United Cook Inlet Drift Association

43961 K-Beach Road, Suite E • Soldotna, Alaska 99669 • (907) 260-9436 • fax (907) 260-9438
• www.ucida.org •

May 18, 2020

Mr. Simon Kinneen, Chair
Mr. David Witherell, Executive Director
Dr. Sherri Dressel, Co-Chair of SSC
Dr. Anne Hollowed , Co-Chair of SSC
North Pacific Fishery Management Council
1007 West Third, Suite 400
Anchorage, Alaska 99501

Dear Mr. Kinneen, Mr. Witherell, Dr. Dressel and Dr. Hollowed:

We are writing to bring to your attention some issues that require resolution in the development of a new amendment to the Salmon FMP for Alaska. In the course of our participation in the Cook Inlet Salmon Committee we have encountered some critical, fundamental barriers to a successful outcome, two of which we address in this letter.

First, the North Pacific Fishery Management Council (Council) and National Marine Fisheries Service (NMFS) must revisit the conclusion reached during the Amendment 12 process that the State of Alaska's salmon management practices and escapement goals meet the requirements of the MSA and the 10 National Standards. That conclusion was based on representations that are no longer true. The prior conclusion was based on a letter from ADF&G Commissioner Denby Lloyd, followed by a paper explaining how state management of the salmon fisheries complies with the MSA, including how escapement goals are set.[1] The State represented, among other things, that "escapement goals are typically set at the range of escapements that provided 90% or more of MSY."; and "for salmon, maximum sustained yield is achieved by fishing appropriately to maintain the spawning **escapement at levels that provide potential to maximize surplus production**."[2] Those statements are now demonstrably incorrect. In fact, ADF&G is now deliberately and explicitly setting escapement goals substantially lower than 90% of MSY and is managing the Cook Inlet salmon fishery to minimize, not maximize, surplus production. ADF&G's present practices do not resemble its prior representations, and its present practices do not meet the requirements of the MSA and the National Standards.

Second, and by contrast, many of the technical tasks, on which the Cook Inlet Salmon Committee has spent many fruitless hours, were previously developed, and accepted by the Council, in the development

[1] ADF&G, 2010. State of Alaska's Salmon Fisheries Management Program. Response to Council request (June 30, 2010.) Correspondence. Juneau, Alaska. Attachment.

[2] Ibid, p.5

and passage of Amendment 12. As set forth below, some of these components are generally still applicable and should not need to be re-created for the new amendment.

Additionally, on May 7, 2020, President Trump signed an Executive Order titled "Executive Order on Promoting American Seafood Competitiveness and Economic Growth." This order mandates that regional fishery management councils develop a prioritized list of actions to reduce burdens on and to increase production from sustainable fisheries. The prioritized list must be produced with 180 days, and the changes must be proposed with one year. The information contained in our letter describes what is needed to increase production rapidly from the Cook Inlet salmon fishery, meet the requirements of the MSA and meet the new requirements of the Executive Order.

Alaska Salmon Management

Salmon management practices and salmon escapement goals developed by the State of Alaska do not meet the requirements of federal law. The Magnuson-Stevens Act (MSA) and National Standard 1 (NS1) requires achieving optimum yield (OY) from each fishery, establishes maximum sustained yield (MSY) as the basis for fishery management and requires that fishing mortality does not jeopardize the capacity of a fishery to produce MSY. Given that salmon populations exhibit compensatory and density dependent stock recruitment dynamics, achieving OY on a continuing basis for salmon stocks requires that salmon escapement goals be set as close as possible to MSY. Maximum sustained yield and OY are only achieved when MSY-centered escapement goals are established, and the fishery is managed for escapements that stay within that escapement goal range and distribute escapements within that range to achieve MSY as an average.

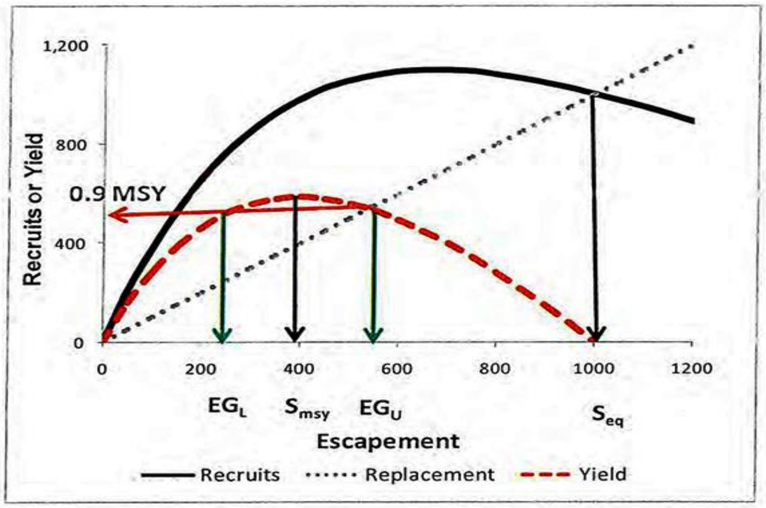
In the 2010 Salmon Fisheries Management Program document that Alaska provided the Council, the state asserted that salmon escapement goals were set at MSY within a 90% range. The following is an excerpt from that paper:

> "The compensatory nature of salmon populations is reflected in the Ricker stock recruitment model (Figure 1). Appropriate biological reference points used as benchmarks in status determinations, and in setting escapement goals can be determined from the Ricker model parameters estimated by fitting the Ricker model to historical stock-recruit data (Ricker 1954). ... **Escapement goals are typically set at the range of escapements that provided 90% or more of MSY.** The approach of using the fitted Ricker stock-recruit model to set escapement goals is routinely used by ADF&G for stocks where stock specific runs can be estimated and there is sufficient contrast in the historical escapement data to reflect density dependence." [3]

Figure 1, on the next page, is the Figure they reference in this paragraph.

[3] Ibid, p.5

Figure 1. ADF&G used this Ricker stock recruit model to illustrate the model that they said they routinely use for setting escapement goals.

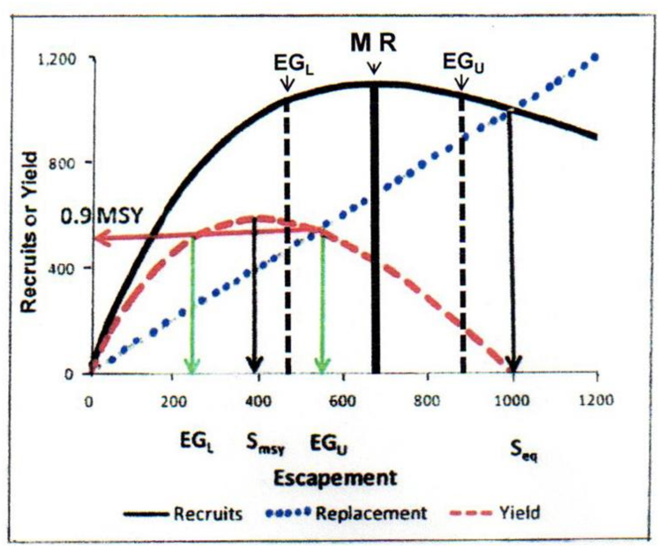


"Figure 1. Biological reference points associated with the Ricker stock-recruit model (R) and Ricker yield (Y) model, included are maximum sustained yield (MSY) escapement (Smsy), recruits at MSY escapement (Rmsy), equilibrium escapement (Seq), the lower end (EGL) and upper end (EGU) of escapement goal range, the MSY harvest rate (Umsy, the slope of line tangent to R at Smsy), and the overfishing rate (Uof, the slope of line tangent to R at the origin)."

A goal set for 90% of MSY encompasses a range of 10% on either side of the Smsy point on a yield curve (see the red line labeled *0.9 MSY* in Figure 1). **ADF&G and the Alaska Board of Fisheries (BOF) are no longer setting escapement goals that meet 90% of MSY for most salmon stocks.** Currently many salmon escapement goals are set very broadly. Instead of a range of 90% of MSY, they may encompass ranges as much as 30% below to 80% beyond Smsy. Achieving MSY becomes a random occurrence with goals this broad and yield is increasingly reduced with every degree on either side of Smsy on the yield curve.

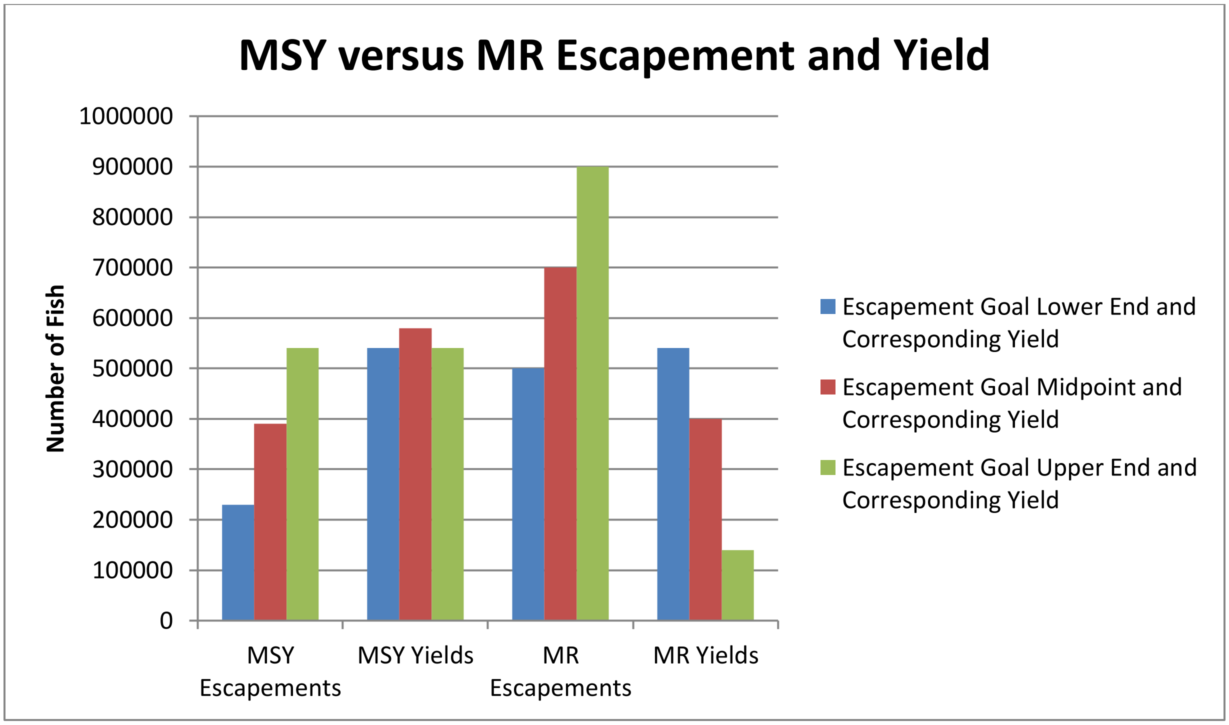
ADF&G is setting some goals on the recruitment curve, described as maximum recruitment (MR), with the lower end of this escapement range set beyond Smsy. When we compare MSY and MR on the same model it is clear that the range of the MR goal greatly reduces yield and almost entirely misses the 90% of MSY range. (See Figure 2.)

Figure 2. Same Ricker stock recruit model with maximum recruitment (MR) range added.



The further the goals depart from either side of the Smsy point on the yield curve, the greater the loss of yield. When you calculate the numbers from Figure 2, the difference in yield between MSY and MR become more apparent, as in Figure 3.

Figure 3. Graph of escapement and yield ranges demonstrating MSY (90% range) vs Maximum Recruitment; numbers extrapolated from Figure 2.



This graph is an alternate method of showing data from Figure 2. With escapement goals set at 90% of MSY, an escapement range of 230k to 540k produces a yield of 540k to 580k. In the maximum recruitment (MR) example, an escapement range of 500k to 900k produces a yield of 540k to 130k. The upper end of the MR escapement goal range decreases the yield or harvest by as much as 78%. If the MSY exploitation rate on this stock is about 58% and you reduce that exploitation rate by 78% or more due to an artificial goal or by mismanagement, there is very little yield or harvestable surplus left. This magnitude of yield/harvest reduction is economically devastating to the commercial fishing industry and does not meet the MSA and NS1 requirement of managing the fishery on the basis of MSY.

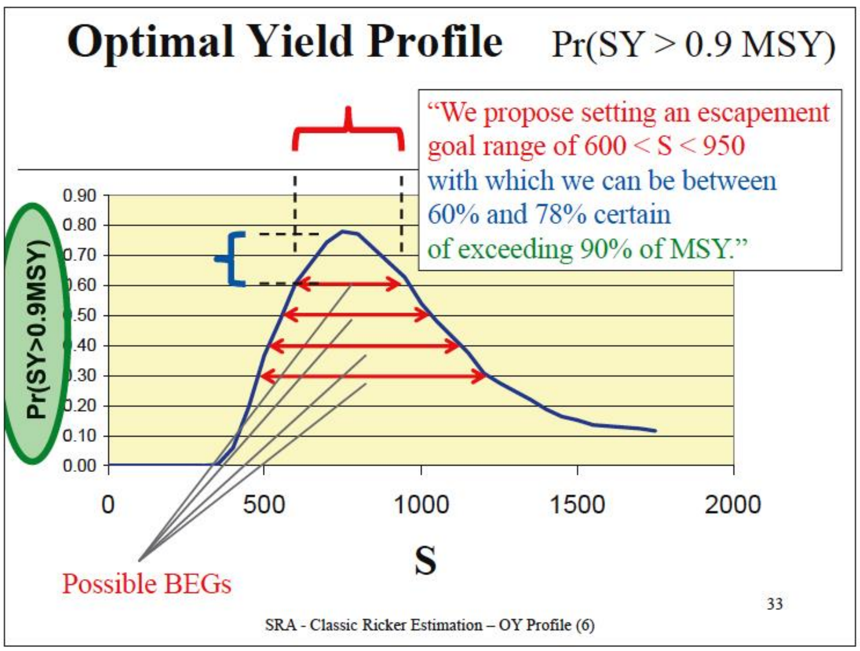
Figure 4. Correlation between goals, underfishing and overfishing.

Escapement Goal range set as percentage of Smsy = % chance of achieving MSY	At Escapement Goal Lower end (EGL) = increasing % chance of overfishing	Escapement Goal Upper end (EGU) = increasing % chance of underfishing
90%	10%	10%
80%	20%	20%
70%	30%	30%
50%	50%	50%

Setting escapement goals farther away from the Smsy point goal decreases the probability of achieving MSY and directly increases the probability of overfishing or underfishing. Setting goals based on MR virtually eliminates any possibility of achieving MSY.

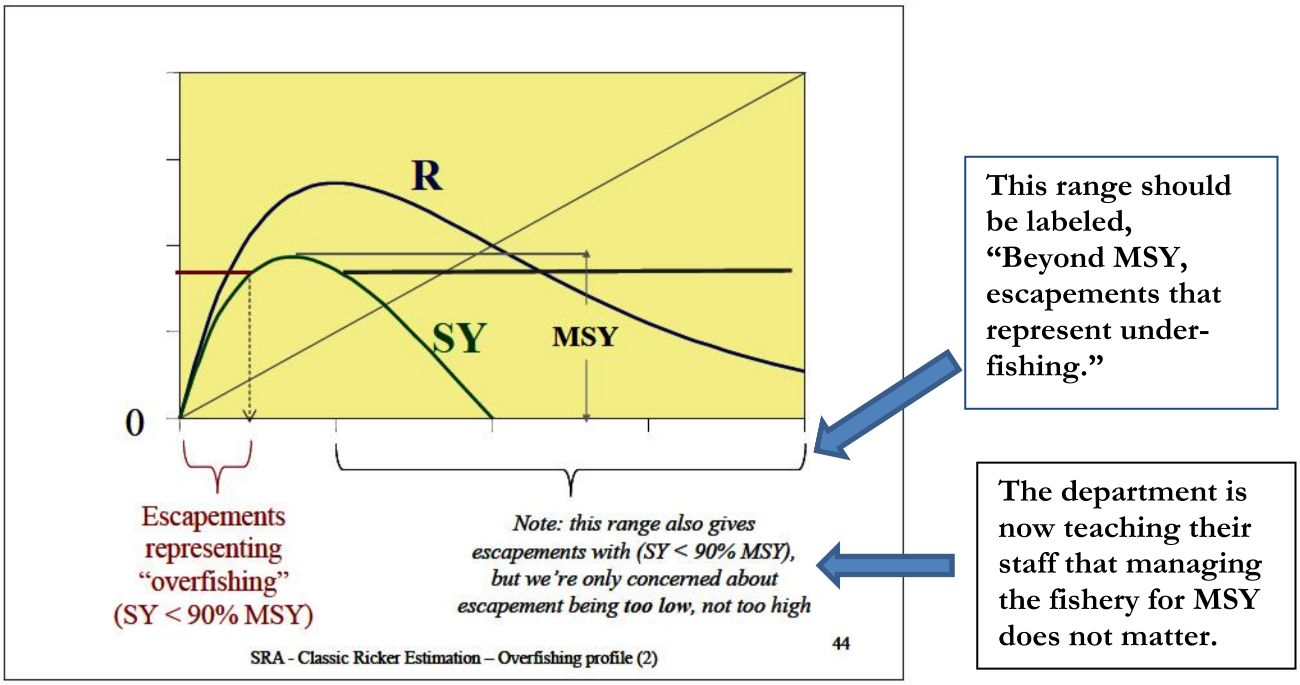
ADF&G is now deliberately and explicitly setting escapement goals substantially lower than 90% of MSY. The department's "Mechanics of Escapement Goal Analysis in Alaska" lecture slides, for staff training, recommend numerous strategies for setting escapement goals that do not meet the standard of 90% of MSY (see Figures 5 and 6).

Figure 5. Slide 33, 2020 ADF&G Mechanics of Escapement Goal Analysis in Alaska; Stock-Recruit Analysis: Ricker Stock-Recruit Relationship.



Here ADF&G recommends a relatively low probability of achieving 90% of MSY, 60% of EGL to 60% of EGU with a peak of 78% probability of achieving 90% of MSY at the peak. This translates to a 30% chance of overfishing at EGL to a 30% chance of under fishing at EGU. While this graph states this goal is between 60-78% "certain" of exceeding 90% of MSY, it is not, it is only a probability of 90%. As Figure 3 illustrated, broadening escapement goals and reducing the percentage of MSY achieved to less than 90% of MSY significantly decreases yield.

