Red Snapper Monitoring Plan

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I. Introduction

In a memorandum to the Southeast Fisheries Science Center (SEFSC) from the Southeast Regional Office (SERO) dated February 13, 2009 a request was made to “develop a monitoring plan for red snapper for inclusion in Amendment 17.” On March 5, 2009, the South Atlantic Fisheries Management Council (SAFMC) passed Motion #13, which states “Evaluate a red snapper monitoring program based on a research set-aside to include an experimental headboat fishery with observers (intent for scientists to develop recommendations on #trips, areas to fish, etc.).” The SAFMC request is clearly more prescriptive than the SERO request. We have chosen to write this report to address the SERO request, with the SAFMC request response included as a sub-part.

This report will be divided into two main topics: (1) fishery independent methods for monitoring red snapper, and (2) using headboats to monitor red snapper. An important aspect of either of these two topics is that the scope should not necessarily be limited to simply red snapper. Red snapper tend to be caught with many other species (Shertzer and Williams 2008). Therefore it makes sense to consider monitoring most if not all snapper-grouper species when considering any monitoring plan.

Of course if money were not an object of concern, the ideal monitoring plan would be for a fishery independent survey that captured all snapper-groupers. Unfortunately, cost is a big concern and therefore we must consider cost saving efficiencies in any monitoring design. We should try to build upon existing data sources and not necessarily consider re-designing existing data collection systems.

II. Fishery Independent Methods for Monitoring Red Snapper

A proposed framework for an improved fishery-independent data collection program targeting red snapper in the U.S. South Atlantic waters is addressed in **Report 1**. The framework proposes to continue the long-term data series from MARMAP surveys and adds a complementary sampling program to expand needed coverage. The expanded sampling program would include NOAA-SEFSC and MARMAP to jointly plan annual survey efforts (**Report 1**).

III. Using Headboats to Monitor Red Snapper

In many ways the headboat fishery seems like a good tool for monitoring red snapper and most of the snapper-grouper complex. In most of the South Atlantic SEDAR stock assessments, the catch-per-unit-effort (CPUE) index derived from the Southeast Region Headboat Survey (SRHS) produces the longest time series of relative abundance information. This long duration, continuous from the 1970s to present, is invaluable for assessing stock status. In most cases where fishery independent surveys have produced reliable estimates of abundance, the indices derived from the SRHS match well.

The SRHS is a relatively reliable fishery dependent data source for abundance indices primarily because of the manner in which the fishing activity occurs. Often fishery dependent abundance indices are biased because of the targeting nature of fishing for profit. Headboats tend to target habitat areas and types, often attempting to maximize the fishing experience for their patrons, rather than targeting individual species. This property lends itself to producing nearly unbiased measures of abundance. An ideal fishery independent survey would most likely be based on a stratified random sampling design, in which the habitat was stratified and random samples collected within each strata proportional to the fish abundance in each strata. Headboats do not operate randomly, but the most productive habitat areas do get fished (sampled) and most importantly they cover these habitats based on overall fish catches, not necessarily focusing on one particular species.

This is not to say that headboats will always produce a reliable abundance index. Catch-per-unit-effort from headboats is a 'relative' measure of abundance and can be affected by management regulations and economics. For example, if bag limits are low enough so that anglers are reaching the limit on almost every trip, then the CPUE tells us nothing about relative abundance of that species. An example of economics affecting CPUE may have been realized in 2008 when fuel prices reached all time highs. Some headboat captains reported traveling shorter distances relative to past years for some of their trips in 2008. If headboats are not fishing the more productive areas or fishing in shallower waters, then this can impact the relative CPUE for some species.

In the case of red snapper, the headboat survey produced an index of relative abundance used in the SEDAR 15 stock assessment. Ideally, we would keep this index intact by eliminating any forces that might alter the behavior of the fleet, which in turn could affect the relationship between CPUE and abundance. Some of these forces are out of our control. Ideally, it would be best to allow headboats to operate in the same manner year after year. Therefore if headboats are to be used as a monitoring tool, it would be best to leave the fishery unencumbered by any regulations, other than those already in existence.

