The NOAA Pre-season 2015 Pink Salmon Forecast for Southeast Alaska

Based on data from the Southeast Alaska Coastal Monitoring (SECM) research project

Southeast Purse Seine Task Force Meeting, Petersburg, Alaska – 03 Dec. 2014 (rev. 17 Dec.)

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Researchers from the Auke Bay Laboratories (ABL) of the Alaska Fisheries Science Center (AFSC) have provided pre-season forecasting information to stakeholders of the pink salmon (*Oncorhynchus gorbuscha*) resource of Southeast Alaska (SEAK) since 2004. These forecasting metrics and models are derived from an ongoing time series of data collected by the Southeast Alaska Coastal Monitoring (SECM) project. Initiated in 1997, the SECM project samples stations in the vicinity of Icy Strait and the Gulf of Alaska (GOA). These surveys collect oceanographic data in May, June, July, and August annually, and juvenile salmon data with surface trawls (~20m width x 20m depth) in the latter three months.

In nine of the past eleven years, NOAA's pre-season pink salmon forecast estimates, based on the SECM data, have been within 20% of actual harvests, with an average deviation of only 9%. The two anomalous years, 2005/06 and 2012/13, were years of extremely low (12 M) and high (95 M) harvests. Nonetheless, most years these forecasts have enabled stakeholders to anticipate harvest with more certainty than previous forecasting methods have allowed. NOAA also shares SECM data with colleagues from the Alaska Department of Fish and Game (ADFG) who have incorporated these data to refine their pink salmon harvest forecast for SEAK developed by a different method. Researchers continue to explore new approaches to integrate the SECM data time series and other ecosystem indicators to improve forecast model accuracy and provide resource stakeholders with the best available pre-season information to help optimize economic efficiency and resource sustainability.

The table below shows the three forecast models developed for the 2015 pink salmon harvest. The final model chosen for the NOAA pre-season forecast is in bold text. The regression model prediction intervals for the forecasts are shown in parentheses.

SECM pre-season forecast models	Regression *P* value	Adj. R^2	AICc	Jack-knife error avg/med	Prediction for 2015
$CPUE_{cal}$ (2-parameter) *Step-wise regression*: $Peak_{JuneJuly}CPUE_{cal}$ + $ISTI_{20m\ temp}$	**< 0.001**	**74%**	**139.7**	**20/11**	**54.5 M (38-71 M)**
$CPUE_{ttd}$ (2-parameter) *Step-wise regression*: $Peak_{JuneJuly}CPUE_{ttd}$ + $May_{20mtemp}$	< 0.001	81%	134.4	27/29	71.5 M (57-86 M)
Ecosystem rank (6-parameter) *Bivariate correlation avg. ranks*: $CPUE_{cal}$, $CPUE_{ttd}$, seasonality, proportionality of $pinks_{JuneJulyAug}$, predation impact, and the NPI	< 0.001	73%	138.3	24/14	57.9 M (42-74 M)

Model selection criteria and discussion

Several factors went into choosing the final SECM forecast model for the 2015 SEAK pink salmon harvest. The $CPUE_{ttd}$ two parameter model fit the data series best, based on the R^2 and AIC_c metrics. However, when the three forecast models were evaluated for accuracy using a jackknife procedure, the $CPUE_{cal}$ model performed the best, with the lowest average and median deviations over the 1998-2014 time series. The Ecosystem Rank model was second best, and the $CPUE_{ttd}$ third. The $CPUE_{cal}$ and Ecosystem Rank models were similar in how well they fit the data, and gave similar forecasts substantially less than the $CPUE_{ttd}$ model. Also, ecosystem metrics such as the NPI and migration timing (seasonality) indicate more of an average run, suggesting the higher forecast is excessive. For these reasons, and because the $CPUE_{cal}$ is the parameter that has been the basis of SECM harvest predictions since 2004, the model with $CPUE_{cal}$ and Icy Strait temperature index (ISTI) was selected as the best model for the 2015 forecast. Most data used for these three models is provided on a matrix spread sheet table on the following page.

