0.046)	1.017 (0.028)	0.829 (0.059)	0.923 (0.071)	0.961	0.792 (0.066)	0.842 (0.050)	0.918
2016	0.998 (0.016)	0.990 (0.007)	0.918 (0.016)	0.813 (0.025)	0.902	0.927 (0.074)	0.709 (0.071)	0.842

Table 5. Continued.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
2017	NA	0.962 (0.008)	0.943 (0.015)	0.849 (0.022)	0.921	0.913 (0.020)	1.145 (0.104)	1.070
2018	0.983 (0.025)	0.953 (0.007)	0.950 (0.016)	0.823 (0.036)	0.907	0.851 (0.039)	0.946 (0.150)	0.974
2019	0.965 (0.027)	0.968 (0.006)	0.981 (0.011)	0.774 (0.019)	0.880	1.029 (0.084)	0.734 (0.110)	0.857
2020	0.914 (0.041)	0.991 (0.049)	1.025 (0.109)	0.834 (0.092)	0.913	0.985 (0.090)[b]	0.762 (0.057)[b]	0.873[b]
2021	0.936 (0.029)	1.070 (0.045)	1.089 (0.083)	0.681 (0.043)	0.825	0.757 (0.071)[b]	0.795 (0.029)[b]	0.892[b]
2022	0.940 (0.023)	0.881 (0.027)	0.992 (0.043)	0.681 (0.034)	0.825	1.265 (0.198)[b]	0.737 (0.091)[b]	0.858[b]
2023	0.942 (0.028)	0.958 (0.043)	0.995 (0.063)	0.776 (0.042)	0.881	0.963 (0.049)[b]	0.936 (0.053)[b]	0.967[b]
2024[a]	1.078 (0.107)	0.925 (0.061)	1.276 (0.284)	0.850 (0.210)	0.922	0.785 (0.055)[b]	0.685 (0.067)[b]	0.828[b]
Mean	**0.954 (0.010)**	**0.937 (0.009)**	**0.938 (0.017)**	**0.773 (0.022)**	**0.876 (0.014)**	**0.861 (0.035)**	**0.817 (0.028)**	**0.900 (0.016)**

a. Estimates are preliminary and subject to change.
b. Estimates for 2020-2024 in the reaches between McNary Dam and Bonneville Dam used a different method than in prior years.

Table 6. Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River **steelhead** (hatchery and wild combined), 1993–2024. Standard errors in parentheses. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; MCN–McNary Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR-MCN	MCN-BON	LGR–BON	Trap–BON
1993	0.905 (0.006)	NA	NA	NA	NA
1994	0.794 (0.009)	NA	NA	NA	NA
1995	0.945 (0.008)	0.739 (0.066)	NA	NA	NA
1996	0.951 (0.015)	0.688 (0.046)	NA	NA	NA
1997	0.964 (0.015)	0.728 (0.053)	0.651 (0.082)	0.474 (0.069)	0.457 (0.067)
1998	0.924 (0.009)	0.649 (0.013)	0.770 (0.081)	0.500 (0.054)	0.462 (0.050)
1999	0.908 (0.011)	0.688 (0.010)	0.640 (0.024)	0.440 (0.018)	0.400 (0.017)
2000	0.964 (0.013)	0.679 (0.016)	0.580 (0.040)	0.393 (0.034)	0.379 (0.033)
2001	0.911 (0.007)	0.168 (0.006)	0.250 (0.016)	0.042 (0.003)	0.038 (0.003)
2002	0.895 (0.015)	0.536 (0.025)	0.488 (0.090)	0.262 (0.050)	0.234 (0.045)
2003	0.932 (0.015)	0.597 (0.013)	0.518 (0.015)	0.309 (0.011)	0.288 (0.012)
2004	0.948 (0.004)	0.379 (0.023)	NA	NA	NA
2005	0.967 (0.004)	0.593 (0.018)	NA	NA	NA
2006	0.920 (0.013)	0.702 (0.016)	0.648 (0.079)	0.455 (0.056)	0.418 (0.052)
2007	1.016 (0.026)	0.694 (0.020)	0.524 (0.064)	0.364 (0.045)	0.369 (0.047)
2008	0.995 (0.018)	0.716 (0.015)	0.671 (0.034)	0.480 (0.027)	0.478 (0.028)
2009	1.002 (0.011)	0.790 (0.013)	0.856 (0.074)	0.676 (0.059)	0.678 (0.060)
2010	1.017 (0.030)	0.770 (0.020)	0.789 (0.027)	0.608 (0.026)	0.618 (0.032)
2011	0.986 (0.017)	0.693 (0.013)	0.866 (0.038)	0.600 (0.029)	0.592 (0.030)
2012	1.001 (0.026)	0.698 (0.020)	0.856 (0.196)	0.597 (0.138)	0.598 (0.139)
2013	0.973 (0.032)	0.645 (0.026)	0.798 (0.112)	0.515 (0.075)	0.501 (0.075)
2014	1.018 (0.028)	0.740 (0.021)	1.023 (0.088)	0.757 (0.069)	0.771 (0.073)
2015	0.874 (0.046)	0.733 (0.027)	0.663 (0.039)	0.486 (0.034)	0.425 (0.037)
2016	0.998 (0.016)	0.730 (0.020)	0.608 (0.040)	0.444 (0.032)	0.443 (0.032)

Table 6. Continued.

Year	Trap–LGR	LGR-MCN	MCN-BON	LGR–BON	Trap–BON
2017	NA	0.759 (0.019)	1.045 (0.095)	0.793 (0.075)	NA
2018	0.983 (0.025)	0.733 (0.031)	0.802 (0.098)	0.588 (0.076)	0.578 (0.076)
2019	0.965 (0.027)	0.717 (0.017)	0.595 (0.109)	0.427 (0.079)	0.412 (0.077)
2020	0.914 (0.041)	0.807 (0.043)	0.738 (0.052)[b]	0.595 (0.027)	0.544 (0.035)
2021	0.936 (0.029)	0.788 (0.073)	0.602 (0.029)[b]	0.487 (0.026)	0.456 (0.028)
2022	0.940 (0.023)	0.610 (0.055)	0.757 (0.047)[b]	0.553 (0.038)	0.520 (0.038)
2023	0.942 (0.028)	0.718 (0.042)	0.892 (0.076)[b]	0.620 (0.063)	0.584 (0.062)
2024[a]	1.078 (0.107)	0.819 (0.077)	0.550 (0.050)[b]	0.435 (0.038)	0.469 (0.062)
Mean	**0.954 (0.010)**	**0.677 (0.024)**	**0.699 (0.034)**	**0.496 (0.030)**	**0.468 (0.030)**

a. Estimates are preliminary and subject to change.
b. Estimates for 2020-2024 in the reaches between McNary Dam and Bonneville Dam used a different method than in prior years.

Table 7. Estimated survival and standard error (s.e.) through reaches of the lower Columbia River hydropower system for hatchery yearling **Chinook** salmon and **steelhead** originating in the upper Columbia River, 1999–2024. Abbreviations: Rel–Release site; MCN–McNary Dam; JDA–John Day Dam; BON–Bonneville Dam.

