

## Ecological issues and Hierarchical Bayesian modeling techniques: case studies from fisheries ecology

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Atlantic salmon is an anadromous and phylopatric fish species. It shares its life cycle between freshwater, where reproduction and juvenile rearing take place, and the ocean where individuals undertake a long range migration. In Brittany (France) young of the year fish emerge from the gravels of the spawning grounds in early spring and the following spring they face the choice of migrating to the sea (smolt stage) or to stay an additional year in freshwater. For the males staying in freshwater, a second choice is between sexual maturation or remaining immature in their second year of life. After their sea migration and sexual maturation, they home back to their native river where they spawn and die. Scientific observations are taking place all along the salmon cycle, but the state variables themselves, i.e. the quantities that describe the natural phenomenon (and focus the scientist's interest) always remain latent. On three examples from this salmon story, we depict how hierarchical Bayesian modeling (HBM) techniques cast new lights on ecological issues.

- For capture-mark-recapture data, we show that the transfer of information carried through HBM is highly valuable when local information is poor but rather neutral when statistical units are heterogeneous.
- For stock-recruitment studies, we wish to predict the ecological reference points of sustainability for rivers with no or very few data. HBM allows for such predictions and the incorporation of covariates increases the precision of predictions.
- For electro fishing experiments, the estimation of fish stock would not be possible without HBM : only abundance indices could be evaluated with data from every site and many missing data occurring during the experiments would blur the inferential results. Thanks to HBM, one can therefore make a better use of such data easy and quick to collect, that many scientists would have previously looked up for stock evaluation.

In these examples, joint estimation of all the model unknowns is worked out by Bayesian statistical inference using MCMC sampling techniques. The HBM approach allows to evaluate the latent state variables of the system and make the best with the available information to formulate probabilistic judgements on ecological issues.