Revisions to the Kuskokwim River Chinook Salmon Run Reconstruction Model

Zachary Liller & Hamachan Hamazaki
Alaska Department of Fish and Game

Purpose

1. Total inriver abundance of Kuskokwim River Chinook salmon is estimated annually using a maximum likelihood model.

2. ADF&G has updated the model to incorporate new information and advise from two reviews.

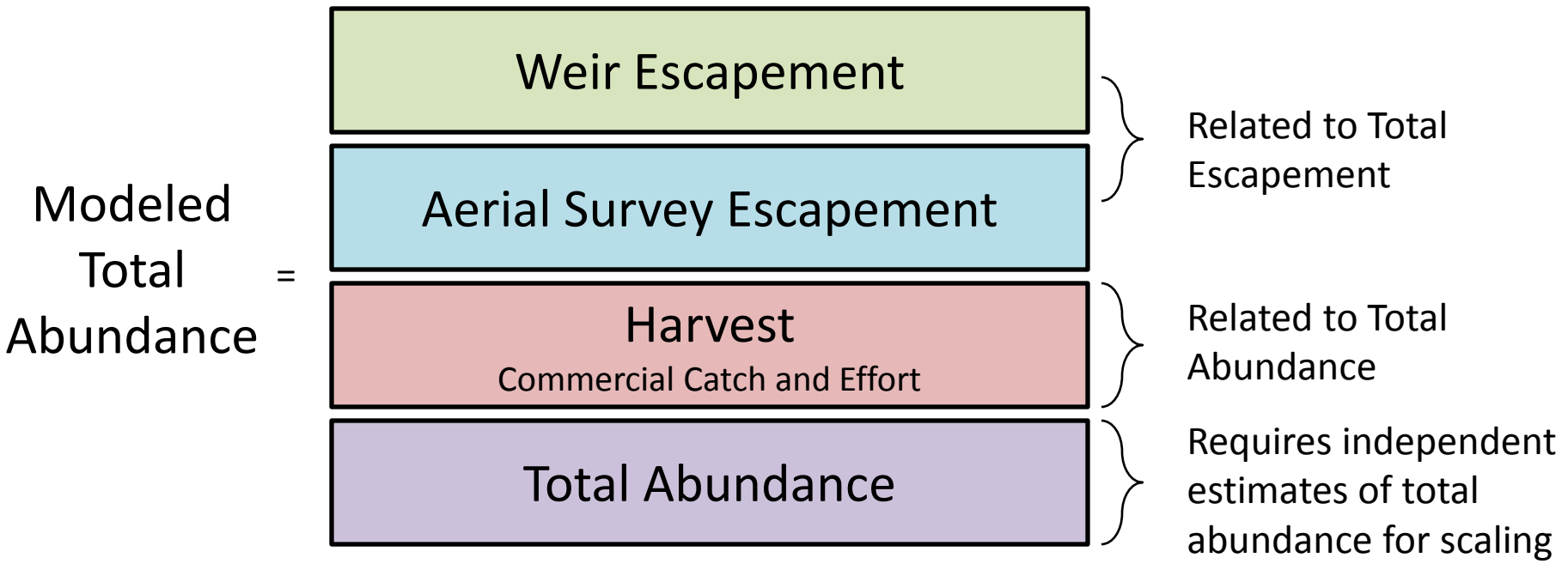
3. ADF&G is recommending the Council adopt the revised model for use in the 3-system index of Western Alaska Chinook Salmon abundance.

Outline

- Overview of current model
- Model review process
- Rationale for model updating
- Model revisions
- Effect on time series of total abundance

Run Reconstruction

Model Framework



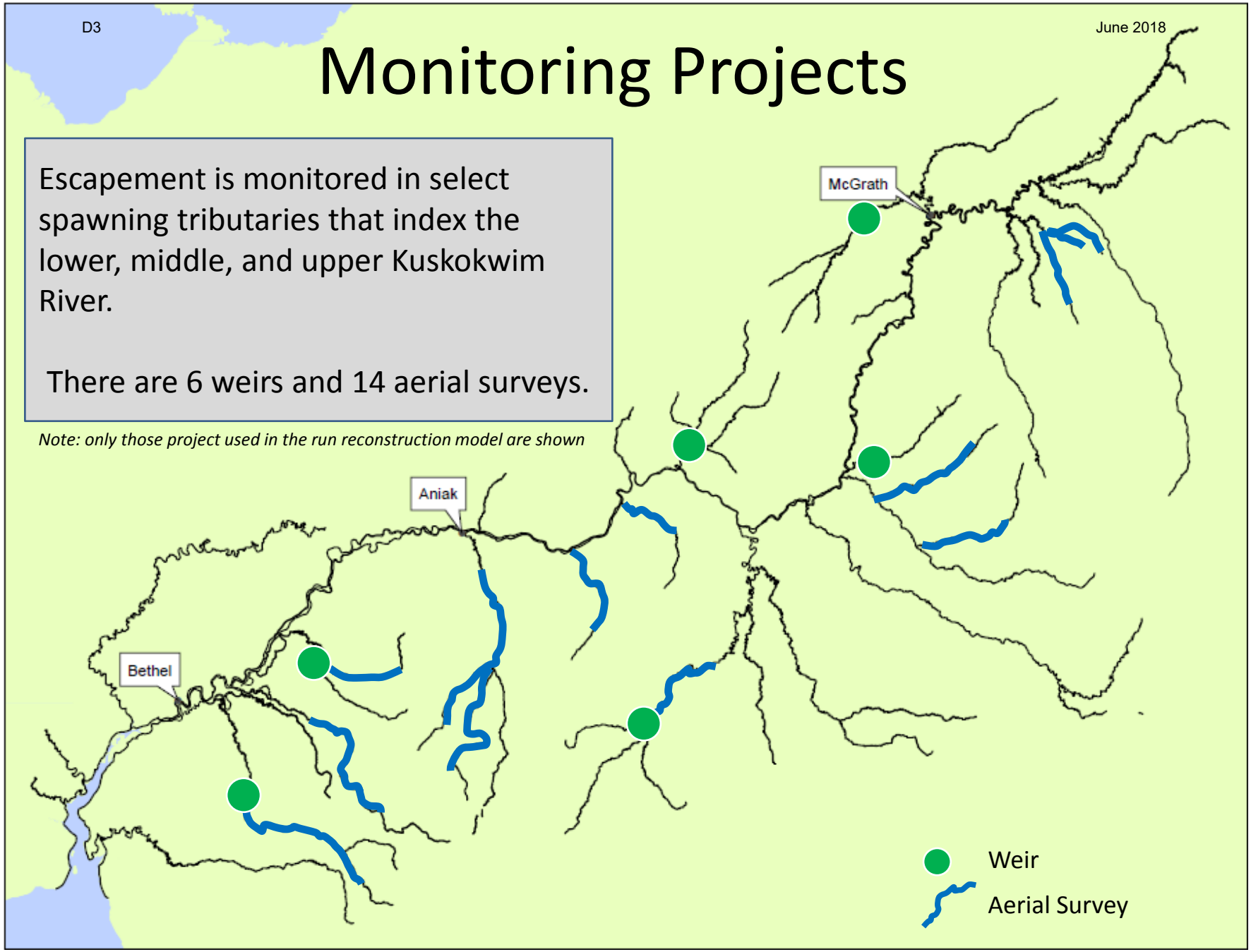
Maximum likelihood model simultaneously considers all available abundance information from 6 weirs, 14 aerial survey locations, harvest, and run-timing to arrive at an estimate of total run for each year, 1976–present.

