Kuskokwim River Salmon Management Working Group

1 (800) 315-6338 (MEET) Code: 58756# (KUSKO)-*this meeting was not teleconferenced*
ADF&G Bethel toll free: 1 (855) 933-2433

Meeting Summary Part 3: Run Reconstruction Presentations

August 21 and 22, 2012- This meeting was not teleconferenced because the main purpose of the meeting was 1) to facilitate an After Action Review of Chinook salmon management and the Working Group process (Mtg. Summary Part 1); and 2) to provide in depth presentations describing the science behind population dynamics and the direction of management on the Kuskokwim River. The complexity of the discussion and presentations required that participants attend in person, and members were asked to attend in person at the Department's expense. *Meetings were held at The Long House Bed and Breakfast in Bethel.*

AGENDA ITEMS:

1) Chinook Management After Action Review (Mtg. summary Part 1)
2) Continuing Business (Mtg. summary Part 2)

August 22

3) **Presentations: Kuskokwim River Chinook salmon run reconstruction, brood table, and spawner recruit concepts. (Kevin Schaberg)**
4) Old business: housekeeping discussions on old action items, attendance, etc. (Tabled, Mtg. Summary Part 2)
5) New Business: Board of Fish proposals (Tabled, Mtg. Summary Part 2)

August 22→ The meetings reconvened at 9:00am on Wednesday morning. Kevin Schaberg delivered three presentations:

1. **The Kuskokwim River Chinook Salmon Run Reconstruction,**
2. **Brood table development, and**
3. **Spawner/Recruit concepts.**

The first two presentations were given between 9:00am and 12:00pm. The third presentation was given between 1:30pm and 3:30pm. Discussion regarding whether to deliver the third presentation can be found in Meeting Summary Part 2 for this meeting.

Have questions about these presentations? Please contact:

Kevin Schaberg
Alaska Department of Fish and Game
Kuskokwim Area Research Biologist (lead)
In Anchorage (907) 267-2174

Presentation 1: Kuskokwim River Chinook salmon Run Reconstruction.

Run Reconstruction Objective

- Estimate total return of Chinook salmon in the Kuskokwim River for all years with adequate data (1976-present)
  - Escapement at weirs
  - Escapement with aerial surveys
  - Mark–recapture estimates of abundance
  - Subsistence harvest
  - Commercial harvest
  - BTF harvest
  - Sport harvest

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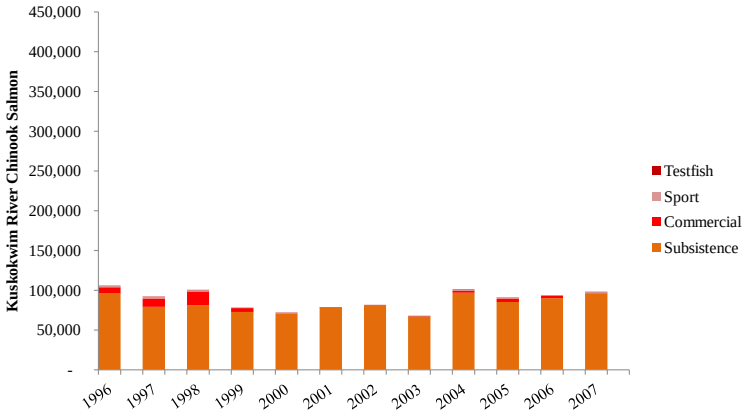
Harvest

Stable; driven by subsistence, not relative to abundance



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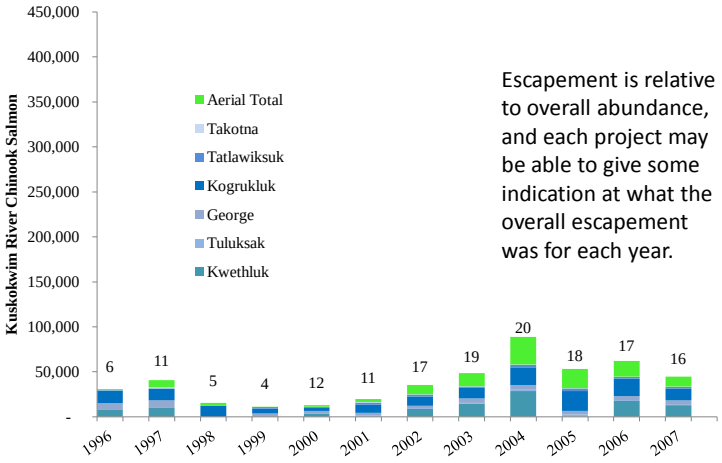
Harvest data does not provide a lot of information on total run in a given year, because the subsistence fishery only harvests the number needed by users, and that need does not change relative to fish abundance.

