Kenai River Sockeye Escapement Goals

United Cook Inlet Drift Association

2014

Evaluating Sockeye Escapement Goals in the Kenai River Utilizing Brood Tables and Markov Tables

This presentation pertains to all proposals related to Kenai River late-run sockeye salmon escapement goals:

Proposal Numbers 157, 159-163

Committee of the Whole (Group 5)

Escapement Goals

The purpose of an escapement goal is to ensure sustainability and to maximize yield (harvest).

State policy requires that escapement goals be developed from the best available data and be scientifically defensible.

Kenai River late-run sockeye is the only stock in the state that is managed with five escapement goals.

These goals include a Sustainable Escapement Goal, an Optimum Escapement Goal and three Inriver Goals depending on the projected strength of the run.

Is this really best management?

90% of Kenai River late-run sockeye rear in either Skilak Lake (70%) or Kenai Lake (15-20%).

Tools for evaluating sockeye escapement goals in the Kenai River:

Brood Tables -

Are combined with other data sets to show the interaction of some of the significant factors that influence the returns and age class diversity of past escapements (e.g. food availability, average fry weight and returns per spawn year by age class).

Markov Tables -

Use historic data on escapements, returns, returns per spawner and yields to illustrate the relationship between escapements and returns.

All data comes from ADF&G

Utilizing the data provided by both of these tools make it possible to evaluate and optimize escapement goals.

Appropriate sockeye escapement goals provide for:

- Maximum sustained yield (harvest);
- A well-distributed range of age classes in each return. This diversity strengthens the stocks' resilience to periodic catastrophic events;
- Equal numbers of males and females.

Brood Table Overview

Kenai River late-run sockeye salmon

Table 2. Kenai late-run sockeye salmon brood table, 1968–2013. Also included are total age-0 and age-1 fall fry abundances in Kenai and Skilak lakes, mean fall fry weights in Skilak Lake, summer (May–October) euphotic zone depth (EZD) and total zooplankton biomass during the ag

Brood		Fall Fry Abundance		Fall Fry Weight		EZD	Zoop Biomass	Adult Return													Total	
Year	Spawners	Age 0	Age 1	Age 0	Age 1	(m)	(mg/m2)	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	Return	Yield
1987	1,982,808	37,071,211	11,066,228	0.9	2.8	12.4	586.0	0	5,664	48,870	776,685	4,549	0	7,024,019	301,848	0	105,399	2,096,053	1,114	14,372	0	10,378,573	8,395,7
1988	1,174,729	13,987,502	782,393	1.2	4.0	10.5	693.2	408	1,156	0	151,779	7,105	0	1,491,124	292,377	596	21,963	576,976	2,873	4,586	0	2,550,942	1,376,2
1989	2,026,638	24,601,413	387,673	1.3	4.7	5.5	495.4	3,927	0	16,803	352,264	77,802	0	2,480,626	558,602	1,416	17,311	955,698	0	16,440	0	4,480,888	2,454,2
1990	733,155	7,126,711	104,391	1.5	7.0	6.3	368.8	1,133	3,457	5,947	223,830	13,944	0	778,479	191,364	0	10,973	284,029	2,423	3,405	0	1,518,983	785,8
1991	696,345	9,540,536	1,732,650	1.8	4.5	9.2	557.9	1,602	4,371	10,371	669,963	22,972	0	2,764,755	252,038	1,839	17,583	690,122	2,928	2,958	3,030	4,444,531	3,748,1
1992	1,188,534	35,687,389	1,280,854	1.2	3.6	7.0	761.9	0	2,651	8,468	345,482	10,423	0	3,443,710	140,781	0	19,993	293,962	2,775	4,497	0	4,272,741	3,084,2
1993	992,096	11,159,398	473,111	1.4	5.7	5.6	428.2	0	0	14,950	289,049	7,055	0	816,428	196,881	1,642	12,463	330,626	14,864	6,306	0	1,690,264	698,1
1994	1,307,440	8,812,895	368,644	1.7	4.0	8.0	507.0	0	1,762	0	484,193	77,318	0	1,727,679	439,434	1,822	17,644	291,755	9,532	0	2,322	3,053,461	1,746,0
1995	771,936	5,582,452	239,582	1.6	3.1	3.5	378.6	0	3,402	8,637	429,237	16,262	0	1,039,520	154,550	0	15,062	230,962	0	2,266	610	1,900,509	1,128,5
1996	916,244	25,316,385	2,459,746	0.9	1.7	5.5	342.5	0	0	13,177	254,848	26,314	0	1,533,117	158,035	0	25,387	246,833	2,554	2,402	0	2,262,667	1,346,4
1997	1,326,202	21,193,560	629,011	0.7	4.0	4.2	273.4	0	1,765	0	230,482	16,857	0	2,142,070	327,237	1,220	16,829	873,782	0	10,985	6,095	3,627,321	2,301,7
1998	877,707	8,330,506	472,469	1.3	4.1	7.4	421.7	0	3,740	3,017	702,252	12,437	0	2,711,407	314,379	1,356	30,292	677,643	6,352	3,477	0	4,466,351	3,588,6
1999	916,632	19,950,396	520,673	1.2	3.2	6.7	489.8	1,833	0	11,713	499,505	4,233	0	3,958,012	426,787	0	18,160	807,764	14,996	10,902	2,295	5,756,200	4,839,5
2000	669,406	22,509,586	3,342,145	1.0	2.6	8.6	386.3	4,396	634	19,641	562,922	7,454	0	4,988,691	123,758	0	67,707	1,262,915	2,295	23,749	4,678	7,068,840	6,399,4
2001	714,201	8,748,692	434,724	1.0	2.8	9.0	535.5	0	0	12,693	133,865	4,838	0	1,110,286	104,717	0	52,176	279,589	4,678	3,511	0	1,706,353	992,1
2002	1,082,561	12,750,428	711,475	1.3	2.1	4.1	344.9	1,906	38	13,197	283,740	10,902	0	2,835,116	156,527	0	94,793	225,727	0	3,416	0	3,625,362	2,542,8
2003	1,395,976	27,574,335	106,971	0.6	1.5	5.9	407.1	0	0	4,678	213,380	23,749	0	1,256,677	149,314	0	20,985	236,693	3,416	0	0	1,908,893	512,9
2004	1,679,806	41,936,000	7,859,788	0.5	2.0	6.0	489.9	0	0	7,228	313,292	14,663	0	1,772,029	240,110	0	7,444	772,210	3,884	7,978	15,342	3,154,177	1,474,3
2005	1,647,023	29,563,865	8,945,317	0.7	1.8	6.6	592.6	0	0	3,416	149,580	3,416	0	1,438,265	151,464	0	23,319	2,800,132	0	0	0	4,569,593	2,922,5
2006	1,876,180	9,138,282	186,842	0.9	4.0	5.4	563.9	0	7,076	3,884	756,998	90,943	0	2,389,594	333,831	0	78,758	1,159,210	0	13,577	0	4,833,873	2,957,6
2007	957,430	20,154,463	688,401	1.3	4.8	10.9	834.7	3,884	7,444	0	488,474	69,957	0	2,127,420	731,463	0	28,869	924,060	0			4,381,571	3,424,7
2008	703,979	10,755,096	460,689	1.6	3.4	9.4	987.4	0	7,978	0	585,265	11,319	0	1,889,869	195,328	0							
2009	843,255	17,778,081	3,796,914	1.2	3.4	6.1	509.6	0	22,637	0	325,692	8,431											
2010	1,015,106	11,809,877	5,442,363	1.2	3.6	7.8	573.2	0	3,392														
2011	1,275,369	23,560,643	2,857,684	1.2	3.3	6.9	778.8																
2012	1,197,518	9,515,604		1.1		5.4																	
2013	1,054,554																						
20-year averag	1,198,781	18,183,240	2,206,202	1.2	3.6	6.8	493.7				398,431	26,143		2,140,250	272,182		33,712	754,634	3,734	6,741	1,719	3,888,195	2,664,7
	20	20	20	20	20	20	20				20	20		20	20		20	20	20			21	