Monitoring Projects

Escapement is monitored in select spawning tributaries that index the lower, middle, and upper Kuskokwim River.

There are 6 weirs and 14 aerial surveys.

Note: only those project used in the run reconstruction model are shown



Current Model Assumptions

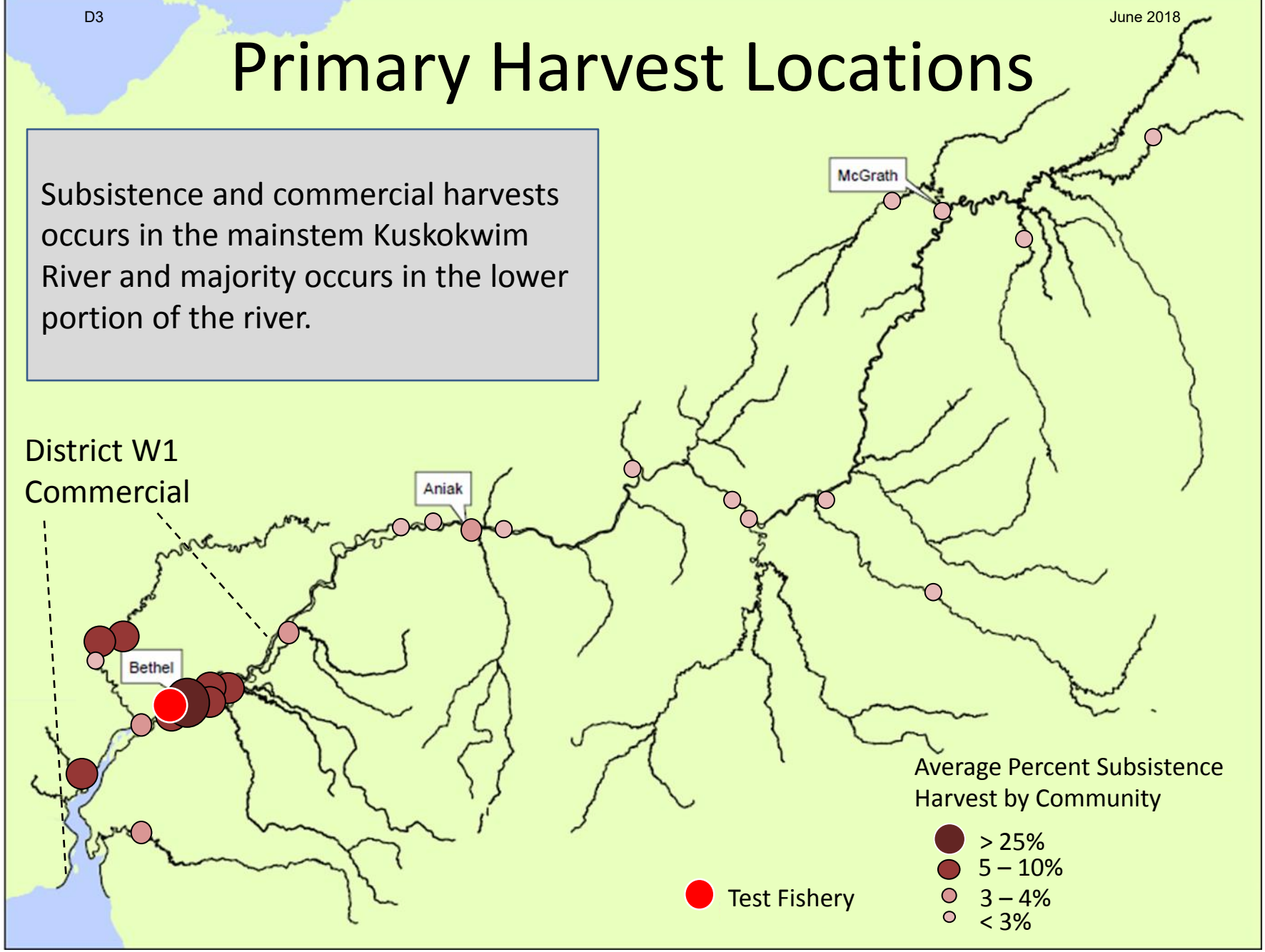
(Escapement component)

- Tributary escapement is a constant proportion of total escapement.

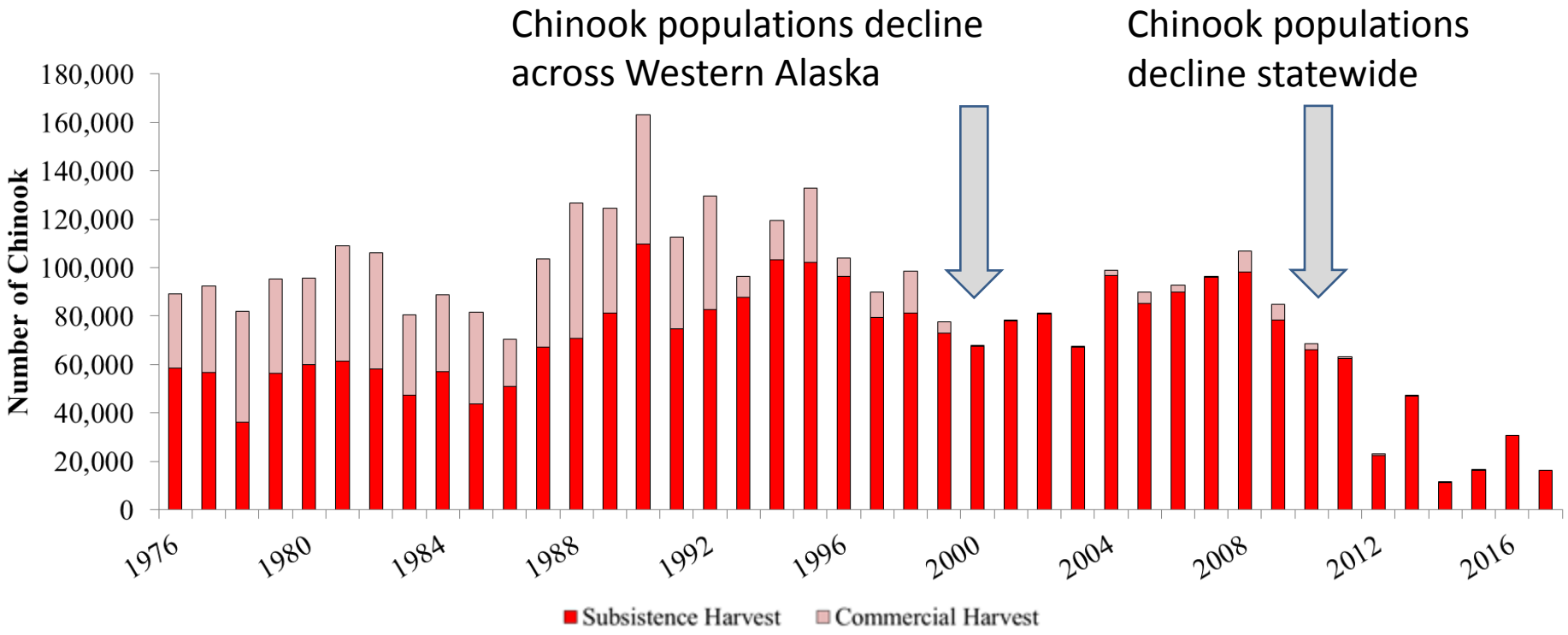
- Errors follow a negative-binomial distribution.