If the relationship between CPUE from the headboats and fish abundance is altered too much, then it will not be useful from a monitoring stand point. An important feature of the usefulness of the headboat CPUE index for monitoring is that we have estimates from the past to compare with future values. Without this relative comparison, we would be starting a brand new index, which may be of little utility with only a few years of data. If there are significant changes in headboat effort or behavior it may be better to start a new fishery-independent index.

<u>Number of headboat trips</u>

As was mentioned above, the ideal situation would be to allow the headboat fishery to continue as is. However, an important question is: Can the headboat fishery operate at full capacity and still allow red snapper recovery? To answer this question we ran several projection scenarios. The results of this analysis are shown in **Report 2**. The results suggest that the headboat fishery cannot operate at full capacity. Without other sectors operating (coastwide shutdown for non-headboats), the headboat fishery could operate at 70% of capacity and still allow for recovery of red snapper. This does not seem like a realistic management scenario, so we analyzed trade-offs between the percent capacity in other sectors and headboats (see Table 1 in **Report 2**). There is a steep trade-off between the fishing mortality rate (*F*) allowed for headboats and the other sectors. For example, the headboats would have to be scaled back to 30% in order to allow just 10% of the remaining sectors to operate. At this point it is not known what size area might need to be closed to reduce the other sectors to 10%. It is important to keep in mind that this 10% is mortality directed toward red snapper. So, areas where red snapper are infrequently encountered may only account for a small percentage, thereby allowing larger areas to remain open.

SRHS abundance index

An important question is: Can a usable abundance index be obtained with a reduced headboat fishery? To answer this question we analyzed the delta-GLM model for estimating the red snapper index from the SEDAR 15 stock assessment in **Report 3**. The results of this analysis suggest the obvious; there is a trade-off between the amount of potential error and the amount of trips which are allowed to run. Figures 2-5 from **Report 3** suggest the main trends of the index remain intact with low numbers of trips. However, the ratio of the index in the terminal year to that in the initial year (which could be viewed as a good proxy for stock status), indicates a steeply increasing amount of error with decreasing trips in the headboat fishery. In the case of computing an index with 30% of the trips, the error on the ratio mentioned above goes to CV = 0.18, which would suggest an error in stock status of +/- 36%. Furthermore, this analysis assumes trips are randomly selected coastwide and follow the area, month, and trip type distributions shown in Tables 1-3 (**Report 3**). Implementing this type of trip allocation may be difficult.

Critical issues

As has been shown above, it is technically possible to maintain a reliable, but noisy CPUE abundance index from a greatly reduced headboat fishery; but can it be put into practice? A few critical issues that arise when dealing with a reduced headboat fishery are, (1) allocating trips following a statistical design, and (2) forces that may affect the relationship between CPUE and true abundance.

Allocating trips following a statistical design that follows past patterns may prove difficult. On average, headboats tend to operate at about 50-60% of passenger capacity. If trips were reduced by 70% or more, it is likely these trips will be run at near full capacity, or we would have to consider capping the number of passengers on any trip. How would trips be allocated? To follow the statistical design, which matches patterns observed in the past, we would have to allocate trips by area, month and trip type. It is very unclear how this would operate, and there are many economic and social considerations involved in this. It seems highly likely headboat captains might change the way they run trips based on the allocation mechanism.

Assuming the allocation could be worked out, there are still issues with avoiding forces mentioned in (2) above. Most notable is Amendment 16, which added more regulations for shallow water grouper and vermilion snapper. This may affect fishing behavior enough to change the current relationship between headboat CPUE and true abundance.

Headboat data collection

The current method for collecting data from headboats in the SRHS is through self-reported catch records (logbooks) and dockside intercepts. The total catch and discards in numbers are entirely self-reported. The dockside samples provide average weights, length measurements, and otolith samples from landed fish for selected trips. This current sampling design would be woefully inadequate under a 30% or less capacity fishery.

