2004 Pollock Year-Class Prediction: <u>Average Recruitment</u>

DATA

This forecast is based on five data sources: three physical properties and two biological data sets. The sources are:

1) Observed 2004 Kodiak monthly precipitation. The Kodiak Weather Service Office (http://padq.arh.noaa.gov/) prepares monthly precipitation totals (inches) from hourly observations. Data for 2004 were obtained from the NOAA National Climate Data Center, Asheville, North Carolina, and the NWS office in Kodiak, Alaska.
2) Wind mixing energy at [57°N, 156°W] estimated from 2004 sea-level pressure analyses. Monthly estimates of wind mixing energy (W m^{-2}) were computed for a location near the southwestern end of Shelikof Strait. To make the estimates, twice daily gradient winds were computed for that location using the METLIB utility (NOAA Tech. Memo. ERL PMEL-54). Gradient winds were converted to surface winds using an empirical formula based on the work of Macklin *et al*. (*J. Geophys. Res., 98*, 16,555–16,569, 1993). Estimates of wind mixing energy were computed using constant air density (1.293 kg m^{-3}) and the drag coefficient formulation of Large and Pond (*J. Phys. Oceanogr*., *2*, 464-482, 1982).
3) Advection of ocean water in the vicinity of Shelikof Strait inferred from drogued drifters deployed during the spring of 2004.
4) Rough counts of pollock larvae from a survey conducted in May 2004.
5) Estimates of age 2 pollock abundance from the 2004 assessment.

ANALYSIS

Kodiak Precipitation*:* Kodiak precipitation is a proxy for fresh-water runoff that contributes to the density contrast between coastal and Alaska Coastal Current water in Shelikof Strait. The greater the contrast, the more likely that eddies and other instabilities will form. Such secondary circulations have attributes that make them beneficial to survival of larval pollock.

The season began with typical precipitation during January (Table 1), and then it turned into one of the six wettest seasons since the beginning of the record in 1961. Three of the six months in the reporting period had significantly greater than normal precipitation. April 2004 was the second wettest April since 1961.

TABLE 1. Kodiak precipitation for 2004.

Month	% 30-yr average
Jan	94
Feb	183
Mar	76
Apr	220
May	103
June	161

Based on this information, the forecast element for Kodiak 2004 rainfall has a score of 2.48. This is "average to strong" on the continuum from 1 (weak) to 3 (strong).

Wind Mixing: Following the decadal trend established in the late 1990s, wind mixing at the southern end of Shelikof Strait was again below the long-term average for the winter and spring months of 2004.

TABLE 2. Wind mixing at the exit of Shelikof Strait for 2004.

Month	% 30-yr average
Jan	39
Feb	58
Mar	80
Apr	92
May	50
June	78

Strong mixing in winter helps transport nutrients into the upper ocean layer to provide a basis for the spring phytoplankton bloom. Weak spring mixing is thought to better enable first feeding pollock larvae to locate and capture food. Weak mixing in winter is not conducive to high survival rates, while weak mixing in spring favors recruitment. This year's scenario produces a wind mixing score of 1.99, which equates to "average".

Advection: From an examination of drifter trajectories and wind forcing, the transport in Shelikof Strait for spring of 2004 was average.

We have hypothesized that very strong transport is bad for pollock survival, that moderate transport is best and that very weak transport, while not as disastrous as strong transport, still is detrimental to larval survival. Advection was given a score of 2.0.

Relating Larval Index to Recruitment: As in last years analysis, a nonlinear neural network model with one input neuron (larval abundance), 3 hidden neurons, and one output neuron (recruitment) was used to relate larval abundance (catch m^{-2}) to age 2 recruitment abundance (billions). The model estimated six weighting parameters.

The neural network model, which used the first 18 observation pairs of Table 3 fit to the model, had an R^2 of 0.143. A plot of the observed recruitment (actual) and that predicted from larval abundance (predicted) are given in Fig. 1, where row number corresponds to the rows of the data matrix given in Table 3.

TABLE 3. Data used in the neural network model.

Year Class	Total	Recruit
1982	66.443	0.4399
1985	80.426	0.4757
1987	324.903	0.3633
1988	256.903	1.6131
1989	537.294	1.0475
1990	335.009	0.4202
1991	54.222	0.2400
1992	563.674	0.1415
1993	45.808	0.2127
1994	124.939	0.8315
1995	600.993	0.4038
1996	472.023	0.1730
1997	561.106	0.1809
1998	72.815	0.2679
1999	102.386	1.1486
2000	486.184	0.7691
2001	174.624	0.1099
2002	276.697	0.1835