Each row lists the data from one brood year including number of spawners, fall fry abundance and weights, euphotic zone depth (EZD), zooplankton biomass, the adult return in subsequent years by age class, total adult return, yield (harvest), harvest rate and return per spawner.

Brood Table Definitions

Brood Year	Spawners
1992	1,188,534
1993	992,096
1994	1,307,440
1995	771,936
1996	916,244
1997	1,326,202
1998	877,707
1999	916,632
2000	669,406
2001	714,201
2002	1,082,561
2003	1,395,976
2004	1,679,806
2005	1,647,023
2006	1,876,180
2007	957,430
2008	703,979
2009	843,255
2010	1,015,106
2011	1,275,369
2012	1,197,518
2013	1,054,554
20-year average	1,198,781
	20

Brood Year –

The spawning year.

Spawners –

Number of late-run sockeye spawners in that brood year.

The number of spawners is derived from the sonar escapement estimate minus the number of fish harvested by sport fisheries upstream of the counters at river mile 19.

Brood Table Definitions

Fall Fry Abundance			Fall Fry Weight	
Age 0	Age 1		Age 0	Age 1
35,687,389	1,280,854		1.2	3.6
11,159,398	473,111		1.4	5.7
8,812,895	368,644		1.7	4.0
5,582,452	239,582		1.6	3.1
25,316,385	2,459,746		0.9	1.7
21,193,560	629,011		0.7	4.0
8,330,506	472,469		1.3	4.1
19,950,396	520,673		1.2	3.2
22,509,586	3,342,145		1.0	2.6
8,748,692	434,724		1.0	2.8
12,750,428	711,475		1.3	2.1
27,574,335	106,971		0.6	1.5
41,936,000	7,859,788		0.5	2.0
29,563,865	8,945,317		0.7	1.8
9,138,282	186,842		0.9	4.0
20,154,463	688,401		1.3	4.8
10,755,096	460,689		1.6	3.4
17,778,081	3,796,914		1.2	3.4
11,809,877	5,442,363		1.2	3.6
23,560,643	2,857,684		1.2	3.3
9,515,604			1.1	
18,183,240	2,206,202		1.2	3.6

Fall Fry Abundance and Weight –

- Fry are counted and weighed in Skilak Lake every fall. Fry counts and weight are presented in the Brood Table according to the brood year (year spawned)
- Age 0 fry spend less than 1 year in fresh water
- Age 1 fry spend 1 year in fresh water
- Fry Weight is measured in grams.
- Fry tend to spend 2 years in freshwater if they do not grow large enough in their first year for out-migrating.

Brood Table Definitions

EZD (m)	Zoop Biomass (mg/m2)
7.0	761.9
5.6	428.2
8.0	507.0
3.5	378.6
5.5	342.5
4.2	273.4
7.4	421.7
6.7	489.8
8.6	386.3
9.0	535.5
4.1	344.9
5.9	407.1
6.0	489.9
6.6	592.6
5.4	563.9
10.9	834.7
9.4	987.4
6.1	509.6
7.8	573.2
6.9	778.8
5.4	
6.8	493.7

EZD -

Euphotic Zone Depth – depth in meters of the penetration of sufficient light in the lake to allow for photosynthesis to occur. It is affected by seasonal changes in turbidity and irregular effects like flooding. EZD is directly related to the Zooplankton Biomass (food levels).