It is probably not a good idea to have a species recovery monitoring be based entirely on self-reported data. The catch and discard numbers would have to be recorded independently, at-sea. There is really only one way to collect data at-sea, and that is using observers. One advantage of using headboats for monitoring, as opposed to private, charter, or even commercial boats, is they constitute some of the largest vessels fishing for snapper-grouper. The large size makes it easier for putting observers on board and efficiently collecting large amounts of data. If headboats were used as the sole source for monitoring red snapper, then sampling would likely have to be at a high rate (i.e. observer coverage would need to be near 100% of trips).

There are many details that would need to be worked out if observers were to be used for collecting data aboard headboats. Some decisions would have to be made about the following: (1) the type of data to be collected (e.g. numbers, lengths, weights, discards), (2) the percentage of trips to be covered, and (3) the degree of sub-sampling of fish on a given trip, just to name a few. Those details have not been worked out here because the amount of sampling and total costs would have to considered first.

It should be noted that any reduction in the headboat fishery will affect data collection for all other snapper-grouper species. Forcing a statistical design of headboat trips based on red snapper by definition will be insufficient or inadequate for other snapper-groupers. **The reduction of the headboat fishery will likely mark the end of usable CPUE indices for most of the snapper-grouper complex.** To date more South Atlantic stock assessments have used the SRHS derived CPUE indices than any other source of abundance data. It is of critical importance to stock assessments in the South Atlantic.

Report 1. Fishery-independent monitoring for red snapper - Draft sampling framework

Purpose

The purpose of this document is to describe a proposed framework for an improved fishery-independent data collection program targeting red snapper (*Lutjanus campechanus*) in US South Atlantic waters. The (1) flexibility in terms of geographical focus and (2) robustness (multiple gears / data collection methods) of the proposed program would satisfy the need for improved fishery-independent data on red snapper given pending management actions (i.e., actions under Amendment 17 to the Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region) and enable the program to address and fulfill future data needs for other federally managed species within the snapper-grouper complex.

Background on current fishery-independent sampling efforts

The *MA*rine *R*esources *M*onitoring *A*ssessment and *P*rediction (MARMAP) Program is the sole fishery-independent data collection program in the US South Atlantic that provides data on reef-associated federally-managed species within the snapper-grouper complex. Based out of the South Carolina Department of Natural Resources Marine Resources Research Institute, MARMAP performs fishery-independent sampling to provide data and analyses to the federal government and South Atlantic Fisheries Management Council to aid in fisheries management. MARMAP uses multiple gears for fishery-independent sampling of hardbottom-, softbottom- and associated species. Efforts targeting natural hardbottom (reef) associated species are described below.

MARMAP reef fish sampling program details

- Sample domain: Cape Lookout, NC to St. Lucie Inlet, FL (but see below).
- Habitats sampled: natural hardbottom areas along the continental shelf and shelf break ranging from ~ 15 to 230 meters depth, with depth ranges differing by gear type (see below).
- Sampling occurs from ~ May – September each year, with supplemental sampling in other months.
- Gear: three gears are used to collect CPUE and length frequency data and/or biological samples (e.g. otoliths and gonads) to assess relative densities, age, and sex structure of population:
    1. Chevron traps (Fig. 1, used in depths of 13-100 meters)
    2. Short bottom long-line (used to survey sloping hardbottom areas where it is difficult to use chevron traps; depths = 25 – 223m)
    3. Rod and reel (depths = 15 - 230m). Several methodologies of rod and reel sampling (including the use of commercial snapper reels) are utilized to collect species-specific CPUE data and biological samples.


Figure 1

- Annual survey design:
    1. Chevron traps: 600-700 sites for surveys are randomly chosen from a total number of ~ 2,500 known hard bottom sites. About 330 to 500 of the selected sites are sampled annually.
    2. Short bottom long-line: 100-200 randomly selected sites are sampled from of a total of 1,000 sampling sites.
    3. Rod and reel: sampling occurs opportunistically over natural hardbottom habitat.

MARMAP has used traps to sample and monitor hardbottom-associated reef fish populations (including red snapper) in the US South Atlantic since 1978, and chevron traps since 1990. Short bottom long-lining and rod and reel sampling has occurred since 1978. Thus, an extended time series exists on which to build an improved sampling program.