Primary Harvest Locations

Subsistence and commercial harvests occurs in the mainstem Kuskokwim River and majority occurs in the lower portion of the river.



Harvest Patterns



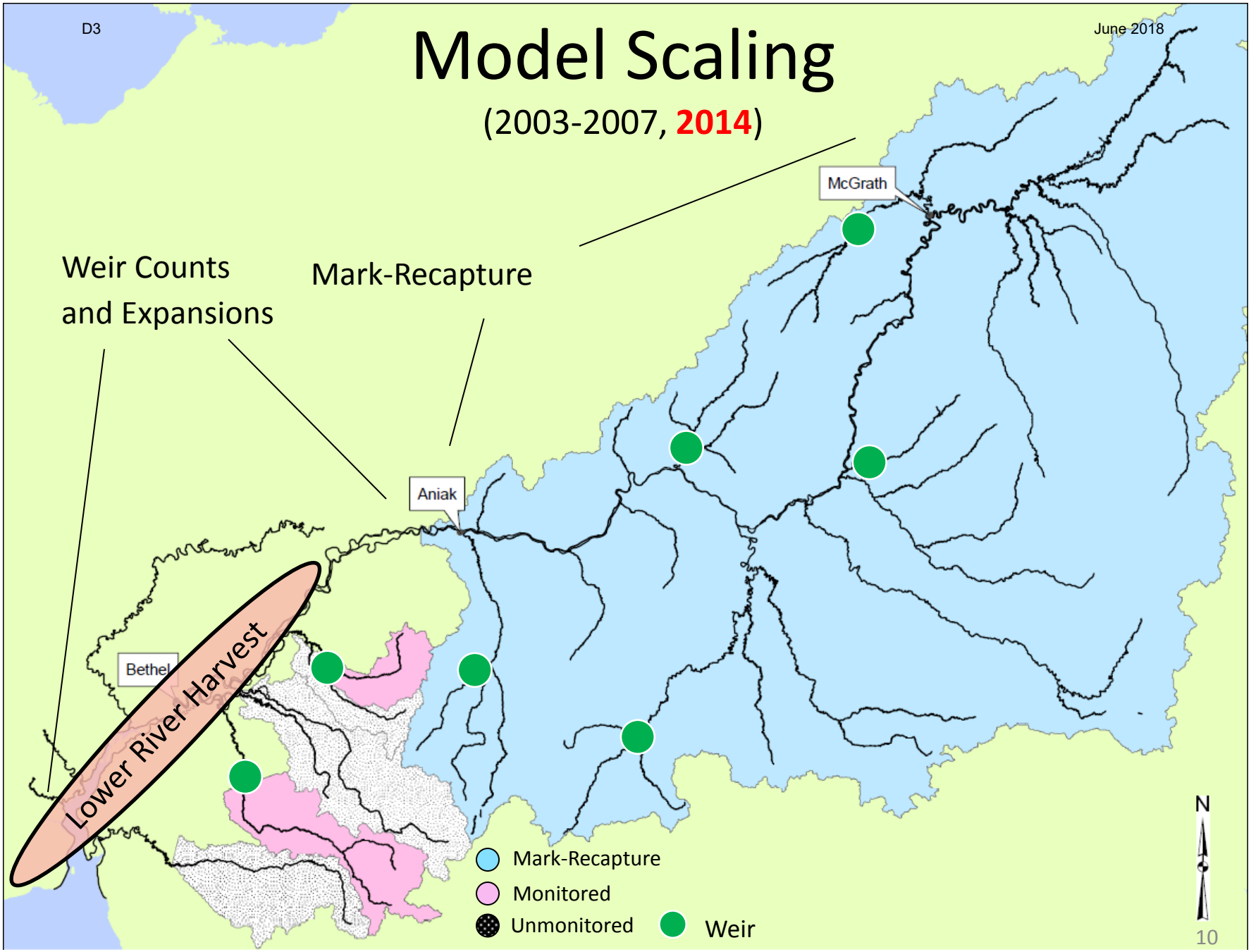
Current Model Assumptions

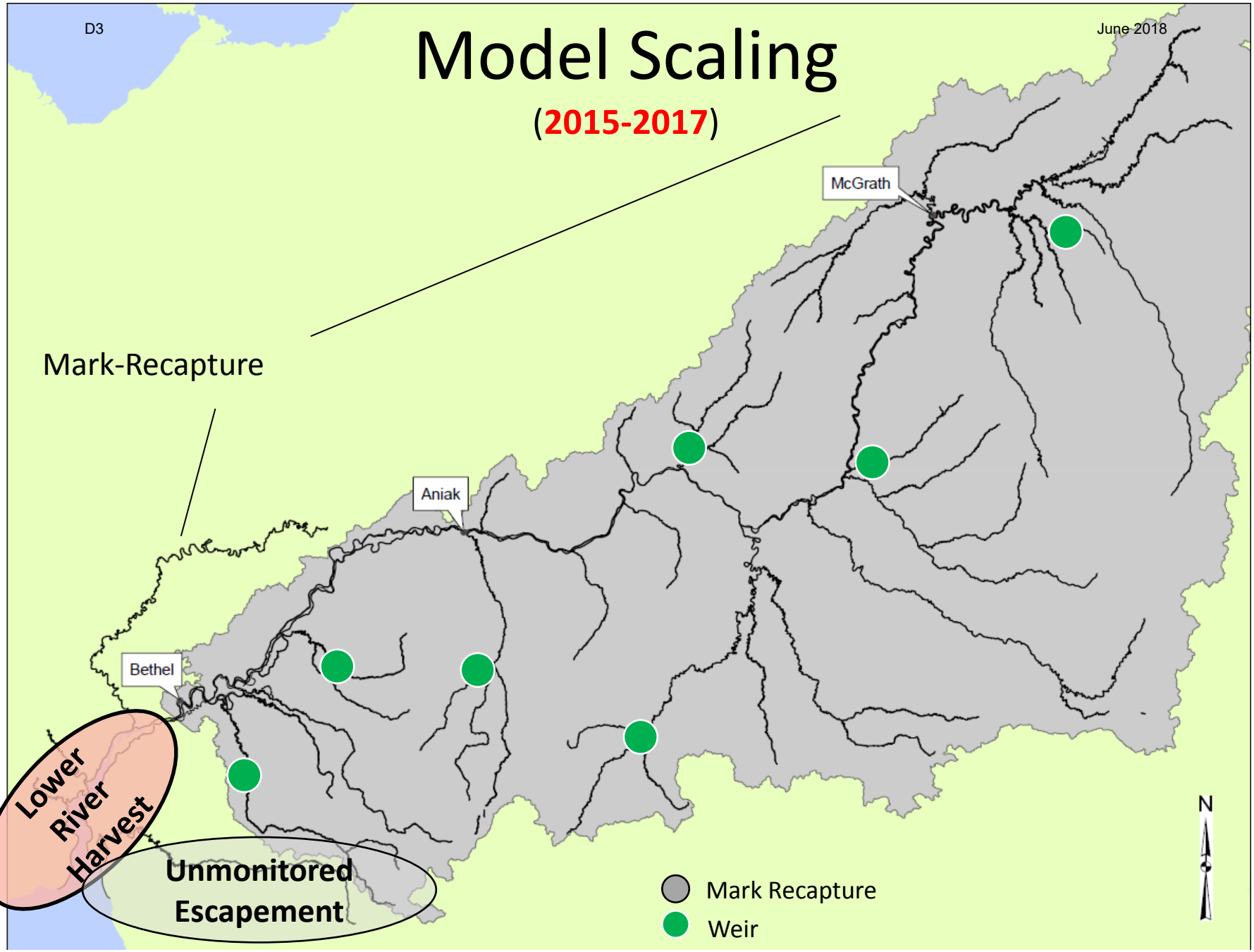
(Commercial harvest component)

- The relationship between commercial catch and effort is non-linear.