Monitored escapement

Number of projects vary, but Kogrukluk is consistent to 1976.



Escapement is relative to overall abundance, and each project may be able to give some indication at what the overall escapement was for each year.

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Monitored escapement

- How much of the total escapement does each weir monitor?
- We can't answer this until we get an estimate of total escapement.
  - Major component of Run Reconstruction

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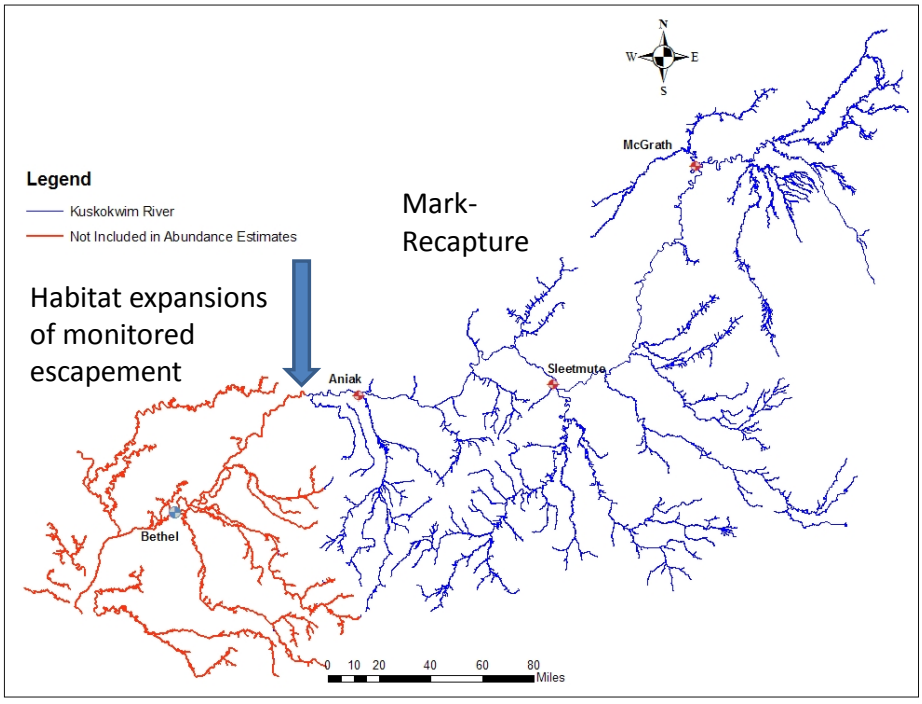
Reconstruction of Total Escapement



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Reconstruction of Total Escapement

*Mark–recapture

Estimates of abundance for Chinook salmon **upstream of Birch Tree Crossing, 2003-2007**. From Schaberg et al. 2012

	Project Year				
	2003	2004	2005	2006	2007
Abundance Estimate above Birch Tree Crossing	125,235	224,519	174,317	245,043	130,279
Lower 95% CI	83,679	136,933	121,499	163,722	91,483
Upper 95% CI	185,292	334,729	250,596	338,966	182,968

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Reconstruction of Total Escapement

* Lower Kuskokwim River tributaries

Estimates of lower Kuskokwim River escapement, derived from weir counts, and expansion of habitat based estimates of escapement. From Schaberg et al. 2012

	Watershed Area (km²)	Year				
		2003	2004	2005	2006	2007
Kwethluk River ***Escapement***	1,439	14,474	28,605	22,836	17,619	12,927
Eek River (Above tidal)	1,655	15,945	31,513	25,157	19,410	14,241
Kisaralik/Kasigluk Rivers	2,495	21,185	41,868	33,424	25,788	18,921
Tuluksak River ***Escapement***	316	1,064	1,475	2,653	1,044	394
Fog River	374	1,196	1,657	2,981	1,173	443
Lower Kuskokwim River Escapement		53,864	105,118	87,051	65,034	46,925
Lower 95% CI		45,142	87,883	73,286	54,418	39,137
Upper 95% CI		62,586	122,353	100,817	75,650	54,713

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Habitat model says that the number of fish a river can support is closely related to the size of the watershed, i.e. larger watersheds have more fish because there is more habitat available.

