Division of Commercial Fisheries
Sam Rabung, Director

Headquarters Office
PO Box 115526
Juneau, AK 99811-5526

Alaska Department of Fish and Game
Doug Vincent-Lang, Commissioner

PO Box 115526
Juneau, AK 99811-5526
www.adfg.alaska.gov

Advisory Announcement

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CONTACT: Andy Piston
Southeast Alaska Pink and Chum Salmon Project Leader
andrew.piston@alaska.gov
907-225-9677

2023 NOAA FISHERIES–ALASKA DEPARTMENT OF FISH AND GAME SOUTHEAST ALASKA PINK SALMON HARVEST FORECAST

The Southeast Alaska (SEAK) pink salmon harvest in 2023 is predicted to be in the *weak* range with a point estimate of **19 million fish (80% prediction interval: 12–29 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 62-year period 1960–2021:

Category	Range (millions)	Percentile
Poor	Less than 11	Less than 20th
Weak	11 to 19	20th to 40th
Average	19 to 34	40th to 60th
Strong	34 to 48	60th to 80th
Excellent	Greater than 48	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 near-shore ocean conditions on year-class strength of salmon and ecologically related species (Orsi et al. 2000). Since 2018, the SECM project has been conducted cooperatively by NOAA and the Alaska Department of Fish and Game (ADF&G) using the ADF&G research vessel *Medeia*, and the two agencies have combined efforts to produce a joint pink salmon harvest forecast using SECM data (Piston et al. 2019). 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 2023 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 surface trawl 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 2022 juvenile pink salmon abundance index (natural log monthly peak juvenile CPUE; standardized catch based on 20-minute trawl sets) of 1.45 was the second lowest even-year juvenile index in the 26 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 water 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 SEAK pink salmon harvest, β_1 is the coefficient for the natural log of CPUE +1, β_2 is the coefficient for water temperature, and ε represents the normally distributed error term. The water temperature index was either the May–July upper 20-m integrated water column temperature collected during the SECM survey and averaged into an Icy Strait Temperature Index (ISTI) or one of 16 temporal and geographical combinations of Southeast Alaska satellite sea surface temperature data (Miller et al. 2022). A one-step-ahead mean absolute percent error (MAPE) model performance metric (for the last 5- and 10-year periods) and significant coefficients (i.e., covariates) were used to evaluate and compare the forecast accuracy of the 18 models considered (17 with a temperature variable and one without). The 80% prediction interval around the forecast was calculated using the *car* package (Fox and Weisberg 2019) in program R version 4.1.2 (R Core Team 2021).

Forecast Discussion

The 2023 harvest forecast of 19 million pink salmon is just over half of the recent 10-year average harvest of 33 million pink salmon. A forecast of 19 million pink salmon would be a significant drop from the previous odd-year harvest in 2021 (48.5 million) and is only 39% of the average harvest over the past 10 odd years (49 million). The 2022 peak June–July juvenile pink salmon index value (1.45) ranked 21st out of the 26 years that SECM information has been collected. Pink salmon harvests associated with juvenile indices below 2.0 have ranged from 8 to 21 million fish (mean=16 million fish).

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 the forecast model. 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). In 2020 and 2021, we began exploring the potential use of satellite sea surface temperature data (available from the NOAA National Environmental Satellite data and Information Service[1]) in forecast models. Satellite data allow for averaging of temperature readings over an almost infinite variety of temporal and geographic units. The ISTI variable used in most recent forecasts incorporates water column temperature to a depth of 20 meters, which may better represent juvenile salmon habitat as they migrate through upper Chatham and Icy Straits. However, this temperature index is spatially restricted to the locations physically sampled during the survey.

Eighteen separate models were considered for the 2023 forecast, 17 of which included a marine water temperature variable (Miller et al. 2022). All models incorporating a temperature variable performed better than the single variable model (CPUE only), which demonstrates the importance of temperature in our forecast model. While all 17 models incorporating temperature performed relatively well, the top three performing models, based on the MAPE model performance metric, all incorporated satellite sea surface temperature data for the month of May in either Icy Strait, Chatham Strait, or for all northern Southeast Alaska inside waters (Miller et al. 2022). Increased model performance when including May temperature suggests that juvenile migration patterns through inside waters and/or survival may already be determined by late spring. The top performing model was based on juvenile CPUE and satellite sea surface temperature data for northern Southeast Alaska inside waters in May (Figures 3 and 4). While this model performed better than the standard model incorporating the ISTI that we have used in most recent years, both models produced identical forecast point estimates of 19 million pink salmon for 2023 (Figure 3) with very similar prediction intervals.

