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Abstract

A dynamic metapopulation model for the Atlantic salmon (*Salmo salar*). Consequences for management

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Dynamic models of populations of Atlantic salmon (*Salmo salar*) are often based on the assumption that young migrating salmons (smolts) will infallibly return to the river in which they were born to breed. This is the strict "*homing*" hypothesis (Guegen & Prouzet, 1994). According to this hypothesis, the functioning populations in each river can be considered to be independent. Models are often used for population management purposes, especially to set catch limits for angling in each river (Potter et al., 2003). This is the case in Brittany – Basse Normandie, where the total authorised catches (TAC) are defined in a specific way for each river (Prévost & Porcher, 1996).

However, individual fish can stray from their native river. In particular, when rivers are near to one another and they have similar characteristics (environmental, geophysical and chemical conditions), major exchanges of fish can take place between each population when the adults migrate upstream to the spawning grounds (Altukhov & Salmenkova, 1994; Potter & Russel, 1994; Jonsson et al., 2003). It is likely that there can be a significant exchange of individuals between many small coastal river systems in Europe. The occurrence of these exchanges is related to the fundamental concept of metapopulation (Hanski, 1999), that has major consequences in terms of species biology, evolution, and also in terms of population dynamics (Rieman & Dunham, 2000; Young, 1999). In terms of management, the relevance of using TAC values defined for each individual river can be called into question by these exchanges (Policansky & Magnuson, 1998; Cooper & Mangel, 1999).

We will illustrate this problem by a dynamic population model explicitly taking into account the exchanges of fish between neighbouring rivers during the upstream migration of salmon in freshwater (Rivot, 2003). The proposed model refers to a branched river network. Each branch of the network is characterized by two variables: the area of habitat suitable for the production of juvenile salmon and the carrying capacity, defined as the number of smolts produced per unit area of suitable habitat. One model describes the distribution of adults in the various branches of the network during their return migration up the river for spawning. This model can be used to test several hypotheses between the extremes of strict homing and a total loss of memory of the place of birth by all the fish in the network leading to a completely random distribution during the upstream migration.

As an example, we use a river system composed of two coastal rivers, the Sée and the Sélune (Basse Normandie,

France), that have a shared estuary in Mont St Michel bay (Rivot, 2003; Baglinière et al., 2005). We have a very comprehensive time series of demographic data derived from monitoring migrations in the Oir, a tributary of the Sélune, plus a series of angling catch statistics in the Sée and Sélune. These data have been used to estimate the main exchange parameters in the river network using a Bayesian statistical method (Gelman et al., 1995; Rivot, 2003). The estimates show that on average, more than 30% of the adult fish lose their memory of the branch in the network in which they were born (Sée or Sélune). The consequences of these exchange rates in terms of population dynamics and management are discussed.

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