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MEMORANDUM FOR: F/NWR5 – Ritchie Graves

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SUBJECT: Preliminary survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2020

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 2020 spring outmigration. We also provide preliminary estimates of the proportion of Snake River smolts that were transported from Snake River dams in 2020. Our complete detailed analyses and report for the spring migration will follow this memo at a later date. As in past years, changes in the database between the time of our annual summer memo and the publication of our final report may result in differences of up to 3 or 4% in estimated survival values. Of particular note in 2020, survival estimates to Bonneville Dam are not currently available. If PIT-tag recoveries from estuary bird colonies in fall 2020 are sufficient, such estimates will be published in the detailed report.

Summary of Research

The global pandemic caused by COVID-19 severely limited field work by NOAA Fisheries and other agencies during the 2020 migration season. Many planned activities did not take place. No fish were tagged by NOAA Fisheries at Lower Granite Dam in 2020. The Columbia River estuary trawl, which is usually the primary source of juvenile-detection data downstream of Bonneville Dam, was not operated in 2020.

Survival estimates provided in this memorandum are derived from data from fish PIT tagged by various 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 which are less than or equal to 100%.

We have estimated survival probabilities for migrating PIT-tagged salmonids since 1993. In this memo, we compare 2020 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.

The absence of tagging at Lower Granite Dam in 2020 lowered sample sizes for survival estimation. This deficit was partially compensated for by the operation of a new PIT-tag detection system in the RSW spillway at Lower Granite Dam, installed in the winter of 2019/20. Without data from the "spillway detector" it is likely that very few survival estimates would have been possible in the system in 2020.

The mean estimated annual percentage of yearling Chinook smolts detected passing Lower Granite Dam in 2007-2019, when detection was possible only in the juvenile bypass system (JBS), was 26.1%. The estimated overall percentage detected in 2020 was 31.8%, with only 6.3% detected in the JBS and 25.5% detected by the spillway detector.

In 2019, the total numbers of smolts detected or collected and tagged at Lower Granite Dam were 32,341 Chinook and 71,623 steelhead, and in 2020 the total numbers detected were 53,436 Chinook and 51,369 steelhead. That is, overall sample sizes of fish leaving Lower Granite Dam were similar between the two years.

However, tagging at Lower Granite Dam has been used in past years to bolster numbers of wild smolts in the tagged groups, and there was a deficit in this category in 2020, particularly for steelhead. In 2019, the total number of wild Chinook in the Lower Granite Dam daily groups was 9,962, compared to 4,904 in 2020. For wild steelhead, the numbers were 17,254 in 2019, but only 2,955 in 2020.

Unfortunately, even for groups with seemingly sufficient sample sizes leaving Lower Granite Dam, survival estimation in 2020 was hampered by especially low detection probabilities at downstream dams, where detection is possible only in juvenile bypass

systems. A combination of low to average flow and high levels of spill made 2020 the worst year on record for overall detection downstream of Lower Granite Dam. Every dam besides Lower Granite had a detection rate below the 2007-2019 average, and several, including Little Goose Dam, Lower Monumental Dam, and McNary Dam, had detection rates less than half the 2007-2019 average. These extremely low detection rates resulted in highly imprecise survival estimates for component reaches between Lower Granite Dam and McNary Dam.

Furthermore, the lower Columbia River PIT trawl has been the predominant source of detection data downstream of Bonneville Dam in past years, but was not operated in 2020. Consequently, data is not sufficient at this time to estimate survival to Bonneville Dam for any group. In coming weeks, PIT tags will be recovered from various piscivorous bird colonies downstream of Bonneville Dam. Once this data becomes available, it may be sufficient to allow survival estimation to Bonneville Dam, which we would include in our detailed report.

We have also explored additional sources of detection data downstream of Bonneville Dam. These sites were an experimental PIT-tag detector barge (data currently available from PTAGIS as "passive recaptures" at site COLR3) and an automated site installed on a pile dike (interrogation site PD7 in PTAGIS). Detection at these sites is relatively rare, and not sufficient for survival estimation. For example, among yearling Chinook detected passing Bonneville Dam, 1.06% were detected at COLR3 or PD7, compared to an annual average of 3.05% detected by the PIT trawl 2007-2019. We will use these detections to augment detections downstream of Bonneville Dam in future analyses.

PIT-tagged yearling Chinook salmon have been released from each of the Snake River Basin hatcheries Dworshak, Kooskia, Lookingglass/Imnaha Weir, Rapid River, McCall/Knox Bridge, Pahsimeroi, and Sawtooth every year from 1993 through 2020 (except Pahsimeroi in 1996). Across these seven "index" hatcheries, the annual mean estimated survival from release to Lower Granite Dam has been relatively stable since 1998 (Figure 1, Table 1). The mean survival in 2020 was 67.6%, which was slightly higher than the long-term mean (1998-2020) of 64.7% and well above the very low mean of 54.4% in 2019.

Downstream of Lower Granite Dam, mean estimated survival for Snake River yearling Chinook salmon (hatchery and wild combined) in 2020 was below average in the Lower Granite to Little Goose reach and above average in the Little Goose to Lower Monumental

and Lower Monumental to McNary reaches (Table 2, Figure 2). However, these estimates were very imprecise due to very low detection at Little Goose and Lower Monumental Dams. The overall estimate from Lower Granite Dam to McNary Dam in 2020 was 76.1% (95% CI 69.0-83.2%), which was slightly above the long term average of 73.5% (Table 3). This estimate had better precision than the estimates for the component reaches but was still the least precise estimate on record for the Lower Granite to McNary reach.

Estimated survival for hatchery and wild yearling Chinook salmon in the Lower Granite project (head of reservoir to tailrace) was 85.4%, based on fish PIT tagged at and released from the Snake River trap. This estimate marks the third year in a row that the estimate for the Lower Granite project was below the long-term average of 92.1%.

For wild Snake River yearling Chinook, mean estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace was 71.1% (95% CI: 56.2-86.0%), very similar to the long-term average of 72.1% but also very imprecise. Estimated survival from the Snake River trap to Lower Granite Dam tailrace was 70.3% (48.5-92.1%), which was far below the long term average of 91.6%. However, this estimate was very imprecise and based on an extremely small sample size of just 69 wild Chinook smolts tagged at the Snake River trap. It is unlikely that this sample is large enough to provide an accurate representation of the composite population of wild yearling Chinook passing the Snake River trap, at the head of Lower Granite Reservoir.

For Snake River steelhead (hatchery and wild combined), mean estimated survival in 2020 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. Estimated survival for the overall reach from Lower Granite Dam to McNary Dam was 79.4% (95% CI 71.0-87.8%), well above the long-term average of 66.8% (Table 4, Figure 2). However, all survival estimates for hatchery and wild steelhead had poor precision due to very low detection probabilities at dams other than Lower Granite Dam.

Estimated survival for hatchery and wild steelhead through Lower Granite reservoir and dam was 92.0%, based on steelhead PIT tagged at and released from the Snake River trap. This estimate was slightly below the long-term average of 95.1% (Table 5).

Estimated survival for wild steelhead through Lower Granite reservoir and dam was 77.4% (95% CI 57.2-97.6%), which was far below the long-term average of 94.4%. However, this estimate was imprecise; based on a small sample size of only 124 wild steelhead smolts tagged at the Snake River trap. No survival estimate was possible for wild Snake River steelhead below Lower Granite Dam in 2020, as a result of the low number of wild smolts detected at Lower Granite Dam, the absence of a tagging program at Lower Granite Dam, and low detection probabilities at sites downstream of Lower Granite Dam.