Reconstruction of Total Return

Total inriver abundance for Chinook salmon in the Kuskokwim River 2003-2007 combining harvest and estimates derived from mark-recapture and habitat model techniques. From Schaberg et al. 2012.

Component	2003	2004	2005	2006	2007
Abundance Upstream of Birch Tree Crossing	125,235	224,519	174,317	245,043	130,279
Escapement Downstream of Birch Tree Crossing	53,864	105,118	87,051	65,034	46,925
Total Harvest	62,518	93,020	84,446	86,171	89,015
Total Inriver Abundance	241,617	422,657	345,814	396,248	266,219
Lower 95% CI	182,710	298,728	270,560	281,847	211,280
Upper 95% CI	326,202	577,993	453,516	528,218	340,445

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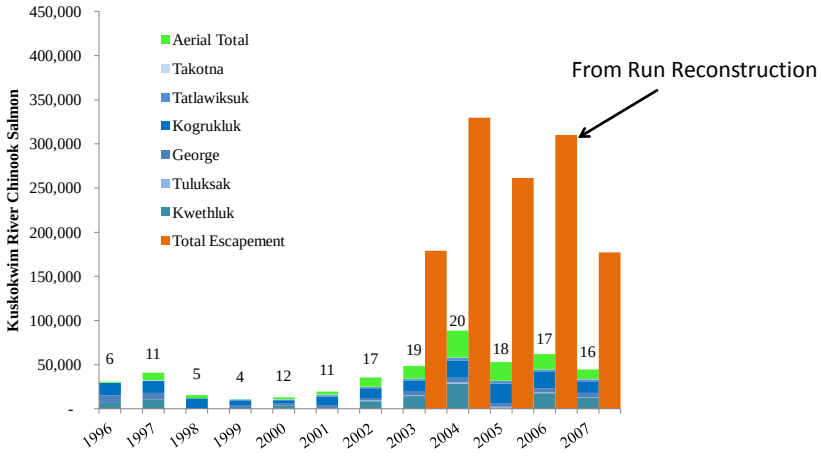
Escapement
Monitored and Total Estimated



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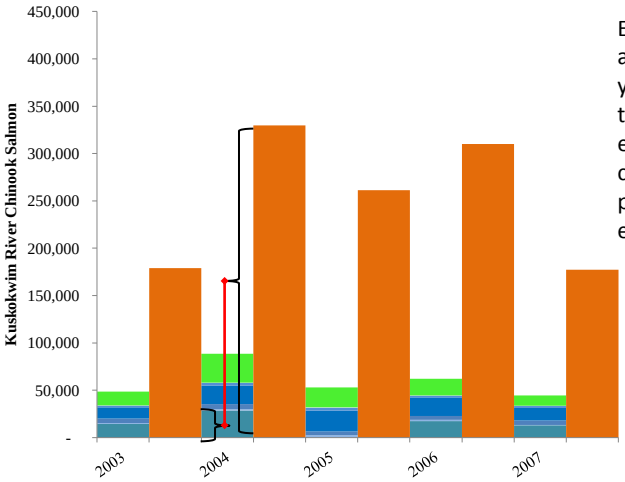
The estimates of total run allow us to see how much each project monitors relative to the total abundance. This figure shows that all our projects combined only monitor a small part of the total.

Estimate escapement from monitored projects only by relating to total escapement estimates (scaling).



Each project is looked at relative to the years where we have total escapement estimates, to find the contribution of each project to the total escapement.

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How much of total escapement does each weir monitor?

Think of the parameter estimates as the number you need to multiply the observed escapement at that project by to estimate the total escapement. There are ranges which come from the different years. When we do this for all projects we get a bunch of estimates for each year, that reflect possibilities .

	Parameter	95% Bound		
	Estimate	Lower	Upper	CV
Weir Projects				
Kwethluk Weir	16.8	12.5	22.0	14%
Tuluksak Weir	153.0	110.0	205.0	16%
George Weir	37.4	28.0	48.0	14%
Kogrukluk Weir	13.3	10.5	17.0	12%
Tatlawiksuk Weir	89.4	70.0	112.5	12%
Takotna Weir	335.2	240.0	450.0	16%

There are also Parameter estimates for all aerial surveys, CPUE (BTF, Comm), Total inriver abundance (when available) From Bue et al. *In press*

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This model takes the suite of estimates from each project and it's parameter estimate, and gives us the most likely answer for total escapement given the range of possibilities.

