Scientific concerns about escapement goal review for Chignik sockeye salmon (Finkle et al. 2022) as it pertains to Alaska Board of Fisheries Proposal #105

Daniel Schindler, Professor, School of Aquatic and Fishery Sciences, University of Washington;
deschind@uw.edu

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As part of their routine review of escapement goals for salmon stocks in Alaska, in 2020 the ADFG assessed whether the escapement goals for salmon managed in the Chignik Management Area needed revision. The conclusion reached in this review was that the two dominant stocks of sockeye salmon, which have been managed independently for decades, should be collapsed into a single stock for management purposes. The scientific basis for this decision as described in Finkle et al. (2022) is illogical and has almost no empirical support for it. In fact, the rich dataset available for assessing the status of the Chignik sockeye salmon stocks is in direct disagreement with the conclusions drawn in this report.

The purpose of this document is to highlight some of the erroneous conclusions and factual errors reported in the ADFG escapement goal review. Comments in italics are verbatim statements from Finkle et al. (2022) and are followed by my comments about why these are scientifically indefensible. The end of this report presents the data to answer the question about whether the two Chignik sockeye salmon stocks are demographically independent or can be assumed to be one single well-mixed stock.

A) Page 3, Finkle et al. (2022): *However, from 2014 through 2017, the inseason use of genetics to estimate early- and late-run stock proportions demonstrated the variable timing of entry into Chignik River and presented the department with the challenge of applying these proportions for management purposes.*

DS: This observation highlights why inseason genetic approaches were developed by ADFG to improve management of multiple sockeye salmon stocks at Chignik. The timing of entry into the Chignik River has always been variable as it responses to changes in migration timing of each of the stocks (presumably a response to change in ocean conditions) and to changes in the relative strengths of the early- and late-runs. For decades, managers at Chignik used scale-pattern analysis to differentiate the early- and late-runs but these approaches were prone to substantial uncertainty. ADFG developed world-class, cutting-edge genetics approaches (GSI) to eliminate nearly all of the uncertainty in assigning fish to the early-run and late-run stocks. Further, the ADFG collaborated with UW to develop state-of-the-art hierarchical statistical models to interpret GSI data - as they were produced inseason - to allow managers to refine their inseason assessments of the timing and run strength of the early- and late-runs (DeFilippo et al. 2019). This peer-reviewed publication has been apparently discarded by ADFG and is not even acknowledged in the Finkle et al. (2022) escapement review.

In a time of rapid and ongoing environmental change, scientifically-based fishery management should be using all of the scientific tools available to adapt harvest strategies as the best assessments of run strength become available. It is not logical why ADFG has discarded this toolkit. The reasons they have provided are simply not valid (e.g., takes too long to be useful). The DeFilippo et al. (2019) paper demonstrated that GSI provided information in near real-time that had direct utility to inseason management for optimizing harvest and protecting stock diversity.

B) Page 7, Finkle et al. (2022): *"Data from brood years 1983-2013 were used to explore changes in productivity coincidental to recent stabilization of the upper Chignik River, as reported by the US Army Corps..."*

DS: USACOE reported that the downcutting of the Black River channel had stabilized. It was not a biological assessment of habitat conditions nor was it an assessment of whether the productivity of the ecosystem or of the salmon stocks had stabilized. Thus, there is no logical reason why this specific time frame was used to define escapement goals. As we showed in other written testimony (Schindler and Cunningham 2023), using this truncated time frame for assessing escapement goals added substantial uncertainty into stock-recruit models upon which the escapement goals were based. The biological rationale for using this time frame is simply not credible, particularly when one of the longest high-quality time-series of data on stock and recruitment are available for this ecosystem. Most managers can only dream of having the data available to them that managers at Chignik do.