	Yearling Chinook Salmon				Steelhead			
Year	Rel–MCN	MCN-JDA	JDA-BON	MCN–BON	Rel–MCN	MCN-JDA	JDA-BON	MCN–BON
1999	0.572 (0.014)	0.896 (0.044)	0.795 (0.129)	0.712 (0.113)	NA	NA	NA	NA
2000	0.539 (0.025)	0.781 (0.094)	NA	NA	NA	NA	NA	NA
2001	0.428 (0.009)	0.881 (0.062)	NA	NA	NA	NA	NA	NA
2002	0.555 (0.003)	0.870 (0.011)	0.940 (0.048)	0.817 (0.041)	NA	NA	NA	NA
2003	0.625 (0.003)	0.900 (0.008)	0.977 (0.035)	0.879 (0.031)	0.471 (0.004)	0.997 (0.012)	0.874 (0.036)	0.871 (0.036)
2004	0.507 (0.005)	0.812 (0.019)	0.761 (0.049)	0.618 (0.038)	0.384 (0.005)	0.794 (0.021)	1.037 (0.112)	0.823 (0.088)
2005	0.545 (0.012)	0.751 (0.042)	NA	NA	0.399 (0.004)	0.815 (0.017)	0.827 (0.071)	0.674 (0.057)
2006	0.520 (0.011)	0.954 (0.051)	0.914 (0.211)	0.871 (0.198)	0.397 (0.008)	0.797 (0.026)	0.920 (0.169)	0.733 (0.134)
2007	0.584 (0.009)	0.895 (0.028)	0.816 (0.091)	0.730 (0.080)	0.426 (0.016)	0.944 (0.064)	0.622 (0.068)	0.587 (0.059)
2008	0.582 (0.019)	1.200 (0.085)	0.522 (0.114)	0.626 (0.133)	0.438 (0.015)	NA	NA	NA
2009	0.523 (0.013)	0.847 (0.044)	1.056 (0.143)	0.895 (0.116)	0.484 (0.018)	0.809 (0.048)	0.935 (0.133)	0.756 (0.105)
2010	0.660 (0.014)	0.924 (0.040)	0.796 (0.046)	0.735 (0.037)	0.512 (0.017)	0.996 (0.054)	0.628 (0.038)	0.626 (0.033)
2011	0.534 (0.010)	1.042 (0.047)	0.612 (0.077)	0.637 (0.077)	0.435 (0.012)	1.201 (0.064)	0.542 (0.101)	0.651 (0.119)
2012	0.576 (0.012)	0.836 (0.035)	1.140 (0.142)	0.953 (0.115)	0.281 (0.011)	0.862 (0.047)	1.240 (0.186)	1.069 (0.159)
2013	0.555 (0.013)	0.965 (0.050)	1.095 (0.129)	1.056 (0.117)	0.384 (0.020)	0.957 (0.071)	0.974 (0.104)	0.932 (0.099)
2014	0.571 (0.013)	0.974 (0.047)	0.958 (0.122)	0.933 (0.114)	0.468 (0.043)	0.883 (0.124)	0.807 (0.153)	0.712 (0.130)
2015	0.512 (0.015)	0.843 (0.043)	1.032 (0.081)	0.870 (0.062)	0.351 (0.019)	0.807 (0.084)	0.707 (0.073)	0.570 (0.043)
2016	0.610 (0.009)	0.857 (0.027)	0.942 (0.068)	0.807 (0.055)	0.416 (0.011)	0.771 (0.037)	0.633 (0.046)	0.487 (0.032)
2017	0.582 (0.013)	0.853 (0.030)	1.107 (0.142)	0.944 (0.120)	0.437 (0.025)	0.880 (0.062)	1.095 (0.210)	0.964 (0.188)
2018	0.608 (0.016)	0.914 (0.044)	0.820 (0.096)	0.749 (0.084)	0.416 (0.021)	0.942 (0.062)	1.232 (0.194)	1.161 (0.186)

Table 7. Continued.

	Yearling Chinook Salmon				Steelhead			
Year	Rel–MCN	MCN-JDA	JDA-BON	MCN–BON	Rel–MCN	MCN-JDA	JDA-BON	MCN–BON
2019	0.506 (0.018)	0.853 (0.042)	0.920 (0.066)	0.785 (0.056)	0.342 (0.016)	0.812 (0.048)	0.746 (0.054)	0.606 (0.047)
2020	0.629 (0.025)	0.867 (0.045)	0.922 (0.094)	0.800 (0.083)	0.420 (0.035)	0.879 (0.082)	0.859 (0.084)	0.756 (0.092)
2021	0.529 (0.028)	0.807 (0.066)	0.773 (0.071)	0.624 (0.053)	0.324 (0.025)	0.854 (0.100)	0.661 (0.066)	0.564 (0.050)
2022	0.480 (0.035)	0.810 (0.079)	0.952 (0.092)	0.772 (0.080)	0.222 (0.023)	1.581 (0.241)	0.567 (0.077)	0.897 (0.117)
2023	0.436 (0.018)	0.815 (0.042)	0.913 (0.051)	0.744 (0.045)	0.341 (0.021)	1.048 (0.074)	0.901 (0.054)	0.944 (0.073)
2024[a]	0.465 (0.028)	0.974 (0.092)	0.734 (0.068)	0.715 (0.060)	0.214 (0.028)	1.024 (0.184)	0.615 (0.088)	0.629 (0.096)
Mean[b]	**0.547 (0.011)**	**0.889 (0.018)**	**0.891 (0.032)**	**0.794 (0.025)**	**0.389 (0.017)**	**0.936 (0.040)**	**0.830 (0.045)**	**0.762 (0.040)**

a. Estimates are preliminary and subject to change.
b. For each river segment, simple arithmetic mean is across all years for which estimates are available for that segment.

Table 8. Estimated survival and standard error (s.e.) for **sockeye** salmon (hatchery and wild combined) from Lower Granite Dam tailrace to Bonneville Dam tailrace for fish originating in the Snake River, and from the Lower Wenatchee River Trap to Bonneville Dam tailrace for fish originating in the upper Columbia River, 1996–2024. Note that estimates in this table are provided regardless of the precision, which in some years was very poor. Abbreviations: LGR–Lower Granite Dam; MCN–McNary Dam; BON–Bonneville Dam; WENA4T– Lower Wenatchee River Trap.

	Snake River Sockeye			Upper Columbia River Sockeye		
Year	LGR-MCN	MCN-BON	LGR-BON	WENA4T-MCN	MCN-BON[a]	WENA4T-BON
1996	0.283 (0.184)	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA
1998	0.689 (0.157)	0.142 (0.099)	0.177 (0.090)	NA	1.655 (1.617)	NA
1999	0.655 (0.083)	0.841 (0.584)	0.548 (0.363)	NA	0.683 (0.177)	NA
2000	0.679 (0.110)	0.206 (0.110)	0.161 (0.080)	NA	0.894 (0.867)	NA
2001	0.205 (0.063)	0.105 (0.050)	0.022 (0.005)	NA	NA	NA
2002	0.524 (0.062)	0.684 (0.432)	0.342 (0.212)	NA	0.286 (0.110)	NA
2003	0.669 (0.054)	0.551 (0.144)	0.405 (0.098)	NA	NA	NA
2004	0.741 (0.254)	NA	NA	NA	1.246 (1.218)	NA
2005	0.388 (0.078)	NA	NA	NA	0.226 (0.209)	NA
2006	0.630 (0.083)	1.113 (0.652)	0.820 (0.454)	NA	0.767 (0.243)	NA
2007	0.679 (0.066)	0.259 (0.084)	0.272 (0.073)	NA	0.642 (0.296)	NA
2008	0.763 (0.103)	0.544 (0.262)	0.404 (0.179)	NA	0.679 (0.363)	NA
2009	0.749 (0.032)	0.765 (0.101)	0.573 (0.073)	NA	0.958 (0.405)	NA
2010	0.723 (0.039)	0.752 (0.098)	0.544 (0.077)	NA	0.627 (0.152)	NA
2011	0.659 (0.033)	NA	NA	NA	0.691 (0.676)	NA
2012	0.762 (0.032)	0.619 (0.084)	0.472 (0.062)	NA	0.840 (0.405)	NA
2013	0.691 (0.043)	0.776 (0.106)	0.536 (0.066)	NA	0.658 (0.217)	NA
2014	0.873 (0.054)	0.817 (0.115)	0.713 (0.096)	0.332 (0.079)	0.565 (0.269)	0.053 (0.044)
2015	0.702 (0.054)	0.531 (0.151)	0.373 (0.037)	0.430 (0.062)	0.446 (0.200)	0.195 (0.064)
2016	0.523 (0.047)	0.227 (0.059)	0.119 (0.030)	0.270 (0.055)	0.545 (0.126)	NA

Table 8. Continued.

