Appendix V

Supporting Analytic Data

1. Closed Area Model

Description

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, 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 allocates effort to specific block, month combinations for each vessel holding a valid year 2005 multispecies permit, and landing groundfish during the time period 2001-2004. A four year period is used to smooth out any peaks or valleys in the data. Data used by the model includes average catch per unit effort (CPUE) by species, gear type, block and month, prices by species and month, and effort by vessel and month. Vessels are assigned a specific gear type based on which gear they used to land the majority of their groundfish catch between 2001 and 2004. All prices were set to year 2000 levels in order to remove the influence of inflation from the analysis. The model attempts to maximize profit for each vessel by allocating their effort to the highest profit blocks. However, 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 also be modified to incorporate changes in allowable days at sea, trip limits, differential days at sea and changes in CPUE by species and stock area.

Based on the economic and social science peer review which took place in January, 2004 (http://www.nefsc.noaa.gov/groundfish) several modifications were made to the original closed area model on the advice of the external reviewers. 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 based on their fishing year 2005 allocation. This differs from previous models where vessels were allocated their average days-at-sea over a four year period. By allowing vessels to fish up to their allocated effort, there is no longer an issue of latent effort being activated and not being 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 can be reported rather than relying on a single point-estimate. This is consistent with the percentiles that are reported for the rebuilding trajectories, and with the target that is used for reducing fishing mortality.

An initial model run was made based on the status quo management regime. Subsequent runs were made for each of the seven management options considered by the Council and the no-action alternative. The no-action alternative differs from the status-quo because of additional management measures that will occur on May 1st of fishing year 2006 under the default provisions of Amendment 13. The estimated catch stream from each option is compared to the status quo catch stream, and the percentage change in landings is calculated. These numbers should be interpreted as the percent change in exploitation brought about by the proposed management action. These estimates were then adjusted by the estimated impact of the days at sea leasing program (see Appendix I). The change in exploitation rate must be considered in light of the impacts of the DAS leasing program.

Closed Area Model Performance

The primary analytic tool used to evaluate the measures proposed to reduce commercial fishing mortality is the Closed Area Model (CAM). 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 estimates of fishing mortality and fishery revenues.

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 under-estimated 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 is 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

	GARM II		PDT Estimate	Fishing Mortality, Percent Change from 2001 to:		A13 Estimated Mortality Reduction	
Stock	**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%			

Economic Impacts Based on CAM Results

The CAM was also used to estimate economic impacts of the measures designed to achieve rebuilding. Amendment 13 included two types of economic analysis. The first analysis was a comparison of different rebuilding strategies and assumed perfect implementation of the strategy – that is, target fishing mortality rates were precisely achieved. The second analysis used the output of the CAM to estimate short-term changes in revenues for vessels with a groundfish permit and reflects the fact that for some stocks the management measures were expected to reduce mortality more than necessary. The following comparisons are based on the second set of analyses.

The economic analyses of Amendment 13 were derived in large measure from the changes in groundfish revenue determined by the CAM, but several algorithms external to the CAM were used to determine changes in revenue on groundfish trips, and changes in total fishing revenues. This analysis focuses on the changes in groundfish revenue. Since the CAM described changes in revenue in relative terms, the same approach is used to measure the effectiveness of the model. Note that the model results were not described as point estimates by Amendment 13 but were described as indications of the relative change in revenues that could be expected from the management measures.

The model was subject to several limitations. First, it cannot capture price changes that may result due to changes in supply or other factors. Second, the model estimated the impacts of the effort controls used by vessels fishing on Category A DAS and did not estimate revenues that would result from Category B DAS programs.

Unlike fishing mortality, which is calculated on a calendar year basis, groundfish revenues can be summarized by fishing year and for this comparison FY 2004 data was used. There may be some revisions to these data in future years as additional records are added or corrected. Since the model inputs and economic analyses were done in nominal dollars, the same approach was used for this comparison. Revenues were adjusted to constant 1999 dollars to account for inflation.

CAM results for Amendment 13 groundfish revenues were predicted to decline by twenty-five percent from the 1998-2001 average. Nominal groundfish revenues in FY 2004, less revenues from SAPs and the Category B (regular) DAS Program, declined by thirty-one percent from the FY 1998-2001 average used in the economic analysis. These analyses adequately characterized the impact of the proposed measures. One reason for the difference could include price effects that cannot be evaluated by the model, as the CAII yellowtail SAP was observed to depress prices for yellowtail flounder, haddock, and winter flounder in the summer of 2004. A second reason could be due to revenues lost as a result of in-season management adjustments in the U.S./Canada area.

2. Impacts of Proposed Recreational Fishing Measures

The proposed alternatives would implement changes in the minimum size or seasonal prohibitions on cod possession in the Gulf of Maine. Analysis of the impact of these measures on expected mortality of Gulf of Maine cod required compilation of data on the seasonal and size distribution of recreational harvest of cod by mode. Additionally, since potential changes to the Gulf of Maine cod bag limit had been considered, the distribution of harvested catch by numbers of cod landed needed to be developed. The Marine Recreational Fisheries Statistics Survey (MRFSS) represents the best available source of data to meet these requirements for several reasons. First, no other data are collected to estimate the needed relationships for the private boat mode. While VTR records do provide sufficient information on total harvested cod, no data are collected on the size of fish caught nor is it possible to ascertain numbers of fish caught by individual anglers.