Figure 6. Slide 44, 2020 ADF&G Mechanics of Escapement Goal Analysis in Alaska; Stock-Recruit Analysis: Ricker Stock-Recruit Relationship.



This slide clearly illustrates that the department is not concerned with loss of yield or managing the fishery for MSY. They state that they are “only concerned about escapement being **too low**, not too high.” This is a striking departure from the state’s 2010 assertions to Council that:

- “Escapement goals are typically set at the range of escapements that provided 90% or more of MSY.”; and
- “For salmon, maximum sustained yield is achieved by fishing appropriately to maintain the spawning **escapement at levels that provide potential to maximize surplus production**.”[4]

When ADF&G now says that they are not concerned about managing the fishery for MSY, this contradicts their previous statements to the Council in 2010 and is contrary to the language in the findings and the purpose of the MSA and the requirements in NS1.

In the same training slide series, on slides 36 and 37, the guidelines repeat the following statement: “High performance requirements are associated with narrower goals; lower performance requirements are associated with wider goals.”[5] Another way to say this is that narrow goals, such as 90% of MSY, require adaptive in-season management. Apparently, the ADF&G is very willing to forego harvest of surplus stocks (yield) for the sake of making their job easier. It is also a simple way to avoid accountability for

[4] Ibid, p.5, p.4
[5] 2020 ADF&G Mechanics of Escapement Goal Analysis in Alaska; Stock-Recruit Analysis: Ricker Stock-Recruit Relationship.

poor in-season management. The MSA and NS1 require managing this valuable resource for MSY. The State of Alaska, NMFS or the Council cannot decide that a lower standard for management is acceptable.

The state's policies of wider goals and lower performance requirements are affecting state-wide salmon management. In the following pages we examine a few of the many Cook Inlet salmon stocks that are <u>not</u> being managed to MSY, but are being managed with "wider goals" and "lower performance requirements." These examples include Eastside Susitna River Chinook, Deshka River Chinook, Kasilof River sockeye and Kenai River late-run sockeye.

The Eastside Susitna River Chinook and the Deshka River Chinook escapement goals have not been based on 90% of MSY for some time. Escapement goals were set extremely broadly, not at levels that provide potential to maximize surplus production. The consequences were over-escapements, run failures and fishing restrictions that all resulted in significant lost yield. We will examine the historic escapement goals and then the harvest rates on these Chinook stocks.

Eastside Susitna River Chinook

Eastside Susitna River Chinook escapement goals are set so high as to almost miss the 90% of MSY range. This is an example of ADF&G using maximum recruitment to set the goal.

Figure 7. Eastside Susitna River Chinook as modified from Reimer, 2020. (Reimer, A. M., and N. A. DeCovich. 2020. Susitna River Chinook salmon run reconstruction and escapement goal analysis. Alaska Department of Fish and Game, Fishery Manuscript No. 20-01, Anchorage. p.54)

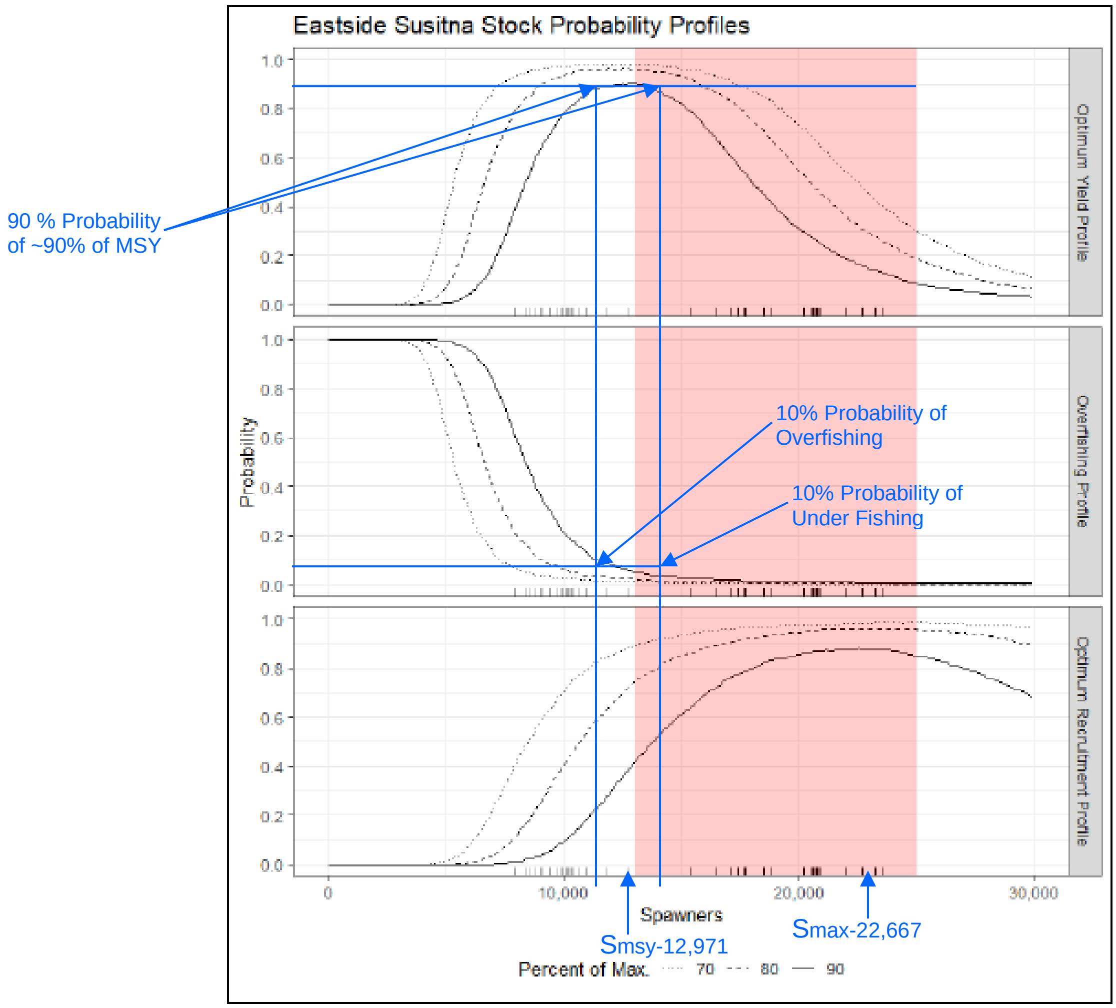


Figure 11.–Optimal yield (OYP), overfishing, and optimum recruitment (ORP) profiles for the Eastside Susitna Chinook salmon stock. Profiles show the probability that a specified spawning abundance will result in specified fractions (70%, 80%, and 90% line) of maximum sustained yield (OYP and overfishing) or maximum sustained recruitment (ORP).

Note: Pink shaded areas bracket the proposed goal range; grey and black marks along the x-axis show comparable lower and upper bounds, respectively, scaled by S_{MSY} ratios for other Alaskan Chinook salmon stocks (see Methods).

The pink shaded area delineates ADF&G's proposed goal range for Eastside Susitna Chinook. Ninety percent of MSY and other calculations have been added in blue. Under-fishing is guaranteed. For 90% of MSY the escapement goal would be ~11,000 to 14,000, not 13,000 to 25,000 as ADF&G has suggested.

ADF&G's escapement goal range is from slightly above SMSY at the lower end, to 2,300 past Smax, **basically ensuring no yield in any fishery**, and not 90% of MSY as they previously claimed.

Figure 8. Eastside Susitna River Chinook as Modified from Reimer, 2020. (Reimer, A. M., and N. A. DeCovich. 2020. Susitna River Chinook salmon run reconstruction and escapement goal analysis. Alaska Department of Fish and Game, Fishery Manuscript No. 20-01, Anchorage. p.53)

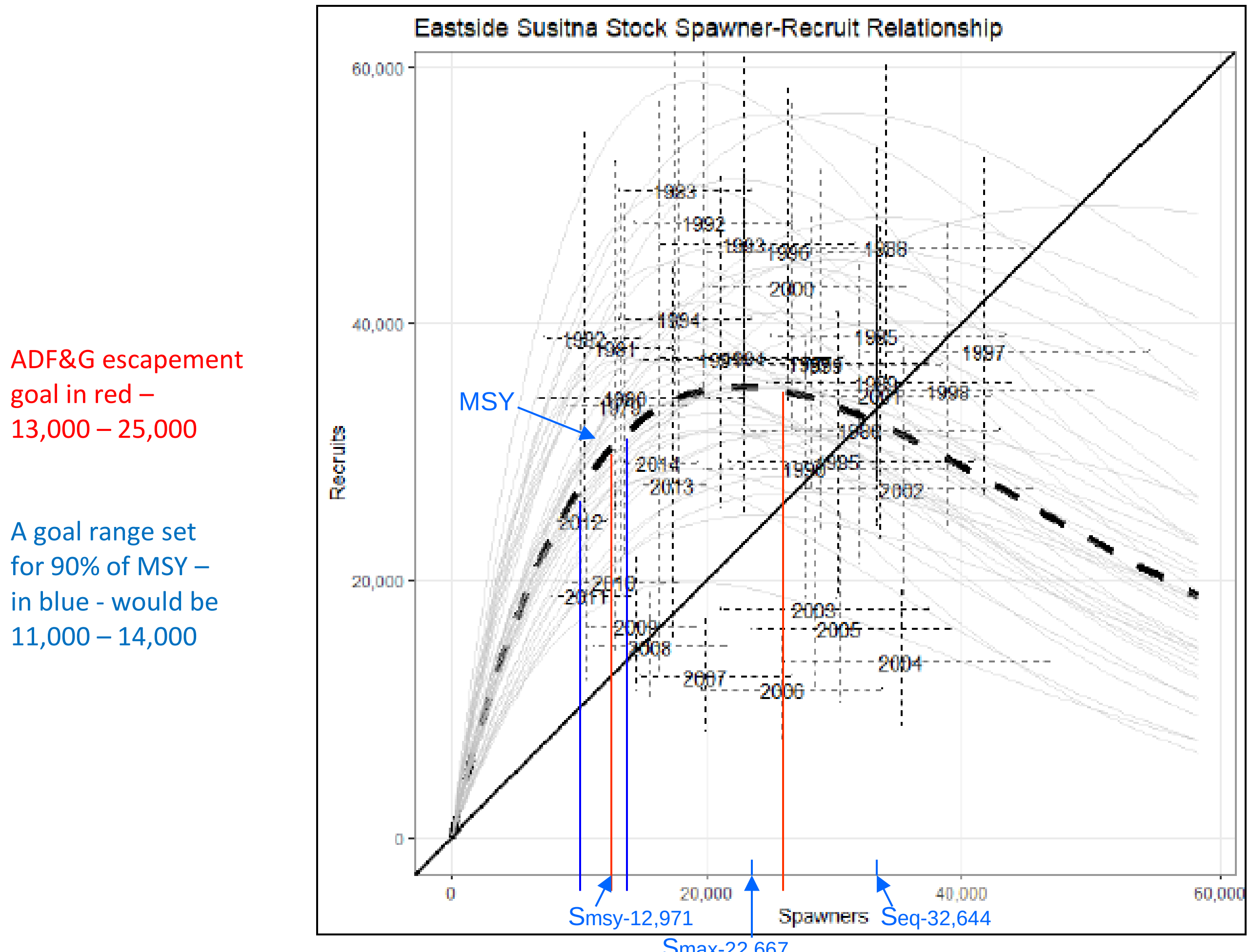


Figure 10.–Plausible spawner-recruit relationships for the Eastside Susitna Chinook salmon stock as derived from an age-structured state-space model fitted to abundance, harvest, and age data for 1979–2017.

Note: Posterior means of R and S are plotted as brood year labels with 95% credibility intervals plotted as light dashed lines. The heavy dashed line is the Ricker relationship constructed from $\ln(\alpha')$ and β posterior medians. Ricker relationships are also plotted (light grey lines) for 40 paired values of $\ln(\alpha')$ and β sampled from the posterior probability distribution, representing plausible Ricker relationships that could have generated the observed data. Recruits replace spawners ($R = S$) on the diagonal line.

Prior to 2020, ADF&G and the BOF created numerous restrictions, in regulation, to commercial, sport and subsistence fisheries because of low escapement counts of these Chinook. The low escapement counts were likely due to the department's use of poor assessment techniques, usually consisting of single aerial surveys. From this analysis we now see that those restrictions were not necessary. In the data set for 1979 to 2017 in the above graph, only two years had escapements below their inflated goal, and none are below a 90% of MSY range of 11,000 – 14,000

Deshka River Chinook

Prior to 2020, the Deshka River Chinook had a goal range similar to that of the Eastside Susitna, as illustrated in Figure 6. For decades it cycled between over-escaping, and under-escaping, with numerous fishing restrictions. This has resulted in a 1:1 return per spawner ratio which, in a managed stock, is a clear case of a management failure. As of 2020 the goals were changed but they are still too wide.

Figure 9. Deshka River Chinook S/R Analysis as modified from Reimer, 2020. (Reimer, A. M., and N. A. DeCovich. 2020. Susitna River Chinook salmon run reconstruction and escapement goal analysis. Alaska Department of Fish and Game, Fishery Manuscript No. 20-01, Anchorage. p.49)

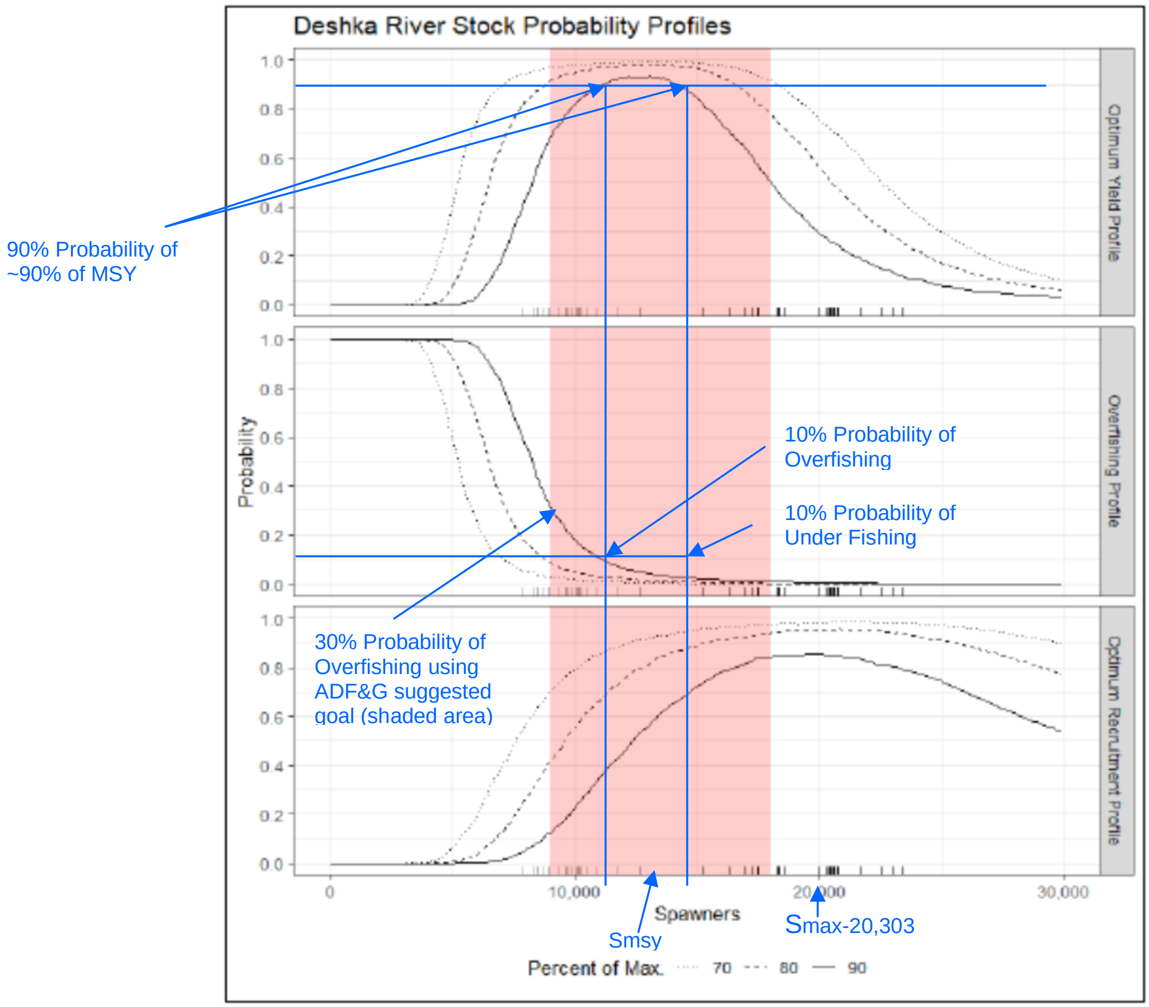


Figure 6.–Optimal yield (OYP), overfishing, and optimum recruitment (ORP) profiles for the Deshka River Chinook salmon stock. Profiles show the probability that a specified spawning abundance will result in specified fractions (70%, 80%, and 90% line) of maximum sustained yield (OYP and overfishing) or maximum sustained recruitment (ORP).

Note: Pink shaded areas bracket the proposed goal range; grey and black marks along the *x*-axis show comparable lower and upper bounds, respectively, scaled by S_{MSY} ratios for other Alaskan Chinook salmon stocks (see Methods).

The pink shaded area delineates ADF&G's proposed goal range for Deshka Chinook. Ninety percent of MSY and other calculations have been added in blue. A goal range set for 90% of MSY would be ~11,000 to 15,000, not 9,000 to 18,000 as ADF&G has suggested.

