Annex A: Bayesian stock assessment: a review and example application using the logistic model

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Bayesian stock assessment: a review and example application using the logistic model

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Bayesian statistical methods have recently been combined with conventional methods for fisheries stock assessment (e.g. catch-age analysis) to provide a conceptually elegant approach for providing fishery management advice under uncertainty. Uncertainties in the advice provided can be conveyed using posterior probability distributions (or "posteriors") for the potential outcomes of each policy option. Posteriors can be estimated using data (e.g. catch-age data and relative abundance indices) for the fish population of interest and prior probability distributions for population model parameters (e.g. stock-recruit function parameters) based on data from similar fish populations. Despite growing interest, Bayesian methods remain accessible to relatively few. To increase the accessibility of these methods, the conceptual basis for Bayesian statistical estimation is reviewed and set in the context of fisheries stock assessment. The use of Bayesian methods is illustrated by fitting a logistic model to relative abundance indices for Namibian hake (*Merlucius capensis* and *M. paradoxus*) and presenting a decision analysis of alternative harvest policy options. Some alternative approaches are outlined for constructing prior and posterior probability distributions and some recent applications in fisheries. Some of the problems that can be encountered while implementing Bayesian methods are also discussed.

Key words: Bayesian, decision analysis, policy evaluation, prior distribution, posterior distribution, uncertainty, stock assessment, fishery management.

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Introduction

Until recently, policy advice to fishery managers from stock assessments has frequently been based on single point estimates of biological quantities; uncertainties in fisheries stock assessments over stock size and productivity and the potential biological and economic consequences of alternative policy (e.g. total allowable catch) options were seldom conveyed and taken seriously. Recognition of the potential disadvantages of ignoring uncertainty in policy advice, for example, increased risks of resource collapse and underutilization, has led to the development of a variety of approaches to accounting for uncertainties in stock assessment and in providing policy advice (Walters and Hilborn, 1976; Bergh and Butterworth, 1987; Francis, 1992; Restrepo *et al.*, 1992; Hilborn and Walters, 1992; Smith *et al.*, 1993; Walters and Ludwig, 1994). Among these, the Bayesian alternative offers a simple and conceptually elegant approach to fisheries stock assessment. Bayesian methods have recently been developed to rigorously incorporate expert judgment and inferences into conventional stock assessment methods using data from similar fish populations; these methods have also been used to convey uncertainties in policy advice to decision makers.

In this paper the Bayesian approach to fisheries stock assessment is reviewed and a detailed example application provided in order to increase the accessibility of Bayesian methods to a wider audience. In the introductory sections that follow, the basic problems of decision making under uncertainty faced by fishery managers are briefly outlined. Three commonly used approaches to

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