Evaluating the Effects of Amendment 13C, Amendment 16, and Amendment 17 Regulations on Red Snapper Removals by south Atlantic Commercial Fisheries

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Introduction/Background

A recent stock assessment of red snapper off the south Atlantic coast of the United States indicates the stock is undergoing overfishing and is severely overfished (SEDAR15 2009). Red snapper fishing mortality during 2006 was 7.67 times higher than the fishing mortality rate associated with F_{MSY} (=$F_{40\%SPR}$) and spawning stock biomass (SSB) was 2 percent of the SSB at maximum sustainable yield (SEFSC 2009). The south Atlantic Fishery Management Council (SAFMC) is currently developing Amendment 17 to the Snapper-Grouper Fishery Management Plan to address overfishing of red snapper and rebuild this stock (SAFMC 2009). Alternatives under consideration include a year-round prohibition on red snapper harvest, possession, and retention in the south Atlantic EEZ, as well as year-round spatial area closures for all snapper-grouper harvest and possession, (except with spearfishing equipment). The overall size and extent of these area closures is contingent on bycatch mortality outside the closed areas and the overall percent reduction in fishing mortality needed to end overfishing. Assuming average recruitment, given $F_{MSY} = F_{40\%SPR}$, an 85 percent reduction in total removals of red snapper is needed to reduce F by 87% and end overfishing.

In October 2006, the SAFMC implemented Snapper-Grouper Amendment 13C. This amendment was developed, in part, to address overfishing of snowy grouper, golden tilefish, and black sea bass through quota reductions and alterations to allowable gear configurations. On July 29, 2009 the SAFMC implemented Snapper-Grouper Amendment 16. This amendment was developed to address overfishing of gag and vermilion snapper in the south Atlantic. Amendment 16 establishes a four month commercial and recreational closed season (January-April) for shallow-water grouper, establishes a five-month recreational closed season for vermilion snapper (November-March), modifies gag and vermilion snapper commercial quotas, and reduces bag limits for vermilion snapper, gag, and other groupers.

The intent of this analysis is to evaluate potential changes in red snapper commercial harvest and discards associated with Amendment 13C and Amendment 16 regulatory changes, and to evaluate the cumulative effects of these regulations in conjunction with the regulations proposed by Amendment 17.

Methods

Baseline

To determine baseline landings for red snapper, landings reported in the commercial logbook (provided by Kevin McCarthy, SEFSC, on April 6, 2009) were summarized by statistical area for 2005 – 2007 using custom software written in SAS (SAS Institute Inc., Cary, NC). To maintain confidentiality, some landings were aggregated across grids. Year was assigned using the date the fish were landed. South Atlantic red snapper landings were considered any landings reported in statistical areas 2400 through 3700. Additionally, the number of unique trips and vessels were summarized by year and area. Because the commercial logbook does not account for all commercial landings (e.g. sales made on state permits), landings were scaled up to account for this missing data. Percent scalars for 2005 and 2006 logbook landings were determined using commercial landings estimates reported in SEDAR 15 (2009; see Table 4, p. 19). The percent scalar for 2007 logbook landings was determined using commercial landings estimates derived using identical methods to SEDAR15 (D. Gloeckner, NMFS Beaufort Lab, pers. comm.). Logbook landings for 2005, 2006, and 2007 were scaled up by the respective SEDAR and Beaufort Lab scalars to create baseline commercial landings for these years. Next, an average of 2005 – 2007 landings was computed for each area. These scaled landings represent the baseline total commercial landings by area.

Reliability of Depth Records

To determine the utility of partitioning commercial landings by area and depth, the accuracy of reported fishing depth in the commercial logbook was investigated. Digitized bathymetric maps (www.nauticalcharts.noaa.gov) for the south Atlantic were projected in ArcGIS (ESRI, Redlands, CA) and overlaid with commercial logbook grids. The maximum and minimum depths in fathoms within each grid cell were visually identified, then converted to feet. To establish a buffer for measurement uncertainty, 50 feet was subtracted from minimum depths and added to maximum depths. Next, depth records for red snapper landings reported in the commercial logbook were compared to the valid range of depths for the relevant logbook grid area. Unrealistic reported depth values were flagged. Additionally, mean depth of fishing was summarized on a trip level for commercial trips reporting logbook landings of managed reef fish species in the south Atlantic from 2005-2008. Finally, the percentage of reporting landings at depths between 30-73 m among trips landing red snapper within cells closed by Alternatives 5 and 6 was summarized.

Economic Trip Reduction Model

To predict the impacts of regulations associated with Amendments 13C and 16 upon commercial trips that had previously encountered red snapper, and project associated reductions in take, an economic trip reduction model was developed (Waters 2008).

The model hypothetically imposed proposed regulations on individual fishing trips as reported to the logbook database. Each reported trip was examined with regard to a combination of regulations implemented in Amendment 13C as well as proposed rules in Amendment 16, and the various proposed alternatives in Amendment 17. The effects of the rules on trip catches, revenues and costs were calculated from a model run using an opportunity cost of $52 per person. A three-year average was used to estimate the expected effects of proposed regulations so that anomalies that may have affected fishing success in any one year would be averaged out. Logbook data for the three year period, 2005 – 2007, were used to simulate the fishery. A comprehensive description of the model may be found in Appendix A.

Evaluating Impacts of Management Alternatives

Outputs from the economic trip reduction model were summarized to quantify landings, trips, and discards by area and by management action for simulations based on 2005, 2006, and 2007 logbook records. The impacts of Amendment 13C (A16_NO_ACTION), Amendment 16 (A17_NO_ACTION), and various alternatives of Amendment 17 (A17_ALT2, A17_ALT3, A17_ALT4, A17_ALT5, A17_ALT6) were evaluated (Table 1). Red snapper landings (A13C_NO_ACTION, A16_NO_ACTION, A17_NO_ACTION) and discards attributable to proposed red snapper fishery closures (A17_ALT2, A17_ALT3, A17_ALT4, A17_ALT5, A17_ALT6) were computed by area for 2005, 2006, and 2007. Discards were assumed to be zero for fish harvested with spearfishing gear.

Projected annual landings and new management discard estimates were then scaled up to represent all commercial fishing activities using the scalars described previously. Next, three-year average removals were computed for each management scenario. Note that these removals do not account for baseline discard rates, which will be discussed later.

Because the baseline case for the economic trip reduction model (A13C_NO_ACTION) eliminates unprofitable trips, outputs for all model runs underestimate landings. Projected cumulative reductions in total removals by area were computed by calculating percent reductions in removals by area for each management scenario relative to the baseline model, then multiplying this percentage by the baseline landings by area.

Total Removals

Total removals by the commercial fishery must account for discards. In August 2001, the Southeast Fisheries Science Center (SEFSC) initiated a program to collect information regarding the numbers of fish that were being discarded in Gulf of Mexico and south Atlantic fisheries (e.g., 'undocumented discards'). To collect this information, the SEFSC developed a form that supplements the existing vessel coastal logbook forms that are currently mandatory for those fisheries (Poffenberger and McCarthy, 2004). A 20% random sample of the vessels with south Atlantic snapper-grouper, king mackerel,

Spanish mackerel or shark permits were selected to report the number of animals discarded by species. To assure that the sample was representative of the total universe of vessels with these Federal permits, the universe of permitted vessels was stratified and a random sample selected, without replacement, from each stratum (SEDAR15 2009).

Following the general linear modeling approach used in SEDAR 15 (2009), estimates of red snapper discards in the south Atlantic were derived for 2005 – 2007. These estimates differed slightly from previously published (SEDAR15 2009) estimates due to additional quality control on the logbook data (NMFS SEFSC Miami, FL, pers. comm.).

Discard estimates in numbers were converted to discard estimates in weight using the mean (2007 – 2009) ratio of discards in weight to discards in numbers from red snapper stock assessment projection scenario H1 ($F = F_{current}$) in SEFSC (2009). Discard estimates in weight for each year (2005 – 2007) were converted to dead discards by multiplying by the commercial release mortality for red snapper, estimated at 90% (SEDAR15 2009). These baseline dead discards were assumed to occur spatially in proportion to landings by grid. A mean dead discard estimate for 2005 – 2007 was computed and added to mean annual (e.g. 'baseline') landings to obtain an estimate for baseline removals.

To compute reductions in red snapper mortality due to management actions, projected landings under scenarios permitting red snapper harvest (A13C_NO_ACTION, A16_NO_ACTION, A17_NO_ACTION) and projected new discards attributable to proposed red snapper fishery closures (A17_ALT2, A17_ALT3, A17_ALT4, A17_ALT5, A17_ALT6) were treated as proxies for the commercial fishery's rate of interaction with the red snapper stock. The percent reductions in these 'rates of interaction' from the baseline model (e.g. A13C_NO_ACTION) were used as scalars to compute dead discards 'rescaled from baseline' for each model scenario. 'New dead discards' were computed as projected new discards attributable to proposed red snapper fishery closures multiplied by the commercial release mortality for red snapper, estimated at 90% (SEDAR15 2009).

Dead discards were distributed spatially in proportion to landings under scenarios permitting red snapper harvest and in proportion to projected new discards attributable under scenarios modeling red snapper fishery closures. To compute total removals under scenarios permitting red snapper harvest (A13C_NO_ACTION, A16_NO_ACTION, A17_NO_ACTION), landings were added to 'rescaled from baseline' dead discards. To compute total removals under scenarios prohibiting red snapper harvest (A17_ALT2, A17_ALT3, A17_ALT4, A17_ALT5, A17_ALT6), projected 'new dead discards' were added to 'rescaled from baseline' dead discards.

Results

Baseline

Logbook reported landings of red snapper, in thousand pounds whole weight (TP), for red snapper by area were highest in grid 3080 in 2007 (38 TP), and ranged annually between 81 – 117 TP for the entire south Atlantic (Table 2). Annual scalars to account for unreported commercial landings ranged from 3 – 6% (Table 3). Baseline scaled landings by area are reported in Table 4.

Red snapper commercial landings occur predominantly off the northeast coast of Florida (Figure 1). Based on a three-year average (2005 – 2007), over 32 TP (30% of the fishery) per year were landed in cell 3080, and the majority of other landings occur in bordering areas (2880, 2980, 3081, 3180, and 3179). A large portion of commercial red snapper landings also occur off the coast of South Carolina (Areas 3278, 3279, and 3378). Similarly, the majority of trips occur off the northeast coast of Florida and off the coast of South Carolina (Figure 2).

Reliability of Depth Records

Depth was determined to be an unreliable field in the commercial logbook, as depth records were often unavailable (Table 5). Reporting of depth improved through time, with no missing 'depth' records in 2007. However, a significant percentage of reported depths each year were well outside the range of depths available within the reported fishing statistical area. Some landings of red snapper were reported in cells with minimum depths beyond 1000 ft, but these cases only represented 1.43% of total landings.

When averaging across all years (2005-2008), all gears, and all statistical areas, mean depth of fishing was 133 ± 1 ft (mean ± SE). Removing the closed cells in Alternative 6 from consideration had little impact upon this average, suggesting the impacts of this closure upon the average fishing depth for the south Atlantic commercial fleet may be minimal. When considering only trips landing red snapper, the mean fishing depth was 140 ± 1 ft. Excluding trips in the areas closed by Alternative 6 unexpectedly increases mean fishing depth to 152 ± 2 ft.

A total of 1663 out of 2167 (77%) of trips reporting red snapper landings in the statistical areas closed by Alternative 5 reported their red snapper landings within the depth range (30-73 m) that would be closed by Alternative 3. Alternative 3 only closes 59% of the area closed by Alternative 5. Similarly, 2503 out of 3104 (81%) of trips reporting red snapper landings in the statistical areas closed by Alternative 6 reported their red snapper landings within the depth range (30-73 m) that would be closed by Alternative 4. Alternative 4 only closes 54% of the area closed by Alternative 6. These observations all suggest a non-homogenous distribution of the stock, with a greater concentration of red snapper between 30-73 m.

Economic Trip Reduction Model

Table 6 lists projected commercial removals of red snapper, not including baseline discards, under various management scenarios derived by applying economic trip reduction model percent reductions in landings from baseline A13C_NO_ACTION model to baseline commercial landings. Numbers for Amendment 13C, Amendment 16, and Amendment 17: No Action represent projected landings. As all other Amendment 17 actions prohibit the harvest of south Atlantic red snapper, numbers for other Amendment 17 actions represent new discards.

Figure 3 illustrates projected commercial landings of south Atlantic red snapper by area, based on economic trip reduction model scenario A17_NO_ACTION, which incorporates anticipated reductions in landings given implementation of Amendment 13C and Amendment 16. The largest percent reductions from baseline landings tend to occur in the areas previously described as the core of the red snapper fishery.

Total Removals

The mean (2007 – 2009) ratio of discards in weight to discards in numbers from the south Atlantic red snapper stock assessment projection scenario H1 ($F = F_{current;}$ SEFSC 2009) was 1.49 ± 0.05 lbs/fish (mean ± SD). Using this ratio, the mean (2005 – 2007) baseline discard estimate in weight was computed as 25.62 ± 2.99 TP·yr^{-1} (Table 7).

As the economic trip reduction model predicted significantly reduced rates of fishery interactions with red snapper, the discard rate was also expected to decline. Table 8 lists projected commercial discards (TP) under various management scenarios. Projected discards (excluding discards due to new management regulations) range from 25.6 TP at baseline to 7.4 TP (29% of baseline) under Amendment 17, Alternative 6. Projected total removals by area were computed by applying the commercial release mortality rate of 90% (SEDAR15 2009) and adding landings and new management dead discards (Table 9). Overall removals were projected to decline from 130.8 TP at baseline to 34.7 TP (a 73.5% reduction) under Amendment 17, Alternative 6. Amendment 13C was projected to provide little reduction in red snapper removals (1.2% reduction); whereas Amendment 16 regulations were projected to reduce total removals by 16.5% from baseline removals.

Figures 4 – 10 illustrate the spatial distribution and projected weight of removals under various management scenarios. For the baseline scenario, assuming no impacts of Amendment 13C or Amendment 16, red snapper removals were concentrated in Northeast Florida and coastal South Carolina, with the majority occurring in grids 3080, 2980, 2880, 3279, 3378, and 3278 (Figure 4). Amendment 13C and Amendment 16 were projected to reduce removals in the core of the fishery between 10 – 40%, with the most significant reductions off the coast of South Carolina (Figure 5). Amendment 17, Alternative 2 was projected to generate substantial reductions (10 – 90%) in the core

of the fishery, with some reductions along the fringes (Figure 6). Amendment 17, Alternative 3 was projected to substantially reduce removals (>50%) in the core of the Northeast Florida fishery, with less substantial reductions off South Carolina (Figure 7). Amendment 17, Alternative 4 was projected to substantially reduce removals (>50%) off both Northeast Florida and South Carolina (Figure 8). Amendment 17, Alternative 5 was projected to reduce removals even more than Alternative 4 off Northeast Florida, but less off South Carolina (Figure 9). Amendment 17, Alternative 6 was projected to reduce removals throughout the fishery, with removals remaining above 3 TP in only statistical area 3378 (Figure 10).

Closures of logbook grid areas to all snapper – grouper fishing may provide substantial additional reductions in red snapper removals. If none of the current alternatives from Amendment 17 are implemented, and Amendment 13C and Amendment 16 have no effect, an 87% reduction in red snapper removals by the commercial fishery might be obtained through closure of ten grid cells to all snapper – grouper fishing (Table 10). If Amendment 13C and Amendment 16 have the effects predicted by the economic trip reduction model, an 87% reduction in red snapper removals by the commercial fishery might be obtained through closure of nine grid cells to all fishing resulting in red snapper discards (Table 11). If Amendment 13C, Amendment 16, and Amendment 17, Alternative 4 are all implemented and have the effects predicted by the economic trip reduction model, an 87% reduction in red snapper removals by the commercial fishery might be obtained through closure of five grid cells (3378, 3080, 3279, 3476, 3081) to all fishing resulting in red snapper discards (Table 12), in addition to the partial closures proposed by Amendment 17, Alternative 4 (see Table 1). It should be noted that two of these cells would be partially closed under Alternative 4 (3080 and 3279), but discards still exist due to depth and gear exceptions present in the proposed regulations. For Amendment 17, Alternative 6, an 87% cumulative reduction in commercial fishing removals could be obtained through closure of two grid cells (3378 and 3476) to all fishing resulting in red snapper discards (Table 13), in addition to the partial closures proposed by Amendment 17, Alternative 6 (see Table 1).

Discussion

In this report, baseline landings for south Atlantic red snapper were computed as a three-year average of logbook reported landings adjusted up for underreporting. Baseline removals of red snapper were computed by adding a baseline discard weight derived from a generalized linear model of observer reported red snapper discards on commercial vessels (SEDAR15 2009) and a stock production model's projected relationship between red snapper discard numbers and weight (SEFSC 2009). The impacts of various management regulatory measures implemented in Amendment 13C and proposed in Amendments 16 and 17 upon red snapper interaction rates (e.g. landings and discards) were simulated using an economic trip reduction model described in Waters (2008). Model outputs suggested minimal reductions (< 2%) in red snapper removals from Amendment 13C, slight reductions (16%) from Amendment 16,

and substantial reductions from the various management alternatives proposed in Amendment 17 (55 – 81%). Under all scenarios, area closures in addition to those currently proposed in Amendment 17 would be necessary to achieve the 87% reduction in red snapper removals necessary to end overfishing based on an $F_{MSY} = F_{40\%SPR}$.

As with any fishery-dependent dataset, the commercial logbook data upon which the majority of these analyses are based has its limitations. As a trip-level reporting form, the coastal logbook datasheet only allows for reporting of one area and one depth fished per species, although the species reported as landed on the form may have been caught in several different areas at several different depths over the length of a single fishing trip. Over the 2005 – 2007 period, 'depth' was either unavailable or unrealistic in 8 – 30% of reported records. As such, 'depth' was not considered in these analyses.

The distribution of red snapper landings based on reported 'area fished' corresponded with anecdotal information that the bulk of the south Atlantic red snapper fishery occurs off the coast of Northeast Florida, with an additional fishery off the coast of South Carolina. There were probably some inaccuracies in this field, given that a small percentage of red snapper landings were reported in cells with depths beyond 1000 ft. These are likely trips that were targeting a deep water species that landed red snapper in transit.

Discards of red snapper were computed using a generalized linear model applied to observed discards on commercial vessels (SEDAR15 2009). The number of trips reporting red snapper in the south Atlantic was very low and the number of individual fish reported as discarded was also low. Stratification of the available data was limited because of the small sample sizes and, therefore, likely does not capture much of the variation in numbers of discards within the red snapper fisheries. How that may affect the number of calculated discards (over or under estimate) is unknown (SEDAR15 2009). Dead discards were added to landings to obtain total removals. Assuming no redistribution of effort and no impacts of Amendments 13C or 16, an 87% reduction in red snapper removals might be achieved by closing ten grid cells to all snapper – grouper fishing.

The impacts of Amendments 13C, 16, and 17 were simulated using an economic trip reduction model that hypothetically imposed proposed regulations on individual fishing trips as reported to the logbook database (Waters 2008). Each reported trip was then examined with regard to a combination of rules proposed in Amendments 13C, 16, and 17. The effects of the rules on trip catches, revenues and costs were calculated. Trips that were deemed unprofitable were eliminated and the impacts on red snapper interactions were calculated (Waters 2008).

The following discussion of the economic trip reduction model is taken from Waters (2008): *The logbook data used in this analysis reflected the full range of harvesting activities and outcomes for trips in the commercial snapper-grouper fishery, from*

targeted to incidental capture of various species, and included differences in species composition and fishing activities by area, gear, duration of trip, crew size, good luck and bad luck, and so forth. In this sense, this analysis was more realistic than conventional bioeconomic models, which specify homogeneous fishing activity within a few discrete fishing classes defined by vessel size, gear type, area fished, or scale of operation.

The economic trip reduction model accounted for behavioral responses by fishermen to new regulations by eliminating currently observed trips that likely would become unprofitable. However, the simulation model did not account for more complex behavioral responses such as a redirection of fishing effort among different types of fishing as fishermen react to minimize the adverse effects of management. Conversely, fishing effort in the snapper-grouper fishery may increase with time if proposed regulations are successful in increasing the long-term abundance of economically important species. This analysis did not account for potential changes in fishing effort with time, and additional econometric analysis is needed to model this type of behavioral response to changes in resource abundance and regulation.

Analyses using the economic trip reduction model suggested that regulations associated with Amendments 13C and 16 might reduce overall red snapper removals in the commercial fishery by 16%, and would require major area closures or some combination of area closures and regulations proposed in Amendment 17 to reduce overall red snapper removals by the commercial fishery to 85%. Of the proposed alternatives, Alternatives 4 and 6 came closest to achieving the 85% reduction, but each would require additional area closures. For example, Amendment 17, Alternative 6 would prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279. The complete closure of two additional grid cells (3378, 3476) to all fishing resulting in red snapper discards would reduce red snapper harvest by greater than 85% overall for the commercial fishery. Similar patterns were observed for Amendment 17 Alternatives 4 and 6. This is not surprising, given that the area closures are identical between the two alternatives except that Alternative 4 provides for some open depths within each cell where red snapper occur in less abundance.

An opportunity cost of $52 per person per day was used to determine whether a trip would occur. Opportunity cost expresses the surplus revenue per person per day relative to cost of the trip required for the trip to occur. All labor expenses for the trip plus some portion of annual fixed costs such as vessel maintenance must be covered by this surplus. Given these expenses, an opportunity cost of $52 per person per day may not provide sufficient surplus to cover labor expenses for a typical fishing day, even with payment at minimum wage (http://www.dol.gov/esa/whd/flsa/). As such, the trip reductions projected by the model may be underestimated. Improved estimation of this parameter may increase confidence in model predictions.

Further investigations into the sensitivity of these model predictions and the actions required to reduce red snapper removals in the recreational fisheries will be required to fully ascertain the impacts of previously implemented and currently proposed Amendments. Additional investigations of the impacts of proposed regulations on deep water species also found in Amendment 17 may also be prudent, although their effects on red snapper discard rates are expected to be minimal.

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Table 1. Proposed or implemented regulations under various management actions integrated into economic trip reduction simulation model. Parentheses indicate model run that incorporates management action.

Action (Model)	Status	Management Actions*
Amendment 13C (A16_NO_ACTION)	Implemented (Oct 2006)	Decrease commercial quota for snowy grouper from 151 TP gw in 2006 to 118 TP gw in 2007, and decrease trip limit from 275 lbs gw in 2006 to 175 lbs gw in 2007. Reduce golden tilefish commercial quota to 295 TP wg, reduce trip limit to 4 TP gw, reduce trip limit to 300 lbs gw if 75% quota taken by 1 Sept. Establish 1.1 MP gw quota for vermilion snapper. Reduce black sea bass quota from 477 TP gw (June 1, 2006 - May 31, 2007) to 423 TP gw (June 1, 2007 - May 31, 2008), require use of ≥2 inch mesh for entire back panel of pots, remove pots from water when quota is met. Increase trip limit for red porgy to 120 fish (May - December), establish quota of 127 TP gw.
Amendment 16 (A17_NO_ACTION)	Proposed (Public Comment)	Establish closed season from January to April for all shallow water grouper. Establish 352,940 lbs gw quota for gag. Reduce vermilion snapper quota to 315,523 lbs gw (January - June) and 302,523 lbs gw (July - December).
Amendment 17 Alternative 1 (A17_NO_ACTION)	Proposed	Continue the 20 inch size limit (commercial & recreational).
Amendment 17 Alternative 2 (A17_ALT2)	Proposed	Prohibit all commercial harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ.

Amendment 17 Alternative 3 (A17_ALT3)	Proposed	Prohibit commercial harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ.
Amendment 17 Alternative 4 (A17_ALT4)	Proposed	Prohibit commercial harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ

Amendment 17 Alternative 5 (A17_ALT5)	Proposed	Prohibit commercial harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ
Amendment 17 Alternative 6 (A17_ALT6)	Proposed	Prohibit commercial harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ

*impacting commercial fisheries

Table 2. Logbook reported landings (thousand lbs, whole weight) for south Atlantic red snapper, 2005 – 2007, by area.

AREA	2005	2006	2007	Grand Total	Average 2005 - 2007	Percent of Total
3080	29.3	24.5	37.7	91.5	30.5	29.59%
2980	13.7	7.5	15.2	36.4	12.1	11.76%
3279	15.5	6.1	7.5	29.0	9.7	9.38%
2880	7.9	5.5	9.5	22.8	7.6	7.36%
3278	9.4	5.8	6.6	21.7	7.2	7.01%
3378	9.3	6.0	6.0	21.3	7.1	6.89%
3179	9.6	3.3	2.9	15.8	5.3	5.12%
3081	2.6	4.9	7.3	14.8	4.9	4.79%
3180	3.5	2.6	3.8	9.9	3.3	3.21%
3476	3.0	2.6	2.1	7.7	2.6	2.50%
3377	1.9	2.4	1.0	5.2	1.7	1.68%
2879	0.5	1.7	1.8	4.0	1.3	1.29%
3376	0.3	0.1	3.5	3.9	1.3	1.26%
2482	1.7	2.0	0.0	3.7	1.2	1.19%
2481	1.3	1.0	0.3	2.5	0.9	0.82%
2480	0.7	0.9	0.7	2.3	0.8	0.73%
2780	0.8	0.3	0.5	1.6	0.5	0.53%
3477	0.5	0.6	0.5	1.5	0.5	0.49%
2981	0.3	0.6	0.3	1.2	0.4	0.39%
3474	0.4	0.5	0.2	1.1	0.4	0.36%
3277	0.0	0.3	0.7	1.0	0.4	0.33%
3079	0.6	0.2	0.2	1.0	0.3	0.31%
2580	0.5	0.2	0.0	0.8	0.3	0.25%
3379	0.1	0.5	0.2	0.8	0.3	0.26%
2679	0.0	0.5	0.1	0.6	0.2	0.19%
3178	0.4	0.1	0.1	0.6	0.2	0.18%
2779	0.1	0.1	0.2	0.4	0.1	0.14%
3280	0.2	0.1	0.1	0.4	0.1	0.13%
3575	0.0	0.1	0.1	0.1	0.1	0.06%
Other*	2.9	0.0	0.1	3.0	1.8	0.0178
Grand Total	**117.1**	**80.9**	**108.9**	**306.8**	**103.1**	

Source: Commercial Logbook database, SEFSC, accessed April 6, 2009.

*Landings from areas with fewer than 3 vessels per year are aggregated into this 'Other' category.

Table 3. Annual scalars accounting for commercial landings (thousands of pounds, whole weight) unreported in commercial logbook.

	2005	2006	2007
Logbook	117.1	80.9	108.8
All Comm Landings	124.4*	83.2*	115.7†
Lbs Difference	7.3	2.3	6.8
%Difference	6.24%	2.83%	6.28%

*Source: SEDAR 15: south Atlantic Red Snapper (SEDAR15 2009).

†Source: D. Gloeckner, NMFS Beaufort Lab, NC.

Table 4. Commercial landings (thousand lbs, whole weight) for south Atlantic red snapper, 2005 – 2007, by area, with baseline average (2005 – 2007) used for subsequent commercial landings comparisons.