Data

Estimates of recreational harvest of Gulf of Maine cod were obtained by combining intercept and household data collected through the MRFSS for the states of Maine, New Hampshire, and Massachusetts. All harvested cod (catch types A and B1) attributable to intercept sites in either Maine or New Hampshire were assumed to be harvested from the Gulf of Maine. Massachusetts intercept sites border either the Gulf of Maine or Georges Bank with Cape Cod (Barnstable County) being a dividing line between the two. Therefore, all cod landed at Massachusetts intercept sites in counties north of Cape Cod were assigned to the Gulf of Maine while cod landed at intercept sites southward of the Cape were assigned to Georges Bank. Cape Cod itself was divided between the Gulf of Maine and Georges Bank depending upon which stock area was immediately adjacent to the intercept site. In general, this meant that sites with immediate access to Cape Cod Bay were be assigned to the Gulf of Maine while others on the South side of the Cape were assigned to Georges Bank. A post-stratified estimate of numbers of harvested cod was obtained by multiplying the estimated mean harvest (MRFSS intercept survey) by the weighted estimate of effort (MRFSS household survey) for each wave/mode strata and summing across all strata.

Monthly Distribution of Harvested Gulf of Maine Cod

The MRFSS sampling design is based on six 2-month waves beginning with wave one in January-February and ending with wave 6 in November-December. In the New England states, the MRFSS is not conducted during wave one and is not conducted in either Maine or New Hampshire during wave six due to low levels of fishing activity. Although sampling is based on a 2-month wave, dates for both intercepted trips and for household interviews are recorded making it possible to calculate monthly estimates of recreational harvest. Note, however, that monthly estimates for November and December are based only on cod fishing activity from Massachusetts and no data were available to estimate cod harvest during January and February. The VTR records indicate that total cod retained in the GOM during the months of January and February averaged less than 2% of annual totals from 2001 to 2004 so the absence of data for wave 1 is not likely to have an appreciable affect on estimates of biological impact. The absence of MRFSS data for Maine and New Hampshire during the months of November and December may under-represent the total harvest of cod in the party/charter mode during these months by approximately 30%. However, November and December only account for a small proportion of total harvested cod such that the combined effect of missing wave one and wave 6 data amount to just over 2% of total harvested cod in the party/charter mode. The potential impact of missing information on MRFSS estimates for the private boat mode is not known since there are no other independent data sources to use as a basis for comparison. Given weather conditions prevailing during

January and February it seems likely that private boat effort in the Gulf of Maine would be very low. Similarly, private boat effort during the months of November and December is also likely to be low, so the potential information loss during waves one and six seems likely to be even less than that of the party/charter mode.

With the exception of calendar year 2001, the monthly pattern of cod harvested in the party/charter mode is similar in all years with about half of all Gulf of Maine cod landed from March through June (Figure 1). In general the party/charter season begins in April, runs through the summer months and into September but starts to wind down in October through December. Note that the inter-annual differences in the proportion of cod (calculated by subtracting the cumulative percent from one month to the next) are greater during the spring and early summer (March through July) than they are in the late summer and fall. This means that potential impacts of measures effective during March-July may be more uncertain in a relative sense than estimated impacts for measures implemented from August-December.

The monthly pattern in MRFSS estimates for the private boat mode indicates that the seasonal distribution of harvested cod differs considerably from year to year (Figure 2) although the fishing season appears to be similar to that of the party/charter mode. That is, most cod tends to be caught during the summer months (May through August) with the exception of 2004 where more cod were harvested in September than in any other month. It is notable that proportionally mode cod are harvested in the Gulf of Maine by private boat anglers during the late fall as compared to party/charter anglers. Given the observed inter-annual variability in monthly harvest of cod the potential impact of recreational fishing measures that involve a seasonal prohibition on possession of cod will be subject to uncertainty.

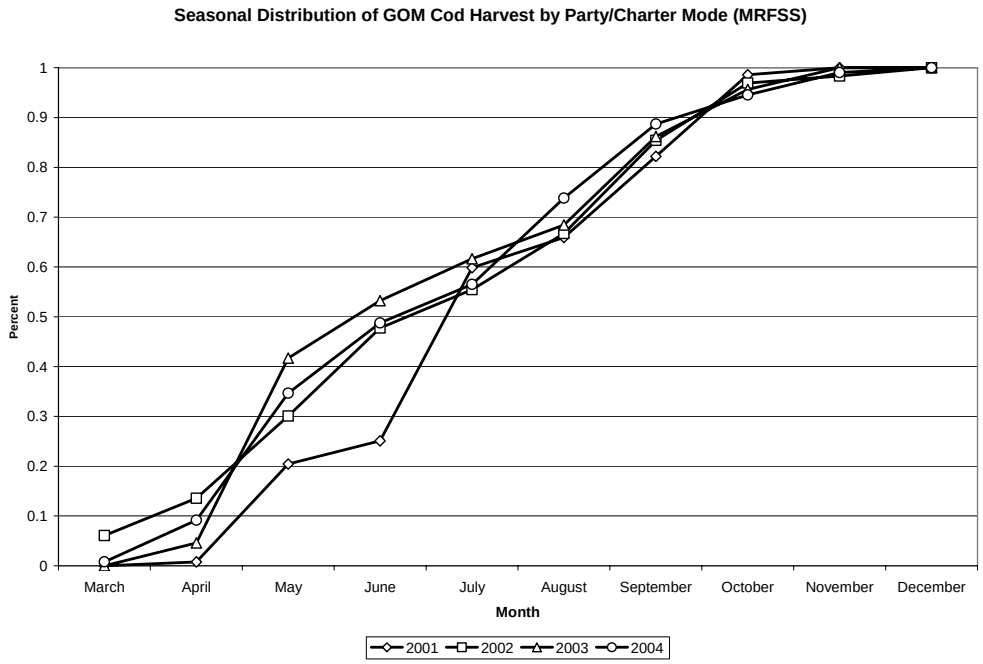

Figure 1 - Seasonal Distribution of Harvested Gulf of Maine Cod in the Party/Charter Mode for Calendar Years 2001 – 2004.