Zoop Biomass – Food Supply

Zooplankton Biomass - (measured in micrograms of zooplankton per square meter) an estimate of food levels available for fry residing in lake.

Brood Table Definitions

Adult Return Age Class Columns –

Show the subsequent adult returns from the brood year in columns by fish age.

Each age class of returned adults is further broken down by the time the fish spent in freshwater before migrating. The first number is the number of years spent in freshwater, the second number is the number of years spent in saltwater.

The full age in years (in red) of the adult fish is the combined total of the fresh and saltwater years plus one.

Actual age in years of returned adult fish:

3	3	4	4	4	5	5	5	5	6	6	6	7	7
						Adult Return							
0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3
0	2,651	8,468	345,482	10,423	0	3,443,710	140,781	0	19,993	293,962	2,775	4,497	0
0	0	14,950	289,049	7,055	0	816,428	196,881	1,642	12,463	330,626	14,864	6,306	0
0	1,762	0	484,193	77,318	0	1,727,679	439,434	1,822	17,644	291,755	9,532	0	2,322
0	3,402	8,637	429,237	16,262	0	1,039,520	154,550	0	15,062	230,962	0	2,266	610
0	0	13,177	254,848	26,314	0	1,533,117	158,035	0	25,387	246,833	2,554	2,402	0
0	1,765	0	230,482	16,857	0	2,142,070	327,237	1,220	16,829	873,782	0	10,985	6,095
0	3,740	3,017	702,252	12,437	0	2,711,407	314,379	1,356	30,292	677,643	6,352	3,477	0
1,833	0	11,713	499,505	4,233	0	3,958,012	426,787	0	18,160	807,764	14,996	10,902	2,295
4,396	634	19,641	562,922	7,454	0	4,988,691	123,758	0	67,707	1,262,915	2,295	23,749	4,678
0	0	12,693	133,865	4,838	0	1,110,286	104,717	0	52,176	279,589	4,678	3,511	0
1,906	38	13,197	283,740	10,902	0	2,835,116	156,527	0	94,793	225,727	0	3,416	0
0	0	4,678	213,380	23,749	0	1,256,677	149,314	0	20,985	236,693	3,416	0	0
0	0	7,228	313,292	14,663	0	1,772,029	240,110	0	7,444	772,210	3,884	7,978	15,342
0	0	3,416	149,580	3,416	0	1,438,265	151,464	0	23,319	2,800,132	0	0	0
0	7,076	3,884	756,998	90,943	0	2,389,594	333,831	0	78,758	1,159,210	0	13,577	0
3,884	7,444	0	488,474	69,957	0	2,127,420	731,463	0	28,869	924,060	0		
0	7,978	0	585,265	11,319	0	1,889,869	195,328	0					
0	22,637	0	325,692	8,431									
0	3,392												

Brood Table Definitions

It takes 7 years to see the total adult returns (escapement plus yield) on a single spawning brood year.

Healthy sockeye (and chinook) stocks include a variety of age classes in each return. This diversity strengthens the stocks' resilience to periodic catastrophic events.

Actual age in years of returned adult fish:

3	3	4	4	4	5	5	5	5	6	6	6	7	7
								Adult Return					
0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3
0	2,651	8,468	345,482	10,423	0	3,443,710	140,781	0	19,993	293,962	2,775	4,497	0
0	0	14,950	289,049	7,055	0	816,428	196,881	1,642	12,463	330,626	14,864	6,306	0
0	1,762	0	484,193	77,318	0	1,727,679	439,434	1,822	17,644	291,755	9,532	0	2,322
0	3,402	8,637	429,237	16,262	0	1,039,520	154,550	0	15,062	230,962	0	2,266	610
0	0	13,177	254,848	26,314	0	1,533,117	158,035	0	25,387	246,833	2,554	2,402	0
0	1,765	0	230,482	16,857	0	2,142,070	327,237	1,220	16,829	873,782	0	10,985	6,095
0	3,740	3,017	702,252	12,437	0	2,711,407	314,379	1,356	30,292	677,643	6,352	3,477	0
1,833	0	11,713	499,505	4,233	0	3,958,012	426,787	0	18,160	807,764	14,996	10,902	2,295
4,396	634	19,641	562,922	7,454	0	4,988,691	123,758	0	67,707	1,262,915	2,295	23,749	4,678
0	0	12,693	133,865	4,838	0	1,110,286	104,717	0	52,176	279,589	4,678	3,511	0
1,906	38	13,197	283,740	10,902	0	2,835,116	156,527	0	94,793	225,727	0	3,416	0
0	0	4,678	213,380	23,749	0	1,256,677	149,314	0	20,985	236,693	3,416	0	0
0	0	7,228	313,292	14,663	0	1,772,029	240,110	0	7,444	772,210	3,884	7,978	15,342
0	0	3,416	149,580	3,416	0	1,438,265	151,464	0	23,319	2,800,132	0	0	0
0	7,076	3,884	756,998	90,943	0	2,389,594	333,831	0	78,758	1,159,210	0	13,577	0
3,884	7,444	0	488,474	69,957	0	2,127,420	731,463	0	28,869	924,060	0		
0	7,978	0	585,265	11,319	0	1,889,869	195,328	0					
0	22,637	0	325,692	8,431									
0	3,392												