At present, data are not sufficient to estimate survival below McNary Dam for any stock. In addition to the previously mentioned absence of the lower Columbia River trawl, detection rates were very low at both McNary and John Day dams in 2020, severely limiting data in this reach. Once data becomes available from PIT-tag recoveries on bird colonies in the Columbia River estuary we will re-attempt survival estimation for reaches downstream of McNary Dam. Any estimates of acceptable quality will be published in the complete detailed report.

For fish released from upper Columbia River hatcheries, we can estimate survival in the overall reach from release to McNary Dam. However, because of limited PIT-tag detection capabilities at Mid-Columbia River dams, we cannot estimate survival in component reaches upstream of McNary Dam. For PIT-tagged hatchery yearling Chinook salmon originating from the upper Columbia River in 2020, estimated survival from release to McNary Dam tailrace averaged 62.6% (95% CI: 57.9-67.7%; Table 6), which was slightly above the long-term average of 56.0%.

For PIT-tagged hatchery steelhead originating from the upper Columbia River in 2020, estimated survival from release to McNary Dam tailrace averaged 44.0% (95% CI: 36.8-52.6%; Table 6). This estimate is slightly above the long-term average of 41.5%.

Estimated survival in 2020 of Snake River sockeye salmon (hatchery and wild combined) from the tailrace of Lower Granite Dam to the tailrace of McNary Dam was 83.5% (95% CI: 63.1-110.5%; Table 7). Estimated survival in 2020 of Columbia River sockeye salmon (hatchery and wild combined) from the tailrace of Rock Island Dam to the tailrace of McNary Dam was 89.4% (56.3%-142.0%; Table 7). Both estimates were above their respective long-term averages of 64.5% and 70.5%, though both estimates were also extremely imprecise.

Our preliminary estimates of the percentage transported of non-tagged wild and hatchery spring-summer Chinook salmon smolts in 2020 are 18.8% and 12.5%, respectively. For steelhead, the estimates are 20.5% and 11.7% for wild and hatchery smolts, respectively (Figure 3). These estimates represent the percentage of smolts that arrived at Lower Granite Dam that were subsequently transported, either from Lower Granite Dam or downstream at Little Goose or Lower Monumental Dam. Estimated percentages transported in 2020 are among the lowest in our time series.

Discussion

For Snake River yearling Chinook salmon in 2020, estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace was 76.1%; this estimate is slightly above the long-term (1999-2020) average of 73.5%. With the exception of unusually low survival in 2019, Yearling Chinook survival through this reach has been stable since 2005. The 2020 estimate appears to be essentially right in the middle of the stable 2005-2020 survival band.

However, the individual component reach survival estimates for Chinook salmon between the Snake River dams were extremely imprecise (Figure 2). The point estimate for Lower Granite Dam to Little Goose Dam was very low, while that for Little Goose Dam to Lower Monumental Dam was very high. When such a pattern occurs, it is typically the result of the negative statistical correlation between survival estimates in consecutive reaches, and is amplified when sampling variation is high. High sampling variation in these estimates was the result of extremely low detection (1% or even less) for multiple biweekly cohorts at both Little Goose Dam and Lower Monumental Dam. In this case, the CJS model is unable to effectively apportion overall survival between the two reaches.

This pattern can also result from a violation of the assumptions of the CJS model. Wide fluctuations in spill within each day produced by the flex spill program could have led to such a violation. We will investigate this possibility in the upcoming report.

Unlike in 2019, survival upstream of Lower Granite Dam was not consistently low for Chinook salmon in 2020. Most hatchery stocks of Chinook salmon had above average survival from release to Lower Granite Dam. However, survival for both hatchery and

wild Chinook was substantially below average in the reach from the Snake River Trap to Lower Granite Dam; the third consecutive year of below-average survival through the Lower Granite project. We do not have high confidence in the 2020 wild-only estimates for this reach because of extremely small sample sizes, but if this trend of low survival continues it raises a need for further investigation.

For Snake River steelhead in 2020, estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace was 79.4%. This was well above the long-term mean of 66.8%, and actually the highest estimate on record for this reach (Table 5). The 2020 survival estimate is also the least precise estimate for this reach since 1996, though the lower bound of the 95% confidence interval for the 2020 estimate is 71%, which is still above the mean. Similarly to Chinook, the individual component reach survival estimates for steelhead were highly imprecise (Figure 2).

Environmental conditions and management actions in 2020 resulted in a year with overall average water temperatures (but with high variability day-to-day), lower than average flow, and extremely high spill for most of the migration season. Mean flow at Little Goose Dam in 2020 during the main migration period 1 April–15 June was 80.4 kcfs, which was below the long-term (1993-2020) mean of 93.2 kcfs. Daily flow values were well below long-term daily means for most of April; in late April and May a number of short pulses in flow resulted in rapid oscillations from below to above the daily mean (Figure 4).

Mean water temperature at Little Goose Dam during the 2020 migration period was 11.0 °C, which was near the long-term mean of 11.2 °C. However, the rapid oscillations in flow in late April and May were also associated with sharp fluctuations in daily water temperature (Figure 4). Multiple peaks in water temperature were observed in May and June, including extremely rapid warming during the first few days of June.

Mean spill discharge at the Snake River dams during the 2020 migration was 52.4 kcfs, which was far above the 2006-2020 mean of 35.5 kcfs and was the highest mean spill in our time series, except for the high-flow year 2017. Daily spill discharge was only slightly above average for most of April, rose to well above average in late April, and stayed very high for the remainder of the migration period (Figure 5).

Spill as a percentage of flow at Snake River dams averaged 60.7% in 2020, which was nearly double the long-term (2006-2020) mean

of 36.4% and was by far the highest recorded mean spill percent on record. Daily mean spill percentages in 2020 were extremely high for the entire migration period (Figure 5).

Dissolved gas saturation was higher in 2020 than in most years in the 2006-2020 period, especially in May and early June (Figure 6). Dissolved gas saturation rose quickly in late April and stayed above 120% until the second week of June, briefly surpassing 125% for a couple of days at the very end of May.

Flow and temperature were highly variable in 2020, with multiple spikes in both daily time series (Figure 4). Spikes in flow around May 1 and May 14 appeared to be associated with spikes in smolt passage at Lower Granite Dam (Figure 7). However, earlier spikes in smolt passage around April 15 and April 20 occurred during a period of below-average flow; these earlier pulses of migration may be related to the warmer than average water temperature around that time.

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

In 2020, collection for transportation began on 24 April at Lower Granite and Little Goose Dams and on 23 April at Lower Monumental Dam. Similarly, in 2019 collection began on 24 April. These dates were at least 7 days earlier than the start date of 1 May, or later, typical in most recent years. However, the proportion of smolts transported in 2020 was far lower than in 2018 or 2019, indicating that either run timing shifted significantly in 2020 or that collection rates were very low.

The run in 2020 was not particularly early; only a modest proportion of smolts passed the collector dams before transportation began. We estimate that 25.5% of wild and 22.1% of hatchery Chinook salmon, and 10.6% of wild and 37.3% of hatchery steelhead passed prior to the start of transportation. These numbers are lower than in either 2018 or 2019, indicating that run timing is not a cause of the low transportation rate in 2020.

In 2020, very low proportions of passing smolts were collected after the start of transportation. We estimate that 24.0% of wild and 15.7% of hatchery Chinook and 22.7% of wild and 17.2% of hatchery steelhead that passed during transport operations were

collected and transported. These collection rates are less than half of those from 2018 or 2019; this was a result of extremely high spill during the 2020 migration.