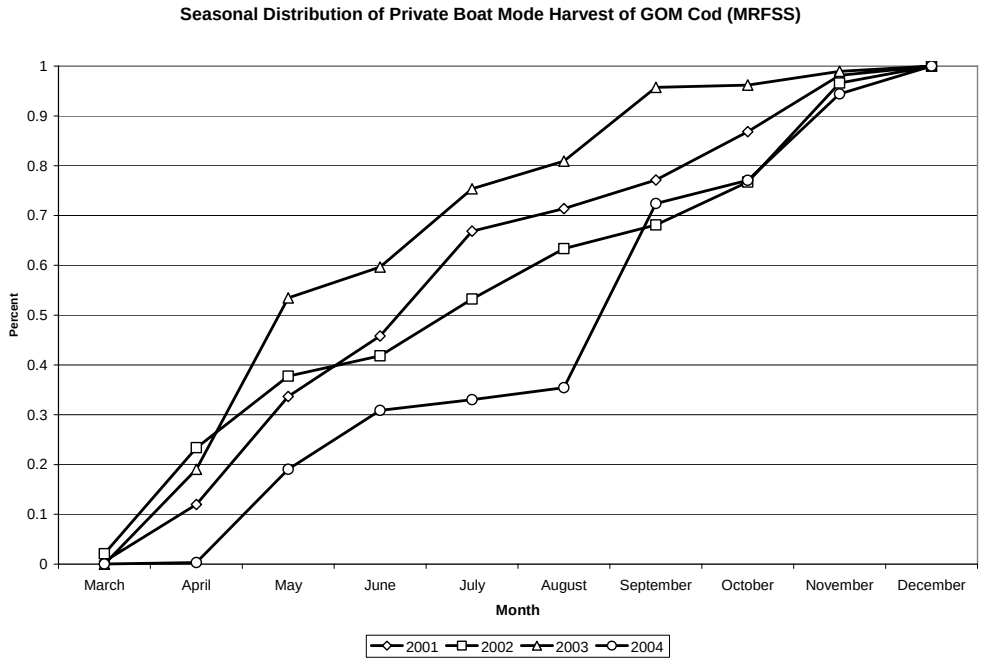

Figure 2 - Seasonal Distribution of Harvested Gulf of Maine Cod in the Private Boat Mode for Calendar Years 2001 – 2004.

Kept Catch Class

The MRFSS intercept survey collects data on numbers of fish kept per angler trip. Estimates of numbers of cod harvested when only one fish is retained or when only two fish are retained, and so on, are obtained by applying the estimated proportions for each catch class from the raw intercept data to the estimated number of trips taken by each wave/mode/state strata then summing across all strata. Due to known low sample sizes in the party/charter mode, beginning in 2003 in the Northeast region, the MRFSS changed its sampling strategy by using a captain call-back to estimate effort and placing samplers on-board party/charter vessels to monitor catch and to conduct biological sampling (lengths and weights) of the catch. This change has lead to a significant increase in the sample sizes needed to estimate the characteristics of the party/charter mode harvested catch. For this reason, the distribution of recreational harvest of gulf of Maine cod by kept catch class was based on calendar year 2003 and 2004.

The distribution of Gulf of Maine cod by kept catch class was nearly identical for both 2003 and 2004 in the party/charter mode (Figure 3). The median number of fish kept per angler was three cod in both years. With full compliance with the bag limit that had been implemented during these years there should be no angler trips that retained more than 10 cod, but in both 2003 and 2004 some portion of the retained catch exceeded the bag limit. These occasions represented respectively, about 2% and 7% of kept catch in 2003 and 2004. Note that even for instances where the bag limit was exceeded the actual measure of non-compliance is the difference between the actual kept catch and the bag limit. That is, the proportion of party/charter mode kept catch that actually exceeded the bag limit was less than 1% in 2003 and just over 2% in 2004.

Retained Gulf of Maine cod in the private boat mode in 2003 differed markedly from that of 2004 (Figure 4) and show an increase in the proportion of harvested cod associated with higher numbers of cod kept per angler trip. For example, in 2003 the median retained catch was about four cod, whereas the median number of cod retained in 2004 was six cod. Compliance with the bag limit was high at 99% or better in both years.