	Snake River Sockeye			Upper Columbia River Sockeye		
Year	LGR-MCN	MCN-BON	LGR-BON	WENA4T-MCN	MCN-BON[a]	WENA4T-BON
2017	0.544 (0.081)	0.324 (0.107)	0.176 (0.055)	0.551 (0.141)	0.611 (0.181)	NA
2018	0.684 (0.061)	0.940 (0.151)	0.643 (0.088)	0.655 (0.064)	0.560 (0.112)	0.364 (0.154)
2019	0.836 (0.053)	0.520 (0.044)	0.434 (0.031)	0.640 (0.135)	0.701 (0.120)	0.264 (0.126)
2020	0.803 (0.111)	0.546 (0.149)	0.439 (0.104)	0.436 (0.095)	0.288 (0.154)	0.106 (0.062)
2021	0.817 (0.094)	0.452 (0.067)	0.369 (0.034)	0.642 (0.238)	0.533 (0.180)	0.361 (0.332)
2022	1.059 (0.189)	0.412 (0.087)	0.436 (0.050)	0.434 (0.088)	1.006 (0.396)	0.458 (0.219)
2023	0.813 (0.064)	0.548 (0.057)	0.445 (0.031)	0.578 (0.226)	0.666 (0.259)	0.567 (0.259)
2024[b]	1.114 (0.300)	0.251 (0.071)	0.279 (0.026)	0.293 (0.102)	0.819 (0.323)	0.122 (0.049)
Mean[c]	**0.688 (0.037)**	**0.539 (0.054)**	**0.404 (0.039)**	**0.478 (0.043)**	**0.704 (0.060)**	**0.277 (0.058)**

a. Estimates in this column based on data for all wild sockeye released upstream of the confluence with the Yakima River, not only those tagged at WENA4T.
b. Estimates are preliminary and subject to change.
c. For each river segment, simple arithmetic mean is across all years for which estimates are available for that segment.

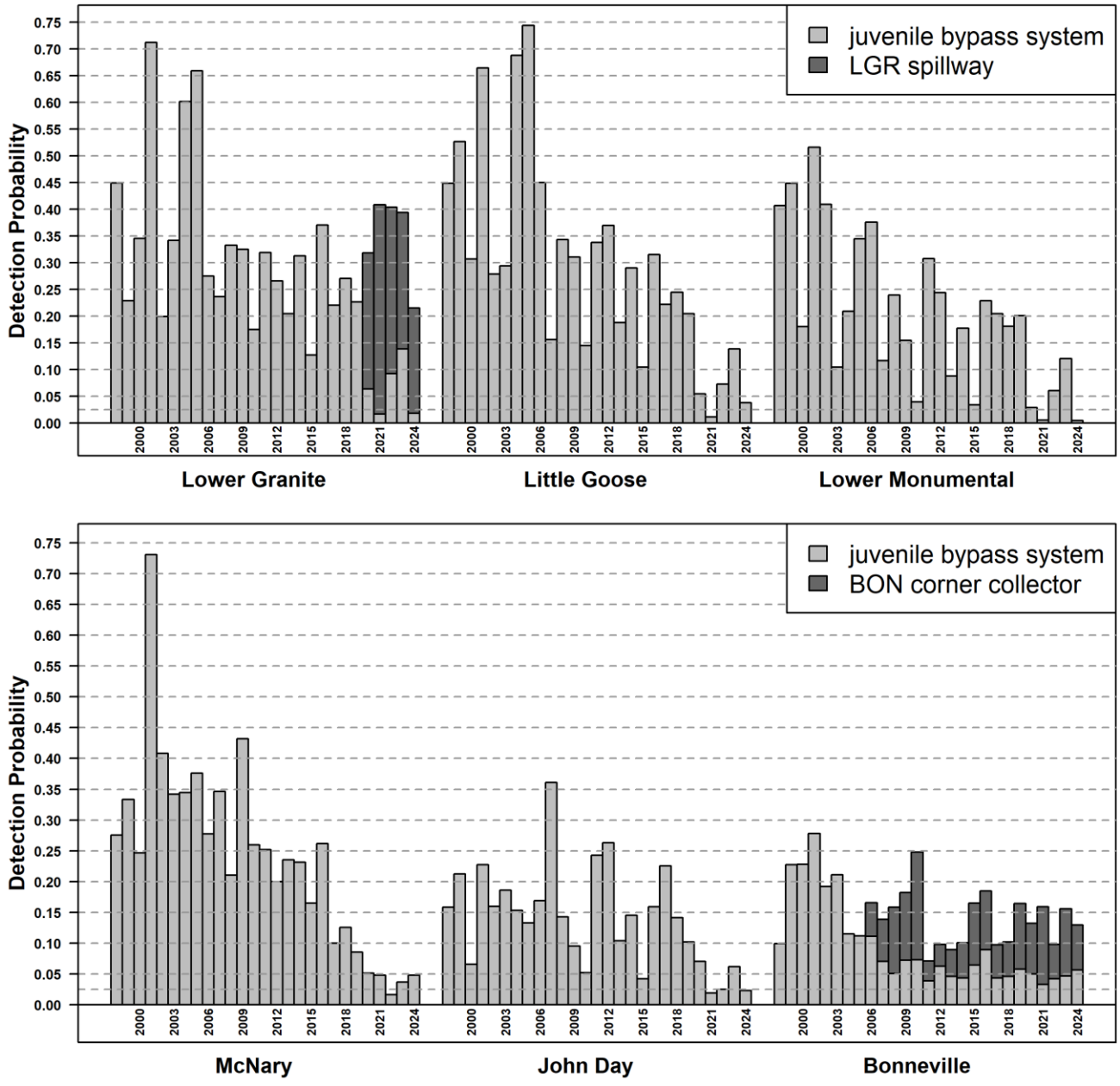

Figure 1. Annual mean detection probability for Snake River yearling Chinook salmon at six major dams on the Snake and Columbia Rivers, 2000-2024. Ice Harbor Dam was excluded because of persistent very low juvenile detection probabilities.