Over the last several years we have noted a trend toward shorter smolt travel times relative to levels of flow and spill. This trend appeared to continue in 2020, at least relative to flow. During early April when flow was well below average (Figure 4), travel times for both Chinook and Steelhead were longer than in many recent years, though still about equal to the overall average. After mid-April, when flow reached near average, travel times for both Chinook and steelhead shortened substantially (Figure 8). In late April and May of 2020 travel time for steelhead was very short, even compared to years with much higher flow than in 2020. Travel time for Chinook during the same period was shorter than in any other year on record. These very short travel times are possibly related to the extremely high spill during the 2020 migration season.

Unfortunately for quantity and quality of data, a side effect of increased spill since 2006 has been a drop in detection rates of smolts at Snake and Columbia River dams. Spill increased further in 2018 and 2019, with a corresponding decrease in detection rates, and the exceptionally high spill in 2020 resulted in exceptionally low detection rates.

In one respect, 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 were similar to past years. However, detection at downstream dams continues to occur only in juvenile bypass systems. Despite otherwise sufficient sample sizes of fish leaving Lower Granite Dam, survival estimates downstream to McNary Dam for 2020 are extremely imprecise.

In addition, low detection rates decrease “resolution” of the information, requiring pooling data into larger temporal groups, for example. For many smaller groups, estimates were so imprecise they are essentially uninformative, or estimation was not even possible. Eventual additional data from downstream of Bonneville Dam (bird-colony recoveries) will improve estimates to McNary Dam very little.

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 the levels of 2020, or even of 2018-2019, 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 is very encouraging. 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. 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 the region should place a very high priority on installing similar systems at other dams on the Snake and Columbia rivers, especially McNary Dam and Bonneville Dam, or investigate alternative technologies that will boost our abilities to detect PIT-tagged fish.

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Table 1. 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), 2018 through 2020.

Hatchery	2018		2019		2020[a]	
	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	0.744 (0.015)	0.546 (0.023)	0.688 (0.013)	0.466 (0.021)	0.813 (0.011)	0.582 (0.034)
Kooskia	0.633 (0.030)	0.438 (0.044)	0.571 (0.022)	0.352 (0.041)	0.739 (0.028)	0.526 (0.069)
Lookingglass (Catherine Cr.)	0.314 (0.008)	0.232 (0.024)	0.454 (0.018)	0.392 (0.044)	0.531 (0.015)	0.416 (0.046)
Lookingglass (Grande Ronde)	0.347 (0.013)	0.238 (0.043)	0.465 (0.038)	0.253 (0.064)	0.466 (0.053)	0.391 (0.180)
Lookingglass (Imnaha Weir)	0.651 (0.012)	0.429 (0.034)	0.627 (0.025)	0.459 (0.048)	0.628 (0.017)	0.456 (0.043)
Lookingglass (Lostine River)	0.600 (0.014)	0.418 (0.057)	0.559 (0.022)	0.414 (0.054)	0.560 (0.029)	0.455 (0.088)
McCall (Johnson Cr.)	0.487 (0.029)	0.370 (0.104)	---	---	0.602 (0.058)	0.402 (0.184)
McCall (Knox Bridge)	0.702 (0.011)	0.519 (0.026)	0.616 (0.014)	0.528 (0.029)	0.734 (0.011)	0.528 (0.032)
Pahsimeroi	0.634 (0.015)	0.342 (0.034)	0.280 (0.008)	0.161 (0.020)	0.565 (0.019)	0.368 (0.052)
Rapid River	0.651 (0.009)	0.491 (0.023)	0.491 (0.009)	0.433 (0.024)	0.568 (0.010)	0.395 (0.026)
Sawtooth	0.519 (0.013)	0.372 (0.029)	0.539 (0.021)	0.358 (0.032)	0.683 (0.020)	0.483 (0.052)
Entiat	---	0.572 (0.037)	---	0.565 (0.053)	---	0.558 (0.054)
Winthrop	---	0.587 (0.046)	---	0.490 (0.055)	---	0.583 (0.067)
Leavenworth	---	0.658 (0.038)	---	0.515 (0.035)	---	0.614 (0.050)

a. Estimates are preliminary and subject to change.

Table 2. Annual weighted means of survival probability estimates for yearling **Chinook** salmon (hatchery and wild combined), 1997–2020. 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 (1993–2020) are given.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
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 (0.008)	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)	0.940 (0.007)	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
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[a]	0.854 (0.060)	0.780 (0.032)	1.272 (0.138)	0.959 (0.138)	0.979	TBD[c]	TBD[c]	TBD[c]
Mean[b]	**0.921 (0.010)**	**0.921 (0.008)**	**0.936 (0.015)**	**0.864 (0.012)**	**0.929 (0.006)**	**0.867 (0.019)**	**0.806 (0.023)**	**0.896 (0.013)**

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. Annual estimates for 1993-1996 are omitted from the table for space.
c. Estimate currently unavailable for this reach. Estimate may be available in the full detailed report, once PIT tag recoveries from avian colonies are complete.

Table 3. Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River yearling **Chinook** salmon (hatchery and wild combined), 1997–2020. 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
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)
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[a]	0.854 (0.060)	0.761 (0.036)	TBD[c]	TBD[c]	TBD[c]
Mean[b]	**0.921 (0.010)**	**0.735 (0.012)**	**0.701 (0.020)**	**0.522 (0.019)**	**0.485 (0.019)**

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. Annual estimates for 1993-1996 are omitted from the table for space.
c. Estimate currently unavailable for this reach. Estimate may be available in the full detailed report, once PIT tag recoveries from avian colonies are complete.

Table 4. Annual weighted means of survival probability estimates for **steelhead** (hatchery and wild combined), 1997–2020. 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 (1993–2020) are given.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
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
2017	NA	0.962 (0.008)	0.943 (0.015)	0.849 (0.022)	0.921	0.941 (0.020)	0.643 (0.040)	0.802
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[a]	0.920 (0.042)	1.019 (0.066)	1.017 (0.118)	0.759 (0.063)	0.871	TBD[c]	TBD[c]	TBD[c]
Mean[b]	**0.951 (0.010)**	**0.935 (0.010)**	**0.916 (0.012)**	**0.774 (0.025)**	**0.876 (0.016)**	**0.842 (0.037)**	**0.800 (0.031)**	**0.891 (0.017)**

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. Annual estimates for 1993-1996 are omitted from the table for space.
c. Estimate currently unavailable for this reach. Estimate may be available in the full detailed report, once PIT tag recoveries from avian colonies are complete.

Table 5. Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River **steelhead** (hatchery and wild combined), 1997–2020. 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
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)
2017	NA	0.759 (0.019)	0.605 (0.037)	0.459 (0.030)	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[a]	0.920 (0.042)	0.794 (0.043)	TBD[c]	TBD[c]	TBD[c]
Mean[b]	**0.951 (0.010)**	**0.668 (0.026)**	**0.676 (0.037)**	**0.470 (0.033)**	**0.457 (0.036)**

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. Annual estimates for 1993-1996 are omitted for space.
c. Estimate currently unavailable for this reach. Estimate may be available in the full detailed report, once PIT tag recoveries from avian colonies are complete.

Table 6. 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, 1999–2019. 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)
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[a]	0.626 (0.025)	TBD[c]	TBD[c]	TBD[c]	0.440 (0.040)	TBD[c]	TBD[c]	TBD[c]
Mean[b]	**0.560 (0.011)**	**0.897 (0.021)**	**0.900 (0.039)**	**0.812 (0.029)**	**0.415 (0.013)**	**0.892 (0.028)**	**0.864 (0.054)**	**0.764 (0.048)**

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.
c. Estimate currently unavailable for this reach. Estimate may be available in the full detailed report, once PIT tag recoveries from avian colonies are complete.