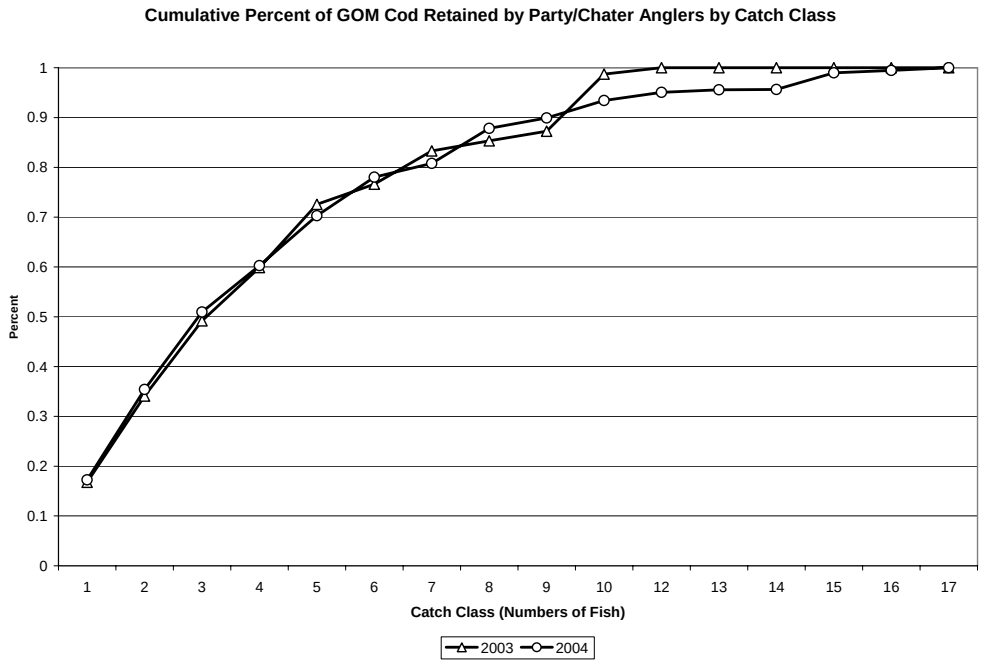

Figure 3 - Distribution of Gulf of Maine Party/Charter Mode Harvest of Cod by Catch Class in Numbers of Cod

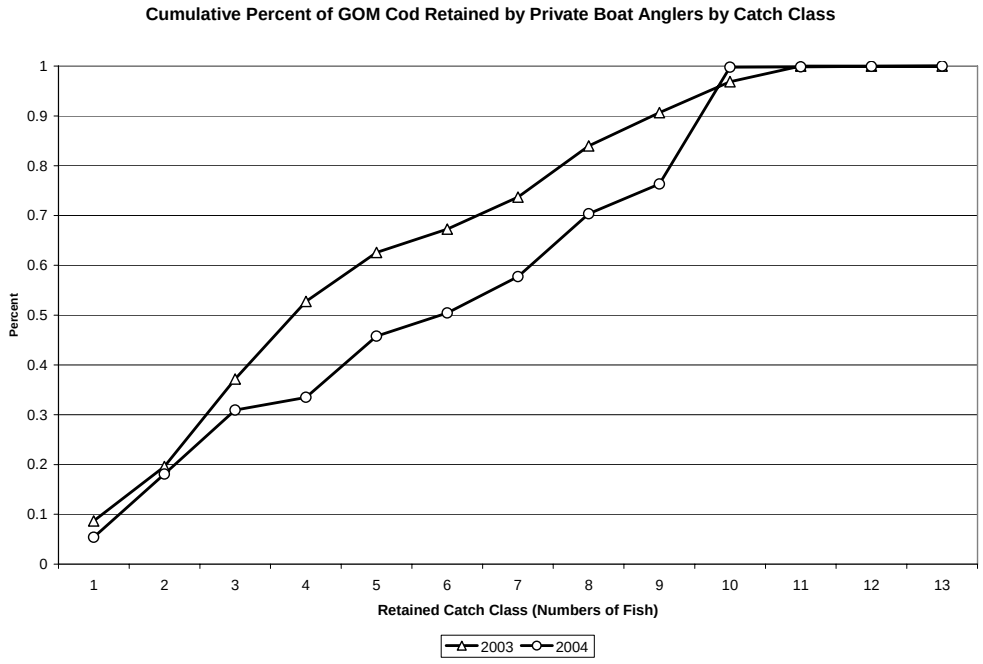

Figure 4 - Distribution of Gulf of Maine Private Boat Mode Harvest of Cod by Catch Class in Numbers of Cod

Size Distribution of Harvested Gulf of Maine Cod

The size distribution of recreationally harvested cod was estimated by calculating the proportion of fish in each size increment (in inches) from measured fish on the MRFSS intercept survey. As noted previously, the MRFSS changed its sampling strategy beginning in 2003 in the Northeast by using a captain call-back to estimate effort and placing samplers on-board party/charter vessels to monitor catch and to conduct biological sampling (lengths and weights) of the catch. This change has lead to a significant increase in the sample sizes needed to estimate the size distribution of the party/charter mode harvested catch. For this reason, the size distribution of recreational harvest of gulf of Maine cod was based on calendar year 2003 and 2004.

The size distribution of Gulf of Maine cod harvested in the party/charter mode was similar in both 2003 and 2004 (Figure 5) although the cumulative distribution for calendar year 2004 lies everywhere to the left of 2003 which is indicative of a change in the size distribution in 2004 resulting in proportionally more fish harvested at smaller sizes than was the case in 2004. The size distribution of harvested fish (i.e. those fish that are actually retained by the angler) includes both legal (22" or greater) and sub-legal fish. The proportion of harvested cod that were below the minimum size was about 5% in 2003 and 7% in 2004.

Compared to party/charter mode, there were much greater differences in the size distribution for Gulf of Maine cod harvested in the private boat mode between calendar years 2003 and 2004 (Figure 6). Specifically, the size distribution for 2004 is shifted much more toward smaller size cod than was the case in 2003 as the median size cod was 25-inches in 2003 but was 23-24-inches in 2004. The proportion of cod below the minimum size was also larger in 2004 (17%) than it was in 2003 (14%).