Other considerations for our salmon forecast model selection included: 1) the anomalously warm 2014 ocean conditions juvenile pink salmon experienced after Icy Strait, 2) the relative abundance of pink salmon in the GOA compared to Icy Strait, and 3) higher than normal predator scaring on juvenile pink salmon. This year a warm water mass in the North Pacific, which became known as the "warm blob", extended northward to Alaska in summer and was associated with the occurrence of ocean sunfish, pomfret, thresher sharks, and skipjack tuna. Furthermore, an ENSO warming event began to emerge this past year that may compound anomalously warm conditions throughout the central GOA. These warmer than normal conditions could impact salmon food resources or harbor warm-water predators moving northward. Another impact in 2014 was the relative low abundance of juvenile pink salmon in the GOA compared to Icy Strait. This comparison was based on offshore catches of juvenile pink salmon available from other GOA research using surface trawls in July of 2010-2014 from a subset of stations from Whale Bay to Icy Point 0-30 miles offshore. Peak juvenile pink salmon catches ($CPUE_{ttd}$) between Icy Strait and the GOA are significantly correlated over the past five year period. In the regression relationship between Icy Strait and GOA, the 2014 regression point residual was below the line (i.e., equivalent CPUE), thus suggesting a lower than average juvenile pink salmon abundance in the GOA compared to Icy Strait this past year. The final impact considered in 2014, was a higher than normal incidence of scared juvenile pink salmon with "bird strike marks" on their dorsal surfaces in Icy Strait. These "near miss" survivors represented 1.5% of the fish observed from a sample of over 1,600 fish from several trawl hauls. In concert, these examples further suggest the higher forecast from the $CPUE_{ttd}$ model may not be appropriate, and that a more precautionary forecast seems prudent.

Consistent with past SECM forecasts, a bootstrap procedure was applied to produce forecast confidence intervals for the selected forecast regression model to account for measurement error in the trawl sampling data. For the 2015 forecast of 54.5 million pink salmon, the 80% bootstrap confidence interval was 48-58 million.

If this applied research is helpful you as a pink salmon resource stakeholder, we encourage you to contact any of these NOAA research managers and let them know:

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	A	B	C		D	E	F	G	H	I	J	K	L		M
	Pink salmon parent brood year				**Chronological ecosystem variables**										**Pink salmon harvest**
	Brood year (BY)	SEAK pink harvest (M)	Pink regional proportionality (% Northern harvest: Green= 40-60%, Yellow= >20<40%, or >60<80%, Red = <20%>80%)	SEAK pink escapement index	**Ocean entry year (BY lagged 1 yr later)**	Auke Creek fry outmigration (1,000s) Lat 58°N	Upper 1-20 m avg. Icy Strait temp. "ISTI" May-Aug	Juvenile peak pink (CAL) CPUE June or July	Juvenile peak pink (TTD) CPUE June or July	Peak seaward migration month	Proportion of pink in trawl hauls in June-July-Aug	Adult coho predation impact Coho total #s/J-pink CPUE	North Pacific Index (June, July, Aug)	**Ranking of the avearge annual scores of the six significant variables**	**SEAK pink harvest (M) (BY lagged 2 yrs later)**	**SEAK pink harvest (M) (response variable)**
	Data source	*ADFG* $_1$	*ADFG*	*ADFG* $_2$		*NOAA* $_1$	*NOAA* $_2$	*NOAA* $_2$	*NOAA* $_2$	*NOAA* $_2$	*NOAA* $_2$	*NOAA* $_2$ *ADFG* $_3$	*CGD*	↓		*ADFG* $_1$
	1996	64.6	17%	18.1	**1997**	31.1	9.5	2.5	2.2	July	18%	1.5	15.6	11	**1998**	42.4
	1997	28.9	47%	14.8	**1998**	60.8	9.7	5.6	5.3	June	46%	0.8	18.1	1	**1999**	77.8
	1998	42.4	44%	14.3	**1999**	53.5	9.0	1.6	1.4	July	9%	3.9	15.8	16	**2000**	20.2
	1999	77.8	50%	27.3	**2000**	132.1	9.0	3.7	3.3	July	28%	1.0	16.9	4	**2001**	67.0
	2000	20.2	39%	10.8	**2001**	61.5	9.5	2.9	2.6	July	30%	2.0	16.8	8	**2002**	45.3
	2001	67.0	22%	18.6	**2002**	150.1	8.6	2.8	2.5	July	26%	2.5	15.6	10	**2003**	52.5
	2002	45.3	49%	16.6	**2003**	95.1	9.8	3.1	2.7	July	20%	1.8	16.1	9	**2004**	45.3
	2003	52.5	44%	20.0	**2004**	169.6	9.7	3.9	3.4	June	32%	1.4	15.1	5	**2005**	59.1
	2004	45.3	54%	15.7	**2005**	87.9	10.2	2.0	1.7	Aug	35%	3.3	15.5	15	**2006**	11.6
	2005	59.1	51%	19.9	**2006**	65.9	8.9	2.6	2.3	June	23%	1.9	17.0	7	**2007**	44.8
	2006	11.6	72%	10.2	**2007**	81.9	9.3	1.2	1.0	Aug	17%	3.7	15.7	18	**2008**	15.9
	2007	44.8	29%	17.6	**2008**	117.6	8.2	2.5	2.2	Aug	24%	2.1	16.1	12	**2009**	38.0
	2008	15.9	14%	9.5	**2009**	34.8	9.5	2.1	2.7	Aug	26%	1.7	15.1	13	**2010**	24.0
	2009	38.0	31%	12.7	**2010**	121.6	9.6	3.7	5.0	June	60%	0.9	17.6	2	**2011**	58.9
	2010	24.0	43%	11.2	**2011**	30.9	8.9	1.3	1.6	Aug	27%	4.1	15.7	17	**2012**	21.3
	2011	58.9	81%	14.3	**2012**	61.8	8.7	3.2	4.3	July	49%	1.1	16.7	3	**2013**	94.7
	2012	21.3	13%	11.0	**2013**	51.2	9.2	1.9	2.6	July	13%	2.8	16.0	14	**2014**	37.2
	2013	94.7	44%	25.2	**2014**	47.4	9.4	3.4	4.6	July	57%	2.1	15.8	6	**2015**	**??.?**
	Harvest correlations	0.46	0.24	0.39		0.29	-0.20	**0.81**	**0.84**	**-0.65**	**0.61**	**-0.81**	**0.61**	Pearson correlation "*r*"		
	Probability value=	0.06	0.36	0.13		0.28	0.46	**0.00***	**0.00***	**0.01***	**0.01***	**0.00***	**0.01***	(*=significant@p<0.05)		

