#### Chilkat Lake Sockeye Salmon

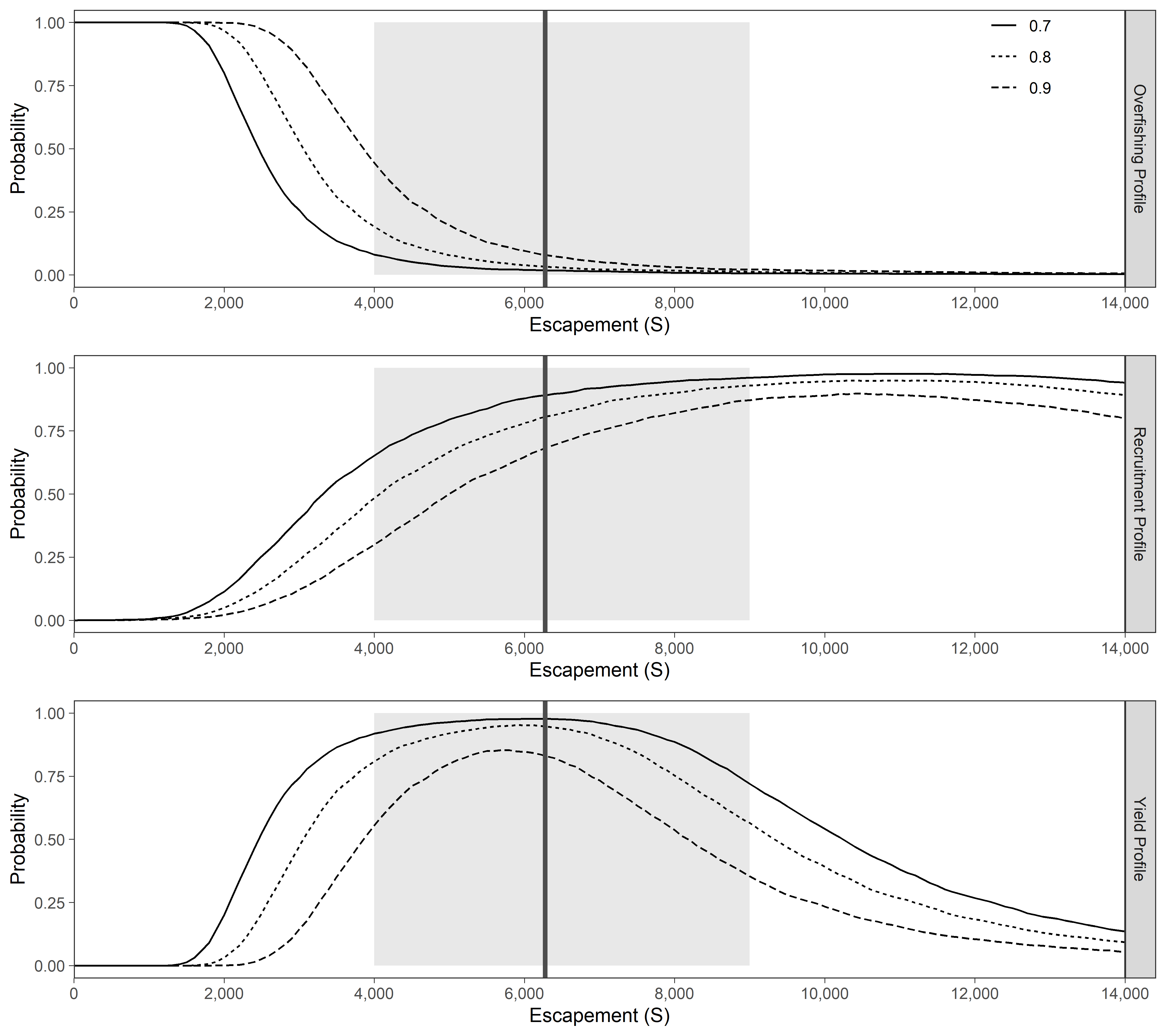
Chilkat Lake, located approximately 44 river km upstream from the city of Haines, supports one of the largest runs of sockeye salmon in Southeast Alaska. Chilkat Lake sockeye salmon are primarily harvested in the District 15 commercial drift gillnet fishery in northern Lynn Canal. Smaller but unknown portions of the Chilkat run are harvested in the commercial purse seine fisheries that target pink salmon in Icy and northern Chatham straits (Ingledue 1989; Gilk-Baumer et al. 2015) and in subsistence fisheries in Chilkat Inlet and in the Chilkat River. As noted above, scale pattern analysis has been used to apportion District 15 commercial harvests of sockeye salmon bound for Chilkat Lake and other systems in the area (McPherson 1990). Chilkat Lake sockeye salmon escapements have been estimated through weir counts (1967–1993), weir counts with concurrent mark–recapture estimates (1994 and 1995, 1999–2007), mark–recapture estimates only (1996–1998), and Dual-frequency Identification Sonar (DIDSON) counts with concurrent mark–recapture estimates (2008–2022) (Eggers et al. 2010; Sogge and Bachman 2014; ; Zeiser et al. 2020; Ransbury et al. 2021). Visual weir counts provided minimum estimates of escapement due to flow reversals, turbid water, and frequent lowering of a boat gate in the middle of the weir, all of which potentially allowed fish to pass undetected. Conversely, mark–recapture estimates may be greatly inflated, but may provide an index of escapement (Bednarski et al. 2017). DIDSON counts are also considered minimum estimates of escapement due to undetected passage of small numbers of fish at night during flow reversals; however, confidence in DIDSON counts is much greater than in the visual weir counts.