$$L(\theta|data) = \prod_y \prod_i \frac{\Gamma(I_{yi} + \hat{m}_i)}{\Gamma(\hat{m}_i) I_{yi}!} \left(\frac{\hat{m}_i}{\hat{I}_{yi} + \hat{m}_i}\right)^{\hat{m}_i} \left(\frac{\hat{I}_{yi}}{\hat{I}_{yi} + \hat{m}_i}\right)^{I_{yi}}$$

Weir Escapement

$$\prod_y \prod_a \frac{\Gamma(I_{ya} + \hat{m}_a)}{\Gamma(\hat{m}_a) I_{ya}!} \left(\frac{\hat{m}_a}{\hat{I}_{ya} + \hat{m}_a}\right)^{\hat{m}_a} \left(\frac{\hat{I}_{ya}}{\hat{I}_{ya} + \hat{m}_a}\right)^{I_{ya}}$$

Aerial Escapement

$$\prod_y \prod_j \frac{1}{\sigma_\varepsilon \sqrt{2\pi}} exp^{\frac{-(\ln C_{yj} - \ln \hat{C}_{yj})^2}{2\sigma_\varepsilon^2}}$$

Commercial Harvest and Effort

$$\prod_y exp^{\frac{-(N_y - \hat{N}_y)^2}{2\sigma_{\hat{N}_y}^2}}$$

Total Inriver Abundance

Model simultaneously estimates total return and produces the Most Likely Estimate (MLE) of Total Escapement and Abundance

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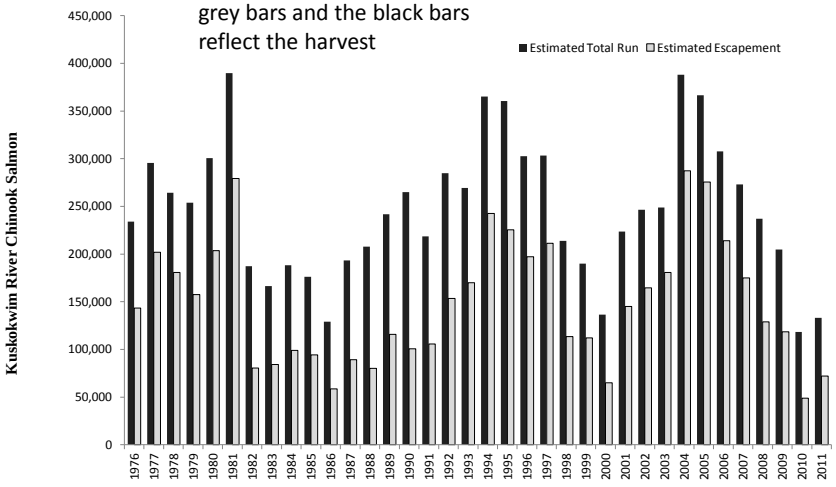
Run Reconstruction Model Output

The difference between the grey bars and the black bars reflect the harvest



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Presentation 2: Brood Table Development

Brood Table Terms

- Brood Table – Displays the recruitment of each age class for individual brood years to evaluate productivity.
- Spawners – Fish that reproduced (Escapement)
- Brood Year – Year of Parental Escapement
- Recruits – Fish that returned from a single Brood Year (Offspring)
- Total Run – Number of fish that entered the river in a given year (Return)

2

Age composition of run in 1992

Brood Year	Total Run	Age Class 0.2	1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5
1984													
1985													
1986													
1987													
1988													
1989													
1990													
1991													
1992	285,370	0.0	1.4	26.9	0.0	40.6	0.4	41.5	0.1	2.0	0.2	0.0	0.0
1993													
1994													
1995													
1996													
1997													
1998													
1999													
2000													
2001													

Percent of each age group in whole run. Combined samples from Harvest (commercial, subsistence, test fishery), and escapement (all weir projects)

From Run Reconstruciton

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The percent of each age class that returned in 1992. This is estimated by pooling together samples from escapement projects and subsistence and commercial harvests.

How many fish of each age group returned this year?

Brood Year	Total Run	Total Age 3	4	5	6	7	8
1984	188,574						
1985	176,513						
1986	129,337						
1987	193,820						
1988	208,238						
1989	242,487						
1990	265,205						
1991	219,115						
1992	285,370	7,109	76,311	95,222	100,459	6,246	8
1993	269,846						
1994	366,006						
1995	361,170						
1996	302,793						
1997	303,511						
1998	214,458						
1999	189,525						
2000	136,532						
2001	223,576						

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Multiply the percent of each age class by the total run estimate, to get the number of fish in each age group that returned in 1992.