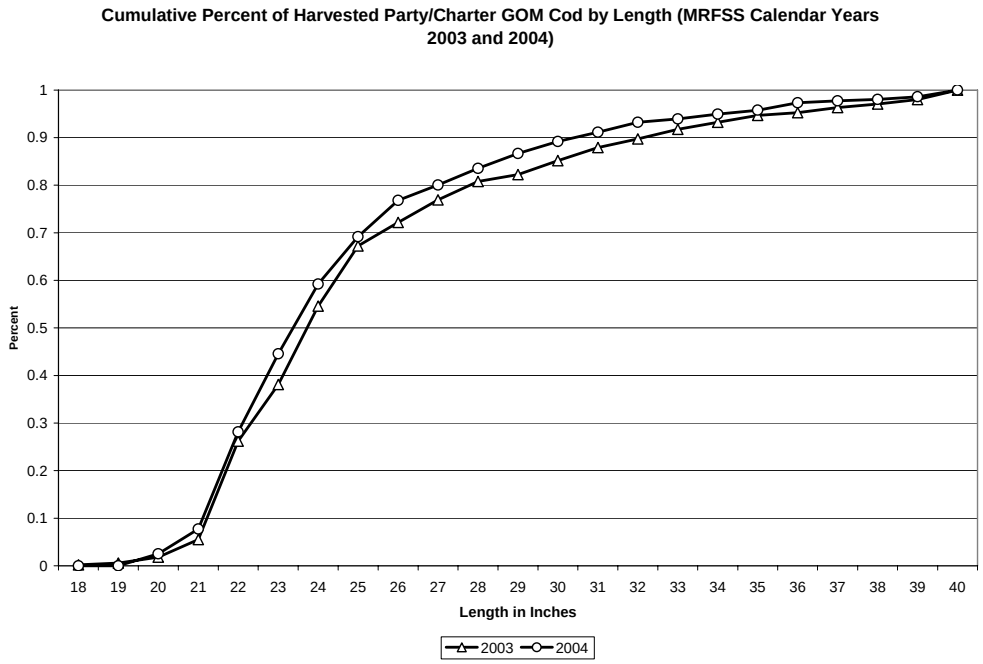

Figure 5 - Size distribution of Gulf of Maine cod harvested in the party/charter mode (MRFSS calendar years 2003 and 2004)

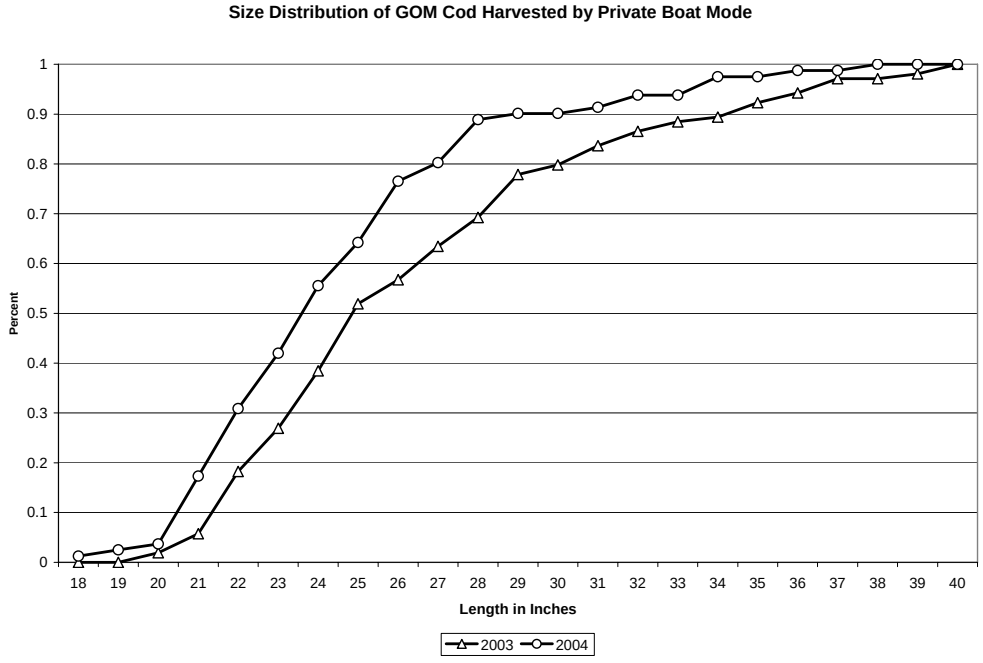

Figure 6 - Size distribution of Gulf of Maine cod harvested in the private boat mode (MRFSS calendar years 2003 and 2004)

Method

Data for calendar year 2004 were selected for purposes of analyzing the impact of the proposed recreational fishing measures. These data were selected because they represent the most recent available and should, therefore, reflect contemporary stock conditions such as abundance and size distribution of the Gulf of Maine cod population exploited by recreational anglers. The impact of the recreational measures on harvested Gulf of Maine cod was simulated by applying these measures to the observed harvest by mode. The underlying assumption herein is that trips taken during calendar year are representative of fishing trips in terms of catch and numbers of trips that would be taken in 2006 when the proposed measures would be implemented. This assumption may be more likely to hold for the party/charter mode since the seasonal pattern of landings, kept catch class, and size distribution of kept catch were reasonably stable from year to year. By contrast, inter-annual differences in private boat mode trips were considerably greater. Thus, at least in relative terms, the estimated impacts of the proposed recreational measures are likely to be more uncertain for the private boat as compared to the party/charter mode.