The current biological escapement goal range of 70,000–150,000 sockeye salmon (Eggers et al. 2008, 2010) was established in 2009. Following a comprehensive review of historical stock assessment data (Bednarski et al. 2017), the escapement goal analysis was most recently update in 2018 by Miller and Heinl (2018). Miller and Heinl (2018) fit age-structured state-space spawner-recruit models to 1976–2016 data on abundance, harvest, age composition, and coefficients of variation to examine the effect of autocorrelation and fry stocking on recruits, to account for multiple overlapping methods of escapement enumeration and missing data (age composition was considered unknown in the model for years 1996–1998 when the weir was not operated). DIDSON escapement counts were treated as the ‘true’ counts and the weir counts and mark–recapture estimates of escapement were treated as indices of escapement in the state-space models. Despite the additional years of data (brood years 1976−2012), a more sophisticated age-structured model framework, a slightly different Ricker model form, and the exclusion of the fry stocking term, the resulting parameter estimates were very similar to those estimated by Eggers et al. (2010). As a result, the current biological escapement goal of 70,000–150,000 sockeye salmon, counted with the DIDSON system at the Chilkat Lake weir site (Heinl et al. 2017), remained unchanged.

With the accumulation of more brood year returns (brood years 1976−2016), the escapement goal was recently reviewed. A similar approach to Miller and Heinl (2018) was taken; an age-structured state-space spawner-recruit model. *The estimated spawning abundance that produced maximum sustained yield from Eggers et al. (2010) was 105,000 spawners. The posterior median of escapement leading to maximum sustained yield from the output of the state-space model was 98,370 spawners (95% credibility interval 66,765–223,966 spawners). The probability of achieving 90% of maximum sustained yield (MSY) at the upper and lower bounds of the current escapement goal is estimated to be 62% and 34%, respectively (Appendix Figure B 10), and an average 65% over the entire escapement goal range. Yield would be maximized at escapements near SMSY (near 84% probability of achieving 90% of MSY). These probabilities improve substantially with respect to achieving 80% of MSY. The escapement goal review committee recommended maintaining the current biological escapement goal of 70,000–150,000 fish counted with the DIDSON system at the Chilkat Lake weir site.*

**Table 1.**–*Parameter estimates from the state-space model fitted to the Speel Lake sockeye salmon data for calendar years 1983–2019. Posterior medians are point estimates; the 2.5th and 97.5th percentiles define 95% credible intervals for the parameters.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **2.5th Percentile** | **Median** | **97.5th percentile** |
| ** | 1.95 | 3.45 | 7.31 |
| ln(**) | 0.67 | 1.24 | 1.99 |
| ln(**)’ | 0.80 | 1.36 | 2.23 |
| ** | 3.08 x 10-5 | 9.38 x 10-5 | 1.83 x 10-4 |
| ** | -0.21 | 0.28 | 0.74 |
| **R | 0.35 | 0.46 | 0.63 |
| *S*EQ | 10,504 | 14,782 | 29,740 |
| *S*MAX | 5,452 | 10,666 | 32,515 |
| *S*MSY | 3,916 | 5,946 | 12,824 |
| *U*MSY | 0.36 | 0.55 | 0.77 |
| D.sum | 10 | 17 | 28 |
| *p*4 | 0.32 | 0.37 | 0.41 |
| *p*5 | 0.56 | 0.60 | 0.65 |
| *p*6 | 0.02 | 0.03 | 0.04 |
| B.sum | 4 | 7 | 12 |

