**Speel Lake Sockeye Salmon**

**Escapement Goal Revisited**

**Background**

The current biological escapement goal for Speel Lake sockeye salmon is **4,000–13,000** spawners, based on a stock-recruit analysis of 1983–1996 brood years and range of escapements expected to produce at least 80% of maximum sustained yield (MSY) (Riffe and Clark 2003).

In the current analysis (Heinl et al. 2014 *in prep.*), we expanded the dataset to include brood years 1983–2011 by updating harvest and weir escapement data. Weir counts in most years during 1984–2001 were truncated due to early weir removal (in late August). We expanded those counts by regressing cumulative escapement by date on cumulative total weir counts in 1983, 1995, and 2002–2013. We also gathered updated harvest data from the traditional mixed-stock District 11 fishery, and the Port Snettisham common property terminal and DIPAC cost-recovery fisheries in District 11.

Instead of using a traditional simple linear regression model, Speel Lake sockeye salmon spawner-recruit data were analyzed using a Bayesian age-structured state-space model to assess the uncertainty introduced into the estimated spawning size that produces MSY (*S*MSY), due to the following factors:

1. The truncation of weir counts that were expanded based on regressing cumulative

escapement by date on cumulative total weir counts in 1983, 1995, and 2002–2013; potential for large measurement error in the spawning escapement counts.

(2) Missing 1993 and 1994 escapements.

(3) Missing harvest estimates in years 1983–1985, 1991, 2012, and 2013.

(4) 1988 escapement was very small.

**Escapement Goal Guidelines**

Compared to the traditional linear regression point estimates, posterior medians (output) from the state-space model are less biased and interval estimates have better coverage of *S*MSY. Based on the data (Table 1) and figures (Figures 1-2) from the output of the state-space model, we have decided on a few escapement goal options to discuss (Table 2). First, though, a few guidelines that we need to follow.

*Guidelines:*

1. The state space model’s output provides general guidelines to help determine the escapement goals. We can make the goal and then find a way to support it with the figures, as long is the goal is reasonable and the stock can be realistically managed for under the escapement goal range.
2. We believe there is no reason to *increase* the escapement goal range of 4,000–13,000.
3. The current upper bound of 13,000 is too high. It should at the least be lower than equilibrium spawning abundance, where return exactly replaces spawners (SEQ), 12,370 (Table 1).
4. The recommended goal should bracket *S*MSY (4,390) and escapement leading to maximum production(*S*MAX) 6,068 (Table 1).
5. The goal should be supported by information provided by the probability profiles in figures 1 and/or 2.
6. There are two types of probabilities to consider.
   1. The first type of probabilities are represented by the three curves in figure 1 and three curves in figure 2. Probability that a specified spawning abundance will achieve X% (80% or 90%) of MSY is the optimal yield profile. Probability that a given escapement will produce an average recruitment that exceeds X% (80%or 90%) of maximum recruitment is the optimal recruitment profile. Probability that reducing the escapement to a specified abundance will result in less than X% (80% or 90%) of MSY is the overfishing profile.
   2. The second type of probabilities are indirectly based on the three curves in figure 1 and three curves in figure 2. For example, if you want the probability of achieving 90% MSY, you follow a point on the x axis (a possible escapement value) up to the optimal yield profile curve in figure 2 and then over to the y-axis for the probability (%). The same method is used for the overfishing and optimal recruitment profiles.
7. We recommend using the 90% probability profiles (Figure 2) for the lower bound escapement goal because at the lower bound, the 90% optimal yield profiles are more conservative than the 80% optimal yield profiles (the lower bound escapement goal will be higher, thus more conservative, using the 90% optimal yield profile or optimal recruitment profile).
8. An extra margin on the upper bound escapement goal reflects uncertainty in past escapement size, the potential for high harvest rates, and the fact that we will not be able to estimate harvest very well going forward.
9. From 1983-2013, on average, there was only 2 days difference between when cumulative weir counts reached 3,500 fish and 4,000 fish. In 11 years the cumulative count actually reached 3,500 and 4,000 on the same day. So a change in the lower bound may not result in that much change in timing of fisheries management.

**Tables and Figure**

**Table 1.–**Parameter estimates for the state-space model fitted to the Speel Lake sockeye salmon data for calendar years 1983–2013. Posterior medians are point estimates and the 2.5% and 97.5% credible percentiles define the 95% credible intervals for the parameters.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | 0.025 Percentile | Median | 0.975 percentile | Posterior CV |
| SEQ | 9,725 | **12,370** | 18,910 | 0.42 |
| SMAX | 4,134 | **6,068** | 12,070 | 0.50 |
| SMSY | 3,325 | **4,390** | 6,935 | 0.32 |
| UMSY | 0.54 | **0.73** | 0.86 | 0.22 |

