

## **Appendix II**

### **Closed Area Model**

#### **Description and Performance**

## The Closed Area Model

Management measures considered under this action include trip limits, differential days-at-sea counting, seasonal area closures and an overall days-at-sea reduction through changing the A/B day split. As with Amendment 13, and Framework 42, one of the primary analytic tools used to analyze both the biological and economic impacts of the proposed alternatives to achieve mortality objectives is the closed area model (CAM). The CAM projects changes in mortality brought about by area closures, revised trip limits and changes in days-at-sea through a non-linear programming model using the General Algebraic Modeling System (GAMS). The CAM was designed so that the impact of all three types of management measures can be analyzed *simultaneously*. There are no other models currently available which can analyze the combined impact of reductions in days-at-sea, closed areas and trip limits simultaneously. Management measures, such as mesh size changes, special access programs, or the use of "B" days-at-sea cannot be analyzed within the CAM. However, they can be analyzed outside the CAM, and the results incorporated in the analysis. Additionally, the CAM is a **one-year** model, meaning that it only estimates changes for a one-year period. The main utility in using the CAM is to evaluate management alternatives when mortality needs to be reduced to meet rebuilding targets.

The CAM allocates effort to specific block, month combinations for each vessel holding a valid year 2007 multispecies permit, and landing groundfish in 2007. The model maximizes profit for each vessel by allocating their effort to the highest profit blocks. Because the revenue functions embedded in the model are downward sloping, effort stops flowing to a block when marginal profit hits zero. The model can incorporate changes in allowable days at sea, trip limits, and differential days at sea and changes in CPUE by species and stock area.

In order to assess the impact of the proposed suite of management measures, an initial model run is made to calibrate model parameters to approximate the distribution of effort based on observed effort levels. Once this process is complete, another model run is made with the management measures from the status quo management regime included as constraints. Subsequent runs are then made for each proposed alternative, where an alternative is a complete set of management measures. The estimated catch from each option is compared to the status quo catch, and the percentage change in landings is calculated. These numbers are be interpreted as the percent change in exploitation brought about by the proposed management action. The percent change in exploitation is then converted to a percent change in F, and that number is compared to the needed change in F based on the stock status. For example, if the stock assessment concluded that stock x needed a 50% reduction in F, and the closed area model results indicated that the management measures would yield a 51% reduction, then that particular option would be considered adequate to meet the mortality reductions.

## Changes in the Closed Area Model

The closed area model has been modified, based on external peer reviews, and comments received as part of the PDT deliberations from the original model used in Amendment 13. The first set of changes took place prior to use of the model for Framework 42, and was based on the advice of the external reviewers during the economic and social science peer review in January, 2004 (<http://www.nefsc.noaa.gov/groundfish>). The first change was to incorporate costs in the model so each vessel would maximize profit, as opposed to revenue. The second change concerned choice of fishing location. Previously, vessels were restricted to fishing in block-month combinations where records showed they fished. Now, vessels are allowed to shift their effort to blocks where they hadn't fished previously based on the fishing locations of similarly configured vessels from their fishing ports. Thirdly, the total amount of effort available to a fishing vessel is now based on their fishing year allocation. This differs from previous versions where vessels were allocated their average days-at-sea used over a four year period. By allowing vessels to fish up to their allocated effort, the possibility latent effort could be activated is now incorporated in the model. Finally, the model was run 250 times for each option incorporating a stochastic CPUE for each species-block-month-gear combination. Thus, the median (50th percentile) outcome could be reported rather than relying on a single point-estimate. This was consistent with the percentiles that are reported for the rebuilding trajectories, and with the target that is used for reducing fishing mortality.