AREA	2005	2006	2007	Grand Total	Average	Pct of Total
3080	31.2	25.2	40.1	96.4	**32.1**	29.83%
2980	14.6	7.7	16.1	38.4	**12.8**	11.89%
3279	16.5	6.2	7.9	30.6	**10.2**	9.48%
2880	8.4	5.6	10	24	**8**	7.43%
3278	10	6	7	22.9	**7.6**	7.07%
3378	9.9	6.2	6.3	22.4	**7.5**	6.94%
3179	10.2	3.4	3	16.7	**5.6**	5.17%
3081	2.8	5.1	7.7	15.6	**5.2**	4.82%
3180	3.7	2.7	4.1	10.5	**3.5**	3.23%
3476	3.2	2.7	2.3	8.1	**2.7**	2.51%
3377	2	2.4	1	5.4	**1.8**	1.68%
2879	0.5	1.7	2	4.2	**1.4**	1.30%
3376	0.3	0.1	3.7	4.2	**1.4**	1.28%
2482	1.8	2	0	3.9	**1.3**	1.19%
2481	1.4	1	0.3	2.7	**0.9**	0.83%
2480	0.8	0.9	0.7	2.4	**0.8**	0.73%
2780	0.9	0.3	0.6	1.7	**0.6**	0.53%
3477	0.5	0.6	0.6	1.6	**0.5**	0.49%
2981	0.4	0.6	0.3	1.3	**0.4**	0.39%
3277	0	0.3	0.7	1.1	**0.4**	0.34%
3474	0.5	0.5	0.2	1.2	**0.4**	0.36%
2580	0.6	0.2	0	0.8	**0.3**	0.25%
3079	0.6	0.2	0.2	1	**0.3**	0.31%
3379	0.1	0.6	0.2	0.8	**0.3**	0.26%
2679	0	0.5	0.1	0.6	**0.2**	0.19%
2779	0.1	0.1	0.2	0.5	**0.2**	0.14%
3178	0.4	0.1	0.1	0.6	**0.2**	0.18%
3280	0.2	0.1	0.1	0.4	**0.1**	0.13%
3575	0	0.1	0.1	0.1	**0**	0.04%
Other*	3	0	0	3.1	**1**	0.98%
Grand Total	**124.4**	**83.2**	**115.7**	**323.3**	**107.8**	

*Landings from areas with fewer than 3 vessels per year are aggregated into this 'Other' category.

Table 5. Reliability of depth records in commercial logbook, as indicated by percentage of records missing depth information, and percentage of reported depths falling outside the bounds of available depths within reported fishing area (i.e. 'unrealistic').

Year	Rows	Unavailable Depth	%Unavailable	Unrealistic Depth	%Unrealistic
2005	1342	333	24.8%	70	5.2%
2006	1154	73	6.3%	66	5.7%
2007	1326	0	0.0%	111	8.4%

Source: Commercial Logbook database, SEFSC, accessed April 6, 2009.

Table 6. Projected commercial fishery interaction rate with red snapper, expressed as projected landings or new management discards (thousands of pounds, whole weight), given implementation of Amendment 13C (A13C), Amendment 16 (A16), and various management alternatives proposed in Amendment 17 (A17). Note these totals do not include baseline discards, which are also a source of removals.

	Landings			Amendment 17 New Discards				
	A13C	A16	A17 No Action	ALT2	ALT3	ALT4	ALT5	ALT6
Total	107.8	106.4	89.8	53.2	40.4	31.0	36.4	21.9
%Baseline	**100.0%**	**98.8%**	**83.4%**	**49.4%**	**37.5%**	**28.8%**	**33.8%**	**20.3%**

Table 7. Baseline commercial discards, in thousands of fish and thousands of pounds (whole weight), for south Atlantic red snapper, for 2005 – 2007. Estimates of discards in numbers generated by K. McCarthy, NMFS SEFSC Miami. Conversion to discards in weight performed using mean 2007 – 2009 ratio of discard in numbers to discard in lbs from projection scenario H1 (SEFSC 2009).

Year	D(1000)	D(1000 lb)
2005	15.25	22.67
2006	17.18	25.53
2007	19.28	28.65
Mean	**17.24**	**25.62**

Table 8. Estimated baseline commercial discards (thousands of pounds, whole weight) given implementation of Amendment 13C (A13C), Amendment 16 (A16), and various management alternatives proposed in Amendment 17 (A17).

Area	Status Quo	A16	A17 No Action	A17 ALT2	A17 ALT3	A17 ALT4	A17 ALT5	A17 ALT6
3080	7.6	7.6	6.8	3.7	0.9	0.9	0.2	0.2
2980	3.0	2.9	2.7	1.0	0.5	0.5	0.2	0.2
3279	2.4	2.4	1.8	1.5	1.6	0.6	1.6	0.0
2880	1.9	1.9	1.8	0.4	0.3	0.3	0.2	0.2
3278	1.8	1.8	1.4	1.2	1.3	0.5	1.4	0.1
3378	1.8	1.8	1.3	1.1	1.3	1.4	1.3	1.4
3179	1.3	1.3	0.9	0.8	1.0	0.1	1.0	0.0
3081	1.2	1.2	1.0	0.4	0.4	0.5	0.4	0.5
3180	0.8	0.8	0.6	0.4	0.1	0.1	0.0	0.0
3476	0.6	0.6	0.5	0.5	0.6	0.6	0.6	0.6
3377	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
2879	0.3	0.3	0.2	0.1	0.2	0.3	0.2	0.3
3376	0.3	0.3	0.3	0.0	0.1	0.2	0.1	0.2
2482	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1
2481	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
2480	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
2780	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3477	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2981	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
3474	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3277	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3079	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3379	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2580	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
TOTAL DISCARDS (TP)	**25.6**	**25.3**	**21.4**	**12.6**	**9.5**	**7.4**	**8.6**	**5.2**
%Status Quo	**100.0%**	**98.8%**	**83.4%**	**49.4%**	**37.5%**	**28.8%**	**33.8%**	**20.3%**

*Landings from areas with fewer than 3 vessels per year are aggregated into this 'Other' category. Statistical areas with less than 50 lbs landings omitted from table.

Table 9. Total estimated removals of south Atlantic red snapper by area (thousands of lbs, whole weight) given implementation of Amendment 13C (A13C), Amendment 16 (A16), and various management alternatives proposed in Amendment 17 (A17).

Area	Status Quo	A16	A17 NOACT	A17 ALT2	A17 ALT3	A17 ALT4	A17 ALT5	A17 ALT6
3080	39.0	38.8	34.7	17.5	4.1	4.1	1.2	1.2
2980	15.5	14.9	13.7	4.6	2.4	2.4	1.0	1.0
3279	12.4	12.2	8.9	7.2	7.6	2.9	7.7	0.0
2880	9.7	9.7	9.1	2.1	1.4	1.4	1.1	1.1
3278	9.3	9.2	7.4	5.8	6.3	2.2	6.3	0.4
3378	9.1	9.1	6.8	5.4	5.9	6.4	6.0	6.4
3179	6.8	6.6	4.6	3.7	4.5	0.5	4.5	0.0
3081	6.3	6.3	5.2	1.7	2.1	2.5	2.1	2.5
3180	4.2	4.2	3.2	2.0	0.3	0.3	0.0	0.0
3476	3.3	3.2	2.8	2.4	2.6	2.7	2.6	2.7
3377	2.2	2.2	1.6	1.5	1.5	1.6	1.6	1.6
2879	1.7	1.7	1.1	0.3	0.9	1.5	0.9	1.5
3376	1.7	1.7	1.3	0.2	0.5	1.0	0.5	1.0
2482	1.6	1.5	1.5	0.6	0.6	0.6	0.6	0.6
2481	1.1	1.1	1.1	0.4	0.4	0.4	0.4	0.4
2480	1.0	1.0	0.9	0.4	0.4	0.4	0.4	0.4
2780	0.7	0.7	0.6	0.3	0.3	0.4	0.3	0.4
3477	0.6	0.6	0.5	0.4	0.4	0.5	0.4	0.5
2981	0.5	0.5	0.5	0.1	0.1	0.1	0.1	0.1
3474	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
3277	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
3079	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.4
3379	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1
2580	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0
2679	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0
3178	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2779	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0
3280	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
2579	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Other	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1
REMOVALS (TP)	**131**	**129**	**109**	**59**	**45**	**35**	**40**	**24**
%Reduction	**0%**	**1%**	**17%**	**55%**	**66%**	**74%**	**69%**	**81%**

Note: Release mortality is applied to new management discards and baseline discards for A17 alternatives 2 - 6.

*Landings from areas with fewer than 3 vessels per year are aggregated into this 'Other' category. Statistical areas with less than 50 lbs landings omitted from table.

Table 10. Percent reduction in commercial fishery removals (R), in thousands of lbs (TP), whole weight, of south Atlantic red snapper given closures to all snapper – grouper fishing in specific logbook grid cells, assuming no impacts of Amendment 13C or Amendment 16.

Area	Status Quo	Pct of Removals	Cum Pct Reduction if Closed
3080	39.0	29.8%	29.8%
2980	15.5	11.9%	41.7%
3279	12.4	9.5%	51.2%
2880	9.7	7.4%	58.7%
3278	9.3	7.1%	65.7%
3378	9.1	6.9%	72.7%
3179	6.8	5.2%	77.8%
3081	6.3	4.8%	82.7%
3180	4.2	3.2%	85.9%
3476	3.3	2.5%	88.4%

*from baseline total of 130.8 thousand lbs, assuming no redistribution of fishing pressure onto other spatial locations with red snapper.

Table 11. Cumulative percent reductions in projected commercial fishery removals (R) relative to baseline removals of 130.8 thousands lbs (TP), whole weight, of south Atlantic red snapper, given additional spatial closures to all fishing resulting in red snapper discards in specific logbook grid cells, given implementation of Amendments 13C and 16.

Area	SQ(TP)	R(TP)	Cumulative Percent Reduction
A13C+A16	**130.8**	**109.2**	**16.54%**
3080	39.0	34.7	43.09%
2980	15.5	13.7	53.57%
2880	9.7	9.1	60.53%
3279	12.4	8.9	67.37%
3278	9.3	7.4	72.99%
3378	9.1	6.8	78.18%
3081	6.3	5.2	82.13%
3179	6.8	4.6	85.65%
3180	4.2	3.2	88.13%

*from baseline total of 130.8 thousand lbs, assuming no redistribution of fishing pressure onto other spatial locations with red snapper.

Table 12. Cumulative percent reductions in projected commercial fishery removals (R) relative to baseline removals of 130.8 thousands lbs (TP), whole weight, of south Atlantic red snapper, given additional spatial closures to all fishing resulting in red snapper discards in specific logbook grid cells, given implementation of Amendments 13C, 16, and 17 Alt. 4.

Area	SQ(TP)	R(TP)	Cumulative Percent Reduction
A13C+A16+A17 Alt4	**130.8**	**34.6**	**73.5%**
3378	9.1	6.4	78.4%
3080	39.0	4.1	81.6%
3279	12.4	2.9	83.8%
3476	3.3	2.7	85.9%
3081	6.3	2.5	87.8%

*from baseline total of 130.81 thousand lbs, assuming no redistribution of fishing pressure onto other spatial locations with red snapper.

Table 13. Cumulative percent reductions in projected commercial fishery removals (R) relative to baseline removals of 130.8 thousands lbs (TP), whole weight, of south Atlantic red snapper, given additional spatial closures to all fishing resulting in red snapper discards in specific logbook grid cells, given implementation of Amendments 13C, 16, and 17 Alt. 6.

Area	SQ(TP)	R(TP)	Cumulative Percent Reduction
A13C+A16+A17 Alt6	**130.8**	**24.5**	**81.3%**
3378	9.1	6.4	86.2%
3476	3.3	2.7	88.3%

*from baseline total of 130.81 thousand lbs, assuming no redistribution of fishing pressure onto other spatial locations with red snapper.

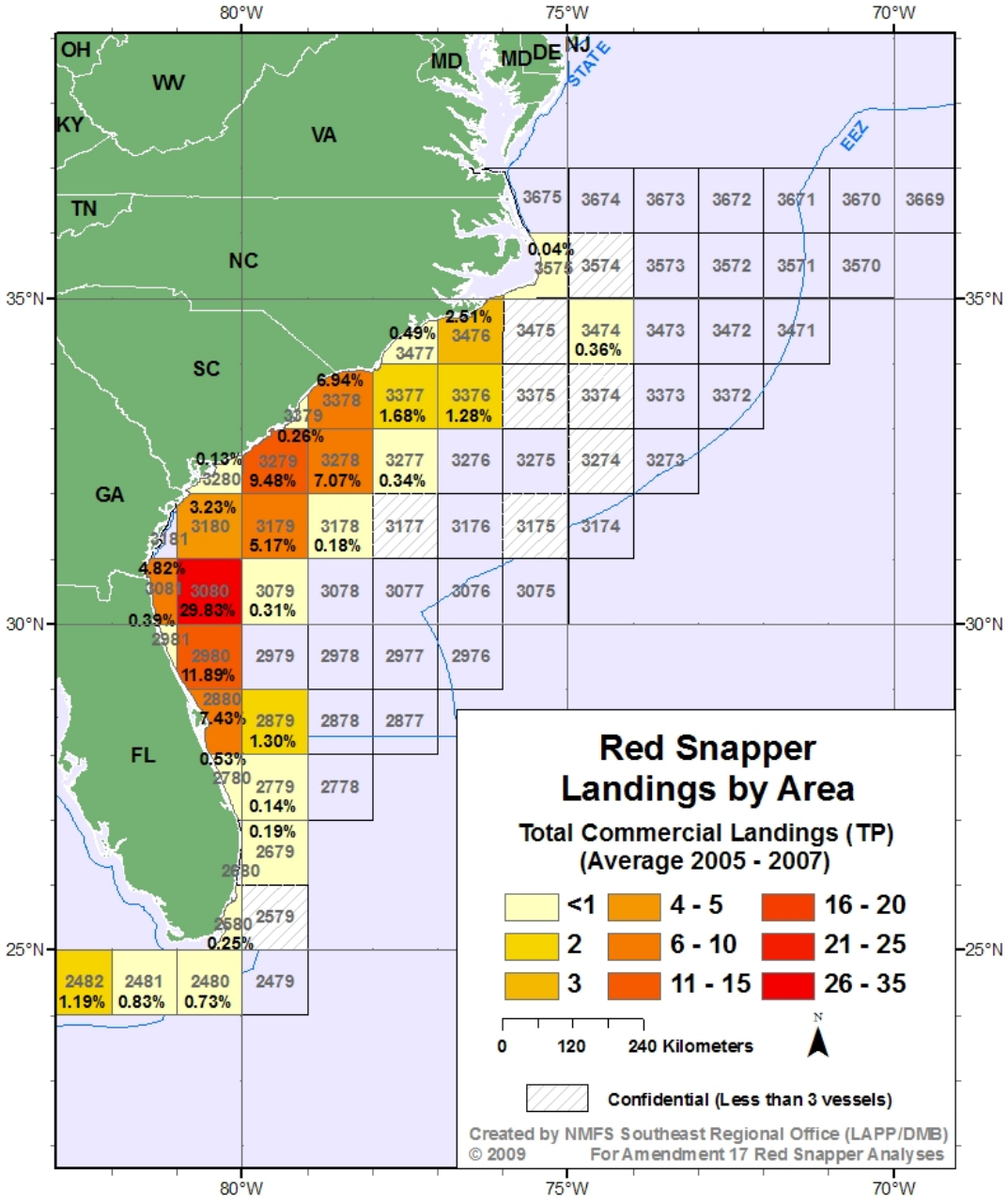

Figure 1. Total commercial landings of south Atlantic red snapper by area, based on scaled 2005 – 2007 average. Color scale denotes landings in thousands of pounds whole weight, and percentage of overall landings is indicated for each grid cell.

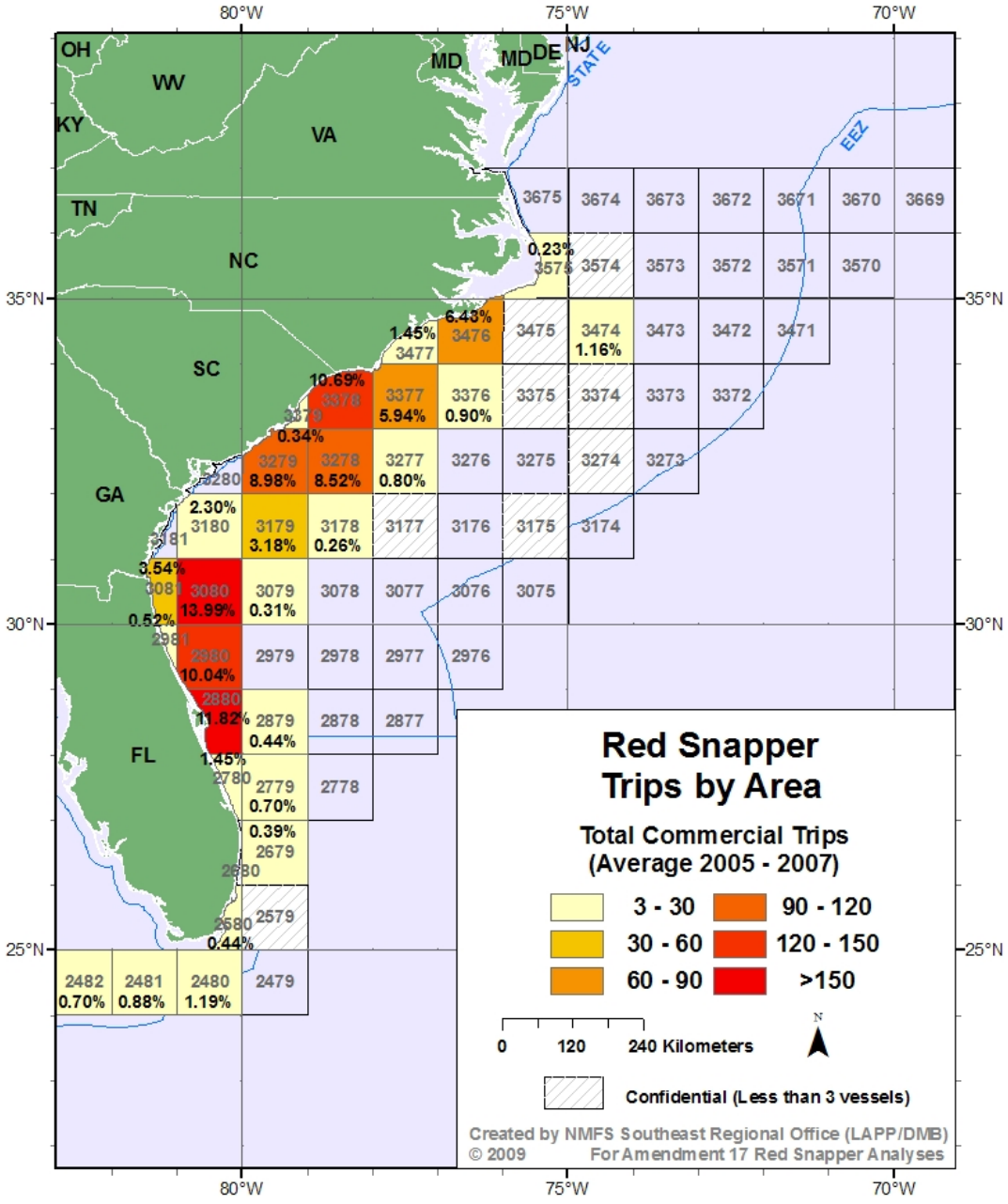

Figure 2. Total commercial trips landing south Atlantic red snapper by area, based on scaled 2005 – 2007 average. Color scale denotes number of trips, and percentage of overall trips is indicated for each grid cell.

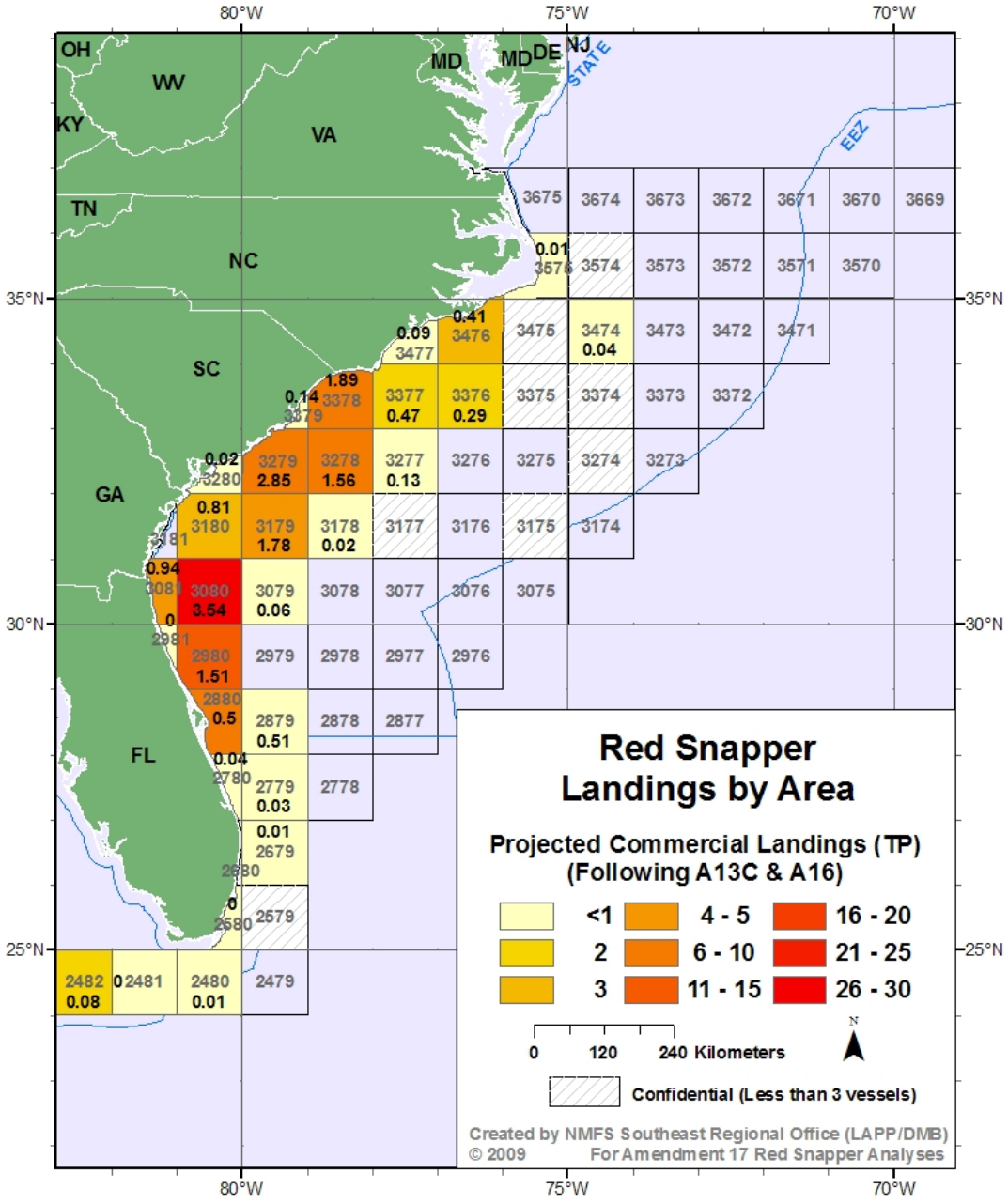

Figure 3. Projected commercial landings of south Atlantic red snapper by area, based on economic trip reduction model scenario A17_NO_ACTION, which incorporates anticipated reductions in landings given implementation of Amendment 13C and Amendment 16. Color scale denotes landings in thousands of pounds (TP) whole weight, and reduction from baseline landings (TP) is given in each cell.

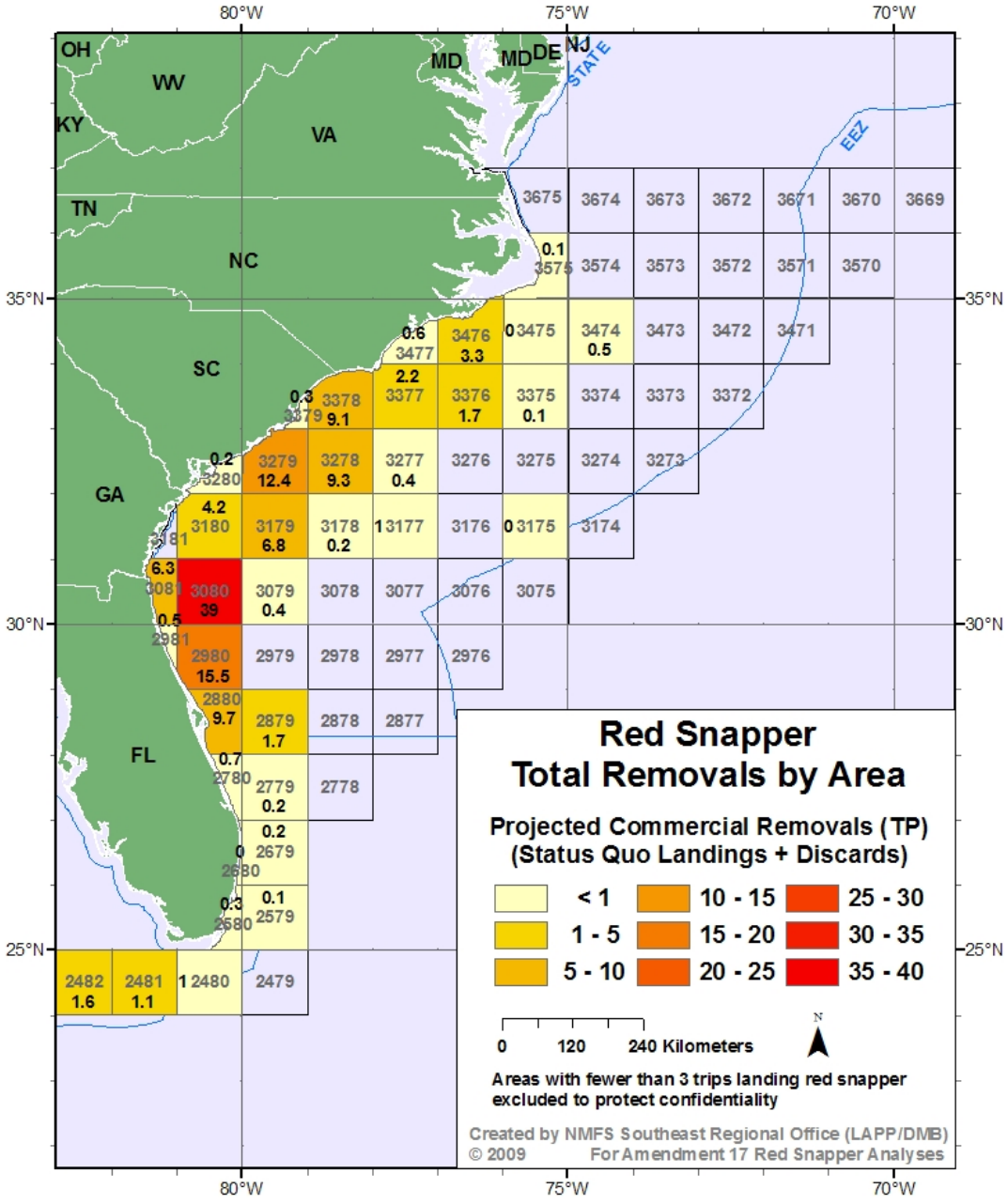

Figure 4. Baseline commercial removals of south Atlantic red snapper by area. Color scale denotes landings in thousands of pounds (TP) whole weight.