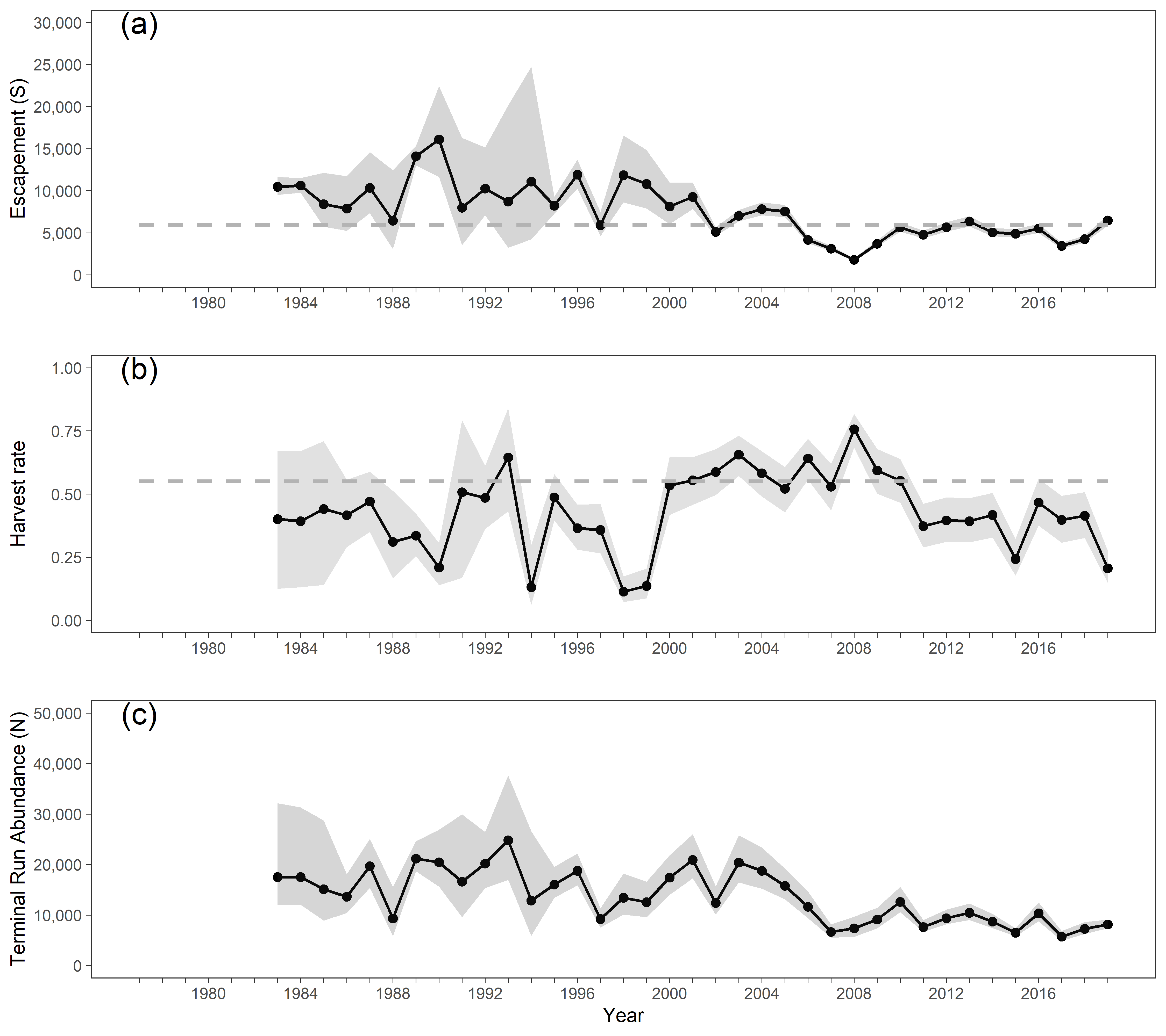


**Figure 1.**–*Overfishing profiles (OFPs), optimal recruitment profiles (ORPs), and optimal yield profiles (OYPs) for Speel Lake sockeye salmon. OYPs and ORPs show probability that a specified spawning abundance will result in specified fractions (70%, 80%, and 90% line) of maximum sustained yield or maximum recruitment. OFPs show the probability that reducing escapement to a specified spawning abundance will result in less than specified fractions of maximum sustained yield. The shaded region shows the current sustainable escapement goal range of 4,000 to 9,000 spawners and the solid vertical line is the posterior median of spawning abundance at maximum sustained yield (SMSY) obtained from the state-space model.*