Table 7. 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 Rock Island Dam tailrace to Bonneville Dam tailrace for fish originating in the upper Columbia River, 1998–2019; years prior to 1998 omitted for space. 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; RIS–Rock Island Dam.

	Snake River Sockeye			Upper Columbia River Sockeye		
Year	LGR-MCN	MCN-BON	LGR-BON	RIS-MCN	MCN-BON	RIS-BON
1998	0.689 (0.157)	0.142 (0.099)	0.177 (0.090)	0.624 (0.058)	1.655 (1.617)	1.033 (1.003)
1999	0.655 (0.083)	0.841 (0.584)	0.548 (0.363)	0.559 (0.029)	0.683 (0.177)	0.382 (0.097)
2000	0.679 (0.110)	0.206 (0.110)	0.161 (0.080)	0.487 (0.114)	0.894 (0.867)	0.435 (0.410)
2001	0.205 (0.063)	0.105 (0.050)	0.022 (0.005)	0.657 (0.117)	NA	NA
2002	0.524 (0.062)	0.684 (0.432)	0.342 (0.212)	0.531 (0.044)	0.286 (0.110)	0.152 (0.057)
2003	0.669 (0.054)	0.551 (0.144)	0.405 (0.098)	NA	NA	NA
2004	0.741 (0.254)	NA	NA	0.648 (0.114)	1.246 (1.218)	0.808 (0.777)
2005	0.388 (0.078)	NA	NA	0.720 (0.140)	0.226 (0.209)	0.163 (0.147)
2006	0.630 (0.083)	1.113 (0.652)	0.820 (0.454)	0.793 (0.062)	0.767 (0.243)	0.608 (0.187)
2007	0.679 (0.066)	0.259 (0.084)	0.272 (0.073)	0.625 (0.046)	0.642 (0.296)	0.401 (0.183)
2008	0.763 (0.103)	0.544 (0.262)	0.404 (0.179)	0.644 (0.094)	0.679 (0.363)	0.437 (0.225)
2009	0.749 (0.032)	0.765 (0.101)	0.573 (0.073)	0.853 (0.076)	0.958 (0.405)	0.817 (0.338)
2010	0.723 (0.039)	0.752 (0.098)	0.544 (0.077)	0.778 (0.063)	0.627 (0.152)	0.488 (0.111)
2011	0.659 (0.033)	NA	NA	0.742 (0.088)	0.691 (0.676)	0.513 (0.498)
2012	0.762 (0.032)	0.619 (0.084)	0.472 (0.062)	0.945 (0.085)	0.840 (0.405)	0.794 (0.376)
2013	0.691 (0.043)	0.776 (0.106)	0.536 (0.066)	0.741 (0.068)	0.658 (0.217)	0.487 (0.155)
2014	0.873 (0.054)	0.817 (0.115)	0.713 (0.096)	0.428 (0.056)	0.565 (0.269)	0.242 (0.111)
2015	0.702 (0.054)	0.531 (0.151)	0.373 (0.037)	0.763 (0.182)	0.446 (0.200)	0.340 (0.130)
2016	0.523 (0.047)	0.227 (0.059)	0.119 (0.030)	0.807 (0.082)	0.545 (0.126)	0.448 (0.144)
2017	0.544 (0.081)	0.324 (0.107)	0.176 (0.055)	0.719 (0.113)	0.611 (0.181)	0.500 (0.332)
2018	0.684 (0.061)	0.940 (0.151)	0.643 (0.088)	0.927 (0.118)	0.560 (0.112)	0.344 (0.124)
2019	0.836 (0.053)	0.520 (0.044)	0.434 (0.031)	0.941 (0.125)	0.701 (0.120)	0.737 (0.191)
2020	0.835 (0.120)	TBD[c]	TBD[c]	0.894 (0.214)	TBD[c]	TBD[c]
Mean[b]	**0.645 (0.034)**	**0.564 (0.066)**	**0.407 (0.049)**	**0.705 (0.033)**	**0.714 (0.070)**	**0.506 (0.052)**

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. Annual estimates for 1995-1996 are omitted for space.
c. Estimate currently unavailable for this reach. Estimate may be available in the full detailed report, once PIT tag recoveries from avian colonies are complete.

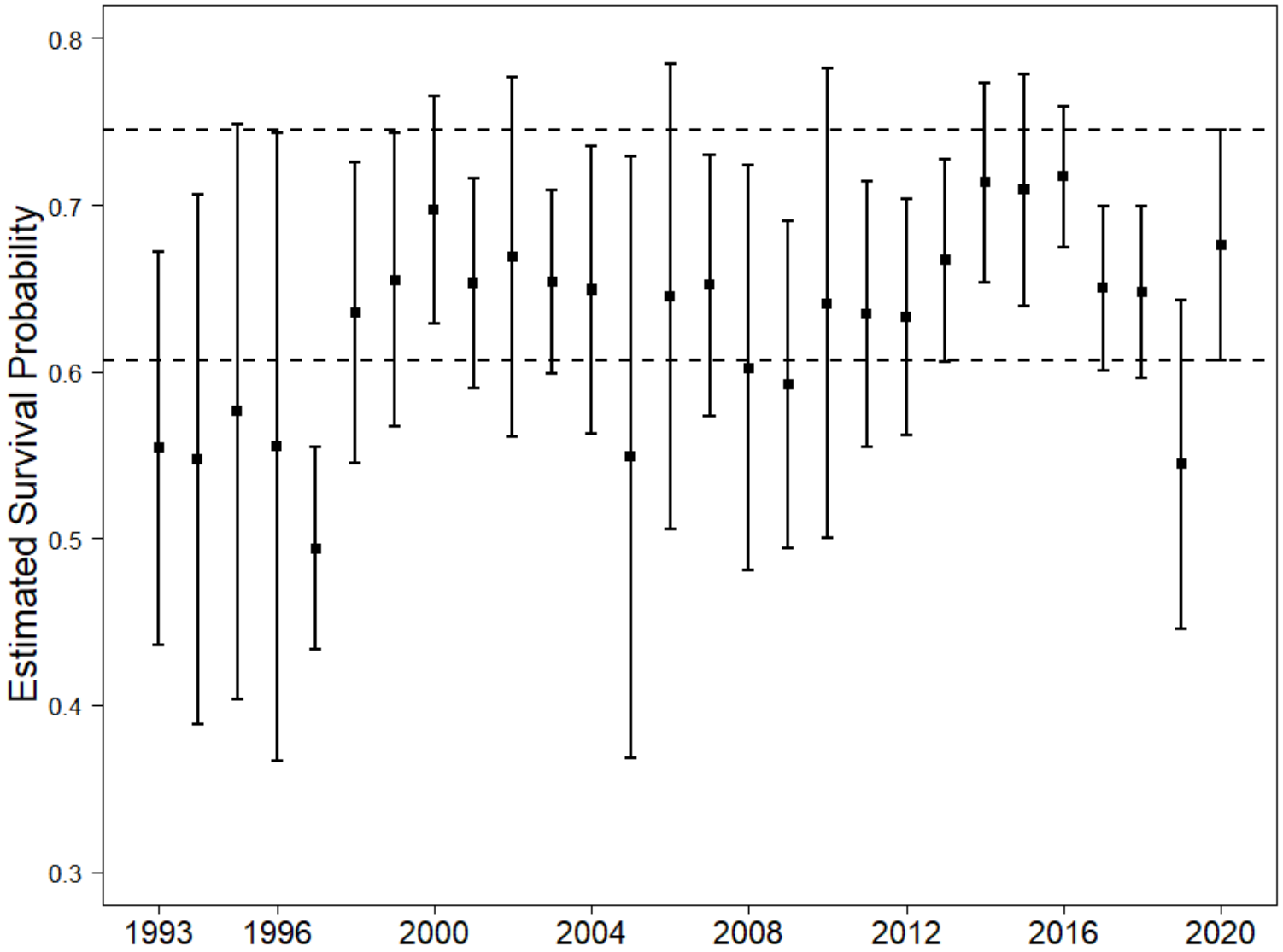

Figure 1. Annual average survival estimates from release to Lower Granite Dam for PIT-tagged yearling **Chinook** salmon released from Snake River Basin hatcheries, 1993-2020. Hatcheries used for average (index groups) are those with consistent PIT-tag releases through the series of years shown. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are the 2020 confidence interval endpoints and are shown for comparison to other years.