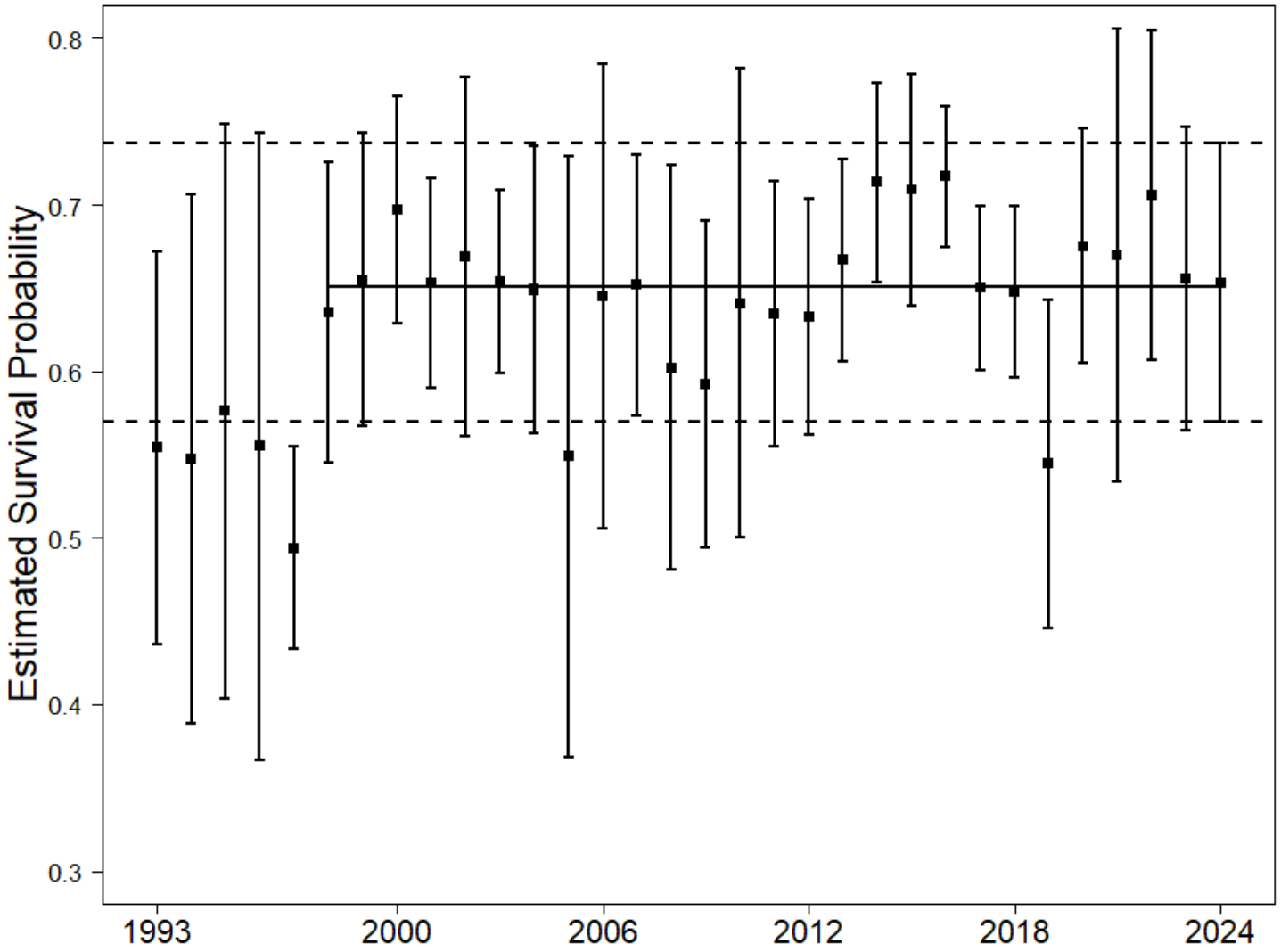

Figure 2. Annual mean survival estimates from release to Lower Granite Dam for PIT-tagged yearling **Chinook** salmon released from Snake River Basin hatcheries, 1993-2024. Hatcheries used for the mean (index groups) are those with consistent PIT-tag releases through the series of years shown. Vertical bars represent 95% confidence intervals. The 1998-2024 mean is shown as a horizontal solid line. Horizontal dashed lines are the 2024 confidence interval endpoints and are shown for comparison to other years.

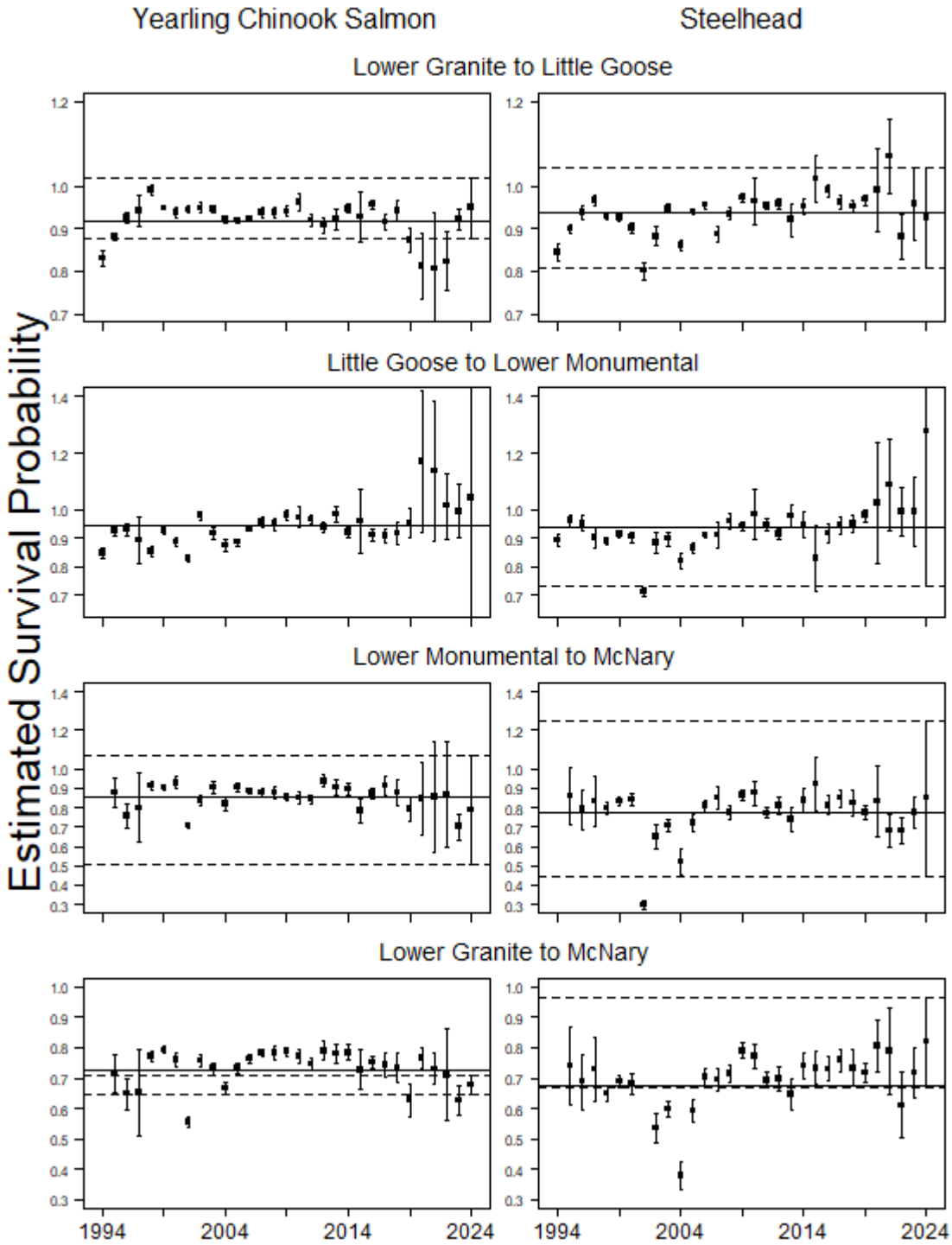

Figure 3. Annual mean survival estimates for PIT-tagged yearling **Chinook** salmon and **steelhead**, hatchery and wild fish combined. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are 95% confidence interval endpoints for 2024 estimates, and horizontal solid lines represent long-term means.

