Accounting for changes in fishing mortality when comparing density-dependent to density-independent mortality in Gulf of Mexico red snapper

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Comment: Accounting for changes in fishing mortality when comparing density-dependent to density-independent mortality in Gulf of Mexico red snapper

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Gazey et al. (2008) investigated the potential for density-dependent total mortality acting upon the juvenile red snapper (Lutjanus campechanus) population in the western Gulf of Mexico. The analysis compares two density-dependent total mortality models and a density-independent total mortality model using length frequency data of red snapper bycatch from the shrimp fishery from July 1999 – February 2007. The models were compared using Akaike Information Criterion (AIC) and Bayes posterior factor for their respective fits to the data through the model's estimation of a total mortality for young-of-year and age-1 red snapper (Z_0 and Z_1) and other parameters. The authors note the primary modeling assumption as, "total mortality is either a function of recruitment (density-dependent) or constant over the study." However, none of the models account for changes in fishing mortality over the time period and therefore do not adequately represent the nature of the system enough to make a legitimate comparison.

The assumption of constant total mortality for the density-independent model is unreasonable due to the known changes in fishing effort. During the study period, the relative shrimp fishing effort for the western Gulf of Mexico varied between 0.79 – 1.97 (Figure 1; SEDAR Red Snapper Update 2009). The assumption of constant total mortality requires the density-independent mortality model to fit the data by averaging these changes into one value. Because not all easily identifiable factors are accounted for in the model, the constraint of constant total mortality for the density-independent mortality model is comparable to fitting an intercept-only regression to data that shows a linear trend. The density-dependent mortality model may have a better fit compared to the density-independent mortality models because the former model has the ability to vary total mortality over time. Therefore, these two models are not comparable and the ability to draw conclusions about the mechanisms of red snapper population dynamics are not valid. Thus, the statistical support for density-dependent natural mortality is equivocal.

Additional support that the density-dependent total mortality model presented by Gazey et al. (2008) is not a justifiable model can be found by examining their estimates of recruitment. The estimates of recruitment for 1999 – 2006 from the 2009 update assessment of red snapper were divided by the mean recruitment for this time period and then plotted alongside the recruitment index reported in Table 7 (Figure 2; Gazey et al. 2008, SEDAR Red Snapper Update 2009). The trend in recruitment estimated by Gazey et al. (2008) exhibits an opposite pattern of the recruitment estimates from the update assessment. These contrary patterns suggest that the model in Gazey et al. (2008) does not estimate the parameters as expected. One speculative explanation for this discrepancy is that the estimation of recruitment is responding to the actual total mortality of the system because the model estimates a constant value for total mortality that is then modified by changes in recruitment. Thus, the recruitment values might be changing to fit to the total mortality, but do not accurately represent changes in recruitment. Overall, the extreme difference in the recruitment trend is additional evidence that the density-dependent total mortality model presented by Gazey et al. (2008) may not adequately model the true population dynamics of juvenile red snapper in the Gulf of Mexico.

Gazey et al. (2008) calls for an increase in natural mortality by 0.7 for age-0 red snapper by comparing the average estimate of total mortality from 2001 to 2003 of their model to the average of values estimated in SEDAR 7 (2005). The value of total mortality for age-0 in 2003 estimated by Gazey et al. (0.686; 2008) is well below the value assumed in the assessment (0.983; SEDAR 7 2005) and is actually lower than the suggested amount of increase in age-0 natural mortality by Gazey et al. (0.7; 2008). If the estimate of fishing mortality from the update assessment for 2003 on age-0 fish (0.298; SEDAR Red Snapper Update 2009) is assumed correct and the total mortality for 2003 from Gazey et al. (0.686; 2008) is used, the value calculated for natural mortality rate would be 0.388, also much lower than the value used in the assessment (0.983; SEDAR 7 2005). Aside from the invalid assumptions in the models, the discrepancy in interpretation of the results calls into question the recommendation to increase the estimate of natural mortality in an assessment. Though other studies recommend an increase in natural mortality for age-0 and age-1 red snapper (SEDAR Red Snapper Update 2009) the results of this study are largely variable over time and are based on invalid assumptions that undermine the authors' suggestions.

If two models that account for changes in fishing mortality were constructed, a density-dependent natural mortality model which assumed natural mortality varied with recruitment and a density-independent natural mortality model which assumed constant natural mortality, then a comparison of the two models would be valid despite the difference in assumptions. However, none of the models presented in Gazey et al. (2008) adequately account for changes in fishing mortality. For an adequate comparison of density-dependent natural mortality to density-independent natural mortality the models must include an estimation of fishing mortality at age each year. To aid the estimation of fishing mortality, the models should incorporate data on relative shrimp fishing effort for the time series. Additionally, a fishery-independent index of larval recruitment, such as that provided by the SEAMAP Groundfish Trawl survey separated into an age-0 and an age-1 index in the recent update red snapper assessment or the SEAMAP Larval Trawl, would provide a supplementary source of data to aid the estimation of recruitment and potentially assist the estimation of natural mortality. Incorporating these recommendations into the framework provided by Gazey et al. (2008) would provide a convincing comparison of density-dependent against density-independent natural mortality in juvenile red snapper, from which a convincing argument for the use of density-dependent natural mortality could be made.

