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

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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, total removals of red snapper need to be reduced to 82,000 pounds to end overfishing. This equates to a reduction in *F* of 87%.

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 in removals. All other alternatives fall short, although both Alternative 3 and Alternative 5 come within a few percent of the needed reduction.

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.

	Total Removals (lbs)				
Alternative	Commercial	Headboat	MRFSS	All modes	% reduction
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	58,978	35,501	187,063	281,542	53%
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, none of the alternatives achieve the needed cumulative reduction in red snapper removals. However, Alternatives 4 and 6 fall 1-3% short.

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

	Total Removals (lbs)				
Alternative	Commercial	Headboat	MRFSS	All modes	% reduction
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 in removals.

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.

	Total Removals (lbs)				
Alternative	Commercial	Headboat	MRFSS	All modes	% reduction
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	26,213	35,501	187,063	248,777	59%
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 4 and 6 achieve the needed cumulative reduction in removals, and Alternatives 3 and 5 come within 1-2%.

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

	Total Removals (lbs)				
Alternative	Commercial	Headboat	MRFSS	All modes	% reduction
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 in removals.

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.

	Total Removals (lbs)				
Alternative	Commercial	Headboat	MRFSS	All modes	% reduction
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	42,595	26,626	140,298	209,519	65%
Alt 3*	32,279	9,009	31,152	72,440	88%
Alt 4**	24,960	6,964	27,354	59,278	90%
Alt 5	29,011	9,009	31,152	69,172	89%
Alt 6	17,694	6,964	27,354	52,012	91%

* 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 in removals. Both Alternatives 3 and 5 fall short by 1-2%.

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

	Total Removals (lbs)				
Alternative	Commercial	Headboat	MRFSS	All modes	% reduction
Status quo	130,810	73,387	398,658	602,855	0%
Alt 2	86,689	34,402	151,597	272,688	55%
Alt 3*	47,157	11,832	33,216	92,205	85%
Alt 4**	32,399	8,625	29,249	70,274	88%
Alt 5	43,661	11,832	33,216	88,708	85%
Alt 6	25,132	8,625	29,249	63,007	90%

* MRFSS and headboat data same as Alt 5

** MRFSS and headboat data same as Alt 6

Discussion

Total red snapper removals must be reduced to less than 82,000 pounds and *F* must be reduced by 87% (based on an $F_{MSY} = F_{40\%SPR}$) 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 desired 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 (59-65%) in removals was realized from Scenarios 2A and 3A. To achieve the needed reduction in total removals, 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 and 3A achieve the required 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 and 1B 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. Scenario 1B also predicts 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 the needed 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, five of six scenarios achieve the desired reduction in red snapper removals. Only Scenario 1B falls short of the reduction target by less than 1%. 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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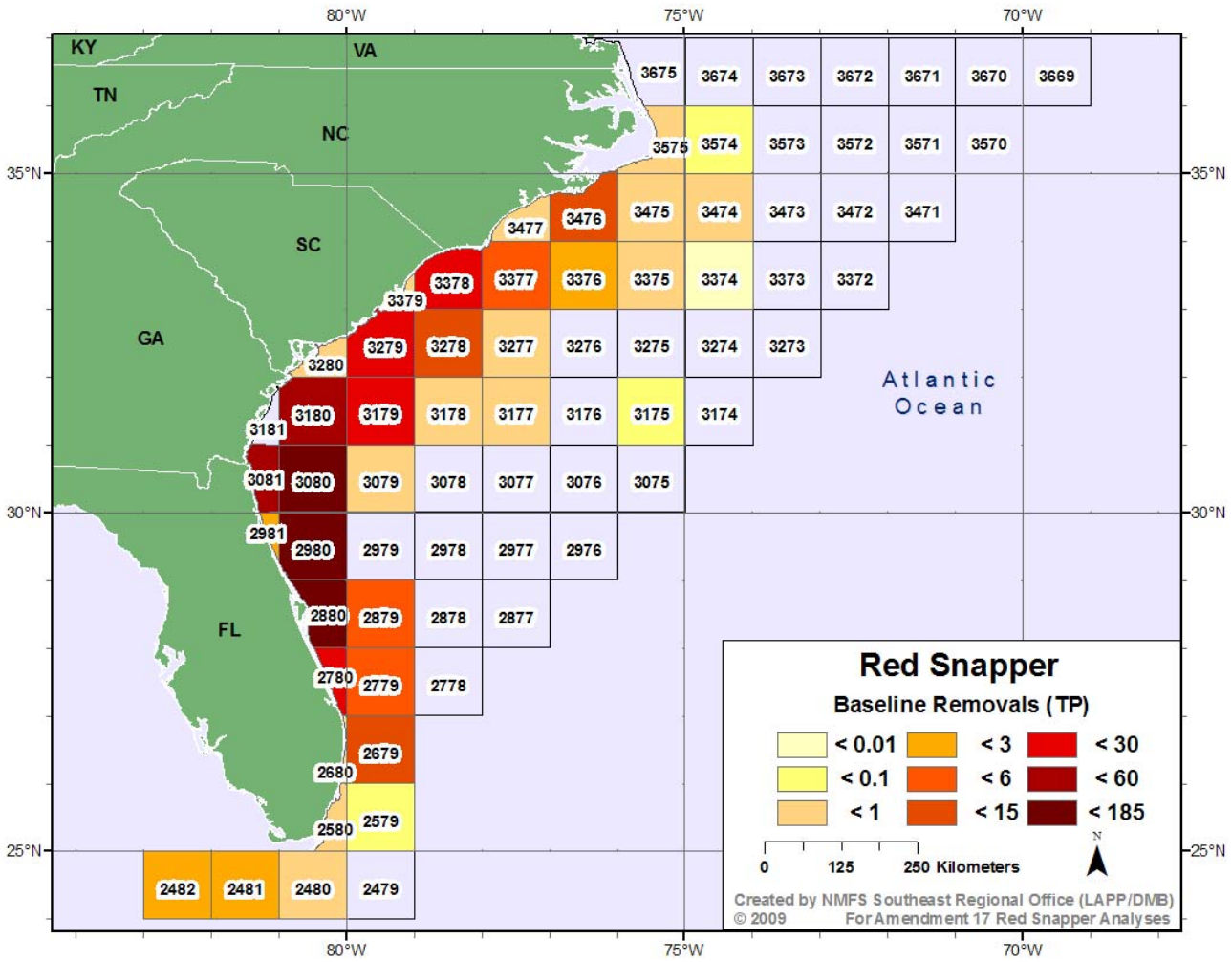