When did the fish that returned this year get deposited as eggs?

Brood Year	Total Run	Age Group # 3	4	5	6	7	8
1984							8
1985						6,246	
1986					100,459		
1987				95,222			
1988			76,311				
1989		7,109					
1990							
1991							
1992	285,370						
1993							
1994							
1995							
1996							
1997							
1998							
1999							
2000							
2001							

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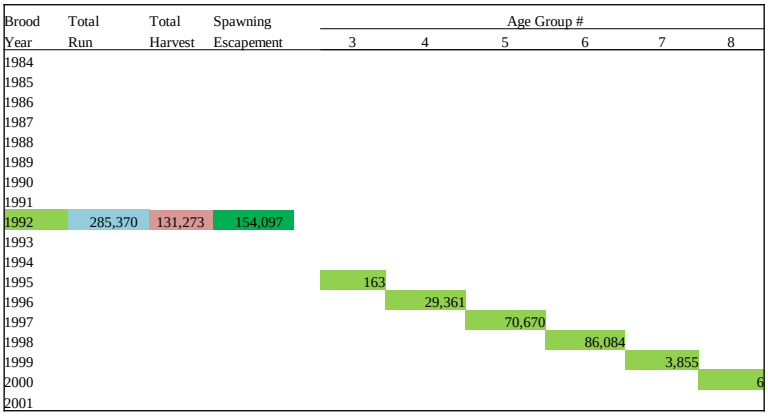
Chinook salmon return as 3-8 year old adults. This means an eight year old fish was put in the gravel eight years before it returns, thus its parents spawned in 1984 and eight yr. old fish are recruited from 1984.

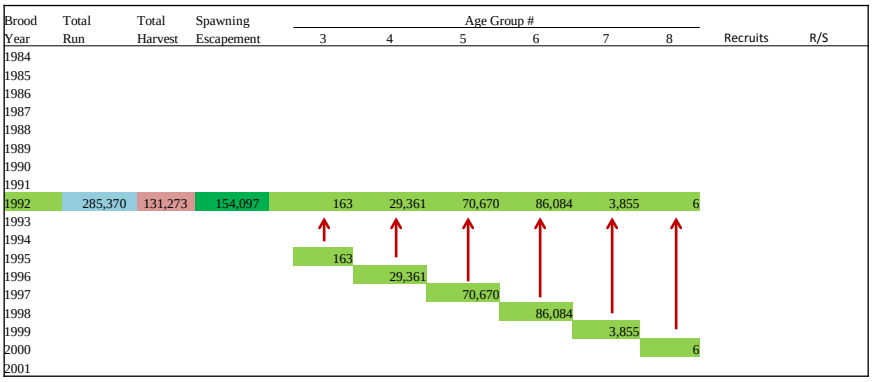
When do recruits from this spawning event return?



Brood Year	Total Run	Total Harvest	Spawning Escapement	Age Group # 3	4	5	6	7	8
1984									
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992	285,370	131,273	154,097						
1993									
1994									
1995				163					
1996					29,361				
1997						70,670			
1998							86,084		
1999								3,855	
2000									6
2001									

An egg put in the gravel in 1992 returns 3-8 years later as an adult. A brood year cannot be evaluated until all the fish are recruited (8 years later).

Recruitment from spawning event (BROOD YEAR)



Brood Year	Total Run	Total Harvest	Spawning Escapement	Age Group # 3	4	5	6	7	8	Recruits	R/S
1984											
1985											
1986											
1987											
1988											
1989											
1990											
1991											
1992	285,370	131,273	154,097	163	29,361	70,670	86,084	3,855	6		
1993											
1994											
1995				163							
1996					29,361						
1997						70,670					
1998							86,084				
1999								3,855			
2000									6		
2001											

We can move the recruits that returned in 1995-2000 up to the 1992 line to show how many recruits of each age class were produced in 1992.