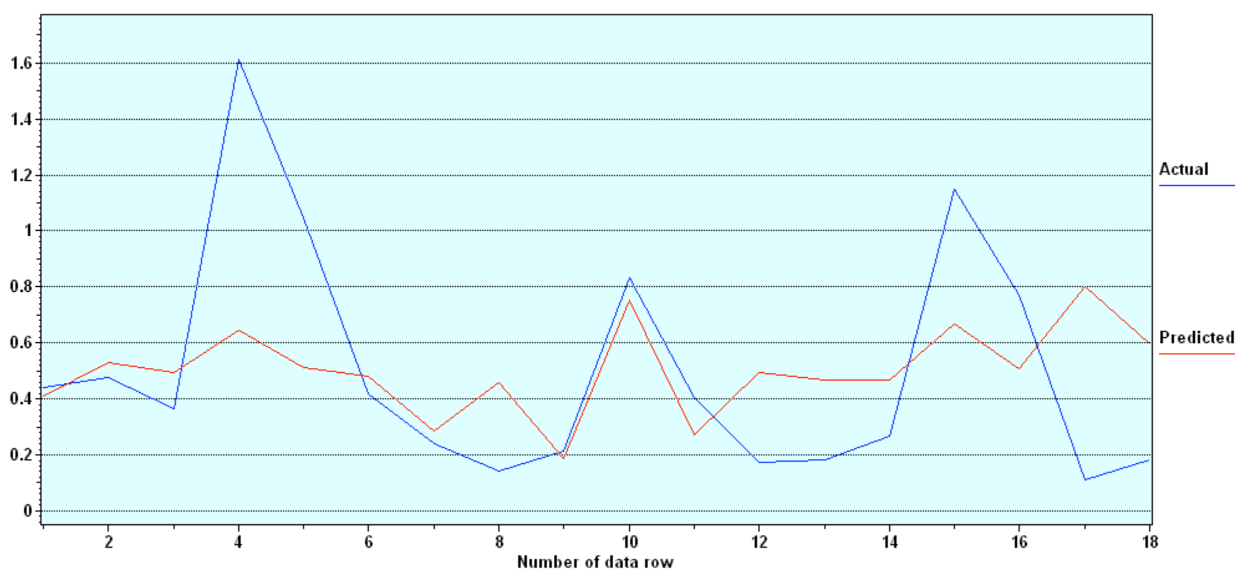

FIGURE 1. Observed and predicted recruitment values from the larval index-recruitment neural network model.

The trained network was then used to predict the recruitment for 2003 and 2004. The predictions are given in Table 4.

TABLE 4. Neural network model predictions for 2003 and 2004.

Year	Actual Recruitment	Predicted Recruitment
2003	n/a	0.538
2004	n/a	0.108

These values, using the 33% (0.340938) and 66% (0.691343) cutoff points given below, correspond to a weak 2003-year class and a weak 2004-year class.

Larval Index Counts: Plotting the data by year and binning the data into catch/10 m^2 categories (given below) provides another view of the data. The pattern for 2004 (based on rough counts) shows that all data fall into the three lowest binning categories, indicating that the 2002-year class may one of the weakest in this time series.

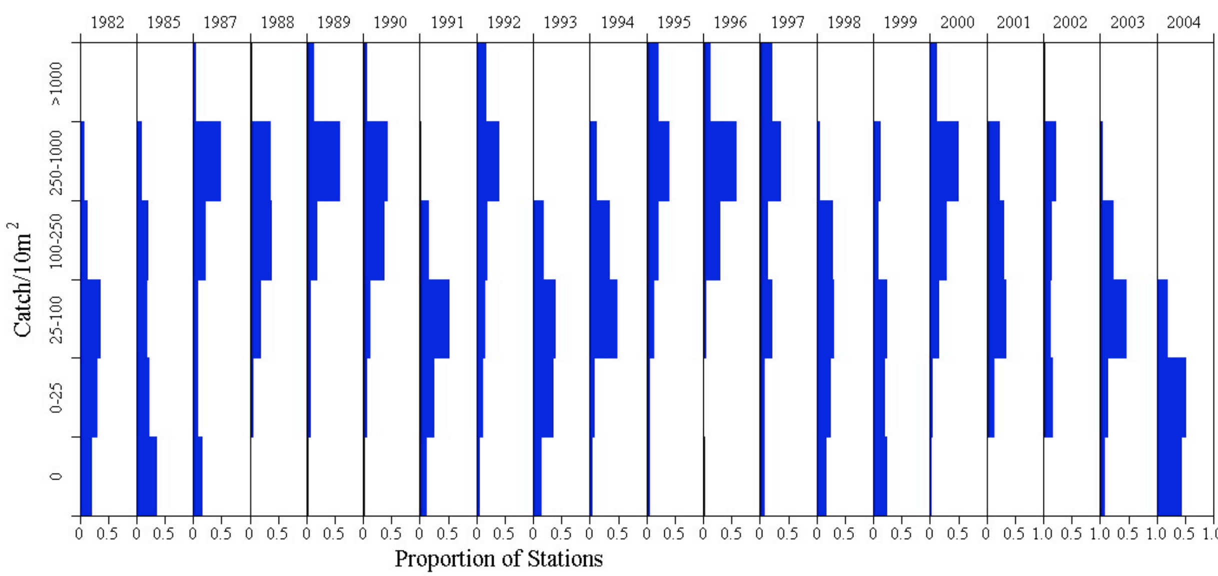

FIGURE 2. A series of histograms for larval walleye pollock densities in late May from 1982 to 2004. Data were binned into catch/10 m^2 categories. The data from 2000-2004 are rough counts taken at sea, and the 2004 data are from the 5MF04 cruise that was completed on June 1.