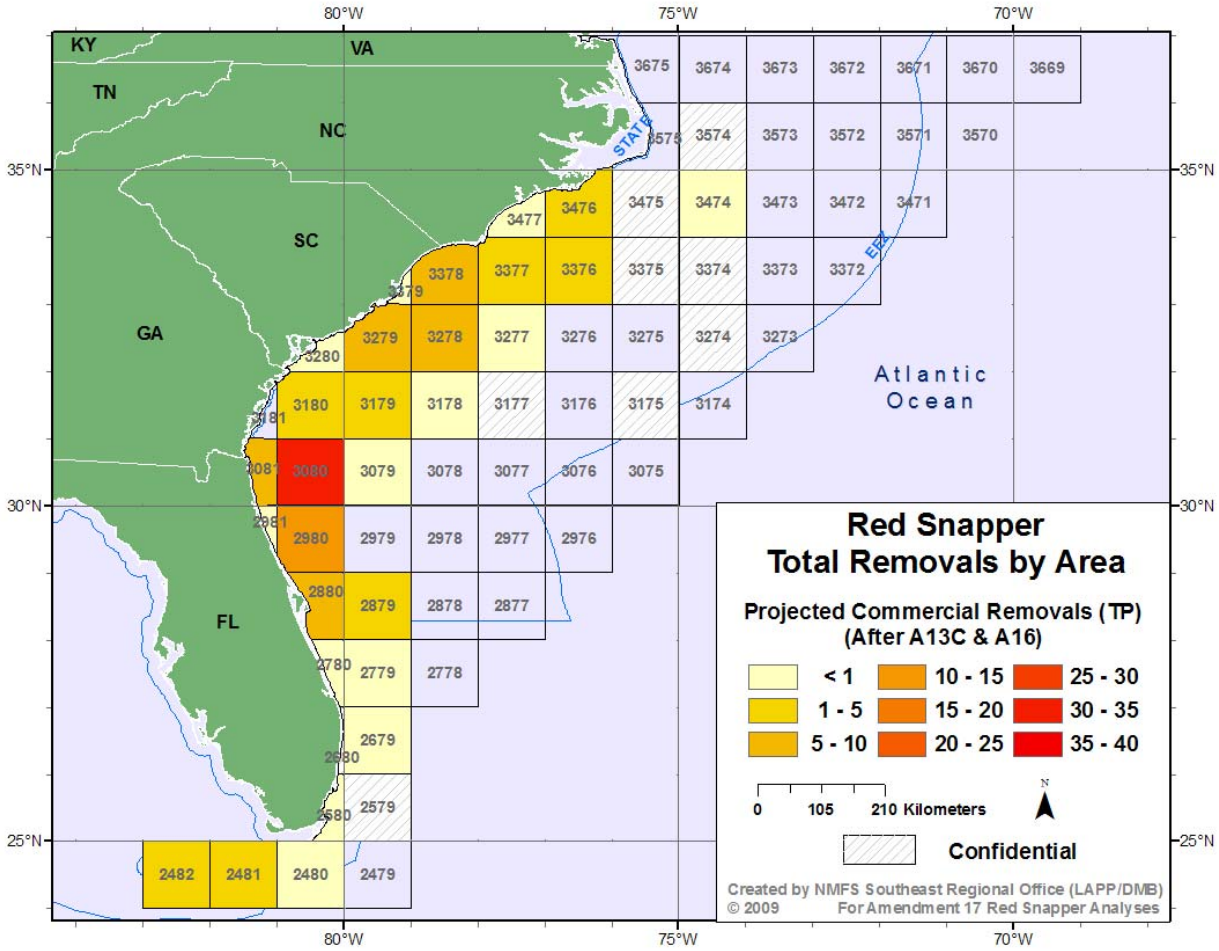

Figure 5. Estimated commercial removals of south Atlantic red snapper by area following implementation of Amendment 13C and Amendment 16. Color scale denotes removals in thousands of pounds (TP) whole weight, with value for baseline removals (TP) given in each cell.

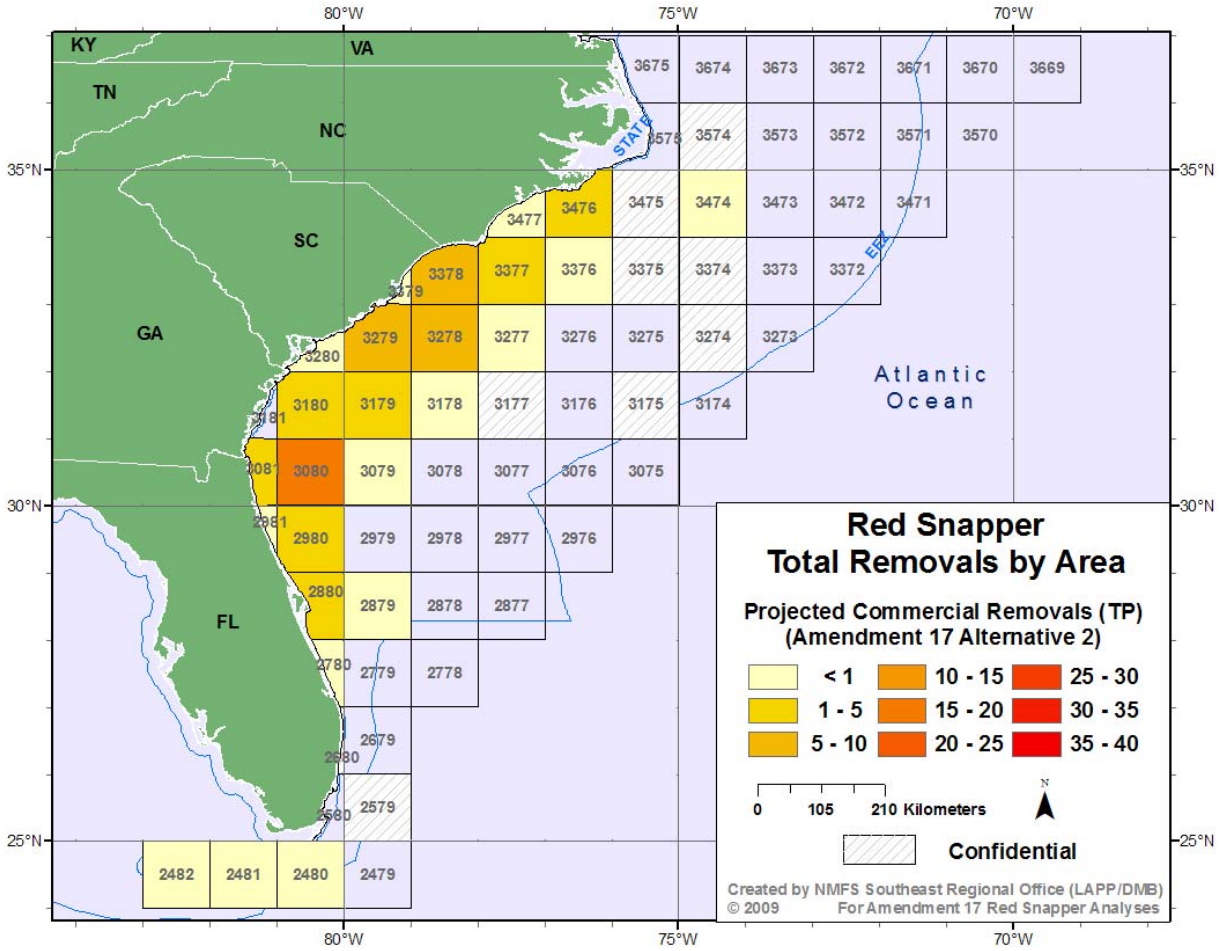

Figure 6. Estimated commercial removals of south Atlantic red snapper by area following implementation of Amendment 13C and Amendment 16 and Amendment 17, Alternative 2. Color scale denotes removals in thousands of pounds (TP) whole weight, with value for baseline removals (TP) given in each cell.

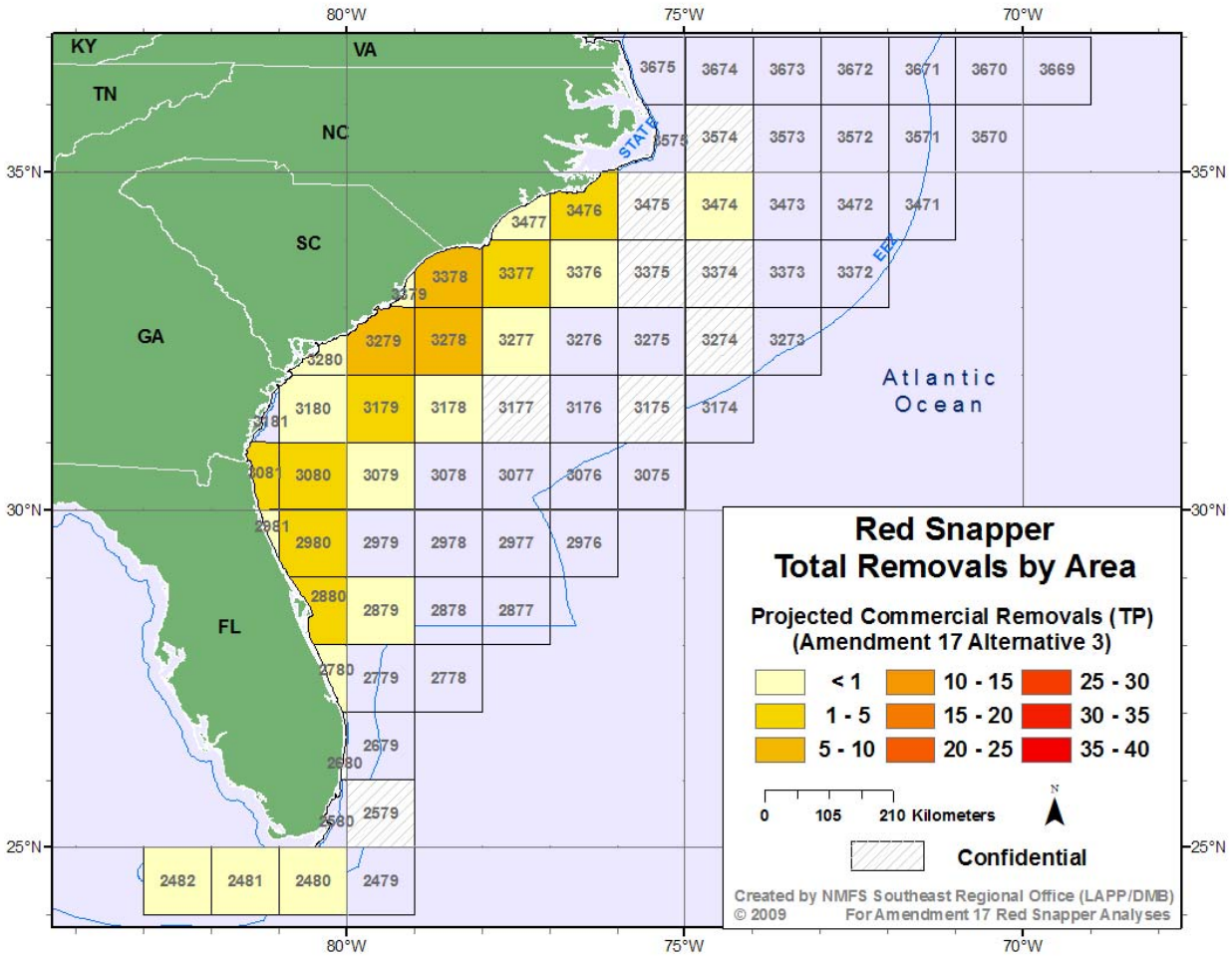

Figure 7. Estimated commercial removals of south Atlantic red snapper by area following implementation of Amendment 13C and Amendment 16 and Amendment 17, Alternative 3. Color scale denotes removals in thousands of pounds (TP) whole weight, with value for baseline removals (TP) given in each cell.

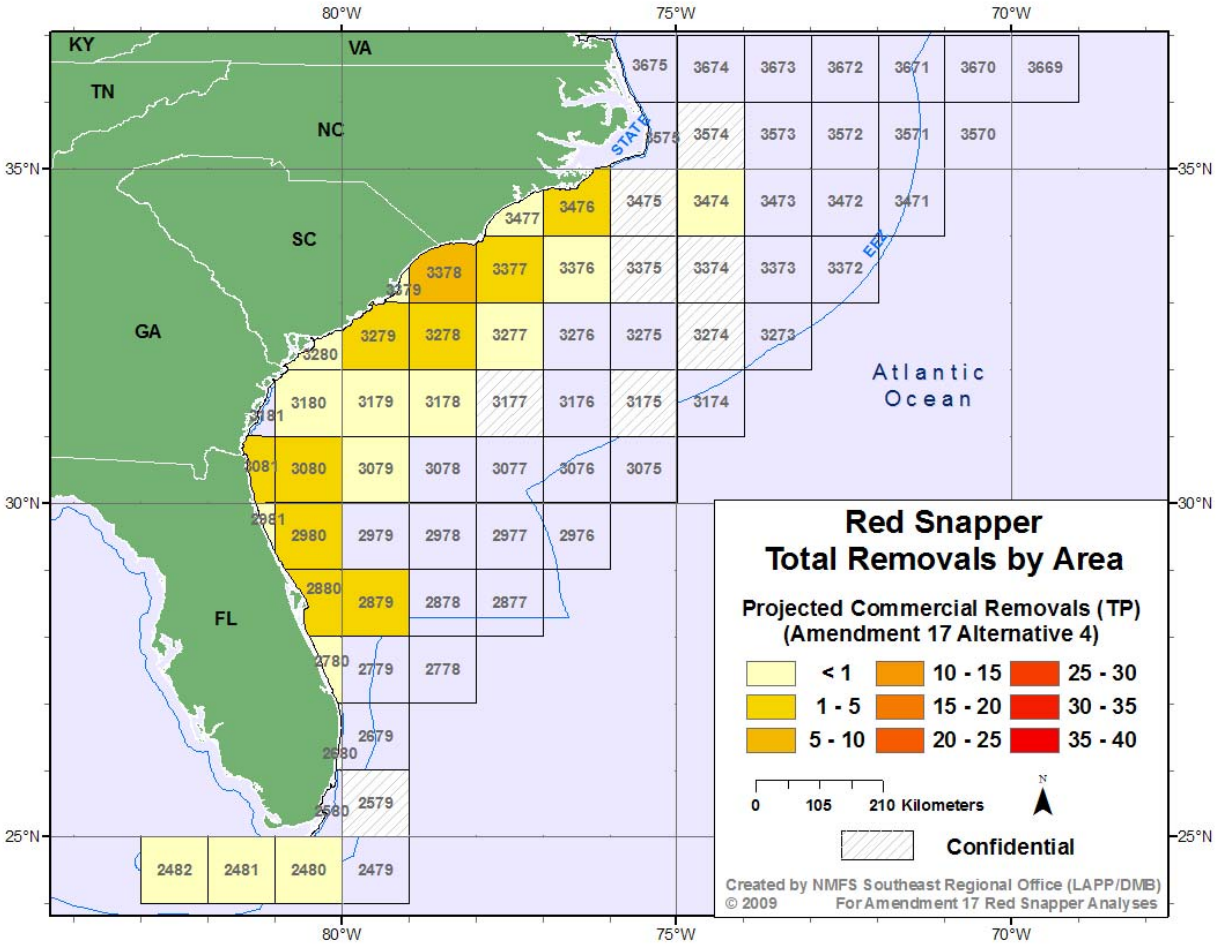

Figure 8. Estimated commercial removals of south Atlantic red snapper by area following implementation of Amendment 13C and Amendment 16 and Amendment 17, Alternative 4. Color scale denotes removals in thousands of pounds (TP) whole weight, with value for baseline removals (TP) given in each cell.

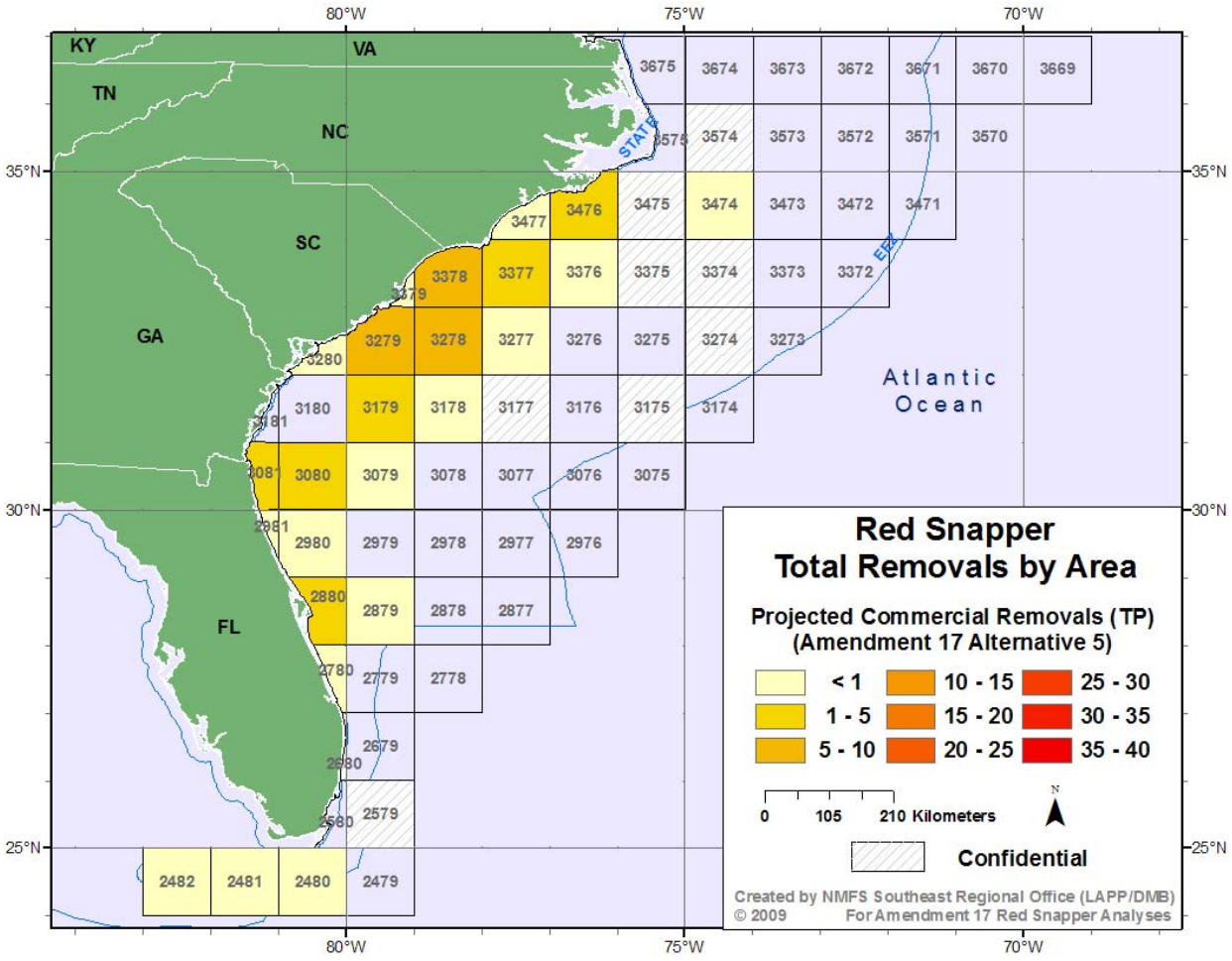

Figure 9. Estimated commercial removals of south Atlantic red snapper by area following implementation of Amendment 13C and Amendment 16 and Amendment 17, Alternative 5. Color scale denotes removals in thousands of pounds (TP) whole weight, with value for baseline removals (TP) given in each cell.

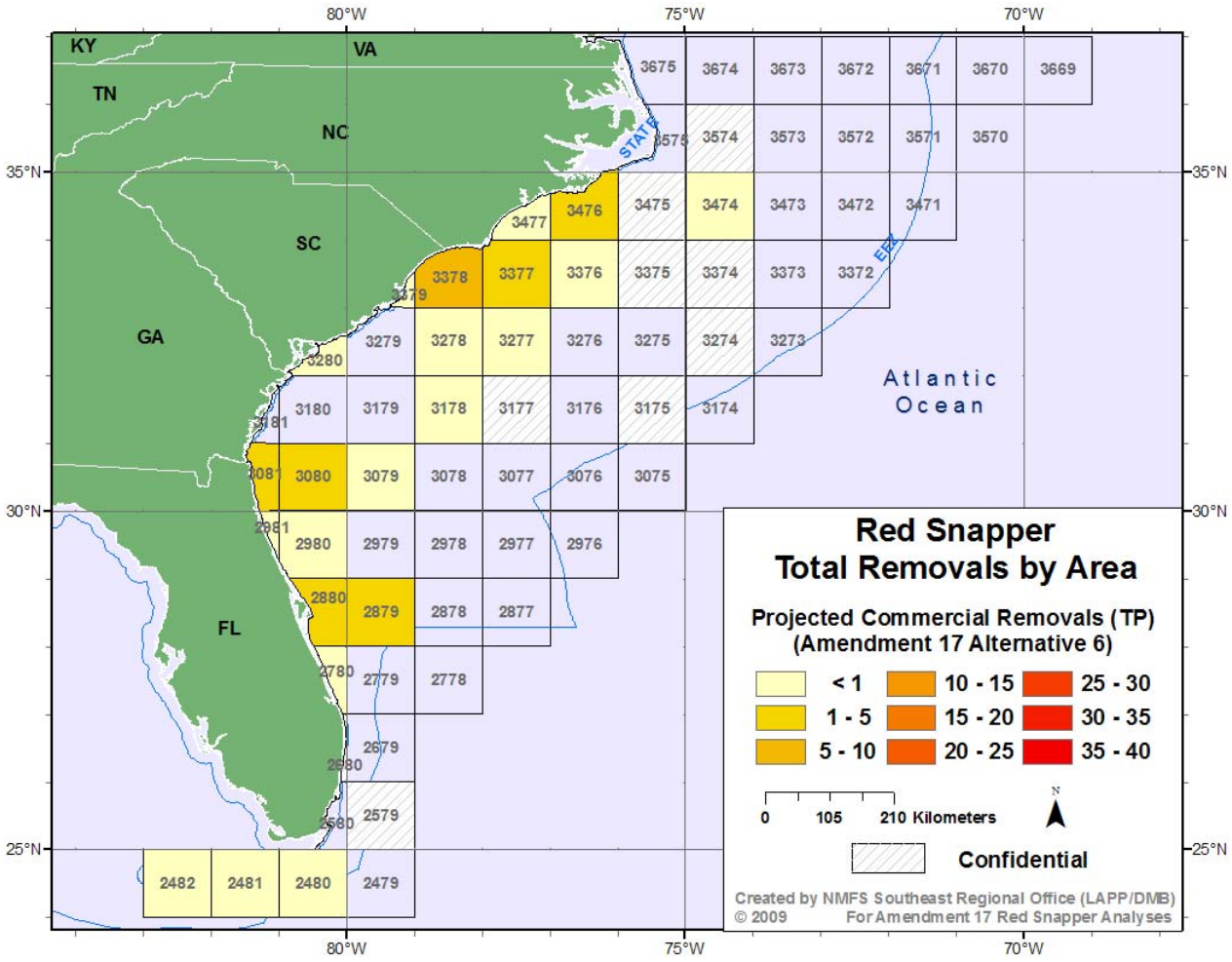

Figure 10. Estimated commercial removals of south Atlantic red snapper by area following implementation of Amendment 13C and Amendment 16 and Amendment 17, Alternative 6. Color scale denotes removals in thousands of pounds (TP) whole weight, with value for baseline removals (TP) given in each cell.

Appendix A

Description of Economic Trip Reduction Model

The following description of the model is drawn from Amendment 16: An Economic Model to Analyze Management Alternatives Proposed for the Commercial Fishery in Amendment 16 to the Atlantic Snapper-Grouper Fishery Management Plan (Waters 2008).

Logbook trip reports include information about landings by species, but do not include information about trip revenues. Therefore, average monthly prices were calculated from the NMFS Accumulated Landings System and merged with logbook trip reports by year, month, species and state. Trip revenues for each species were calculated as the product of average monthly prices and reported pounds per trip.

Information about trip costs was obtained from a sample of snapper-grouper boats that was required to report trip costs in 2002-2003 in conjunction with their normal logbook reporting requirements. Data that were collected included their costs per trip for major variable inputs such as fuel, bait, ice, food and other disposable supplies. Trip costs were estimated for each major gear type as a function of pounds landed, days per trip away from port, crew size and other trip characteristics, with the explanatory variables chosen to match the types of information reported for each trip in the logbook database (Perruso and Waters 2005).[1] Then, the estimated coefficients from the trip cost equations were used to calculate expected trip costs for each trip in the logbook database for 2005-2007. The expected trip costs were adjusted to constant 2007 dollars with the producer price index for #2 diesel fuel.[2]

Net operating revenues for trip j in year t were calculated as trip revenues from all species s, $TR_{j,t} = \sum R_{s,j,t}$, minus predicted trip costs, $TC_{j,t}$, which include fuel, oil, bait, ice, and other supplies, and exclude fixed costs and labor costs. Fixed costs were not deducted because data are not available with which to determine the fraction of each boat's fixed costs that should be allocated to red snapper fishing relative to its other fishing activities. Therefore, net operating revenues represent the return to fixed factors of production, labor (including crew) and boat owner. Net operating revenues

[1] Perruso, Lawrence A., and James R. Waters. 2005. Trip level cost function estimation for the south Atlantic snapper-grouper commercial fishery. Social Science Research Group Working Paper SEFSC SSRG 9, National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami FL 33149.

[2] The producer price index for #2 diesel fuel can be found at http://data.bls.gov. See series WPU057303.

were adjusted to constant 2007 dollars with the consumer price index for all items and all urban consumers.[3]

Fishermen were presumed willing to embark on a trip if net operating revenues exceeded an opportunity cost of labor defined as $50 per person per day fished in 2005. Opportunity cost does not measure actual payments to labor. Rather, it is used in the model as a proxy for the unknown minimum amount that fishermen would be willing to accept for each trip, and is used in the model to determine if trips are still worth taking after accounting for the effects of regulation. The proxy value of $52 per person per day fished is slightly more than the current minimum wage rate of $5.85 per hour for an 8-hour work day, which is the minimum that could be earned in less risky land-based employments. Opportunity cost was adjusted annually for changes in the cost of living between 2005 and 2007 with the consumer price index for all items and all urban consumers and a base year of 2007.

If trip revenues exceeded trip costs plus opportunity cost after accounting for the likely effects of proposed restrictions on trip-level harvests, then short-term economic losses were measured as the resulting reduction in trip revenues. Conversely, if the combination of proposed alternatives would cause trip revenues to fall below the sum of trip costs and opportunity cost, then the trip was recorded as not taken, and losses were measured as a reduction in net operating revenues, which included the loss in revenues from all species minus the savings of trip costs not incurred.

Net operating revenues for the combination of proposed rules denoted by a in rebuilding year t, $NOR_{a,t}$, were totaled for all trips within each logbook year, k, from 2005-2007, with annual totals averaged across all three years.

$$NOR_{a,t} = \frac{\sum_{k=2005}^{k=2007} \sum_{j=trips} (TR_{a,j,k} - TC_{a,j,k})}{3}$$

The three-year average is interpreted as the expected annual economic effect of the proposed combination of rules on industry net operating revenues in rebuilding year t, $NOR_{a,t}$. Each analysis was conducted for a single rebuilding year, t = 2009.

This approach is interpreted as follows. If 2009 is similar to fishing conditions that existed in 2006, then the analysis of proposed regulations with logbook data from 2006 would represent the predicted outcome of proposed regulations for 2009. However, if 2009 turns out to be similar to fishing conditions that existed in 2005, then the analysis of proposed regulations with data from 2005 would represent the predicted outcome

[3] The consumer price index for all urban consumers can be found at http://data.bls.gov. See series CUUR0000SAO, which was adjusted to a 2005 base period for this study.

for 2009. We do not know exactly what conditions will prevail in 2009; therefore we construct an average predicted outcome based on the three most recent years for which data are available.

The predicted outcome for rule-combination *a* is compared to the predicted outcome for no-action (*i.e.*, no additional management) to determine if the proposed alternatives are expected to generate net benefits or losses to commercial fishermen. Net benefits are expected to accrue to the fishery if the predicted outcome for rule combination *a* exceeds the predicted outcome without additional regulation. A net loss would accrue if the predicted outcome for rule combination *a* is less than the predicted outcome for no additional management. Because the analysis is short-term for rebuilding year 2009 only, we expect it to estimate the short-term losses associated with implementation of rules proposed in Amendments 13C, 16, and 17.