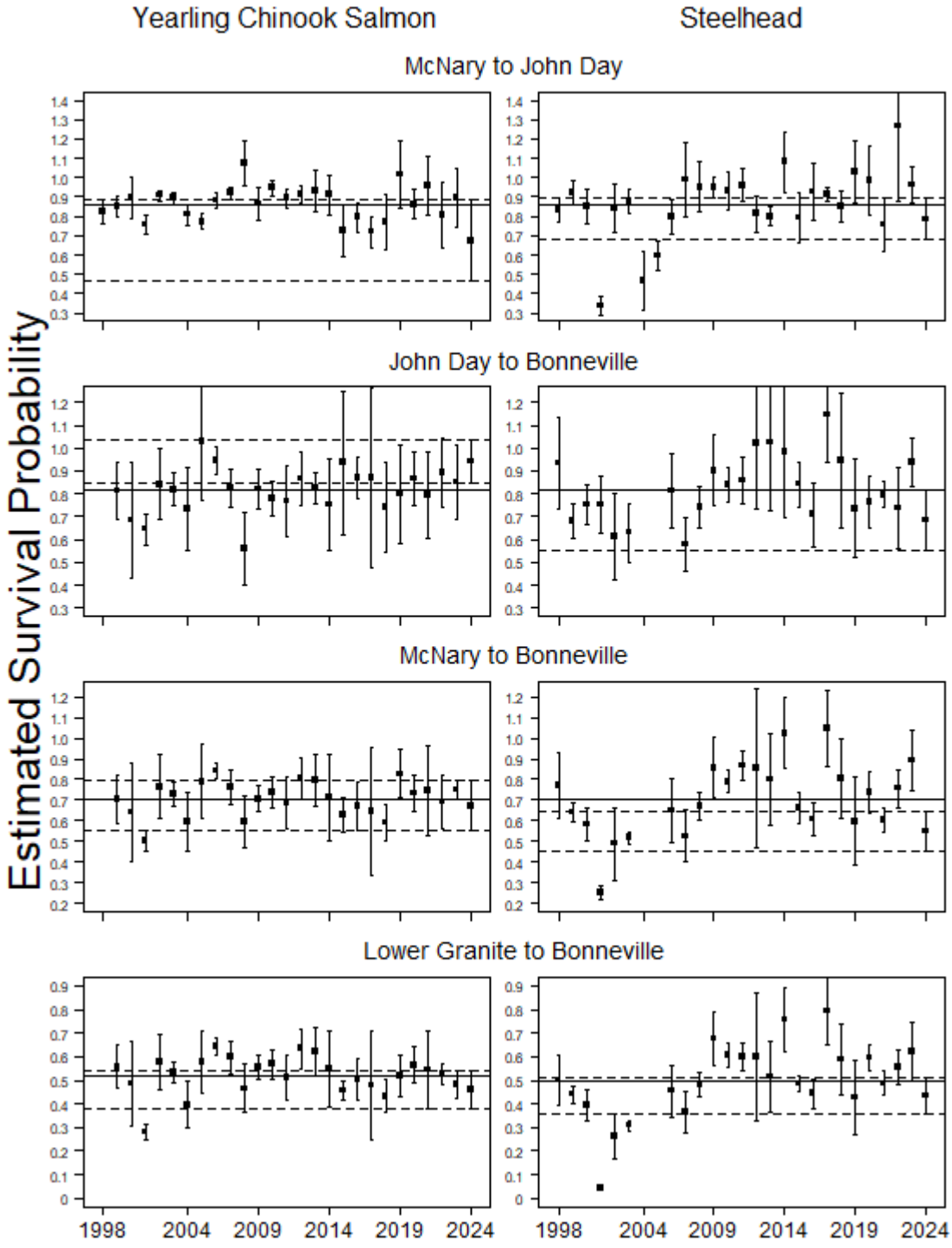

Figure 4. Annual mean survival estimates for PIT-tagged yearling **Chinook** salmon and **steelhead**, hatchery and wild fish combined. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are 95% confidence interval endpoints for 2024 estimates, and horizontal solid lines represent long-term means.