Subsequent to Framework 42, several additional improvements were made based on deliberations made by the Plan Development Team (PDT), and also the availability of better spatial data. The first change was to use 2007 VMS data to construct effort locations, resulting in greater spatial coverage for each vessel. This allowed use of a single year of data rather than a range of years. Secondly, lease information was explicitly considered for each vessel based on past leasing behavior. Vessels were given an increase in their days-at-sea allocation if they leased days from other vessels during 2007, and had days subtracted if they leased days to other vessels. Thirdly, cost and discard data from vessels fishing in 2007 were used in the model. Fourthly, the opportunity cost of labor was included in the model as part of the cost function. An hourly rate was converted into a daily rate based on a manufacturing wage rate of \$20 per hour. This is because crew needs to earn income in order for them to fish. Fifthly, only one iteration using a mean CPUE was conducted for each management option. This was because the stochastic version of the model used in Framework 42 resulted in very narrow confidence intervals on the catch distribution. Thus, additional information was not being gained by using the stochastic version of the CAM. Finally, and perhaps most importantly, profit per block was estimated based on all species caught by a gear type, and not just groundfish species. This resulted in higher revenues per block and month than if just groundfish species were included. This change also assured that species like monkfish and skates that require use of a groundfish DAS were included.

### **Closed Area Model Performance**

An earlier version of the CAM was used to evaluate the biological and economic impacts of the management measures proposed in Amendment 13. The estimates published in

Amendment 13 were compared to realized estimates of fishing mortality. The results shown below are based on the analysis done for Amendment 13.

### **Biological Impacts**

One of the inputs for the CAM used to analyze measures for Amendment 13 was the number of DAS used. Since more DAS are allocated to vessels than are used, and since other measures (DAS leasing, the DAS transfer program) made it uncertain how many DAS would be used, the CAM was run with three different scenarios on DAS use. The conclusion was that fishing mortality targets would be met under all three assumptions, though at the higher level of DAS use there was more uncertainty in the results, particularly for two stocks: GOM cod and witch flounder. The results of the CAM reflect a change in exploitation, which is converted into a change in fishing mortality while taking into account other management measures - such as changes in mesh size - that cannot be incorporated into the model. Amendment 13 also cautioned that the model results should not be considered as point estimates, but reflected the likelihood of achieving management targets..

Evaluating the performance of the model with respect to fishing mortality is complicated for several reasons. First, fishing mortality is based on the calendar year, while management measures are designed for a fishing year. Since Amendment 13 was implemented on May 1, 2004, the mortality estimates determined by GARM II for calendar year 2004 do not reflect a full year under Amendment 13 regulations. Second, as described in GARM II, the assessments of several groundfish stocks exhibit retrospective patterns; that is, the fishing mortality estimated in the terminal year of the assessment is typically revised in later assessments when additional years of data are added to the assessment. In most cases, the original terminal year estimate of mortality is underestimated compared to subsequent estimates of fishing mortality for the same year. These retrospective patterns, however, are not always consistent in magnitude or direction between assessments. The CAM predicts changes in exploitation/fishing mortality. The determination whether those changes are large enough to meet mortality targets relies on measuring those changes from the most recent estimate of mortality. If that estimate of mortality is in error or is later revised, the model may correctly predict the magnitude of a change but mortality targets may still be exceeded. Finally, the model is used to assess how three distinct management measures -- days at sea changes, trip limits and area closures, interact to change fishing exploitation rates, which are then converted into changes in fishing mortality (F). Management measures which are imposed in addition to the three main measures, such as mesh size changes, need to have their potential impact on F estimated outside the model, and then incorporated into the CAM results. Measures such as the eastern Georges Bank resource sharing agreement with Canada also have the potential to influence the realized versus the predicted outcome from the CAM. For example, closing the eastern portion of Georges Bank when a TAC is met can force vessels to shift their effort to inshore locations. Because TAC management is not an option in the CAM, the shift in effort would not be predicted by the CAM, and therefore the realized changes in F may be different than what was predicted.

The model results are reported below (Table 1). Amendment 13 predictions of changes in fishing mortality that assumed a 39% and a 50% reduction in used DAS are compared to the GARM II estimates of CY 2004 fishing mortality. Actual DAS use in FY 2004 approached a 50 percent reduction in used DAS. For major stocks with age-based assessments, the predictions are also compared to Groundfish PDT estimates of CY 2004 mortality based on preliminary landings information (see the biological impacts discussion in FW 42 for details). Two comparisons are made for GB yellowtail flounder since two assessments were accepted by GARM II.