Modeling Management Alternatives

This section describes the method of modeling the effects of management actions on the commercial snapper-grouper fishery. Management alternatives implemented or proposed by Amendments 13C, 16, and 17 include minimum size limits, limits on catch per trip, seasonal closures, quotas, and limits on the numbers of black sea bass pots fished per trip. Each type of regulation was modeled by restricting the ability to catch and/or keep fish that were reported on logbook trip reports.

Minimum size limits:

Larger minimum size limits were modeled by assuming that an additional (when compared to the baseline) percentage, ρ_s^{msl}, of species *s* on each trip are undersized and must be culled from the catch and discarded.

$$q_{s,j,t} = h_{s,j,t}(1-\rho_s^{msl})$$

Variable $h_{s,j,t}$ represents quantity of species *s* caught on trip *j* in year *t*, and $q_{s,j,t}$ denotes quantity kept after accounting for the effects of the larger minimum size limit. Each trip is assumed to catch the same quantity of species *s* as without the size limit, but that undersized fish would be discarded and subject to release mortality. Revenues for species *s* on trip *j*, $R_{s,j,t} = p_{s,j,t}\ q_{s,j,t}$, are based on quantities kept, $q_{s,j,t}$, and price per pound, $p_{s,j,t}$. The harvest of other species on trip *j*, $h_{sp,j,t}$ for $sp \neq s$, is assumed not to be affected by the proposed minimum size limit for species *s*. If trip revenues exceeded trip costs after accounting for the proposed minimum size limit and other jointly-proposed rules, then the expected losses for trip *j* due to a minimum size limit were calculated as a reduction in trip revenues for species *s*, $p_{s,j,t}\ (q_{s,j,t} - h_{s,j,t})$. However, if the trip became unprofitable with the proposed combination of rules, then losses were measured as a reduction in net operating revenues, which included the loss in revenues from all species minus the savings of trip costs not incurred because the trip would not be taken, $\sum_s p_{s,j,t}\ h_{s,j,t} - TC_{j,t}$.

In the simulation model, trip costs are a function of total catch, including discards, and are not changed by the minimum size limit. Data were not available with which to estimate the potential additional costs of culling and discarding undersized fish.

The percentages that define the additional undersized fish associated with each proposed minimum size limit were held constant throughout the analysis and regardless of the alternatives proposed for other species in the fishery. When effective biologically, minimum size limits gradually change the age and size distribution of the resource and the percentage of undersized fish landed. However, this analysis does not include a biological component with which to endogenously determine changes in the proportion of undersized fish that would be landed each year.
These percentages refer to numbers of fish smaller than the proposed minimum size limits. However, the simulation model works with quantities of each species landed as reported on logbook trips rather than numbers of fish. Hence, this method of simulating the effect of minimum size limits is an approximation for the preferred method that would use numbers of fish, and is likely to overestimate the effect of the minimum size limit when the average weight per fish for species *s* exceeds 1 pound.

Mesh regulations for black sea bass pots:
Mesh regulations were implemented in Amendment 13C and affect the proportion of small fish that would be retained by fish pots. Hence, they were modeled in a similar way as minimum size limits by specifying the additional percentage, ρ^{mesh}, of fish on each trip that would be too small to be retained in fish pots. The primary difference between mesh regulations and minimum size limits is that mesh regulations affect catches and revenues from all species caught in pots, whereas the effects of minimum size limits are specific to species *s*. Although black sea bass constitute the bulk of catches in fish pots, mesh regulations are modeled to reduce the catch of all species that were landed with fish pots.

$$q_{s,j,t} = h_{s,j,t}(1-\rho^{mesh}) \qquad for\ all\ s$$

If trip revenues exceeded trip costs after accounting for larger mesh and other jointly-proposed rules, then losses were measured as a reduction in trip revenues for all species caught on trip *j* in year *t,* $\sum p_{s,j,t}\,(q_{s,j,t} - h_{s,j,t})$. Fish that would not be retained due to the larger mesh were assumed to have never been caught, and hence would not be subject to release mortality. Therefore, trip costs could change due to implementation of mesh regulations if empirical evidence suggests that trip costs are a function of total quantity harvested.

Some combinations of management alternatives would implement larger mesh regulations and larger minimum size limits. Since mesh regulations and minimum size limits both act to reduce the catch of smaller fish, the combined percentage, ρ_s^C, of species *s* that would be lost due to mesh and size limit regulations would be the greater of the two effects.

$$\rho_s^C = \max[\rho_s^{msl},\ \rho^{mesh}]$$

where ρ^{mesh} pertains to all species caught with pot gear on trip *j* and ρ_s^{msl} pertains only to species *s* for which the minimum size limit applies. The combined effects of mesh regulations and minimum size limits were modeled as:

$$q_{s,j,t} = h_{s,j,t}(1-\rho_s^C)$$

Variable $\rho^{mesh} > 0$ only for pot gear. Otherwise, $\rho^{mesh} = 0$, and $\rho_s^C = \rho_s^{msl}$. If neither minimum size limits nor mesh regulations are proposed, then $\rho_s^C = 0$.

Limit on number of pots fished per trip:

A limit on the number of pots that may be fished per trip is modeled by restricting the number of pots to the pot limit, and reducing catch per trip proportionally. If $P_{j,t}$ denotes the number of pots reported for trip *j* in year *t*, and *PL* represents the pot limit, then

$$q_{s,j,t} = h_{s,j,t}\frac{PL}{P_{j,t}} \qquad for\ P_{j,t} > PL$$

$$q_{s,j,t} = h_{s,j,t} \qquad for\ P_{j,t} \le PL$$

Pot limits affect the ability to catch fish of all species on trips using pots. Hence, potential reductions in catch due to pot limits are considered in the model to occur prior to the effects of other kinds of management rules, such as minimum size limits and trip limits, that restrict the ability of fishermen to keep their catches.

Trip limits:

Trip limits for species *s* impose a maximum allowable catch per trip, and trips with catches of species *s* in excess of the trip limit, TL_s, were modeled by restricting their catches to the trip limit. Some management actions combine trip limits and minimum size limits and/or mesh regulations. In this event, the simulation model reduced catches according to the percentage, ρ_s^C, of undersized fish on trip *j* before determining if the trip limit would be restrictive.

$$q_{s,j,t} = TL_s \qquad when\ h_{s,j,t}(1-\rho_s^C) \ge TL_s$$

Losses attributable to the trip limit were measured as the value of the difference between catches for species *s* that would have occurred with and without the trip limit, $p_{s,j,t}\,[TL_s - h_{s,j,t}\,(1 - \rho_s^C)]$. Please note that losses due to the trip limit would be equal to the difference between the trip limit and reported catches, $p_{s,j,t}\,[TL_s - h_{s,j,t}]$, only when there were no proposed minimum size limits or mesh regulations. The portion of the overall loss measured by $[p_{s,j,t}\ h_{s,j,t}\ \rho_s^C]$ is attributable to the minimum size limit and/or mesh regulation rather than the trip limit. The quantity of species *s* in excess of the trip limit, after accounting for the effects of minimum size limits and mesh regulations, is assumed to have been caught, discarded, and subject to release mortality because the trip would continue in search of other species. In this event, trip costs would not change due to implementation of trip limits.

Trips with catches less than the trip limit, after accounting for the effects of minimum size limits and mesh regulations, would not incur additional losses due to the trip limit.

$$q_{s,j,t} = h_{s,j,t}(1-\rho_s^C) \qquad when\ h_{s,j,t}(1-\rho_s^C) < TL_s$$

The simulation model includes a behavioral assumption about the effect of trip limits on the duration of trips and the cost of fishing. Trips are modeled to terminate after the trip limit is filled if the regulated species is the primary source of revenue on the trip. In this event, trip costs are reduced due to the shorter trip duration and smaller quantity harvested. However, if the regulated species is not the primary source of revenue, then the trip is modeled to continue even if the trip limit is filled. In this event, fish caught in excess of the trip limit are presumed to be caught and discarded. Trip costs would not change. Trip limits create an incentive for fishermen to take shorter, but more frequent fishing trips. However, this behavioral response has not been modeled for this analysis.

Seasonal closures:

Seasonal closures for species *s* were modeled by defining variable $open_s$ = 0 when the season is closed for species *s* and $open_s$ = 1 when it is open, and then multiplying by the reported catch of species *s* on trip *j*. Therefore, catch of species *s* would be affected by a seasonal closure policy only during the closed season; *i.e.*, $q_{s,j,t}$ = 0 only when $open_s$ = 0.

$$q_{s,j,t} = h_{s,j,t}(1-\rho_s^C)\ open_s \qquad when\ h_{s,j,t}(1-\rho_s^C) < TL_s$$

$$q_{s,j,t} = TL_s\ open_s \qquad when\ h_{s,j,t}(1-\rho_s^C) \geq TL_s$$

Seasonal closures create an incentive for boats to re-schedule trips to minimize the likely effect of the closure. However, the model does not accommodate this type of behavioral adaptation to regulation. Logbook data record the month and day landed for each reported trip, and the duration of each trip so that start dates could be calculated. The model uses landed date to identify the trips that would be subject to the closure.

Quotas:

Fishery-wide quotas were modeled in a similar way as seasonal closures. The primary difference between seasonal closures and quotas is that seasonal closures have fixed beginning and ending dates, whereas quotas may or may not result in fishery closures. When quotas are filled, the closure dates vary annually depending on the speed at which the fishery lands its quota for species *s*. The closure extends through the end of the fishing year once the quota is filled.

The equations that describe the short-term economic effects of quotas are the same as already presented for seasonal closures. The model sets variable $open_s$ = 0 to reflect a no-harvest rule resulting from seasonal closures or fishery closures after the quota is filled. Otherwise, it sets $open_s$ = 1 to indicate that the fishery for species *s* is open and that trips are unaffected by either quota or seasonal closure.

The model compares the accumulated fishery landings of species *s* with its quota to determine if and when the fishery would be closed. This is accomplished by sorting

logbook trip reports by year, month and day landed, and then performing a chronological trip-by-trip accumulation of landings that likely would occur given the selected combination of proposed management alternatives. The model sets $open_s = 1$ at the beginning of each fishing year, and sets $open_s = 0$ as soon as accumulated landings exceed the quota for species *s*.

Quotas tend to promote a race for fish as fishermen compete to maximize their shares of the overall catch before the fishery is closed. The model does not include the possibility that fishermen might accelerate their trips in anticipation of a fishery closure, or that dockside prices might fall if market gluts occur due to the accelerated harvesting activity. More work is needed on these issues since they are two of the primary outcomes of quota management.

Evaluating the Effects of Amendment 16 Regulations on 2005-2007 South Atlantic Red Snapper Headboat Removals

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Southeast Regional Office
St. Petersburg, Florida

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Introduction/Background

A recent stock assessment of South Atlantic red snapper indicates the stock is undergoing overfishing and is severely overfished (SEDAR 15 2008). Red snapper fishing mortality during 2006 was 7.67 times higher than the fishing mortality rate associated with F_{MSY} (=$F_{40\%SPR}$) and spawning stock biomass (SSB) was 2% of the SSB at maximum sustainable yield (SEFSC 2009). The South Atlantic Fishery Management Council (SAFMC) is currently developing Amendment 17A to the Snapper-Grouper Fishery Management Plan to address overfishing of red snapper and rebuild this stock (SAFMC 2009). Alternatives under consideration include a year-round prohibition on red snapper harvest, possession, and retention in the South Atlantic EEZ, as well as year-round spatial area closures for all snapper-grouper harvest and possession (except spearfishing equipment) to reduce bycatch mortality of red snapper. The overall size and extent of these area closures is contingent on bycatch mortality outside the closed areas and the overall percent reduction in fishing mortality needed to end overfishing. Assuming average recruitment, given $F_{MSY} = F_{40\%SPR}$, an 85 percent reduction in total removals of red snapper is needed to reduce F by 87% and end overfishing.

In September 2008, the SAFMC approved Snapper-Grouper Amendment 16. This amendment was developed to address overfishing of gag and vermilion snapper, and also reduces the harvest of several other snapper-grouper species. NOAA Fisheries Service partially approved Amendment 16 in March 2009. On July 29, 2009, final regulations were implemented that established a four month commercial and recreational closed season (January-April) for shallow-water grouper (SWG), a five-month recreational closed season for vermilion snapper (November-March), gag and vermilion snapper commercial quotas, and bag limits for vermilion snapper, gag, and other groupers. These regulations may indirectly affect the harvest of red snapper caught on trips targeting either vermilion snapper or SWG. The intent of this analysis is to evaluate potential changes in red snapper harvest associated with Amendment 16 regulatory changes.

Methods

Status quo landings (Amendment 16 has no effect on red snapper catches)

Headboat landings data provided by the Southeast Fisheries Science Center (SEFSC), Beaufort Laboratory were used to determine the magnitude and geographic location of red snapper

landings during 2005-2007 along the southeast coast of the United States. Landings in both numbers and pounds were first summarized by headboat statistical area. To maintain confidentiality, some landings were aggregated across headboat statistical areas. Landings were further summarized by year using the location of the inlet from which each headboat departed on a fishing excursion, following Williams et al. (2009). A total of 109 headboats operate in South Atlantic statistical areas 1-17 and berth in ports located between Cape Hatteras, North Carolina and Key West, Florida. For those vessels that reported red snapper landings during 2005-2007, the home port and assigned inlet fields are complete. In a few instances, the home port of the vessel was a considerable distance from the assigned inlet; port agent information was used in assigning departure inlets (Brennan, pers. comm.). Additionally, some vessels berth in a single port, but utilize different routes and therefore different inlets for their departure. Because landings by inlet include confidential data, this information is not summarized herein. However, these data are available if methods can be established for assigning headboat landings and discards into finer spatial areas using the reported inlet of landing (see Williams et al. 2009 for further discussion).

Defining target trips

Target trips can be defined in numerous ways depending on the data available. For instance, primary and secondary species or species complexes are reported through the Marine Recreational Fisheries Statistics Survey, allowing for determination of species of interest when a trip is made. In the commercial fishery, trips can be evaluated based on their profitability to determine how fishermen may or may not respond to regulations (see SERO 2009). Target trips may also be defined based on what species were or were not caught on a particular trip. Although this may not provide information on the target species sought if it was not caught or only caught in small quantities, it does give an indication of the frequency of occurrence and relative amount of various species caught on trips. Trips and landings occurring during 2005-2007 were assumed to be representative of future behavior and effort in the fishery.

Headboat landings of vermilion snapper, SWG, and red snapper were first summarized by month for the years 2005-2007 and a frequency plot was created to compare monthly landings distributions. Next, headboat catch effort files (CRNF05, CRNF06, and CRNF07) were used to evaluate vermilion snapper and SWG landings frequencies. Only trips occurring during November-March were considered for vermilion snapper and only trips occurring during January-April were considered for SWG. These time periods correspond to proposed closures for these species in Amendment 16. The number of vermilion snapper or SWG caught for each trip was determined and used to evaluate the relative frequency of trips catching various amounts of vermilion snapper or SWG. To determine the relative contribution of vermilion snapper or SWG landings on a particular trip, the ratio of vermilion snapper or SWG landings to overall snapper-grouper landings (all 73 regulated species) was computed for each trip. The percentage of landings for each trip was then used to determine the frequency of trips where vermilion snapper or SWG accounted for a majority (>50%) of the snapper-grouper landings. The total landings of vermilion snapper and/or SWG on a particular trip and the relative contribution of these landings to the trip's overall snapper-grouper landings were used to

define a 'target' trip. All trips not landing a minimum number of vermilion snapper, SWG, or vermilion snapper/SWG combined and not having a minimum percentage of snapper-grouper landings accounted for by vermilion snapper, SWG, or vermilion snapper/SWG combined were defined as 'non-target' trips during the Amendment 16 closed seasons. By defining 'target' trips in terms of both quantity and percentage of landings, trips landings small quantities but high percentages of fish or trips landing large quantities representing a small percentage of the trip's landings were excluded. All trips not occurring during the Amendment 16 closed seasons were defined as 'open-season' trips.

Evaluating changes in overall landings

Once trips were defined as target, non-target, or open-season trips, the sensitivity of 2005-07 red snapper landings to Amendment 16 closed seasons for vermilion snapper and SWG was evaluated. Status quo landings were derived from SEFSC headboat datafiles as described above. These landings were used as a proxy for estimating future red snapper headboat landings.

Catch-effort headboat files provided by the SEFSC were used to evaluate the sensitivity of headboat red snapper landings to Amendment 16 regulations. Reported catch effort files were modified by either eliminating target trips or altering the catch rates on target trips. For this analysis, six scenarios were considered. Scenarios 1-3 defined target trips as trips where 25 or more vermilion snapper and/or SWG were landed, and these landings represented the majority (>50%) of overall snapper-grouper landings on the trip. Scenario 1 eliminated all 'target' trips and assumed those trips would no longer occur when vermilion snapper and/or SWG were closed. Scenario 2 modified 'target' trips, rather than eliminating the entire trip. For this scenario, average red snapper catch rates were computed for target and non-target trips for each vessel by dividing the total number of red snapper caught by the number of anglers fishing on the vessel. Target trip red snapper catch rates were then replaced with the average non-target trip catch rates for each vessel. The adjusted catch rate was then multiplied by the number of anglers fishing to determine the adjusted amount of red snapper caught on the trip. If target catch rates were less than non-target catch rates, then no adjustments to the number of red snapper caught were made. Scenario 3 was similar to Scenario 2, except if target catch rates were less than non-target catch rates then the number of red snapper caught was increased based on the higher catch rate. Scenarios 4-6 defined target trips as trips where 25 or more vermilion snapper and/or SWG were landed, but these landings only needed to represent 25% of the overall snapper-grouper landings on the trip, rather than the 50% required by Scenarios 1-3.

Modified landings estimates derived using the catch-effort headboat files were then used to calculate annual headboat landings based on methods and statistical programs provided by the SEFSC, Beaufort Laboratory. Briefly, catch-effort logbook files were used to estimate landings in numbers. Adjustments to reported landings for each vessel were then made to account for under-reporting, over-reporting, or non-reporting of angler effort. Adjusted landings in numbers were then converted to landings in weight using average weight estimates by species

from annual bio-profile data files. A minimum sample size of 10 fish was used to generate average weight estimates.

Results

Status Quo

During 2005-2007, red snapper headboat landings averaged 45,862 pounds (Table 1). Despite the broad geographic extent of headboat fishing activities along the southeast coast of the U.S., most red snapper landings occurred in the area between Lazaretto Creek Inlet in south Georgia and Port Canaveral, Florida. During 2005-2007, 48.4 percent of all landings occurred in statistical area 8 (Ponce Inlet-Sebastian) (Table 1). Statistical areas 6 and 7 (Georgia-St. Augustine) accounted for an additional 27.7 percent of landings during this same time period (Table 1). The inlet location from which peak landings activities are realized varied among years, but Port Canaveral, Florida was a landing leader during most years. Relatively few red snapper were caught on vessels operating from inlets located north of the St. John's River or south of Port Canaveral.

Table 1. Average 2005-2007 headboat red snapper landings in numbers and pounds by statistical area.

		Landings by year (numbers)				Landings by year (lbs)			
Area	Area Description	2005	2006	2007	2005-07 avg	2005	2006	2007	2005-07 avg
3, 9, 10	Cape Lookout & Cape Fear, NC	106	33	52	64	1,114	385	389	629
4,5	South Carolina	1,004	303	701	669	10,399	3,540	5,016	6,318
6, 7	St. Augustine-Georgia	2,455	1,245	2,389	2,030	16,408	9,536	12,118	12,687
8	Ponce Inlet-Sebastian	4,226	4,148	2,922	3,765	24,333	26,513	15,744	22,197
11	Ft. Pierce-Miami	1,091	111	480	561	6,297	749	2,795	3,280
12, 17	Florida Keys & Dry Tortugas	25	105	345	158	144	709	1,398	750
TOTAL		8,907	5,945	6,889	7,247	58,695	41,432	37,460	45,862

Note: some areas have been aggregated to protect confidentiality.

Target Trips

Peak headboat landings of vermilion snapper and SWG occurred during summer 2005-2007, whereas red snapper landings were more constant throughout the fishing year (Figure 1). Vermilion snapper landings during November-March averaged 8.3% of the total annual landings. Shallow-water grouper landings during January-April accounted for 22.5% of the total annual landings. In comparison, 38.7% of red snapper landings occurred during November-March and 36.2% of red snapper landings occurred during January-April.

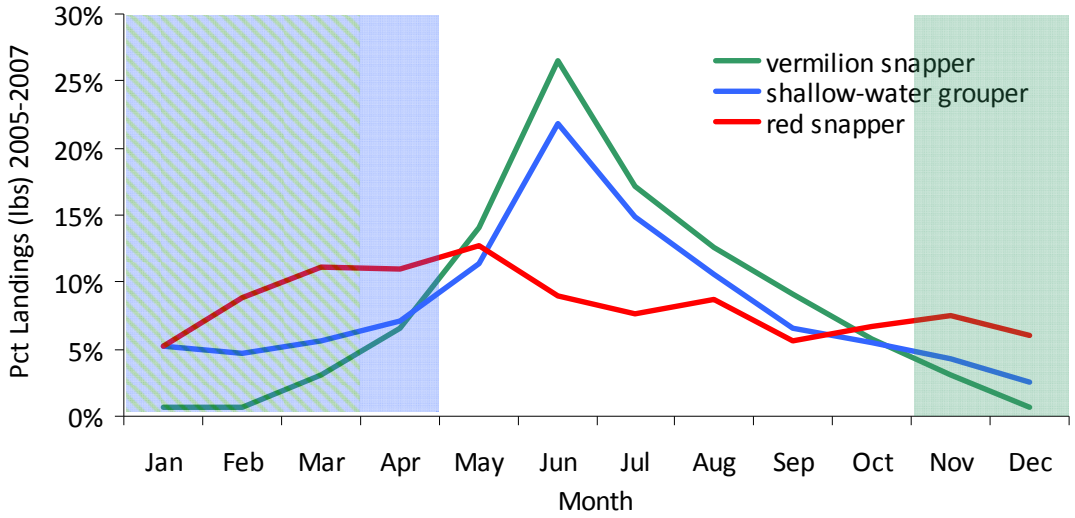

Figure 1. Frequency distribution of vermilion snapper and SWG headboat landings by month, 2005-2007. Shaded areas represent vermilion snapper (green) and SWG closed seasons (blue).

A total of 1,085 trips reported catching one or more vermilion snapper during November-March 2005-2007 (Table 2). Of these trips, 58% landed fewer than 25 vermilion snapper, 73% landed fewer than 50 vermilion snapper, and 16% landed more than 100 vermilion snapper. Vermilion snapper accounted for a majority of the harvest on approximately 25% of these trips (271 of 1,085 trips) (Table 3).

Most trips landing SWG during January-April 2005-2007 landed fewer than 25 SWG on a trip (Table 4). Approximately 5 percent of headboat trips landed more than 25 SWG on a trip (Table 4). Landings of SWG on these trips typically accounted for a small fraction of the total number of snapper-grouper harvested (Table 5); only 27 of the 2,029 trips (1.3%) had SWG landings that accounted for 50% or more of the overall snapper-grouper landings.

Table 2. Percent frequency of trips landing various amounts of vermilion snapper during Nov-Mar, 2005-2007.

N caught	N trips	Pct trips	Cum Pct trips
1-25	627	58%	58%
26-50	166	15%	73%
51-75	57	5%	78%
76-100	58	5%	84%
101+	177	16%	100%
TOTAL	1,085	100%	n/a

Table 3. Number of headboat trips and the relative percentage of vermilion snapper versus total snapper-grouper landings on those trips during Nov-Mar, 2005-2007.

Pct VS vs. Total SG	N trips	Pct trips	Cum Pct trips
1-10%	152	14%	14%
11-20%	210	19%	33%
21-30%	185	17%	50%
31-40%	156	14%	65%
41-50%	111	10%	75%
51-60%	57	5%	80%
61-70%	66	6%	86%
71-80%	47	4%	91%
81-90%	49	5%	95%
91-100%	52	5%	100%
TOTAL	1,085	100%	n/a

Table 4. Percent frequency of trips landing various amounts of shallow-water grouper during Jan-Apr, 2005-2007.

N caught	N trips	Pct trips	Cum Pct trips
1-5	1,451	72%	72%
6-10	299	15%	86%
11-15	112	6%	92%
16-20	51	3%	94%
21-25	22	1%	95%
26-30	19	1%	96%
31-35	15	1%	97%
36-40	15	1%	98%
41-45	11	1%	98%
46-50	7	0%	99%
50+	27	1%	100%
TOTAL	2,029	100%	n/a

Table 5. Number of headboat trips and the relative percentage of shallow-water grouper versus total snapper-grouper landings on those trips during Jan-Apr, 2005-2007.

Pct SWG vs Total SG	N trips	Pct trips	Cum Pct trips
1-5%	1,263	62%	62%
6-10%	395	19%	82%
11-15%	142	7%	89%
16-20%	93	5%	93%
21-25%	38	2%	95%
26-30%	26	1%	96%
31-35%	15	1%	97%
36-40%	11	1%	98%
41-45%	5	0%	98%
46-50%	22	1%	99%
>50%	19	1%	100%
TOTAL	2,029	100%	n/a

Tables 6 and 7 summarize the number of 'target' trips for vermilion snapper and SWG during their respective closed seasons. The number of 'target' trips varied depending on the landing and percent snapper-grouper thresholds. For vermilion snapper, 'target' trips represented 12-35% of the overall trips occurring during the five month closure. These trips accounted for 10-36% of the red snapper landings (in numbers) during the closure months and 2-8% of the total 2005-2007 landings (n = 18,610 for 2005-2007 CRNF files). For SWG, 'target' trips represented 0-10% of the overall trips occurring during the four-month closure. Red snapper landings on these 'target' trips accounted for 0-6% of the red snapper landings (in numbers) during the closure months and 0-1% of the total 2005-2007 landings

Table 6. Number of vermilion snapper 'target' headboat trips during Nov-Mar 2005-2007 based on various trip landings and snapper-grouper thresholds. N red snapper = number of red snapper caught on 'target' trips. Note: red snapper landings are from CRNF headboat files and have not been adjusted.

N landed	Pct VS vs Total SG	N trips	Pct trips	N red snapper
25	50%	204	19%	633
50	50%	171	16%	547
75	50%	149	14%	500
100	50%	125	12%	426
25	25%	380	35%	1,489
50	25%	270	25%	1,001
75	25%	222	20%	841
100	25%	173	16%	643
Total	n/a	1,085	100%	4,149

Table 7. Number of shallow-water grouper 'target' headboat trips during Jan-Apr 2005-2007 based on various trip landings and snapper-grouper thresholds. N red snapper = number of red snapper caught on 'target' trips. Note: red snapper landings are from CRNF headboat files and have not been adjusted.

N landed	Pct SWG vs Total SG	N trips	Pct trips	N red snapper
25	50%	<3	0%	0
10	50%	3	0%	0
25	25%	4	0%	0
10	25%	34	2%	13
25	10%	36	2%	47
10	10%	109	5%	82
25	5%	78	4%	77
10	5%	204	10%	218
Total	n/a	2,029	100%	3,749

Change in Landings Resulting from Amendment 16

During 2005-2007, an average of 47,390 pounds of red snapper was landed on headboats in the South Atlantic. Elimination or modification of 'target' trips in response to Amendment 16 regulatory actions and various 'target' trip definitions resulted in landings increasing by 0.8 percent or being reduced by 7.7 percent relative to status quo (Table 8).

Table 8. Estimated changes in red snapper headboat landings associated with Amendment 16 closed seasons for vermilion snapper and SWG. Note: the "Non-target>Target" criterion refers to whether or not a vessel's average non-target catch rate for red snapper was allowed to exceed to exceed a 'target' trips catch rate when modifying trip landings.