Recruitment from spawning event (BROOD YEAR)

Brood Year	Total Run	Total Harvest	Spawning Escapement	Age Group # 3	4	5	6	7	8	Recruits	R/S
1984											
1985											
1986											
1987											
1988											
1989											
1990											
1991											
1992	285,370	131,273	154,097	163	29,361	70,670	86,084	3,855	6	190,138	
1993											
1994											
1995											
1996											
1997											
1998											
1999											
2000											
2001											

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Recruits per Spawner = Productivity

Brood Year	Total Run	Total Harvest	Spawning Escapement	Age Group # 3	4	5	6	7	8	Recruits	R/S
1984											
1985											
1986											
1987											
1988											
1989											
1990											
1991											
1992			154,097							190,138	1.23
1993											
1994											
1995											
1996											
1997											
1998											
1999											
2000											
2001											

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Divide the escapement in 1992 by the total recruitment from that brood year. This is a simple evaluation of the productivity of each brood year.

R/S = Productivity

- An R/S of 1 means that the number of fish that spawned resulted in the same number of recruits as spawners.
- An R/S >1 means that the number of fish that spawned resulted in a greater number of recruits than spawners.
  - This means that more fish are being produced.
- An R/S <1 means that the number of fish that spawned resulted in a smaller number of recruits than spawners.
  - This means the fish are not replacing themselves.

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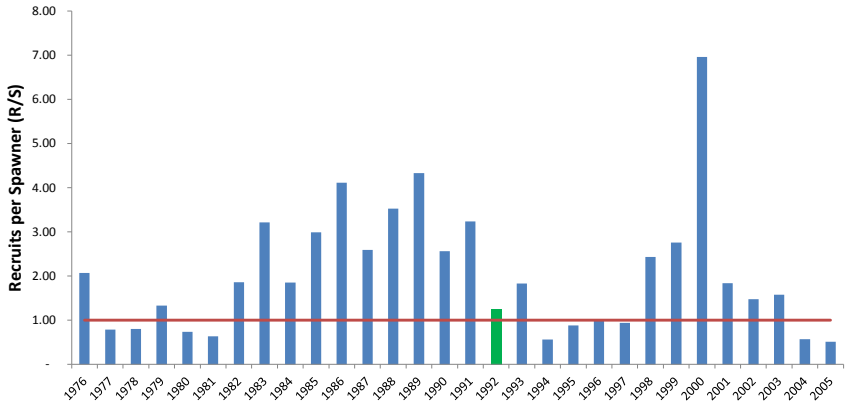

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This figure shows the R/S ratios for the Kuskokwim River Chinook population for brood years 1976 - 2005. The horizontal line is at R/S=1.

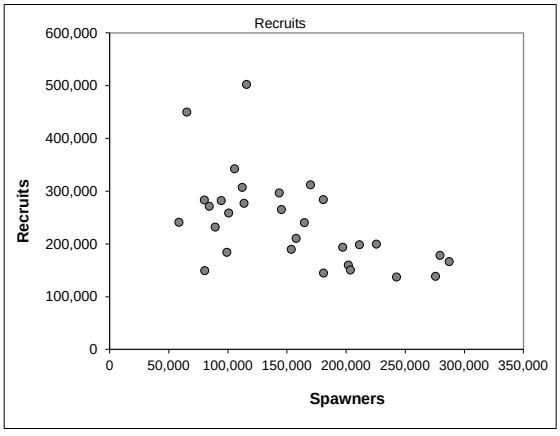
Presentation 3: Spawner / Recruit concepts

Indication points and terms from Productivity model

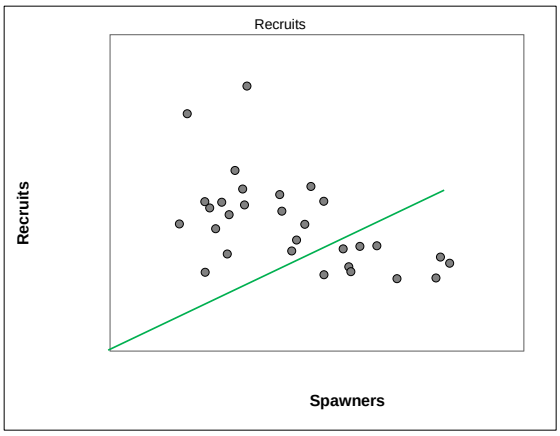
- Replacement Line – One recruit for One Spawner for any level of spawners (R/S=1)
- Yield – Fish available for harvest beyond replacement
- Smax – Spawners necessary to produce maximum number of fish.
- MSY – Maximum Sustained Yield
- Smsy – Spawners necessary to produce MSY
- Seq – Spawners at equilibrium, carrying capacity, maximum number of spawners that achieve replacement

We plot the Spawners and Recruits for each year.