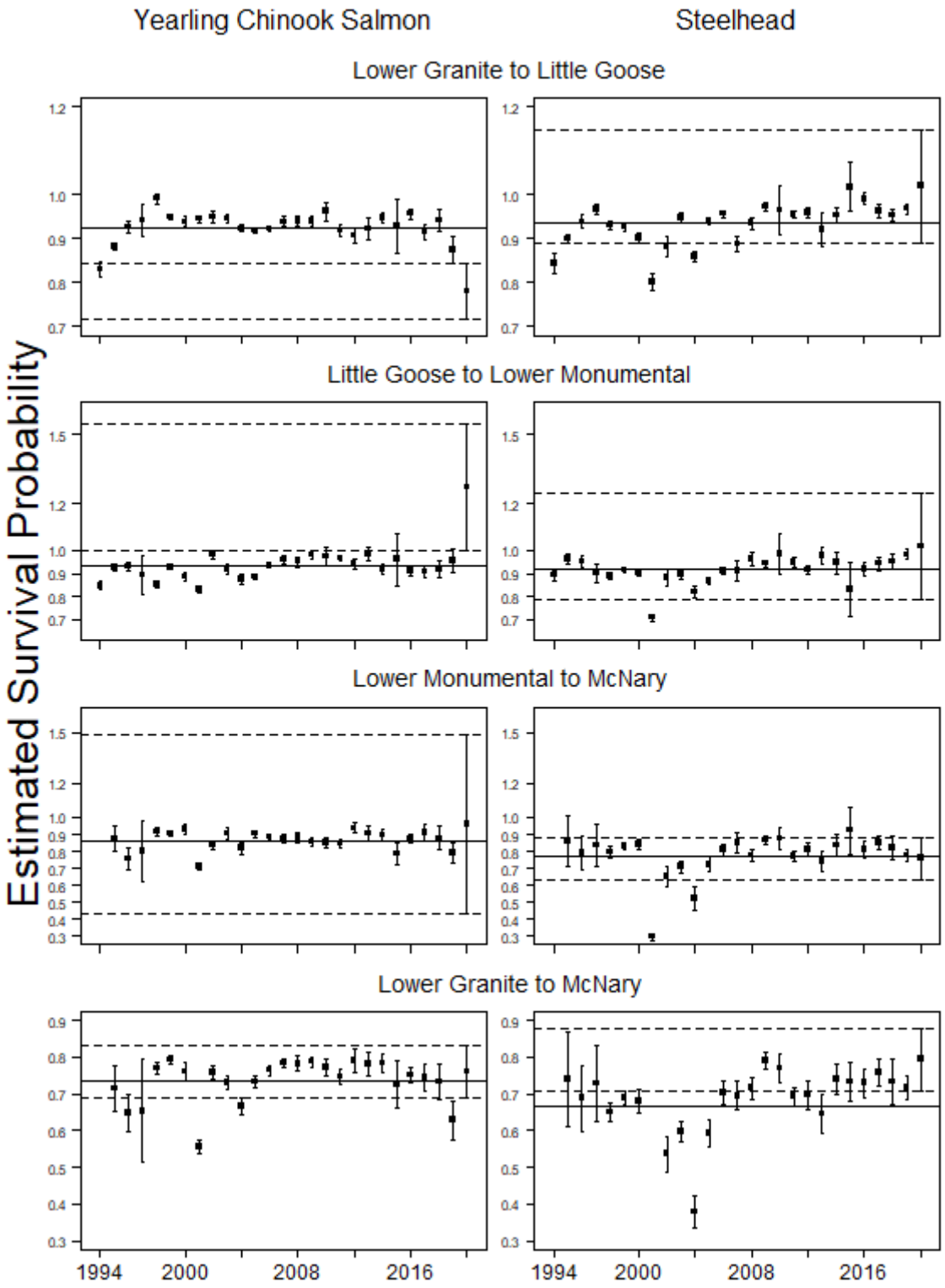

Figure 2. Annual average survival estimates for PIT-tagged yearling **Chinook** salmon and **steelhead**, hatchery and wild fish combined. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are 95% confidence interval endpoints for 2020 estimates.