	Criteria			2005-2007 avg.	% change relative
Scenario	# Caught	% Landings	Non-target>Target	landings (lbs)	to status quo
Status quo (no effect from A16)	n/a	n/a	n/a	45,862	0.0%
Target become non-target trips	25	50%	yes	46,229	0.8%
Target become non-target trips	25	50%	no	45,358	-1.1%
Target trips eliminated	25	50%	no	44,394	-3.2%
Target become non-target trips	25	25%	yes	46,191	0.7%
Target become non-target trips	25	25%	no	44,389	-3.2%
Target trips eliminated	25	25%	no	42,312	-7.7%

Discussion

Based on the results of this analysis, Amendment 16 closed seasons are estimated to have only a small effect on red snapper landings. Few trips, relative to the total number of trips annually, were estimated to target vermilion snapper or SWG during the closure months. In fact, almost no trips were determined to 'target' SWG. Although a greater percentage of trips targeted vermilion snapper during the closure months, landings of red snapper on these trips

represented a small fraction of the overall red snapper annual landings. Red snapper landings during May-October accounted for 50% of the total landings during 2005-2007 (see Figure 1). Because SWG trips have little to no effect on harvest, including the month of April increases the amount of landings unaffected by the closures to 61%. This means that the largest reduction that could be achieved as a result of Amendment 16 management actions would be 39-50% relative to status quo. The realized reduction from these regulatory actions was estimated to be much less than 39-50%, because a majority of vermilion snapper and SWG trips were classified as non-target trips during the Amendment 16 closed seasons.

The results of this analysis may have greatly differed if landings in pounds rather than landings in numbers were used. Because landings in pounds from the headboat catch-effort files are not used for estimating annual landings, quantity rather than weight was used for purposes of this analysis. This results in 'target' trips being defined more often for smaller, more abundant species, such as vermilion snapper, and potentially less often for higher level predators, such as groupers. Regardless, evaluating a range of potential 'target' trip definitions allows for the sensitivity of results to be explored. Numerous additional 'target' trip definitions could have been considered in this report. Any definitions that require higher amounts of fish or higher percentages of fish to be landed, will reduce any reductions occurring from Amendment 16 closed seasons. Similarly, lower landing threshold will increase the number of 'target' trips and result in greater assumed reductions from Amendment 16.

Discard data were not summarized in this report, but discards are assumed to be proportional to landings if trips are eliminated. Therefore, any reduction in landings due to the elimination of a trip would produce an equivalent reduction in discards.

Acknowledgements

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Evaluating the Effects of Amendment 16 and Amendment 17A Regulations on Red Snapper Removals by south Atlantic Recreational Private and Charterboat Fisheries

CONFIDENTIAL DATA HAS BEEN REMOVED

National Marine Fisheries Service
Southeast Regional Office
St. Petersburg, Florida

September 2, 2009

Introduction/Background

A recent stock assessment of south Atlantic red snapper indicates the stock is undergoing overfishing and is severely overfished (SEDAR 15 2009). The south Atlantic Fishery Management Council (SAFMC) is currently developing Amendment 17 to the Snapper-Grouper Fishery Management Plan to address overfishing of red snapper and rebuild this stock (SAFMC 2009). Alternatives under consideration include a year-round prohibition on red snapper harvest, possession, and retention in the south Atlantic EEZ, as well as year-round spatial area closures for all snapper-grouper harvest and possession, (except with spearfishing equipment). The overall size and extent of these area closures is contingent on bycatch mortality outside the closed areas and the overall percent reduction in fishing mortality needed to end overfishing. Assuming average recruitment, given $F_{MSY} = F_{40\%SPR}$, an 85 percent reduction in total removals of red snapper is needed to reduce F by 87% and end overfishing.

The intent of this analysis is to evaluate potential changes in red snapper recreational harvest and discards associated with Amendment 16 regulatory changes, and evaluate the total removals that might result from each of the proposed alternatives in Amendment 17A (Table 1). Implemented in July 2009, Amendment 16 prohibits commercial and recreational harvest of shallow-water grouper in the south Atlantic from January through April. This amendment also establishes a five-month recreational closed season for vermilion snapper (November-March), modifies commercial quotas for gag and vermilion snapper, and reduces bag limits for vermilion snapper, gag, and other groupers. These regulatory actions may indirectly affect red snapper landings and discards if trips formerly targeting vermilion snapper and/or shallow-water grouper no longer occur due to seasonal closures.

Methods

Status Quo

Baseline (e.g. 'status quo') landings and discards for red snapper were summarized using data generated from the Marine Recreational Fisheries Statistics Survey (MRFSS) processed using custom software written in SAS (SAS Institute Inc., Cary, NC) provided by NOAA Fisheries,

Recreational Fisheries Statistics Program (Office of Science and Technology, Silver Spring, Maryland) and modified by Southeast Regional Office personnel. Data were post-stratified for the state of Florida into three south Atlantic regions: Florida Keys, Southeast Florida, and Northeast Florida. Landings and discard data were additionally post-stratified by mode of fishing (e.g. 'Charter' and 'Private/Rental').

Mean annual landings and discards in numbers and weight were computed for 2005-2007. Annual landings in weight were computed using custom software written in SAS that expanded intercepted weights within south Atlantic states and subregions to compute total weight of fish landed within regions of interest. To avoid issues with limited sample size, computations of weight of fish landed were not stratified by mode of fishing. In certain instances, the program could not generate a landings estimate in weight due to the partitioning of the data and the lack of biological sampling, in which case the ratio of landings in weight to landings in numbers at the post-stratified south Atlantic state level (e.g. 'East Florida', 'Georgia', 'South Carolina', 'North Carolina') from the MRFSS website (http://www.st.nmfs.noaa.gov/st1/recreational/) was used to compute landings in weight from landings in numbers. Landings and discards reported as occurring in inshore waters were aggregated into state water landings and discards, respectively.

Discard estimates in numbers were converted to discard estimates in weight using the mean (2007-2009) ratio of discards in weight to discards in numbers (1.48 lbs/fish) from SEFSC (2009) south Atlantic red snapper stock assessment projections (Scenario H1, $F = F_{current}$). Discard estimates in weight for each year (2005-2007) were converted to dead discards by multiplying by the recreational release mortality for red snapper, estimated at 40% (SEDAR 15 2009). Total removals were computed by adding landings and dead discards.

Impacts of Amendment 16

MRFSS intercept files were used to assess the number of trips harvesting red snapper that may potentially be impacted by Amendment 16 seasonal closures. Frequency plots of vermilion snapper and shallow-water grouper (SWG; 11 species) landings were computed per angler per trip. Only trips occurring during November-March 2005-2007 were considered for vermilion snapper and only trips occurring during January-April 2005-2007 were considered for SWG. The number of vermilion snapper or SWG landed per angler for each trip was determined and used to evaluate the relative frequency of trips landing various amounts of vermilion snapper or SWG. To determine the relative contribution of vermilion snapper or SWG landings on a particular trip, the ratio of vermilion snapper or SWG landings to overall snapper-grouper landings (all 73 regulated species) was computed for each trip.

A trip was defined as a target trip for vermilion snapper and/or SWG if it occurred during a closed month, exceeded a numeric landings threshold, and the majority (>50%) of the snapper-grouper landings on the trip (e.g. 'percent landings threshold') were a species whose harvest would be prohibited during that month following implementation of Amendment 16. Primary and secondary target species identified in the MRFSS intercept records were also used to

identify 'target' trips. If anglers reported targeting vermilion snapper and/or shallow water grouper, then the trip was identified as a 'target' trip for these species during the closure months. All trips not landing a minimum number of vermilion snapper, SWG, or vermilion snapper/SWG combined and not having a minimum percentage of snapper-grouper landings accounted for by vermilion snapper, SWG, or vermilion snapper/SWG combined were defined as 'non-target' trips during the Amendment 16 closed seasons. By defining 'target' trips in terms of both quantity caught and percentage of landings, trips landing small quantities but high percentages of fish or trips landing large quantities representing a small percentage of the trip's landings were excluded. All trips not occurring during the Amendment 16 closures were defined as 'open-season' trips.

Once 'target' trips were defined, these trips were removed from the MRFSS intercept records and assumed to no longer occur. Landings and discards were then re-estimated using the MRFSS post-stratification program and modified intercept records.

Impacts of Amendment 17A

A similar approach for determining 'target' trips was used to evaluate changes in landings and discards associated with the Amendment 17A year-round closed season for red snapper. In the most conservative approach, if red snapper was identified as a primary or secondary target species in the MRFSS intercept records then the trip was classified as a 'target' red snapper trip. Less conservative approaches considered targeted and directed effort. Because MRFSS target species are often defined by species family (e.g., 'snapper family'), directed effort at a particular species was also considered though evaluation of frequency plots of red snapper landings per angler per trip during 2005-2007. The number of red snapper landed per angler for each trip was determined and used to evaluate the relative frequency of trips landing various amounts of red snapper. The ratio of red snapper landings on each trip (in numbers) to overall snapper-grouper landings was used to determine the relative contribution of red snapper landings on a particular trip.

The overall quantity of red snapper landed on a particular trip combined with the overall percentage of snapper-grouper landings accounted for by red snapper was then used to define a 'target' trip. Trips that did not land a minimum number of red snapper and or had a low percentage of snapper-grouper landings accounted for by red snapper were defined as 'non-target' trips. No 'open season' trips were defined. 'Target' trips were removed from MRFSS intercept records and assumed to no longer occur because of the year-round red snapper closed season. MRFSS post-stratified landings and discards were then recomputed using modified intercept records.

Spatially Partitioning Removals

To evaluate the impacts of Amendment 17A spatial area closures, MRFSS landings had to be partitioned into statistical grids. MRFSS red snapper landings in the south Atlantic are reported primarily by state (FL, GA, SC, and NC), mode (charter, private), and area fished (federal waters,

state waters, and inland waters, providing little spatial resolution to where red snapper landings occur. In order to partition MRFSS removals (landings + discards) into logbook grids, headboat removals by logbook grid were used as a proxy (see SERO 2009). MRFSS removals were assigned to logbook grids using equation 1:

$$R_a = \frac{\%L_a}{\sum_{a=1}^{\Omega} \%L_a} * R_{\Omega} \quad (1)$$

where, *R* is MRFSS removals, *a* is logbook grid, *%L* is the percentage of headboat landings, and *Ω* is MRFSS post-stratified region. In some instances, logbook grids overlapped state boundaries. If the majority of a logbook grid occurred in the MRFSS post-stratified region, then MRFSS post-stratified landings were assigned to that logbook grid.

Combined Effects of Amendment 16 and Amendment 17A

Cumulative reductions in removals resulting from Amendment 16 and Amendment 17A combined were evaluated under three different scenarios. Scenario 1 assumed no impacts from Amendment 16, but eliminated all 'target' trips for red snapper based on Amendment 17A criterion. Scenario 2 eliminated Amendment 16 'target' trips for vermilion snapper and SWG and all MRFSS intercepts that explicitly identified vermilion snapper, SWG, and/or red snapper as primary or secondary target species. Scenario 3 was the same as Scenario 2, except red snapper trips landing 1 or more red snapper per angler were also eliminated before re-estimating landings and discards.

Lastly, reductions in removals associated with Amendment 17A red snapper spatial closure alternatives were determined. Removals by post-stratified region from Scenario 3 were partitioned into logbook grids (see Equation 1). Removals from logbook grids proposed for closure to all snapper-grouper fishing were then set to zero. Total removals were then recomputed for the remaining open areas.

Results

Status Quo

Post-stratified baseline removals, in numbers of fish and pounds, are summarized in Table 2 and Figures 1 and 2. On average, 270,882 red snapper were caught during 2005-2007 (Table 2A), weighing an estimated 609,694 pounds (Table 2B). A majority of the fish caught were discarded. When release mortality rate is applied to discards (r = 40%), an estimated 398,658 pounds of red snapper were removed by private and charterboat anglers during the baseline years (Table 2C). Nearly 80% of red snapper removals occurred off northeast Florida (southern Brevard County to FL/GA border; Figure 1). Georgia accounted for 8% of the red snapper

removals, followed by southeast Florida (5.9%), South Carolina (2.1%), and North Carolina (1.5%).

Impacts of Amendment 16

Frequency distributions of the number of vermilion snapper landed per angler per trip indicated most trips reported landing 5 or less vermilion snapper per angler per trip and a majority of trips landed 1 or fewer vermilion snapper per angler per trip (Figures 3A-C). Similarly, nearly all trips reporting SWG landed 1 or fewer SWG per angler per trip (Figures 4A-C). Based on these frequency plots, 'target' trips for vermilion snapper were defined as either a trip landing on average 1 or more vermilion snapper per angler or a trip landing on average 5 vermilion snapper per angler. For SWG, 'target' trips were defined as any trip on average landing 0.5 or more SWG per angler per trip or any trip landing on average 1 or more SWG per angler per trip. Elimination of 'target' trips for vermilion snapper and SWG based on the most conservative criterion (1 vermilion snapper and/or 0.5 SWG per angler per trip) resulted in estimated removals of 389,461 lbs, which was 2.3% less than baseline removals (Table 3C). Using the less conservative criterion (5 vermilion snapper and/or 1 SWG per angler per trip) for defining 'target' trips resulted in a similar reduction (2.3%) in removals relative to the baseline (Table 4C). This was because few trips landing 1 or more vermilion snapper and/or 0.5 SWG per angler also reported landing or discarding red snapper.

Impacts of Amendment 17A

Frequency distributions of the number of red snapper landed per angler per trip indicated most trips reported landing 1 or less red snapper per angler per trip (Figures 5A-C). 'Target' trips were defined as any trip that landed on average 1 or more red snapper per angler per trip.

Eighty-seven percent of MRFSS removals were estimated to be from five logbook grids (Table 6, Figure 2). [CONFIDENTIAL TEXT REMOVED]. Six of the top eight logbook grids accounting for the most recreational removals are currently being considered by the South Atlantic Fishery Management Council for year-round closure to all snapper-grouper fishing (Table 1). [CONFIDENTIAL TEXT REMOVED].

Spatially Partitioning Removals

An examination of coarse post-stratified state-area (southeast FL, northeast FL, GA, SC, and NC) aggregated landings for MRFSS and headboat suggests a reasonably similar pattern in red snapper removals, although MRFSS reports higher relative landings off Northeast Florida and lower relative landings off South Carolina (Table 5).

Combined Effects of Amendment 16 and Amendment 17A

Assuming Amendment 16 has no effect on red snapper removals, but explicitly targeted trips for red snapper are eliminated (Scenario 1), total removals would be 202,129 pounds, or 49.3%

less than the baseline level (Table 7). Assuming Amendment 16 has no effect on red snapper removals, but explicitly targeted and directed trips landing >1 red snapper per angler are eliminated (Scenario 2), total removals would be 198,727 pounds, or 49.8% less than the baseline level (Table 8).

Assuming Amendment 16 'target' trips for vermilion snapper and/or SWG are eliminated and MRFSS trips explicitly identifying vermilion snapper, SWG, and/or red snapper as primary or secondary target species are eliminated (Scenario 3), then total removals would be reduced to 197,695 pounds, or 50.4 percent less than the baseline level (Table 9). If all 'target' trips for vermilion snapper, SWG, and red snapper are eliminated (Scenario 4), then total removals would be reduced to 187,063 pounds, or 53.1% less than the baseline level (Table 10, Figure 6). None of these scenarios are sufficient to achieve the 87% reduction in red snapper fishing mortality necessary to end overfishing without additional management measures.

Table 11 summarizes estimated reductions in red snapper removals associated with Alternatives 5 (closes four logbook grids) and 6 (closes seven logbook grids) in Amendment 17A. Alternative 5, in combination with reductions from Amendment 16 and elimination of target red snapper trips, is estimated to reduce removals by 89.6%. Alternative 6, which would close three additional logbook grids, is estimated to reduce removals by 90.9%. Both of these alternatives would achieve the necessary reductions in recreational removals needed to end overfishing of red snapper. Reductions in removals associated with Alternatives 3 and 4 are not presented here, because depth specific information is lacking to determine reductions with closure of the 98-240 foot depth contour. However, reductions from these alternatives are expected to be equal to or less than Alternatives 5 and 6, since less fishing areas would be closed by these alternatives.

Discussion

The results of this analysis indicate Amendment 16 would provide minimal reductions (2.3%) in red snapper removals. When 'target' trips are eliminated in response to the Amendment 17A year-round closure, a much greater reduction in removals is estimated to occur (53.1%). However, simply closing red snapper harvest in the south Atlantic is not sufficient to achieve the necessary reduction in fishing mortality to end overfishing. Only Amendment 17A, Alternatives 5 and 6, which consider spatial area closures to all snapper-grouper fishing were estimated to achieve the necessary reduction in removals. Alternative 5, which proposes closing four logbooks grids along the northeast Florida and Georgia coast, was estimated to achieve an 89.6% reduction in removals. Alternative 6 was estimated to achieve a 90.9% reduction in removals.

Reductions associated with Amendment 17A, Alternatives 3 and 4, could not be analyzed because depth specific landing and discard information was not available for the private or charterboat sector. Alternatives 3 and 4 propose closing only depths of 98-240 feet within 4-7 logbook grids (see Table 1). Reductions associated with these alternatives are estimated to be equal to or less than those determined for Alternatives 5 and 6. However, it is unknown what

fraction of removals would occur in areas closed by Alternatives 5 and 6 that would not be closed under Alternatives 3 and 4. Any removals occurring in depths of less than 98 feet or greater than 240 feet would be subject to release mortality, as red snapper harvest would be prohibited in all south Atlantic waters.

As with most statistical analyses, assumptions can limit the applicability of results and conclusions. Assumptions in this analysis included: 1) discards occur in same proportion as landings, 2) no effort shifting from closed areas occurs, 3) there will be 100% compliance with closed area restrictions, 4) release mortality rate remains unchanged when areas are closed, and 5) headboat landings are reasonable spatial proxies for private and charter boat landings.

Given that MRFSS spatial data are not reported beyond Federal, state, and inland waters, assumption #5 is the most critical to analyzing the effects of Amendment 17A. If headboat landings are not a good spatial proxy for charter and private landings, then reductions resulting from closed areas could be over- or underestimated, thereby biasing results. An evaluation of post-stratified landings patterns suggests similar spatial exploitation levels at the extremely coarse state-area scale. It is difficult to ascertain whether these similarities would hold true at a higher-resolution spatial scale; headboats may tend to fish closer to shore to maximize fishing time and conserve fuel. An examination of species exploitation patterns is unlikely to provide much clarification to this issue, as the species targeted by the headboat, private recreational, and charterboat fisheries may be different even within the same general area. Improved spatial catch-effort data from the recreational fisheries would be of great benefit to these analyses and should be a major data collection priority in the years to come.

Assumptions 2 and 3 are the least conservative when estimating reductions in removals. If compliance with closures is lower or effort shifting occurs, then reductions in removals will be less than estimated in this report. Assumption 1 is less worrisome since the highest discards often occur in the areas with the highest landings. Lastly, assumption 4 would tend to underestimate reductions in removals if release mortality was reduced following implementation of proposed Amendment 17A management actions.

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Table 1. Proposed or implemented regulations under various management actions impacting recreational fisheries and potentially red snapper removals.

Action	Status	Management Actions*
Amendment 16	Implemented July 29, 2009	Establish four month commercial and recreational closed season (January-April) for shallow-water grouper, establish a five-month recreational closed season for vermilion snapper (November-March), and reduce bag limits for vermilion snapper, gag, and other groupers.
Amendment 17A, No Action	Proposed	Continue the 20 inch size limit (commercial & recreational).
Amendment 17A, Alternative 2	Proposed	Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ.
Amendment 17A, Alternative 3	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ.
Amendment 17A, Alternative 4	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ

Amendment 17A, Alternative 5	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ
Amendment 17A, Alternative 6	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ

Table 2A. Baseline average (2005-2007) harvest (A+B1) and discards (B2) of red snapper by state and area as reported to MRFSS, in numbers.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	802	3,228	380	24,178	52	2,599	0	1,578	0	1,001	33,818
Discards	4,525	8,926	6,251	196,468	367	18,224	0	2,129	173	0	237,064
Catch	**5,327**	**12,154**	**6,632**	**220,646**	**419**	**20,823**	**0**	**3,707**	**173**	**1,001**	**270,882**

Table 2B. Baseline average (2005-2007) harvest (A+B1) and discards (B2) of red snapper by state and area as reported to MRFSS, in lbs.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	2,192	18,164	428	202,211	483	21,139	0	7,369	0	5,982	257,967
Discards	6,714	13,243	9,275	291,496	545	27,039	0	3,158	257	0	351,727
Catch	**8,906**	**31,407**	**9,703**	**493,707**	**1,028**	**48,178**	**0**	**10,528**	**257**	**5,982**	**609,694**

Table 2C. Average (2005-2007) harvest (A+B1) and dead discards (B2) of red snapper by state and area as reported to MRFSS, in lbs.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	2,192	18,164	428	202,211	483	21,139	0	7,369	0	5,982	257,967
Dead Discards	2,686	5,297	3,710	116,598	218	10,815	0	1,263	103	0	140,691
Removals	**4,877**	**23,461**	**4,138**	**318,809**	**701**	**31,954**	**0**	**8,632**	**103**	**5,982**	**398,658**

Table 3A. Projected harvest (A+B1) and discards (B2) of red snapper by state and area as reported to MRFSS, in numbers, given Amendment 16 trip reduction criterion of 1 vermilion snapper and 0.5 shallow-water grouper caught per angler.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	802	3,230	380	23,672	52	2,603	0	1,614	0	1,001	33,354
Discards	4,527	8,933	6,253	188,553	367	17,987	0	2,330	173	0	229,123
Catch	**5,329**	**12,163**	**6,634**	**212,225**	**419**	**20,590**	**0**	**3,944**	**173**	**1,001**	**262,477**

Table 3B. Projected harvest (A+B1) and discards (B2) of red snapper by state and area as reported to MRFSS, in lbs, given Amendment 16 trip reduction criterion of 1 vermilion snapper and 0.5 shallow-water grouper caught per angler.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	2,192	18,170	428	197,245	483	21,168	0	7,815	0	5,982	253,483
Discards	6,716	13,254	9,278	279,752	545	26,686	0	3,457	257	0	339,945
Catch	**8,908**	**31,425**	**9,706**	**476,997**	**1,028**	**47,854**	**0**	**11,272**	**257**	**5,982**	**593,427**

Table 3C. Projected harvest (A+B1) and dead discards (B2) of red snapper by state and area as reported to MRFSS, in lbs, given Amendment 16 trip reduction criterion of 1 vermilion snapper and 0.5 shallow-water grouper caught per angler.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	2,192	18,170	428	197,245	483	21,168	0	7,815	0	5,982	253,483
Dead Discards	2,686	5,302	3,711	111,901	218	10,675	0	1,383	103	0	135,978
Removals	**4,878**	**23,472**	**4,139**	**309,146**	**701**	**31,843**	**0**	**9,198**	**103**	**5,982**	**389,461**

Table 4A. Projected harvest (A+B1) and discards (B2) of red snapper by state and area as reported to MRFSS, in numbers, Amendment 16 trip reduction criterion of 5 vermilion snapper and 1 shallow-water grouper caught per angler.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	802	3,230	380	23,660	52	2,603	0	1,614	0	1,001	33,342
Discards	4,525	8,932	6,253	189,092	367	17,987	0	2,236	173	0	229,565
Catch	**5,327**	**12,161**	**6,634**	**212,752**	**419**	**20,590**	**0**	**3,850**	**173**	**1,001**	**262,907**

Table 4B. Projected harvest (A+B1) and discards (B2) of red snapper by state and area as reported to MRFSS, in lbs, Amendment 16 trip reduction criterion of 5 vermilion snapper and 1 shallow-water grouper caught per angler.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	2,192	18,170	428	197,137	483	21,168	0	7,815	0	5,982	253,375
Discards	6,714	13,252	9,278	280,551	545	26,686	0	3,317	257	0	340,600
Catch	**8,906**	**31,422**	**9,706**	**477,689**	**1,028**	**47,854**	**0**	**11,132**	**257**	**5,982**	**593,975**

Table 4C. Projected harvest (A+B1) and dead discards (B2) of red snapper by state and area as reported to MRFSS, in lbs, given Amendment 16 trip reduction criterion of 5 vermilion snapper and 1 shallow-water grouper caught per angler.

	Southeast Florida		Northeast Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Harvest	2,192	18,170	428	197,137	483	21,168	0	7,815	0	5,982	253,375
Dead Discards	2,686	5,301	3,711	112,221	218	10,675	0	1,327	103	0	136,240
Removals	**4,877**	**23,471**	**4,139**	**309,358**	**701**	**31,843**	**0**	**9,142**	**103**	**5,982**	**389,615**

Table 5. Average estimated red snapper removals by post-stratified state-area for headboat ('HB') and combined private recreational and charterboat fisheries ('MRFSS').

State	HB landings	HB pct	MRFSS landings	MRFSS pct
Southeast Florida	10,325	8%	28,339	7%
Northeast Florida	93,999	69%	322,947	81%
Georgia	9,533	7%	32,655	8%
South Carolina	19,598	14%	8,632	2%
North Carolina	1,881	1%	6,085	2%
Total	**135,335**		**398,658**	

Table 6. Average estimated MRFSS red snapper removals by logbook grid, 2005-2007.

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Table 7. Projected removals of red snapper by state and area as reported to MRFSS, in lbs, given trip reductions due to Amendment 17A (targeted only).

	SE Florida		NE Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Removals	3,917	11,929	5,132	158,404	1,233	16,383	0	2,430	308	2,393	202,129

Table 8. Projected removals of red snapper by state and area as reported to MRFSS, in lbs, given trip reductions due to Amendment 17A (targeted or >1 red snapper).

	SE Florida		NE Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Removals	3,149	11,930	3,894	148,033	411	16,383	0	2,172	321	12,433	198,727

Table 9. Projected removals of red snapper by state and area as reported to MRFSS, in lbs, given trip reductions due to Amendment 16 (targeted or >5 vermillion or >1 SWG), and Amendment 17A (targeted only).

	SE Florida		NE Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Removals	3,149	11,933	3,894	156,892	411	16,248	0	2,672	103	2,393	197,695

Table 10. Projected removals of red snapper by state and area as reported to MRFSS, in lbs, given trip reductions due to Amendment 16 (targeted or >5 vermillion or >1 SWG), and Amendment 17A (targeted or >1 red snapper).

	SE Florida		NE Florida		Georgia		South Carolina		North Carolina		
	State	EEZ	State	EEZ	State	EEZ	State	EEZ	State	EEZ	TOTAL
Removals	3,149	11,935	3,895	146,516	411	16,248	0	2,414	103	2,393	187,063

Table 11. Projected cumulative reductions in removals of red snapper by recreational fisheries as reported to MRFSS, in lbs, given Amendment 16 (A16) trip reduction criterion of 5 vermilion snapper and 1 shallow-water grouper caught per angler per trip, and Amendment 17A (A17) criterion of at least 1 red snapper per angler, as well as targeted trips for these species during closed months.

Alternative	Total Removals (lbs)	% Reduction
Baseline	398,658	0.0%
A16 & A17, Alt 2	187,063	53.1%
A16 & A17, Alt 5	41,536	89.6%
A16 & A17, Alt 6	36,472	90.9%

Note: Depth information unavailable to evaluate reductions associated with Amendment 17A Alternatives 3 and 4, but these should be less than or equal to the reductions provided by Alternatives 5 and 6, respectively.