Since some portion of the 2004 harvest did not comply with existing minimum size or bag limits, the portion not in compliance was trimmed to avoid the possibility of double-counting these observed illegal harvests as either a conservation benefit or additional mortality. The trimmed data represent a benchmark against which the impact of changes to recreational regulations was measured. Procedurally, these changes were estimated by first identifying the portion of the 2004 harvested catch that may be affected by the regulations and the portion of the harvest that would not be affected. The latter was assumed to be harvested while the former was assumed to either be retained illegally or released where released cod were assumed to be subject to some mortality. The observed non-compliance rates for 2004 by mode (17% and 10% for minimum size for private boat and party/charter modes respectively) were assumed to apply to any new size limit. There have been no published studies of release mortality for recreationally caught cod. As part of a study by Farrington (1998) on survival of longline-caught cod and haddock 129 cod were caught using a jig on the third cruise and used as a comparison to longline caught cod. Fish were caught, kept in a tank with chilled and aerated seawater before they were placed in cages where they were held for 72 hours. Cages were set on the sea floor at depths equivalent to the depths in which the fish were caught. After 72 hours, cages were retrieved and dead and alive cod and haddock were removed. 44 percent of jigged cod were alive and 56 percent were dead. For fish over 38 cm (38 cm was the modal length in this experiment), 50 percent were alive/dead. For fish less than 38 cm, 27 percent were alive and 73 percent were dead. Researchers were uncertain whether to attribute this substantial mortality to the handling process or the fish capture process. Fish were brought to surface quickly and air bladders were distended. While this study may not duplicate recreational conditions it does indicate that release mortality for hook-caught fish may exceed 50%. To account for this uncertainty a sensitivity analysis was conducted using release mortality of from zero to 50% in increments of 10%.

Summing the three sources of mortality (legal harvest, illegal harvest, and release mortality) results in an estimate of the total mortality associated with the proposed measures. This estimate is then compared to the benchmark (calendar year 2004) to compute a percent reduction in exploitation by mode.

Results

Option 1 – Option 1 would implement a prohibition on possession of Gulf of Maine cod November 1 through March 31 and an increase in the size limit to 24-inches. This measure would not prevent either private or party/charter passengers from fishing for groundfish (haddock in particular) which would likely result in some uncertain bycatch of cod. However, since the

MRFS data is not adequate to estimate potential bycatch rates of cod when anglers are targeting haddock, it was assumed that the closure would be equivalent to a cessation of fishing. This assumption is evaluated in a subsequent section.

The estimated impact on Gulf of Maine cod mortality of the combined Option 1 measures ranged from a high of about 41% for both private and party/charter modes at zero release mortality to a low of 31% and 24% for private boat and party/charter modes respectively when discard mortality is assumed to be as high as 50% (Table 2). The estimated impacts between the two modes diverge as assumed release mortality increases because proportionally more 22 and 23-inch cod were in the party/charter mode total harvest in 2004 than was the case for the private boat mode. This means that as the release mortality increases the estimated biological impact declines more rapidly compared to the private boat mode.

The results in Table 1 also demonstrate that the seasonal closure for possession of cod and the size limit change have very different impacts on the two recreational modes. A closed season alone reduces cod exploitation by 21% as compared to 6% for the party/charter mode. This is because a larger proportion of the private boat harvest of cod occurs during the closure months (the month of November in particular) as compared to the party/charter mode. This does not appear to be an artifact of the MRFSS calendar year selected for analysis since the selected closure months accounted for an average of 17% of total private boat harvest of Gulf of Maine cod as compared to almost 7% for the party/charter mode for calendar years 2001-2004.

Table 2 - Impact of Recreational Harvest of Gulf of Maine Cod by Proposed Measure and Mode

	Seasonal Closure Impact		Size Limit Impact		Combined Impact	
Release Mortality	Private Boat	Party/Charter	Private Boat	Party/Charter	Private Boat	Party/Charter
0%	-20.9%	-6.2%	-24.8%	-36.8%	-40.6%	-40.8%
10%	-20.9%	-6.2%	-22.4%	-33.2%	-38.6%	-37.3%
20%	-20.9%	-6.2%	-19.9%	-29.5%	-36.6%	-33.8%
30%	-20.9%	-6.2%	-17.4%	-25.8%	-34.7%	-30.4%
40%	-20.9%	-6.2%	-14.9%	-22.1%	-32.7%	-26.9%
50%	-20.9%	-6.2%	-12.4%	-18.4%	-30.7%	-23.5%

While the season closure had a comparatively larger impact on the private boat mode the opposite would be true if the 24-inch size limit were the only measure. The size limit has a comparatively larger impact on the party/charter mode, because as noted previously, proportionally more 22-24 cod are landed in the party/charter mode than in the private boat mode.

The impact of both recreational measures implemented simultaneously is not equal to the sum of the individual measures. This is because the impact of the seasonal closure does not include the benefit of the increased size. Similarly, the impact of a size limit does not include the benefit from the closed season. Notably, the conservation objective for Gulf of Maine cod cannot be met for both modes simultaneously by implementing either measure separately but would be met as proposed depending on the realized release mortality. The sensitivity test indicates that the conservation objectives would be met for both private boat and party/charter modes up to a release mortality of 30%.

Option 2 – Option 2 would implement a 10-month seasonal cod possession prohibition inside the Western Gulf of Maine Closure area. While the seasonal prohibition would affect both private boat and party/charter vessels, the MRFSS does not provide any information other than distance from shore that would identify how much cod may be harvested from this area. The VTR records provide the only data source that may be used to evaluate the impact of a prohibition on cod possession inside the closure area. During fishing year 2004 46% of total GOM cod retained by party/charter anglers came from trips taken in the WGOM closure area. The proposed 10 month seasonal prohibition on cod possession from June 1 to March 31 would result in a 35% reduction in GOM cod exploitation. Given monthly proportion of GOM cod landed in the WGOM area (see Table 3) there may be other combinations of closure months that would meet the same reduction in exploitation. For example, an April 1 to August 31 seasonal prohibition would also yield a 35% reduction in exploitation.

