A Comparative Analysis of Surplus Production Models and a Maximum Entropy Model for Estimating the Anchovy’s Stock in Korea

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Abstract

For fishery stock assessment and optimum sustainable yield of anchovy in Korea, surplus production (SP) models and a maximum entropy (ME) model are employed in this paper. For determining appropriate models, five traditional SP models—Schaefer model, Schnute model, Walters and Hilborn model, Fox model, and Clarke, Yoshimoto and Pooley (CYP) model—are tested for effort and catch data of anchovy that occupies 7% in the total fisheries landings of Korea. Only CYP model of five SP models fits statistically significant at the 10% level. Estimated intrinsic growth rates are similar in both CYP and ME models, while environmental carrying capacity of the ME model is quite greater than that of the CYP model. In addition, the estimated maximum sustainable yield (MSY), 213,287 tons in the ME model is slightly higher than that of CYP model (198,364 tons). Biomass for MSY in the ME model, however, is calculated 651,000 tons which is considerably greater than that of the CYP model (322,881 tons). It is meaningful in that two models are compared for noting some implications about any significant difference of stock assessment and their potential strength and weakness.

Key words: Fishery stock assessment, Surplus production (SP) models, Maximum entropy (ME) model, anchovy

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I. INTRODUCTION

The concept of sustainable yield has long dominated the analysis of renewable resources (Schaefer, 1954; Beverton and Holt, 1957). The best known proxy for sustainability is maximum sustainable yield (MSY), defined as the largest annual catch that can be taken while maintaining resource sustainability. With the rationalization paradigm to overcome the open access dynamics, the strategy of maximum economic yield (MEY), which is the sustainable level of catch that produces the greatest economic profits, has become popular. MSY and MEY represent main reference points for fisheries sustainability and benchmarks for fishery management.

Without precise information on age and growth, the most common alternatives to age-based or length-based fisheries stock assessment techniques are biomass dynamics models, commonly referred to as SP models (e.g. Schaefer, 1954; Schnute, 1977; Walters and Hilborn, 1976; Fox, 1970; Clarke, Yoshimoto and Pooley, 1992; Pella and Tomlinson, 1969). A critical underlying assumption of the SP models is that catch in any one year is a linear function of effort and SP models can be represented by the equilibrium state in which the level of catch is equal to the level of surplus growth. This assumption means that SP models cannot estimate biomass annually.

In order to overcome several limits on SP model, ME model developed by Golan et al. (1996a, 1996b) can also be applied to estimate the yearly fishery stock, MSY, and the maximum sustainable biomass, using non-linear programming.

The objective of this paper is to evaluate and compare a SP model and a ME model, using a time-series of data for catch and effort of anchovy, which is one of a major species occupying 7% in the total fisheries landings of Korea. Since the recruitment of anchovy is much more uncertain than the abundance of the adult stages, the stock assessments are also more uncertain. Furthermore, no TAC (Total Allowable Catch) or adaptive management is in place, so the administrations do not require monitoring in order to manage the fisheries. Jacobson et al. (2001) argue that it is difficult to apply existing age-based or length-based fisheries stock assessment techniques to stock assessment of small pelagic fishes such as anchovy and sardine because several characteristics - recruitment variability, rapid somatic growth, and high mortality rates of small pelagic fishes make their age-structured analysis difficult. Even though current biomass of anchovy can be estimated by using acoustic surveys and trawl surveys (Choi et al., 2001; Bailey and Simmonds, 1990), it is impossible to estimate the yearly fishery stock and parameters. Such things are the most important reasons to conduct fisheries stock assessment of anchovy using indirect methods.

This paper presents SP models and ME model for anchovy stock assessment after a brief summary of fishing types of anchovy and time series data for catch and effort. The remaining part of the paper summarizes the results of two models and their implications for anchovy fisheries.