Limitations of current fishery-independent sampling efforts

While the MARMAP sampling domain covers a large area of the southeast US continental shelf, logistical, weather, and funding constraints result in relatively low levels of sampling effort in the northern and southern regions of the survey area. Additionally, and regardless of spatial focus of sampling, greater sample sizes are required to develop robust indices of abundance for many federally managed species. Finally, multiple species of management interest require the use of multiple gears for effective sampling, and some are not effectively sampled with traps and long line gear. While MARMAP historically has utilized a variety of gear types, currently only chevron traps and short bottom long line gear are used consistently to develop abundance trends. Thus, as a likely combined result of (1) insufficient realized spatial coverage, (2) insufficient survey sample size, and (3) lack of appropriate gears to effectively sample some species, MARMAP surveys alone cannot generate effective abundance indices for stock assessments for all species of management interest. *An improved fishery independent survey program is needed to support stock assessments and management actions.*

Proposed framework for an improved sampling program focusing on red snapper

We propose a framework that continues the long-term data series from MARMAP surveys and adds a complementary sampling program to expand needed coverage. The improved sampling plan would increase the (1) spatial footprint (central FL to Cape Hatteras, NC), (2) sample size, and (3) number of gears utilized over current survey levels, thereby considerably improving program effectiveness. The spatial and sample size expansions would be made possible by the participation of NOAA-SEFSC (Beaufort Laboratory) staff. The core aspects of the current sampling program (survey design, chevron trap, short bottom long-line and rod and reel sampling) would remain the core of the improved program, enabling comparisons of data collected in the improved program with those collected during previous years by MARMAP. Additional gears would be added and utilized by both NOAA-SEFSC and MARMAP (detailed below), with gear effectiveness research performed by NOAA-SEFSC. NOAA-SEFSC would coordinate with MARMAP to plan annual survey efforts (e.g., spatiotemporal focus of sampling) as guided by SAFMC and NMFS (SERO and SEFSC) data needs.

Improved program details

- The improved program would range from Cape Hatteras, NC to St. Lucie Inlet, FL (Fig.2). Targeting of specific geographical areas (e.g., offshore of northern FL and southern GA where the majority of red snapper landings occur) would be anticipated and would be guided by specific management actions.