The low juvenile abundance index in 2022 was unexpected given generally robust escapements in most of the region in 2021. In southern Southeast Alaska, escapement indices exceeded the upper bound of management targets for 10 of 18 stock groups. The most notable environmental event potentially related to brood year 2021 juvenile salmon survival was a record setting and extended cold snap that encompassed Southeast Alaska from early December 2021 through early January 2022. Low temperatures at the Juneau airport were in the teens or single digits in all but one day from 12 December 2021 to 9 January 2022, including three days near the end of the cold snap that were more than 20°F below normal (minimum -8°F). Similarly, at Ketchikan in the southern part of the region, low temperatures were below freezing from 2 December 2021 to 10 January 2022, and new record lows were set in December. It is possible that this extended period of freezing temperatures in early winter negatively impacted developing embryos, but we do not know for certain what caused the low juvenile abundance in the 2022 SECM survey. Juvenile pink salmon caught in 2022 SECM survey trawls were near average in size (in length) for the 26-year time series and further growth and survival will depend on favorable resources in the Gulf of Alaska.

[1] https://www.nesdis.noaa.gov/

Despite the uncertainties that surround every salmon forecast, the track record of our pink salmon harvest forecasts has been relatively good (Figure 2), especially considering the difficulties unique to forecasting pink salmon runs (Haeseker et al. 2005). The department will manage the 2023 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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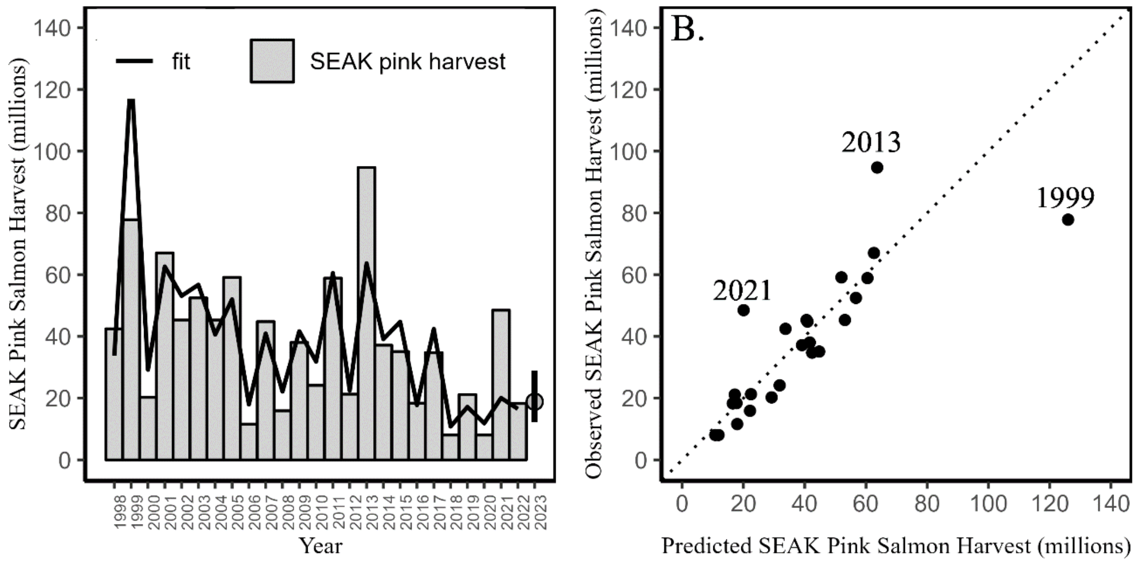

Figure 1. Forecast model fit (hindcasts) for total Southeast Alaska (SEAK) pink salmon harvest, 1998–2022 by year (A) and by the fitted values (B) for the model based on CPUE and satellite sea surface temperature readings in northern Southeast Alaska inside waters. In panel A, the 2023 forecast is shown as a grey circle 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 B, the dotted line represents a one-to-one line; circles above the line represent hindcasts that produced a point estimate lower than the actual harvest and circles below the line represent hindcasts that produced a point estimate higher than the actual harvest.