Table 3 - Monthly Proportion of GOM Cod Landed Inside the WGOM Closure Area for FY2004

Month	Proportion
February	0.01%
March	1.33%
April	3.27%
May	8.57%
June	7.13%
July	7.66%
August	8.15%
September	6.21%
October	3.18%
November	0.83%
December	0.07%

The estimated reduction in party/charter exploitation may be biased upwards since it does not account for the possibility that party/charter trips will be taken elsewhere in the GOM. Further, the estimated change in exploitation may not be sufficient to achieve the conservation objectives unless the proportion of the private boat mode harvest is similar to that of the party/charter mode.

Option 3 – Option 3 would make implement a prohibition on possession of Gulf of Maine cod during the months of April and May for both private and for party/charter anglers. Based on calendar year 2004 MRFSS data, this closure would result in a 19% reduction in exploitation in the private mode and a 34% reduction in the party/charter mode. The estimated exploitation rate change for the party/charter mode is consistent with the 2001-2004 four-year average proportion of landings (33%) for April and May. By contrast, the proportion of harvested Gulf of Maine cod in the private boat mode in April and May was a four-year low in calendar year 2004. With a four-year average of 36% the estimated impact of the April-May closure of 19% based on 2004 data alone appears to underestimate the impact on private boat mode harvest of Gulf of Maine cod; perhaps by as much as half.

Assessment of By-Catch Rates of GOM Cod on Party/Charter Trips that Target Haddock

The proposed recreational measures all include some form of a seasonal prohibition on the possession of cod. As noted by the PDT a prohibition on possession of cod does not necessarily mean that no cod will be caught as long as private boat and party/charter vessels continue to take groundfish trips. According to estimates using MRFSS data the proportion of trips that targeted haddock across modes ranged from a low of 36% in the private boat mode in 2003 to a high of 80% in the party/charter mode in 2002 (Table 4). These data are suggestive that cod is frequently caught on trips targeting haddock but cannot be used to estimate a bycatch rate due to low sample sizes. Instead, the party/charter VTR's were queried for purposes of calculating an estimate of cod bycatch on directed haddock trips. Note that even these data may not completely reflect potential changed fishing practices in response to a zero possession of cod since cod possession was legal on all observed trips to date.

Table 4 - Proportion of Gulf of Maine Trips that Targeted Haddock that also Caught Cod by Mode (MRFSS 2001-2004)

	Private Boat	Party/Charter
2001	0.44	0.48
2002		0.80
2003	0.36	0.56
2004	0.51	0.53

According to the Recreational Advisory Panel, party/charter vessels are able to target haddock with low bycatch of cod and went on to note that many trips have already switched over to targeting haddock instead of cod. To assess potential cod catch rates on targeted haddock trips the party/charter VTR were queried for FY2001 through FY2004.

During FY2001 only 8 trips (0.2%) reported keeping only haddock in the GOM and 2,028 trips (44%) only kept cod (Table 5). Of the remaining trips, the overwhelming majority (2,243 compared to 325) retained more cod than haddock. In FY2002 the relative importance of haddock increased and has increased in every year since such that only 807 of 4,280 trips (19%) retaining either cod or haddock kept only cod in FY2004. The number of trips that retained only haddock increased to 62 in FY2004 but still represented only 1.4% of the total.

Table 5 - Total trips by composition of cod and haddock on GOM Party/Charter VTR's reporting retention of either cod or haddock.

Trip Type	FY 2001	FY 2002	FY 2003	FY 2004
More Haddock Than Cod	325	639	808	1621
More Cod Than Haddock	2243	2160	2309	1790
Only Cod	2028	1392	1205	807
Only Haddock	8	33	36	62
Total Trips	4604	4224	4358	4280

Table 4.

The number of trips where the number of haddock retained exceeded cod nearly doubled from FY2001 (325) to FY2002 (639); increased by about 25% from FY2002 to FY2003 (808) but doubled from FY2003 to FY2004 (1621) (see Table 4). At a minimum, these trips represent occasions where haddock was strictly greater than 50% of total combined cod and haddock. Compared to FY2001 the distribution of the proportion of haddock retained has shifted in all

other years toward higher retention of haddock for percentiles at the median or above (Table 6). For example, in FY2001 the proportion of haddock retained was 69% at the 75th percentile but increased to between 75 and 78% in FY2002 through FY2004. These data indicate that targeting of haddock has increased relative to FY2001.

Table 6 - Distribution of proportion of haddock to total combined cod and haddock for GOM party/charter trips retaining both cod and haddock.