- Commercial catch and weekly run proportions indexed at the Bethel Test Fishery are known without error.

- Errors follow a lognormal distribution.


D3
June 2018
Model Scaling
(2003-2007, 2014)
McGrath
Weir Counts
and Expansions
Mark-Recapture
Aniak
Bethel
Lower River Harvest
Mark-Recapture
Monitored
Unmonitored
Weir
N
10


D3
June 2018
Model Scaling
(2015-2017)
Mark-Recapture
McGrath
Aniak
Bethel
Lower River Harvest
Unmonitored Escapement
Mark Recapture
Weir
N

Current Model Assumptions

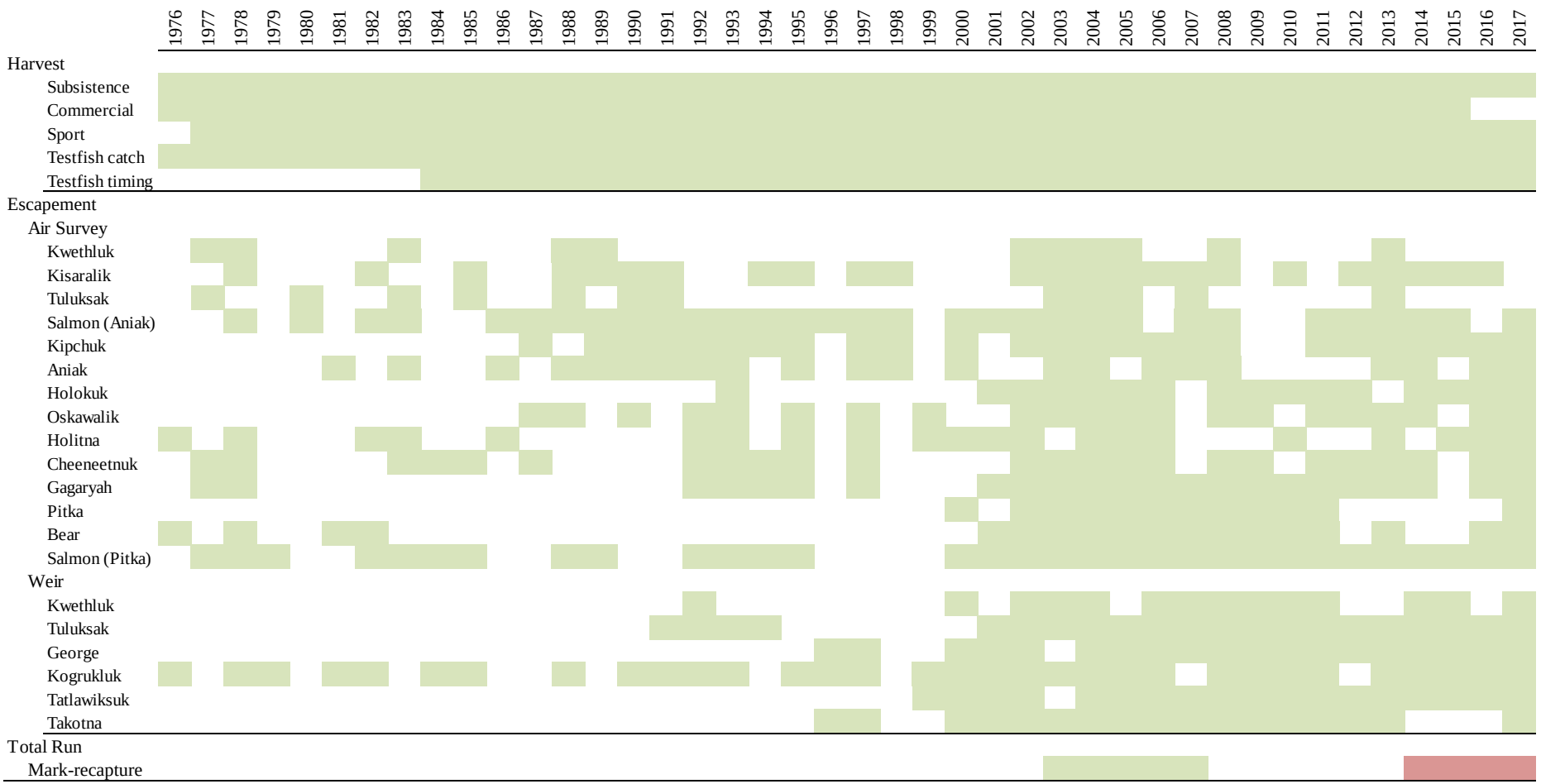
(Total run "scaling" component)

- The total run estimates used to scale the model are accurate and uncertainty is properly estimated.

- Errors follow a normal distribution.