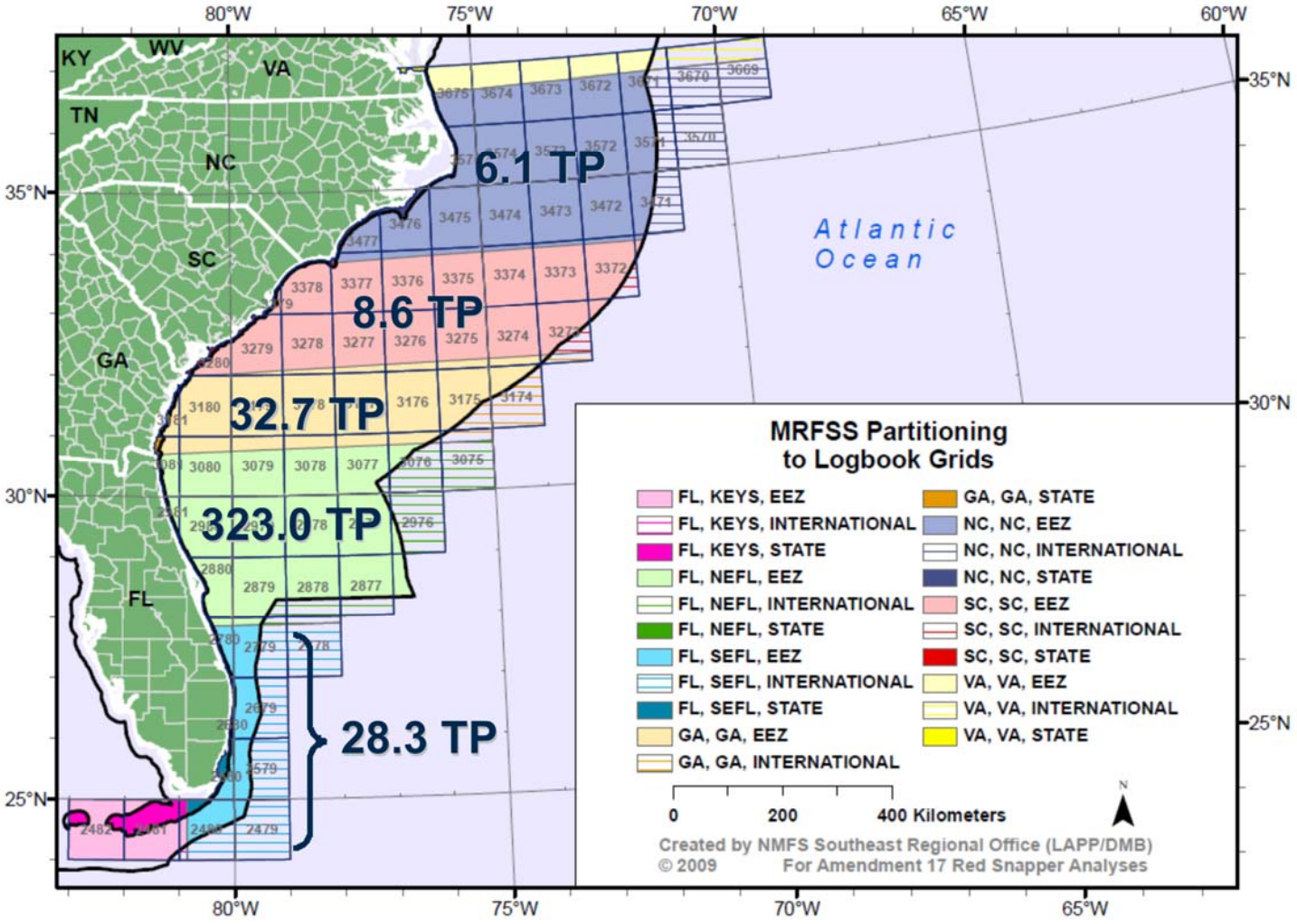

Figure 1. Post-stratified baseline removals reported to MRFSS partitioned to logbook grid, illustrating finest spatial resolution of MRFSS data available.

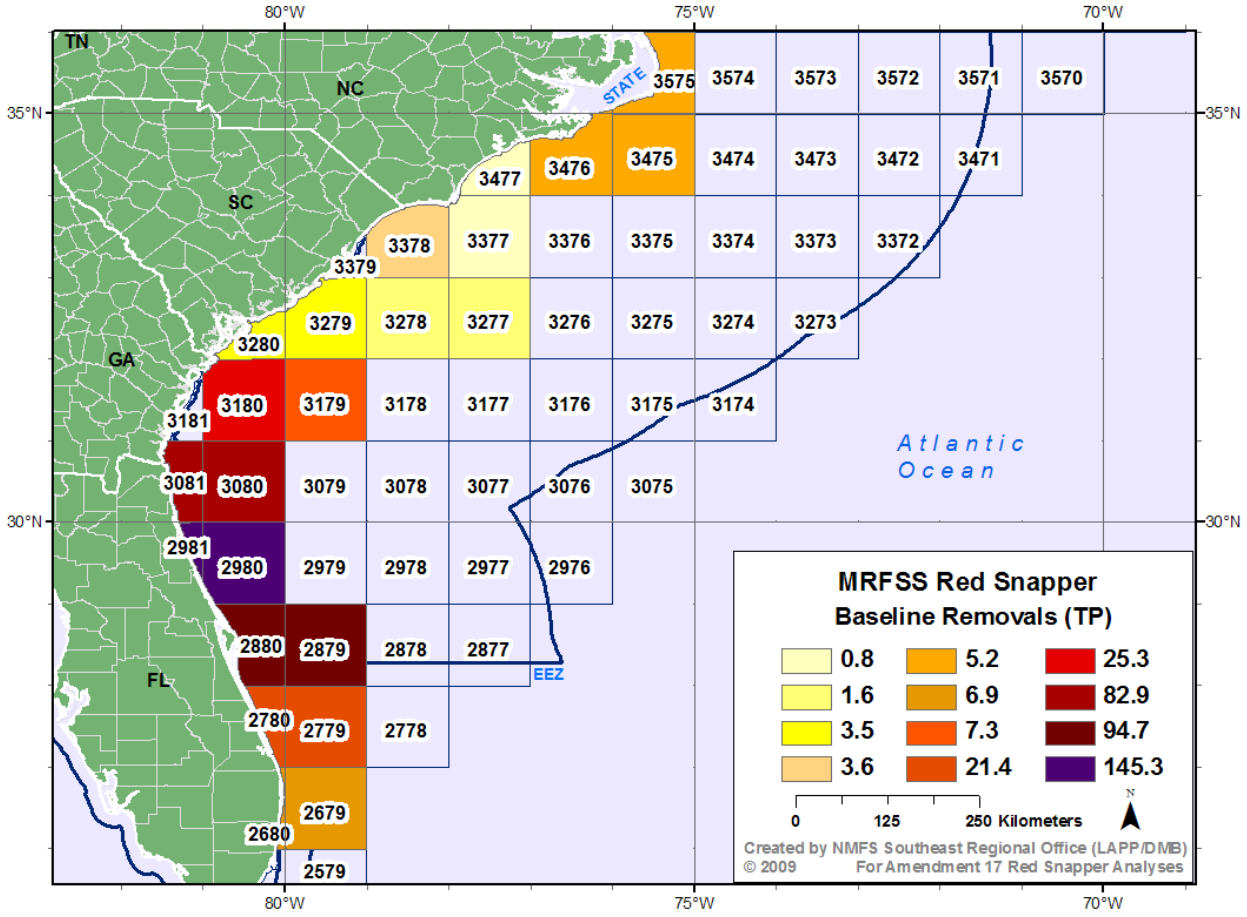

Figure 2. MRFSS baseline removals partitioned to logbook grid cells using headboat landings as proxy for spatial distribution of removals within MRFSS post-stratified subregions. Note some cells have been aggregated to maintain confidentiality.

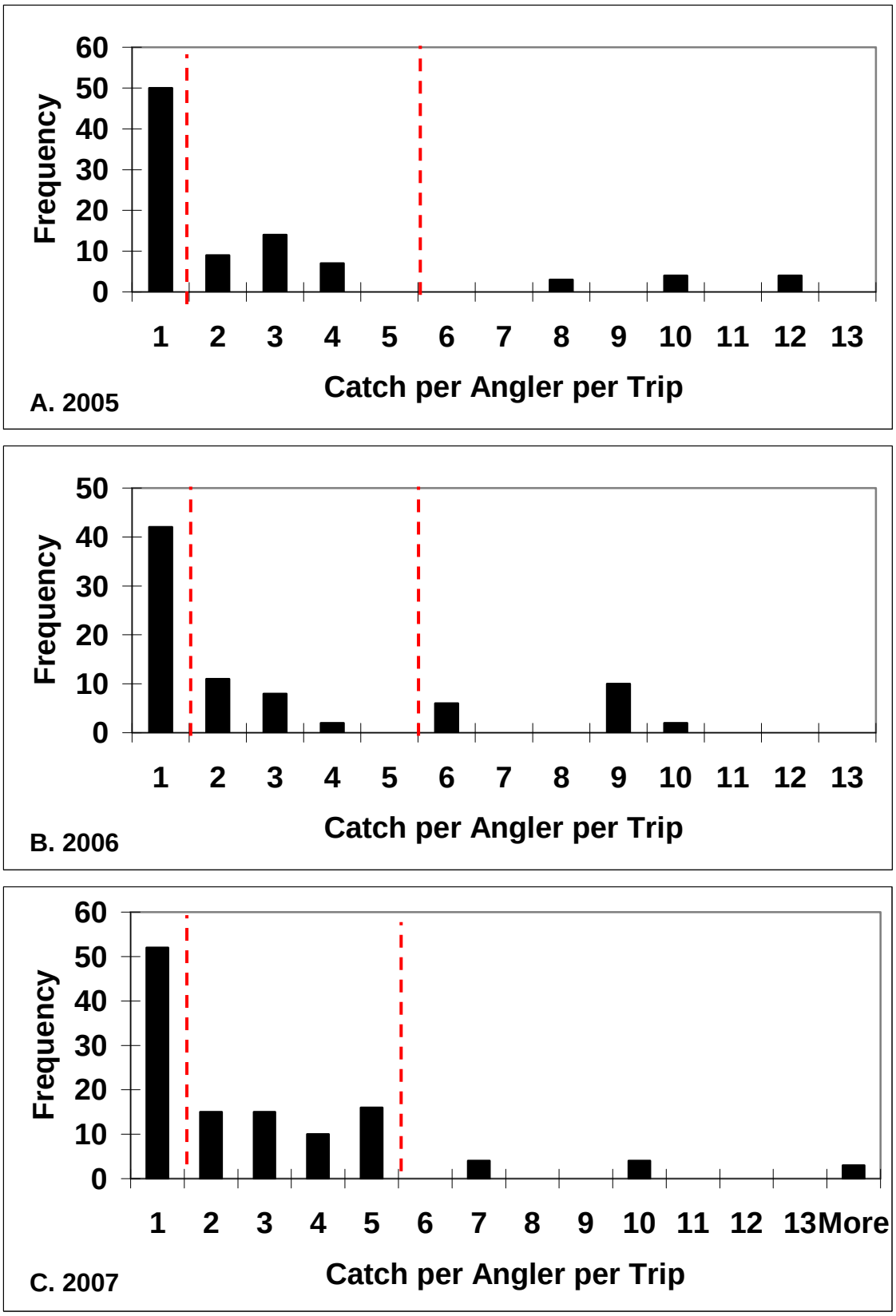

Figure 3. Histograms of number of vermilion snapper landed per angler per trip.

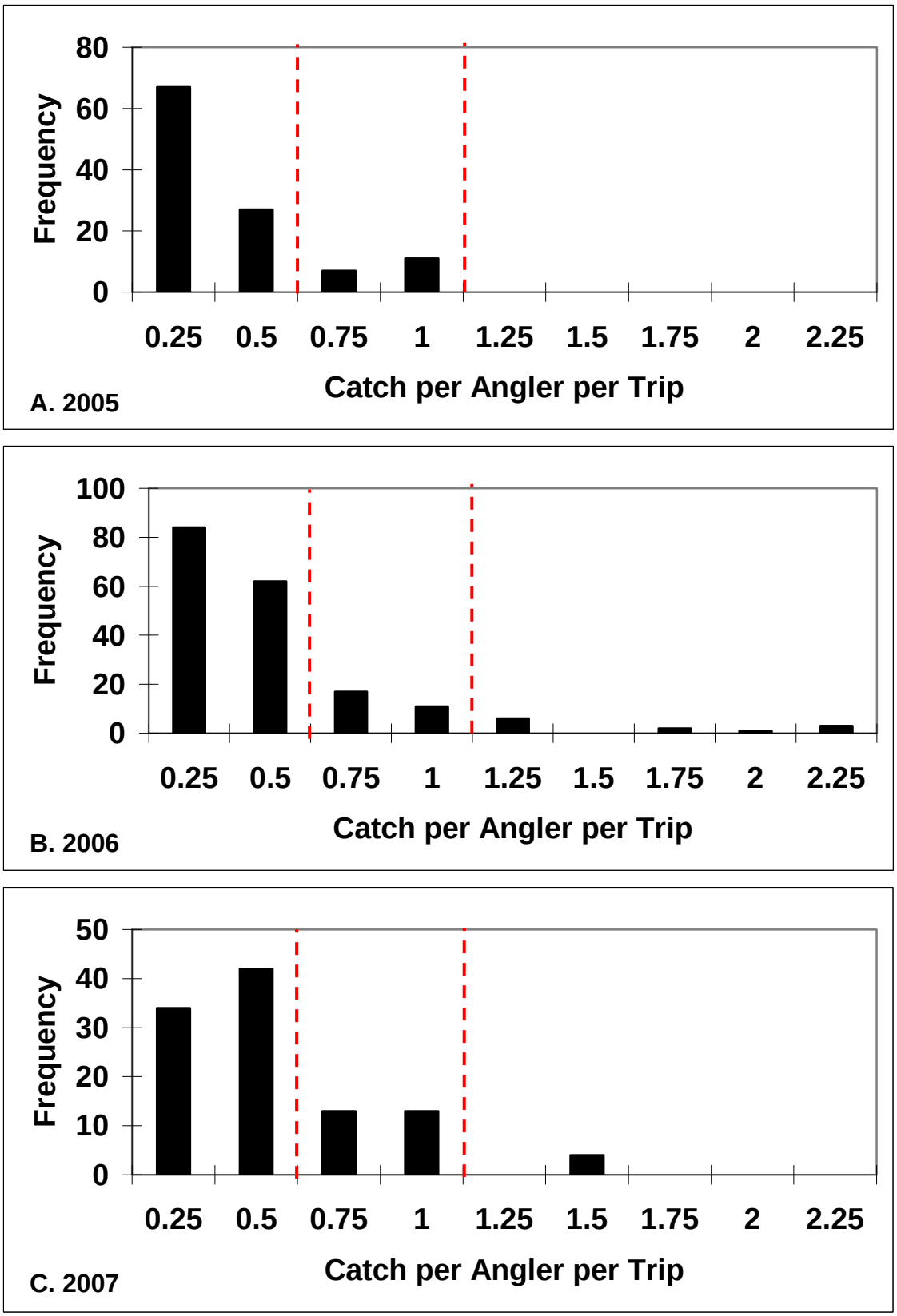

Figure 4. Histograms of number of shallow water grouper landed per angler per trip.

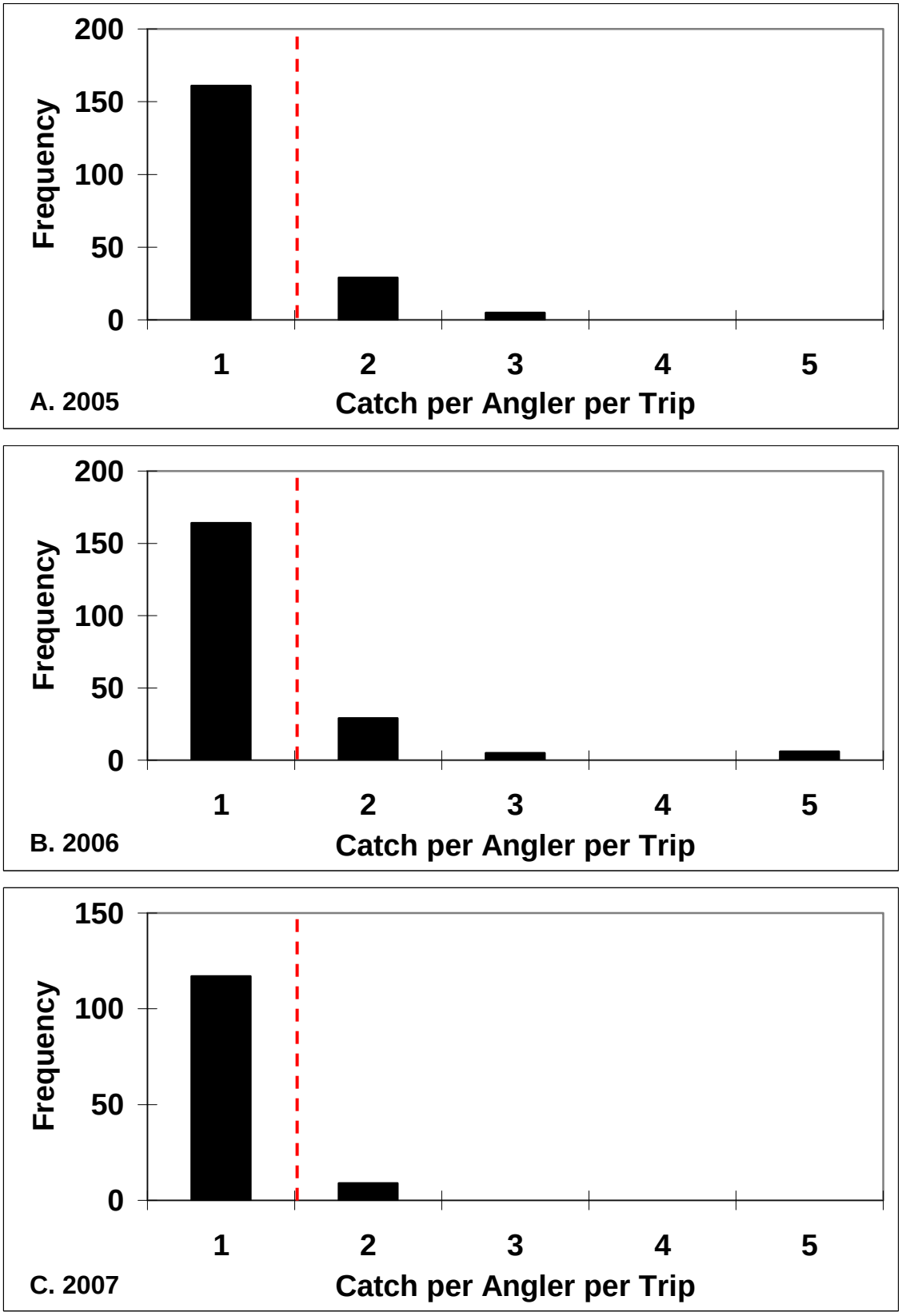

Figure 5. Histograms of number of red snapper landed per angler per trip.

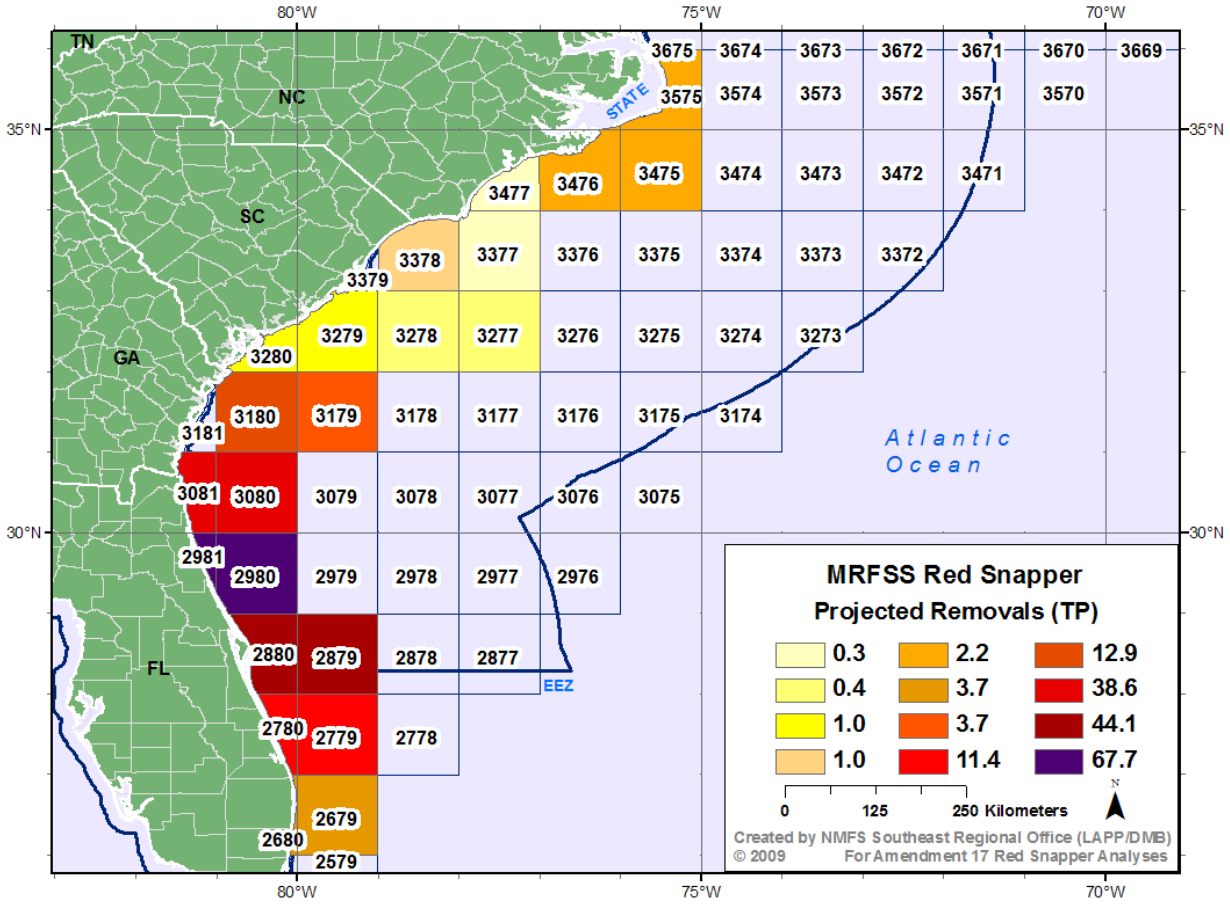

Figure 6. MRFSS projected removals partitioned to logbook grid cells using headboat landings as proxy for spatial distribution of removals within MRFSS post-stratified subregions. Assumptions include Amendment 16 elimination of trips targeting or landing >5 vermilion snapper or >1 shallow water grouper during closed months and Amendment 17A Alternative 2 elimination of trips targeting or landing >1 red snapper. Note some cells have been aggregated to maintain confidentiality.

Evaluating the Effects of Amendment 17A Regulations on 2005-2007 South Atlantic Red Snapper Headboat Removals

National Marine Fisheries Service
Southeast Regional Office
St. Petersburg, Florida

September 3, 2009

Introduction/Background

A recent stock assessment of South Atlantic red snapper indicates the stock is undergoing overfishing and is severely overfished (SEDAR 15 2008). Red snapper fishing mortality during 2006 was 7.67 times higher than the fishing mortality rate associated with F_{MSY} (=$F_{40\%SPR}$) and spawning stock biomass (SSB) was 2 percent of the SSB at maximum sustainable yield (SEFSC 2009). The South Atlantic Fishery Management Council (SAFMC) is currently developing Amendment 17A, which includes management measures to address overfishing of red snapper and rebuild this stock (SAFMC 2009). At least an 87 percent reduction in red snapper fishing mortality (based on an F_{MSY} = $F_{40\%SPR}$) and an 85 percent reduction in total removals (landings + dead discards) is needed to end overfishing and rebuild red snapper stocks in the south Atlantic region.

The intent of the present analysis is to quantify changes in red snapper landings and discards associated with Amendment 17A management alternatives. These alternatives include a year-round closure of the recreational and commercial red snapper fisheries in South Atlantic (Cape Hatteras to Key West) Exclusive Economic Zone (EEZ) waters within the federal jurisdiction (3-200 miles). Additionally, because red snapper also are caught (as bycatch) when fishing for other species (particularly other snapper and grouper species) and because considerable mortality results from the bycatch (estimated at 40% of harvest for recreational red snapper fishing activities), modifications to the management regime for the entire South Atlantic snapper-grouper complex also will have to be instituted. Alternatives under consideration include:

Alternative 1 (Status quo)-This would continue the 20 inch size limit (commercial & recreational) and the recreational 2 fish bag limit (included in the 10 snapper per person limit).

Alternative 2-Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the South Atlantic EEZ.

Alternative 3-Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish

harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the South Atlantic EEZ.

Alternative 4-Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the South Atlantic EEZ.

Alternative 5-Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the South Atlantic EEZ.

Alternative 6-Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the South Atlantic EEZ.

Alternative 7-Modify the bag and/or size limit.

Sub-alternative 7a-Remove the existing commercial and recreational 20 inch size limit.
Sub-alternative 7b-Reduce the bag limit to 1.

Alternative 8-Allow transit.

Sub-alternative 8a-The prohibition on possession does not apply to a person aboard a vessel that is in transit with fishing gear appropriately stowed.
Sub-alternative 8b-The prohibition on possession does not apply to a person aboard a vessel that has snapper grouper species onboard if the vessel is in transit.

Sub-alternative 8c-The prohibition on possession does not apply to a person aboard a vessel that has wreckfish onboard if the vessel is in transit.

Methods

Identification and categorization of headboats

Headboat landings data provided by the Southeast Fisheries Science Center (SEFSC), Beaufort Laboratory, were used to determine the magnitude and geographic location of red snapper headboat landings during 2005-2007 along the southeast coast of the United States. Landings in both numbers and pounds are typically summarized based on statistical areas of fishing (Table 1). These statistical areas provide insufficient geographic resolution for evaluating the effects of Amendment 17A, so landings were further summarized by logbook grid (LG) and inlet to provide finer spatial resolution. Landings were assigned by vessel and year using the location of the inlet from which each headboat departed on a fishing excursion, following Williams et al. (2009). A total of 63 headboats reported red snapper landings during 2005-2007 in South Atlantic statistical areas 1-17. These vessels berth in ports located between Cape Hatteras, North Carolina and Key West, Florida. For those vessels that reported red snapper landings, the home port and assigned inlet fields were complete. In a few instances, the home port of the vessel was a considerable distance from the assigned inlet. Additionally, some vessels share a berthing port but utilize different routes to the sea and therefore different inlets for their departure. In all cases, port agent information was used to assign and verify departure inlets (Brennan, pers. comm.).

Determining fishing location, and in particular the LG of fishing, was more complex. Headboat operators report fishing location at two levels of resolution, coarsely by LG (boxes defined by latitude and longitude coordinates to the nearest hour) and at a finer scale of resolution using a subgrid embedded within each LG. The LG are squares defined by points of latitude and longitude and with sides of length 1^{o} latitude x 1^{o} longitude. Each LG originates from and is named according to the latlong coordinate in the lower right corner of the LG. LGs are further subdivided into a subgrid consisting of thirty-six 10 minute by 10 minute units. Units are denoted along the latitudinal transect by the numbers 1-6, with number 1 most northerly and number 6 most southerly, and along the longitudinal transect by the letters A-F, with the letter A most westerly and the letter F most easterly. Thus, the box F6 within LG 3280 would represent the area encompassed by 32^{o}00’ N to 32^{o}10’N latitude and 80^{o}00’W to 80^{o}10’W longitude.

Table 1. South Atlantic headboat statistical areas.