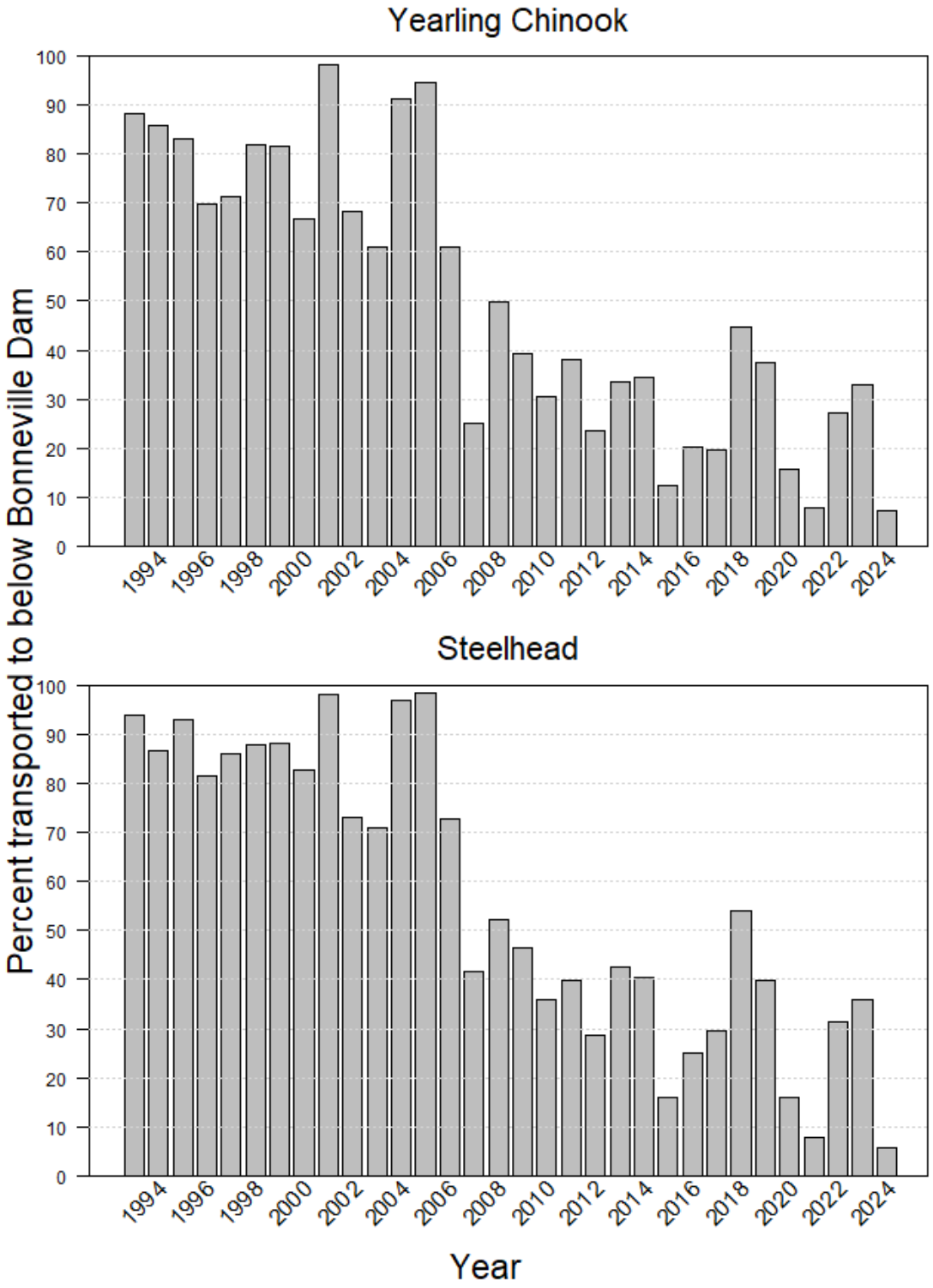

Figure 5. Annual estimates of the percentage of yearling Chinook salmon and steelhead smolts (mean of estimates for hatchery and wild smolts) that arrived at Lower Granite Dam that were subsequently transported, either from Lower Granite Dam or downstream from Little Goose or Lower Monumental Dam, to below Bonneville Dam (1993-2024).

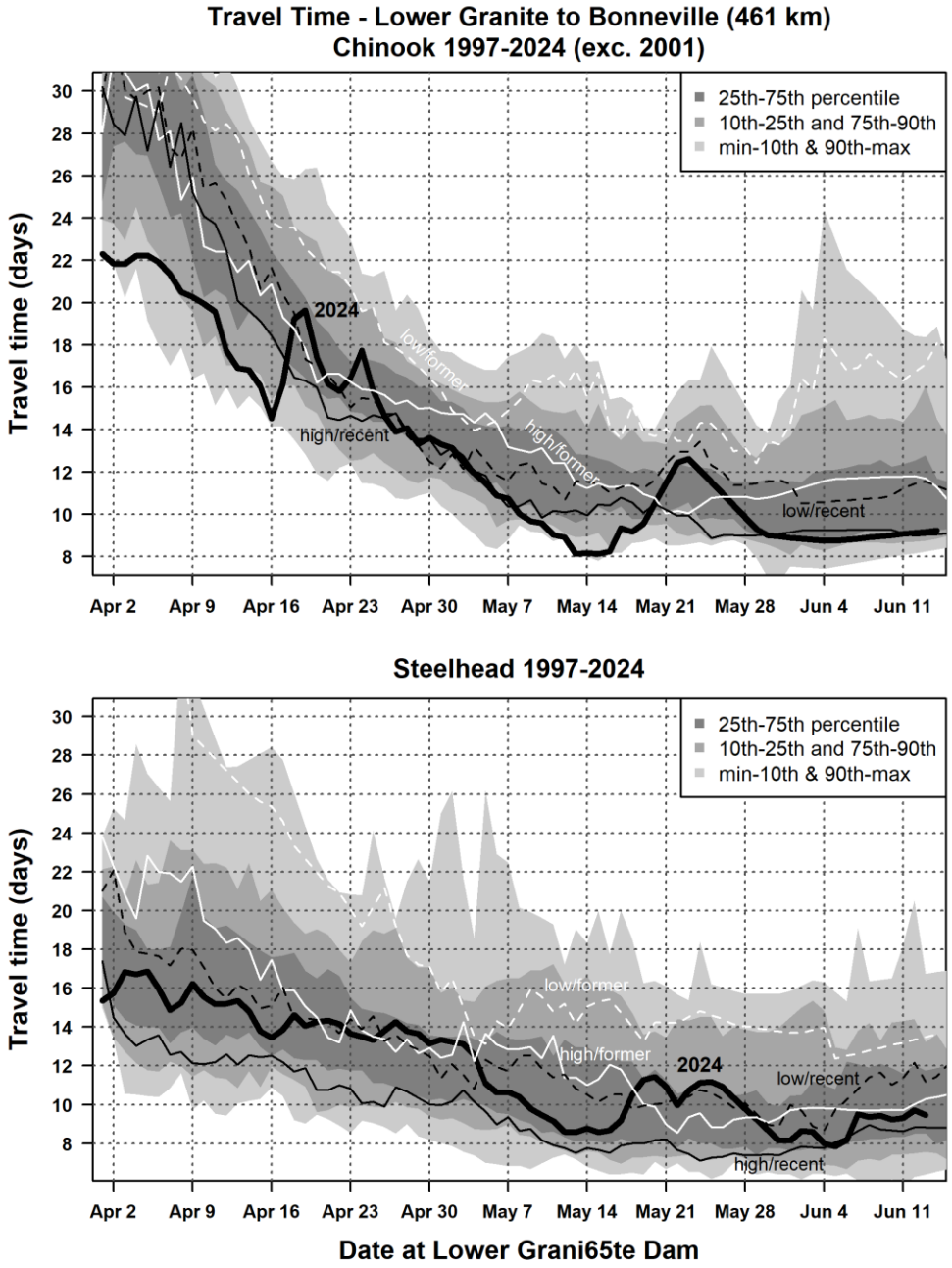

Figure 6. Median travel time (d) from Lower Granite to Bonneville Dam (461 km) vs. date passing Lower Granite Dam for yearling Chinook salmon and juvenile steelhead. Shaded regions show daily quantiles during 1997-2024 (excluding 2001). Lines show daily medians from selected subsets of years: low-flow years during the former (2004-2005) and recent spill regimes (2007, 2010, 2013, 2015, and 2021); high-flow years during the former (1997-1999 and 2006) and recent spill regimes (2011, 2012, 2017, 2018, and 2019).