Brood Table Definitions

Total Return	Yield	R/S
4,272,741	3,084,207	3.6
1,690,264	698,168	1.7
3,053,461	1,746,021	2.3
1,900,509	1,128,573	2.5
2,262,667	1,346,423	2.5
3,627,321	2,301,119	2.7
4,466,351	3,588,644	5.1
5,756,200	4,839,568	6.3
7,068,840	6,399,434	10.6
1,706,353	992,152	2.4
3,625,362	2,542,800	3.3
1,908,893	512,917	1.4
3,154,177	1,474,371	1.9
4,569,593	2,922,570	2.8
4,833,873	2,957,692	2.6
4,381,571	3,424,141	4.6
3,888,195	2,664,745	3.5

- Average 1987 - 2006

- **Total Return** - escapement plus harvest of adults returned from the brood year.

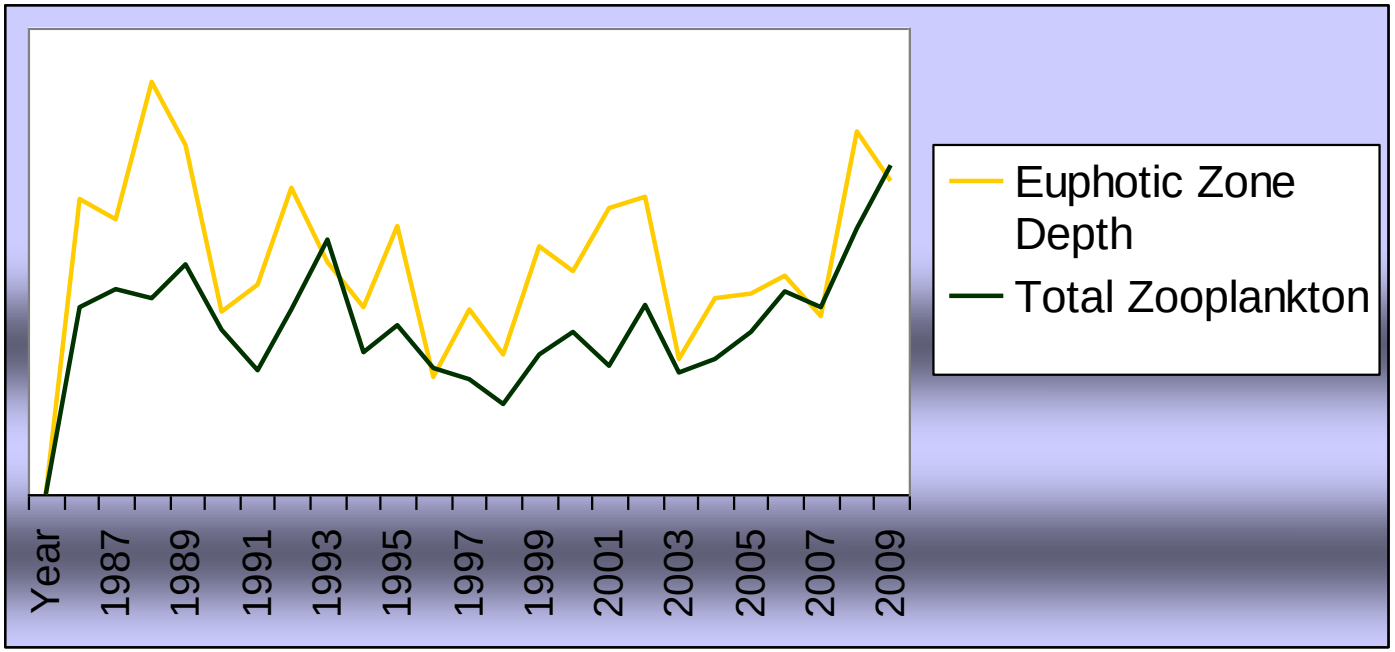
- **Yield** – the available, harvestable surplus of salmon.

- **R/S** - Return per spawner – number of adults returned per spawner for the brood year.

Brood Table Utilization

Organizing these data by brood year illustrates the relationships between some of the factors that influence sockeye production.

The Zooplankton abundance (food supply) is reflective of the EZD. (These are seasonally adjusted average values.)



The importance of the relationship between the food supply and the number of spawners is illustrated in the comparison of these three data sets from the Brood Table.

An above average food supply will produce a higher yield from fewer spawners.

An average or below average food supply significantly reduces yield when the number of spawners is above average.

What the Brood Table Tells Us:

2003 - Lots of spawners – below average food supply – poor yields – worst yield we've seen in over 30 years

2007 - Fewer spawners with above average food supply – better yields

2008 - Even fewer spawners, best food supply – still waiting on yields*

* It takes a full 7 years to see the adult returns (escapement plus yield) on a single spawning year

A closer look at the results from the 2003 spawning year:

•1.4 million spawners were put into the Kenai River with a below average food supply in Skilak Lake.

•The average fall fry weight was only half of the 20 year average (.6 gm fry versus 1.2 gm fry).

•Food supply could not support the number of fry in Skilak Lake and the return was significantly reduced (return per spawner was 1.4 versus 20 year average of 3.5)

•Total Yield was 513,000; only 20% of the 20 year average yield of 2.6 million

•No seven year olds came back.

•No three year olds came back.

