The NOAA Pre-season 2016 Pink Salmon Forecast for Southeast Alaska

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

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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 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 Coastal Monitoring (SECM) project. Initiated in 1997, the SECM project samples stations in the vicinity of Icy Strait and the Gulf of Alaska. These surveys collect oceanographic data in May, June, July, and August annually, and juvenile salmon with surface trawls (~20 x 20m width x depth) in the latter three months.

In nine of the past twelve years (75% of the time), NOAA's pre-season pink salmon harvest forecast estimates--based on the SECM data--have been within 20% of actual harvests. The three return years that departed from this accuracy, 2006, 2013, and 2015, represented years of anomalously low (16 M), high (95 M), and moderate (34 M) harvest. Nonetheless, most years these forecasts have enabled stakeholders to anticipate harvest with more certainty than previous forecasting methods have allowed. NOAA also shares SECM juvenile pink salmon catch data with Alaska Department of Fish and Game (ADFG) colleagues who have incorporated this data to help refine their pink salmon harvest forecast for SEAK based on an exponential smoothing method based on brood year strength. Researchers continue to explore new approaches to integrate the SECM data time series and other ecosystem indicators to improve forecast model accuracy and provide the resource stakeholders with the best available pre-season data to help optimize economic efficiency and promote resource sustainability.

The table below shows the four best forecast models considered for the 2016 SEAK pink salmon harvest. The final model chosen for the NOAA pre-season forecast is in bold text.

SECM pre-season forecast models	Adj. R^2	AICc	Regression *P* value	Prediction for 2015
$CPUE_{cal}$ (1-parameter) *Step-wise regression*:	59%	153.2	< 0.001	34.6
$CPUE_{cal}$(2-parameter) *Step-wise regression*: $Peak_{JuneJuly}CPUE_{cal}$ + $ISTI_{20m\ temp}$	70%	149.4	< 0.001	24.2 M
Ecosystem rank (6-parameter) *Bivariate correlation avg. ranks*: $CPUE_{cal}$, $CPUE_{ttd}$, seasonality, proportionality of $pinks_{JuneJulyAug}$, predation impact, and the NPI	68%	148.8	< 0.001	37.1 M
Ecosystem rank ***Step-wise regression*:** **Average rank + May_{temp}**	**78%**	**143.8**	**< 0.001**	**30.4 M (16-45)**

Model selection criteria and discussion

Several factors went into the decision making process for the final NOAA pink salmon forecast model for the 2016 SEAK harvest. The first was an evaluation of the four best SECM forecast models for accuracy, namely choosing the model with the highest adjusted R^2 (best fit with the data) and the lowest AICc (over parameterization value). The best model selected based on these criteria was the Ecosystem rank model that incorporated 6 variables to estimate an average rank score which was paired with a May_{temp} variable to explain residual error in the regression relationship. Since we cannot bootstrap confidence intervals for this "blended" variable assemblage, we are relying on the regression prediction confidence intervals of 16 to 45 M in this 30 M pink salmon forecast prediction. We will of course continue to track the performance of both types of models during the ensuing year.

Another factor considered when assessing the best model for pink salmon harvest was how to anticipate the state of later ocean conditions influencing juveniles in the Gulf of Alaska (GOA). For example, currently we are in the midst of the onset of El Niño conditions and the infamous "warm blob" has been present in the North Pacific Ocean for over a year. These conditions may have contributed to lower than anticipated pink salmon harvests in southern SEAK in 2015 resulting from warmer than normal conditions impacting salmon food resources or harboring more southerly complex of salmon predators or competitors. For example, record harvest/escapements occurred regionally in SEAK in 2013 (brood year of the 2015 harvest), yet southern SEAK pink returns failed in 2015, in stark contrast to above average returns in northern SEAK and record returns further north in PWS and westward. This suggests ocean conditions in the southern GOA were unfavorable in 2015 and possibly may continue into 2016.

To assess potential impacts on of juvenile pink salmon entering the ocean south of Icy Strait, we examined a "GOA grid" of sampling stations from another series of trawl surveys conducted July, 2010-2015. This GOA grid encompasses a 3-30 mile offshore section of trawl stations from Whale Bay to Icy Point within a larger region of sampling further offshore. Over these six years, we compared juvenile pink salmon CPUE between Icy Strait and the GOA grid and found peak Icy Strait CPUE marginally ($P<0.10$) correlated to GOA grid CPUE. Also, paired annual data points did cluster on opposing ends of the linear relationship into odd and even ocean years, and corresponded to differences in even (lower) and odd (higher) years of SEAK harvests the ensuing year. The paired data point for 2015, representing Icy Strait and GOA grid CPUE, was very close to the regression line with only a negligible residual compared to the other five years. This suggests pink catches in 2015 were relatively similar in Icy Strait and the GOA grid and later ocean conditions appeared to not impact GOA CPUE and therefore did not warrant the use of a more conservative pink salmon forecast model (i.e., [$CPUE_{cal}$(2-parameter)] = 24 M).