Figure 1. Baseline removals of South Atlantic red snapper by logbook grid, 2005-2007. Removals include landings and dead discards from the commercial, headboat and private/charterboat sectors. Removals correspond to Scenario 1.

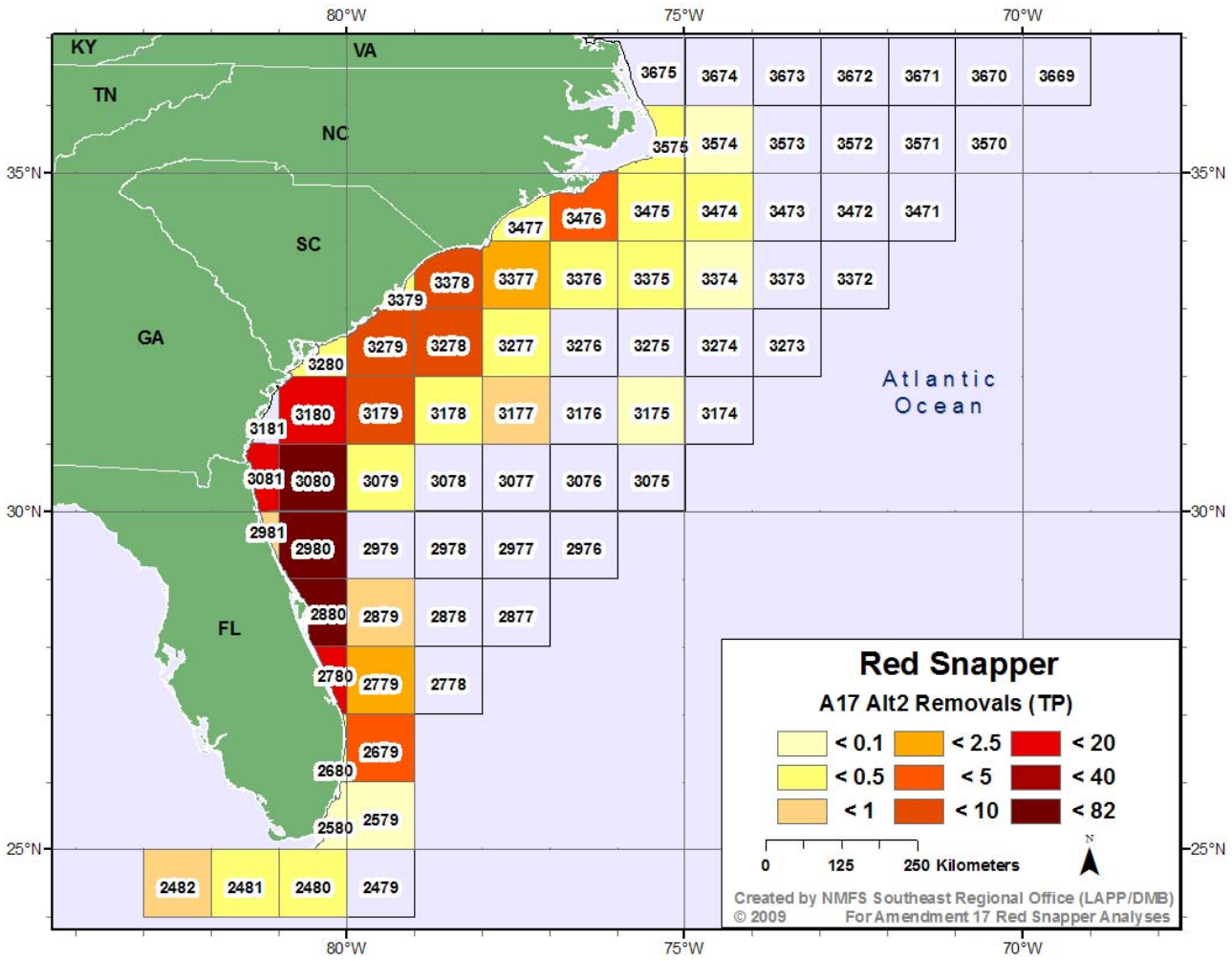

Figure 2. Estimated removals of South Atlantic red snapper associated with Amendment 17A, Alternative 2. Removals are by logbook grid and include landings and dead discards from the commercial, headboat and private/charterboat sectors. Removals correspond to Scenario 1.