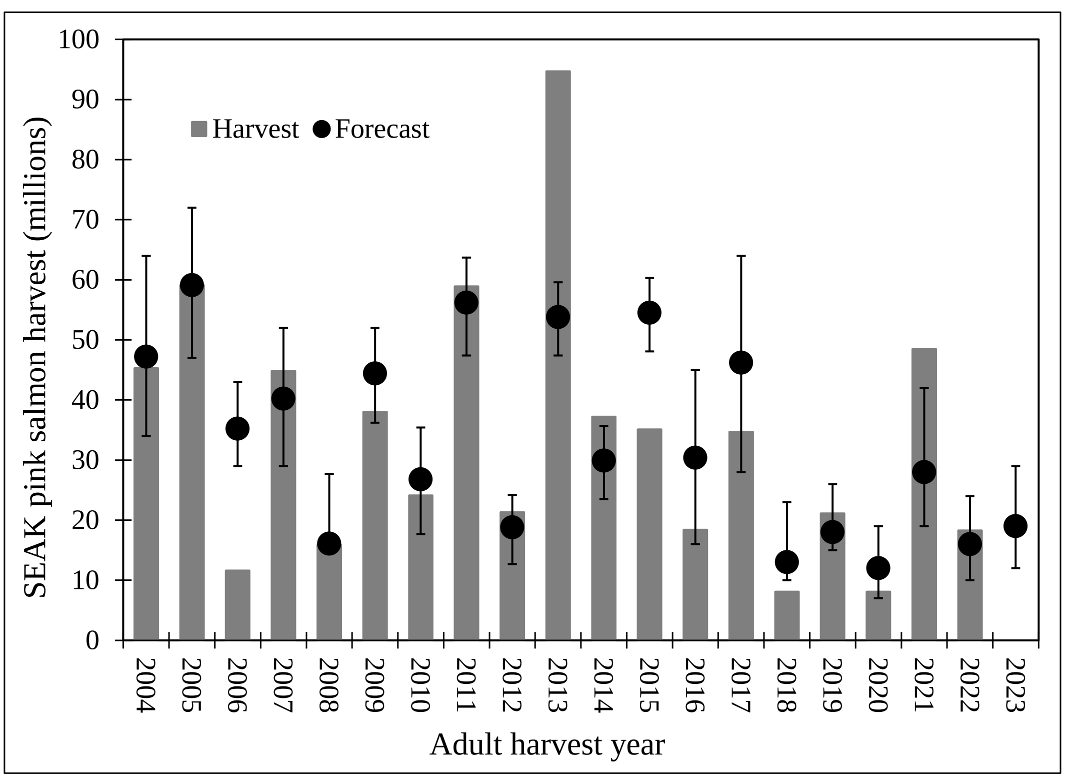

Figure 2. SECM preseason forecasts compared to the annual SEAK pink salmon harvest, 2004–2023. The error bars represent either 80% confidence or 80% prediction intervals of the forecasts, depending on the modeling method used.