Brood year	Spawners	Recruits
1976	143,420	296,724
1977	201,852	159,889
1978	180,853	144,790
1979	157,668	210,564
1980	203,605	150,587
1981	279,392	178,270
1982	80,353	149,444
1983	84,188	271,408
1984	99,062	184,122
1985	94,365	282,231
1986	58,556	241,062
1987	89,222	231,998
1988	80,055	283,295
1989	115,704	502,456
1990	100,614	258,635
1991	105,589	342,483
1992	153,573	189,842
1993	169,816	312,128
1994	242,616	137,304
1995	225,595	199,669
1996	197,092	193,813
1997	211,247	198,527
1998	113,627	277,124
1999	112,082	307,272
2000	65,180	450,011
2001	145,232	265,278
2002	164,635	240,378
2003	180,687	284,036
2004	287,178	166,576
2005	275,598	138,634



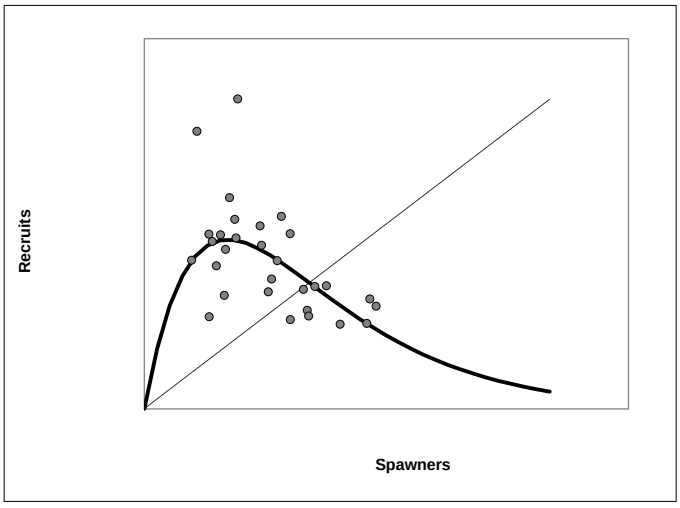
We plot the Replacement Line.



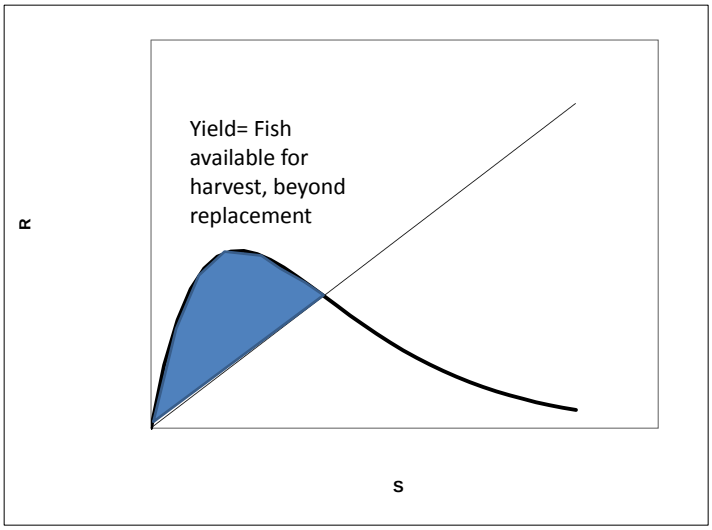
Replacement line = 1 Recruit per 1 Spawner

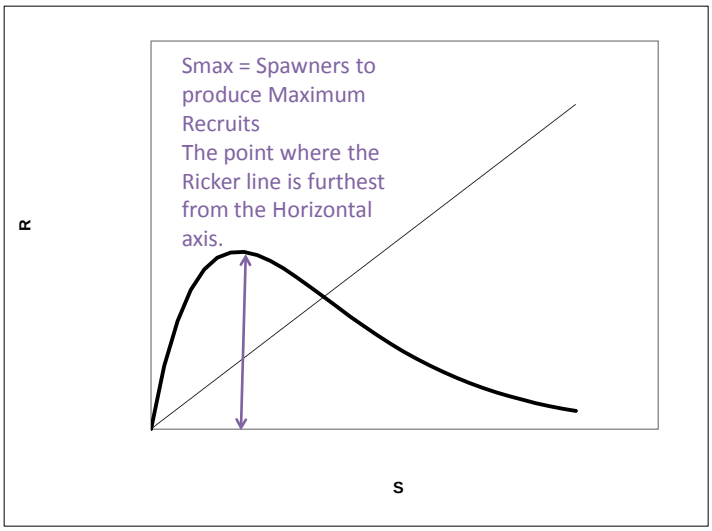
If Points are above this line they have an S/R ratio>1, if under they have an R/S<1. Note that there are no points below the replacement line win average or below average escapement years, and there are none above in higher escapement years.