Data Availability

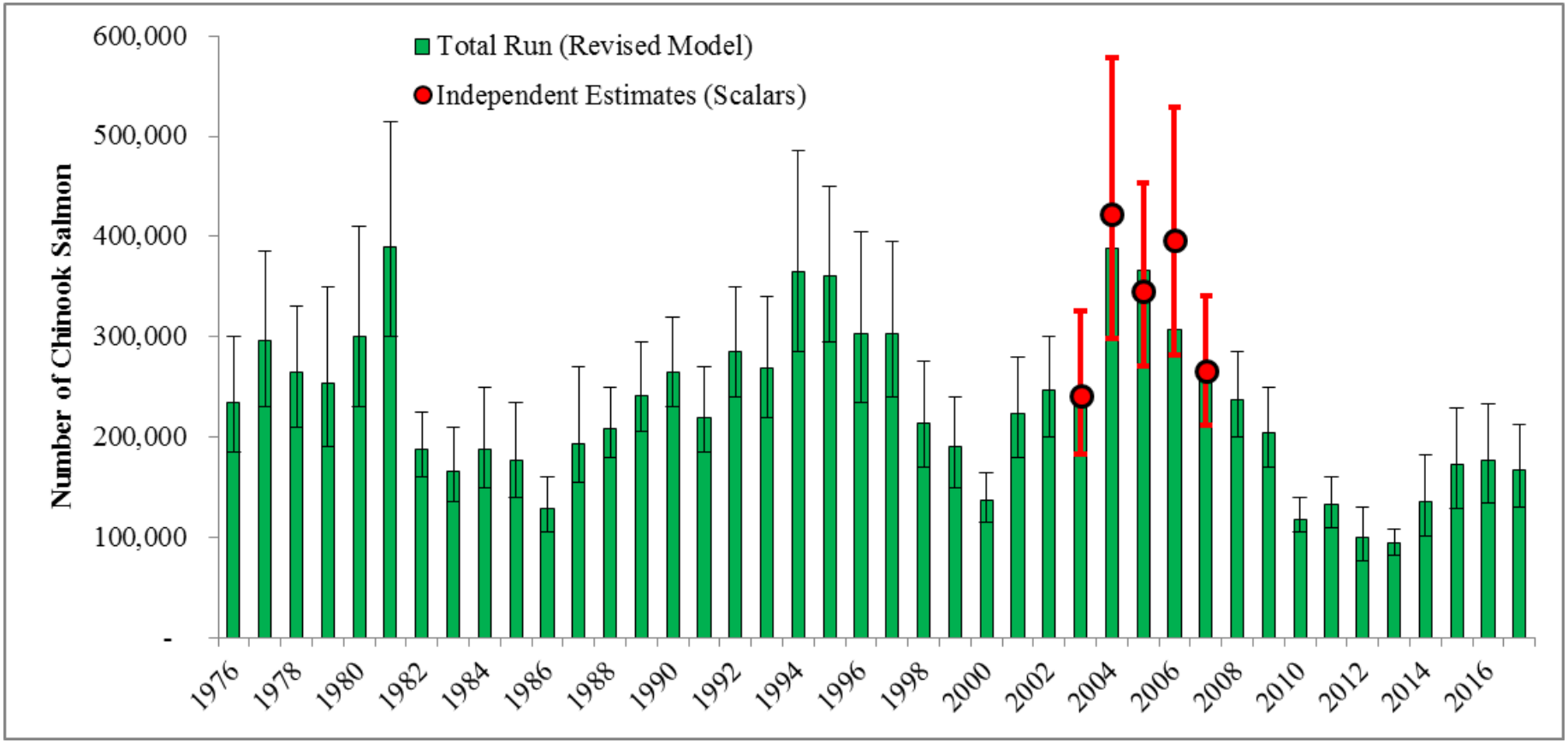
(Represents data used in the current model)



Green cells = data used in current model

Red cells = data collected as part of model evaluation (i.e., not used in current model)

Current Model Output



Published estimates: Bue et al. 2012; Hamazaki and Liller 2015; Liller and Hamazaki 2016; Liller 2017; Smith and Liller 2018

Model Review Timeline

2012
- Publication – Bue et al. 201

2013
- ADF&G approves funding for three years of drainagewide mark-recapture and lower river tributary surveys.

2014
- Year 1: evaluation of model performance using mark-recapture.
- Stability issue reported in Hamazaki and Liller 2015.

2015
- Year 2: evaluation of model performance using mark-recapture.
- AYK SSI: developed plans to convene an independent expert panel to review the current model.

2016
- Year 3: evaluation of model performance using mark-recapture.
- ADF&G developed plans to convene an interagency model development team.

2017
- Year 4: additional year of funding to evaluate of model performance using mark-recapture.
- AYK SSI and ADF&G reviews ongoing.

2018
- AYK SSI and ADF&G model teams convene for a collaborative workshop.
- ADF&G revised model based on new information and recommendations.

Model Update Rationale

- The 2003–2007 independent estimates of total run size used to scale the current model were suspected to be biased high. ADF&G conducted validation studies in 2014–2016 and new information is available to improve model scaling.

- ADF&G undertook a four-year effort (2014–2017) to generate independent estimates of drainagewide run size. ADF&G determined the model overestimated total run size during these recent years of low run size. Incorporation of these new data nearly doubles the amount of information used for model scaling and represents both record high and record low run sizes.

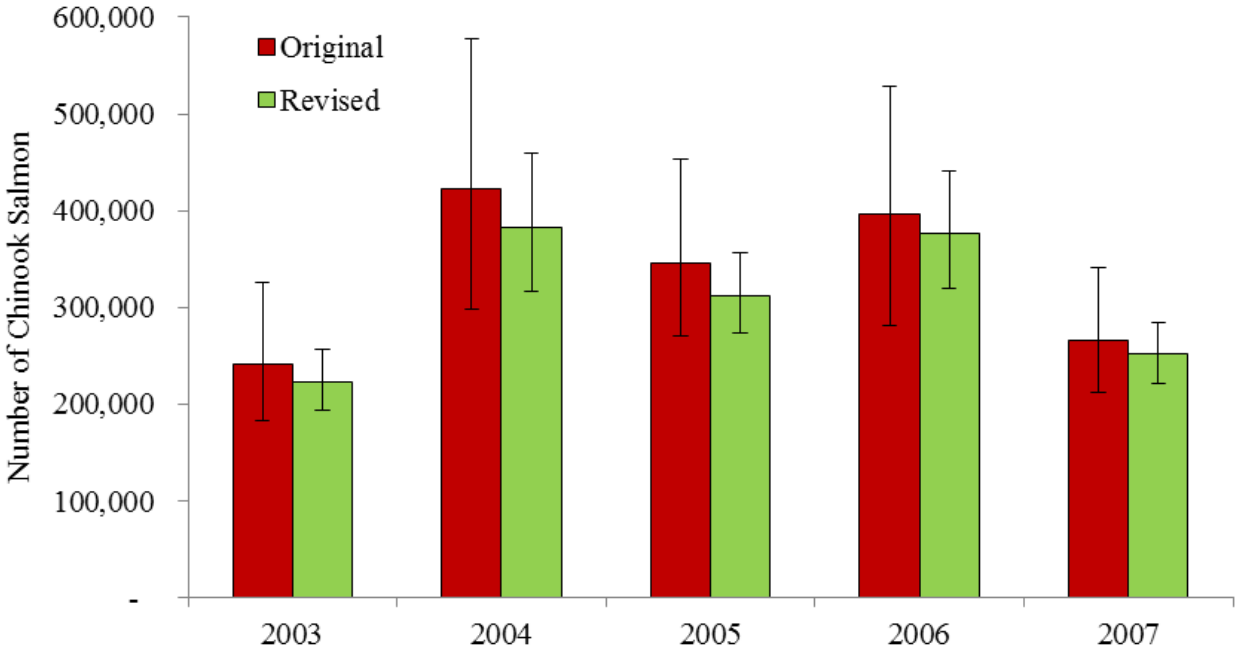
- In recent years, there have been changes in the fishery management which affected salmon spawning distribution relative to the conditions upon which the model was originally based.

- The current model is highly sensitive to starting values and can produce multiple estimates of total run size depending on the starting values used in the model fitting process.

- Agency and independent expert panels have reviewed the current model and recommended changes to improve model stability and reduce complexity.

Model Update Rationale, cont.

- Historical scalars (2003-2007) biased high.



Revised expansion factors for scaling Kwethluk River weir passage to unmonitored tributaries.