C) Page 7, Finkle et al. (2022): *"to account for density-dependent effects interacting in Chignik Lake, Smsy was estimated for the total Chignik sockeye salmon run using data from 1998-2013, during which.... To assess periods of potential low stock interactions and average to higher productivity, Smsy was estimated for the total run using the full data set from 1983-2013."*

DS: The rationale for combining the two stocks into a single stock is neither clear nor reasonable. Why would combining the brood tables account for density-dependence in a more formal way than managing the stocks separately? This conclusion assumes that the two stocks are interchangeable, which means that they are strongly synchronous through time and respond to changes in the environment in similar ways. This is the key assumption involved in the Finkle et al. (2022) conclusion. If this assumption were correct, then the productivity of the two stocks should have become more synchronized through time – i.e. if there was a single bottleneck in the watershed. A very straightforward examination of the data show clearly that this assumption is severely violated and that the early-run and late-run stocks operate nearly independently. Therefore, all efforts should be reasonably made to manage the stocks independently (as has been done at Chignik for decades).

D) Page 10, Finkle et al. (2022): *"... with late-run juveniles outcompeting early-run juveniles in Chignik Lake (Griffiths et al. 2013)."*

DS: This is not what the Griffiths et al (2013) paper concluded. We have no way to assess who is outcompeting whom in the watershed. What we showed in this paper is that the two stocks overlap in Chignik Lake and compete with each other during their freshwater residency. We also showed that juvenile sockeye salmon leave Black Lake when they are physiologically stressed but seem to settle in and show similar physiological condition as Chignik Lake fish once they have dispersed to the downstream lake. Further, if there was some sort of asymmetry in the competition between the two stocks, you would want to manage the two stocks independently to control this level of interaction! So the ADFG is actually acting against their own incorrect conclusion.

E) Page 10, Finkle et al. (2022): *"With watershed morphology stabilized...it is unlikely that the utilization of the entire watershed by early-run juvenile sockeye salmon will change"*

DS: There is no logical way to support this conclusion over other hypotheses. In fact, with ongoing climate change the relative profitability of different habitats within the Chignik watershed will certainly change, independent of any further geomorphic changes. It is fair to assume that the Chignik watershed has always

changed historically and that it will continue to change with ongoing climate change. That is why there is no single strategy that juvenile sockeye salmon use in this watershed – in Walsworth et al. (2020) we showed that the early-run fish that survive to spawn show a remarkable diversity of behavioral patterns both among the individuals in the population and among years.

F) Page 10 "*Further, a single goal addresses the limited rearing capacity of Chignik Lake, which supports both the early- and late-run juveniles.*"

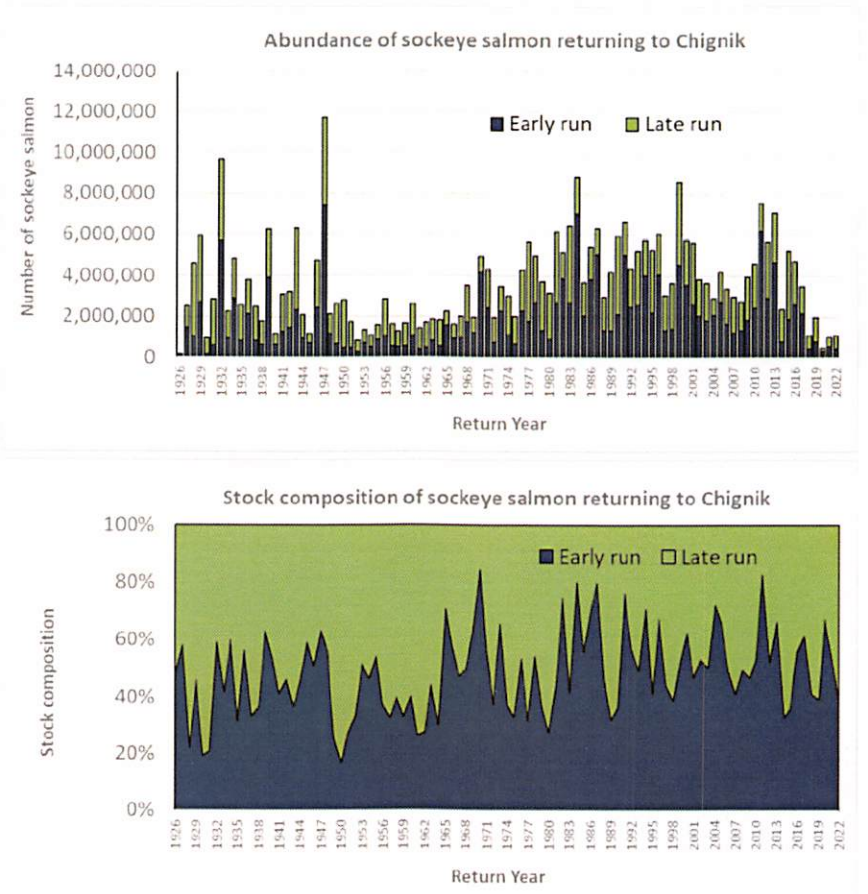
DS: This is another illogical conclusion. Why would a single goal address the limited rearing capacity of Chignik Lake? The extension of this conclusion is that a single bottleneck is synchronizing the dynamics of the early and late runs (i.e., the stocks go up and down together). The analyses at the end of this report show how incorrect this assumption is.