Ricker model line describes data from estimates of Spawners and Recruits

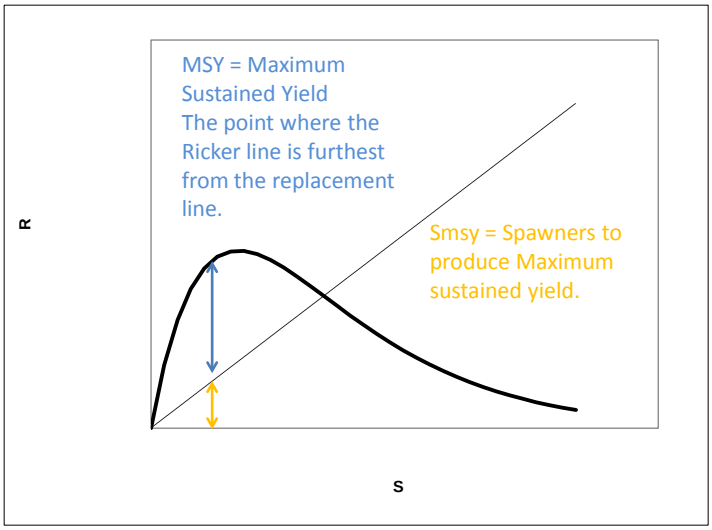


The Ricker line can be thought of as the average recruitment at different levels of escapement derived from the Spawner Recruit data.

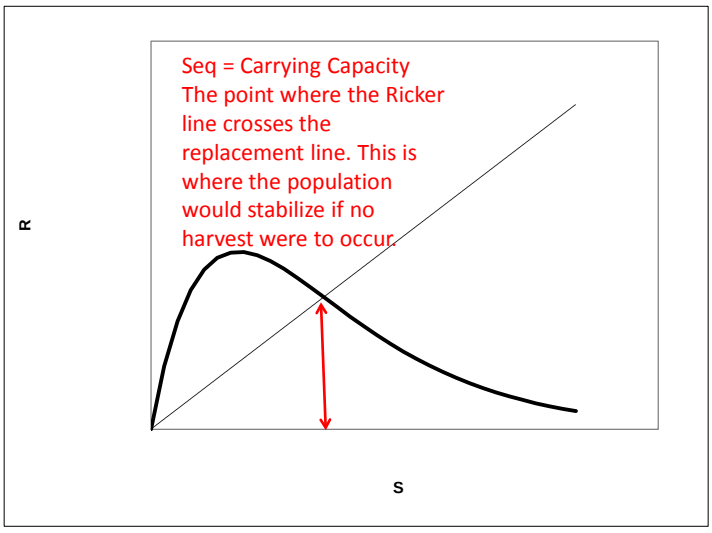




This is the estimated escapement that would produce the highest Recruitment in future years.



This is the estimated escapement that would provide the most number of fish available for harvest.



Production models describe what our current data estimates the production of the system to be. When assessing for escapement goals we think about it as how many recruits will be produced

given a specified escapement. This is the total recruitment (8 yrs. later) we would expect to see. For these estimates of recruitment to result in total returns at the estimated level, we need to be within the identified escapement range for multiple years (Until all brood years that contribute to total run have resulted in the escapement range).

GLOSSARY OF ACRONYMS:

Alaska Department of Fish and Game (**ADF&G**), Orutsararmiut Native Council (**ONC**), Kuskokwim Native Association (**KNA**), Association of Village Council Presidents (**AVCP**), U.S. Fish and Wildlife Service (**USFWS**), Bethel Test Fishery project (**BTF**), Catch Per Unit Effort (**CPUE**), Coastal Village Seafoods (**CVS**), ADF&G Commercial Fisheries Division (**CF**), ADF&G Sport Fisheries Division (**SF**), Regional Advisory Council (**RAC**), Kuskokwim River Salmon Management Working Group (**KRSMWG or Working Group, WG**), Sustainable Escapement Goal (**SEG**), Biological Escapement Goal (**BEG**), Management Objective (**MO**), Amounts Reasonably Necessary for Subsistence (**ANS**), Emergency Order (**EO**)