

Modeling the Bi-Stable State of Herring in Prince William Sound

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As part of our development of a population dynamics of herring in Prince William Sound, we have examined Alaska Fish and Game's Age Structure Analysis (ASA) Models for Prince William Sound. As discussed in a second presentation at this symposium, the ASA time series for the population of adult herring and 3 year old recruitment display distinct patterns that have helped guide development of our model. These patterns include the existence of bi-stable states for the adult populations and the existence between 1976 and 1992 of bi-modal distributions in recruitment. We suggest that these patterns are an expression of the internal biological dynamics of the herring population. In order to test this suggestion we will run our model of herring population dynamics to determine whether its predictions are consistent with output from the ASA model. Our model, which will be run for the period from 1980 to 2005, predicts changes in the population of all stages of the herring's life cycle.

We believe that our model contains formulations that match well the features that emerge from the ASA analysis. The most significant component of the model is a nonlinear, density-dependent formulation of changes in the probability of survival at one or more stages in the herring's life history. According to such a formulation, at a given stage thresholds in the density of population will drive large variations in survival. If the density of individuals entering a given stage is below the threshold value, survival is low, and if the density exceeds the threshold, survival is high. One or more of such bottlenecks can create both bi-stable states in population size and bimodal distributions in recruitment. The system of equations also include formulations the spatial expansion and contraction of the herring's habitat with changes in the size of the adult population, differences in the reproductive success of 4 year old recruits and the older adults, and stochastic events such as the dramatic increase in herring recruitment that occurred in the mid-70s within the Gulf of Alaska.