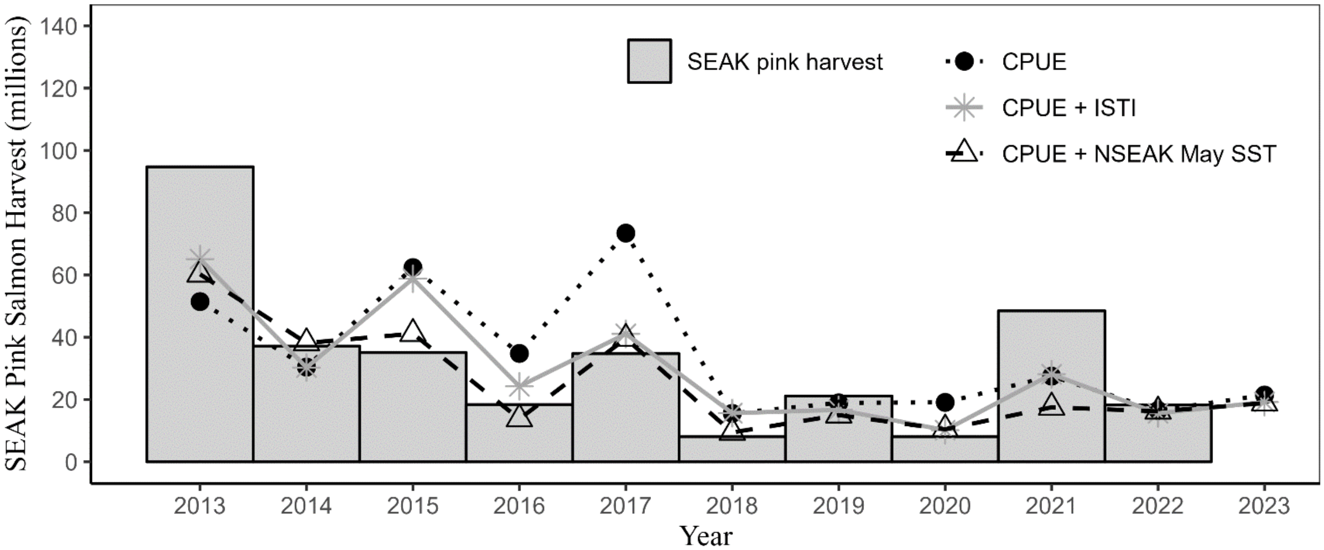

Figure 3. SEAK pink salmon harvest (millions) by year, 2013–2022, compared to one-step-ahead forecasts for three models: 1) CPUE only model, 2) a model that includes CPUE and the ISTI temperature index, and 3) a model that includes CPUE and a May temperature index based on northern Southeast Alaska satellite SST data.

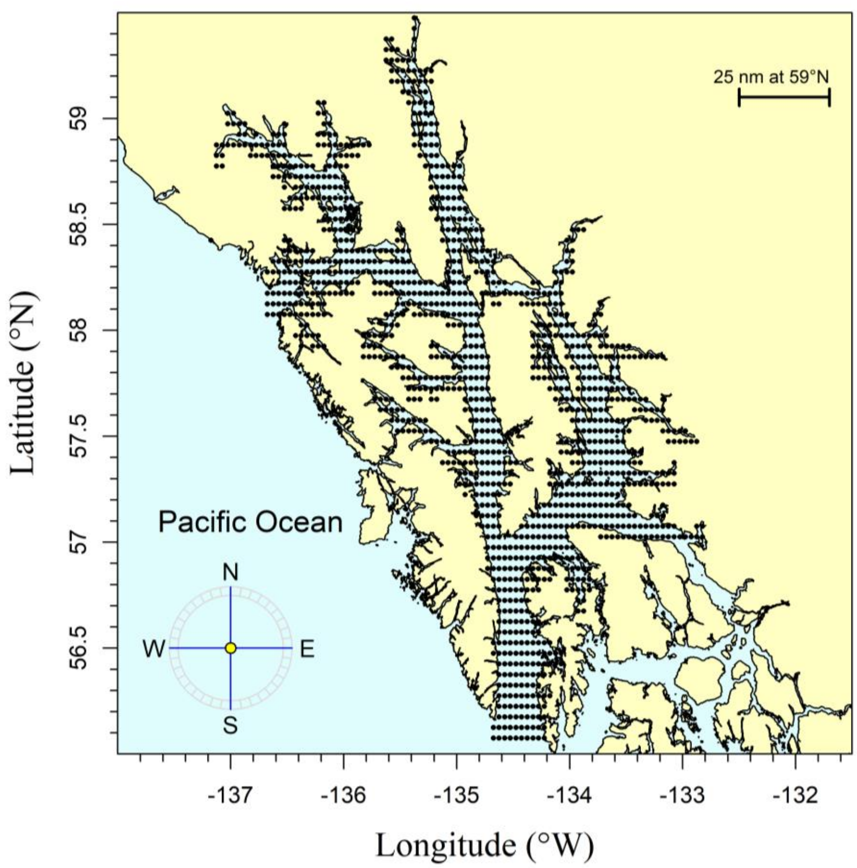

Figure 4. The northern Southeast Alaska (NSEAK) region encompasses northern Southeast Alaska inside waters from 59.475 to 56.075° north latitude and from -137.175 to -132.825° west longitude. There are 1,344 satellite data points (black circles) in the NSEAK region.

Andy Piston, Steve Heinl, Sara Miller, and Rich Brenner, Alaska Department of Fish and Game
Wesley Strasburger, Jim Murphy, Emily Fergusson, and Andrew Gray, NOAA, Auke Bay Lab, Alaska Fisheries Science Center