G) Page 11, Finkle et al. (2022): "*The rationale behind a single goal was twofold: a single goal recognizes that juvenile early-run fish adapt to variable environmental conditions in Black Lake… The single goal also better addresses the bottleneck in rearing conditions in rearing capacity of Chignik Lake because it provides a level of escapement that 1 lake can sustain for both stocks…*".

DS: These conclusions are simply not supported by scientific data or by logic. The data show clearly that the runs do not operate as a single, homogeneous population. Because the seasonal migration period at Chignik is so long (e.g., over 3 months at Chignik compared to about 3 weeks in Bristol Bay) and because the migration timing of the two dominant stocks is so distinct, there is simply no scientific reason for managing the stocks as a single population. Managing as a single stock runs the risk of overexploiting one of the stocks when it is weak, and probably reduces the long-term fishery yield from this ecosystem.

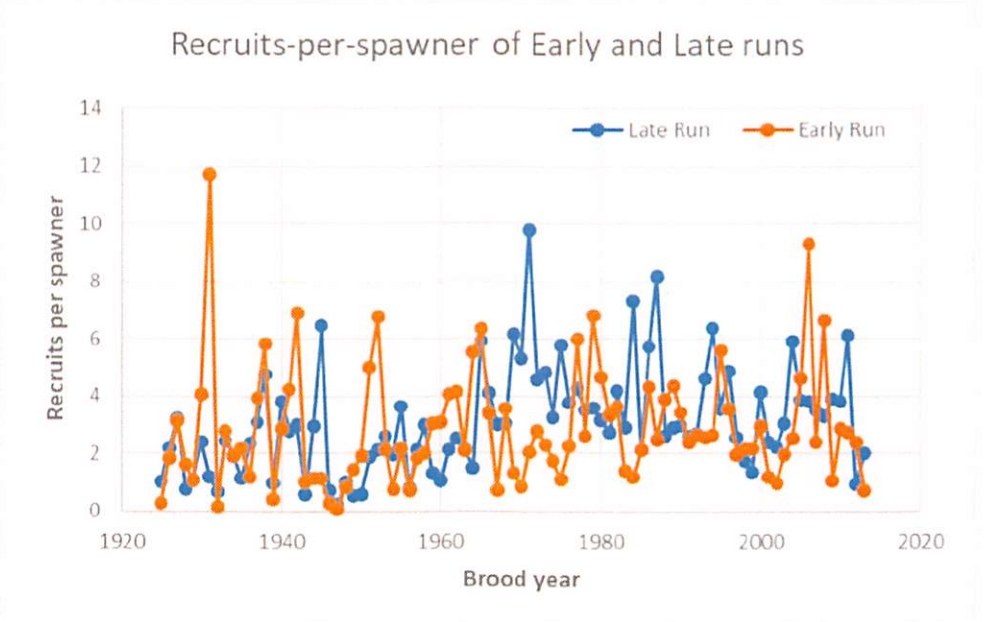
Appendices -Are the population dynamics of the Early- and Late-Run sockeye salmon stocks in Chignik becoming synchronized? (as assumed in ADFG decision to move to a single escapement goal).

Figure 1. The abundance of sockeye salmon that returned to the Chignik watershed from 1926 to 2022, split into contributions from the early-run and late-run (top panel). The bottom panel illustrates the relative contribution of the early-run and late-run to the total over this time frame.