Figure 10. Deshka River Chinook Spawner-Recruit Relationship analysis as modified from Reimer, 2020. (Reimer, A. M., and N. A. DeCovich. 2020. Susitna River Chinook salmon run reconstruction and escapement goal analysis. Alaska Department of Fish and Game, Fishery Manuscript No. 20-01, Anchorage. p. 48)

ADF&G goal range prior to 2020 in Red:
13,000 – 27,000
(Smsy – 17,230)

New ADF&G 2020 goal in Green:
9,000 – 18,000
(Smsy – 12,564)

A goal range set for 90% of MSY would be 11,000 – 15,000 (see previous figure)

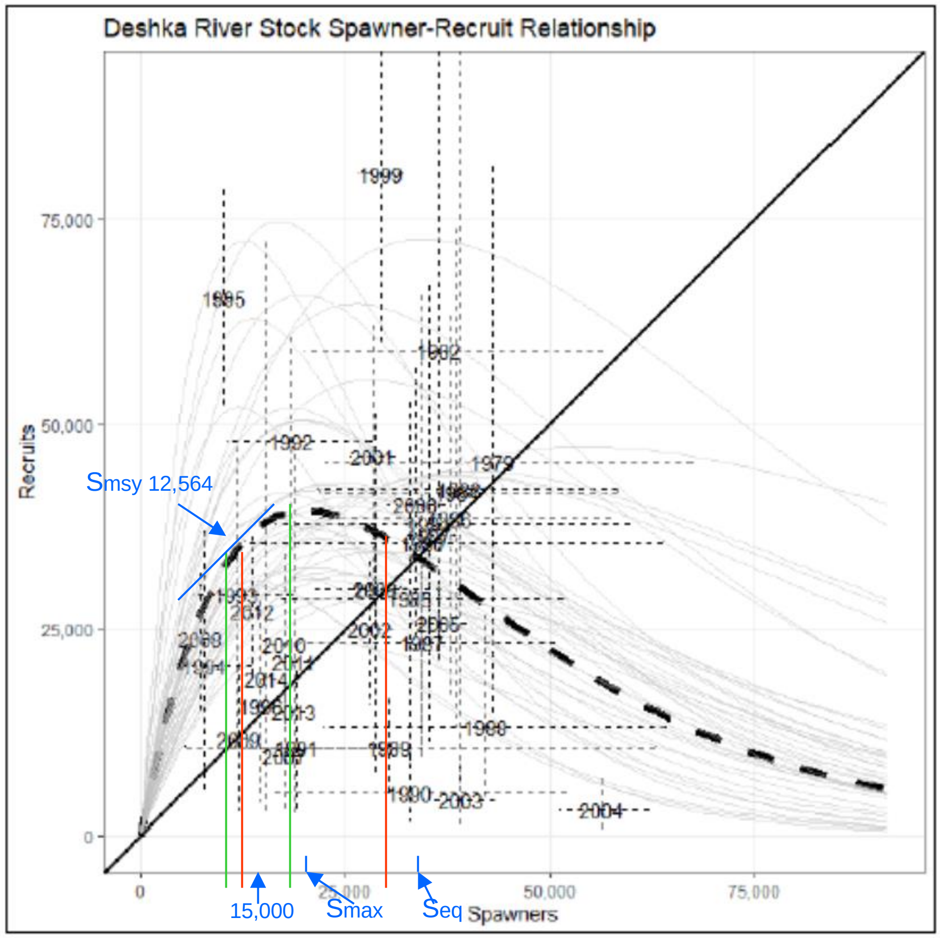


Figure 5.–Plausible spawner-recruit relationships for the Deshka River Chinook salmon stock as derived from an age-structured state-space model fitted to abundance, harvest, and age data for 1979–2017.

Note: Posterior means of R and S are plotted as brood year labels with 95% credibility intervals plotted as light dashed lines. The heavy dashed line is the Ricker relationship constructed from ln(α′) and β posterior medians. Ricker relationships are also plotted (light grey lines) for 40 paired values of ln(α′) and β sampled from the posterior probability distribution, representing plausible Ricker relationships that could have generated the observed data. Recruits replace spawners (R = S) on the diagonal line.

From 1999 to 2019 ADF&G's goal range, in RED, was set using 20% less than Smsy to 50% beyond Smsy, with the upper end of the goal being set at ~Smax. Beginning in 1979, in 14 of 36 years the escapements were to the right of and below replacement, causing numerous restrictions. From 1979-2009 the average harvest was 5,500, far below the expected yield of 25,000. (2009 was the date of the last available harvest table.)

Using ADF&G's new 2020 goal, in GREEN, Smsy drops by 5,000 Chinook and the new goal is 9,000 to 18,000. Most past escapements, in 21 of 36 years, were over the top end of this new goal. Yet fishing restrictions remain in place, in regulation and management plans, guaranteeing the continued loss of yield of these and other stocks.

In Figure 11, ADF&G's records show the significant yield loss in these Chinook stocks since 1979, illustrating the consequences of the inappropriate escapement goals. Over 38 years, the Deshka lost an average of 80% of the available Chinook yield and East Susitna lost an average of 58%.

Figure 11. Chinook Harvest Rates as modified from Reimer, 2020. (Reimer, A. M., and N. A. DeCovich. 2020. Susitna River Chinook salmon run reconstruction and escapement goal analysis. Alaska Department of Fish and Game, Fishery Manuscript No. 20-01, Anchorage. p.65)

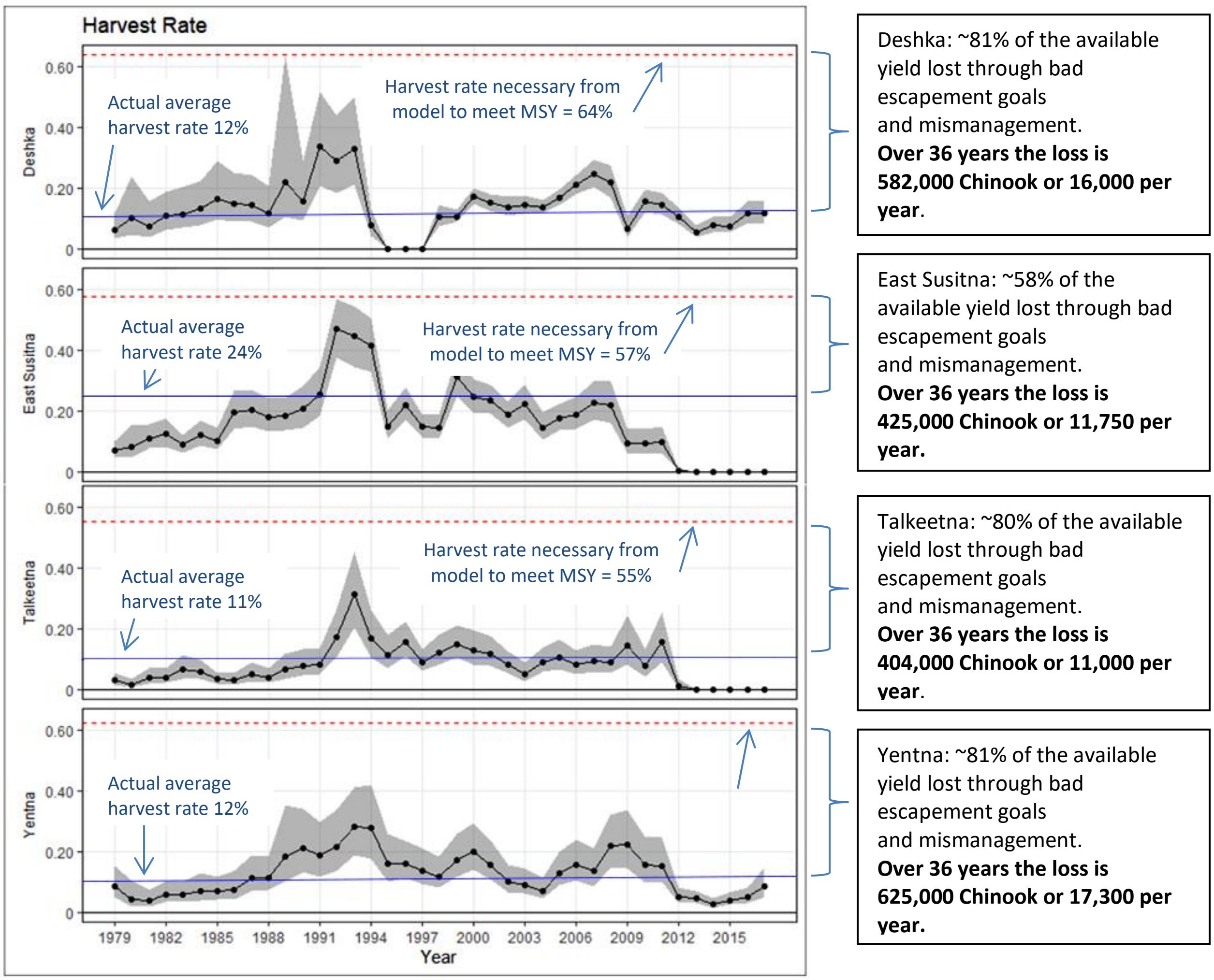


Figure 22.–Point estimates (posterior medians; solid lines) and 95% credibility intervals (shaded areas) of harvest rate from a state-space model by stock, 1979–2017.

Note: The posterior median of U_{MSY} is plotted as short-dash horizontal reference line.

The average annual lost yield from just these four examples adds up to well over 50,000 Chinook per year. These lost yield figures do not account for lost future yields within these systems or the significant lost yield of other species due to fishing restrictions. Bad management of these stocks perpetuate commercial, sport and subsistence fishing restrictions even though yields on these stocks are so low. These incorrect Chinook salmon goals and others just as contrived, like the Little Susitna River coho goal, **are very deliberately used by the BOF and ADF&G as justifications for restricting commercial fishing on all stocks.**

Kasilof River sockeye

The escapement goal for Kasilof River sockeye salmon is also set far too broadly. It is not set at 90% of MSY. ADF&G has the goal set at 140,000 to 320,000 rather than 90% of MSY, which would be ~160,000 to 260,000 salmon. This goal range has a 50% chance of overfishing and a 50% chance of underfishing and only a 50% chance of achieving MSY.

Figure 12. Kasilof River Optimum Yield Profiles as modified from McKinley, 2019 McKinley, T., N. DeCovich, J. W. Erickson, T. Hamazaki, R. Begich, and T. L. Vincent. 2020. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2019. Alaska Department of Fish and Game, Fishery Manuscript No. 20-02, Anchorage. p.41

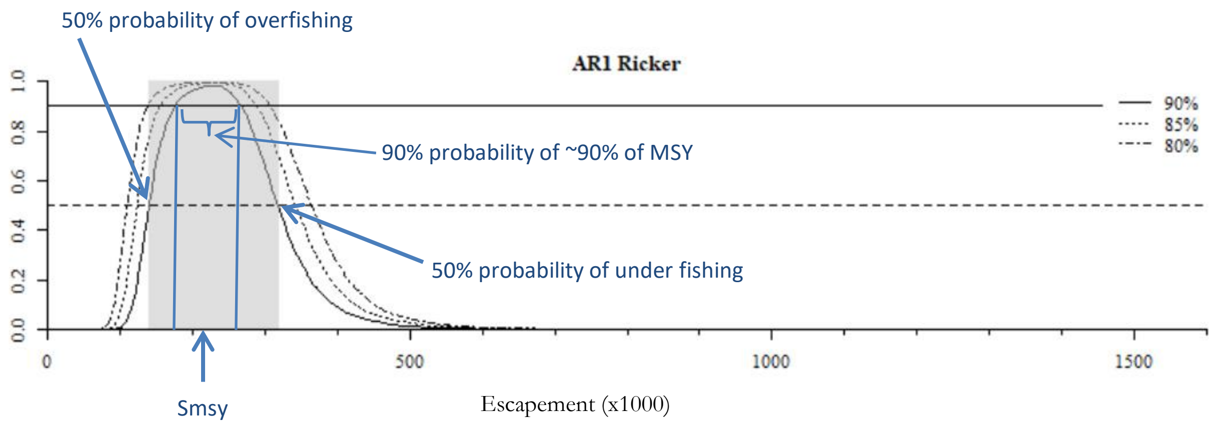


Figure 8.–Optimum yield profiles for Kasilof River sockeye salmon. Note: Profiles show the probability that a specified spawning abundance will result specified fractions (80%, 85%, and 90% lines) of maximum sustained yield for 5 spawner-recruit models fit to data from brood years 1968–2012. Shaded ranges represent the recommended escapement goal (140,000–320,000)

ADF&G's in-season management of Kasilof River sockeye is also failing to keep escapement numbers within any defined goal range. In 14 of the last 20 years the Kasilof sockeye escapement exceeded the upper end of the inflated goal range and in 16 of the last 20 years the escapement exceeded the upper end of 90% of MSY. If the management practices are not achieving the goal of MSY, then those practices must change.

Kenai River late-run sockeye

In the past, Kenai River late-run sockeye goals were set based on the Markov Table. Beginning about 20 years ago the department began using models to establish the goals. All the models predicted better returns at a higher level of escapement than the Markov Table demonstrated. **This 20 year experiment has been an undeniable failure.** In the last 20 years, the predicted higher level of return has never been realized from escapements over 1 million sockeye. **In the last 51 years of data, there has only been one year, 1987, that saw a higher than average return from a spawning escapement of over 1 million.**

It is important to note that in the field of statistics, there is a truism that states "**All models are wrong, but some models are useful**". The idea that complex physical or biological systems can be exactly and reliably described by a few mathematical formulas is absurd. In this application the models that ADF&G

are using to set escapement goals for the Kenai River sockeye are not only wrong, they are harmfully wrong. They are harmful to the salmon resource, they are harmful to the economies that are built around the harvest of surplus salmon stocks and they are harmful to the coastal communities whose social and economic well-being depend on these resources.

Figure 13, below, contains the empirical data from over four decades of Kenai River late-run sockeye. This is the best scientific information available (National Standard 2). The highlighted range of escapements shows the level of spawners that produces the highest average yield and the highest average return.

Figure 13. Kenai River late-run sockeye Markov Table for brood years 1969-2012 in 200,000-fish overlapping intervals of escapement.

Escapement Interval (000)	n	Mean Spawners (000)	Mean Returns (000)	Return per Spawner	Yield Mean (000)	Yield Range (000)
0-200	3	120	679	6	564	358-871
100-300	3	165	798	5	633	449-871
200-400	2	292	1,055	4	763	578-947
300-500	4	414	2,179	5	1,764	580-3,413
400-600	9	497	2,448	5	1,950	580-3,413
500-700	8	563	3,046	5	2,483	999-6,361
600-800	9	734	4,636	6	3,902	713-8,832
700-900	8	768	4,497	6	3,729	713-8,832
800-1,000	7	943	3,664	4	2,720	692-4,806
900-1,100	7	970	3,612	4	2,642	692-4,806
1,000-1,200	2	1,082	3,628	3	2,546	2,504-2,588
1,100-1,300	5	1,291	3,291	3	2,082	277-3,229
1,200-1,400	6	1,266	3,250	3	1,985	277-3,229
> 1,300	12	1,701	4,321	3	2,619	520-8,345

Returns per spawner and mean yields both decline significantly when mean spawners increase above 900,000.

Further analysis of historical data reinforces this conclusion. When spawners, returns and yields are sorted by the escapement size (number of spawners), there is a distinct range that produces the highest yield (see Figure 14). The same escapement range of 600,000 to 800,000 produced the highest average yield.

Figure 14 (Part 1 of 2). Yield from the number of spawners from ADF&G brood tables, 1969-2012, sorted by size of escapements/spawners, for Kenai River sockeye salmon.

Brood Year	Spawners	Returns	Yield	Return per Spawner	Harvest Rate
1969	72,901	430,947	358,046	5.91	0.83
1970	101,794	550,923	449,129	5.41	0.82
1975	184,262	1,055,373	871,111	5.73	0.83
1974	209,836	788,067	578,231	3.76	0.73
1979	373,810	1,321,039	947,229	3.53	0.72
1971	406,714	986,397	579,683	2.43	0.59
1972	431,058	2,547,851	2,116,793	5.91	0.83
1984	446,397	3,859,109	3,412,712	8.65	0.88
1973	507,072	2,125.986	1,618,914	4.19	0.76
1976	507,440	1,506,012	998,572	2.97	0.66
1978	511,781	3,785,040	3,273,259	7.40	0.86
1981	535,523	2,464,323	1,928,800	4.60	0.78
1986	555,207	2,165,138	1,609,931	3.90	0.74
1985	573,836	2,587,921	2,014,085	4.51	0.78
1980	615,382	2,673,295	2,057,913	4.34	0.77
2000	696,899	7,058,348	6,361,449	10.13	0.90
2008	708,833	3,377,884	2,669,051	4.77	0.79
1991	727,159	4,436,074	3,708,915	6.10	0.84
2001	738,229	1,698,142	959,913	2.30	0.57
1982	755,672	9,587,700	8,832,028	12.69	0.92
1995	776,880	1,899,870	1,122,990	2.45	0.59
1983	792,765	9,486,794	8,694,029	11.97	0.92
1990	794,754	1,507,693	712,939	1.90	0.47
2009	848,117	3,983,872	3,135,755	4.70	0.79

This highlighted range of spawners, between 600,000 and 800,000, produced the highest average yield of 3.9 million salmon. Four of the nine years have a yield over 3 million. No other range on this or the following section of the table is comparable.

Figure 14 (Part 2 of 2). Yield from the number of spawners from ADF&G brood tables, 1969-2012, sorted by size of escapements, for Kenai River sockeye salmon.

Brood Year	Spawners	Returns	Yield	Return per Spawner	Harvest Rate
1998	929,091	4,465,328	3,536,237	4.81	0.79
1999	949,276	5,755,063	4,805,787	6.06	0.84
1977	951,038	3,112,620	2,161,582	3.27	0.69
1996	963,125	2,261,757	1,298,632	2.35	0.57
2007	964,261	4,376,406	3,412,145	4.54	0.78
1993	997,730	1,689,779	692,049	1.69	0.41
2010	1,037,666	3,625,388	2,587,722	3.49	0.71
2002	1,126,642	3,630,740	2,504,098	3.22	0.69
1992	1,207,382	4,271,576	3,064,194	3.54	0.72
2012	1,212,837	1,490,134	277,297	1.23	0.19
1988	1,213,047	2,546,639	1,333,592	2.10	0.52
2011	1,284,486	4,513,815	3,229,329	3.51	0.72
1994	1,309,695	3,052,634	1,742,939	2.33	0.57
1997	1,365.746	3,626,402	2,260,656	2.66	0.62
2003	1,402,340	1,922,165	519,825	1.37	0.27
2005	1,654,003	4,802,362	3,148,359	2.90	0.66
2004	1,690,547	3,240,428	1,549,881	1.92	0.48
2006	1,892,090	5,003,585	3,111,495	2.64	0.62
1987	2,011,772	10,356,627	8,344,855	5.15	0.81
1989	2,026,637	4,458,679	2,432,042	2.20	0.55

For the 21 data points within the range of 848,000 to 2,027,000 spawners, the average yield is 2.6 million salmon. This is about 33 percent <u>less</u> than the average yield of 3.9 million salmon within the range of 600,000 to 800,000 spawners. Only 2 of the 21 data points for escapements above 800,000 spawners have a yield equal to or above 3.9 million. The excess escapements put future returns at risk.