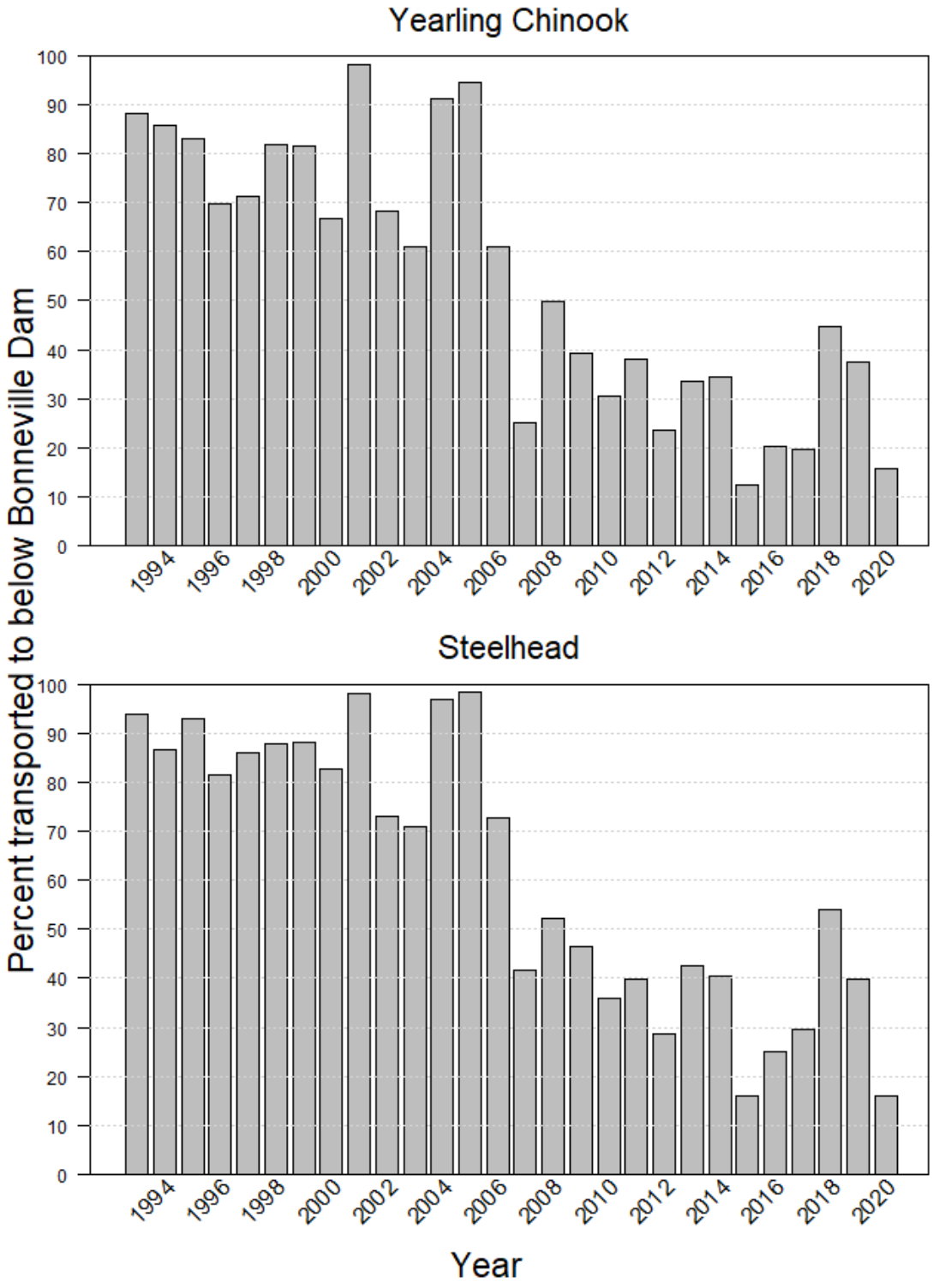

Figure 3. Annual estimates of the percentage of yearling Chinook salmon and steelhead smolts (mean of estimates for hatchery and wild smolts) that arrived at Lower Granite Dam that were subsequently transported, either from Lower Granite Dam or downstream from Little Goose or Lower Monumental Dam, to below Bonneville Dam (1993-2020).

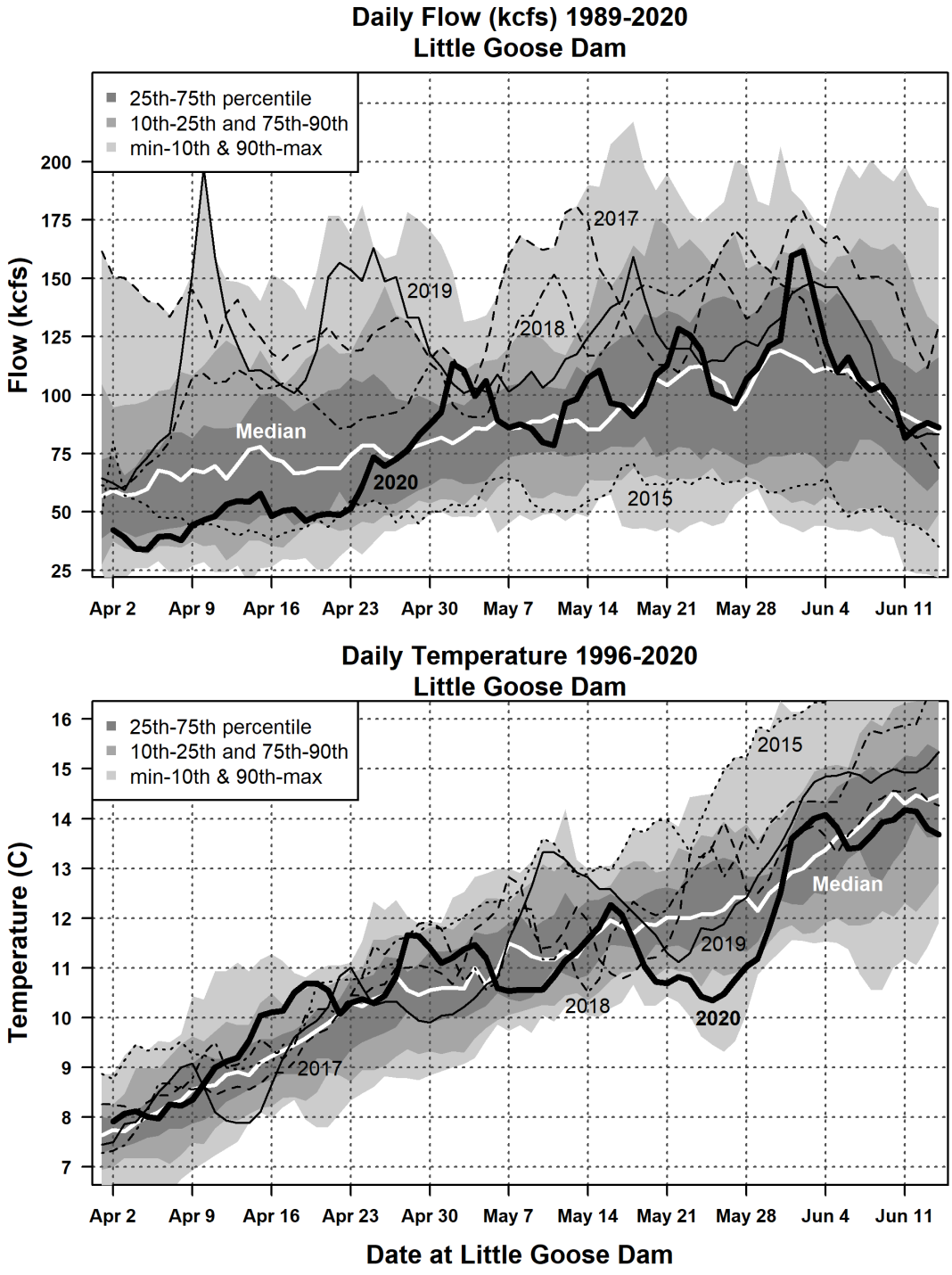

Figure 4. Upper panel shows daily mean Snake River flow from April to mid-June at Little Goose Dam. Long-term median flow and daily mean flows for 2020 and selected recent years are plotted as lines. Shaded areas illustrate quantiles for each date in the 1989-2020 data set. Lower panel uses the same format to show daily mean temperature at Little Goose Dam. Quantiles for daily temperature are calculated from the 1996-2020 data set.