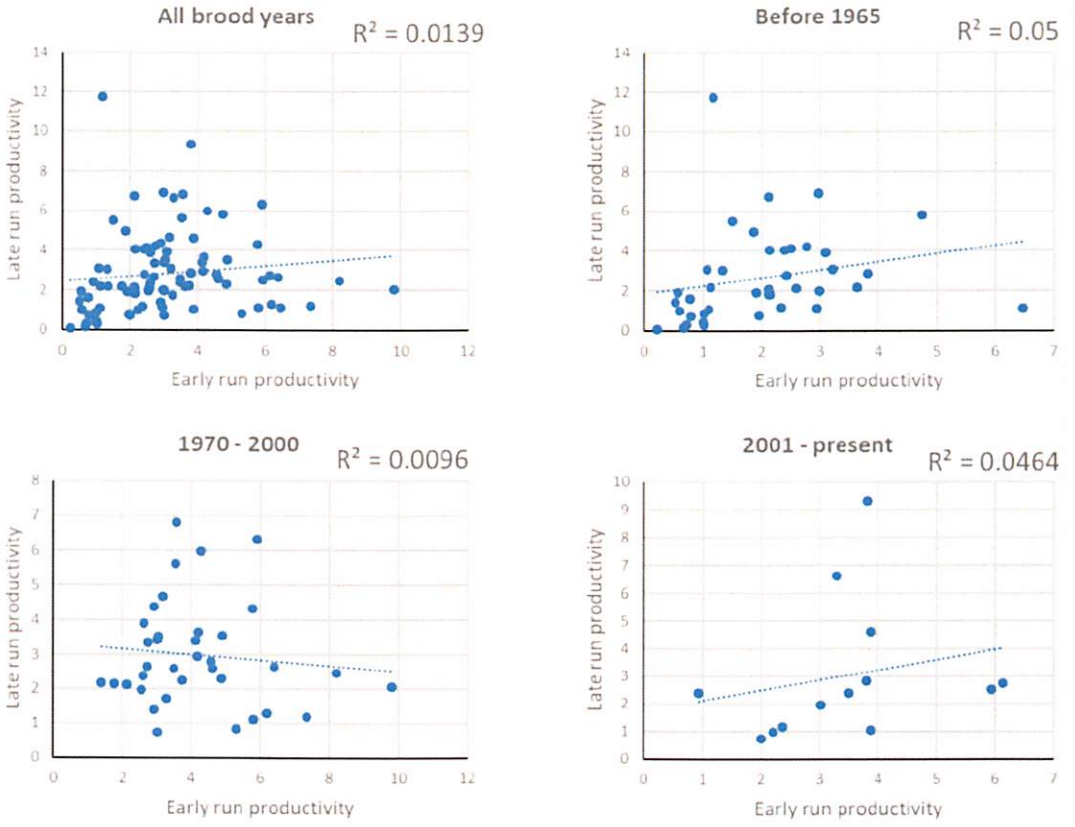
Key message: The overall sockeye salmon run to Chignik has been variable among decades and among years. The relative contribution of fish from the early-run and the late-run varies considerably from year to year. A low return in one stock is often buffered by a high return in the other stock. Stock diversity matters.

Figure 2. Changes in the productivity of the early-run and late-run stocks of Chignik sockeye salmon as indicated by the average number of recruits produced per spawner (R/S) for brood years 1926 to 2013. At a R/S of 1.0 there is only a single recruit produced per spawner meaning that the population only replaced itself in that generation. All values of R/S above 1.0 indicate surplus production above what is needed to replace the spawner population and this can be harvested in the fisheries.



Key message: The productivity of Chignik sockeye salmon is highly variable through time. Years where the stock barely replaces itself are not uncommon. Years of low productivity in one stock are often the same years when high productivity of the other stock is observed. The early-run, in particular, has exhibited brood years with very low productivity (i.e., ~1.0) many times in the last century, but also shows years with very high productivity (i.e. R/S > 5). During the same brood years, the Chignik system can exhibit high productivity in one stock and very low productivity in the other. The demographics of the two stocks are clearly not synchronized.