Data sources: ADFG (S. Heinl$_1$, A. Piston$_2$, and L. Shaul$_3$), CGD = Climate & Global Dynamics (J. Hurrell, http://www.cgd.ucar.edu/cas/jhurrell/indices.data.html), & NOAA Auke Bay Laboratories (J. Joyce$_1$ - Auke Creek research station & E. Fergusson/J. Orsi/E. Yasumiishi$_2$ - Southeast Coastal Monitoring project)

See a further explaination of each of the column metrics (A through M) on the reverse side

Column	Explanation of each ecosystem metric column and the respective color-coded annual matrix data (typically in each column, the highest six cell scores are in green, the middle six cell scores are in yellow, & the lowest six cell scores are in red)
A	Total Southeast harvest (minus Yakatat) of the parent brood year of pink salmon related to the upcoming harvest *Data source: Alaska Department of Fish and Game*
B	Proportion of harvest of the parent brood year of pink salmon related to the upcoming harvest that occurred in the northern region of Southeast (Green = 40 to 60%; Yellow = between 20 and 40%, or between 60 and 80%; Red = less than 20% or greater than 80% *Data source: Alaska Department of Fish and Game*
C	Pink salmon ecapement index of the parent brood year of pink salmon related to the upcoming harvest *Data source: Alaska Department of Fish and Game*
D	Pink salmon fry production from Auke Creek near Juneau. The only wild pink salmon stream monitored in Southeast Alaska with a recent time series of fry outmigration counts related to the upcoming harvest *Data source: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Auke Creek research station*
E	The upper 20 m water temperature index from Icy Strait (ISTI) representing 1-m temperature readings from eight stations to a 20 m depth averaged over the months of May, June, July, and August: 640 measurements each year *Data source: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project*
F	Peak June or July average catch of juvenile pink salmon per trawl calibrated among most vessels (CPUEcal) *Data source: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project*
G	Peak June or July average catch of juvenile pink salmon per trawl track distance ($CPUE_{ttd}$) *Data source: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project*
H	Peak seaward migration month of juvenile pink salmon: early departures more conducive to stronger subsequent adult returns and vice versa *Data source: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project*
I	Proportion of juvenile pink salmon in the catches over the entire season in relation to the other species of salmon. A higher percentage of pink salmon in the catch indicates a strong relative abundance compared to other salmon species and a high frequency of occurrence *Data source: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project*
J	Adult coho salmon predator impact is the total abundance of adult cohos (wild and hatcher commercial catch, M) divided by the peak abundance of juvenile pink salmon in June or July ($CPUE_{ttd}$). A high ratio of retuning adults to outmigrating juvenile pink salmon is undesirable and vice versa *Data sources: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project, and Alaska Department of Fish and Game*
K	North Pacific Index average value June, July, and August. The North Pacific Index (NP index or NPI) is the area-weighted sea level pressure over the region 30°N-65°N, 160°E-140°W. The NP index is defined to measure interannual to decadal variations in the atmospheric circulation. The NPI is inversely related to the Aleutian Low and may influence coastal downwelling in the Gulf of Alaska and the width of the Alaska Coastal Current *Data source: NCAR, https://climatedataguide.ucar.edu/climate-data/north-pacific-np-index-trenberth-and-hurrell-monthly-and-winter*
L	Annual ranking of the six ecosystem metrics significantly correlated with harvest. The ranking shows the best (1) to the worst (18) years over the time series, with 2014 being the 6th best ocean year based on these metrics. The Ecorank model uses the actual 2014 rank score (6.7) and estimates harvest by entering this score in the regression relationship between average ecosystem rank score (1997-2013) and harvest (1998-2014) *Data source: NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project*
M	The production response variable of Southeast Alaska pink salmon harvest (minus Yakatat) *Data source: Alaska Department of Fish and Game*