An additional comment on this paper that is unrelated to the validity of the model, but important none the less is about the terminology used to describe recruitment. The paper defines the recruitment parameters (ΔR) as the logarithmic deviation in recruitment. However, the formula of equations (2a) and (2c) ($N_{0,1}$=ΔR_1 and $N_{0,i+1}$=$\Delta R_{y(i+1)}$) show ΔR to actually be the logarithm of recruitment. The logarithmic deviation in recruitment would be represented by the calculation $\Delta R_{y(i)} - \frac{1}{y}\sum_{y=1}^{Y} \Delta R_{y(i)}$. This calculation of recruitment deviation is presented in the square brackets of equation (1a) and used to scale density-dependent total mortality. This misuse of terminology is easily overlooked, but potentially a major source of error for anyone attempting to replicate the methodology presented.

Density-dependent mortality still remains a potential factor in the population dynamics of juvenile red snapper in the Gulf of Mexico, but the inclusion of density-dependent natural mortality within an assessment based solely upon the results presented in Gazey et al. (2008) is not recommended. Additionally, an increase in the assumed value for natural mortality of age-0 red snapper within an assessment should be considered carefully, given slight changes in natural mortality can have large ramifications upon the estimation of stock status. A comparison of many sources of estimates of natural mortality and hypotheses of natural mortality variation should be conducted before any values or methodologies are instituted in an assessment.

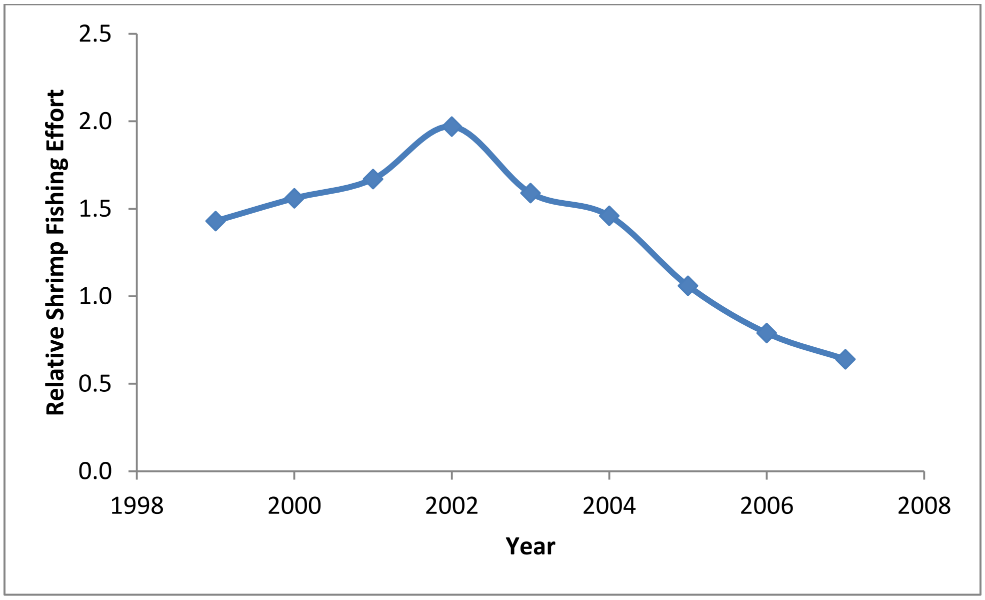

Figure 1. Observed shrimp effort values used in the stock assessment for years 1999 to 2007 (copied from Table 29). Values are expressed as proportion relative to the 2001-2003 effort average.

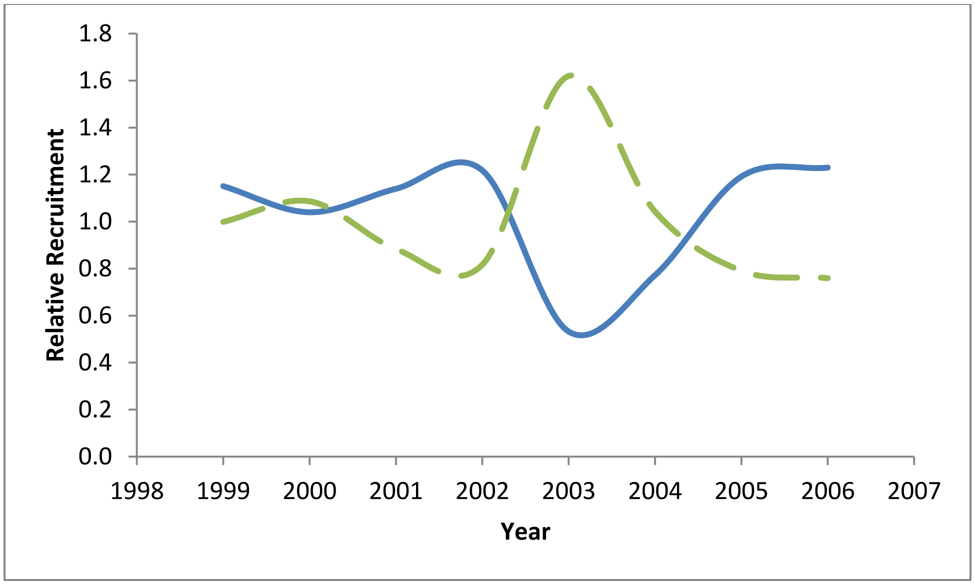

Figure 2. Estimate of red snapper Recruitment Index in the Western Gulf of Mexico from Table 7 Gazey et al. (2008) represented by the solid line for 1999 to 2007. The dashed line represents estimates from the update stock assessment (SEDAR Red Snapper Update 2009) divided by the mean recruitment for 1999 to 2007.

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