**Methods**

Biophysical variables based on data from northern Southeast Alaska were used to forecast the harvest of adult pink salmon in SEAK, a year in advance using hierarchical models and a model-averaging approach. Pink salmon harvest data was the response variable and satellite-derived surface temperature SST data, SECM survey temperature data at a 20 m depth from 8 stations in Icy and Chatham Straits, and SECM survey juvenile abundance data (CPUE) were used as potential predictive biophysical variables in the models.

**Biophysical Predictor Variables**

**Satellite-derived SST data**

Monthly satellite-derived sea surface temperature data from April 1997 through July 2021 were pulled from NOAA Coral Reef Watch (2021a; 2021b) and matched to pre-determined coordinates from four spatial regions to use as potential predictor variables in the pink salmon forecast models. Satellite sea surface temperature data were summarized by region and year (i.e., average of May (May), the average over the months of May, June, and July (MJJ), the average over the months of April through June (AMJ), and the average over the months of April through July (AMJJ)) from 1997 to 2021 (Table 1). The monthly data for July 2021 was not available, so the daily data for July 2021 were summarized by month and region, and then combined with the monthly data from April 1997 through June 2021 to create the SST dataset (April 1997 through July 2021; NOAA Coral Reef Watch 2021b). This satellite-derived SST data set was then matched to pre-determined coordinates from four spatial regions (Icy Strait, Chatham Strait, northern SEAK (NSEAK), SEAK) that corresponded to sixteen variables of interest (four regions and four temporal variables per region; see Satellite-derived SST variables). The Icy Strait region encompasses waters of Icy Strait from the east end of Lemesurier Island to a line from Point Couverden south to Point Augusta (Table 1; Figure 1; Figure 2). The Chatham Strait region encompasses waters of Chatham and Icy Straits east of Lemesurier Island to Point Couverden, south to the approximate latitude of 56.025 degrees north (roughly Cape Decision off Kuiu Island; Table 1; Figure 2; Figure 3). The NSEAK region encompasses northern Southeast Alaska from 59.475 to 56.075 degrees north latitude (approximately Districts 9 through 15, and District 13 inside area only; northern Southeast Inside subregion for Southeast Alaska (NSEI; Table 1; Figure 2; Figure 4). The SEAK region encompasses Southeast Alaska from 59.475 to 54.725 degrees north latitude (Table 1; Figure 2; Figure 5). These sixteen variables were then used as potential predictor variables in the pink salmon forecast models.

**Southeast Coastal Monitoring project survey data**

The Southeast Coastal Monitoring project (SECM) has been conducting annual surveys to evaluate the status of the pelagic ecosystem, including juvenile pink salmon, in the northern region of Southeast Alaska since 1997 (Piston et al., 2021). Data collected during the SECM surveys include surface trawl sampling for salmon and other pelagic species, 60 cm bongo net sampling for zooplankton, conductivity-temperature-depth profiles for temperature (°C) and salinity (PSU) data, and a water sample for chlorophyll-a (ug∙L-1). Fish are sampled at each station with a NETS Nordic 264 rope trawl fished for 20 min at each station at least once during June through August with tow speeds of approximately 1.5 m∙sec-1 and typical fishing dimension of 18 m wide by 24 m deep. Data from these surveys are summarized annually, and provide information to forecast pink salmon returns.

***Temperature data***

Survey temperature (°C) data were summarized by year (1997 to 2021), and month (average over the months of May, June, and July) for the 20 m integrated water column in the Icy Strait and Upper Chatham transects combined. The Icy Strait and Upper Chatham transects include 8 sampling stations (stations ISA, ISB, ISC, ISD, UCA, UCB, UCC, UCD). The summarized variable ISTI is the overall average 20 m integrated water column temperature during May through July at the 8 stations in Icy Strait (Table 1; Figure 1; Figure 2). This variable (ISTI) was then used as potential predictor variable in the pink salmon forecast models.