Percentile	FY 2001	FY 2002	FY 2003	FY 2004
Maximum	0.96	0.98	0.99	0.99
0.99	0.93	0.96	0.97	0.96
0.95	0.85	0.92	0.91	0.91
0.9	0.78	0.88	0.87	0.88
0.75	0.69	0.78	0.75	0.78
Median	0.61	0.65	0.65	0.67
0.25	0.57	0.57	0.57	0.58
0.1	0.53	0.54	0.54	0.54
0.05	0.52	0.53	0.53	0.53
0.01	0.51	0.51	0.51	0.51
Minimum	0.51	0.51	> 0.50	> 0.50
N	325	639	808	1621

Data reported in Table 5 represent trips where haddock was more than 50% of retained catches of cod and haddock; a level that, while high, may not be considered reflecting potential bycatch rates of cod while targeting haddock during a seasonal prohibition on cod retention. Instead by-catch rates of cod were estimated for trips where haddock was at least 75% of combined cod and haddock. The bycatch rate of cod for all trips in the GOM that retained at least 75% haddock ranged within a narrow interval of 0.19 and 0.21 from FY2001 through FY2004 (Table 7). The estimated bycatch rate does not differ substantially from the GOM average across options indicating that approximately 1 cod may be expected to be discarded for every five haddock retained, regardless of which option is eventually selected.

Table 7 - Estimated bycatch rate for cod on GOM party/charter trips where haddock was at least 75% of combined cod and haddock.

	FY 2001	FY 2002	FY 2003	FY 2004
Option 1	NA	NA	0.20	0.21
Option 2	0.28	0.21	0.23	0.22
Option 3	0.21	0.19	0.18	0.18

Option 1 closed season is November through March throughout GOM
Option 2 closed season is June through March in the WGOM
Option 3 closed season is April and May throughout the GOM

The impact that such a discard rate would have on the conservation objectives for cod depends on the release mortality. Assuming a release mortality of 50% means that 1 cod may be expected to be killed for every 10 haddock retained while a release mortality of 10% would mean that 1 cod would be killed for every 100 retained haddock. For this reason, the impact on Gulf of Maine cod mortality associated with fishing for haddock during a seasonal prohibition on cod possession is

uncertain. However, some discard mortality may be expected which should be accounted for in assessing the conservation effectiveness of any proposed option.

3. Analyses of differences in flipping rates between observed and non-observed eastern Georges Bank haddock SAP trips during FY2005

This analysis addresses whether there were significant differences between the flipping rates for fishing trips with and without an observer in the eastern US/Canada Haddock SAP during FY2005. If the occurrence of a flipped trip was independent of an at-sea observer being present, then the expected number of flipped trips that would be the product of the probability of an observed trip times the probability of a flipped trip times the total sample size. These expected values are shown on the right-hand side of Table 1 below.

Two tests for independence of the two factors (flipping and at-sea observer) were applied: Likelihood Ratio Chi-square and Fisher's exact test. Since the marginal total is fixed for the number of observed trips (the number of observed trips was chosen) but the marginal total for the number of flipped trips was not (the number of flipped trips depended on fish catch amount and compliance), one would generally use the Chi-square test for independence in this case. However, several of the expected cell counts were below 5 trips (see Table 8). As a result, the application of the Chi-Square test may not be appropriate since its distributional assumptions may not be satisfied. Thus, both tests were used to evaluate whether flipping rate was independent of having an at-sea observer onboard.

As in previous analyses, the hypothesis that flipping and observation were independent was tested at the α=0.10 level. At this confidence level, one would expect to see larger deviations than those observed roughly 1 out of 10 times due to chance alone. The odds ratio of 1:10 was judged to be adequate to draw a conclusion given that the binomial sample size needed to detect a difference of 0.25 (from a default proportion of p=½) with a power of 0.8 is roughly 31, somewhat lower the total number of trips (n=39 trips). Computer output from SAS v8 contingency table analyses are shown below.

Table 8 - Observed and expected counts of flipped trips by quarter

Observed Counts of Flipped Trips
Observed Eastern US/CAN Haddock SAP in FY2005

	Observed	Not Observed	Marginal Totals
Flipped	3	0	3
Not Flipped	6	30	36
Marginal Totals	9	30	39

Expected Counts Assuming Independence of Trip Flip Rate and Observation

Expected Eastern US/CAN Haddock SAP in FY2005

	Observed	Not Observed	Marginal Totals
Flipped	1	2	3
Not Flipped	8	28	36

Marginal Totals	9	30	39

Both tests indicated that the hypothesis of independence should be rejected (Table 9, Likelihood Ratio Chi-Square Test, P<0.01). The evidence indicates that the processes of having a trip flipped and having a trip observed were dependent for the Eastern US/Canada Haddock SAP in FY2005. No confidence intervals for the proportions of flipped trips on observed versus non-observed trips could be evaluated since all of the flipped trips occurred with an observer (p=100%) and no trips were flipped without an observer.

Table 9 - Contingency Table Analysis of FY2005 Eastern US/Canada Haddock SAP Trip Flipping Rates

Contingency Table Analysis of Flipping Rates in 2005 Eastern US/CAN Haddock SAP 1

Null hypothesis: Observed flipping rate is independent of at-sea observation

14:12 Friday, December 23, 2005
The FREQ Procedure
Table of a by b

a(FLIPPED TRIP) Frequency	b(OBSERVED TRIP) YES	NO	Total
YES	3	0	3
NO	6	30	36
Total	9	30	39

Statistics for Table of a by b

Statistic	DF	Value	Prob
Chi-Square	1	10.8333	0.0010
Likelihood Ratio Chi-Square	1	9.6955	0.0018
Continuity Adj. Chi-Square	1	6.6475	0.0099
Mantel-Haenszel Chi-Square	1	10.5556	0.0012
Phi Coefficient		0.5270	
Contingency Coefficient		0.4663	
Cramer's V		0.5270	

WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Fisher's Exact Test

Cell (1,1) Frequency (F)	3
Left-sided Pr <= F	1.0000
Right-sided Pr >= F	0.0092
Table Probability (P)	0.0092
Two-sided Pr <= P	0.0092

Sample Size = 39