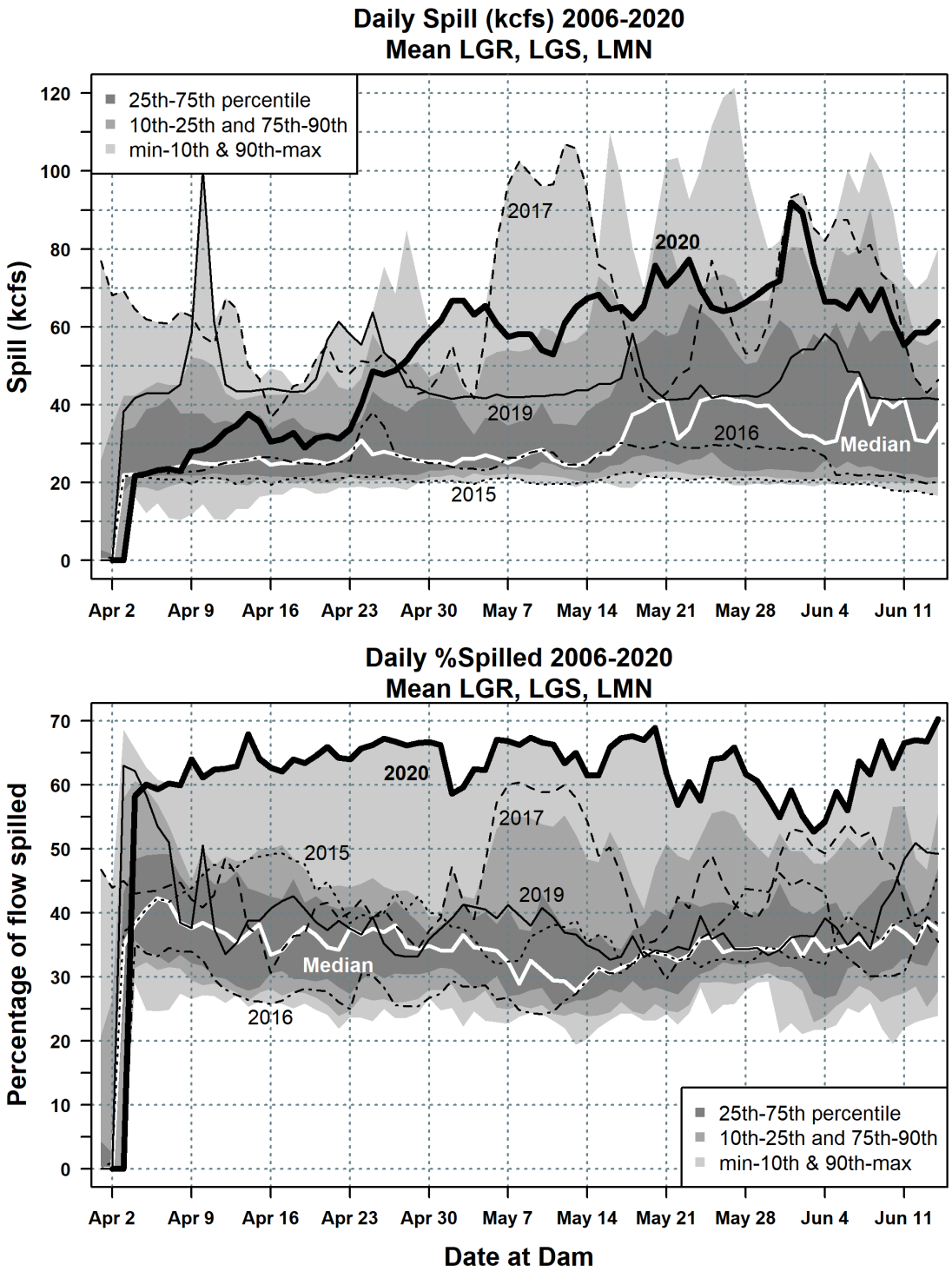

Figure 5. Upper panel shows daily mean (kcfs) Snake River spill from April to mid-June, averaged across Lower Granite, Little Goose and Lower Monumental Dams. Lower panel shows daily spill as a percentage of total flow. Daily values for 2020, the long-term median, and selected recent years are plotted as lines. Shaded areas indicate quantiles for each date from the long-term data set 2006-2020.

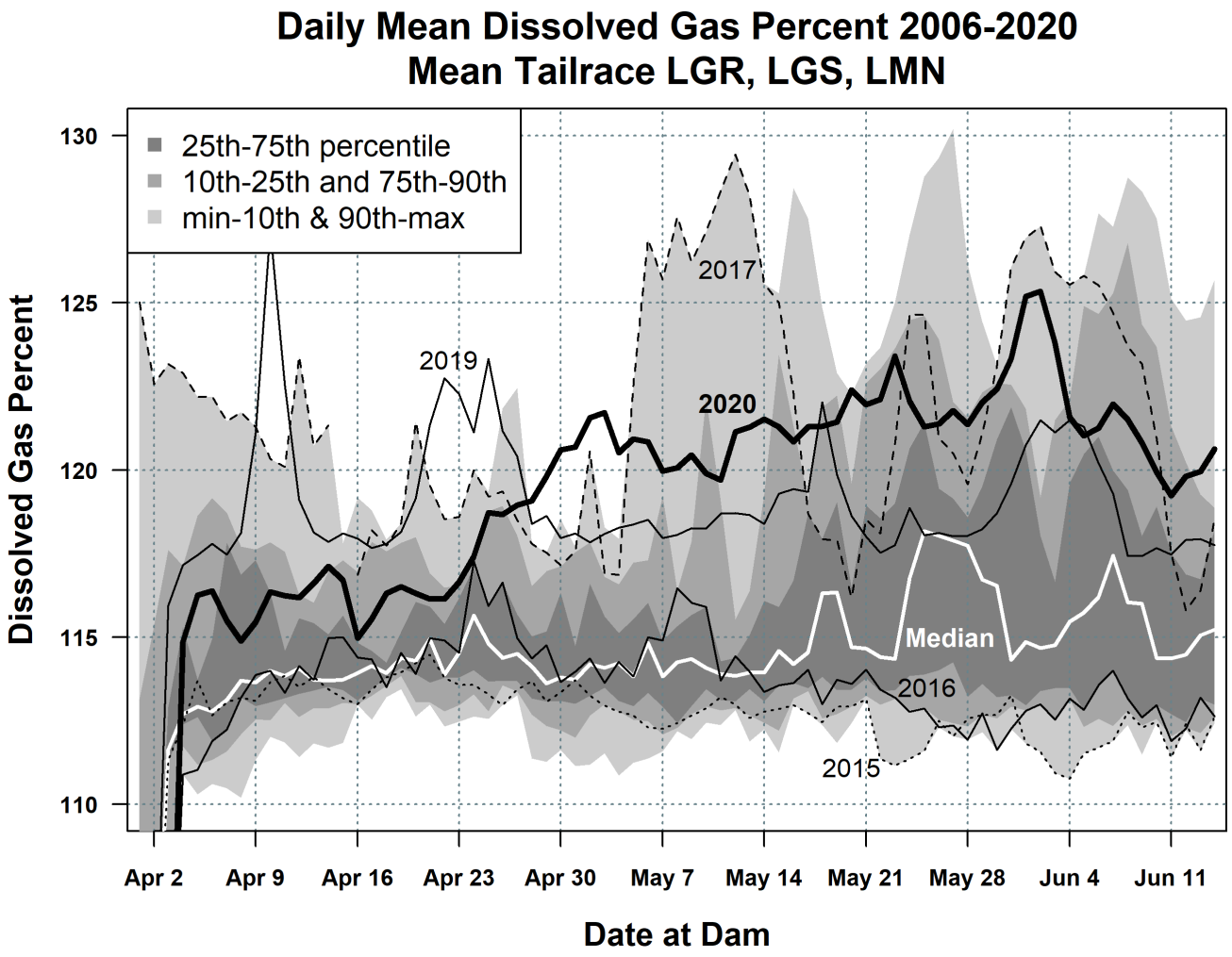

Figure 6. Daily mean percentage of dissolved gas averaged across Lower Granite, Little Goose and Lower Monumental Dam from April to mid-June. Daily percentages from 202 and selected recent years are plotted against the long-term median from 2006 to 2020, with shaded areas indicating daily mean quantiles.