•Majority of the fish came back as five year olds

Risks of maintaining excessively high escapement goals:

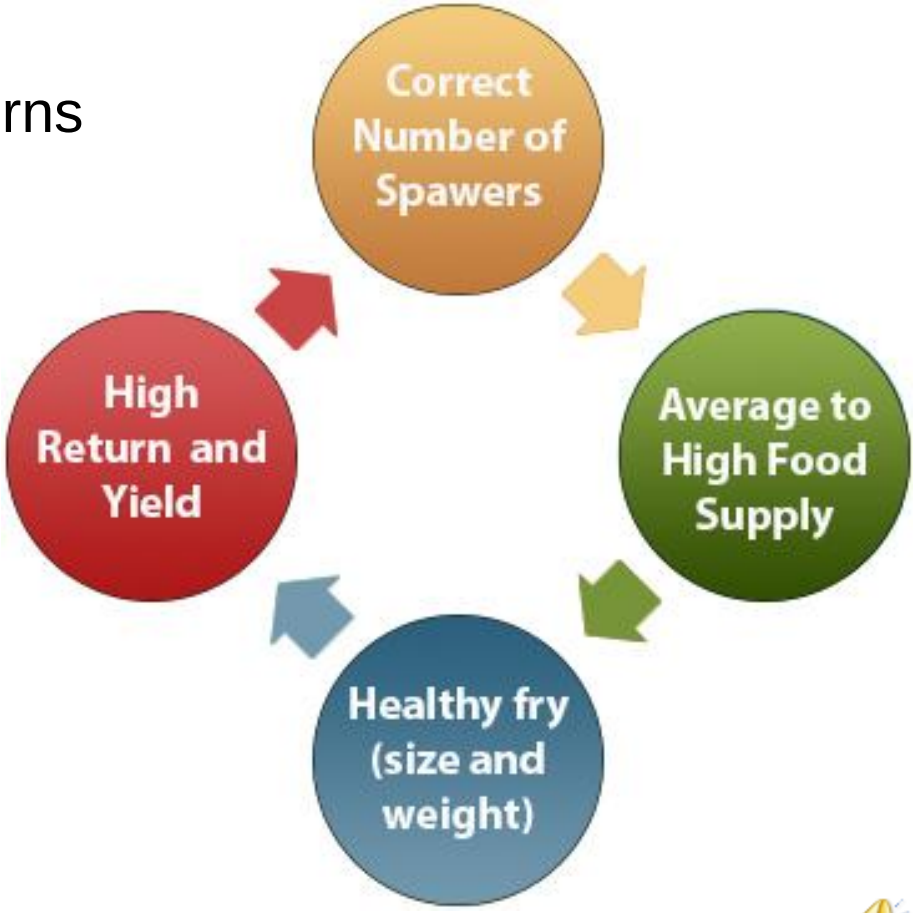
- Continued excessive escapements will lead to density-dependent effects that result in poor returns and the eventual collapse of the fish stock.
- Examples of areas that were devastated by density dependent effects resulting from persistent over-escapements:
  - Coghill (Prince William Sound)
  - Karluk (Kodiak)
  - Frazer (Kodiak)
- Excessively high escapement goals cause density-dependent processes that lead to declines in reproductive success due to intensified competition for limiting resources including juvenile food, suitable rearing habitat and adult spawning habitat.

A closer look at the results from the 2007 spawning year:

- 960,000 spawners were put into the Kenai with an above average food supply in Skilak Lake.
- The average fall fry weight was 1.3 gm; eight percent above the 20 year average.
- Return per spawner was average (4.6) and the yield was 3.4 million sockeye, 38% greater than the 20 year average. (The seven year old class of fish from this year has not yet been counted)
- The return age classes were well-distributed across a wide range, providing a diversity that can buffer the effects of catastrophic events

What we need for healthy salmon stocks

- Correct escapement levels
- Good food supply in the lakes
- Wide range of age class in returns



The food supply (Zooplankton biomass) is one of the main predictors of healthy return but is not itself predictable.

Other variables include healthy habitat.

Brood Tables Summary

Brood Tables, with the inclusion of other data sets:

- Show the details of the return of each brood year of salmon from the number of spawners to the ratio of return per spawner.

- Indicate the interaction of some of the various factors that influence the returns and age class diversity of past escapements (e.g. food supply, average fry weight and returns per spawn year by age class).

Brood Tables provide a foundation for understanding and interpreting Markov Tables.

Markov Tables

•Use historic data on escapements, returns, returns per spawner and yields to illustrate the relationship between escapements and returns.

•Provide a straightforward model to predict return/yield based on escapement levels.

Markov Table

We start with the following data for late-run Kenai River sockeye:

- Brood Year
- Spawners
- Return
- Return per Spawner
- Yield (harvest)

