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Advisory Announcement

For Immediate Release: **November 18, 2020**

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2021 NOAA FISHERIES–ALASKA DEPARTMENT OF FISH AND GAME SOUTHEAST ALASKA PINK SALMON HARVEST FORECAST

The Southeast Alaska (SEAK) pink salmon harvest in 2021 is predicted to be in the *average* range with a point estimate of **28 million fish (80% prediction interval: 19–42 million fish).** The categorical ranges of pink salmon harvest in SEAK were formulated from the 20th, 40th, 60th, and 80th percentiles of historical harvest over the 60-year period 1960–2019:

Category	Range (millions)	Percentile
Poor	Less than 11	Less than 20th
Weak	11 to 19	20th to 40th
Average	19 to 33	40th to 60th
Strong	33 to 49	60th to 80th
Excellent	Greater than 49	Greater than 80th

Forecast Methods:

The NOAA Alaska Fisheries Science Center, Auke Bay Laboratories (NOAA) initiated the Southeast Alaska Coastal Monitoring (SECM) project in 1997 to better understand the effects of climate and nearshore ocean conditions on year class strength of salmon and ecologically related species (Orsi et al. 1997). Since 2018, the SECM project has been conducted cooperatively by NOAA and the Alaska Department of Fish and Game (ADF&G), and the two agencies have combined efforts to produce a joint pink salmon harvest forecast using SECM data (Piston et al. 2019). The ADF&G research vessel *Medeia* is now used to conduct the SECM surveys and biologists from NOAA, ADF&G, and the regional aquaculture associations provided direct assistance to the sampling effort during the June and July surveys. We plan to continue working towards increased coordination between agencies and will continue to look for ways to focus and expand the SECM survey to provide a wide variety of valuable information to the fishing industry.

The 2021 SEAK pink salmon harvest forecast (Figures 1 and 2) was primarily based on juvenile pink salmon abundance indices collected by the SECM project in northern SEAK inside waters. These data were obtained from systematic surveys conducted annually in June and July in upper Chatham and Icy straits and are highly correlated with the harvest of adult pink salmon in the following year (Wertheimer et al. 2011). The 2020 juvenile pink salmon abundance index (monthly peak juvenile CPUE; standardized catch based on 20-minute trawl sets) of 2.15 was below the average of 2.63 in the 24 years of SECM surveys.

Forecasts were developed using an approach described by Murphy et al. (2019). A multiple regression model was developed using the juvenile pink salmon abundance index and temperature. The model used is:

$$E(y) = \alpha + \beta_1 X_{1+} \beta_2 X_{2+} \varepsilon$$

where *E(y)* is the expected value for *y*, the natural log of Southeast Alaska pink salmon harvest, β_1 is the coefficient for the natural log of CPUE +1, β_2 is the coefficient for water temperature (e.g., May–July water temperature index in the upper

20 m in Icy Strait), and ε represents the normally distributed error term. Leave-one-out cross validation (hindcast), Akaike Information Criterion for small sample sizes (Burnham and Anderson 2004), and the model performance metric mean absolute scaled error (MASE; Hyndman and Kohler 2006) were then used to examine alternative models. The 80% prediction interval around the forecast was calculated using the *car* package (Fox and Weisberg 2019) in program R version 3.6.3 (R Core Team 2020).

Forecast Discussion:

The 2021 harvest forecast of 28 million pink salmon is just below the recent 10-year average harvest of 34 million pink salmon. A forecast of 28 million pink salmon is an improvement over the previous odd-year harvest in 2019 (21 million) and is just over half of the average odd-year harvest since 2001. The 2020 peak June–July juvenile pink salmon index value (2.15) ranked 16th out of the 24 years that SECM information has been collected. Pink salmon harvests associated with juvenile indices between a value of 2.0 and 2.5 have ranged from 12 to 42 million fish (mean=29 million fish).