Despite this information, gathered from 44 years of Kenai River late-run sockeye runs, ADF&G and the BOF are still setting goals based on the various models, and they are still continuing to increase the goal range. In 2020, ADF&G raised the Kenai River late-run sockeye SEG goal range even higher, now set at 750,000 to 1.3 million. The BOF also raised the allocative “in-river goals”, in 3 different tiers, to range from 1 million to 1.6 million sockeye. In addition, just like in the Kasilof River, the in-season management of the Kenai River late run sockeye is also failing to keep escapement numbers within any defined goal range. In 14 of the last 20 years and in 9 of the last 10 years, the Kenai sockeye escapement exceeded the upper end of the inflated goal range.

In 5 of the last 10 years the Kenai sockeye escapement has exceeded 1.5 million. The in-river sport-fishery does not have the capacity to harvest these excess sockeye, so the result is an immediate loss of 500,000 to a million sockeye that could be harvested by the commercial fishery. We cannot afford to waste these 500,000 or more sockeye that are surplus to spawning needs. Five hundred thousand sockeye, or more, equates to a minimum of 3 million pounds of salmon being wasted annually.

From ADF&G's 2020 analysis shown in Figure 15 below, the estimate of MSY and the goal ranges do not come close to the empirical data estimates of MSY from the Markov Table (Figure 13) or the brood table (Figure 14). The fit of all the ADF&G's models, including the brood year interaction model used since 1999, are very poor and get worse every year. They all over-predict the return from any level of escapement. None of the 90% goal ranges from the models come close to 90% of MSY.

Figure 15. Kenai Sockeye Return per Spawner model (Ricker) from Hasbrouck 2020 (Hasbrouck, J. J., W. D. Templin, A. R. Munro, K. G. Howard, and T. Hamazaki. Unpublished. Spawner–recruit analyses and escapement goal recommendation for Kenai River late-run sockeye salmon. Alaska Department of Fish and Game, Report to the Alaska Board of Fisheries, Anchorage. 2020 p.25)

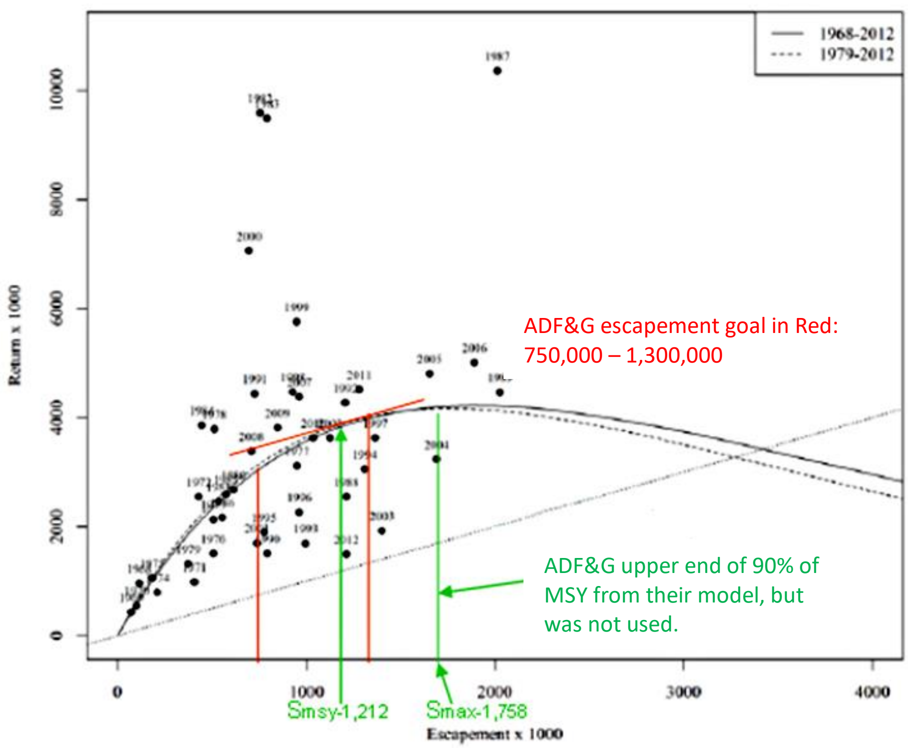


Figure 6.–Classic Ricker model fit to Kenai River late-run sockeye salmon spawner-recruit data from 1968–2012 (solid line) and 1979–2012 (dashed line).

In Figure 16 the escapement goal ranges in red suggested by ADF&G in the yield profiles do not represent 90% of MSY as ADF&G reports in Hasbrouk, et al, 2020. In addition, these analyses do not agree with the empirical data in the Markov Table (Figure 12) from which they originate. A 50% to 70% chance of overfishing does not meet the 90% of MSY standard.

Figure 16. Kenai Sockeye Estimated Yield Profiles from Hasbrouck 2020 (Hasbrouck, J. J., W. D. Templin, A. R. Munro, K. G. Howard, and T. Hamazaki. Unpublished. Spawner–recruit analyses and escapement goal recommendation for Kenai River late-run sockeye salmon. Alaska Department of Fish and Game, Report to the Alaska Board of Fisheries, Anchorage. 2020 p.227)

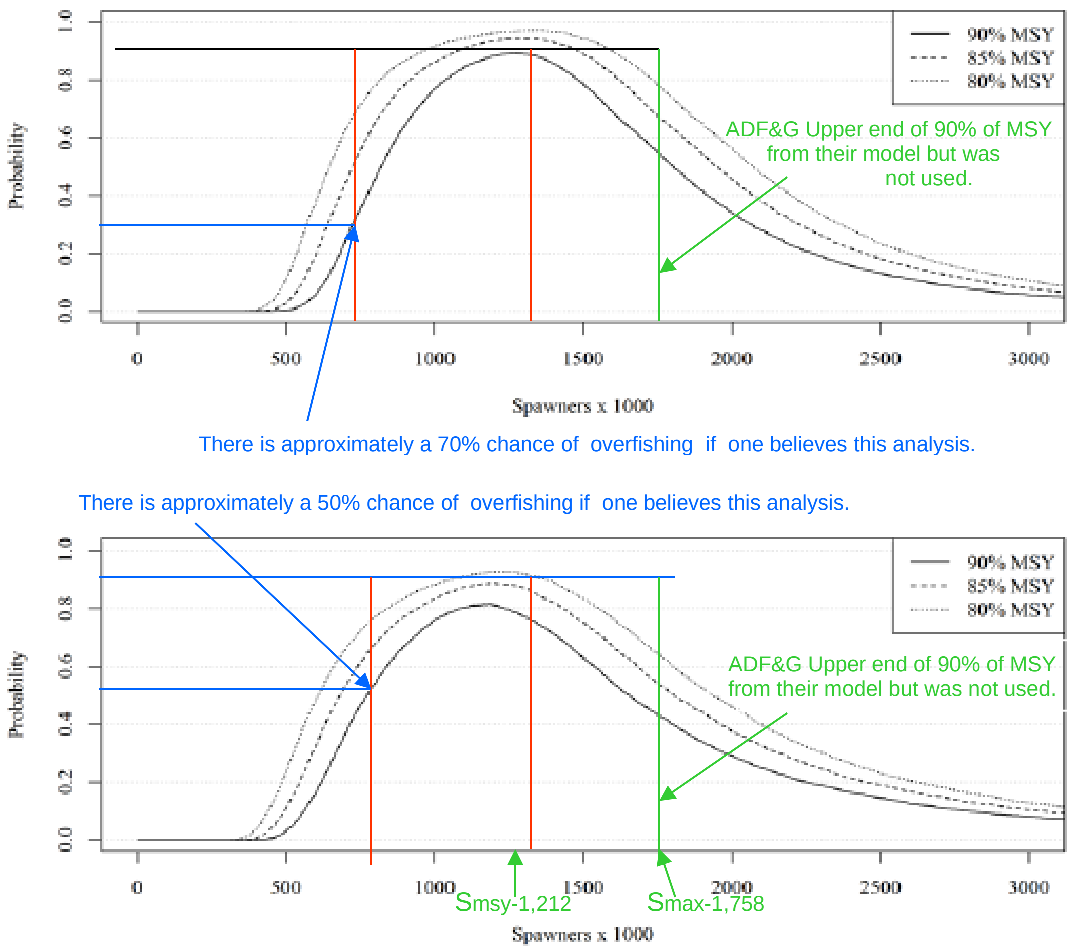


Figure 8.–Estimated yield profiles based on the classic Ricker model using spawner-recruit data from 1968–2012 (top panel) and 1979–2012 (bottom panel).

ADF&G is not setting the goal range using the methods they described to the Council in 2010. In using these yield profile models, they change the parameters so that they fall far outside of the standard of 90% of MSY.

Forty-four years of empirical data (Markov Table) are an asset in setting escapement goals, provided the data is utilized. The data is so clear it begs the question of why ADF&G is not using it to formulate escapement goals for the Kenai River late-run sockeye salmon. It would appear that ADF&G is deliberately trying to reduce yield in the commercial fishery. Harvests have been reduced due to unnecessarily high escapement goals. Harvests have been further reduced by ADF&G's unwritten policy of managing for escapements at the high end of the goal range. Harvests have been even further reduced by escapements exceeding the upper limit of already too-high escapement goals. They are using incorrect escapement goals and prescriptive management plans that limit in-season adaptive management and the result is diminished returns and continued lost yield. In other words, the state is managing the Cook Inlet salmon fishery with the objective of putting the commercial fishing industry out of business.

Many of the methods that ADF&G and the BOF are using to manage the Cook Inlet salmon fishery are very similar to what occurred during the federal management era prior to Alaska statehood, when salmon fisheries were largely managed by fishing schedules and fishing areas defined in regulation pre-season, and in-season adjustments were delayed until they were too late to be effective.

Lost yields are not just lines on a graph or expressions of probability. The "too-high escapements," that ADF&G has declared they are not concerned about, constitute a deliberate waste of harvestable surplus salmon. This deliberate waste has resulted in shuttered seafood processing plants and fishing businesses and the loss of thousands of jobs. It has cost hundreds of millions of dollars of lost commerce for the state and nation and has caused tremendous hardships in coastal communities. This is an irresponsible and irretrievable loss. It does not meet basic standards of MSY or OY. The State of Alaska's salmon fishery management does not comply with the requirements of MSA or the 10 National Standards.

The examples of mismanaged Chinook and sockeye stocks illustrated above are just a few of the many examples that we could describe. The coho, pink and chum runs into Cook Inlet are largely unmonitored and unharvested. There is no attempt by the ADF&G to meet any of the requirements of the MSA or the National Standards for these stocks. The pink salmon run into Cook Inlet is the largest stock that enters Cook Inlet, some years exceeding 20 million salmon, yet there is no active management and only incidental harvest of this stock. This does not meet the NS1 requirement of MSY as the basis for fishery management. In Cook Inlet there are more wild-run pink salmon wasted because of bad management than some pink salmon hatcheries produce (at a cost of millions of dollars) in other areas of the state.

Meeting MSA Requirements in Managing the Cook Inlet Salmon Fishery

UCIDA had the expectation that Cook Inlet stakeholders would be included in the process of developing an FMP for the obvious benefit of providing valuable local knowledge and experience with this particular fishery. Instead, the stakeholders on the Cook Inlet Salmon Committee were initially tasked with developing Status Determination Criteria (SDCs), ACLs and AMs for a portion of the fishery. The Salmon Working Group (consisting of staff members from Council, NMFS and ADF&G) repeatedly described this task to the Salmon Committee as an intractable, unsolvable problem. However, in 2010 the Council accepted the information regarding SDCs, ACLs, and AMs, provided to them by ADF&G and utilized it in developing Amendment 12.

When the Council adopted Amendment 12, they accepted the State's approach as described in the 2010 State of Alaska's Salmon Fisheries Management Program paper that described the exploitation rates, conversions for escapement-based reference points and conversions for catch-based and exploitation rate-based management targets to fit in the OFL/ABC/ACL framework. (The state's document is attached.)

During Cook Inlet Salmon Committee meetings, the Salmon Working Group challenged the stakeholders' recommendations for appropriate exploitation rates of salmon species. However, the stakeholders' recommended exploitation rates were right in line with those described in the State's 2010 paper: "State of Alaska's Salmon Fisheries Management Program," excerpted here:

> "Biological reference points estimated for many salmon stocks demonstrate that salmon populations are extremely productive, with the limit return per spawner (α) averaging 3.7, 4.0, 3.7, 6.0, and 6.9 for pink, chum, coho, sockeye, and Chinook salmon, respectively**. MSY exploitation rates (i.e., the average harvest rates employed to maintain constant escapement in the escapement goal range) are high, averaging 0.53, 0.56, 0.63, 0.65, and 0.68 for pink, chum, coho, sockeye, and Chinook salmon, respectively.** The overfishing exploitation rate (i.e., the fishing rate if continuously applied will deplete the stock) is also very high averaging 0.72, 0.74, 0.80, 0.81, and 0.83 for pink, chum, coho, sockeye, and Chinook salmon, respectively (Eggers and Clark in prep.)."[6]

The MSY exploitation rates shown above, in bold, are what the state is required to be achieving under the MSA and NS1. ADF&G is making no attempt to achieve those exploitation rates in the Cook Inlet salmon fishery. In 2002, ADF&G conducted a marine tagging project designed to estimate the total population size, escapement, and exploitation rates for coho, pink and chum salmon returning to Cook Inlet (Willette et al. 2003). This study estimated the harvest rate of pink salmon in the commercial fishery at about 0.02, the harvest rate of chum salmon in the commercial fishery at about 0.06, and the harvest rate of coho salmon in the commercial fishery at about 0.10 of the total run. (The harvest rate of coho was actually less than ten percent because the study ended before the Kenai coho run started.) The low harvest rates on these stocks are a direct result of restrictive management plans for the commercial fishery. We have not been allowed to harvest these abundant stocks.

In the current Discussion Paper, under "2.5.2 Alternative 2: Cooperative management with the State," the three tier method described is clearly designed to maintain the status quo in the exploitation rates of Cook Inlet salmon stocks. This is unacceptable to the stakeholders and, as described above, does not meet the requirement in NS1 that establishes maximum sustained yield as the basis for fishery management. Stakeholders on the Cook Inlet Salmon Committee have repeatedly explained that the three tier method that is used for the East Area in the Salmon FMP cannot be applied to the Cook Inlet salmon fishery. In Cook Inlet, except for Chinook stocks, all other stocks are intermingled spatially in one large stock complex with some temporal stratification.

In Cook Inlet Salmon Committee meetings, NMFS staff asserted that FMPs did not, and could not, address underfishing. It is clearly stated in the findings and the purpose of the MSA that FMPs are to develop fisheries on stocks that are underutilized. National Standard 1 requires that conservation and management measures "shall prevent overfishing while achieving, on a

[6] ADF&G, 2010. State of Alaska's Salmon Fisheries Management Program. Response to Council request (June 30, 2010.) Correspondence. Juneau, Alaska. Attachment. p.5

continuing basis, the optimum yield from each fishery for the United States fishing industry." **Achieving optimum yield on a continuing basis on salmon stocks requires setting escapement goals closely centered on MSY and managing for exploitation rates (Fmsy) to achieve those goals. MSY or OY cannot be achieved if either underfishing or overfishing occurs.**

Members of the Salmon Committee brought these discussion points repeatedly to the table at the Cook Inlet Salmon Committee meetings and were rebuffed or dismissed by the Salmon Working Group. The Council and NMFS can no longer continue operating under the assumption that state salmon management practices comply with MSA in the face of this glaring discrepancy between what the MSA requires, what MSY exploitation rates must be to achieve OY, and what is actually occurring in the fishery.

The Salmon Committee was also tasked with reinterpreting ACLs and reference points for the Cook Inlet salmon fishery. In 2010, the State and Council agreed on the methodology, including how to assess the stocks with escapement goals, and how to assess the stocks without escapement goals, using exploitation rates and catch-based reference points. When stakeholders brought this methodology forward at a Salmon Committee meeting it was dismissed.

The parameters for the OFL/ABC/ACL framework for a salmon FMP, that were already accepted by the Council, NMFS and the Secretary of Commerce with Amendment 12, were described in the State of Alaska's Salmon Fisheries Management Program in this excerpt:

> "NSl is implemented with the 2009 MSA Provisions; Annual Catch Limits; National Standards Guidelines; Final Rule, which specifies an OFL/ABC/ACL framework. A tier of reference points are defined: the overfishing limit (OFL) which corresponds with MSY; the acceptable biological catch (ABC) which cannot exceed the OFL; the annual catch limit (ACL); and the annual catch target (ACT). The difference between OFL and ABC depends on how scientific uncertainty is accounted for in the ABC control rule. The difference between ACL and ACT depends on management performance and uncertainty. For salmon, one can define reference points based on escapement, exploitation rate, or catch; however, catch based reference points and associated targets generally cannot be safely determined pre- season, and assessment of compliance can only be assessed post-season.
>
> For escapement-based reference points in the OFL/ABC/ACL framework,
>
> $$S_{OFL} < S_{ABC} = S_{MSY} \leq S_{ACL} < S_{ACT}$$
>
> For exploitation rate- and catch- based reference points,
>
> $$F_{OFL} > F_{ABC} = F_{MSY} \geq F_{ACL} > F_{ACT}$$
>
> $$C_{OFL} > C_{ABC} = C_{MSY} \geq C_{ACL} > C_{ACT}$$"[7]

[7] Ibid, p. 3

Some of these basic elements of Alaska's salmon management program, including the exploitation rates and conversions for escapement-based reference points and catch-based and exploitation rate-based management targets to fit in the OFL/ABC/ACL framework, are generally still applicable for this new amendment.

ADF&G is not currently following the salmon fisheries management program that they described in 2010 for any stock of salmon returning to Cook Inlet. They were not following their program in Cook Inlet in 2010 when they provided that information to the Council and NMFS. While some of Alaska's salmon management program may comply with the requirements and standards of the MSA, their management practices and escapement goals do not.