When compared to the change in mortality between CY 2001 and CY 2004 mortality (which reflects only eight months under Amendment 13 management measures), the CAM model accurately predicted the change in mortality (direction and relative magnitude) that would result from Amendment 13 for six stocks: GB cod, witch flounder, plaice, GOM winter flounder, SNE/MA winter flounder, and GOM/GB windowpane flounder. The model correctly predicted the direction of change, but not the relative magnitude, for three additional stocks: CC/GOM yellowtail flounder, SNE/MA yellowtail flounder, and white hake. The model did not accurately predict the direction of change for eight stocks: GB haddock, GOM haddock, GOM cod, GB yellowtail flounder, GB winter flounder, pollock, SNE/MA windowpane flounder, and halibut. Mortality for redfish is too low to draw meaningful conclusions on model performance.

The first full calendar year under Amendment 13 management measures was 2005. The Groundfish PDT used six months of preliminary landing statistics to estimate the likely fishing mortality for CY 2005 for nine stocks that have age-based assessments and associated projections. The uncertainty associated with these estimates is described in FW 42. Based on these estimates, the CAM appears to have underestimated the reduction in mortality for four stocks: GB cod, GB yellowtail flounder, witch flounder, and SNE/MA winter flounder. Model results appear accurate for three stocks: CC/GOM yellowtail flounder, SNE/MA yellowtail flounder, and plaice, while the model over-estimated the mortality reduction for GB haddock and GOM cod.

Over-estimates of the mortality reduction for GB haddock (CY 2004 and CY 2005), GB winter flounder (CY 2004), and GB yellowtail flounder (CY 2004) may be explained by the CAII yellowtail flounder SAP and the Category B (regular) DAS program. These programs were not modeled by the CAM, and these three stocks were targeted in all three programs. At the time of development of Amendment 13, fishing mortality for GB yellowtail flounder was believed to be less than half of  $F_{MSY}$ ; recent GARM II estimates indicate that fishing mortality in 2001 was threefold higher than  $F_{MSY}$ . Measures in Amendment 13 were based on the GARM I estimate and the CAII SAP was created to allow fishing mortality on this stock to increase. Amendment 13 analysis cautioned that the catch of GB winter flounder would also likely increase as a result of these programs.

The CAM results for GOM cod cannot be readily explained. GARM II noted that the fishery in CY 2004 was targeting weak year classes, but it is not certain if this entirely explains the difference between the model results and mortality changes. The DAS leasing program also contributed to increased GOM cod catches, but analysis suggests

these increases were relatively minor. Additionally, the US-Canada resource sharing agreement, and subsequent management of some stocks with hard TACs may have caused a shift of effort to inshore waters. This may also explain the underestimate of the mortality reduction for GB cod and yellowtail flounder, since vessels were prohibited from the eastern part of Georges bank once the yellowtail flounder TAC was met.

From the standpoint of biological objectives, the CAM used for Amendment 13 appears to have adequately determined the changes in mortality that would result for most stocks, the exception being GOM cod. While the model appears to have correctly characterized the changes for CC/GOM yellowtail flounder, SNE/MA yellowtail flounder, SNE/MA winter flounder, and white hake, GARM II revised the estimate of 2001 mortality for those stocks and as a result the mortality targets were not met in 2004 and will probably not be met in 2005.

**Table 1 – Comparison of changes in fishing mortality to Amendment 13 estimates**

Stock	GARM II		PDT Estimate	Fishing Mortality, Percent Change from 2001 to:		A13 Estimated Mortality Reduction	
	2001	2004	2005	2004	2005	50% DAS	35% DAS
GB Cod	0.58	0.24	0.16	-59%	-72%	-49%	-42%
GB Haddock	0.18	0.24	0.18	33%	0%	-41%	-30%
GB Yellowtail(1)	0.91	1.19	0.2	31%	-78%	-36%	-28%
GB Yellowtail(2)	0.8	1.75	0.4	119%	-50%	-36%	-28%
SNE/MA Yellowtail	1.83	0.99	0.58	-46%	-68%	-65%	-56%
CC/GOM Yellowtail	1	0.75	0.48	-25%	-52%	-69%	-63%
GOM Cod	0.36	0.58	0.34	61%	-6%	-47%	-38%
Witch Flounder	0.631	0.199	0.13	-68%	-79%	-53%	-42%
Plaice	0.33	0.15	0.14	-55%	-58%	-51%	-42%
GOM Winter Flounder	0.58	0.13		-78%		-50%	-34%
SNE/MA Winter Flounder	0.85	0.38	0.27	-55%	-68%	-49%	-37%
GB Winter Flounder*	1.25	1.86		49%		-38%	-28%
White Hake	1.36	1.18		-13%		-42%	-32%
Pollock	3.53	3.51		-1%		-40%	-31%
Redfish							
Ocean Pout	0.007	0.003		-57%			
GOM/GB Windowpane	0.05	0.04		-20%		-30%	-23%
SNE/MAB Windowpane	0.38	0.44		16%			
GOM Haddock	0.12	0.18		50%		-43%	-33%
Halibut	0.06	0.09		50%			