The juvenile abundance index in 2020 was higher than in the past three years and may reflect improved freshwater and early marine survival in Southeast Alaska. Pink salmon catches were well distributed throughout the Upper Chatham and Icy Strait stations in 2020, which resulted in a higher average log-transformed abundance index in 2020 than 2019, although the total catches were similar between these two years. Juvenile pink salmon caught in the 2020 SECM survey trawls were near the average size (in length) for the 24-year time series (Figure 3) and further growth and survival will be dependent on favorable resources being available over winter in the Gulf of Alaska. Unlike many recent years, the juvenile pink salmon heading to sea in 2020 did not experience the anomalously warm sea surface temperatures that persisted throughout the Gulf of Alaska from fall 2013 through much of 2016 (Bond et al. 2015; Di Lorenzo and Mantua 2016; Walsh et al. 2018) and in 2018 and 2019[1]. Sea surface temperatures were still modestly above average in the summer and fall of 2020 through much of the Gulf of Alaska, but the summer water temperature index in the upper 20 m in Icy Strait was slightly below average indicating more moderate marine temperatures for juvenile salmon heading to sea in 2020.

Point estimates of our forecasts have been above the actual harvest in five of six years since 2015 (Figure 2), and there is some concern that the actual harvest may be below our forecast estimate for 2021. The reason for the tendency to over forecast in recent years is unknown but may be related to increased offshore mortality in the Gulf of Alaska, error introduced in vessel calibrations and calculation of the juvenile abundance index, and/or error in how temperature is incorporated in the forecast model. Pink salmon escapements in the parent year (2019) were poor throughout northern Southeast Alaska inside waters and the escapement goal was not met in that subregion. The poor run in 2019 was a dramatic departure from what have generally been strong odd-year runs. Pink salmon escapement goals for the Southern Southeast and Northern Southeast Outside subregions were met in 2019, and most of the region's harvest occurred in the southern half of the region. It will be challenging to reach a regionwide harvest of 28 million fish in 2021 without a strong rebound in northern inside waters. As noted above, the total catch of juvenile pink salmon in the 2020 trawl surveys was similar to the total catch in 2019, which produced a very low forecast and harvest in 2020. The distribution of juvenile salmon in the trawl catches has a large impact on the average log-transformed juvenile abundance index. Conceptually, consistent catches of juvenile pink salmon in most trawls conducted over a wide geographic area (as occurred in 2020) would reasonably relate to higher overall juvenile abundance compared to a survey in which one or two trawls accounted for most of the catch and many trawls captured few or no fish (as occurred in 2019); however, the low raw juvenile pink salmon catches in 2020 are still concerning.

Temperature has been included in most historical NOAA pink salmon forecast models and several different measures of temperature have been used since 2004 (Wertheimer et al. 2013). Temperature is a significant negative covariate in our forecast model and the negative linear relationship between temperature and harvest, as well as the positive effect of temperature on pink salmon growth, suggests that temperature may impact forecasts through effects on juvenile distribution and migration (Murphy et al. 2019). Recently, we began exploring the potential use of satellite temperature data (available from the NOAA National Environmental Satellite data and Information Service[2]) in our forecast models and preliminary results have been encouraging. Satellite data allows for averaging of temperature readings of an almost infinite variety of temporal and geographic units. An initial model run incorporating satellite sea surface temperature data at the location of the upper Chatham Strait SECM trawl stations produced a lower forecast range for the 2021 pink salmon harvest than we

[1] https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v5.
[2] https://www.nesdis.noaa.gov/

presented here. We plan to examine alternative approaches for incorporating temperature data and alternative power transformations of the catch data in greater detail prior to the 2022 forecast. Despite the uncertainties that surround every salmon forecast, the track record of our pink salmon harvest forecasts has been good (Figure 2), especially considering the difficulties unique to forecasting pink salmon (Haeseker et al. 2005).

The department will manage the 2021 commercial purse seine fisheries inseason based on the strength of salmon runs. Aerial escapement surveys and fishery performance data will continue, as always, to be essential in making inseason management decisions.