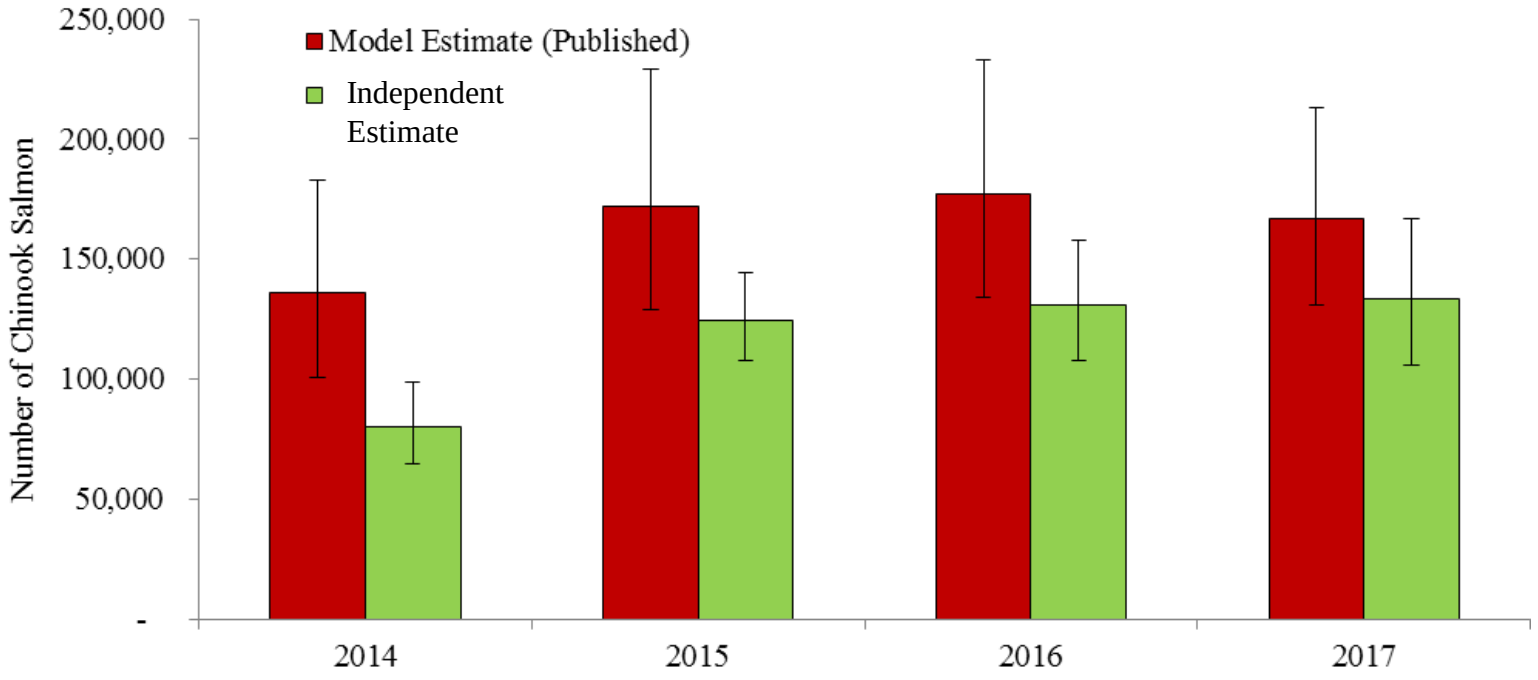
	Habitat-based	Ground-based		
Unmonitored Tributary	Expansion	Expansion	SD	% Change
Eek River	1.102	0.534[a]	0.1253	-52%
Kisaralik/Kasigluk River	1.464	0.585[b]	0.0919	-60%

[a] Expasion factor caculated from paired helicopted surveys.

[b] Expasion factor radiotelemetry studies.

Model Update Rationale, cont.

- 2014-2017 independent estimates showed the current model overestimated total run size during recent years of low run abundance.



Model Changes

(**Data Changes**)

1. An additional 4 years (2014–2017) of independent estimates of total run abundance were added. The revised model is now scaled with nine independent estimates of total run abundance representing both record high and record low run sizes.
2. Independent estimates of drainagewide run size from years 2003–2007 were adjusted to account for new information about the likely escapement to unmonitored tributaries in the lower river.
3. Estimates of variance for the mark–recapture component of the annual model scalars (2003–2007) were recalculated using a closed-form solution.
4. Variance estimates for the annual scalars (2003–2007 and 2014–2017) were recalculated to account for additional uncertainty associated with tributary escapement monitoring and subsistence harvest estimation.
5. Annual estimates of total Chinook salmon escapement past the Kwethluk and Tuluksak weirs (used as model input) were recalculated using a hierarchical Bayesian estimation framework (e.g., Head and Smith 2018).
6. All weir and aerial survey data used as model input were reviewed and minor edits were made to ensure consistency with the ADF&G database (Smith and Liller 2018).
7. Annual CPUE from commercial harvest opportunities using restricted mesh 1976–1984 was removed from the model.

Model Changes

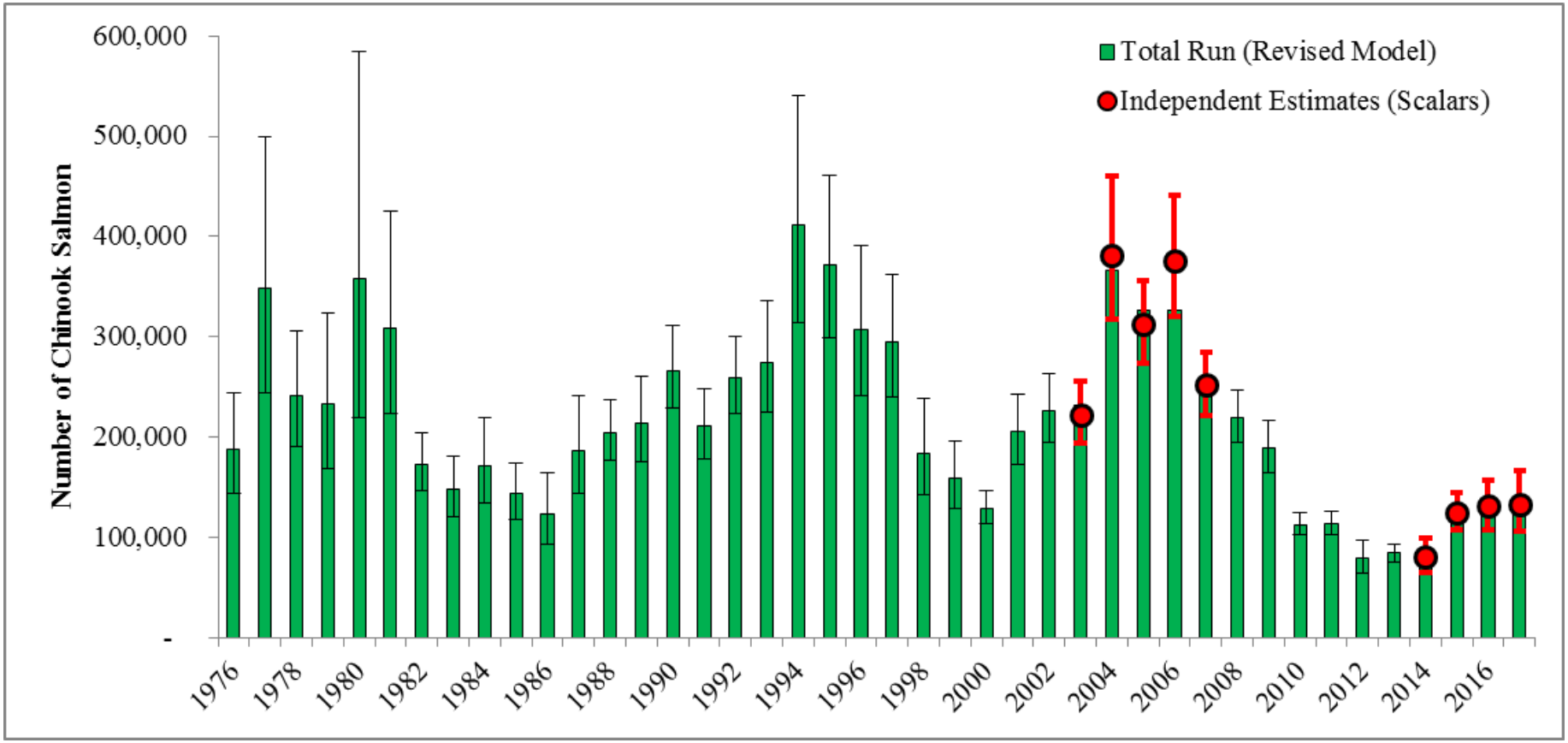
(Software Changes)