Diagram

Description automatically generated with medium confidence

**Figure 2.**–*Plausible spawner-recruit relationships (shaded regions around the dashed line) for Speel Lake sockeye salmon as derived from a Bayesian state-space model fitted to abundance, harvest, and age data for calendar years 1983–2019. Posterior medians of recruits and spawners are plotted as brood year labels with 95% credible intervals (grey lines). The heavy dashed line is the Ricker relationship constructed from ln(α’) and β posterior medians with 90% and 95% credible intervals (shaded areas). Recruits replace spawners on the solid diagonal line.*



**Figure 3.**–*Point estimates (posterior medians; circles with solid lines) and 95% credible intervals (gray shading) of (a) spawning escapement, (b) harvest rate, and (c) run abundance from the state-space spawner-recruit model of Speel Lake sockeye salmon, 1983–2019. Posterior medians of optimal escapement, SMSY, and harvest rate, UMSY, are plotted as dashed horizontal reference lines in (a) and (b), respectively.*

Appendix B .–Chilkat Lake sockeye salmon.

Chilkat Lake is a relatively clear lake located approximately 43 river km upstream from the city of Haines. The Chilkat drainage supports one of the larger runs of sockeye salmon in the region, which is harvested primarily in the District 15 Lynn Canal commercial drift gillnet fishery. Chilkat Lake sockeye salmon escapements have been estimated through weir counts (1967–1993), weir counts with concurrent mark–recapture estimates (1994, 1995, and 1999–2007), mark–recapture estimates only (1996–1998), and DIDSON counts with concurrent mark–recapture estimates (2008–2016) (Eggers et al. 2010; Sogge and Bachman 2014; Bednarski et al. *in press*.).

**Escapement Goals and Stock Status:** The Chilkat Lake sockeye salmon run has been managed for at least five different escapement goals since 1976. Informal goals of 60,000–70,000 fish (1976–1980) and 70,000–90,000 fish (1981–1989) (Bergander et al. 1988) were replaced in 1990 with a biological escapement goal range of 52,000–106,000 sockeye salmon based on a stock-recruit analysis (McPherson 1990). Efforts to update the escapement goal were hindered by lake stocking in the 1990s and concerns regarding accuracy of weir counts (Geiger et al. 2005). Geiger et al. (2005) converted the weir based goal to mark–recapture units and the goal was revised to a sustainable escapement goal range of 80,000–200,000 sockeye salmon from 2006 to 2008. In 2009, the Chilkat Lake escapement goal was revised to the current biological escapement goal range of 70,000–150,000 sockeye salmon (Eggers et al. 2008, 2010). Eggers et al. (2010) scaled weir counts to mark–recapture estimates, then fit a hierarchal set of stock-recruit models to the Chilkat River recruits from parental escapements of the 1979 to 2002 brood years. The biological escapement goal is the escapement range that produces ≥ 90% of maximum sustained yield as determined by an autoregressive Ricker (density dependence with first order autoregressive term) model with fry plants. A recent review (Miller and Heinl *in press*.; and in this report) suggests the escapement goal should remain unchanged. Escapements were within or above the escapement goal range in 5 of the past 5 years (Appendix Figure B 9).



Appendix Figure B .–Estimated Chilkat Lake sockeye salmon escapements (and 95% credibility intervals), 1976–2016, and biological escapement goal range of 70,000–150,000 fish. Expanded DIDSON counts are shown as data points, 2008–2016.

Chart, histogram

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Appendix Figure B .–Chilkat Lake sockeye salmon 80% and 90% probability profiles for optimal recruitment, optimal yield, and overfishing based on updated brood year escapement and return data, 1976–2016 (Miller and Heinl *in press*). The shaded region shows the current biological escapement goal range of 70,000 to 150,000 and the solid vertical line is the posterior median of spawning abundance at maximum sustained yield (approximately 98,000 fish) from the state-space model.