Brood Year	Spawners	Returns	Return per Spawner	Yield
1969	72,901	430,947	5.91	358,046
1970	101,794	550,923	5.41	449,129
1975	184,262	1,055,374	5.73	871,112
1974	209,836	788,067	3.76	578,231
1979	373,810	1,321,707	3.54	947,897
1971	406,714	986,397	2.43	579,683
1972	431,058	2,547,851	5.91	2,116,793
1984	446,397	3,865,134	8.66	3,418,737
1973	507,072	2,125,986	4.19	1,618,914
1976	507,440	1,506,075	2.97	998,635
1978	511,781	3,785,623	7.40	3,273,842
1981	527,553	2,465,818	4.67	1,938,265
1986	546,614	2,174,842	3.98	1,628,228
1985	573,611	2,592,968	4.52	2,019,357
1980	600,813	2,675,007	4.45	2,074,194
2000	668,510	7,061,112	10.56	6,392,602
2001	713,484	1,705,699	2.39	992,215
1990	730,471	1,518,983	2.08	788,512
1982	755,413	9,591,200	12.70	8,835,787
1991	756,348	4,444,531	5.88	3,688,183
1995	771,935	1,900,509	2.46	1,128,574
1983	792,368	9,489,648	11.98	8,697,280
1998	877,434	4,466,351	5.09	3,588,917
1999	916,047	5,755,767	6.28	4,839,720
1996	916,244	2,262,667	2.47	1,346,423
1977	951,038	3,112,852	3.27	2,161,814
1993	992,096	1,690,264	1.70	698,168
2002	1,081,577	3,625,113	3.35	2,543,536
1988	1,173,656	2,550,942	2.17	1,377,286
1992	1,188,434	4,272,741	3.60	3,084,307
1994	1,307,269	3,053,461	2.34	1,746,192
1997	1,326,202	3,627,321	2.74	2,301,119
2003	1,395,432	1,908,893	1.37	513,461
2005	1,646,987	2,650,255	1.61	1,003,268
2004	1,678,521	3,149,511	1.88	1,470,990
2006	1,876,088	4,449,367	2.37	2,573,279
1987	1,982,501	10,378,573	5.24	8,396,072
1989	2,027,299	4,480,888	2.21	2,453,589

Markov Table

Markov Table for late-run Kenai River sockeye salmon, brood years 1969 - 2006						
Escapement	n	Mean	Mean	Return per	Yield	
Interval (000)		Spawners (000)	Returns (000)	Spawner	Mean (000)	Range (000)
0-200	3	120	679	5.7	559	358-871
100-300	3	165	798	5.0	633	449-871
200-400	2	292	1,055	3.6	763	578-948
300-500	4	414	2,180	5.1	1,766	580-3,419
400-600	9	495	2,450	5.0	1,955	580-3,419
500-700	8	555	3,048	5.3	2,493	999-6,393
600-800	8	724	4,798	6.6	4,075	788-8,697
700-900	7	771	4,731	6.1	3,960	788-8,697
800-1,000	5	931	3,458	3.8	2,527	698-4,840
900-1,100	5	971	3,289	3.4	2,318	698-4,840
1,000-1,200	3	1,148	3,483	3.0	2,335	1,377-3,084
1,100-1,300	2	1,181	3,412	2.9	2,231	1,377-3,084
1,200-1,400	3	1,343	2,863	2.2	1,520	513-2,301
> 1,300	8	1,655	4,212	2.5	2,557	513-8,396

We choose the Escapement (Spawner) Interval - 200,000 in this case

The brood year data is then grouped into the appropriate escapement interval.

“n” is the number of brood years in each interval.

Markov Table

Markov Table for late-run Kenai River sockeye salmon, brood years 1969 - 2006						
Escapement	n	Mean	Mean	Return per	Yield	
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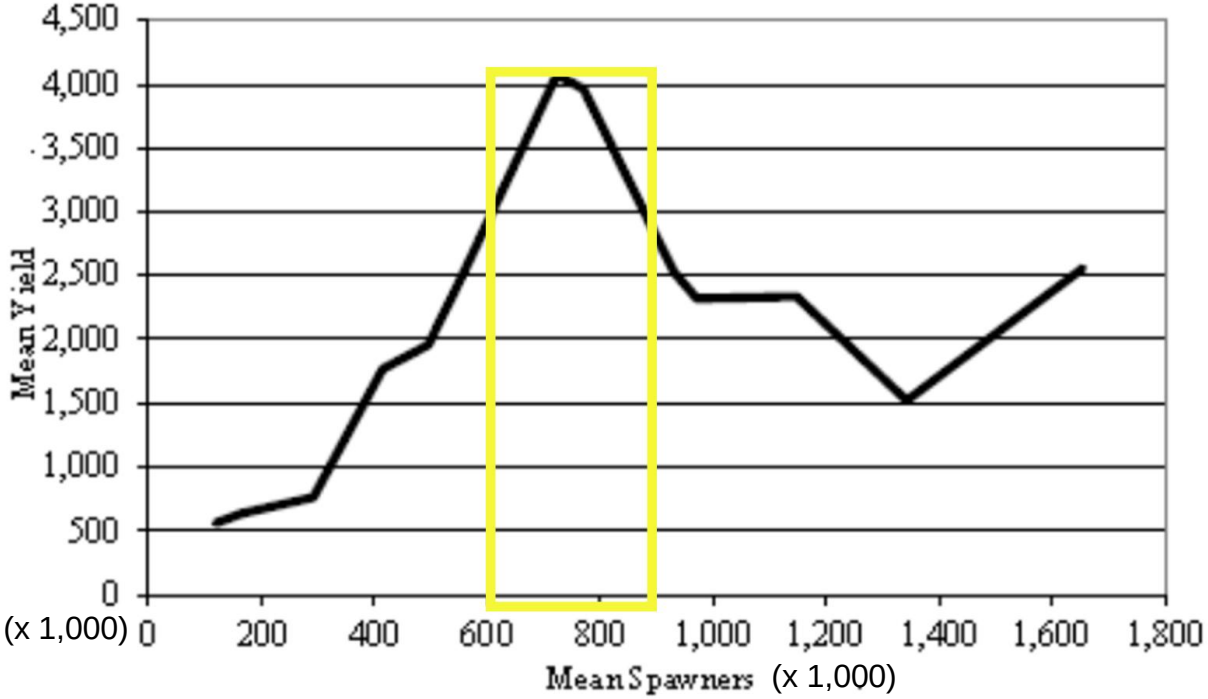
> 1,300	8	1,655	4,212	2.5	2,557	513-8,396

The table shows the escapement (spawner) interval level, the number of years the escapement fell within that level, the mean spawners, mean returns, return per spawner and yield (harvestable surplus).