8. Modeling software changed from R (Optim) to ADMB.

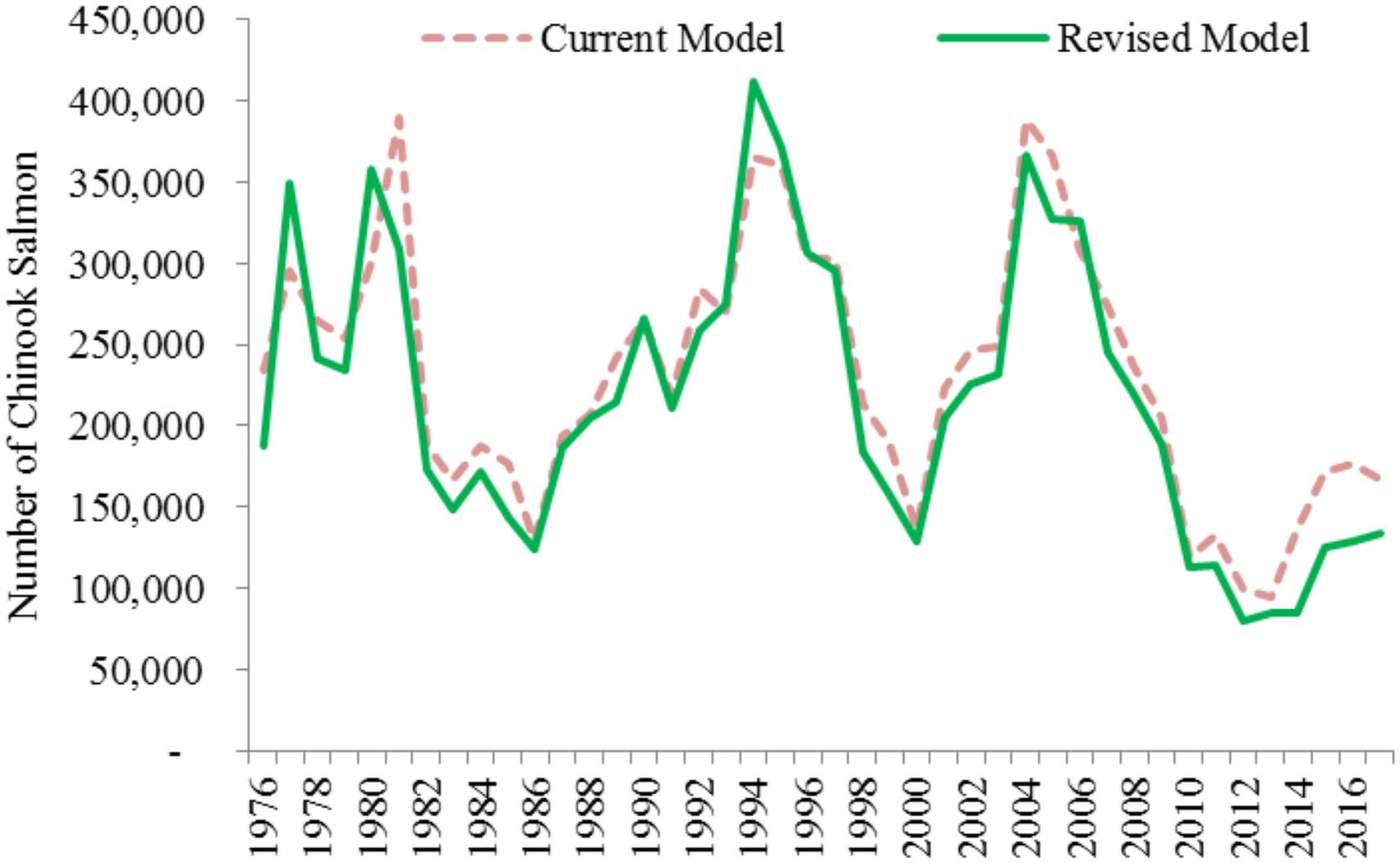
(**Structural Changes**)

9. Lognormal likelihood was assumed for all data.
10. Variance was combined within each data type (weir, aerial, and commercial CPUE).
11. The revised model assumes a linear relationship between catch and effort. The model was fit to annual CPUE for each type of commercial fishery opportunity (Unrestricted and Restricted Mono filament 1985–2017).