The Council and NMFS did not meet their obligation and responsibility during the development of Amendment 12 to confirm that the management program described by ADF&G was actually being implemented. No effort has been made since then to fulfill that requirement. All the problems with the goals and the management that we have described above would have been revealed years ago, if the Council had met the requirement of a post season SAFE report; instead it's been left to the stakeholders to bring this information forward.

The Council and NMFS must require and ensure, through diligent oversight, that all Cook Inlet salmon management plans, escapement goals, regulations, in-season management practices and post season SAFE reports are all designed and implemented to achieve what the MSA requires.

On May 7, 2020, President Trump signed an Executive Order titled "Executive Order on Promoting American Seafood Competitiveness and Economic Growth". Section 4 of that executive order is excerpted below.

> "Sec. 4. Removing Barriers to American Fishing. (a) The Secretary of Commerce shall request each Regional Fishery Management Council to submit within 180 days of the date of this order, a prioritized list of recommended actions to reduce burdens on domestic fishing and to increase production within 1 year of the date of this order."

Clearly, the Cook Inlet salmon fishery is not being managed for MSY. There is tremendous potential to increase production rapidly and sustainably in this fishery, it just requires the fishery to be managed to the higher level of standards that are already required under the MSA.

Sincerely,

Erik Huebsch, Vice President

CC: James Armstrong, NPFMC
Jeff Berger, Cook Inlet Processor Stakeholder
Forrest Bowers, ADF&G
Karla Bush, ADF&G
Doug Duncan, NOAA
Jordan Watson, NOAA
Diana Evans, NPFMC
Gretchen Harrington, NOAA
Georgie Heaverley, Cook Inlet Stakeholder
Hannah Heimbuch, Cook Inlet Stakeholder
John Jensen, NPFMC
Lauren Smoker, NOAA
Mike Downs, SSC
Marcus Hartley, Northern Economics

Attachment:1

Attachment 1: ADF&G, 2010. State of Alaska's Salmon Fisheries Management Program. Response to Council request (June 30, 2010.) Correspondence. Juneau, Alaska. Attachment

State of Alaska's Salmon Fisheries Management Program

Introduction

The Fishery Management Plan (FMP) for salmon fisheries in the Exclusive Economic Zone (EEZ) off Alaska's coast defers salmon management to the State of Alaska. Compliance with the Magnuson - Stevens Fishery Conservation and Management Act (MSA) and National Standards (NS) guidelines requires the Regional Management Councils, with some exceptions, to establish a mechanism for specifying annual catch limits (ACLs) and accountability measures (AMs) to prevent overfishing of stocks that are covered under the FMP (MSA § 303(a)(15); 16 U.S.C. §1853(a)(l5)). The North Pacific Fishery Management Council (Council) has requested the assistance of Alaska Department of Fish and Game (ADF&G) in evaluating the State of Alaska's salmon management program with regard to the requirements of the MSA. This document describes how the State of Alaska salmon management system is a successful and appropriate system for meeting MSA requirements to prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

The Council generally applies catch quota based fishery management systems for managing groundfish fisheries in the EEZ off Alaska. Annual catch quotas, often allocated among different users, are specified for each stock. The quota is based on the assessment of the stock biomass and the application of a suitable exploitation rate. Stock Assessment and Fishery Evaluation (SAFE) documents, which detail stock assessment and final acceptable biological catch (ABC) recommendations, are prepared in the year prior to the fishing season using stock assessment data collected as recently as the year prior to the fishery. However, proposed ABC recommendations are made for one and two years prior to the fishery based on data gathered up to two or three years before the fishery is conducted. This minimum 2-year lag between data acquisition and the years for the proposed recommendations allows suitable time for the lengthy public and government review process required under Federal law. The final ABC recommendations are very often close to the proposed ABCs, which require 2-year population projections. This is generally appropriate because groundfish fisheries under Council jurisdiction primarily occur on long-lived stocks where new recruits are not a significant component of the stock biomass, and projection models tend to use consistent growth and natural mortality rates. Because projections are reasonably accurate and quotas are small compared to the stock biomass, there is little risk of overfishing imposed by erroneous projection of stock assessment information; an inherent risk in relying on early projections to establish catch quotas. Furthermore, groundfish stocks are iteroparous, so management can adapt over time with conservation action taken in a subsequent year to increase the productive biomass and increase the allowable catch to respond to overly conservative management thereby minimizing foregone harvest.

Alaska salmon fisheries pose a different case because

1) unlike ground fish stocks salmon are semelparous reproducing once in the life cycle;

2) the harvestable surplus is entirely new recruits and catch is almost exclusively comprised of mature salmon;
3) the productivity of a specific year class cannot be improved by limiting harvest in subsequent years;
4) foregone harvest cannot be recaptured in future years; and
5) since abundance cannot be estimated effectively in advance, in-season estimations of abundance using contemporary data with appropriate management actions taken to assure escapement and optimum production in future years is the most effective way to avoid the risk of overfishing.

Alaskan salmon fisheries are managed by allowing fishing in specific times and areas. With the exception of Chinook salmon in the Southeast Alaska troll fishery, Alaska salmon fisheries generally occur on maturing fish in areas terminal or near-terminal to natal spawning systems, where fish are concentrated and highly vulnerable. Although salmon are vulnerable to fishing for only a short time, run timing is consistent and predictable from year to year. Salmon are relatively short-lived and highly productive, with sustainable catch levels large relative to the spawning stock. Because salmon run sizes are highly variable and unpredictable, specifying a catch quota based on pre-season abundance forecasts is a much inferior approach to salmon management than actively managing for monitored in-season abundance.

During the federal management era prior to Alaska statehood, salmon fisheries were largely managed by fishing schedules and fishing areas defined in regulation pre-season. There were provisions for in-season adjustments, but these were ineffective and rarely implemented due to the need for secretarial review and lack of in-season assessment information. By the time in-season adjustments were implemented it was too late for effective conservation measures. The inability to curtail fishing during weak runs and extended periods of poor productivity led to the depletion of Alaskan salmon stocks at the time of Alaska statehood. With the exception of the Southeast Alaska troll fishery and the Area M June net fisheries, catch quota based fishery management systems have never been used in State management of Alaska salmon fisheries (catch quotas were abandoned for the Area M June fishery in about 2003). These two fisheries occur on distant stocks with catch quotas comprising a relatively small portion of the overall stock.

In the State fishery management era, the vast majority of salmon may be taken only in fishing periods established in-season by emergency order. Fishing is allowed to continue only if in-season assessment of run strength indicates harvestable surpluses. The level of fishing time allowed depends on the strength of the in-season run. Authority to open and close fisheries is delegated to local area managers by the Commissioner of Fish and Game. This enables timely and effective fishery management responses to in-season information. Under State management, stock assessments are focused on obtaining escapement estimates for stocks targeted in fisheries. At the time of statehood, escapement data were available only for Bristol Bay sockeye salmon, a few Kodiak sockeye systems, Chignik sockeye, and aerial surveys were utilized to assess pink salmon escapement in coastal areas throughout the Gulf of Alaska. Escapement enumeration programs have since been greatly expanded, with direct or appropriate indicator stock monitoring of escapements for most sockeye, Chinook, and pink salmon stocks targeted in Alaska salmon fisheries, as well as important chum salmon stocks in Arctic-Yukon-Kuskokwim (AYK) region. This management and stock assessment framework addresses the principal overfishing risk in managing salmon fisheries: allowing intense fishing during weak runs. Because occasional weak runs are inevitable, timely and accurate assessment of run strength avoids overfishing by implementing conservative fishing schedules conditioned on in-season abundance.

A fishery management system based on strict catch quotas and associated ACLs and AMs, implicit in the NS implementation, would be problematic for Alaska salmon fisheries. ACLs are inconsistent with the State's salmon fisheries management system which has a long-term, successful history of avoiding overfishing. Their implementation would not be beneficial for meeting the goals and requirements of MSA to prevent overfishing.

National Standards Guidelines

National Standards 1 (NS1) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires that conservation and management measures "shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry."
Overfishing occurs whenever a stock or stock complex is subjected to a level of fishing mortality that jeopardizes the capacity of the stock or stock complex to produce maximum sustained yield (MSY) on a continuing basis. The MSA establishes MSY as the basis for fisheries management and requires that fishing mortality does not jeopardize the capacity of a fishery to produce MSY.

NSl is implemented with the 2009 MSA Provisions; Annual Catch Limits; National Standards Guidelines; Final Rule, which specifies an OFL/ABC/ACL framework. A tier of reference points are defined: the overfishing limit (OFL) which corresponds with MSY; the acceptable biological catch (ABC) which cannot exceed the OFL; the annual catch limit (ACL); and the annual catch target (ACT). The difference between OFL and ABC depends on how scientific uncertainty is accounted for in the ABC control rule. The difference between ACL and ACT depends on management performance and uncertainty. For salmon, one can define reference points based on escapement, exploitation rate, or catch; however, catch based reference points and associated targets generally cannot be safely determined pre- season, and assessment of compliance can only be assessed post-season.

For escapement based reference points in the OFL/ABC/ACL framework,

$$S_{OFL} < S_{ABC} = S_{MSY} \leq S_{ACL} < S_{ACT}$$

For exploitation rate- and catch- based reference points,

$$F_{OFL} > F_{ABC} = F_{MSY} \geq F_{ACL} > F_{ACT}$$

$$C_{OFL} > C_{ABC} = C_{MSY} \geq C_{ACL} > C_{ACT}$$

NSl requires that each FMP specify objective and measurable criteria (status determination criteria - SDC) for identifying when stocks or stock complexes covered by the FMP are overfished. The guidelines for NS1 specify that status determination criteria must specify both a maximum fishing mortality threshold (MFMT) and a minimum stock size threshold (MSST).

The fishing mortality threshold cannot exceed the MFMT or level associated with the MSY control rule. Exceeding MFMT for a period of 1 year constitutes overfishing. The MSST should be expressed in terms of spawning biomass or other measure of productive capacity, and should equal whichever of the following is the greater; one-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years. If the spawning stock size falls below the threshold for a year, the stock complex is considered overfished.

Due to their unique life history, implementation of the SDC as outlined in NS1 is problematic for salmon. Salmon are semelparous, short-lived (2-7 years), and generally vulnerable to exploitation only during their spawning migration (except immature salmon are vulnerable to some extent as bycatch in groundfish fisheries and immature Chinook salmon are targeted in ocean troll salmon fisheries). Thus, depending on maturity schedules, only a small to moderate fraction of the stock is vulnerable to fishing in a given return year. The inter-annual abundance of salmon spawning populations is typically highly variable, due to variable year-class strength and variable maturation schedules, and fishing mortality rates are expressed as a fraction of the spawning stock. This is very different than fishing mortality rates on long-lived iteroparous populations, where all fully recruited age classes are considered vulnerable to fishing. Status determinations for salmon must account for multiple return years from a single brood.

There are also difficult problems with implementation of an exploitation rate or catch based OFL/ABC/ACL/ACT framework for salmon. Alaskan salmon fisheries are generally managed under a constant escapement harvest policy where exploitation rates and catch fluctuate with variation in salmon run strength, with escapement targets fixed in time. The MSY control rules for salmon fisheries are more safely implemented by targeting management actions to achieve a target escapement level rather than a target fishing mortality rate or a target catch level. It is possible to determine catch- based and exploitation rate- based management targets for salmon on a post season basis. Here $F_{MSY} = (1-S_{MSY}/R)$ and $C_{MSY} = F_{MSY} R$. Because salmon runs are highly variable and impossible to accurately forecast, catch based management targets would be very risky and routinely result in over-harvest in the commonly encountered situation of an unanticipated weak run. Catch based MSY control rules are not appropriate for salmon fisheries. MSY exploitation rates on salmon are, on average, very high relative to those for iteroparous populations. With the highly variable and unpredictable nature of salmon spawning abundance, it is very difficult and risky to implement a fixed MSY exploitation rate harvest policy. ACLs and associated ACTs as described in NS1, clearly focus on a catch based management system. Because of high risk associated with catch-based management targets, which are based on inherently inaccurate pre-season forecasts of salmon runs, these approaches are inferior to escapement based management for avoiding overfishing of salmon stocks.

Salmon Stock Assessment and Management

For salmon, maximum sustained yield is achieved by fishing appropriately to maintain the spawning escapement at levels that provide potential to maximize surplus production. Salmon populations exhibit compensatory and density dependent stock recruitment dynamics, driven by intra-specific competition for limited spawning and rearing habitat. In salmon populations, sustained yield is driven by increased production in response to fishing induced reductions in spawning escapement and concomitant increased survival accompanying decreased competition. Sustained yield in iteroparous populations is driven by fishing induced increased growth in biomass over biomass lost to natural maturity (i.e., yield per recruit). This concept has no relevance for salmon since the vast majority of fish are harvested at the end of their life.

Biological reference points for salmon populations are estimated based on long-term, stock specific assessment of recruits from parent escapement or long-term assessment of escapement. Estimating biological reference points for salmon populations requires direct assessment of the spawning stock. Biological reference points for iteroparous populations can and usually are estimated without direct stock- recruit assessment data. The salmon stock assessment programs employed by ADF&G are designed to monitor stock and age-specific catch and escapements. The program employs comprehensive sampling of catch and escapements by age; comprehensive escapement monitoring using tower counts, weir counts, sonar counts, mark-recapture experiments, aerial counts, and foot counts; and routine monitoring and stock identification of catch using a variety of methods including, genetic stock identification (GSI) , coded wire tags , and otolith marks. These data enable the current season run (i.e., catch plus escapement) to be assigned to prior brood years (i.e., the return from stock specific parent escapement). Comprehensive implementation of the ADF&G salmon stock assessment programs, over time, provides stock- recruit data necessary for developing MSY based escapement goals. Since the catch and escapement monitoring programs are conducted in real-time, they provide in-season assessments of run strength necessary for managers to implement ADF&G's escapement based harvest polices. In fisheries, where escapement monitoring occurs distant from the fishery, test fisheries are employed to provide more real-time assessment.

The compensatory nature of salmon population dynamics is reflected in the Ricker stock recruit model (Figure 1). Appropriate biological reference points used as benchmarks in status determinations, and in setting escapement goals can be determined from the Ricker model parameters estimated by fitting the Ricker model to historical stock-recruit data (Ricker 1954). These include α, the productivity of the stock and the overfishing harvest rate ($U_{of} = 1 - 1/\alpha$); the equilibrium escapement (S_{eq}); MSY escapement (Smsy), (typically between .35 and .45 of the equilibrium escapement), and the MSY harvest rate (Umsy). Escapement goals are typically set at the range of escapements that provides 90% or more of MSY. The approach of using the fitted Ricker stock-recruit model to set escapement goals is routinely used by ADF&G for stocks where stock specific runs can be estimated and there is sufficient contrast in the historical escapement data to reflect density dependence.

Biological reference points estimated for many salmon stocks demonstrate that salmon populations are extremely productive, with the limit return per spawner (α) averaging 3.7, 4.0, 3.7, 6.0, and 6.9 for pink, chum, coho, sockeye, and Chinook salmon, respectively. MSY exploitation rates (i.e., the average harvest rates employed to maintain constant escapement in the escapement goal range) are high, averaging 0.53, 0.56, 0.63, 0.65, and 0.68 for pink, chum, coho, sockeye, and Chinook salmon, respectively. The overfishing exploitation rate (i.e., the fishing rate if continuously applied will deplete the stock) is also very high averaging 0.72, 0.74, 0.80, 0.81, and 0.83 for pink, chum, coho, sockeye, and Chinook salmon, respectively (Eggers and Clark in prep.).

Currently ADF&G has established 290 escapement goals (72 Chinook salmon stocks, 70 chum salmon stocks, 29 coho salmon stocks, 41 pink salmon stocks, and 78 sockeye salmon stocks) for stocks where escapements are routinely monitored (Munro and Volk 2010). Escapement goals have been established for target stocks in every salmon fishery that ADF&G manages. A variety of methods are used to estimate escapement goals. Most methods directly estimate MSY escapement range from stock productivity data as well as rearing and spawning habitat considerations. In the absence of stock-recruit information, many escapement goals are set based on the percentile method (Bue and Hasbrouck, (unpublished). **[Note – not only was this paper unpublished, it was not peer reviewed and should not be used because the upper tier recommended escapement goals that exceeded the carrying capacity of the habitat and were found to be unsustainable.]** For stocks with high contrast in historical escapement data, the escapement goal is the central 50 percentile range of historical escapements and for stocks with low contrast or low harvest rates, the escapement goal is the central 85 percentile of historical escapements. Eggers and Clark (in prep) show that the percentile method provides a reasonable and conservative proxy for MSY escapement goal ranges. Computer simulations demonstrate that results from the percentile method are virtually equal to the actual MSY escapement range (Eggers and Clark in prep.) if the stock is exploited in a manner that provides MSY (Figure 2). The simulations also demonstrate that the 25 percentile of historical escapements is well above the lower bound of the MSY escapement goal range, except for situations where the stock is heavily exploited above the level that provides for MSY (Figure 2). For situations where the stock is exploited below MSY levels, the percentile method estimates escapements above the MSY escapement range (Figure 2).

A meta-analysis of stock-recruit data from ADF&G salmon stocks (42 sockeye salmon stocks, 7 Chinook salmon stocks, 5 coho salmon stocks, 6 chum salmon stocks, and 7 pink salmon stocks) demonstrates that escapement goals estimated by applying the percentile method were consistent with or above MSY escapement ranges as well as the established ADF&G goals for stocks where the MSY escapement goal was estimable (Eggers and Clark in prep). There were several sockeye salmon stocks where the percentile method escapement goals appeared less conservative than the meta-analysis MSYs or the ADF&G established escapement goals. In these cases, there was a demonstrated lack of density dependence in the stock recruit data which precluded a statistically significant estimate of the MSY escapement level. In these cases, escapement goals were established based on yield analyses with escapement goals based on consistent and high levels of yield. The fact that the central 50 percentile escapement ranges were above the MSY escapement range for most stocks demonstrates that salmon are generally exploited below MSY. Fishing is constrained during weak runs and available surpluses with strong runs are rarely achieved due to conservative fishery management, market constraints, or limited fishing power.