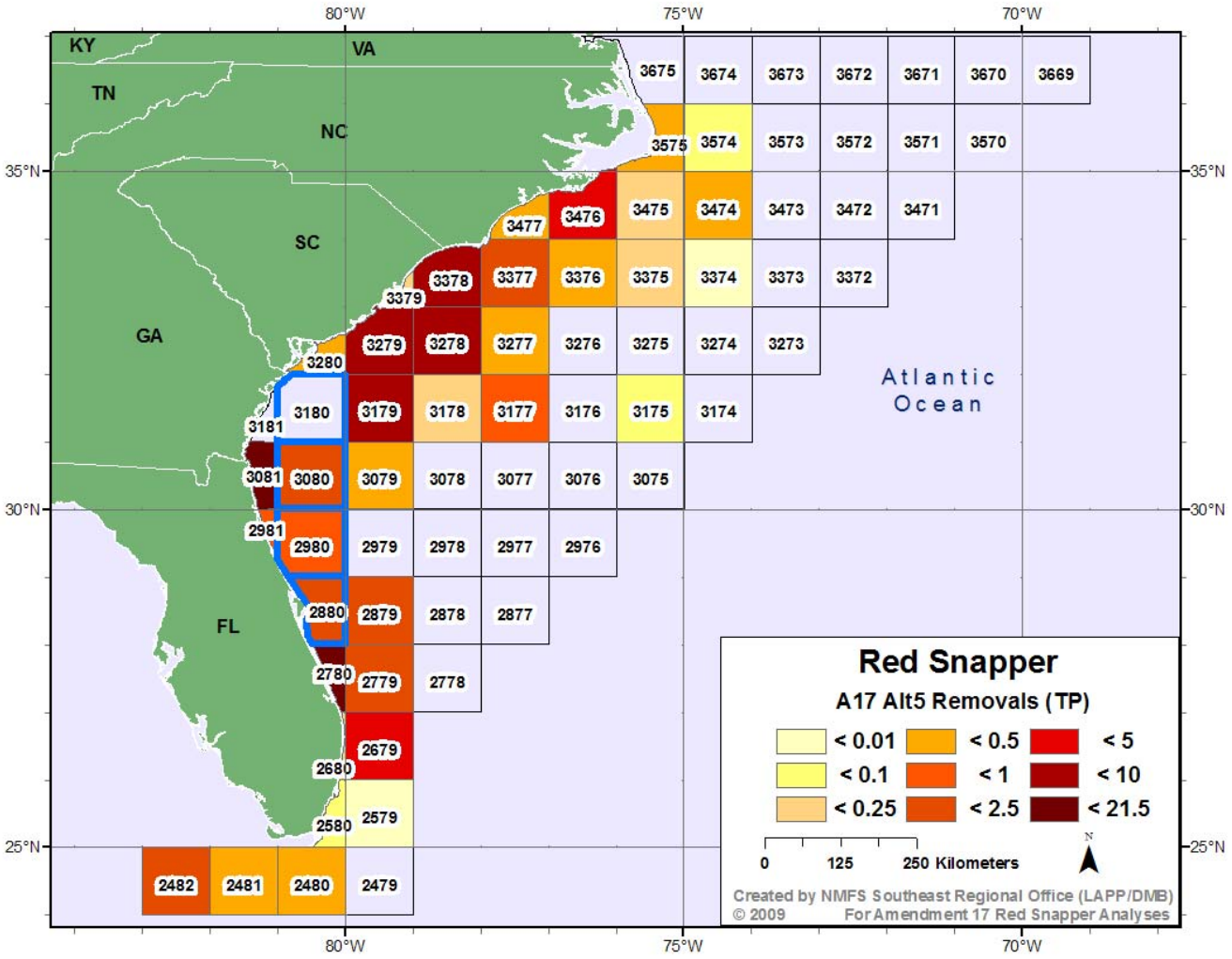

Figure 3. Estimated removals of South Atlantic red snapper associated with Amendment 17A, Alternative 5. Removals are by logbook grid and include landings and dead discards from the commercial, headboat and private/charterboat sectors. Logbook grids highlighted in blue would be closed to all snapper-grouper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

