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Incorporating Integrated Ecosystem Assessment products into stock assessments in the Gulf of Mexico: A first experience with gag grouper (*Mycteroperca microlepis*)

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Summary

A large Integrated Ecosystem Assessment (IEA) program has been initiated in the Gulf of Mexico (GOM). One goal of the GOM IEA program is to incorporate ecosystem products into single-species stock assessments. In 2013-2014, ecosystem considerations were introduced in the Stock Synthesis (SS) assessment model of GOM gag grouper (*Mycteroperca microlepis*). These ecosystem considerations included a time-varying red tide mortality term and estimates of recruitment anomalies from the stock-recruitment curve due to oceanography. Consideration of red tide mortality in the SS model improved model fit, and was incorporated into the base stock assessment model of gag grouper. Estimates of annual recruitment deviations produced using a biophysical model were incorporated in the SS model as a sensitivity run. These estimates explained about one-third of the variation in the stock-recruitment deviates from the assessment model, and their consideration in the SS model informed the recent years of the assessment where cohort strength is poorly estimated. Natural mortalities of adult gag grouper due to causes other than predation evaluated with ecosystem models developed within the GOM IEA program were consistent with the red tide mortalities reconstructed for the SS model. GOM IEA products will be tested and, eventually, incorporated in upcoming stock assessments.

Introduction

A large Integrated Ecosystem Assessment (IEA) program has been initiated in the Gulf of Mexico (GOM) to inform decisions in ecosystem-based management. In March 2013, the GOM fisheries management council's standing and ecosystem Scientific & Statistical Committees (SSCs) passed two motions expressing their desire to integrate IEA products into single-species stock assessments and living marine resource management decisions on a regular basis. In 2013-2014, the GOM IEA program informed the stock assessment of GOM gag grouper (*Mycteroperca microlepis*) conducted under the auspices of SEDAR (SouthEast Data, Assessment, and Review). The contribution of the GOM IEA program to gag grouper stock assessment (SEDAR 33) included the estimation of size- and time-specific natural mortality rates with ecosystem models (WFS Reef fish EwE; Chagaris and Mahmoudi, 2013; WFS Red tide EwE; Gray *et al.*, 2013; and OSMOSE-WFS; Grüss *et al.*, submitted for publication), and of recruitment anomalies from the stock-recruitment curve due to environmental factors with a biophysical model (the Connectivity Modeling System (CMS); Karnauskas *et al.*, 2013). Moreover, a statistical study conducted within the GOM IEA program evaluated the impacts of including a time-varying red tide mortality term in the Stock Synthesis (SS) assessment model of GOM gag grouper (Sagarese *et al.*, 2014).

Materials and Methods

WFS Reef fish EwE is an Ecopath with Ecosim model of the West Florida Shelf, one of the main subregions of the GOM where the bulk of the U.S. gag grouper population is found. WFS Red tide EwE was built on WFS Reef fish EwE to investigate the impacts of red tides for gag grouper. OSMOSE-WFS is an individual-based, multi-species model of the West Florida Shelf. WFS Reef fish EwE, WFS Red tide EwE and OSMOSE-WFS were used to evaluate ontogenetic patterns in gag grouper natural mortality and diet over the recent period for SEDAR 33.

Sagarese *et al.* (2014) used the base SS model of gag grouper (13 age classes: 0, 1 … 12+ year old individuals) and an abbreviated version of this model (3 age classes: youngs-of-the-year, juveniles and adults) to link natural mortality of each plus age group to a red tide index. Six scenarios based on candidate red tide indices and methods for inclusion in the SS model were devised and compared.

Karnauskas *et al.* (2013) applied the CMS to gag grouper. To estimate recruitment strength of gag grouper due to oceanographic factors alone, particles representing eggs were released from known spawning areas on a yearly basis and tracked through time with a real-time oceanographic hindcast giving a best estimate of the specific oceanographic conditions at each point in time. The percentage of particles that successfully reach settlement habitat, given parameterized biological limitations (e.g., pelagic larval duration) then represents the expected recruitment anomaly for that year.

Results and Discussion

Consideration of red tide mortality in the SS model improved model fit, and was incorporated into the base stock assessment model of gag grouper. While this analysis did not provide direct evidence of red tide mortality on gag grouper, nor is the mode of mortality known, results suggested that red tides cause mortality on adults. Estimates of annual recruitment deviations produced using the CMS were incorporated in the SS model as a sensitivity run. These estimates explained about one-third of the variation in the stock-recruitment deviates from the assessment model, and their consideration in the SS model informed the recent years of the assessment where cohort strength is poorly estimated. Natural mortalities of adult gag grouper due to causes other than predation evaluated with ecosystem models were consistent with the red tide mortalities reconstructed for the SS model.

In June 2014, partly due to the successful contribution of the GOM IEA program to gag grouper stock assessment, the GOM fisheries management council's standing and ecosystem SSCs passed new motions defining the products they expect from the GOM IEA program. The GOM IEA program will inform the stock assessments of GOM red grouper (*Epinephelus morio*) in 2014-2016 (SEDAR 42).

References

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