Area	Description
1	Hatteras, NC offshore
2	Cape Fear, NC inshore
3	Cape Fear, NC offshore
4	South Carolina inshore
5	South Carolina offshore
6	Georgia
7	NE Florida (St. Augustine, FL - Jekyll Island, GA)
8	East Central, FL (Ponce Inlet-Sebastian)
9	Cape Lookout, NC inshore
10	Cape Lookout, NC offshore
11	SE FL (Ft. Pierce-Miami)
12	FL Keys, Atlantic based vessels
14	North FL (general)
17	Dry Tortugas (Atlantic/Keys based vessels)

On average during 2005-2007, over 85% of headboats provided complete information on location fished during individual trips (Table 2), leaving a three-year average of almost 15% of trips that reported incomplete fishing location information or reported no location information at all. For those who reported incomplete information, the oversight involved failure to report subgrid location information. Additionally, a small component of the incomplete data involved inaccurate coordinates (e.g., LG location information was on land or far to sea). Location information is also not available for many vessels that did not provide logbook reports during 2005-2007.

Table 2. Percentage of catch records that reported red snapper with a complete location field (Complete), partially filled out location field (Incomplete), or missing location field (None) for headboats operating in the South Atlantic (Source: Williams et al. 2009, Table 1).

	Landings Location Information		
Year	None	Incomplete	Complete
2005	10.0%	6.7%	83.3%
2006	7.1%	5.8%	87.1%
2007	4.7%	9.4%	85.9%
2005-07 avg.	7.2%	7.4%	85.4%

For those vessels and dates for which we did not have complete landings locations, we undertook a hierarchical approach to assigning those landings to statistical grids. If the landings location data were complete and all landings were reported, then complete landings locations were used to assign landings by vessel, year, and month. If the landings location were

complete but some locations were inaccurate (e.g., assigned to a location on land), then landings reported to inaccurate landings locations were reassigned based on the complete landing location information reported for that vessel from other trips. In cases where the vessel reported complete landings information for some but not all trips, the landings were assigned to LG by vessel, year, and month using the complete landings location information that was provided. Reported landings were then re-scaled to account for unreported landings. If an individual vessel reported incomplete or no landings location information, the location classification hierarchy was as follows:

1) if complete location information was provided for any one year, that location information was used to assign landings from years for which no location information was provided;
2) if no landings location information was provided for the entire 2005-2007 period, then location data from 2008 was used as a proxy;
3) if no 2008 data were available, location information was derived from a similar vessel operating from the same inlet;
4) if no location data were available and no proxy vessel existed, then the landings were assigned to the LG nearest to the departure inlet (applied to vessels in SE Florida primarily).

Estimation of discards

Fish that are caught but not kept (i.e., discards) also must be accounted for when determining total mortality rates (harvest + dead discards). To estimate the number and weight of discards contributed by the headboat industry, we applied the ratio of discarded to kept fish (in numbers) derived from the Marine Recreational Fisheries Statistical Sampling (MRFSS) program (Table 3). We then multiplied this ratio by the number of red snapper landed by headboats and converted numbers of discards to weight of discards using the average discard weight data available from the Southeast Fisheries Science Center red snapper projections (2009). Total dead discards were then estimated by applying a release mortality rate of 40%. To evaluate the sensitivity of different discard mortality rates, we conducted analyses using discard mortality rates ranging from 30% to 50%.

Table 3. Estimated headboat discards in numbers and pounds based on MRFSS discard to landings ratios and average discard weight data from SEFSC (2009).

	MRFSS			Avg. discard	Headboat		
Year	# landed	# discarded	discards/landings	weight	# landed	# discarded	discards (lbs)
2005	35028	124044	3.54	1.48	8907	31542	46799
2006	25655	133707	5.21	1.48	5945	30984	45970
2007	40775	453443	11.12	1.48	6889	76610	113665
2005-07	30342	237065	7.01	1.48	7247	46379	68811

Results

Of the 109 headboats operating in the South Atlantic region, 63 had landings of red snapper during 2005-2007. Of those 63 vessels, 23 reported complete landings location information during all years with reported landings and another four reported complete landings location information for at least 90% of their trips. Of those vessels failing to report complete landings location information for at least 90% of their trips, only 10 landed a total of more than 1,000 pounds of red snapper during the three-year period. The cumulative three-year total landings of red snapper reported by the 38 vessels with < 1,000 lbs of landings was 8,470 lbs, only slightly greater than 6% of the total red snapper landings by weight in the South Atlantic during 2005-2007. The cumulative three-year total landings of red snapper reported by vessels with no reported landing locations or no complete landings locations was 26,162 lbs, representing 19% of the total red snapper landings by weight in the South Atlantic during 2005-2007. Sixty-four percent of the landings with unreported or no landing location information were contributed by four vessels operating out of various South Atlantic states.

Two LGs (2880, 2980) accounted for more than 50% of the total landings by weight of red snapper in the EEZ region between Cape Hatteras and Key West. Another six LGs (3080, 3081, 3378, 3180, 3279, and 2780) contributed 39% of landings, with the remaining 18 LGs contributing 11% of the total landings. Results provided in Table 4 enabled analysis of landings data with regard to the various proposed management alternatives (Note: in some instances logbook grid landings have been aggregated to maintain confidentiality). We considered two general scenarios. The first scenario was the most conservative and presumed Amendment 16 would have no effect and no target trips would be eliminated as a result of Amendment 17A. The second scenario was the least conservative and presumed that enactment of Amendment 16 will eliminate trips landing 25 or more vermillion snapper and/or shallow-water grouper; those landings must have also accounted for at least 25% of the overall snapper/grouper landings on the trip (see SERO 2009a for further details). This second scenario also assumes that headboat trips landing one or more red snapper per angler will be eliminated due to Amendment 17A regulations. For each of the two scenarios, we then calculated the predicted total removals of red snapper, in pounds, and the percent reduction resulting from this new total removal estimate relative to the 2005-2007 total removals estimate. For each scenario, these calculations were made for discard mortality rates of 30%, 40%, and 50%.

Results from scenario one, for each of the three discard mortality rates, indicate that only Alternative 6 (complete red snapper closure plus closure of LGs 2880, 2980, 3080, 3179, 3180, 3278, and 3279 to all fishing) will achieve the goal of a minimum 85% reduction in red snapper total removals (Table 5). Moreover, this goal will only be achieved if the discard mortality rate is 30%, but will fall short if realized discard mortality rate is 40% or 50%.

For scenario two, results suggest that Alternative 5 (complete red snapper closure plus closure of LGs 2880, 2980, 3080, and 3180 to all fishing) will achieve the goal of a minimum 85% reduction in total removals (Table 6). This goal will only be achieved if the discard mortality rate is 30%, but will fall short if realized discard mortality rate is 40% or 50%. On the other

hand, Alternative 6 will achieve the goal of a minimum 85% reduction in total removals using discard mortality rates of 30%, 40%, or 50%.

Table 4. South Atlantic headboat red snapper 2005-2007 total landings by logbook grid (LG). Logbook grids have been aggregated in some instances to maintain confidentiality. Landings for logbook grids that have not been aggregated are from 3 or more vessels.

logbook grid	landings lbs	pct landings	cum pct landings
2980	41806	30.4%	30.4%
2880	27186	19.8%	50.1%
3179, 3180, 3279	16704	12.1%	62.3%
3080	13886	10.1%	72.4%
3081	10258	7.5%	79.8%
3378	8145	5.9%	85.8%
2780	6941	5.0%	90.8%
2679, 2779, 2879	3683	2.7%	93.5%
3277, 3278	3560	2.6%	96.1%
2481, 2482	2098	1.5%	97.6%
3475, 3476, 3575	1621	1.2%	98.8%
3280	722	0.5%	99.3%
2981	489	0.4%	99.6%
3377, 3477	260	0.2%	99.8%
2480, 2579, 2580, 2680	230	0.2%	100.0%

Table 5. Anticipated percent reduction in headboat red snapper removals associated with various Amendment 17A management alternatives and discard mortality rates (r = 0.3, 0.4, or 0.5). Reductions assume no effect from Amendment 16 and target trips will not be eliminated as a result of Amendment 17A.

A16 - no effect, r = 0.3

Alternative	Total Removals (lbs)	% Reduction
Alt 1	66506	0.0%
Alt 2	34402	48.3%
Alt 5	11832	82.2%
Alt 6	8625	87.0%

A16 - no effect, r = 0.4

Alternative	Total Removals (lbs)	% Reduction
Alt 1	73387	0.0%
Alt 2	45870	37.5%
Alt 5	15777	78.5%
Alt 6	11500	84.3%

A16 - no effect, r = 0.5

Alternative	Total Removals (lbs)	% Reduction
Alt 1	80269	0.0%
Alt 2	57337	28.6%
Alt 5	19721	75.4%
Alt 6	14376	82.1%

Table 6. Anticipated percent reduction in headboat red snapper removals associated with various Amendment 17A management alternatives and discard mortality rates (r = 0.3, 0.4, or 0.5). Reductions assume Amendment 16 will eliminate trips landing 25 or more vermilion snapper and/or shallow-water grouper, which account for at least 25% of the overall snapper-grouper landings on a trip (see SERO 2009a for further details). Reductions also assume headboat trips landing 1 or more red snapper per angler will be eliminated due to Amendment 17A regulations.

A16 - target trips eliminated, A17 directed trips eliminated, r = 0.3

Alternative	Total Removals (lbs)	% Reduction
Alt 1	66506	0.0%
Alt 2	14540	78.1%
Alt 5	9009	86.5%
Alt 6	6964	89.5%

A16 - target trips eliminated, A17 directed trips eliminated, r = 0.4

Alternative	Total Removals (lbs)	% Reduction
Alt 1	73387	0.0%
Alt 2	19387	73.6%
Alt 5	12013	83.6%
Alt 6	9286	87.3%

A16 - target trips eliminated, A17 directed trips eliminated, r = 0.5

Alternative	Total Removals (lbs)	% Reduction
Alt 1	80269	0.0%
Alt 2	24234	69.8%
Alt 5	15016	81.3%
Alt 6	11607	85.5%

Although red snapper in the South Atlantic are landed on headboats operating throughout the area between Cape Hatteras and Key West, the predominance of landings occur off north Florida and south Georgia, with a secondary center of abundance off South Carolina (Figure 1).

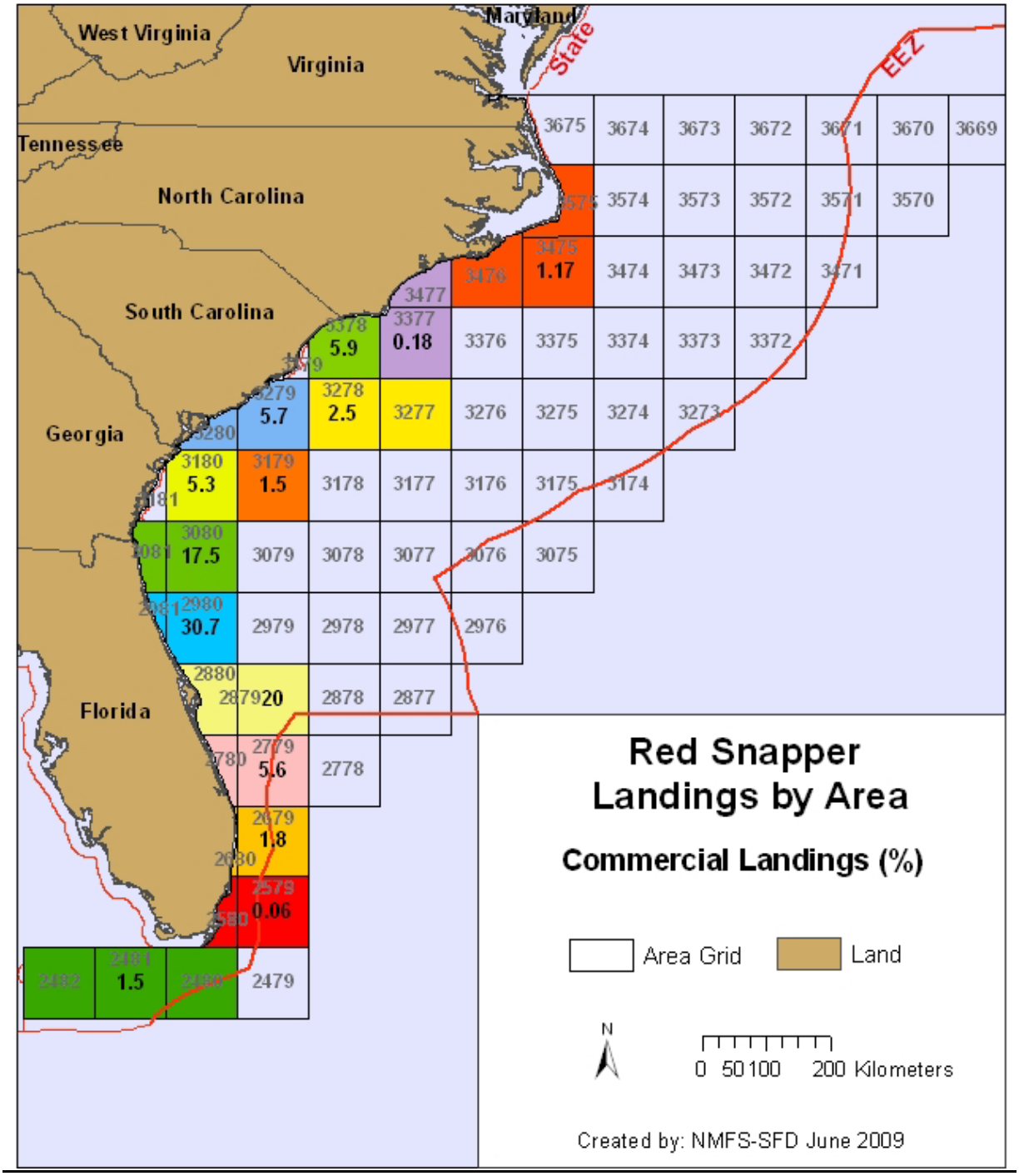

Figure 1. Percentage of headboat red snapper landings by logbook grid (LG). Logbook grids have been aggregated to maintain confidentiality.

Discussion

Red snapper in the South Atlantic are overfished and undergoing overfishing (SEDAR 2009), and several direct and indirect measures have been implemented (Amendment 13C, Amendment 16) or are being considered (Amendment 17A) to reduce take to a level that allows for rebuilding of the red snapper population. Previous analyses suggest that implementation of the regulations outlined in either Amendment 13C or Amendment 16 will not provide a sufficient magnitude of harvest reduction to achieve the stated goal of an 85% decrease in red snapper total removals. It is apparent that more drastic harvest regulations will have to be applied to achieve the reduction goal. The alternatives proposed in Amendment 17A are designed to address the needed reductions in red snapper removals.

Analyses of headboat landings data, the outcomes of which are summarized in this document, indicate that two of the four alternatives that address area closures will achieve the desired outcome of a minimum 85% reduction in total removals from the headboat sector. Implementation of Alternative 6, which assumes no substantial reduction in red snapper landings due to regulations implemented in Amendment 16, requires that seven LGs be closed to achieve the stated reduction. Alternative 5, assuming some contribution to reduced headboat landings from Amendment 16 and a 30% release mortality rate, predicts achievement of the reduction goal with closure of four LGs. In either case, those closures would take place in the area between Cape Canaveral and the central coast of South Carolina.

Both Alternative 3 and Alternative 4 also may achieve the necessary reductions, either in their present form or with some modification to the depth limits proposed in these two alternatives. However, predicting outcomes from these two alternatives is difficult because depth data is not reported in headboat catch files. SERO (2009b) assessed reductions from the commercial fishing sector in response to Amendment 13C, 16, and 17 provisions, but concluded that depth was an unreliable field because depth records were often unavailable and sometimes misreported.

Lastly, it should be noted that several assumptions were incorporated into our analyses. First, we consider that discards occur in the same proportional distribution as landings. We also assume that no effort shifting occurs from the closed areas, and that there is 100% compliance with the closed areas. Finally, we assume that average discard mortality remains unchanged (0.30, 0.40, or 0.50) even when areas of highest abundance and landings are closed. If compliance is less than 100% or effort shifting occurs, then reductions estimated in this report would be less optimistic. Similarly, if release mortality is lower than estimated by SEDAR 15 (2009), then reductions would be greater. Higher release mortality rates would result in lower reductions in overall removals.

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Projected Combined Effects of Amendments 13C, 16, and 17A Regulations on south Atlantic Red Snapper Removals

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Southeast Regional Office
St. Petersburg, Florida

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Introduction

A recent stock assessment of south Atlantic red snapper indicates the stock is undergoing overfishing and is severely overfished (SEDAR 15 2009). The South Atlantic Fishery Management Council (SAFMC) is currently developing Amendment 17A to the Snapper-Grouper Fishery Management Plan (FMP) to address overfishing of red snapper and rebuild this stock (SAFMC 2009). Based on $F_{MSY} = F_{40\%SPR}$ and assuming average recruitment, an 85 percent reduction in total removals of red snapper is needed to reduce *F* by 87% and end overfishing.

Amendment 13C to the Snapper-Grouper FMP reduced harvest and established commercial quotas and/or trip limits for snowy grouper, golden tilefish, black sea bass, red porgy, and vermilion snapper (VS). Amendment 16 to the Snapper-Grouper FMP closes the recreational fishery for VS in the South Atlantic during November through March of each year. Amendment 16 also closes both the recreational and commercial shallow-water grouper (SWG) fisheries during January through April of each year. These regulatory actions may indirectly affect red snapper removals (e.g. landings and dead discards) if trips targeting other regulated species no longer occur due to closed seasons, quota reductions, or trip limits. Additionally, red snapper removals will be directly impacted by the alternatives under consideration in Amendment 17A, which include a year-round prohibition on red snapper harvest, possession, and retention in the south Atlantic EEZ, as well as year-round spatial area closures for all snapper-grouper harvest and possession, with limited exceptions (see Table 1).

Four reports were completed by Southeast Regional Office personnel analyzing the effects of South Atlantic Fishery Management Council (SAFMC) Amendments 13C, 16, and 17A on red snapper removals (SERO 2009a-d). This report is a synthesis of those four reports and estimates overall reductions in red snapper removals across all three fishery sectors – commercial, recreational private/charter, and headboat. To provide a full range of alternatives, this report compares projected removal rates under scenarios assuming indirect effects on red snapper removals resulting from Amendment 13C and 16 regulations with scenarios that consider no effect on red snapper harvest due to these regulations.

Methods

Methodologies for predicting outcomes from the various alternatives proposed in Amendment 17A are fully described for each of the commercial, recreational private/charter, and headboat sectors in previous reports (SERO 2009a-d). Cumulative impacts are now considered. For the six alternatives proposed in Amendment 17A (Table 1), predicted outcomes are considered either within or without the context of indirect red snapper harvest reductions due to Amendment 13C (commercial sector only) and Amendment 16 (commercial, recreational private/charter, and headboat sectors). It should be noted that reductions in MRFSS and headboat removals for Alternatives 3 and 4 are assumed equivalent to projections for Alternatives 5 and 6, respectively. The depth-specific catch information necessary to evaluate Alternatives 3 and 4 was largely unavailable in MRFSS and headboat data. For the commercial fishery, 77% and 81% of trips reporting red snapper landings in the statistical areas closed by Alternatives 5 and 6 reported their red snapper landings within the depth range (30-73 m) that would be closed by Alternatives 3 and 4, respectively (SERO 2009a). The impacts of Alternatives 3 and 4 were explicitly modeled for the commercial fishery due to the availability of depth information; however, it should be noted that this information was not always reported for two of the three years under consideration (2005-2006).

Mortality of discarded red snapper has been estimated at 40% for the recreational fishery and at 90% for the commercial fishery (SEDAR 15 2009). A significant component of this difference in discard mortality rate between recreational and commercial fisheries results from commercial fishermen generally fishing in deeper water, although longer handling time (longer surface interval) in the commercial fishery can also increase the discard mortality rate (SEDAR 15 2009).

Given what is known of the distribution of the red snapper stock, it is reasonable to assume that little additional increase in removals would result from pushing the commercial fishermen into even deeper water (thereby potentially increasing discard mortality to levels even greater than 90%). However, some closure alternatives may result in commercial and recreational fishermen moving into shallower water to fish, potentially decreasing discard mortality rates. Thus, various scenarios that include a substantial reduction (from 90% to 40%) in commercial discard mortality, a moderate reduction (from 90% to 65%) in commercial discard mortality, and a relatively small reduction (from 40% to 30%) in recreational discard mortality are also modeled to evaluate the sensitivity of red snapper reductions to changes in discard mortality rates.

Table 1. Proposed or implemented regulations under various management actions impacting recreational fisheries and potentially red snapper removals.

Action	Status	Management Actions*
Amendment 16	Proposed (Public Comment)	Establish four month commercial and recreational closed season (January-April) for shallow-water grouper, establish a five-month recreational closed season for vermilion snapper (November-March), and reduce bag limits for vermilion snapper, gag, and other groupers.
Amendment 17A, No Action	Proposed	Continue the 20 inch size limit (commercial & recreational).
Amendment 17A, Alternative 2	Proposed	Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ.
Amendment 17A, Alternative 3	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ.
Amendment 17A, Alternative 4	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279 between a depth of 98 feet (16 fathoms; 30 m) to 240 feet (40 fathoms; 73 m). Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ

Amendment 17A, Alternative 5	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, and 3180. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ
Amendment 17A, Alternative 6	Proposed	Prohibit commercial and recreational harvest, possession, and retention of species in the snapper grouper FMU year-round in an area that includes commercial logbook grids 2880, 2980, 3080, 3179, 3180, 3278, and 3279. Allow black sea bass harvest, possession, and retention in the closed area if fish were harvested with black sea bass pots with endorsements. Allow golden tilefish harvest, possession, and retention in the closed area. Allow harvest, possession, and retention of snapper grouper species in the closed area if fish were harvested with spearfishing gear. Prohibit all commercial and recreational harvest, possession, and retention of red snapper year-round in the south Atlantic EEZ

Results

Scenario 1A: Amendments 13C and 16 Eliminate Trips; Constant 40% Recreational Release Mortality and 90% Commercial Release Mortality Rate – In Scenario 1A (Table 2; Figures 1-4), red snapper harvest in the South Atlantic is indirectly reduced as an outcome of reductions in commercial harvest due to Amendment 13C management measures, and the elimination of VS and SWG fishing trips due to Amendment 16 regulatory actions. Red snapper harvest also is directly reduced through elimination of red snapper trips as a result of the Amendment 17A year-round closure. Given constant discard mortality rates for red snapper of 40% for the recreational fishery and 90% for the commercial fishery, both Alternative 4 and Alternative 6 options will achieve the needed cumulative reduction of at least 87%. All other alternatives fall short, although both Alternative 3 and Alternative 5 come within 1%.

Table 2. Scenario 1A projected cumulative effects of Amendment 13C (commercial only), Amendment 16, and Amendment 17A management alternatives on cumulative removals of red snapper in the south Atlantic region.

Alternative	Total Removals (lbs)				% reduction
	Commercial	Headboat	MRFSS	All modes	
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	58,978	19,387	187,063	265,428	56%
Alt 3*	44,694	12,013	41,536	98,243	84%
Alt 4**	34,560	9,286	36,472	80,318	87%
Alt 5	40,168	12,013	41,536	93,717	84%
Alt 6	24,500	9,286	36,472	70,258	88%

* MRFSS and headboat data same as Alt 5

** MRFSS and headboat data same as Alt 6

Scenario 1B: Amendments 13C and 16 Do Not Eliminate Trips; Constant 40% Recreational Release Mortality and 90% Commercial Release Mortality Rate – Scenario 1B (Table 3) anticipates that harvest of red snapper in the South Atlantic will not be affected by Amendment 13C or Amendment 16 management measures. Red snapper removals are directly reduced as a result of the Amendment 17A year-round closure. Given constant discard mortality rates for red snapper of 40% for the recreational fishery and 90% for the commercial fishery, Alternative 6 achieves the needed cumulative reduction in red snapper removals and Alternative 4 comes within 1%. Alternatives 3 and 5 fall 4-5% short of the reduction target.

Table 3. Scenario 1B projected cumulative effects of Amendment 17A management alternatives on removals of red snapper in the south Atlantic region.

Alternative	Total Removals (lbs)				% reduction
	Commercial	Headboat	MRFSS	All modes	
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	120,031	45,870	202,129	368,030	39%
Alt 3*	65,294	15,777	44,287	125,359	79%
Alt 4**	44,861	11,500	38,999	95,360	84%
Alt 5	60,453	15,777	44,287	120,518	80%
Alt 6	34,798	11,500	38,999	85,298	86%

* MRFSS and headboat data same as Alt 5

** MRFSS and headboat data same as Alt 6

Scenario 2A: Amendments 13C and 16 Eliminate Trips; Constant 40% Recreational Release Mortality Rate; Decrease in Commercial Release Mortality From 90% to 40% – Scenario 2A (Table 4) anticipates that red snapper removals in the south Atlantic will be indirectly reduced as an outcome of reductions in commercial harvest due to Amendment 13C management measures, and due to Amendment 16 elimination of VS and SWG commercial and recreational fishing trips. Red snapper removals are directly reduced through elimination of red snapper trips as a result of the Amendment 17A year-round closure. The predicted outcome from this scenario is based upon pre-implementation discard mortality rates for red snapper of 40% for the recreational fishery and of 90% for the commercial fishery. The discard mortality rate for the recreational fishery does not change following implementation of Amendment 17A but the discard mortality rate for the commercial fishery decreases to 40% following implementation of Amendment 17A. This reduction in discard mortality rate might be expected as commercial fishermen move closer to shore to access open harvest areas. Under Scenario 2A, Alternatives 3, 4, 5, and 6 will achieve the needed cumulative reduction of at least 85%.

Table 4. Scenario 2A projected cumulative effects of Amendment 13C (commercial only), Amendment 16, and Amendment 17A management alternatives on cumulative removals of red snapper in the south Atlantic region.

Alternative	Total Removals (lbs)				% reduction
	Commercial	Headboat	MRFSS	All modes	
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	26,213	19,387	187,063	232,663	61%
Alt 3*	19,864	12,013	41,536	73,413	88%
Alt 4**	15,360	9,286	36,472	61,118	90%
Alt 5	17,853	12,013	41,536	71,402	88%
Alt 6	10,889	9,286	36,472	56,647	91%

* MRFSS and headboat data same as Alt 5

** MRFSS and headboat data same as Alt 6

Scenario 2B: Amendments 13C and 16 Do Not Eliminate Trips; Constant 40% Recreational Release Mortality Rate; Decrease in Commercial Release Mortality From 90% to 40% – Scenario 2B (Table 5) anticipates that removals of red snapper in the south Atlantic will not be affected by Amendment 13C or Amendment 16 management measures. Red snapper removals are directly reduced through elimination of red snapper trips as a result of the Amendment 17A year-round closure. The predicted outcome from this scenario is based upon a pre-implementation discard mortality rates for red snapper of 40% for the recreational fishery and 90% for the commercial fishery. The discard mortality rate for the recreational fishery does not change following implementation of Amendment 17A but the discard mortality rate for the commercial fishery decreases to 40% following implementation of Amendment 17A. Under Scenario 2B, Alternatives 3, 4, 5, and 6 achieve the needed cumulative reduction of at least 85%.

Table 5. Scenario 2B projected cumulative effects of Amendment 17A management alternatives on removals of red snapper in the south Atlantic region.

Alternative	Total Removals (lbs)				% reduction
	Commercial	Headboat	MRFSS	All modes	
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	53,347	45,870	202,129	301,346	50%
Alt 3*	29,020	15,777	44,287	89,084	85%
Alt 4**	19,938	11,500	38,999	70,437	88%
Alt 5	26,868	15,777	44,287	86,933	86%
Alt 6	15,466	11,500	38,999	65,965	89%

* MRFSS and headboat data same as Alt 5

** MRFSS and headboat data same as Alt 6

Scenario 3A: Amendments 13C and 16 Eliminate Trips; Decrease in Recreational Release Mortality Rate from 40% to 30% Following Amendment 17A Implementation; Decrease in Commercial Release Mortality Rate From 90% to 65% Following Amendment 17A Implementation – Scenario 3A (Table 6) anticipates that removals of red snapper in the south Atlantic will be indirectly reduced as an outcome of reductions in commercial harvest due to Amendment 13C management measures, and due to elimination of VS and SWG fishing trips affected by Amendment 16 regulatory actions. Red snapper removals are also directly reduced as a result of the Amendment 17A year-round closure. The predicted outcome from this scenario is based upon a pre-implementation discard mortality rate for red snapper of 40% for the recreational fishery and of 90% for the commercial fishery. The discard mortality rate is assumed to decrease to 30% for the recreational fishery and to 65% for the commercial fishery following implementation of Amendment 17A. Under Scenario 3A, Alternatives 3, 4, 5, and 6 achieve the needed cumulative reduction of at least 85%.