### **CAM Performance for Framework Adjustment 42**

As noted, the CAM was also used to design management measures for FW 42 so the expected impacts of those measures on fishing mortality as estimated by the CAM were compared to realized changes in fishing mortality. When FW 42 was developed, the most recent assessment estimated fishing mortality for 2004. An estimate of 2005 catches was used to estimate fishing mortality for each stock. Based on these estimates of fishing mortality and the differences between those values and the rebuilding targets, FW 42 measures were designed to achieve changes in fishing mortality for seven stocks. These targeted changes were compared to the changes in mortality documented by the GARM III results. Since FW 42 was not implemented until late in 2006 and it is unrealistic to expect the measures would have achieved the targeted reductions for the entire year, the comparisons are made between 2005 and 2007 (Table 2). The PDT cautions that the terminal year estimates of mortality – in this case, for 2007 – may be in error even though adjusted for retrospective patterns by GARM III. These comparisons show that the realized reductions in mortality were similar to the targeted reductions for five of the stocks, but exceeded the targeted reductions for GB cod and white hake.

FW 42 also estimated changes in mortality expected to result from the FW 42 measures for a larger group of stocks (essentially all stocks included in the closed area model used to design effort control measures). These were compared to the changes that actually occurred (based on GARM III results). In general, FW 42 under-estimated the mortality reductions for GB cod, haddock, winter flounder, and yellowtail flounder but did reasonably well for estimating reductions for other stocks. Two exceptions are GOM haddock and pollock, where the framework predicted a reduction but mortality increased from 2005 to 2007. A partial explanation for the under-estimate of the impacts of the measures on the four GB stocks may be that the FW 42 analyses (the closed area model) cannot model the in-season regulation adjustments for the US/CA area. Another may be changes in operating costs that occurred over time that might have moved effort onto inshore stocks. The difference in pollock may be partly due to increased targeting of pollock in the Category B (regular) DAS program which is not included in the model.

**Table 2 – Comparison of mortality reduction targeted in FW 42 and actual reduction as determined by GARM III. FW 42 targeted reductions from Table 45, FW 42.**

<b>Stock</b>	<b>FW 42 Targeted Reduction from 2005</b>	<b>Realized Reduction, 2005-2007</b>
GB Cod	0%	-58%
SNE/MA Yellowtail	-55%	-51%
CC/GOM Yellowtail	-46%	-46%
GOM Cod	-32%	-28%
SNE/MA Winter Flounder	-9%	-11%
GB Winter Flounder	-46%	-60%
White Hake	-13%	-45%

**Table 3 – Comparison of mortality change from 2005 to 2007 predicted by FW 42 and as measured by GARM III.**

	<b>FW 42 Predicted Mortality Change</b>	<b>Realized Mortality Change, 05-07</b>
GB Cod	-9%	-58%
GB Haddock	1%	-26%
GB Yellowtail	-40%	-75%
SNE/MA Yellowtail	-63%	-51%
CC/GOM Yellowtail	-49%	-46%
GOM Cod	-44%	-28%
Witch Flounder	-25%	-53%
Plaice	-11%	-63%
GOM Winter Flounder	-52%	NA
SNE/MA Winter Flounder	-19%	-11%
GB Winter Flounder	-41%	-60%
White Hake	-18%	-45%
Pollock	-17%	228%
Redfish	-5%	
GOM Haddock	-22%	35%