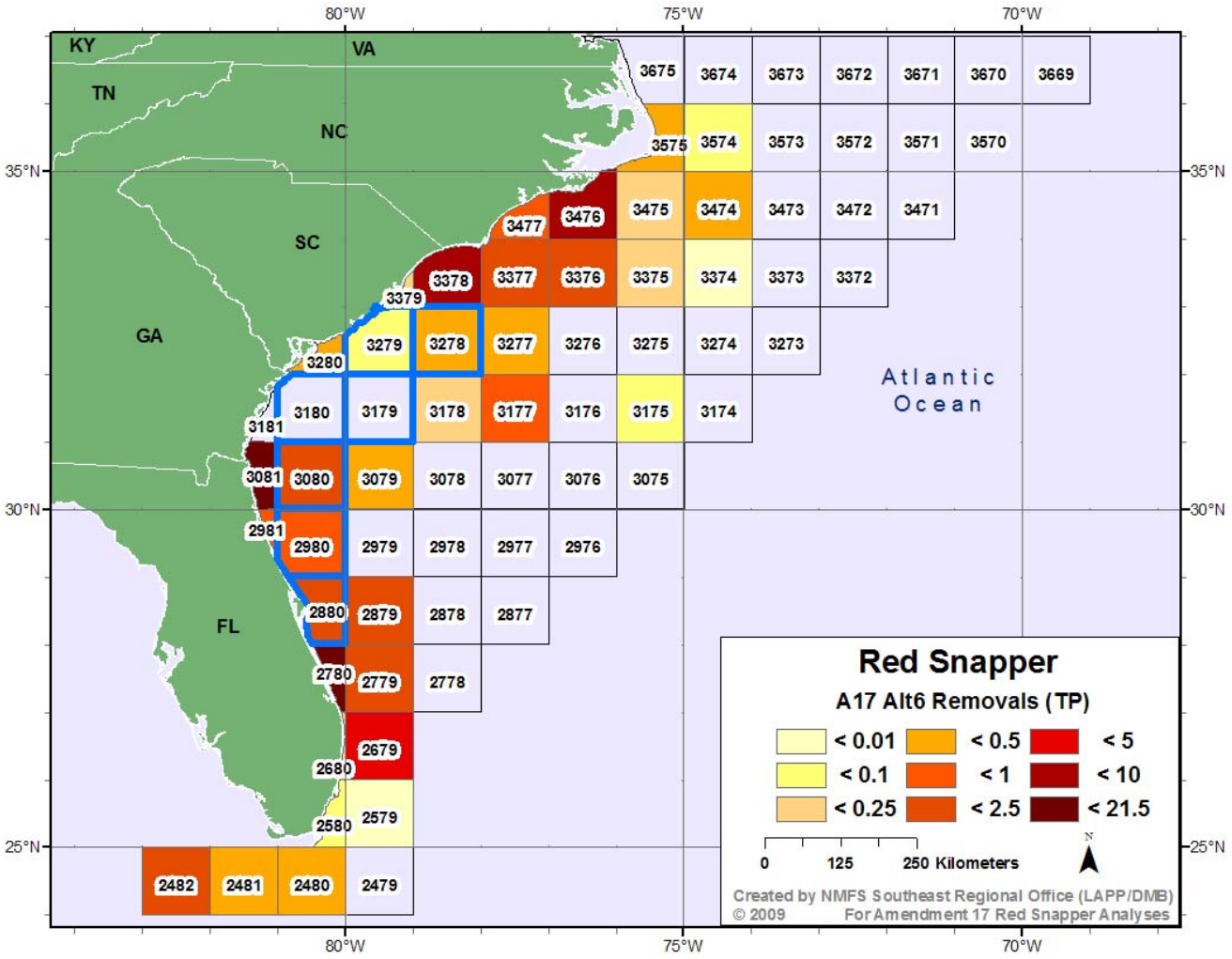

Figure 4. Estimated removals of South Atlantic red snapper associated with Amendment 17A, Alternative 6. Removals are by logbook grid and include landings and dead discards from the commercial, headboat and private/charterboat sectors. Logbook grids highlighted in blue would be closed to all snapper-grouper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