The NOAA presentation information from the 2015 Southeast Alaska Purse Seine Task Force meeting will be made available some on SECM pink salmon forecasting and the SECM project websites: http://www.afsc.noaa.gov/ABL/EMA/EMA_PSF.htm and http://www.afsc.noaa.gov/ABL/EMA/EMA_SECM.htm

If this research is of value to you, feel free to contact any of these NOAA/AFSC managers:

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	A	B	C		D	E	F	G	H	I	J	K	L	M		N
Pink salmon parent brood year				**Chronological ecosystem variables**											**Pink salmon**	
Brood year (BY)	SEAK pink salmon harvest (M)	Pink regional proportionality (% Northern harvest: Green= 40-60%, Yellow= >20<40% or >60<80%; and Red = <20% or >80%)	Pink salmon escapement index for SEAK	**Ocean entry year (BY lagged 1 yr later)**	Auke Creek fry outmigration (1,000s) Latitude 58°N, near Juneau	Upper 1-20 m avg. Icy Strait temperature "ISTI" May, June, July and August	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)	***Average rank score of the six variables***	Ranking of the average rank scores	SEAK pink salmon harvest year (BY lagged 2 yrs. later)	SEAK pink salmon harvest (M) (response variable)
Data source	***ADFG₁***	***ADFG***	***ADFG₂***		***NOAA₁***	***NOAA₂***	***NOAA₂***	***NOAA₂***	***NOAA₂***	***NOAA₂***	***NOAA₂ ADFG₃***	***CGD***	↓	↓		***ADFG₁***
1996	64.6	17%	18.1	1997	31.1	9.5	2.5	2.2	July	17%	1.5	15.6	*12.0*	12	1998	42.4
1997	28.9	47%	14.8	1998	60.8	9.7	5.6	5.3	June	42%	0.8	18.1	*1.8*	1	1999	77.8
1998	42.4	44%	14.3	1999	53.5	9.0	1.6	1.4	July	10%	3.9	15.8	*15.3*	17	2000	20.2
1999	77.8	50%	27.3	2000	132.1	9.0	3.7	3.3	July	25%	1.0	16.9	*6.3*	4	2001	67.0
2000	20.2	39%	10.8	2001	61.5	9.5	2.9	2.6	July	28%	2.0	16.8	*8.3*	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	*11.7*	11	2003	52.5
2002	45.3	49%	16.6	2003	95.1	9.8	3.1	2.7	July	22%	1.8	16.1	*9.0*	9	2004	45.3
2003	52.5	44%	20.0	2004	169.6	9.7	3.9	3.4	June	31%	1.4	15.1	*6.3*	5	2005	59.1
2004	45.3	54%	15.7	2005	87.9	10.2	2.0	1.7	Aug	26%	3.3	15.5	*15.0*	16	2006	11.6
2005	59.1	51%	19.9	2006	65.9	8.9	2.6	2.3	June	26%	1.9	17.0	*7.8*	7	2007	44.8
2006	11.6	72%	10.2	2007	81.9	9.3	1.2	1.0	Aug	15%	3.7	15.7	*17.2*	19	2008	15.9
2007	44.8	29%	17.6	2008	117.6	8.2	2.5	2.2	Aug	29%	2.1	16.1	*11.2*	10	2009	38.0
2008	15.9	14%	9.5	2009	34.8	9.5	2.1	2.7	Aug	27%	1.7	15.1	*12.2*	14	2010	24.0
2009	38.0	31%	12.7	2010	121.6	9.6	3.7	5.0	June	61%	0.9	17.6	*2.3*	2	2011	58.9
2010	24.0	43%	11.2	2011	30.9	8.9	1.3	1.6	Aug	25%	4.1	15.7	*16.2*	18	2012	21.3
2011	58.9	81%	14.3	2012	61.8	8.7	3.2	4.3	July	48%	1.1	16.7	*5.5*	3	2013	94.7
2012	21.3	13%	11.0	2013	51.2	9.2	1.9	2.6	July	13%	2.9	16.0	*13.0*	15	2014	37.2
2013	94.7	44%	25.2	2014	47.4	9.4	3.4	4.6	July	53%	2.0	15.8	*6.8*	6	2015	34.4
2014	37.2	11%	13.8	2015	14.2	9.9	2.2	1.8	June	19%	2.6	15.7	*12.0*	13	2016	?
Harvest correlations	0.33	0.23	0.29		0.31	-0.17	**0.78**	**0.75**	**-0.67**	**0.54**	**-0.80**	**0.61**	Pearson correlation "*r*"			
Probability value=	0.18	0.36	0.24		0.21	0.49	**0.00***	**0.00***	**0.00***	**0.02***	**0.00***	**0.01***	(* = significant @ $p<0.05$)			

Data sources: ADFG (S. Heinl₁, A. Piston₂, and L. Shaul₃), CGD = Climate & Global Dynamics (J. Hurrell, http://www.cgd.ucar.edu/cas/jhurrell/indices.data.html), & NOAA Auke Bay Laboratories (J. Joyce₁ - Auke Creek research station & E. Fergusson/J. Orsi₂ - Southeast Coastal Monitoring project)

See a further explanation of each of the column metrics (A through N) on the reverse side

Column	Generally for each ecosystem metric column, highest 1/3 of scores are green, middle 1/3 scores are yellow, & lowest 1/3 scores are red
A	Total Southeast harvest (minus Yakutat) 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 escapement 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 serie 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 average 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 coho (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: Alaska Department of Fish and Game and NOAA, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute, Southeast Alaska Coastal Monitoring project*
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 down welling 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	Average rank score of six significant variables in columns "F" to "K"
M	Ranking of the average rank scores in cell "L"
N	The production response variable of Southeast Alaska pink salmon harvest (minus Yakutat) *Data source: Alaska Department of Fish and Game*