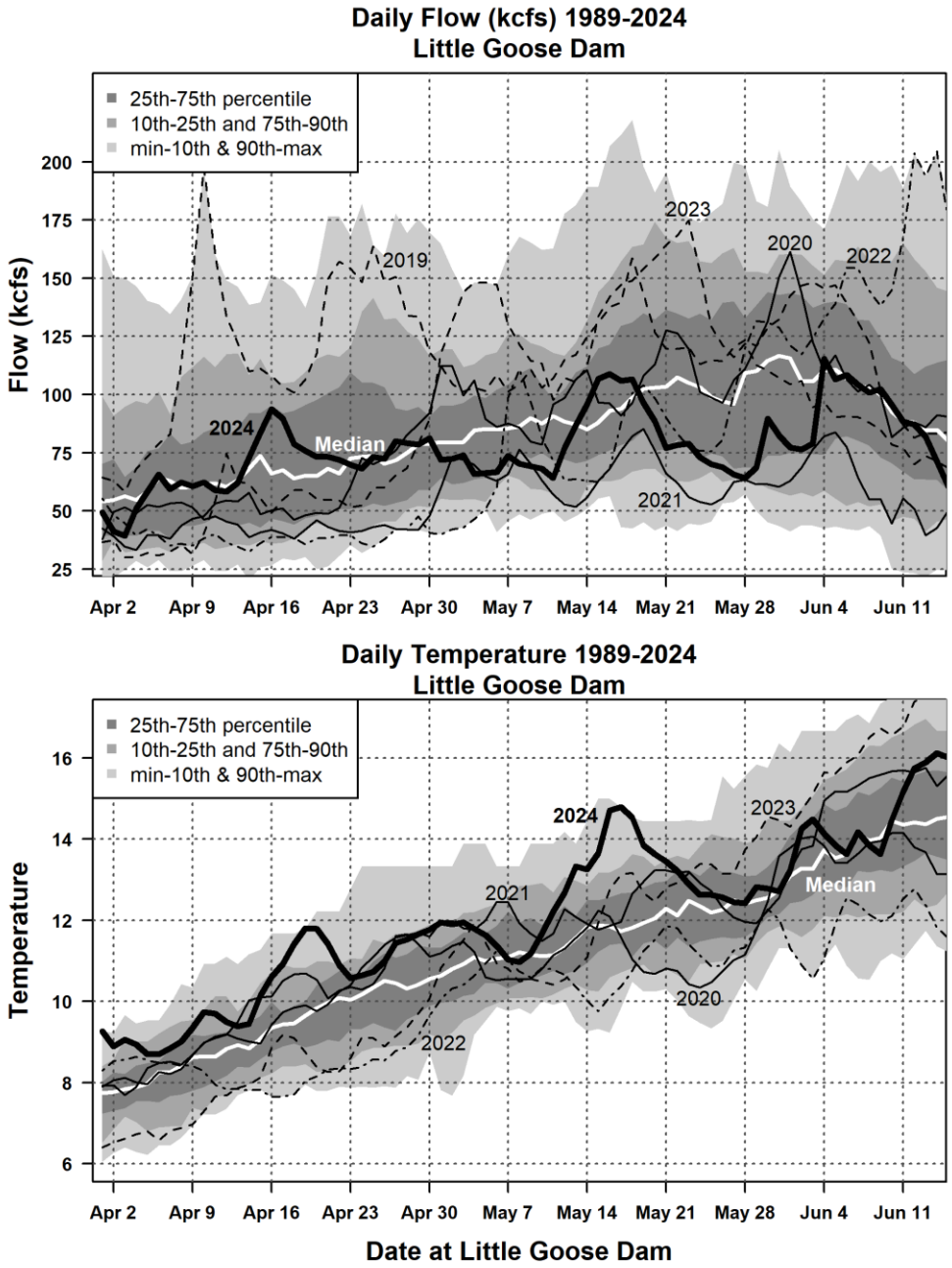

Figure 7. Upper panel shows daily mean flow at Little Goose Dam from April to mid-June. Lines show daily mean flows for 2024 and selected recent years and long-term median. Shaded areas illustrate daily quantiles from 1989-2024. Lower panel uses the same format to show daily mean river temperature (°C) at Little Goose Dam. Quantiles for daily temperature are calculated from 1996-2024.

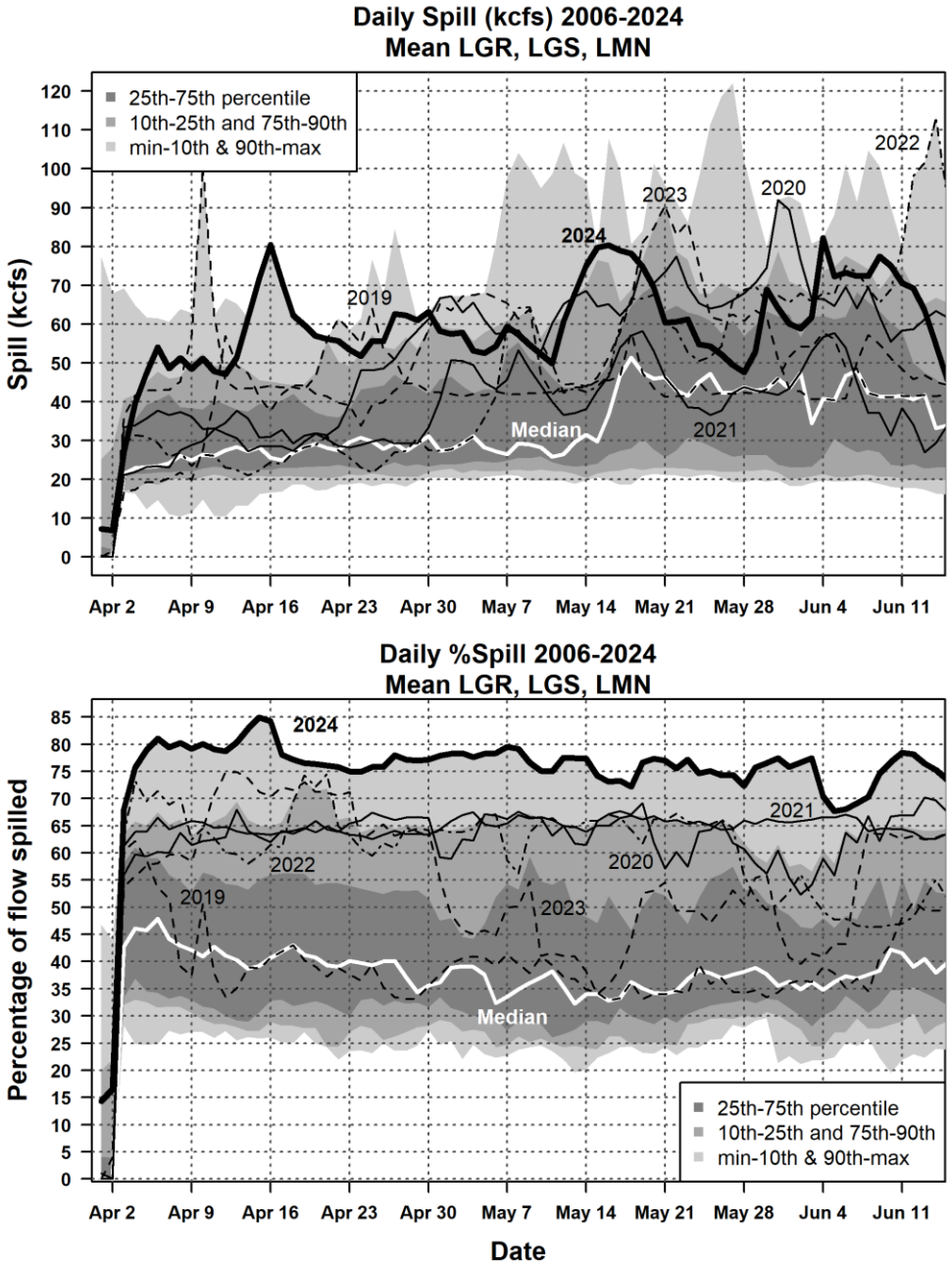

Figure 8. Upper panel shows daily mean Snake River spill (kcfs) from April to mid-June, averaged across Lower Granite, Little Goose and Lower Monumental Dams. Lower panel shows daily spill as a percentage of total flow. Lines show daily values for 2024 and selected recent years and long-term median. Shaded areas indicate daily quantiles for 2006-2024.