The data for Figure 2 are taken from a reference area that is routinely sampled and that usually contains the majority of the larvae. This year's distribution of pollock (Fig. 3) appears to be centered in the typical reference area, and the larval abundance figures in the middle of the reference area seem to be average. Given these two pieces of information, the score for larval index is set to the high end of the weak range or 1.65.

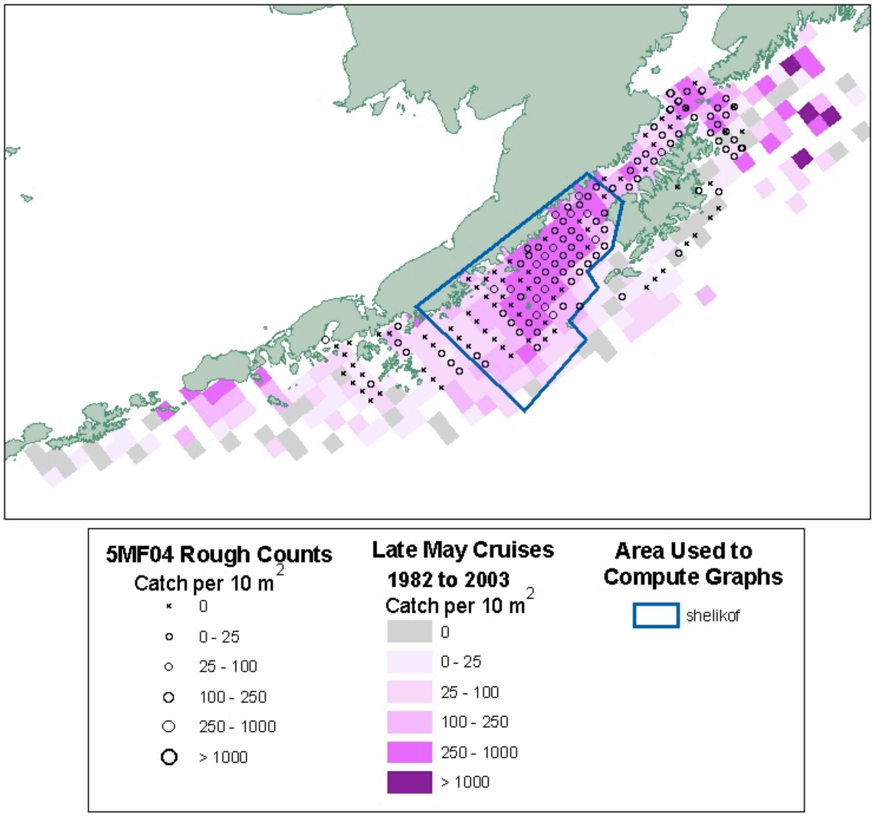

FIGURE 3. Mean catch per 10 m^2 for late May cruises during 1982-2004.

Spawner/Recruit Time Series: The time series of recruitment from this year's assessment was analyzed in the context of a probabilistic transition. The data set consisted of estimates of age 2 abundance from 1961-2004, representing the 1959-2002 year classes. There were a total of 44 recruitment data points. The 33% (0.340938 billion) and 66% (0.691343 billion) percentile cutoff points were calculated from the full time series and used to define the three recruitment states of weak, average and strong. The lower third of the data points were called weak, the middle third average and the upper third strong. Using these definitions, nine transition probabilities were then calculated:

1) Probability of a weak year class following a weak
2) Probability of a weak year class following an average
3) Probability of a weak year class following a strong
4) Probability of an average year class following a weak

5) Probability of an average year class following an average
6) Probability of an average year class following a strong
7) Probability of a strong year class following a weak
8) Probability of a strong year class following an average
9) Probability of a strong year class following a strong

The probabilities were calculated with a time lag of two years so that the 2004-year class could be predicted from the size of the 2002-year class. The 2002 year class was estimated to be 0.183527 billion and was classified as weak. The probabilities of other recruitment states following a weak year class for a lag of 2 years (n=44) are given in Table 5.

TABLE 5. Likelihood of 2004 recruitment based on 2002-year class and time series history.

2004 Year Class		2002 Year Class	Probability	N
Weak	follows	Weak	0.095	4
Average	follows	Weak	0.070	3
Strong	follows	Weak	0.146	6

The probability of a strong year class following a weak year class had the highest probability. We classified this data element as a strong, giving it a score at the low end of strong 2.34.

Each of the data elements was weighted equally.

CONCLUSION

Based on these five elements and the weights assigned in Table 6, below, the FOCI forecast of the 2004-year class is average.

TABLE 6. Final 2004 pollock recruitment forecast.

Element	Weights	Score	Total
Time Sequence of R	0.2	2.34	0.468
Rain	0.2	2.48	0.496
Wind Mixing	0.2	1.99	0.398
Advection	0.2	2.00	0.4
Larval Index-abundance	0.2	1.65	0.33
Total	1.0		2.092 = **Average**