The highlighted rows are the intervals that had the best returns, best return per spawner rates and best mean yields (harvestable surpluses).

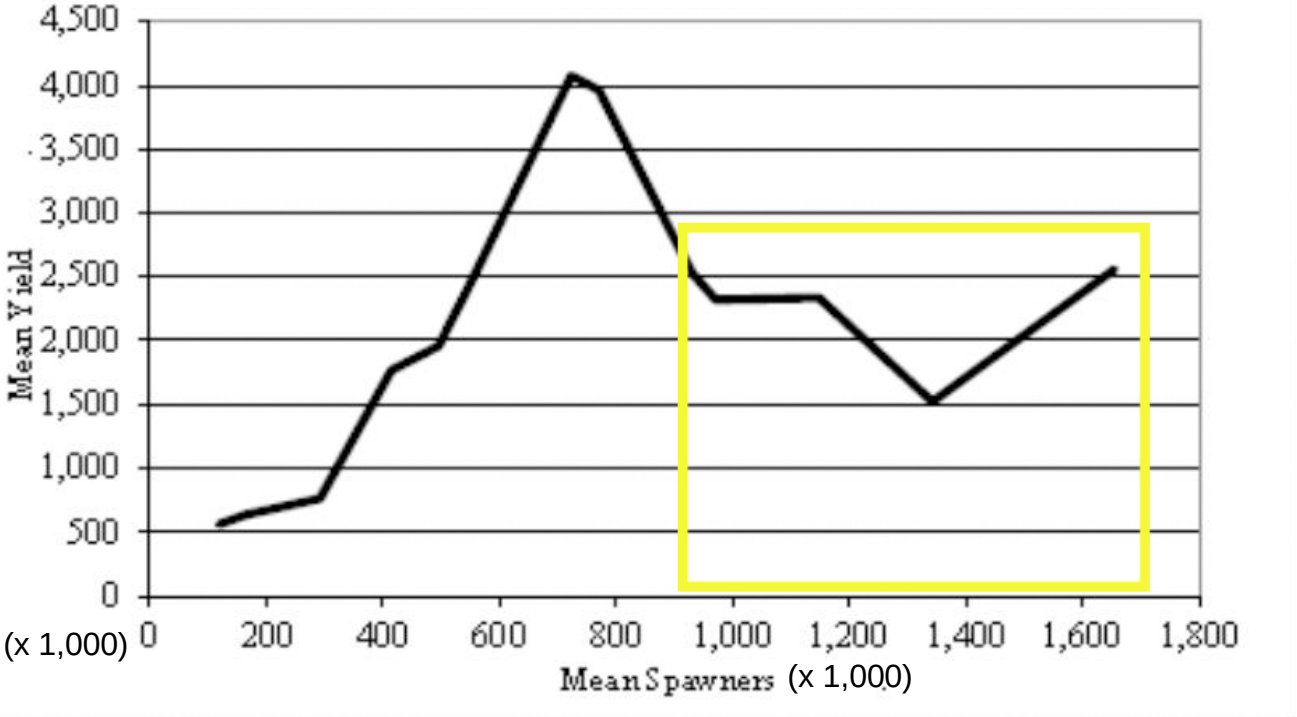
Markov Table Graph Kenai Late-run Sockeye



The graph clearly illustrates that for 37 years (1969 – 2006) the yields were highest when spawner levels were between 600,000 – 900,000.

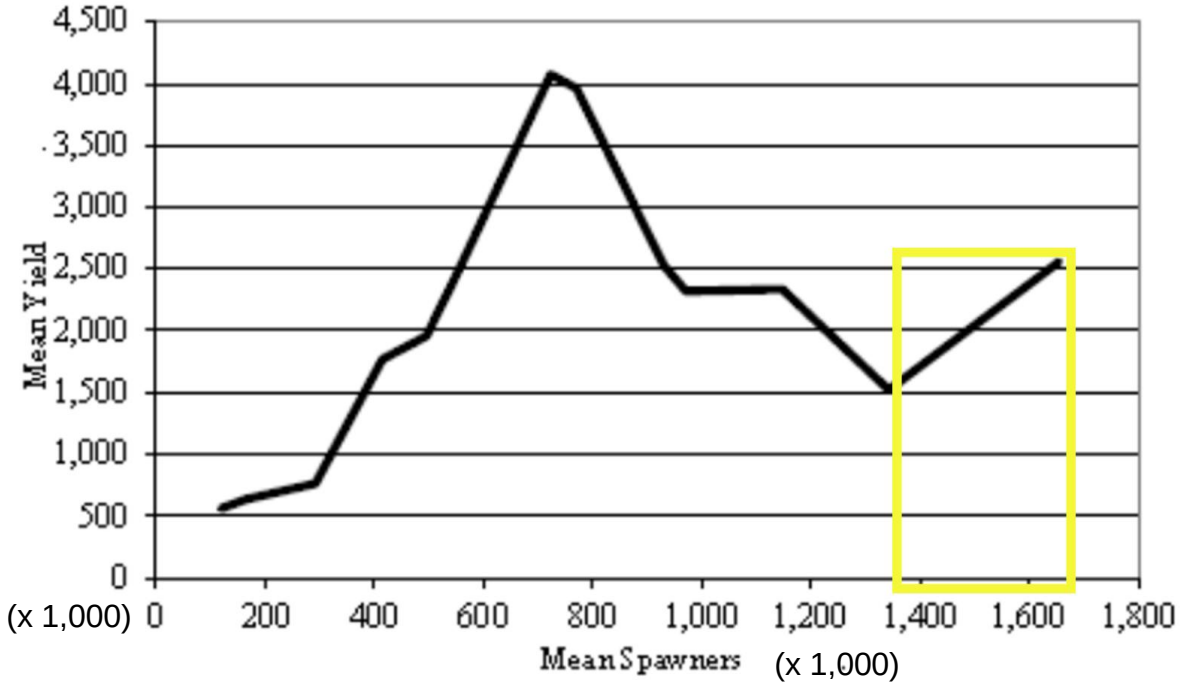
When spawner levels are between 600,000 – 900,000 we see the greatest potential for maximum returns and this means the maximum yield (harvestable surpluses) for all user groups.