State of Alaska's Salmon Status Determination

The State of Alaska stock assessment and fishery management system, as embodied in the *Escapement Goal Policy* (EGP, 5 AAC39.223) and *Policy for the Management of Sustainable*

Salmon Fisheries (PMSSF, 5 AAC 39.222) is consistent with NSl. Escapement goals are based on direct assessments of MSY escapement level (S_{msy}) from stock recruit analysis (i.e., BEG) or a reasonable proxy (i.e., SEG) (c.f. Munro and Volk, 2010). Escapement goals are specified as a range or a lower bound threshold. In general, escapement goal ranges produce 90% of MSY, and escapements are considered neutral within the range. Because yield is relatively flat across escapements that constitute an escapement goal range, these ranges give managers the flexibility to moderate fishing to protect stocks of weak runs that are commonly exploited in mixed stock fisheries.

Alaska's salmon fisheries are managed to maintain escapement within levels that provide for MSY (S_{msy}), escapements are assessed on an annual basis, all appropriate reference points are couched in terms of escapement level, and status determinations are made based on the stock's level of escapements. Three levels of concern are defined in the PMSSF-yield, management, and conservation. The level of concern relevant to status determination is the management concern. A management concern results from a continuing or anticipated inability to maintain escapements within the escapement goal range or above the threshold. Thus, the lower range or threshold of escapement goals is consistent with NS1 minimum stock size threshold and a determination of a management concern is equivalent to a determination of an overfished state in NS1. Overfishing is defined in the PMSSF as a level of fishing that results in a management or conservation concern. With the determination of a management concern, ADF&G and the Board of Fisheries are required to develop an action plan to address the concern. This may include measures to restore and protect salmon habitat, identification of salmon stock rebuilding goals and objectives, implementation of specific management actions needed to achieve rebuilding goals and objectives, and development of performance measures appropriate for monitoring and gauging the effectiveness of the action plan.

ADF&G reviews salmon escapement goals and stock status for each salmon management area on a 3-year cycle, which is consistent with Board of Fisheries cycle of regulatory review of salmon fisheries by management area. Escapement goal and stock status reviews are prepared prior to the Board of Fisheries review. These documents for Southeast Alaska include DerHovanisian et al (2005), Eggers and Heinl (2008), Heinl et al (2008), Eggers et al. (2008), McPherson et al. (2008), Shaul et al.(2008); Prince William Sound includes Evenson et al. (2005) , Lower Cook Inlet includes Otis and Szarzi (2007), Upper Cook Inlet includes Bue and Hasbrouck (2001), Fair et al. (2007), Kodiak includes Nelson et al (2005), Chignik includes Witteveen et al. (2007), Alaska Peninsula includes.Nelson et al. (2006), Bristol Bay includes Baker et al., (2005), and the Arctic-Yukon-Kuskokwim Region includes Brannian et al. (2007) and Molyneux and Brannian (2006).

Analysis of State Revenue from Fisheries

Upper Cook Inlet, 2014

Ninilchik Harbor, photo by Kyle Martin

United Cook Inlet Drift Association

2015

Analysis of State Revenue from Fisheries

1. Introduction

The reality of the economic circumstances facing Alaska requires more than a cursory review of direct revenues generated by one of Alaska's greatest natural and renewable resources - Alaskan seafood. The Alaska commercial seafood industry is the State's second largest industry, the largest employer and a major generator of State tax revenue. Alaska's fishery resources have the potential to provide an even greater benefit to the State treasury. This analysis uses the 2014 Upper Cook Inlet (UCI) salmon fishery to demonstrate additional revenue options and why a comprehensive review of State fishery economics is needed. Results and conclusions from this review provide examples of the types of returns we could expect from other fisheries State-wide.

The greatest value to the State from its' fishery resources will not be realized until the Alaska Department of Fish & Game (ADF&G) and the Board of Fisheries (BOF) incorporate a business model approach to every management policy and plan. Fisheries management needs to be focused on fully utilizing these renewable resources with the understanding that allocation and daily management decisions have direct economic consequences to the welfare of the State. Taxes, licenses and permit fees should be adjusted so that all resource users share in the necessary cost of management.

To illustrate these concepts, this analysis examines the results of changing taxation revenue, license fees and monetizing unharvested surplus salmon. A retrospective analysis based on the fully documented 2014 UCI salmon fishery was chosen over projecting into an uncertain future. The 2014 UCI salmon fishery is the latest year for which harvest data is complete. This retrospective analysis will provide the reader an estimate of State revenues resulting from applying a series of revenue options to the 2014 UCI salmon fisheries. There are several options for additional revenue under consideration. First, a review of unharvested salmon stocks, monetizing the economic value they represent and increasing the commercial fishery business tax to 4%; second, increasing the sport fishing license by $5 for resident and $10 for non-resident anglers; third, implementing a new $30 fee for each original dipnet permit.

In this analysis, the effects on direct State tax and license revenue from UCI salmon fisheries would be:

- Harvesting surplus salmon for an additional $1,505,000 at the current tax rate;
- Applying a 1% increase to the Commercial Fishery Business Tax Rate for an additional $350,000 in commercial revenue and $1,715,000 in revenue from the unharvested salmon, totaling $2,065,000 in new revenues;
- Applying a $5 resident and a $10 non-resident sport fishing license fee increase for $900,000 in new revenue;
- Applying a $30.00 fee to the original personal use permit for $900,000 in new revenue.

Total of potential new tax and license revenue is $3,865,000 for UCI salmon.

2. Salmon Stocks and Harvests

In Table 1 and Figures 1 - 5, the UCI salmon stocks, escapement needs and harvests by the commercial, sport and personal use groups are listed, described and graphically displayed. Table 1 provides stock status, escapement needs and harvests for all five Pacific Salmon species in UCI. Figures 1 - 5 illustrate the above elements for each salmon stock separately using pie charts. Escapement needs are from ADF&G sources. Escapements are estimated for stocks with no established escapement goals.

Table 1. 2014 Upper Cook Inlet Salmon Stock Status & Harvests

	Chinook	Sockeyes	Coho	Pink	Chum	Total All Species
Total Run	250,000	5,500,000	2,750,000	20,000,000	1,500,000	**30,000,000**
Less Escapement Needed	(100,000)	(1,500,000)	(960,000)	(4,000,000)	(450,000)	**(7,000,000)**
Available Harvest	150,000	4,000,000	1,790,000	16,000,000	1,050,000	**23,000,000**
Commercial Harvest	4,600	2,343,032	137,200	642,754	116,083	3,243,669
Percentage	3.1%	58.6%	7.7%	4.0%	11.1%	14.1%
Sport Harvest	18,750	397,985	140,000	50,000	20,000	626,735
Percentage	12.5%	9.9%	7.8%	0.3%	1.9%	2.7%
Personal Use	50	506,079	9,382	26,796	1,860	544,167
Harvest Percentage	0.0%	12.7%	0.5%	0.2%	0.2%	2.4%
Total Harvest(s)	23,400	3,247,097	286,582	719,550	137,943	4,414,572
Percentage By Species	15.6%	81.2%	16.0%	4.5%	13.1%	**19.2%**
Unharvested	126,600	752,903	1,503,418	15,280,450	912,057	18,585,428
Percentage by Species	**84.4%**	**18.8%**	**84.0%**	**95.5%**	**86.9%**	**80.8%**

A. Discussion

- About 30,000,000 salmon returned to UCI streams and rivers in 2014. These salmon returns to UCI are some of the largest wild, native returns in Alaska. After escapement needs (7,000,000), there were approximately 23,000,000 salmon available for harvest. Of the 23 million salmon available for harvest, only around 4.5 million were utilized.
- If harvested in the commercial fishery, the 23 million salmon would be worth over $150 million dollars at the First Wholesale Value level.
- Non-utilized/unharvested describes those salmon in excess of escapement needs that have gone past the commercial, sport and personal use fisheries.
- These abundant salmon stocks should be available for harvest; however, the effects of current BOF and ADF&G management plans and policies result in over 80% of these stocks going unharvested. Specifically, 84.4 % of the Chinook, 18.8% of the sockeyes, 84.0% of the coho, 95.5% of the pinks and 86.9% of the chum salmon stocks swim through UCI untouched.
- The non-utilized stocks represent millions of lost tax revenue dollars to the State Treasury, tens of millions of dollars in lost economic benefit to the regional economies, loss of food products and by-products and lost jobs. These same non-utilized salmon represent an opportunity for growth and diversification in local, regional and State economies.
- The commercial sector is the only user group that has the capacity or the ability to harvest and monetize these non-utilized stocks.