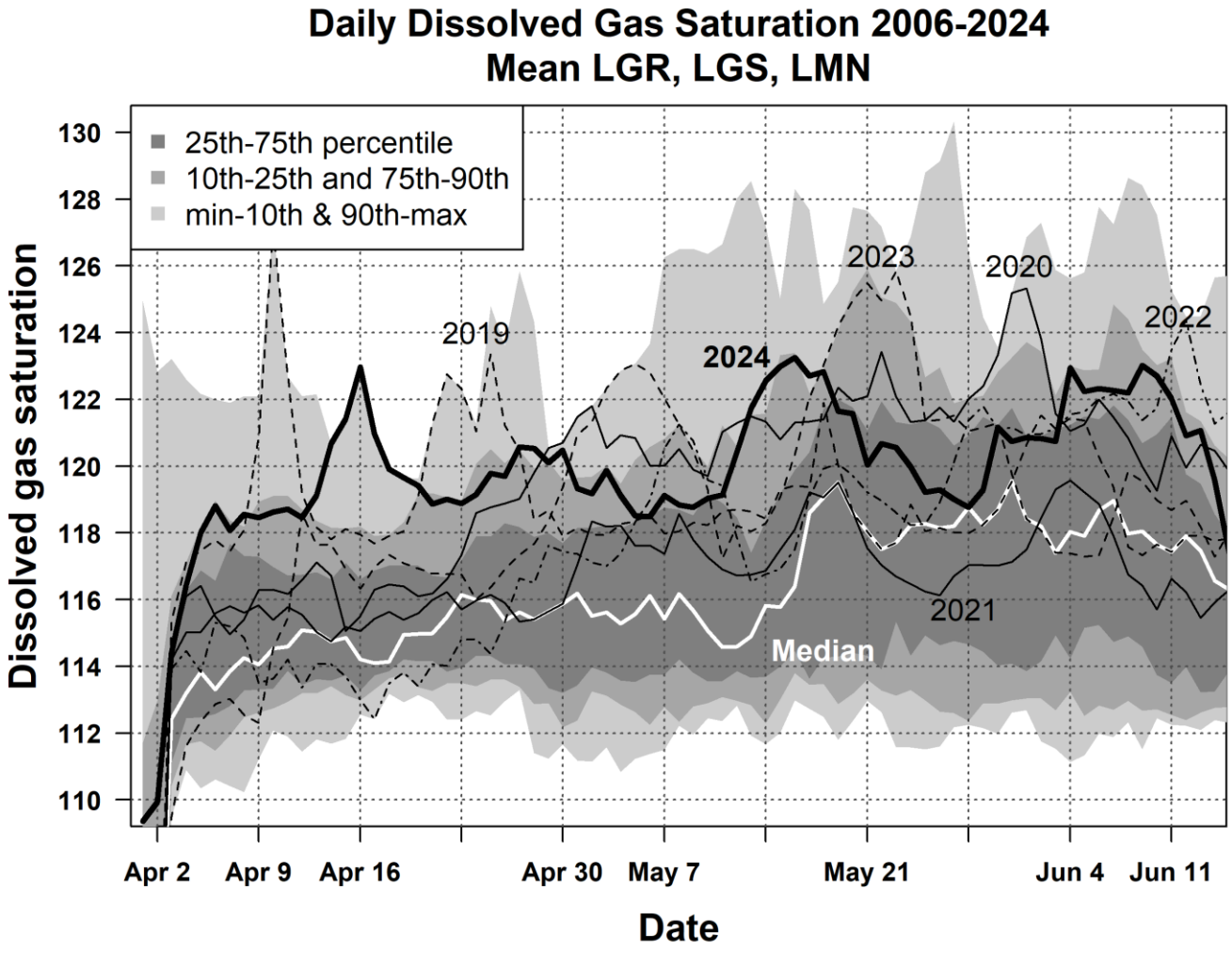

Figure 9. Daily mean percentage of dissolved gas averaged across Lower Granite, Little Goose and Lower Monumental Dam from April to mid-June 2024. Lines show daily percentage for 2024 and selected recent years and long-term median. Shaded areas indicate daily quantiles for 2006-2024.

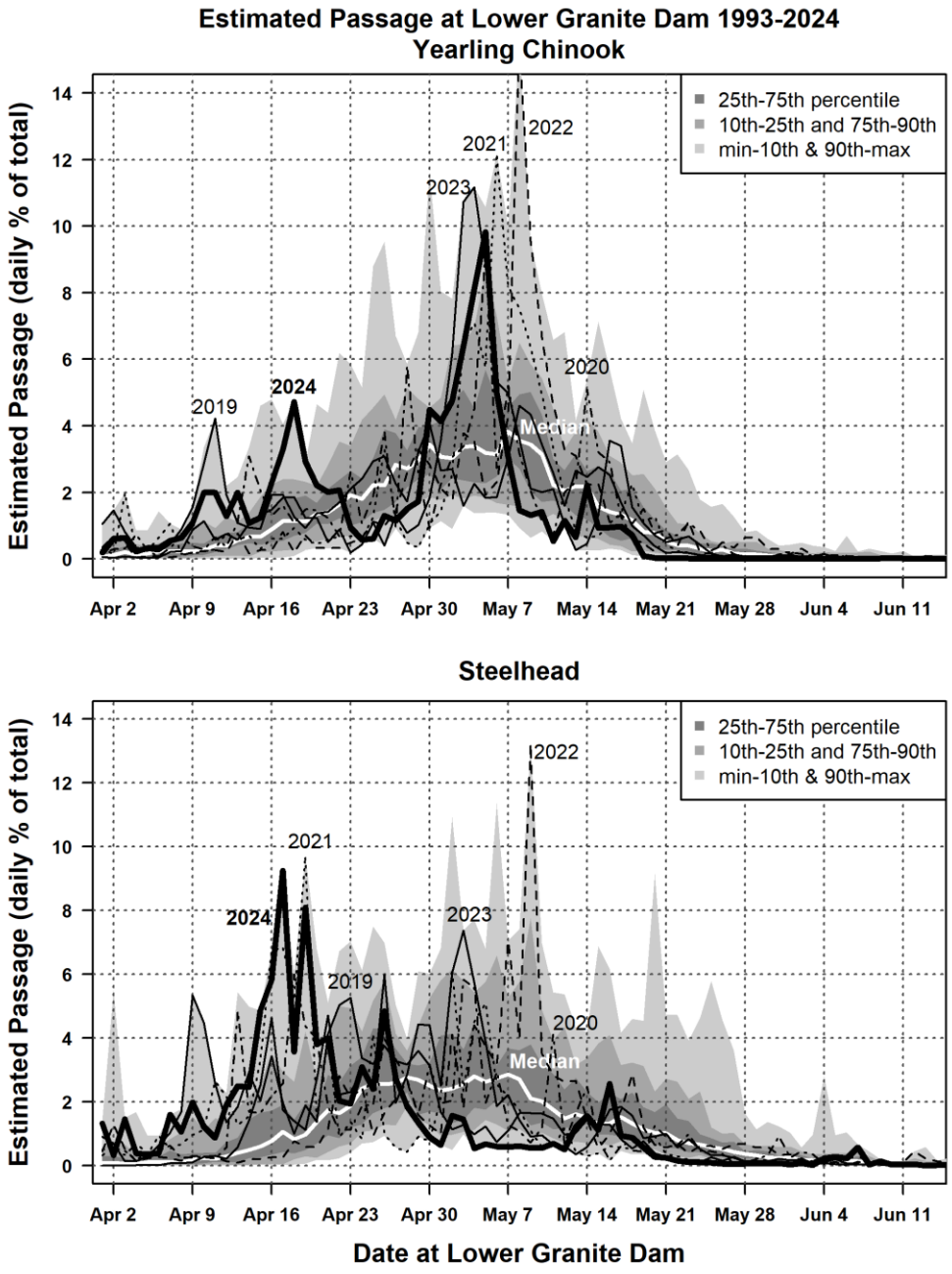

Figure 10. Estimated daily smolt passage at Lower Granite Dam for yearling Chinook salmon and steelhead. Daily passage is expressed as percentage of the yearly total. Lines indicate daily values for 2024, the long-term median, and selected recent years. Shaded areas indicate smolt-passage quantiles from 1993 to 2024.