Markov Table Graph Kenai Late-run Sockeye



Average yields drop significantly once the number of spawners surpasses 900,000.

Markov Table Graph Kenai Late-run Sockeye

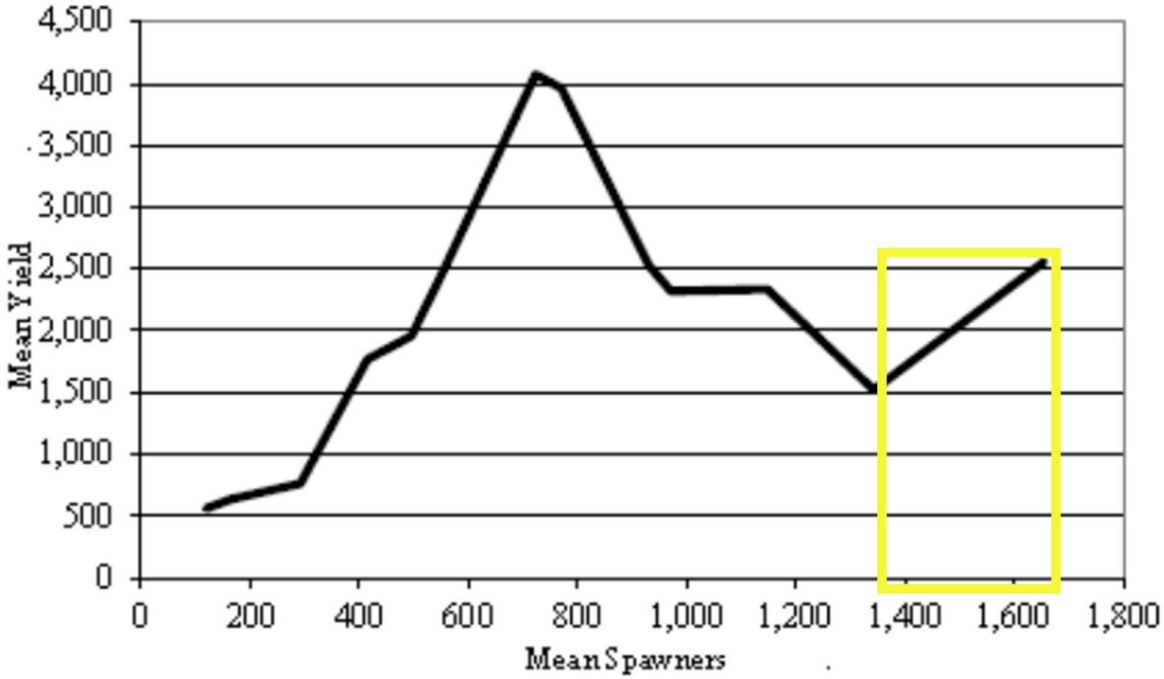


The data trend angles upward again once the escapement exceeds 1.3 million spawners.

However, if we refer back to the table, at these escapement levels we see a very wide range in the yield (513,000 – 8,396,000) and a significant drop in the Return per Spawner.

The extreme highs and lows reflect the variability and unpredictability of food supply and other habitat factors.

Markov Table Graph Kenai Late-run Sockeye



The extreme highs and lows also illustrate the oscillation of returns when escapement levels exceed habitat carrying capacity. Excessively high escapements cause returns to decrease in the next generation. Escapements then decrease, resulting in higher returns in subsequent generations.

These effects can be blurred by changes in habitat conditions and other factors. When factors aren't positively favorable, returns per spawner in the down cycles can fall below replacement levels.

Conclusions

"Overescapement, in general, is not sustainable…"

(Clark, Robert, et al, 2007, Biological and fishery-related aspects of overescapement in Alaskan sockeye salmon, ADF&G.)

Over-escapement is not a myth. Whether escapement goals are exceeded or escapement goals are set too high, salmon populations are at risk when they exceed the carrying capacity of the habitat.

Escapement goals should be based on production capacity, food supplies and historical data. Increasing escapement goals based on annual variations in run size is not scientifically defensible.

Large escapements produce oscillating returns, low return per spawner rates and other density-dependent effects. The extreme variability of returns on large escapements puts at risk future runs and the economies that are built around the harvest of the surplus stocks.

Conclusions

Historical data for Kenai River late-run sockeye indicate that spawner levels between 600,000 and 900,000 provide the best returns, best returns per spawner and best yields.

Kenai River late-run sockeye is the only stock in Alaska that is managed with three different inriver escapement goals depending on the projected strength of the run. This has led to Kenai River late-run sockeye spawner counts between 1.1 million and 1.28 million for each of the past 4 years.

Kenai River late-run sockeye should be managed for a Sustainable Escapement Goal and the Optimum Escapement Goal should be dropped from regulation. This management goal should apply to all user groups and will benefit all user groups.