***Index of juvenile abundance (CPUE)***

The index of juvenile abundance of pink salmon is the predictor variable ‘CPUE’ in the pink salmon forecast models. To calculate this variable, the log-transformed juvenile pink salmon catch-per-unit-effort (Ln (CPUE+1); standardized to an effort of a 20 minute trawl set), by haul, from the SECM survey was multiplied by the pooled-species vessel calibration coefficient; calibrated to the NOAA ship *John N. Cobb*  (Wertheimer et al. 2008, 2009, and 2010; Table 1). Then, this value was averaged by month and year; whichever month (June or July) had the highest average catch in a given year is then used as the juvenile abundance index for that particular year (Table 1).

**Response Variable: Harvest Data**

Time series of the annual southeast Alaska adult pink salmon harvest data is downloaded from the ADF&G Fish Ticket Database System.

**Model averaging (multi-model inference)**

A model-averaged approach, based on eighteen multiple regression models (*i* = 1,2,…, 18) with juvenile pink salmon catch-per-unit-effort (CPUE) and temperature data from either the Southeast Alaska Coastal Monitoring Survey (SECM; Piston et al. 2021) or satellite-derived data (NOAA Coral Reef Watch 2021a; 2021b) and weighted by the inverse variance, was used to forecast the 2022 adult pink salmon harvest in Southeast Alaska. The simplest regression model consisted of only the predictor variable juvenile pink salmon CPUE , while the other seventeen regression models consisted of the predictor variable juvenile pink salmon CPUE and a temperature index,

(1)

The temperature index was either the SECM survey temperature data integrated over 20 m depth (ISTI) or one of the seventeen satellite-derived SST data; Table 1). The predictor variable (*Y*) Southeast Alaska adult pink salmon harvest and CPUE data were log-transformed in the model, but temperature data were not.

The process to weight the model-averaged forecast of Southeast Alaska pink salmon harvest in 2021, and calculate the prediction interval around the model-averaged forecast is as follows:

1. Calculate the bias-corrected (Miller 1984) model-predicted adult pink salmon harvest for 2022 from each of the *i* regression models,

(2)

1. Calculate the model-averaged forecast () in log space by weighting each of the 18 model forecasts by the inverse-variance weight normalized to sum to one,

(3)

The inverse-variance weight, of each model *i* is defined as,

), (4)

where are the observed values (i.e., observed SEAK adult pink salmon harvest) and are the predicted values (i.e., predicted SEAK adult pink salmon harvest) from model *i* using dataup to time *t*-1 in the last five years of the time series. In equation 4, *n*=5 since the last five years are forecasted in the time series. The process for calculating the inverse-variance for each model *i* is as follows:

1. Estimate the regression parameters at time *t* from data up to time *t* – 1 for model *i*.
2. Make a prediction of at time *t* based on the predictor variables at time *t* and the estimate of the regression parameters at time *t* for model *i*.
3. Calculate the inverse-variance weight (equation 4)based on the prediction of at time *t* and the observed value of at time *t*.

d. Repeat this for data up through year 2016 (e.g., data up through year 2016 is *t*−1 and the forecast is for year 2017; *t*), data up through year 2017 (e.g., data up through year 2017 is *t* − 1 and the forecast is for year 2018; *t*), data up through year 2018 to forecast 2019, data up through year 2019 to forecast 2020, and data up through year 2020 to forecast 2021.

To normalize the inverse-variance weights to sum to one, each individual weight is divided by the sum of all the model weights, .

1. Calculate the standard error of the model-averaged forecast (i.e., the square root of the unconditional variance estimator; equation 9 in Buckland et al. 1997; derivation in Burnham and Anderson 2002:159-162) as,

(5)

where is the model-averaged forecast, is the individual model output, and (i.e., the misspecification bias of model ) is computed as . The confidence interval is then calculated as,

(6)

where and for 80% confidence intervals.

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