Figure 1. Distribution of the 250,000 Chinook Run in Upper Cook Inlet, 2014

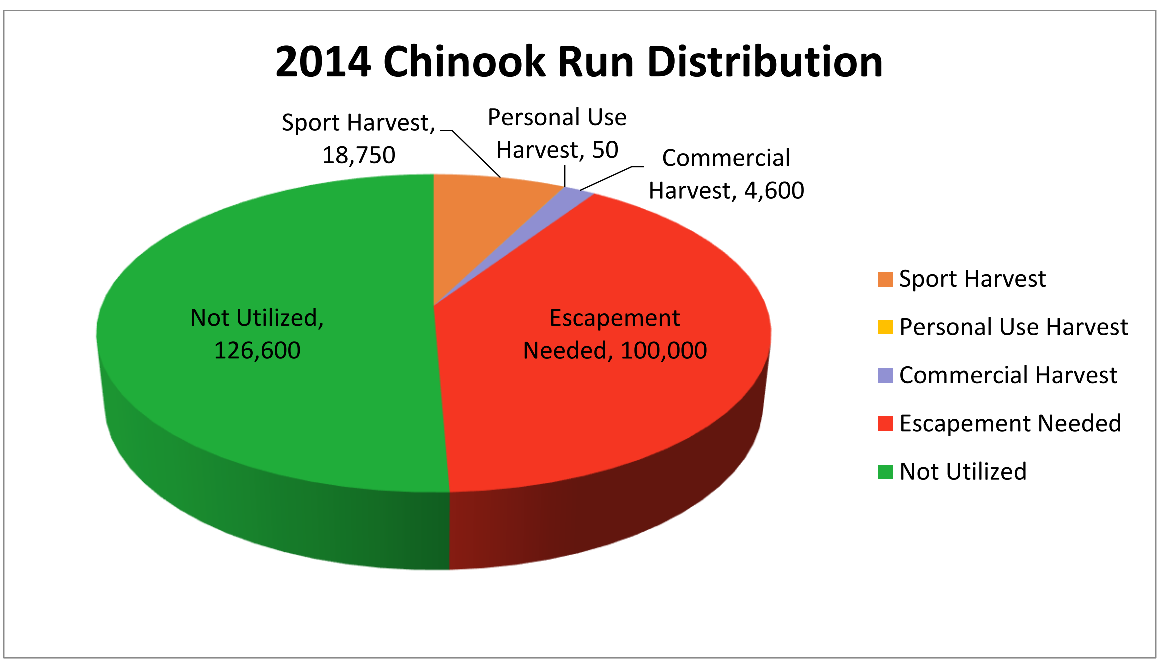


Figure 2. Distribution of the 5,500,000 Sockeye Run in Upper Cook Inlet, 2014

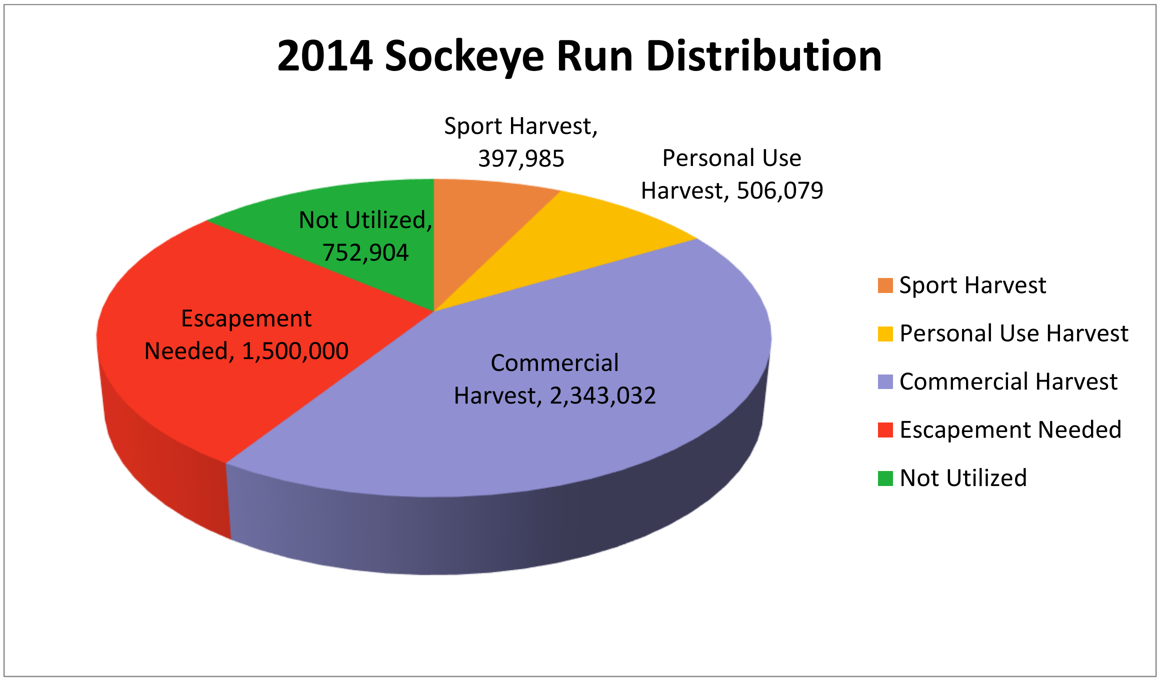


Figure 3. Distribution of the 2,750,000 Coho Run in Upper Cook Inlet, 2014

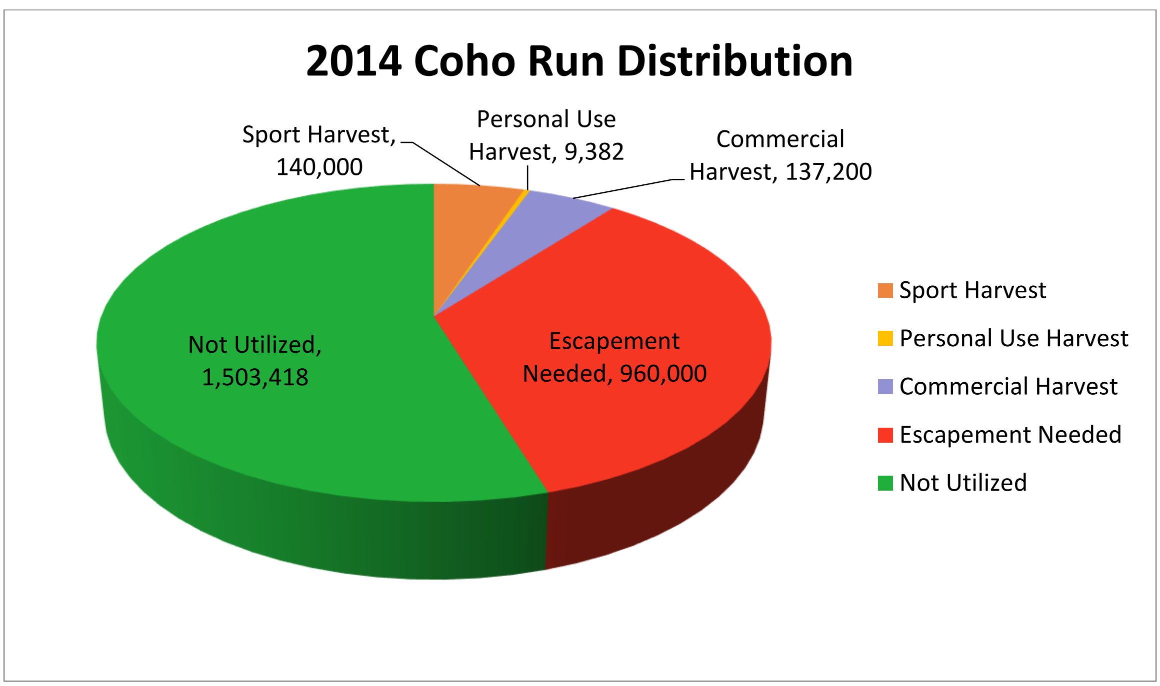


Figure 4. Distribution of the 20,000,000 Pink Run in Upper Cook Inlet, 2014

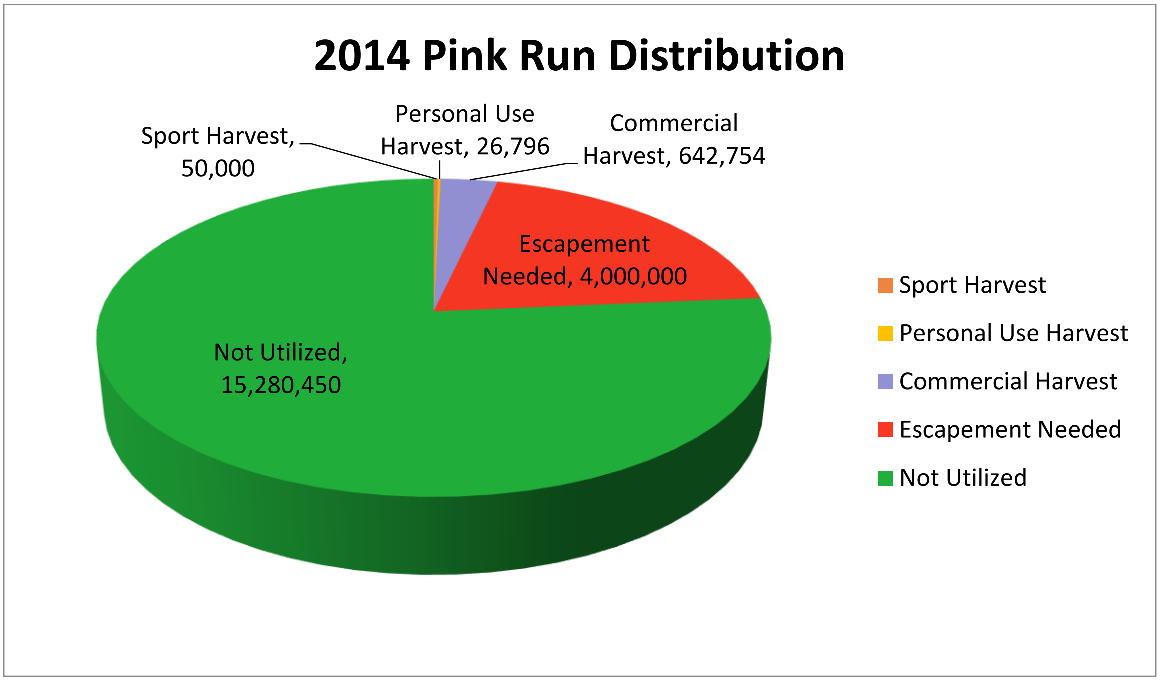
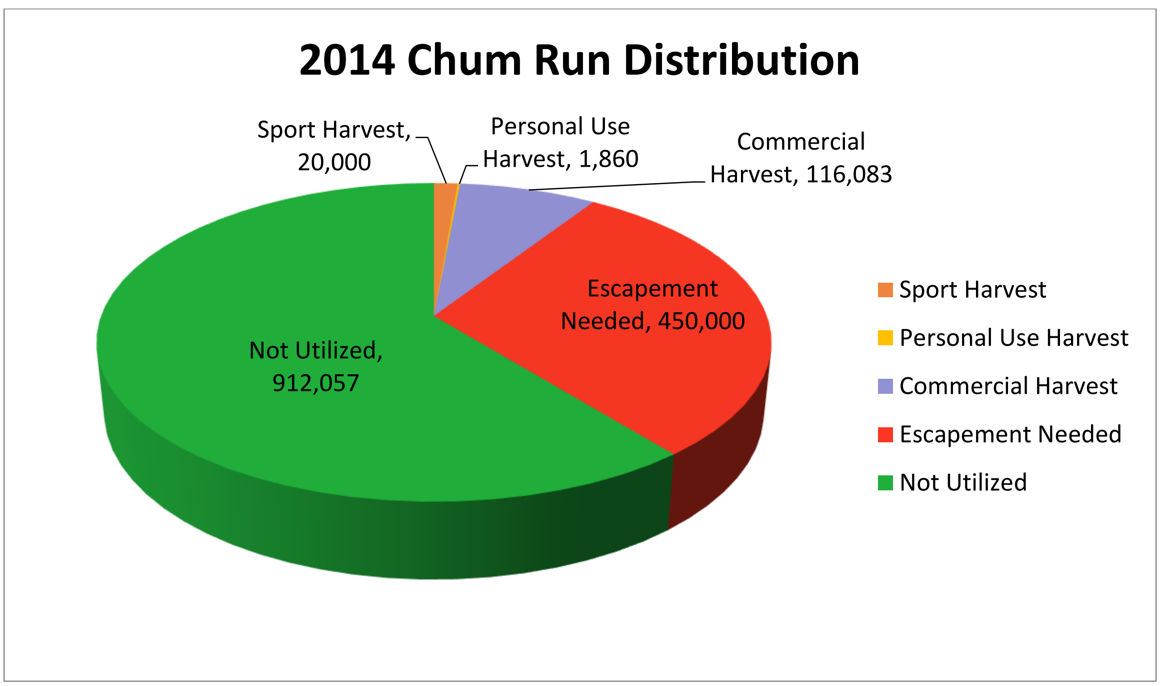


Figure 5. Distribution of the 1,500,000 Chum Run in Upper Cook Inlet, 2014



3. Model Development and Utility

Revenue modeling is the task of building a representation (model) of a real-world revenue situation. Models are designed to represent a simplified version of the revenue performance of a salmon asset or any other asset. Salmon resource revenue modeling allows for the quantification of selected revenue alternatives from which the public, ADF&G management, Legislators and the Governor can choose.

Revenue modeling is illustrated here by a series of examples demonstrating different tax, or fee applications for both the seller (State) and the purchasers (harvesters) and how the anticipated revenues will change.

Revenue models provide all parties the same view of the events, while at the same time fixing a variety of variables to constant values. By purposefully fixing some values and changing a limited number of values, the model isolates the cause and effect, changing revenue values and outcomes for both the State and harvesters.

Revenue models are built around changing inputs and then identifying the resulting output; in this case, annual revenues to the State. The financial models that follow will first represent the existing, real-world State revenues and available unrealized revenue; then the effects of changing a tax rate, license price or permit fee.

Constructing new revenue models also provides an opportunity for an examination of historic asset performance. Have revenues and economic benefits to the regional and State economies been considered in past management decisions? Are the State's fishery resources being managed for the maximum sustained yield as required by the State constitution?

References provided for Tables 2, 3 and 4

- $35,000,000 describes the First Transaction Commercial Value (Ex-Vessel Value) for all five salmon species **harvested** in UCI (2014 ADF&G Annual Management Report), First Transaction Commercial Value is what the fish buyer paid, in dollars, to the permitted CFEC salmon harvester
- $70,000,000 is the First Wholesale Commercial Value sold by the processors for all five salmon species harvested in UCI in 2014 (first dollar value for sales after primary processing: head & gutted, frozen, filleted, etc.)
- The First Transaction Commercial Value (Ex-Vessel Value) of the **unharvested** surplus salmon stocks is approximately $40,000,000, however, fully utilizing the entire surplus may not be practicable; therefore, $21,000,000 was used for calculation of the unharvested tax revenue
- Sport includes guided and non-guided anglers; all license revenues are stated using equivalents, resident sport fishing, combined fishing, hunting and trapping licenses used for Cook Inlet salmon
- Personal Use is limited to salmon harvests in UCI; does not include other finfish or shellfish
- CFEC – Commercial Fisheries Entry Commission, in UCI there are currently 1,319 commercial fishing permits: 573 Drift and 746 Set Net
- Alaska Statute 43.75.015 Fisheries Business Tax of 3.0% – Assessed on First Transaction Commercial Value (Ex-Vessel dollar value)
- Alaska Statute 43.76.365 Marketing Tax of 0.5% – Assessed on First Transaction Commercial Value (Ex-Vessel dollar value)
- Alaska Statute 43.76.011 Enhancement Tax of 2.0% – Assessed on First Transaction Commercial Value (Ex-Vessel dollar value)
- Alaska Statute 43.77.010 Fisheries Landing Tax of 0.5% – Assessed on First Wholesale Commercial Value
- All permits, licenses, registrations and fees are publically available information

Table 2 – Presents a break-out of tax, license and permit revenue generated by the commercial fishery at the current Fishery Business Tax rate of 3%, compared to the proposed increase to 4%.

Table 2. 2014 Upper Cook Inlet Commercial Salmon Fisheries Revenues				
	3%		4%	
Taxes, Permits, Licenses & Fees	**Commercial**	**Unharvested**[3]	**Commercial**	**Unharvested**[3]
Fisheries Business Tax[1]	1,050,000	630,000	1,400,000	840,000
0.5% Marketing Tax[1]	175,000	125,000	175,000	125,000
2.0% Enhancement Tax[1]	700,000	500,000	700,000	500,000
0.5% Fisheries Landing Tax[1]	350,000	250,000	350,000	250,000
Marine Fuel Tax	45,000		45,000	
CFEC Permits[2]	287,000		287,000	
CFEC Crew Member Licenses[2]	200,000		200,000	
Processor Licenses[2]	50,000		50,000	
CFEC Vessel Licenses[2]	50,000		50,000	
DMV Vessel Licenses[2, 4]	6,000		6,000	
DNR Permits[2]	141,000		141,000	
DOT Permits[2]	26,000		26,000	
Corporate Income Tax	1,000,000		1,000,000	
Personal Use Permits[2]				
Resident Sport Fish Licenses[2]				
Non-Resident Sport Fish Licenses				
Existing Revenue, 3%[5]	4,080,000			
Unharvested Revenues, 3%[5]		1,505,000		
Total Revenue, 3%[5]	5,585,000			
New Revenue, 3%[5]	**1,505,000**			
Existing Revenue, 4%[6]			4,430,000	
Unharvested Revenues, 4%[6]				1,715,000
Total Revenue, 4%[6]			6,145,000	
New Revenue, 4%[6]			**2,065,000**	
[1]Harvest (Volume-Based) Annual Revenues, Price progressivity and sensitivity				
[2]Harvest (Non-Volume Based) Permits, Licenses and Fees				
[3]Revenue Lost due to Unharvested Surplus Escapement in 2014 by tax designation				
[4]DMV (AK vessel license sales either by commercial, sport or personal use individuals				
[5]Calculated and summarized using a 3% Fisheries Business Tax				
[6]Calculated and summarized using a 4% Fisheries Business Tax				

A. Details:

- Unharvested revenues are available, but not realized, as shown in Table 2. These revenues are based on a portion of the surplus salmon that entered the rivers of UCI in excess of the escapement needs (see Table 1). The total First Transaction Value of the **unharvested** surplus salmon was approximately $40,000,000. Since full utilization of the surplus is unlikely, $21,000,000 was used for calculation of the unharvested tax revenues.
- In 2014, there was $1,505,000 of lost State tax revenue due to the surplus escapements.
- These unharvested surplus salmon are gone forever as is their tax revenue.
- The unharvested salmon stocks have both short term and long term effects on tax revenues.
- The actual existing revenues of $4,080,000 and the additional available revenues of $1,505,000 were added to determine a grand total of $5,585,000 of possible commercial revenue from UCI in 2014.

B. Discussion:

It is noted that the revenues from the commercial fishery are from 12 unique taxes, permits and licenses.

At present, there are few, if any, consequences for the $1,505,000 in foregone tax revenues or the $21,000,000 in lost harvest revenue. The BOF and ADF&G have no accountability for management plans and regulations that create these losses to the economy and the State Treasury. This needs to change, especially now that the State is struggling with reduced revenues and budgets.

Commercial salmon tax revenues are sensitive to both volume and price. To arrive at the tax revenues payable to the State, multiply the pounds per fish by the price per pound and then multiply by the applicable tax rate. Example: 100,000 lbs x $2.25/lb = $225,000 First Transaction Value. This value multiplied by the 0.03% tax rate equals a payable tax of $6,750. Another example: 100,000 lbs x $0.50/lb. = $50,000 First Transaction Value. This value multiplied by the 0.03% tax rate equals a payable tax of $1,500. This demonstrates that the greater the price per pound, the greater the tax revenue to the State.

In the 2014 UCI season, the First Transaction Value was $2.25 per pound. This value of $2.25/lb for sockeye salmon was 3.6 times greater than some other areas of the State. As such, the price per pound of UCI sockeye salmon provided the State with 3.6 times the tax revenues on a pound by pound comparison. A harvest of 4 million UCI sockeye is the equivalent of, in State revenue and to the regional economy, a 13 million sockeye harvest in other areas of the State.

Due to the larger size and exceptional quality of UCI salmon, they occupy a unique and preferred market status. The UCI commercially harvested salmon are handled utilizing bleeding techniques, icing and slush icing, refrigerated sea water and smaller brailer bags. The salmon are delivered promptly, processed quickly and shipped to fresh markets across the United States.

The multi-level quality control and best practices for the harvesting, processing and shipping of UCI salmon are known to produce food products that are high in quality and freshness. Salmon harvested in UCI have immediate access to sea, land and air transportation services. Currently, most of the salmon harvested in UCI commercial fisheries is shipped fresh to the lower 48 States.

The price progressivity and sensitivity in commercial salmon tax revenues should motivate the State to increase revenue by both maximizing the harvest of surplus salmon in UCI and working to maintain the highest product quality. As an example, in herring fisheries, the herring are sampled by ADF&G and the fishery doesn't occur until roe percentages are high enough to maximize the value of the harvest. Maximizing the market value, and tax revenue return, of UCI salmon requires attention to run timing and harvest area. Another example, the quality of the sockeye salmon harvested in the Kasilof River Special Harvest Area is so poor that processors greatly reduce the price per pound, or may refuse to purchase salmon from this area at all, so that the poor quality salmon doesn't affect the value and perception of the entire Cook Inlet harvest. Generally, salmon harvested further offshore are of higher quality and command a higher price in the marketplace. Maximizing the value of the State's resources should be a factor in fishery management policy.

An increase in the Fisheries Business Tax to 4% has a positive effect of $560,000 on the State Treasury from the Upper Cook Inlet commercial salmon fisheries. State-wide, this new tax rate would increase tax revenues by over 19 million dollars. There are several large-volume fisheries that will be affected. UCIDA does not make any endorsements or comments on behalf of any other fishery group. An increase in the Fisheries Business Tax should only be considered as a component of a comprehensive overhaul of fishery management policies, taxes and license fees.

Additionally, there needs to be a discussion and resolution of how the BOF and ADF&G will be held accountable for the losses in State revenues, economies and food security due to unharvested fishery resources.

Table 3 – Presents the current license fee revenue and the effects of increasing the resident sport fishing license fee from $24.00 to $29.00, increasing the non-resident sport fishing license fee from $50.00 to $60.00, and instituting a personal use permit fee of $30.00.

Table 3. 2014 Upper Cook Inlet Sport & Personal Use Salmon Fisheries Revenues				
Taxes, Permits, Licenses & Fees	**Sport/$24**	**PU/$0**	**Sport/$29**	**PU/$30**
4% Fisheries Business Tax				
0.5% Marketing Tax				
2.0% Enhancement Tax				
0.5% Fisheries Landing Tax				
Marine Fuel Tax				
CFEC Permits				
CFEC Crew Member Licenses				
Processor Licenses				
CFEC Vessel Licenses				
DMV Vessel Licenses	54,000		54,000	
DNR Permits				
DOT Permits				
Corporate Income Tax				
Personal Use Permits		0		900,000
Resident Sport Fish Licenses[1]	1,440,000		1,740,000	
Non-Resident Sport Fish Licenses[2]	3,000,000		3,600,000	
Total Existing Resident & Non-Resident Revenue	**4,494,000**			
Sport License, $29[1]			5,394,000	
Personal Use, $30[3]				900,000
Additional Resident Only Revenue[4]			**1,200,000**	
Additional Non-Resident Revenue			**600,000**	
Total Additional Resident & Non-Resident Revenue			**1,800,000**	
[1]Sport Fish License - Residents - $24 or $29, including hatchery surcharge				
[2]Non-Resident Sport Fish License - $50, or $60				
[3]Personal Use Permit - $0 or $30				
[4]Additional Sport License Revenue plus Personal Use Revenue				

A. Details:

- There will be $300,000 of new revenue as a result of the $29.00 resident sport fishing license fee.
- Currently, a personal use harvest permit is free when a resident sport fishing license is purchased.
- New revenue from purchasing a personal use permit would be $900,000.
- These new harvest fees and revenues were calculated as new revenues, dependent on purchasing a resident sport fishing license. In this model, it would still be required to purchase a resident sport fishing license prior to purchasing a $30.00 personal use harvest permit.
- If residents will be required to purchase both sport fishing and personal use harvest permits, they will be subject to both fees ($29.00 + $30.00 = $59.00).

B. Discussion:

The revenues to the State from the sport fishery rely on two types of license sales. There are no harvest-based or volume-based revenues to the State for either the sport or the personal use fisheries.

UCIDA opposes the current legislation, HB 137, adopted by the Alaska House of Representatives of a stand-alone sport fish license fee increase. The new rate simply does not raise enough revenue. An increase in the sport fish license fee should only be considered as a component of a comprehensive overhaul of fishery management policies, taxes and license fees. The proposed increase is not volume-based and makes no consideration for progressivity.

Sport and personal use harvests in UCI have increased dramatically while the State's license revenues have actually declined. Over the past 20 years, the number of resident sport fishing licenses sold annually has decreased by 20,000. During the same time period, the number of salmon taken by the sport and personal use fisheries in UCI has nearly tripled. With larger harvests and fewer licenses, the State revenues have decreased significantly from the 1996 revenue values.

In 1996, the UCI sport and personal use sockeye harvest was 368,367. In 2014, that number had grown to 904,064 sockeye salmon. That number is greater than the harvest of the commercial set netters and was 60% of the commercial drift gillnet harvest.

Most of this increase in the sport and personal use salmon harvest has been taken directly out of the commercial harvest with no financial compensation to the CFEC permitted users, aquaculture associations or State and municipal governments that receive shared tax revenues. The commercial industry loses the economic benefit of this salmon harvest and the State loses revenue. These losses have never been accounted or considered.

Keep in mind, the sport fish license allows as many daily bag and possession limits as the individual chooses to catch, as well as personal use harvests of salmon and shellfish. It is difficult to measure any economic benefit of these resources to the State when they are harvested in the sport or personal use fishery.

Table 4 – Summarizes the combined effects of the previously discussed changes to taxes, permit fees and harvests.

Table 4. Summary of Proposed Fee Increases, Including Unharvested Surplus

Taxes, Permits, Licenses & Fees	Commercial[1]	Sport[2]	Personal Use[3]
4% Fisheries Business Tax	2,240,000		
0.5% Marketing Tax	300,000		
2.0% Enhancement Tax	1,200,000		
0.5% Fisheries Landing Tax	600,000		
Marine Fuel Tax	45,000		
CFEC Permits	287,000		
CFEC Crew Member Licenses	200,000		
Processor Licenses	50,000		
CFEC Vessel Licenses	50,000		
DMV Vessel Licenses	6,000	54,000	
DNR Permits	141,000		
DOT Permits	26,000		
Corporate Income Tax	1,000,000		
Personal Use Permits			900,000
Resident Sport Fish Licenses		1,740,000	
Non-Resident Sport Fish Licenses		3,600,000	
Total Revenue	**6,145,000**	**5,394,000** [5]	**900,000**
Existing Revenue	4,080,000 [4]	4,494,000	0
Total New Revenue	**2,065,000**	**900,000**	**900,000**
Grand Total	**3,865,000**		

[1]Combined Commercial and Unharvested Revenue At 4% Tax Rate, See Table 2
[2]$29 Sport Fish License, See Table 3
[3]$30 Personal Use Harvest Fee, See Table 3
[4]Existing Revenue 3%, See Table 2
[5]Sport License, $29, See Table 3

4. Conclusion

This is an opportune time for the State to substantially increase revenues and expand local economies by getting the most from its fishery resources. A directive from the Governor's Administration to the BOF and ADF&G to apply a business model to fisheries management could begin a process that would have expanding benefits across the State.

The BOF is comparable to a Board of Directors that is responsible for the conservation of a resource and the development a multi-billion-dollar industry. The current system of creating management policies and regulations is entirely inadequate for businesses of this magnitude. Too often, decisions are made on the basis of a personal bias or prejudice, disregarding the best interest of the State or the fishery resources.

