



**Release:**  
15 April 2010  
[www.prbo.org](http://www.prbo.org)

**Contact:**  
Jennifer Roth

**Phone:**  
(707) 781-2555 x305

**E-mail:**  
[jroth@prbo.org](mailto:jroth@prbo.org)

## Forecasting Chinook salmon returns to the Central Valley

PRBO Conservation Science conducted analyses to evaluate the relationships between salmon abundance, seabird breeding success, and environmental factors and to assess whether the resulting models could be used to inform salmon management by providing predictions of salmon abundance prior to the start of the fishing season. We found that salmon abundance was strongly correlated to Cassin's Auklet breeding success during the ocean phase of the salmon life cycle and that environmental correlates did not improve the predictions.

We used forward stepwise regression to assess whether seabird breeding success or physical environmental measures explained more variability in salmon abundance. We included environmental factors known to affect salmon survival in both the freshwater and marine environments, including outflow from the Sacramento and San Joaquin rivers, spring transition date, sea surface temperature, upwelling intensity, the Southern Oscillation Index, and the Pacific Decadal Oscillation. We also included out-migrating smolt abundance and compared the models using seabird data to jack (2-year-old salmon)-based models currently used by fisheries managers.

We found that there was a strong correlation between salmon abundance and auklet breeding success averaged over the ocean phase of the salmon life cycle. Freshwater and marine environmental correlates did not improve the predictions relative to models that

were based on seabird data alone. The seabird-based models provided better predictions on average than the jack-based models, although there was a lot of variability in model performance from year to year.

Our results indicate that seabirds provide useful information on the health of prey populations (e.g., krill, juvenile rockfish) and the marine ecosystem that cannot be obtained by using only physical environmental measurements (e.g., sea surface temperature). Auklets may be good indicators of marine foraging conditions due to their ability to locate patchy prey even when conditions are poor and prey is scarce. We are continuing to refine our models by exploring why they perform better in some years than others. Ultimately, finding ways to incorporate seabird data into fisheries models may aid fisheries managers in their efforts to set sustainable fishing quotas.

### Main Points

- Chinook salmon abundance is strongly correlated to Cassin's Auklet breeding success during the ocean phase of the salmon life cycle.
- Auklet breeding success can be used to predict salmon abundance and may aid fisheries managers in their efforts to set sustainable fishing quotas.

Table 1. Results of forward stepwise regressions showing relationships between the Sacramento River Index (salmon abundance), Cassin's Auklet breeding success, and environmental factors from 1990-2010.

Model	Sacramento River Index				
	Year x	Year x-1	Year x-2	Year x-3	Average Lag
Independent Variables					
Cassin's Auklet Breeding Success		+	+	+	+
River Outflow					
Out-migrating Smolt Abundance					
Spring Transition Date					
Upwelling Intensity					
Sea Surface Temperature					+
Southern Oscillation Index					
Pacific Decadal Oscillation		+			
Model results					
adjusted $r^2$	N/A	0.64	0.50	0.19	0.72
$p$ -value	N/A	< 0.001	< 0.001	< 0.05	< 0.001

Figure 1. Actual salmon abundance, predictions based on Cassin's Auklet breeding success averaged over the previous three years, and predictions based on jack (2-year-old salmon) returns in the previous year from 1990-2010.