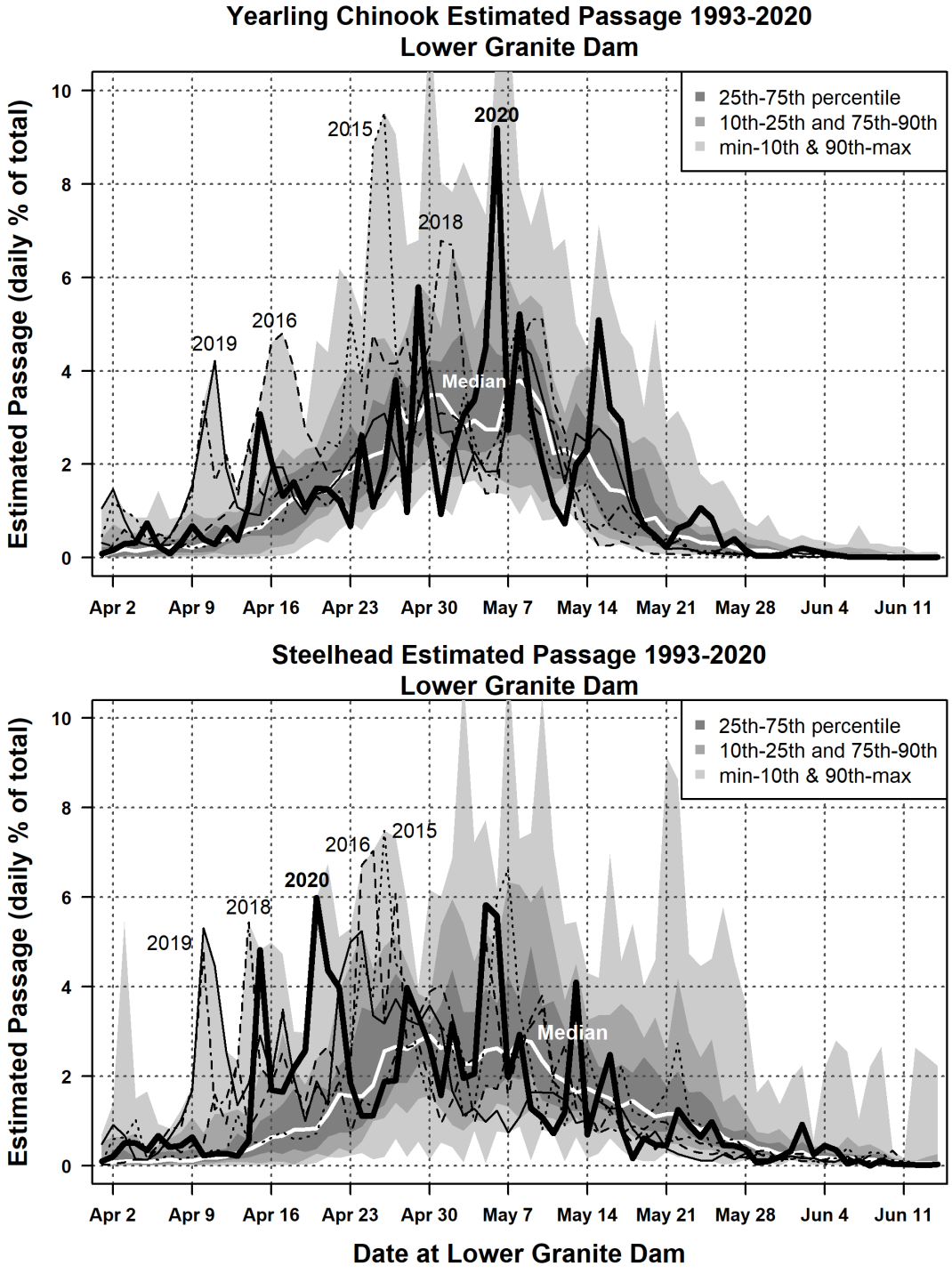

Figure 7. Estimated daily smolt passage at Lower Granite Dam for yearling Chinook salmon and steelhead. Daily passage expressed as percentage of the total for the year. Daily values for 2020, the long-term median, and selected recent years are plotted as lines. Shaded areas indicate quantiles for each date from the long-term data set 1993-2020.

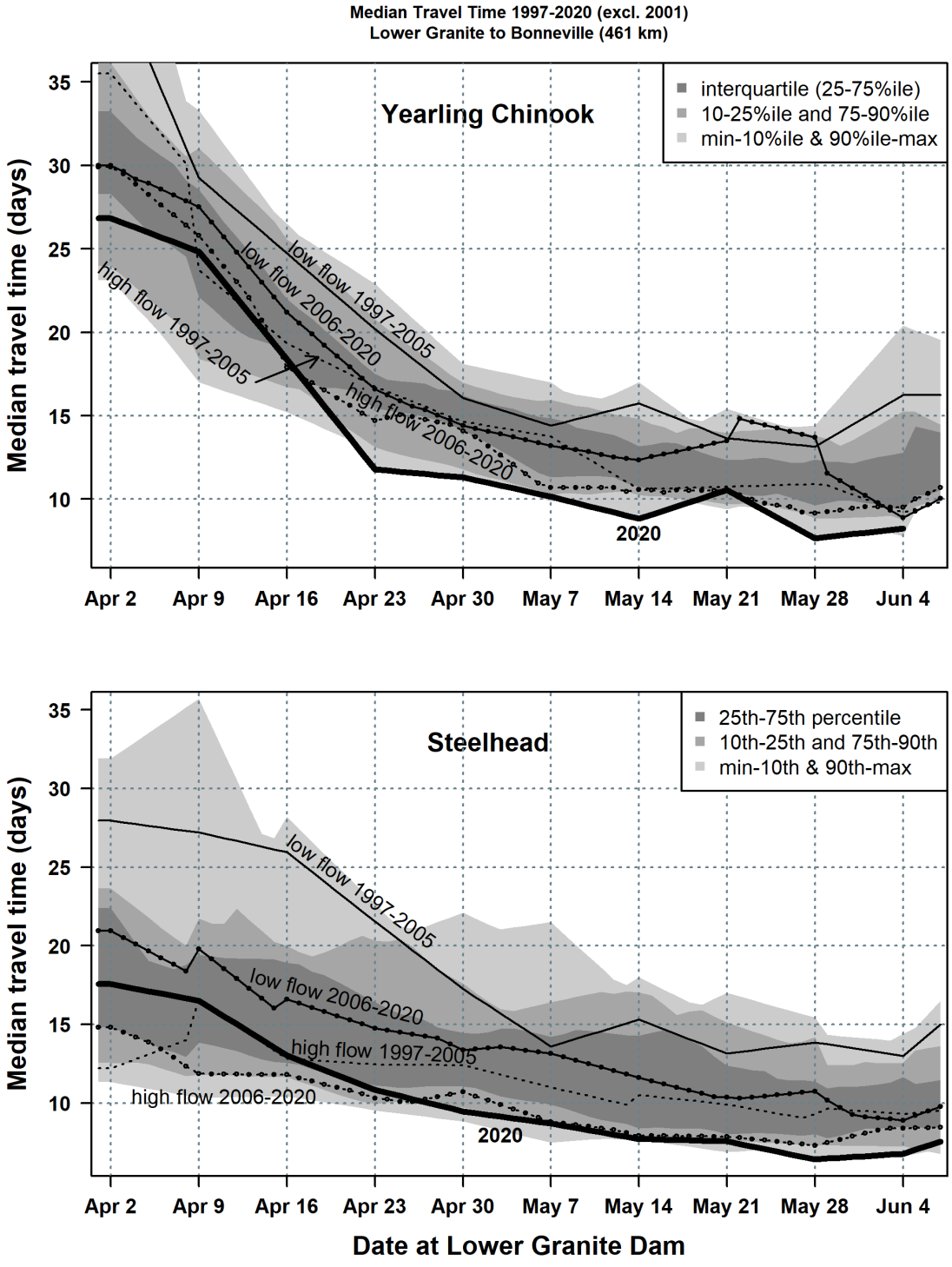

Figure 8. Median travel time (d) from Lower Granite to Bonneville Dam (461 km) for weekly groups of yearling Chinook salmon and steelhead. Shaded regions show daily quantiles during 1997-2020 (excluding 2001). Lines show daily medians from low- and high-flow years by spill regime, with low-flow years for the former (2004-2005) and present regime (2007, 2010, 2013, and 2015) and high-flow years for the former (1997 and 2006) and present regime (2011, 2012, 2017, 2018, and 2019).