Figure 3. Comparison of late-run productivity and early-run productivity (as R/S) for Chignik sockeye salmon, grouped into different time periods. Each dot is an individual brood year. If the two stocks operated as a single, homogenous stock, the years with high productivity in one stock would be associated with high productivity in the other stock, and vice versa. Clearly there is no relationship in any of these time frames.

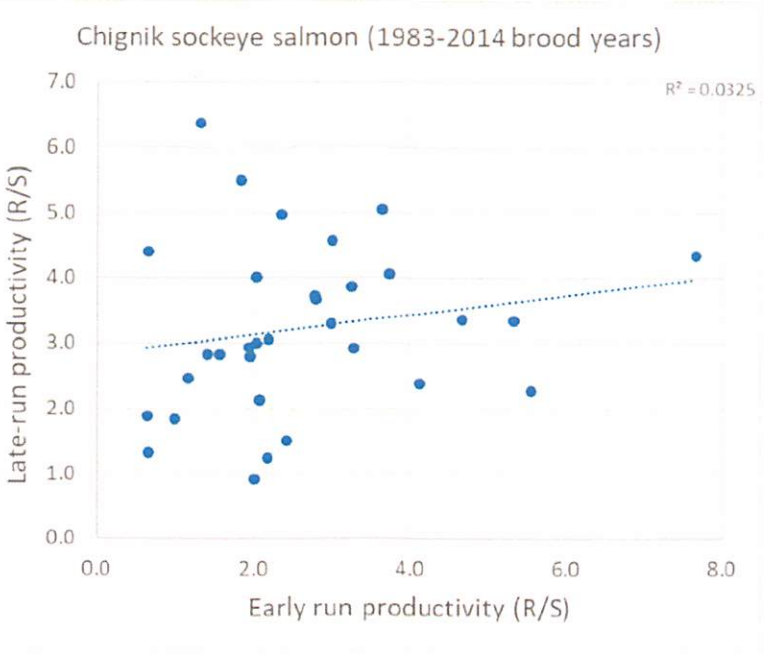


Key messages:

(a) The early-run and late-run stocks of sockeye salmon at Chignik show nearly independent population dynamics. Brood years that produce very high productivity in the early-run can be associated with very low productivity in the late-run, and vice versa. These two stocks clearly do not operate as a single, homogenous population as concluded in Finkle et al. (2022).

(b) Splitting the time series into different time periods can be used to assess whether the two stocks are becoming more synchronized through time, as would be expected if there was a single bottleneck developing in the watershed (as asserted by Finkle et al. 2022). The data clearly show that the two stocks continue to operate nearly independently and there is essentially no evidence that the stocks are becoming synchronized in their productivity. This independence (or 'biocomplexity') of population dynamics in the two runs is the reason why the Chignik sockeye salmon fishery has been managed as two distinct stocks for almost a century.

Figure 4. Comparison of late-run productivity and early-run productivity for Chignik sockeye salmon (as in Figure 3) between brood years 1983-2014 but using the updated brood tables published in 2022.



Key message: The early-run and late-run stocks of sockeye salmon at Chignik show nearly independent population dynamics. The new run reconstruction published in 2022 did not increase the tendency of the two stocks to show coordinated dynamics.

References (peer-reviewed manuscripts attached for reference)

DeFilippo, LB, DE Schindler, K Shedd, and KL Schaberg. 2020. A Bayesian hierarchical approach to integrating historical and in-season genetic data for real-time assessment of a mixed stock fishery. Canadian Journal of Fisheries and Aquatic Sciences https://doi.org/10.1139/cjfas-2020-0092

Finkle, H, KL Schaberg, MB Foster, and T Polum. 2022. Review of salmon escapement goals in the Chignik Management Area, 2020. Alaska Department of Fish and Game, Fishery Manuscript No. 22-05, Anchorage.

Griffiths, JR, DE Schindler, and LW Seeb. 2013. How stock of origin affects performance of individuals across a meta-ecosystem: an example from sockeye salmon. PLoS ONE 8(3): e58584.

Walsworth, TE, JR Baldock, CE Zimmerman, and DE Schindler. 2020. Interaction between watershed features and climate forcing affects habitat profitability for juvenile salmon. Ecosphere 11(10):e03266