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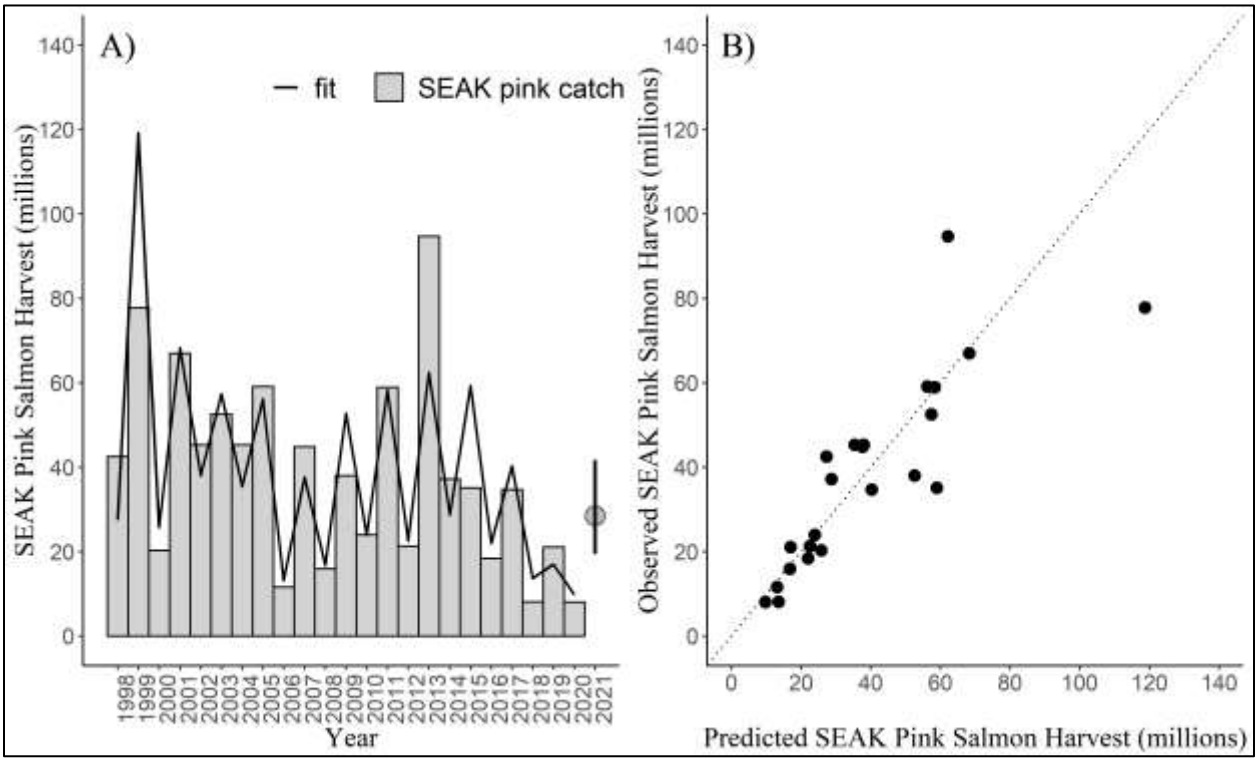

Figure 1. Forecast model fit (hindcasts) for total Southeast Alaska (SEAK) pink salmon harvest, 1998–2020 by year (A) and by the fitted values (B). The 2021 forecast is shown as a grey circle in panel A with the 80% prediction interval as a black vertical line. The observed SEAK pink salmon harvest is represented by the grey bars and the model fit is shown by the black line in panel A. The dotted line in panel B represents a one-to-one line; circles above the line represent hindcasts that would have been less than the actual harvest and circles below the line represent hindcasts that would have been more than the actual harvest.