Policy and management decisions have direct economic consequences at many levels. Costs and benefits must be weighed; exploiting efficiencies and eliminating waste should be a priority. Economic benefits need to be evaluated in numerous contexts, from monetizing resources in general, to employment and supporting small businesses. Regulatory stability is essential for continued investment in the industry and development of value-added ventures.

Revenues must be reinvested for ADF&G to be adequately funded to maintain and sustain the fishery resources for maximum production and habitat protection. A more rational business model approach to fishery management could also reduce the unnecessary allocation conflicts in UCI that have wasted so much energy and salmon over the years.

Specific objectives for UCI management should include developing a cost-benefit analysis decision making model and setting harvest goals. Policy makers and managers need to better understand the consequences of the trade-offs inherent in managing this mixed stock fishery. Harvest and utilization goals for the next two to three years should be increased substantially to begin the process of monetizing this resource appropriately.

Reasonable harvest rates for utilizing the available surplus (after escapement needs) for UCI stocks would be:

- Chinook 50% of available stocks;
- Sockeye 95% of available stocks;
- Coho 70% of available stocks;
- Pinks 60% of available stocks;
- Chum 60% of available stocks.

We also propose that the administration appoint a small working group dedicated to establishing models and recommendations for these fisheries prior to the next UCI BOF meetings on UCI.

The positive news is that many fisheries in Alaska are underutilized and have the potential for boosting State revenues and supporting and retaining small fishing and support businesses. The challenge will be to make the changes required.

Salmon Escapement Goals: Models, Development and Applications

Fishery Models and Applications

Introduction

The purpose of this short paper is to discuss the conditions under which fishery-related models can be applied. Fishery models, if used appropriately, can be used to solve specific problems, but not all fishery management issues require a model. It is therefore necessary to have an idea and necessary application controls before any model can solve a fishery management question. Technical knowledge and appropriate application of fishery models are presented and discussed to give the reader a better understanding concerning the development and utility of models.

The development of escapement goals, as required by Federal law, must utilize the best available science to achieve Maximum Sustained Yield (MSY) or Optimum Yield (OY). These yields, or harvests, secure food supplies and food security for the nation, not just Alaska, while creating and benefiting the national economy. Alaska has a sustainable fishery policy that can be defined as food harvests, as well as social or economic wants, which are often defined as a parochial want.

Federal law mandates require stakeholder and public input opportunities throughout the entire Salmon Fishery Management Plan (SFMP) development process. However, the current State escapement goal process entirely precludes any stakeholder or public process.

Models

An ecosystem (fishery) model is an abstract, usually a mathematical representation of an ecological system (ranging in scale from an individual, population, community, or even an entire biome), which is studied to better understand the real system.

Using data gathered from the field, ecological relationships, such as the relation of spawners to rates of yield, or that between predator and prey populations—are derived, and these are mathematically combined to form fishery models. These model systems are then studied in order to make predictions about the dynamics of the real system. Often, the study of the inaccuracies in models (when compared to empirical observations) will lead to the generation of hypotheses about possible fishery relations that are not yet known or well understood.

Models enable researchers to simulate large-scale experiments that would be too costly or unethical to perform on a real ecosystem. They also enable the simulation of fishery management measures over very long periods of time (i.e. simulating a process that takes centuries in reality, can be done in a matter of minutes in a computer model).

Fishery management models are mathematical representations of ecosystems. Typically, they simplify complex food webs down to their major components or trophic levels and quantify these as either numbers of organisms or biomass. Sustainable Ecosystem (fishery) Management Modeling can assist in the implementation of sustainable developments. Systems analysis that describe how fishery resources can support the sustainable management of natural capital and resources is an increasingly used term for a guide for future development. Sustainability can be considered in terms of three aspects: environmental, economic and social domains.

Modelers Should be Conscious of the Following

1. Modelers and the models they create, or use, are observer-defined abstractions that may or may not reflect reality, but only in the framework of the observers viewpoint. Some models created can leave the arena of science and enter the realm of beliefs.
   Example #1: A belief that overescapement does not occur
   Example #2: Overharvesting and underharvesting beliefs
   Example #3: Every model has errors and estimates of realities

2. There is an optimal degree of model complexity as models become complex and difficult to manage. There is often an increased level of uncertainty. Model complexity increases as variables are added, therefore the level of predictable accuracy declines.

3. Fishery model(s) outputs comprise specific uncertainties. To overcome uncertainties, extensive information is required, collected or generated using Bayesian Methodologies in order to address a precise question or hypothesis.
   Example: Do Bayesian techniques add data that never existed in the real world?

4. Fishery-related models require a clear and precise specification of the focus of the outcomes of the effort. Models must have a clear purpose and outcome prior to constructing any fishery management-related models.

5. Fishery models need intellectually chosen criteria, data inputs and data outcomes with clear distinctions of important and unimportant components. What is relevant to the outcome and what is ‘white noise’ or irrelevant information.
   Example: The use of aerial surveys compared to weir counts.

6. Fishery models can be developed, if necessary or advisable, at individual, population, ecosystem, landscape or biome levels. What is the appropriate level at which any fishery model is to be developed?

7. Fishery management models can illustrate interactive and feedback processes. These are often referred to as density-dependent issues.

8. Fishery models can and may support the decision-making process. Models such as spawner-recruit relationships, number of spawners needed to achieve Maximum Sustained Yield (MSY) or Optimum Yield (OY).

There Are Major Limitations on What Fishery Models Can Do

1. Fishery modeling is not a new form or alchemy. You cannot put in data concerning cohos, pinks, chums along with your hopes and beliefs and expect that the computer model will do magic and produce Chinooks and sockeyes. Thus, the old saying 'garbage in - garbage out' principle holds, regardless of the strength in any belief system.
   Example: This often comes into fishery management discussions by one or more participants saying: 'More fish beget more fish' or 'I don't believe in underharvests, overescapement or surplus escapement.' It is not a matter of belief, but rather a scientific inquiry when constructing fishery management models.

2. Fishery management models cannot function in a vacuum without an appropriate, underlying theoretical framework or problem statement.
   Example: One does not build a fishery management model and then look for an application.

3. Fishery management models cannot function without an empirical database used for development and model testing. Models that rely heavily of Bayesian methodologies are always suspect.
   Example: Especially when Bayesian methodologies use randomly generated data to describe non-random consequences.

4. Fishery management models must be treated skeptically. When they are applied outside of the pre-established validation parameters, most models are developed to show potential future events. However, we can never fully know the current and future forcing functions (rate of climate changes, ocean acidification, ocean thermal refugia and optimal ranges) are having on any model variable (data set) until these have occurred.
   Example #1: In a retrospective look in the rear-view mirror, we often try to retrospectively adjust fishery management models to fit the present-day conditions.

5. Fishery management models rarely produce reliable prognoses that can be used with caution in discussion of future scenarios. Models should not be used for a specific

prognosis. Models are useful in organizing applied outcomes; however, we need to realize that a model's output may never be realized.
Example: No current model for the Kenai River Late-Run Sockeye Salmon predicted or foresaw that within the past 6-7 years, these fish would be, on average, one or more pounds less in weight at the same age. See Issues Paper by UCIDA. That is partly understandable because all current models do not include forcing function of climate change. In this case, the fishery management models are based on data sets that are incomplete or inaccurate.

Bibliography

Numerous articles, books and other documents were reviewed in the writing of this paper. These include:

Box, G. E. P. (1976), "Science and statistics" (PDF), Journal of the American Statistical Association, 71 (356): 791–799, doi:10.1080/01621459.1976.10480949.

Box, G. E. P. (1979), "Robustness in the strategy of scientific model building", in Launer, R. L.; Wilkinson, G. N. (eds.), Robustness in Statistics, Academic Press, pp. 201–236, doi:10.1016/B978-0-12-438150-6.50018-2, ISBN 9781483263366.

Box, G. E. P.; Draper, N. R. (1987), Empirical Model-Building and Response Surfaces, John Wiley & Sons.

Box, G. E. P.; Draper, N. R. (2007), Response Surfaces, Mixtures, and Ridge Analyses, John Wiley & Sons.

Box, G. E. P.; Luceño, A.; del Carmen Paniagua-Quiñones, M. (2009), Statistical Control By Monitoring and Adjustment, John Wiley & Sons.

McCullagh, P.; Nelder, J. A. (1983), Generalized Linear Models, Chapman & Hall, §1.1.4.

McCullagh, P.; Nelder, J. A. (1989), Generalized Linear Models (second ed.), Chapman & Hall, §1.1.4.

Cox, D. R. (1995), "Comment on "Model uncertainty, data mining and statistical inference"", Journal of the Royal Statistical Society, Series A, 158: 455–456.

Steele, J. M., "Models: Masterpieces and Lame Excuses".

Gelman, A. (12 June 2008), "Some thoughts on the saying, "All models are wrong, but some are useful"".

Fasham, M. J. R.; Ducklow, H. W.; McKelvie, S. M. (1990). "A nitrogen-based model of plankton dynamics in the oceanic mixed layer". Journal of Marine Research. 48 (3): 591–639. doi:10.1357/002224090784984678.

Hall, Charles A.S. & Day, John W. (1990). Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories. University Press of Colorado. pp. 7–8. ISBN 978-0-87081-216-3.

Dale, Virginia H. (2003). "Opportunities for Using Ecological Models for Resource Management". Ecological Modeling for Resource Management. pp. 3–19. doi:10.1007/0-387-21563-8_1. ISBN 978-0-387-95493-6.
Forbes, Valery E. (2009). "The Role of Ecological Modeling in Risk Assessments Seen From an Academic's Point of View". In Thorbek, Pernille (ed.). Ecological Models for Regulatory Risk Assessments of Pesticides: Developing a Strategy for the Future. CRC Press. p. 89. ISBN 978-1-4398-0511-4.
Millspaugh, Joshua J.; et al. (2008). "General Principles for Developing Landscape Models for Wildlife Conservation". Models for planning wildlife conservation in large landscapes. Academic Press. p. 1. ISBN 978-0-12-373631-4.
Jørgensen, Sven Erik (1996). Handbook of environmental and ecological modeling. CRC Press. pp. 403–404. ISBN 978-1-56670-202-7.
Grant, William Edward & Swannack, Todd M. (2008). Ecological modeling: a common-sense approach to theory and practice. John Wiley & Sons. p. 74. ISBN 978-1-4051-6168-8.
Odum, H.T. (1971). Environment, Power, and Society. Wiley-Interscience New York, N.Y.
Reuter, Hauke; et al. (2011). "How Valid Are Model Results? Assumptions, Validity Range and Documentation". In Jopp, Fred; et al. (eds.). Modeling Complex Ecological Dynamics. Springer. p. 325. ISBN 978-3-642-05028-2.
Arditi, Roger; Ginzburg, Lev R. (1989). "Coupling in predator-prey dynamics: Ratio-Dependence". Journal of Theoretical Biology. 139 (3): 311–326. doi:10.1016/S0022-5193(89)80211-5.
Arditi, R. and Ginzburg, L.R. (2012) How Species Interact: Altering the Standard View on Trophic Ecology Oxford University Press. ISBN 9780199913831.
Antmann, S. S.; Marsden, J. E.; Sirovich, L., eds. (2009). Mathematical Physiology (2nd ed.). New York, New York: Springer. ISBN 978-0-387-75846-6.
Barnes, D.J.; Chu, D. (2010), Introduction to Modelling for Biosciences, Springer Verlag
Palsson, Bernhard (2006). Systems biology* properties of reconstructed networks. Cambridge: Cambridge University Press. ISBN 978-0-521-85903-5.
Young-Seuk Park, Sovan Lek, in Developments in Environmental Modelling, 2015
Sven E. Jørgensen, Todd M. Swannack, in Encyclopedia of Ecology (Second Edition), 2019

Upper Cook Inlet Drift Gillnet Vessel Costs

This analysis is based on the operational costs to participate in the Upper Cook Inlet (UCI) Drift Gillnet Salmon Fishery. The direct fixed and consumable (fuel) costs are listed and described for three types of vessels: Twin Diesel, Single Gas and Single Diesel. A $100,000 vessel was used as the standard value as appropriate.

Table 1. Fixed Fishing Vessel Costs		
• Annual unless otherwise noted		
Item	Amount $	Notes
Insurance - Hull & Machinery	2,300 - 4,700	Depends on Insured Value
Insurance - Liabillity	1,700 - 2,000	$500,000 or $1,000,000 policy limits
Insurance - Crew	1,200 - 1,400	$600 - $700 per month per crew member
CFEC	420 - 420	Vessel & Permit Fees
Kenai Peninsula Borough	300 - 500	Personal Property Tax on Vessel
Nets & Repair	1,425 - 2,375	Web purchase - $300 each & $175 for hanging
Maintenance	1,400 - 3,000	Welding, Fiberglass, Hydraulics, Electrical,
		Batteries, Lights, Lube, Oil & Filters
Crew - Average 10% of Gross	1,000 - 20,000	Highly Variable
Harbor/Vessel Storage	0 - 3,500	
Propeller/Shaft/Cutlass	1,000 - 3,500	Due to silty and debris-laden waters
Groceries	1,500 - 2,000	
Seasonal Totals	$12,245 - $46,895	
400 Hours per Season	$26.86 - $103.48	
Notes: Not Included in Above Fixed Costs or Annual Payments		
1. Vessel or Permit Payment After Purchase: $7,500 - $15,000		
2. Vessel and Permit Payment After Purchase: $10,000 - $20,000		
3. Diesel Engine - Each $50,000 replacement - $3,000 - $5,000		
4. Electronic Upgrades, GPS, Sonar, Radar Systems, etc.: $500 - $1,000		
5. Pick-up Trucks and Trailers: $5,000 - $10,000		
6. Shop or Maintenance Facility Upkeep: $2,000 - $4,000		
Annual Costs NOT Included in Total Season Cost: ~ $28,000 - $55,000		

Table 1 lists and describes the fixed costs for a drift gillnet salmon vessel at a value of $100,000.

The fixed vessel value costs are quite variable.

These variable costs are a reflection of individual business plans and preferences. The fixed costs may be adjusted by, for example, a business decision to be self-insuring and fishing without any insurance. However, if there is any form of financing of the vessel or permit, then insurance is mandatory. Similarly, a fisherman may choose to hang their own nets, saving $875 (5 nets @ $175.00 each for labor) but with the cost of 5 to 6 days of time spent hanging nets.

Items not included in fixed costs include a variety of additional costs that are unique to individual fishing style and vessel age and condition. The vessel and/or permit purchases will apply to new entrants into the fishery. These costs also apply to a family member that is “taking over” from a parent or other family member that is “self-financing” the new fisherman. These often are a form of “self-financing – retirement” arrangements.

To replace a 350hp diesel engine, with transmission and installation, costs will often exceed $50,000 per engine. Not many fishermen that own their own businesses can actually afford to set aside cash reserves to finance engine replacements. Insurance, second mortgages, government loans and processors often provide the ready cash for these engine or transmission replacements. A well-maintained diesel should last 10,000 hours, a single gas engine about 4,000 hours before a rebuild or replacement. Popular brands include Caterpillar, Cummins, John Deere and Volvo diesels and GMC, Chevy and Mercury Cruiser gas engines.

Table 2. Fishing Vessel Costs present the combined fixed fuel costs and hourly costs for a 16 and 18-hour day.

Table 2 organizes and explains the hourly costs for a fisherman to participate in an 16-hour district wide opening and a 18-hour expanded corridor opening in the UCI Drift Fishery. Some individuals may be surprised to see the actual costs involved. For over 60 years, the UCI drift fishery had a positive economic benefit to the participating fishermen. The benefits are widely shared within the Kenai, Alaska and national economies. However, due to allocative and escapement goal decisions, this UCI fishery is now at an economic impasse. Fishermen have foregone vessel maintenance, insurance and often reducing or eliminating crewmembers in an attempt to remain economically viable. Young, often newly entered fishermen have gone to other areas or to other fisheries.

Every salmon, not just sockeye, are both an economic opportunity and food security for the nation. Most UCI salmon harvested go directly into the fresh fish markets across North America. Upper Cook Inlet salmon, halibut, cod and black cod landings occur in communities that have developed the fishing, processing, transportation and marketing workforces to move these high-quality food supplies to established markets in a timely fashion to maintain a desirable freshness for the end consumer. Because of these location and infrastructure developments, UCI can and does receive a premium price for our salmon and other seafood products.

Table 2. Fishing Vessel Costs						
2a. Hourly Vessel Costs - 400 Hours per Year - District Wide						
Item	Twin Diesel		Single Gas		Single Diesel	
Fuel Cost	$27.39	$27.39	$19.17	$19.17	$15.40	$15.40
Fixed Costs - Low	$30.61		$30.61		$30.61	
Fixed Costs - High		$117.23		$117.23		$117.23
Total Cost per Hour - Low	$58.00		$49.78		$46.01	
Total Cost per Hour - High		$144.62		$136.40		$132.63
2b. Daily Vessel Costs - 18 Hour District Wide Opening						
Item	Twin Diesel		Single Gas		Single Diesel	
Fuel Cost	$493.00	$493.00	$345.00	$345.00	$277.00	$277.00
Fixed Costs - Low	$551.00		$551.00		$551.00	
Fixed Costs - High		$2,110.00		$2,110.00		$2,110.00
Total Cost - Low	$1,044.00		$896.00		$828.00	
Total Cost - High		$2,603.00		$2,455.00		$2,387.00
2c. Daily Vessel Costs - 16 Hour Expanded Corridor Opening						
Item	Twin Diesel		Single Gas		Single Diesel	
Fuel Cost	$438.00	$438.00	$307.00	$307.00	$246.00	$246.00
Fixed Costs - Low	$490.00		$490.00		$490.00	
Fixed Costs - High		$1,876.00		$1,876.00		$1,876.00
Total Cost - Low	$928.00		$797.00		$736.00	
Total Cost - High		$2,314.00		$2,183.00		$2,122.00

Notes concerning Table 2a & 2b

Twin Diesel:

6 hrs from harbor to fishing grounds and back

6 hrs transiting @ 18 gal/hr = 108 gal

12 hrs fishing @ 4 gal/hr = 48 gal

Total gal per day = 156

156 gal @ $3.16/gal = $492.96 per 18 hr day

$492.96/18 hrs = $27.39 per hr

Single Gas:

Half the twin diesel gallons x 1.4

Higher gal/hr and higher cost/gal

Single Diesel:

Half the gal/hr of the Twin Diesel

Half the cost/hr of the Twin Diesel