

## Summer Flounder Project Summary

### Introduction

The Summer Flounder stock assessment conducted by NMFS is limited by a number of science issues. The project was designed to assist fisheries managers with the scientific understanding necessary to improve the confidence level of stock assessment and consisted of four major tasks: 1) development of a sex- and region-specific model; 2) investigate information on natural mortality; 3) investigate information on the stock-recruitment relationship; 4) determine reference points and/or proxies. Products of the project include a manuscript describing methods to estimate natural mortality for summer flounder has been published in the Journal Fisheries Research (M.N. Maunder, R.A. Wong. 2011. Approaches for estimating natural mortality: Application to summer flounder (*Paralichthys dentatus*) in the U.S. mid-Atlantic. Fisheries Research 111, 92–99). A manuscript describing methods to estimate steepness of the stock-recruitment relationship and the calculation of management reference points for summer flounder (Maunder, M.N. Evaluating the stock-recruitment relationship and management reference points: Application to summer flounder (*Paralichthys dentatus*) in the U.S. mid-Atlantic) has been submitted to the Journal Fisheries Research. The research on estimating natural mortality was presented at the PMAFS Summer Flounder Natural Mortality Workshop in October 2010.

### Activities and findings

A sex- and region-specific model was developed using the general stock assessment model Stock Synthesis (SS). The regional aspect of the model consisted of separating out the North Carolina component of the commercial fishery. This model was then used to investigate different aspects of the stock assessment.

#### *Natural mortality*

A review of the literature was undertaken to determine the source of the estimate of natural mortality used in previous assessments and to obtain estimates of natural mortality from similar stocks and species. Natural mortality was also estimated using various methods based on correlations with longevity and life history parameters (e.g. growth rate, age at maturity, fecundity). A range of estimates of natural mortality are available from the different approaches. Methods based on maximum age (longevity) are not appropriate to estimate natural mortality due to both the exploitation history of summer flounder and the sampling design used to collect age data. The estimates of natural mortality from relationships with life history parameters are too imprecise to be useful in the stock assessment. Estimates of natural mortality from other species are variable and many are unreliable. Simulation analysis suggests that given the model assumptions and the type of data available for summer flounder, the stock assessment

model was able to estimate both female and male natural mortality with reasonable precision, but with some bias depending on the true values of natural mortality. The estimates of natural mortality from the original data were 0.29 and 0.54, for females and males respectively, which are considerably higher than the values used in the current assessment. One consistent aspect of the estimates of natural mortality is that natural mortality for males is higher than that for females. Increased natural mortality for young individuals may be important for summer flounder assessments due to the substantial amount of zero year old individuals caught in the fisheries.

#### *Steepness of the stock-recruitment relationship*

A review of the literature was undertaken to obtain estimates of steepness of the stock-recruitment relationship from similar stocks and species. Estimates of steepness of the stock-recruitment relationship from other species are variable and many are unreliable. Simulation analysis suggests that steepness of the stock-recruitment relationship is estimable within the stock assessment model for summer flounder given the available data, but there is a bias towards estimating that the recruitment is independent of stock size. Estimates of steepness of the stock-recruitment relationship for summer flounder from the stock assessment model were close to one (recruitment independent of stock size). Available evidence suggests steepness of the stock-recruitment relationship is high (recruitment insensitive to stock size) for summer flounder

#### *Reference points*

The sensitivity analysis was conducted to determine the sensitivity of management reference points to the steepness of the stock-recruitment relationship, natural mortality and growth. Reference points are highly dependent on the steepness of the stock-recruitment relationship. The Spawning biomass ratio and SPR reference points are not very sensitive to growth or natural mortality when the steepness of the stock-recruitment relationship is high. The fishing mortality reference point is particularly sensitive to natural mortality. Current spawning biomass-per-recruit reference points for summer flounder are too restrictive (i.e. they imply lower fishing mortality than appropriate) and imply a steepness of stock-recruitment relationship that is much lower than the information suggests. However, risk in terms of lost yield is lower for underestimation of the steepness of the stock-recruitment relationship compared to overestimation.

#### **Recommendations**

The assumptions about natural mortality, steepness of the stock-recruitment relationship, and reference points used for the assessment and management of summer flounder should be re-evaluated based on the information obtained during this research project. Specifically, the rate of natural mortality for both males and females should be higher and the spawning biomass-per-recruit based management reference points are too restrictive. A well designed and implemented tagging program may be the best approach to produce reliable estimates of natural mortality for summer flounder. The tagging data could be integrated into the stock assessment model. In the meantime, estimating natural mortality, which differs between males and females, within the stock assessment model appears to be the most appropriate approach. Steepness of the stock-recruitment relationship should be fixed based on the available information, but perhaps at a level somewhat less than one (i.e. make recruitment dependent on stock-size) to reduce the risk of lost equilibrium yield.