**Table 2.–**Possible escapement goal options and the method used.



Table 3. Dates when cumulative counts of sockeye salmon at the Speel Lake weir reached 3,500 fish and 4,000 fish, 1983–2013.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Date 3,500**  **fish reached** | **Date 4,000**  **fish reached** | **Difference**  **In Days** | **Comment** |
| 1983 | 10-Aug | 10-Aug | 0 |  |
| 1984 | 10-Aug | 10-Aug | 0 |  |
| 1985 | 21-Aug | 21-Aug | 0 |  |
| 1986 | 13-Aug | 13-Aug | 0 |  |
| 1987 | 10-Aug | 12-Aug | 2 |  |
| 1988 | – | – | – | Escapement < 3,500 fish. |
| 1989 | 3-Aug | 3-Aug | 0 |  |
| 1990 | 30-Jul | 30-Jul | 0 |  |
| 1991 | – | – | – | Escapement < 3,500 fish. |
| 1992 | 1-Aug | 1-Aug | 0 |  |
| 1993 | – | – | – | Weir not operated. |
| 1994 | – | – | – | Weir not operated. |
| 1995 | – | – | – | Weir not installed until 1-Aug-1995. |
| 1996 | 6-Aug | 6-Aug | 0 |  |
| 1997 | 17-Aug | 22-Aug | 5 |  |
| 1998 | 5-Aug | 7-Aug | 2 |  |
| 1999 | 13-Aug | 14-Aug | 1 |  |
| 2000 | 8-Aug | 8-Aug | 0 |  |
| 2001 | 11-Aug | 14-Aug | 3 |  |
| 2002 | 10-Aug | 23-Aug | 13 |  |
| 2003 | 8-Aug | 14-Aug | 6 |  |
| 2004 | 11-Aug | 14-Aug | 3 |  |
| 2005 | 18-Aug | 18-Aug | 0 |  |
| 2006 | 25-Aug | 29-Aug | 4 |  |
| 2007 | – | – | – | Escapement < 3,500 fish. |
| 2008 | – | – | – | Escapement < 3,500 fish. |
| 2009 | – | – | – | 3,500 reached on 11-Sep-2009 |
| 2010 | 17-Aug | 18-Aug | 1 |  |
| 2011 | 15-Aug | 15-Aug | 0 |  |
| 2012 | 17-Aug | 18-Aug | 1 |  |
| 2013 | 5-Aug | 6-Aug | 1 |  |
| **Average** | **11-Aug** | **12-Aug** | **2** |  |
| **Median** | **10-Aug** | **14-Aug** | **1** |  |



**Figure 1.–**Optimal yield profiles and optimal recruitment profiles for the Bayesian age-structured state-space model. Profiles are provided for optimum yields that are at least 80% of MSY and optimal recruitments that are at least 80% of maximum recruitment. These profiles are used to illustrate the chance of attaining optimal yield and optimal recruitment with a specific escapement as a goal, and the probability of overfishing such that sustained yield is reduced to less than 80% MSY.



**Figure 2.–**Optimal yield profiles and optimal recruitment profiles for the Bayesian age-structured state-space model. Profiles are provided for optimum yields that are at least 90% of MSY and optimal recruitments that are at least 90% of maximum recruitment. These profiles are used to illustrate the chance of attaining optimal yield and optimal recruitment with a specific escapement as a goal, and the probability of overfishing such that sustained yield is reduced to less than 90% MSY.

**References**

Heinl, S. C., S. Miller, and J. A. Bednarski. 2014. In prep. Speel Lake sockeye salmon stock status and escapement goal review. Alaska Department of Fish and Game, Fishery Manuscript Series No. YY-XX, Anchorage.

Riffe, R., and J. H. Clark. 2003. Biological escapement goal for Speel Lake sockeye salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J03-04, Juneau.



**Example 1.–Escapement goal range of 3,000–10,000:** A lower bound of 3,000 fish would provide for 94% probability of achieving 80% of maximum sustained yield (MSY), and only about 6% probability that sustained yield will be reduced to less than 80% of MSY. An upper bound of about 10,000 fish would reduce sustained yield to only 6% probability of achieving 80% of MSY; but would provide greater than 89% probability of achieving 80% of maximum recruitment.



**Example 2.–Escapement goal range of 4,000–8,500:** A lower bound of 4,000 fish would provide for 96% probability of achieving 90% of maximum sustained yield (MSY), and only about 4% probability that sustained yield will be reduced to less than 90% of MSY. An upper bound of 8,500 fish would reduce sustained yield to only 8% probability of achieving 90% of MSY; but would provide greater than 92% probability of achieving 90% of maximum recruitment.



**Example 3.–Escapement goal range of 3,500–9,000:** A lower bound of 3,500 fish would provide for 91% probability of achieving 90% of maximum sustained yield (MSY), and only about 9% probability that sustained yield will be reduced to less than 90% of MSY. An upper bound of about 9,000 fish would reduce sustained yield to only 5% probability of achieving 90% of MSY; but would provide greater than 87% probability of achieving 90% of maximum recruitment.