Table 6. Scenario 3A projected cumulative effects of Amendment 13C (commercial only), Amendment 16, and Amendment 17A management alternatives on cumulative removals of red snapper in the south Atlantic region.

Alternative	Total Removals (lbs)				% reduction
	Commercial	Headboat	MRFSS	All modes	
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	42,595	14,540	187,063	244,198	59%
Alt 3*	32,279	9,009	41,536	82,824	86%
Alt 4**	24,960	6,964	36,472	68,396	89%
Alt 5	29,011	9,009	41,536	79,556	87%
Alt 6	17,694	6,964	36,472	61,130	90%

* MRFSS and headboat data same as Alt 5

** MRFSS and headboat data same as Alt 6

Scenario 3B: Amendment 16 Does Not Eliminates Trips; Decrease in Recreational Release Mortality Rate from 40% to 30% Following Amendment 17A Implementation; Decrease in Commercial Release Mortality Rate From 90% to 65% Following Amendment 17A Implementation – Scenario 3B (Table 7) anticipates that removals of red snapper in the south Atlantic will not be affected by Amendment 13C or Amendment 16 management measures. Red snapper removals are directly reduced through elimination of red snapper trips as a result of the Amendment 17A year-round closure. The predicted outcome from this scenario is based upon a pre-implementation discard mortality rate for red snapper of 40% for the recreational fishery and of 90% for the commercial fishery. The discard mortality rate is assumed to decrease to 30% for the recreational fishery and to 65% for the commercial fishery following implementation of Amendment 17A. Under Scenario 3B, only Alternatives 4 and 6 will achieve the needed cumulative reduction of at least 85%. Both Alternatives 3 and 5 fall short of the 85% benchmark by 2%.

Table 7. Scenario 3B projected cumulative effects of Amendment 17A management alternatives on removals of red snapper in the south Atlantic region.

Alternative	Total Removals (lbs)				% reduction
	Commercial	Headboat	MRFSS	All modes	
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	86,689	34,402	202,129	323,220	46%
Alt 3*	47,157	11,832	44,287	103,277	83%
Alt 4**	32,399	8,625	38,999	80,024	87%
Alt 5	43,661	11,832	44,287	99,780	83%
Alt 6	25,132	8,625	38,999	72,756	88%

* MRFSS and headboat data same as Alt 5

** MRFSS and headboat data same as Alt 6

Discussion

At least an 85% reduction in red snapper total removals and an 87% reduction in fishing mortality (based on an $F_{MSY} = F_{40\%SPR}$) is needed to end overfishing and rebuild the red snapper stock in the south Atlantic region. Amendment 17A, Alternative 2 proposes the closure of the red snapper fishery in the south Atlantic. Our analyses suggest that without additional regulations, this closure will be inadequate to achieve the 85% reduction in red snapper removals necessary to end overfishing of red snapper. This is due to the high rate of encounter with red snapper during other snapper-grouper fishing operations as well as the high release mortality of red snapper. When considering the cumulative impacts on red snapper removals predicted to result from Amendment 17A, Alternative 2, the greatest percentage decrease (59-61%) in removals was realized from Scenarios 2A and 3A. To achieve an 85% reduction, the interaction rate of south Atlantic fisheries with red snapper must be reduced through the closure of specific areas to harvest of all members of the snapper/grouper fishery management unit (FMU), in addition to a general closure of the red snapper fishery.

Amendment 17A, Alternative 3 requires, in addition to a closure of the red snapper fishery, the closure of waters between 98 and 240 feet within four logbook grids to the harvest of all members of the snapper/grouper FMU (Table 1). Due to the lack of depth information in the MRFSS and headboat datasets, Alternative 3 is assumed to have the same impacts upon recreational and headboat fisheries as Alternative 5. Amendment 17A, Alternative 5 requires, in addition to a closure of the red snapper fishery, a complete closure of the four logbook grids partially closed in Alternative 3 (Figure 3). Under Alternative 3, only Scenarios 2A, 2B, and 3A achieve the required 85% reduction. The successful scenarios that result from Alternative 5 are identical to those for Alternative 3.

Amendment 17A, Alternative 4 requires, in addition to a closure of the red snapper fishery, the year-round closure of seven logbook grids between depths of 98 and 240 feet to the harvest of all members of the snapper/grouper FMU. Scenarios 1A, 1B, and 3B fail to achieve the desired cumulative reduction in harvest. Scenarios 1A and 1B assume the highest release mortality rates of any of the scenarios considered. Scenarios 1B and 3B also predict no effect from Amendments 13C (commercial only) and Amendment 16. Scenario 1B is the most conservative combination of parameters explored, and falls short of achieving an 85% reduction for all alternatives save the most restrictive: Alternative 6. Alternative 6 calls for a complete closure of the seven logbook grids closed by Alternative 4, and is projected to yield reductions between 86%-91%.

Great caution should be taken when interpreting model outputs for Alternatives 3 and 4. The assumption that Alternative 3 provides the same protection for red snapper as Alternative 5 (and similarly, Alternative 4 to Alternative 6) in recreational and headboat fisheries is a very liberal assumption. Amendment 17A, Alternatives 3 and 5 include a combination of area and depth defined closures. Depth information was not available for the recreational fishery for this analysis, but some depth information from commercial logbook records was available to evaluate red snapper reductions. For all scenarios considered in this report, MRFSS and

headboat reductions in removals associated with Alternatives 3 and 4 were assumed to be the same as MRFSS and headboat reductions associated with Alternatives 5 and 6, respectively. However, this likely overestimates the actual reductions that would result from Alternatives 3 and 4, since these alternatives would close a smaller area to all snapper-grouper fishing relative to Alternatives 5 and 6. Data from the commercial logbook suggests that actual protections afforded by bathymetric closure alternatives may only be 77-81% as effective as closures of the full statistical area (SERO 2009a). Ongoing SERO analyses of fishery independent MARMAP data may provide insight into the spatial distribution of the red snapper stock to help quantify the relative level of difference between Alternative 3 and 5, and Alternative 4 and 6, in context of the percent of the overall red snapper stock in the closed cells (e.g. Alternatives 5 and 6) also contained within the depths closed by Alternatives 3 and 4. Future analyses should explore the sensitivity of the model to assumptions regarding the relative effectiveness of the bathymetric closures proposed in Alternatives 3 and 4 versus the complete closures proposed in Alternatives 5 and 6.

For Amendment 17A, Alternative 6, all six scenarios achieve the desired 85% reduction in red snapper removals. Alternative 6 proposes the complete closure of the seven logbook grids partially closed by Alternative 4 (Table 1) to harvest of any member of the snapper/grouper FMU (Figure 4). This alternative therefore includes the most extensive closure of harvest areas. As a result, it is the least sensitive to discard mortality rates or to the potential contributions from Amendments 13C and 16. In fact, five of the six scenarios considered for this alternative achieve a harvest reduction of at least 88%.

This report considered scenarios with changes in release mortality. Some level of effort shifting into shallower water, for both the recreational and commercial fisheries, may be expected following implementation of areal closures. Although a variety of factors contribute to discard mortality (e.g., fishing depth, surface interval, hook location, predation, water temperature), depth of capture is an important consideration (GMFMC 2007). This is because a substantial component of the mortality experienced by red snapper following capture and release is due to barotrauma (Campbell 2008) and is therefore directly related to depth of capture (Burns et al. 2004, Rummer 2007). Rummer (2007) estimates that discard mortality may be as low as 20% if the fish is caught in waters < 20 m. If red snapper fishing activity does move closer to shore (particularly into areas 2981, 3081, and 3181) as areas farther offshore are closed (see Figures 3 and 4), then reductions in depth-related discard mortality should be realized. It is difficult to predict exactly what those reductions will be, both because the level and pattern of effort shifting is unknown and because higher discard mortality rates will continue to be experienced in areas of the south Atlantic where areal closures are not implemented.

If the recreational and commercial fisheries move shoreward, a decrease in discard mortality can be expected in those areas where effort shifts. The implications of decreased discard mortality are most profound for the commercial fishery, where discard mortality is currently estimated at 90% (SEDAR 2009). However, the shoreward movement of the fishery is not well-supported by commercial logbook data, which suggests the average depth of fishing for red

snapper in areas that remain open to snapper-grouper fishing may be great then in areas where the snapper-grouper fishery will be closed.

As with most statistical analyses, assumptions can limit the applicability of results and conclusions. Assumptions in this analysis included: 1) discards occur in same proportion as landings, 2) no effort shifting from closed areas occurs, 3) there will be 100% compliance with closed area restrictions, 4) headboat landings are reasonable spatial proxies for private and charter boat landings, 5) no disproportionate redistribution of fishing effort along closure boundaries, 6) historical trends are reasonable proxies for future trends, and 7) no movement of fish across spatial closure boundaries,

If discards do not occur proportionally to landings, the overall reductions generated by spatial closures in Alternatives 3-6 would be different than presented herein. If fishermen relocate their effort to open areas rather than eliminating trips, reductions would be less than presented herein. If fishermen go out of business due to the stringency of proposed regulations, overall reductions might be greater than those presented herein.

Most of the positive benefits of spatial closures, including projected reductions in red snapper, are dependent on compliance with no-take regulations (Fogarty *et al.* 2000). Numerous modeling efforts and case studies have shown that even relatively low levels of poaching can rapidly erode the fisheries benefits of reserves (Tegner 1993, Attwood et al. 1997, Gribble & Robertson 1998, Guzman & Jacome 1998, Murray et al. 1999, Rogers-Bennett et al. 2000; however, see Jennings et al. 1996). Little published data exists to estimate rates of non-compliance (Ward et al. 2001), but a multi-year study in the Great Barrier Reef has reported high levels of intrusion into a no-take zone of the Great Barrier Reef Marine Park (Gribble & Robertson 1998). If compliance is less than 100% or effort shifting occurs, then reductions in red snapper removals might be substantially less than those estimated in this report.

The use of headboat landings locations as spatial proxies for private and charter boat landings is discussed in SERO (2009c). A comparison of post-stratified aggregated landings showed similar patterns in red snapper removals, although MRFSS reports higher relative landings off Northeast Florida and lower relative landings off South Carolina (SERO 2009c). Given the large size of the statistical areas involved in the spatial portioning of landings and the locations of major population centers, it seems reasonable to assume that broad-scale landings patterns between these fisheries might be similar. If charter boat and private recreational landings patterns are not reasonably approximated by the headboat fishery, then overall reductions might be greater or lower than those projected by these analyses.

Movements of exploited fish species across spatial closure boundaries can help maintain fisheries yields but also reduce the ability of the spatial closure to protect spawning stock biomass (Farmer 2009). Fishermen may take advantage of these movements by redistributing fishing effort along closure boundaries (review in Gell & Roberts 2003), further reducing the closed areas ability to control fishing pressure on the stock. Modeling efforts suggest larger spatial closures, such as those proposed in Amendment 17A, provide a buffer, reducing the

impacts of 'fishing-the-line' upon the core population (Fogarty 1999, Bohnsack 2000, Crowder et al. 2000, Walters 2000, Farmer 2009). Regardless, a combination of fish movement across spatial closure boundaries and a redistribution of fishing effort along boundaries might substantially reduce the protections afforded by the closures proposed in Amendment 17A for the red snapper stock.

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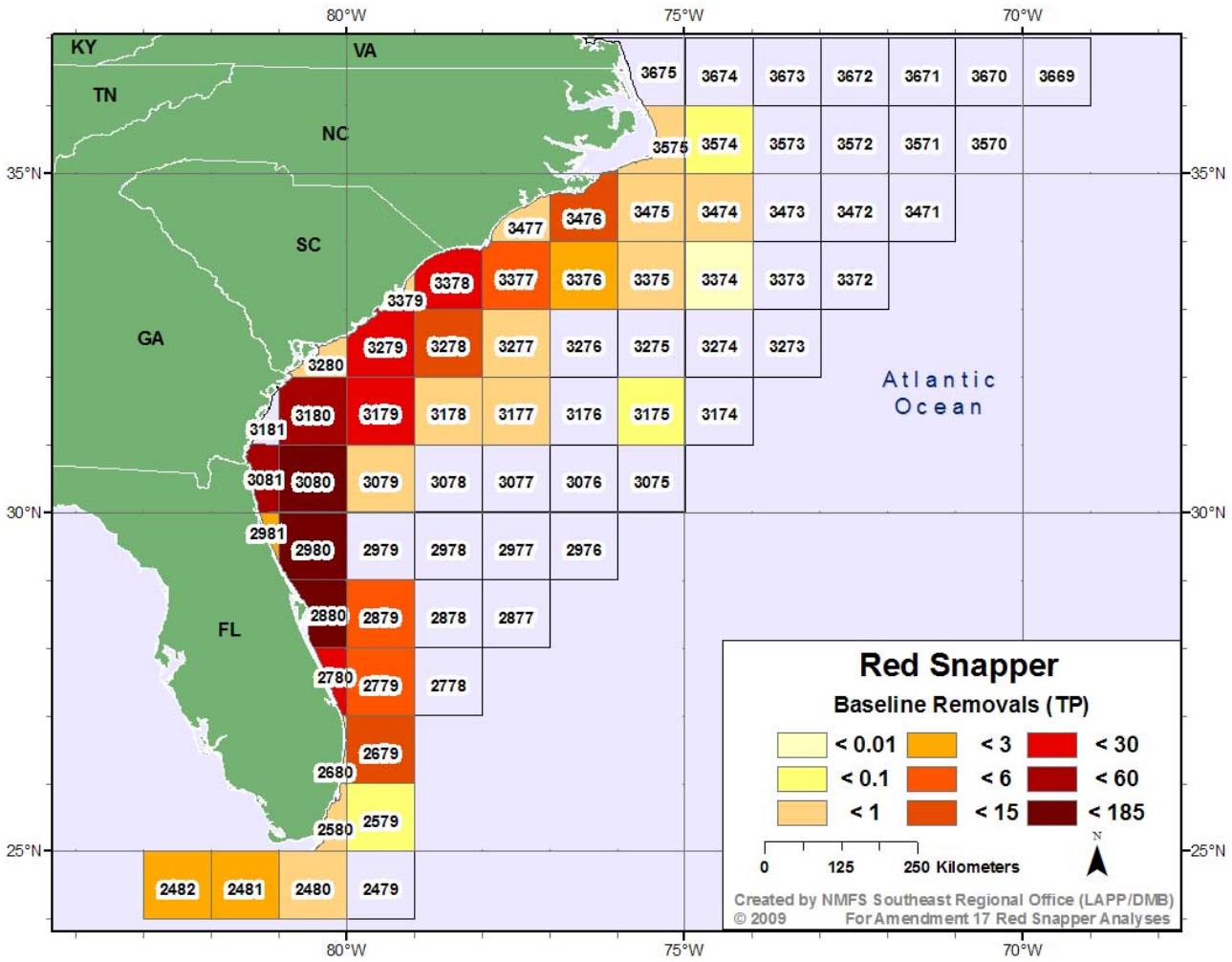

Figure 1. Baseline removals of South Atlantic red snapper by logbook grid, 2005-2007. Removals include landings and dead discards from the commercial, headboat and private/charterboat sectors. Removals correspond to Scenario 1.

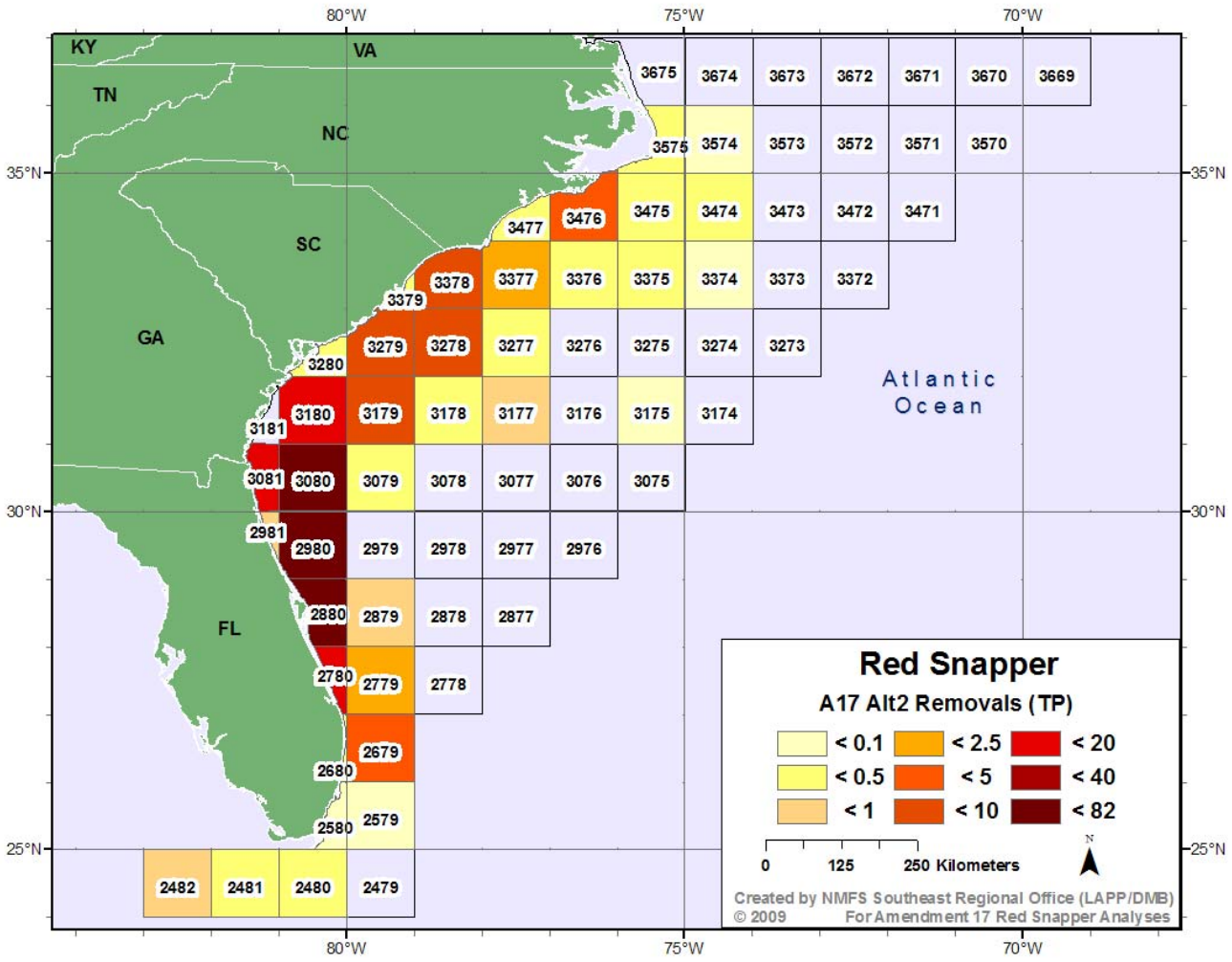

Figure 2. Estimated removals of South Atlantic red snapper associated with Amendment 17A, Alternative 2. Removals are by logbook grid and include landings and dead discards from the commercial, headboat and private/charterboat sectors. Removals correspond to Scenario 1.

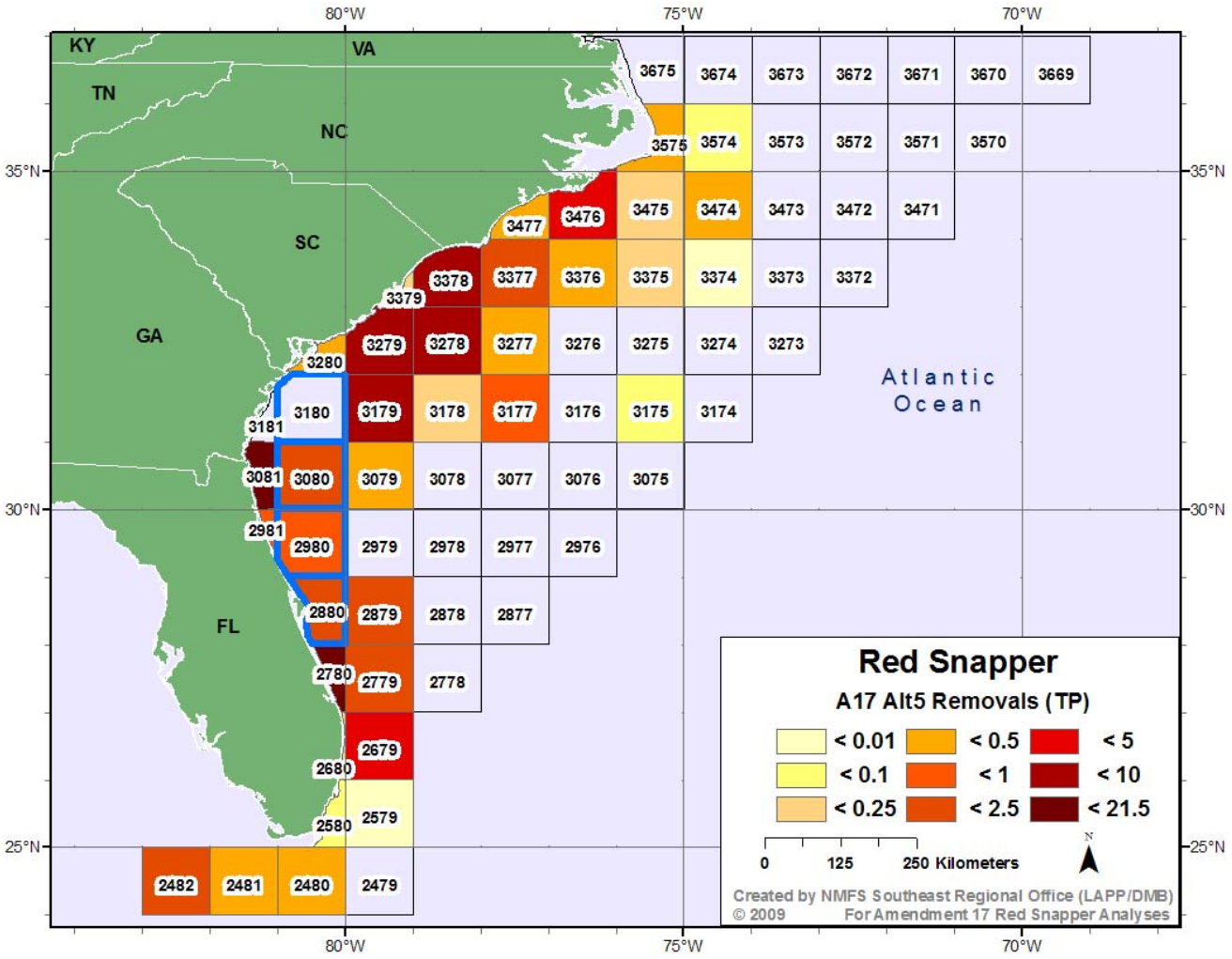

Figure 3. Estimated removals of South Atlantic red snapper associated with Amendment 17A, Alternative 5. Removals are by logbook grid and include landings and dead discards from the commercial, headboat and private/charterboat sectors. Logbook grids highlighted in blue would be closed to all snapper-grouper fishing. Removals correspond to Scenario 1.

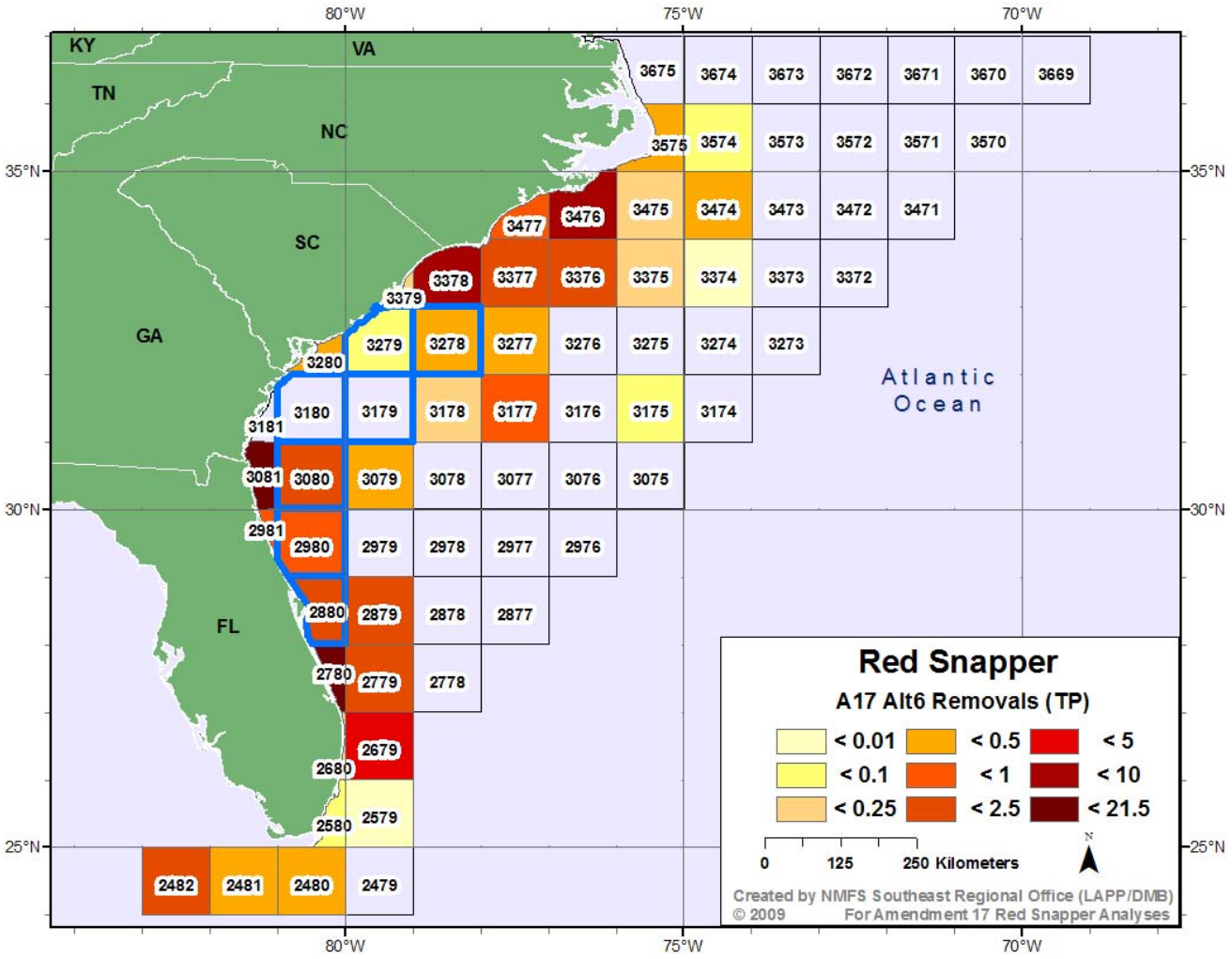

Figure 4. Estimated removals of South Atlantic red snapper associated with Amendment 17A, Alternative 6. Removals are by logbook grid and include landings and dead discards from the commercial, headboat and private/charterboat sectors. Logbook grids highlighted in blue would be closed to all snapper-grouper fishing. Removals correspond to Scenario 1.