

Cubic splines for estimating the distribution of residence time for southern right whales in the Auckland Islands

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Residence time, or stopover duration, is of considerable interest to biologists studying migratory populations. We present a method for estimating the distribution of residence time for a population of southern right whales (*Eubaleana australis*) in the subantarctic Auckland Islands, using photo-ID resightings data from the 1998 winter breeding season. We explain how we can estimate a smooth probability distribution for residence time, by formulating a likelihood penalized for roughness in the residence distribution. The estimated residence distribution is a cubic spline that maximizes the penalized likelihood. The non-parametric approach allows complete flexibility in the shape of the distribution for residence time, and can fit distribution shapes that would be difficult to obtain using a parametric mixture distribution. We show that cubic splines give a general solution to penalized likelihood problems, and fitting the spline is an optimization problem accessible to users of standard statistical software. The methodology is quite general in its potential for fitting smooth probability distributions to data.