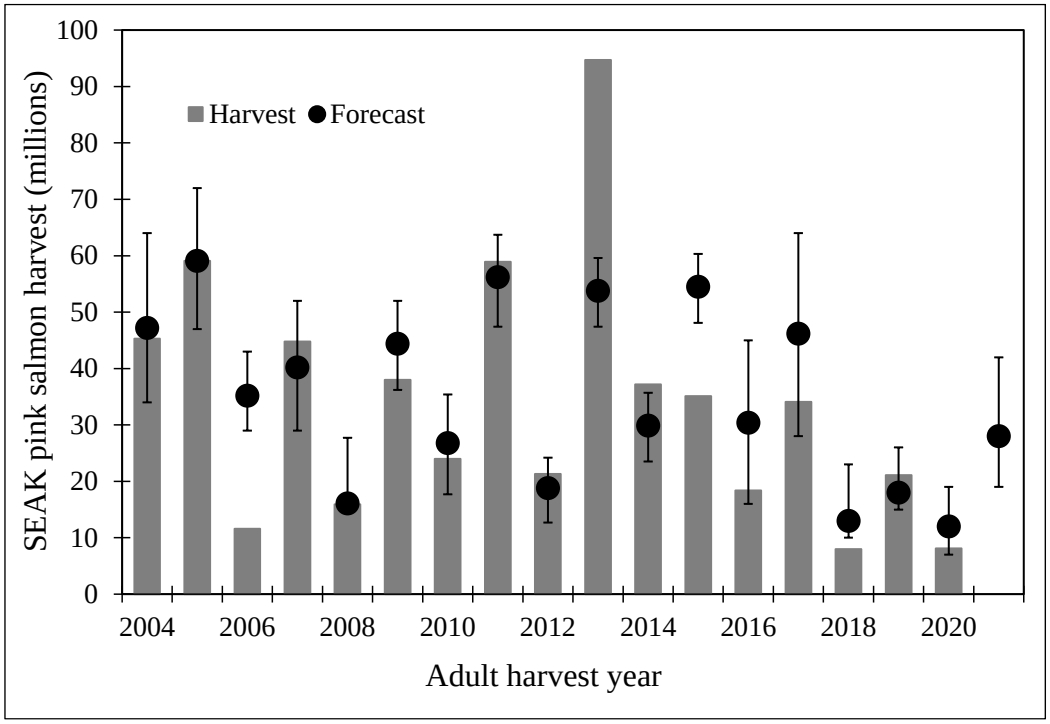

Figure 2. Annual harvests of pink salmon in SEAK compared to the actual preseason harvest forecasts, 2004–2021. The error bars represent the 80% confidence or prediction intervals of the forecasts.

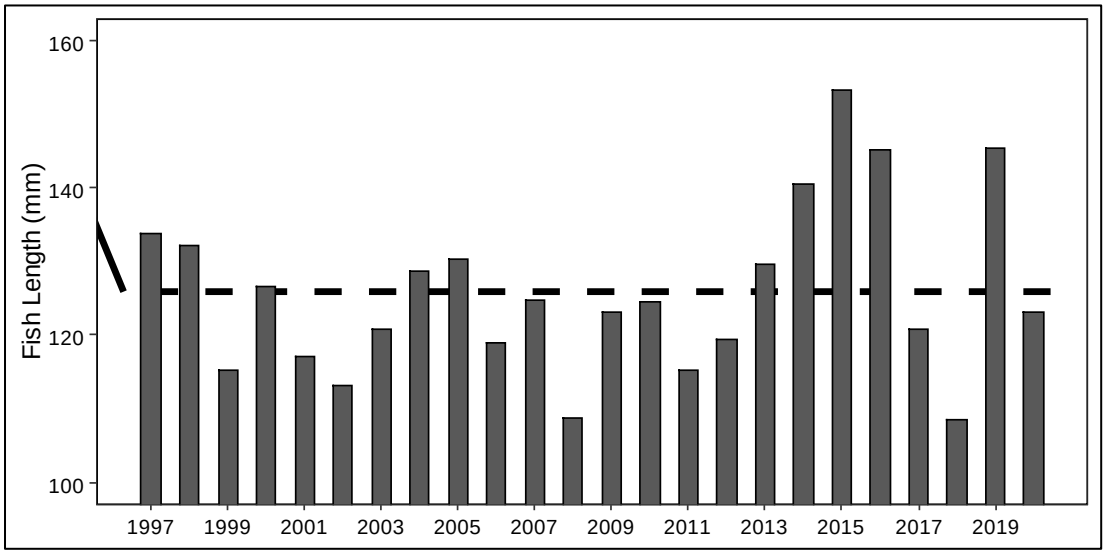

Figure 3. Average snout-to-fork length of juvenile pink salmon (standardized to 24 July) captured during trawl surveys in upper Chatham and Icy straits, 1997–2020. The dashed line represents the 1997–2020 average length.

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