Revised Model Output



Effect on Historical Time Series



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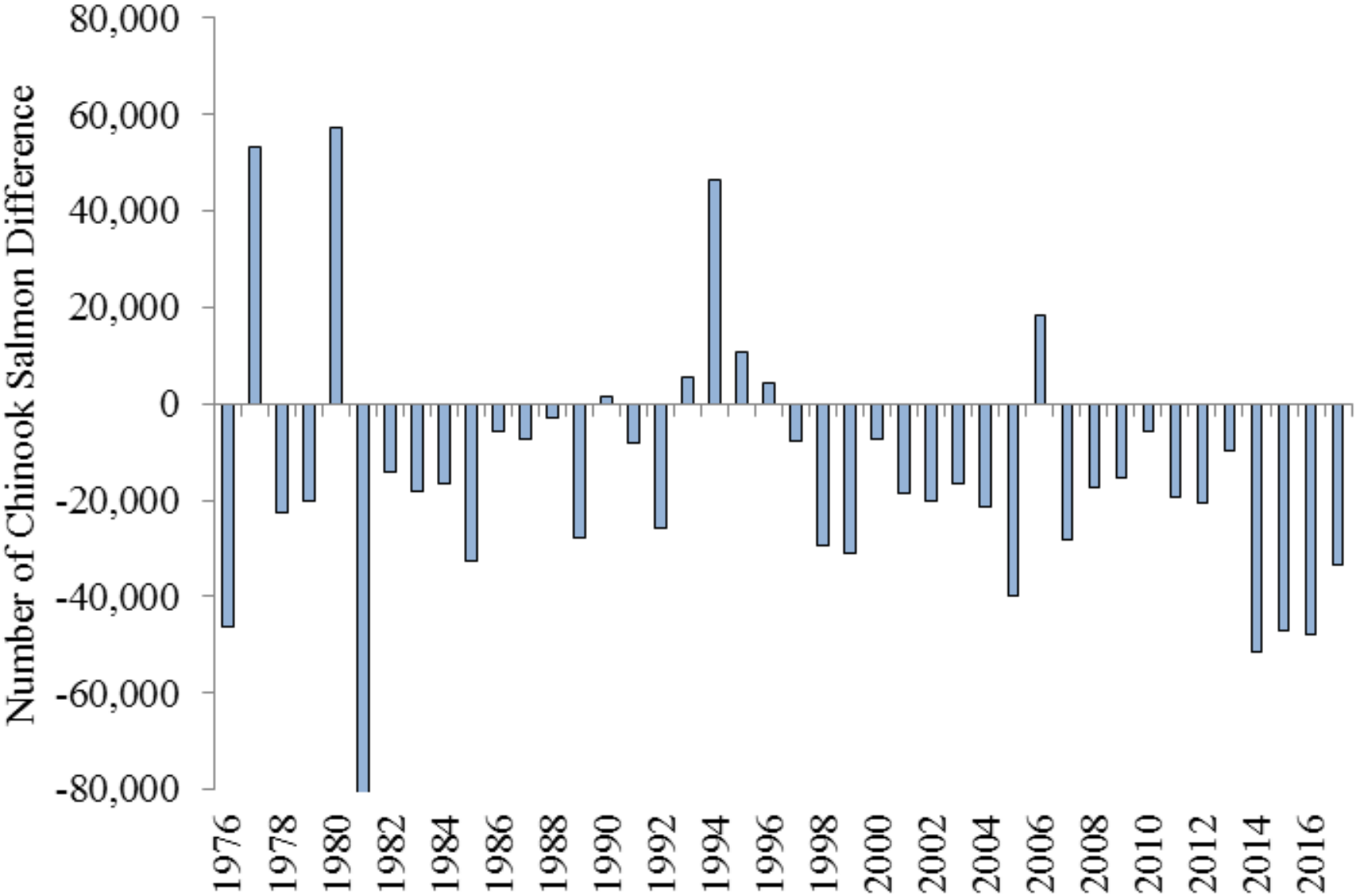
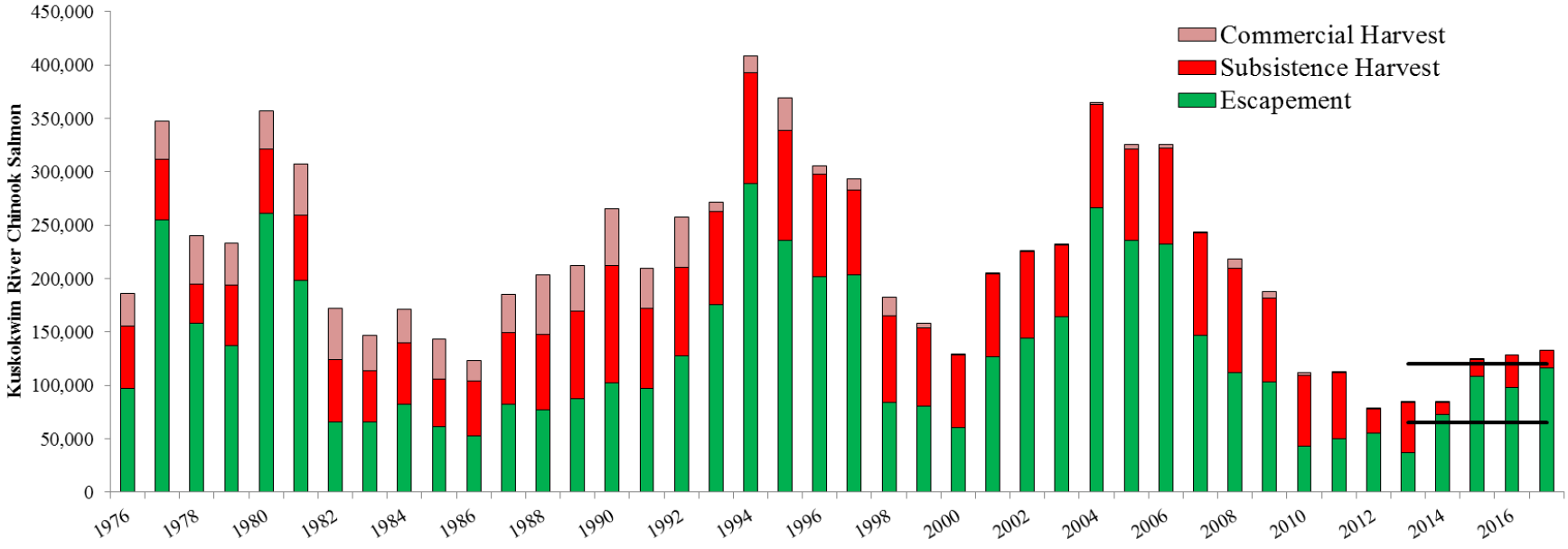


Total Run Performance

(Harvest & Escapement)



Total Run Performance

(Harvest & Escapement)

System	Goal Range [a] Lower	Goal Range [a] Upper	Escapement / harvest 2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Escapement												
Kuskokwim River (Current model)	65,000	120,000	128,978	118,478	49,073	72,097	76,074	47,315	123,987	155,464	145,718	150,193
Kuskokwim River (Revised Model)	65,000	120,000	111,613	103,101	43,541	49,718	55,746	36,823	72,560	108,454	97,640	116,597
Kogrukluk River	4,800	8,800	9,750	9,528	5,812	6,731	.	1,819	3,732	8,081	7,056	9,992
Kwethluk River	4,100	7,500	5,275	5,744	1,669	4,079	.	845	3,187	8,162	7,619	7,429
George River	1,800	3,300	2,563	3,663	1,498	1,547	2,201	1,292	2,993	2,282	1,663	3,685
Kisaralik River	400	1,200	1,074	.	235	.	588	599	622	709	622	.
Aniak River	1,200	2,300	3,222	.	.	.	.	754	3,201	.	718	1,781
Salmon River (Aniak R)	330	1,200	589	.	.	79	49	154	497	810	.	423
Holitna River	970	2,100	.	.	.	.	.	532	.	662	1,157	676
Cheeneetnuk River (Stony R)	340	1,300	290	323	.	249	229	138	340	.	217	660
Gagaryah River (Stony R)	300	830	177	303	62	96	178	74	359	19	135	453
Salmon River (Pitka Fork)	470	1,600	1,033	632	135	767	670	469	1,865	2,016	1,578	687
Harvest												
Subsistence	67,200	109,800	98,103	78,231	66,056	62,368	22,544	47,113	11,234	16,124	30,693	16,380
Commercial	NA		8,865	6,664	2,732	747	627	174	35	8	0	0
Sport	NA		708	904	354	579	0	0	0	0	0	0

[a] Refers to established escapement goal ranges for the entire Kuskokwim River drainage and select spawning tributaries. The Kuskokwim River drainagewide escapement goal was established in 2013.Subsistence harvest range refers to the Amounts Reasonably Necessary for Subsistence uses (ANS) as defined by the Alaska Board of Fisheries 5AAC 01.286. The ANS range was 64,500–83,000 during 2001–2012, but revised in 2013 to the range shown.

Contributors

Kuskokwim River Interagency Model Development Team

- Hamachan Hamazaki (ADF&G)
- Gary Decossas (USFWS OSM)
- William Bechtol (Bechtol Research / KRITFC)
- Matthew Catalano (Auburn University)

AYK SSI Expert Panel

- Daniel Schindler (University of Washington)
- Timothy Walsworth (University of Washington)
- Milo Adkison (University of Alaska Fairbanks)
- Randall Peterman (Simon Fraser University)
- Andre Punt (University of Washington)

Others

- Nick Smith and many other ADF&G staff
- Ben Staton (Auburn University / USFWS YDNWR)
- Joe Spaedar (AYKSSI)

Questions