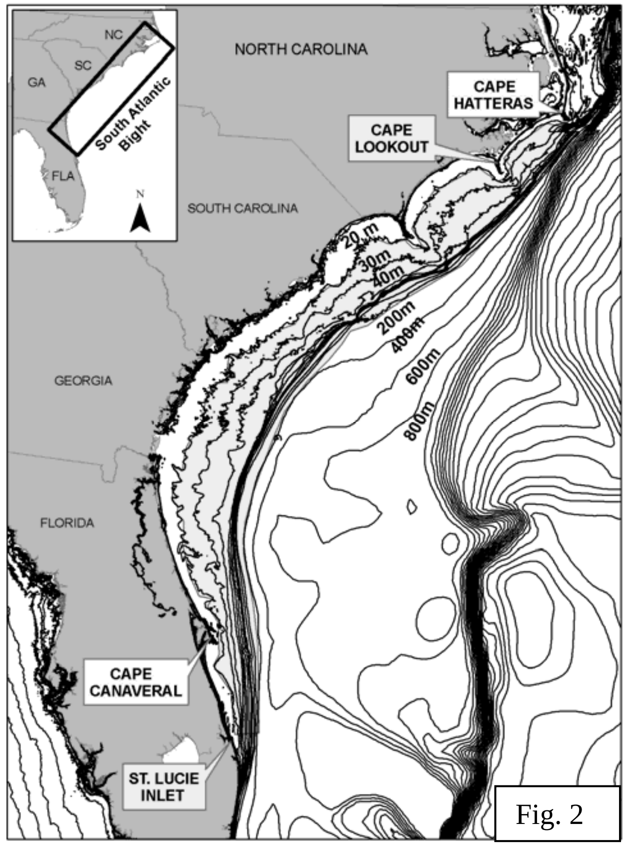

Fig. 2

- Four gear types would be utilized, each resulting in a CPUE estimate or proxy for abundance that could be compared across time and space to assess responses of red snapper and other reef fish populations to management actions:
    - Gears 1 and 2: chevron traps and short bottom long-lines would continue to be utilized following current MARMAP protocols. These gears are effective for sampling many reef fish species. Combined trap-camera studies in the Gulf of Mexico suggests chevron traps efficiently sample red snapper (D. DeVries, personal communication).
    - Gear 3: a trap-deployed camera sampling program would be initiated, building on preliminary gear investigations by MARMAP and utilizing protocols developed and utilized by SEFSC Panama City and Pascagoula laboratories for reef fish surveys in the Gulf of Mexico). The camera sampling program would involve still- or video cameras mounted on traps that would enable quantification of species in the vicinity of the trap. Adding a camera component to the chevron survey would facilitate determination of the relationship between trap CPUE and actual abundance for specific species (e.g., red snapper). The camera component would also improve data collection for species that, unlike red snapper, are not prone to collection in traps (e.g., gag grouper *Mycteroperca microlepis*).
    - Gear 4: rod and reel sampling would be utilized for both CPUE data and the collection of biological samples. Standard methodologies would be applied and variability-inducing factors (e.g., degree of angling experience) would be controlled for and/or considered when generating CPUE estimates.

- Additionally, NMFS-SEFSC would begin to explore the efficiency and utility of visual (scuba-based) surveys as a sampling and gear-assessment method at survey sites < ~ 40m depth, and of split-beam hydroacoustic surveys at all depths.

Sample sizes, spatial focus and required resources
Sample sizes and spatial focus of the improved sampling program would be dependent on and determined by specific management actions under Amendment 17 and by funding and resource availability. Any level of participation in the improved program by NMFS-Beaufort staff would require additional funding for staff, equipment, and potentially vessel support, depending on whether planned ship time on the NOAA ship Pisces materializes beginning in FY10. Additional biological sampling (processing and analysis of otoliths and gonads) would also require additional funding for staff and equipment.

Report 2. Stock recovery projections under a headboat monitoring program

Projection Methods

These projections were similar in structure to those described in previous red snapper projection documents, including the original SEDAR 15 report and, most recently, in a report titled "Red Snapper Projections V" (dated 19 March 2009). The projections here, however, have been customized to investigate the feasibility of using headboats as a monitoring program for red snapper. Customizations are the following:

1) Red snapper were assumed to be retained by headboats only. Other sectors (commercial and general recreational) were treated as discard-only fisheries.
2) The current distribution of fishing mortality rates among sectors, including landings and discards, was assumed to apply into the future. The distribution, without commercial diving, was as follows: commercial landings = 0.2, commercial discards = 0.06, MRFSS landings = 0.33, MRFSS discards = 0.25, headboat landings = 0.1, and headboat discards = 0.06. These current rates, however, were adjusted as described in item 3.
3) Current fishing rate was distributed among sectors according to current proportions, but fishery specific fishing rates were then examined over ranges of discounted levels. The headboat fishery (landings and discards) was examined over a range of 10%, 20%, …, 100% of current headboat fishing mortality. Likewise, the fishing rates of other sectors were considered over the ranges 0%, 10%, 100% relative to the current rates.

Based on item 3 above, scenarios have been labeled as "Scenario X-Y," where X indicates the percentage of current F applied to the headboat sector, and Y the percentage applied to all other (discard-only) sectors. For example, Scenario 30-10 would indicate a projection scenario in which 30% of current headboat $F_{Landings}$ and headboat $F_{Discards}$ were applied to the headboat fishery, 10% of current MRFSS $F_{Landings}$ and MRFSS $F_{Discards}$ were applied to the general recreational fishery, and 10% of current commercial $F_{Landings}$ and commercial $F_{Discards}$ were applied to the commercial handline fishery. In addition, these discard-only sectors (10% in the example) included the proportion of headboat F not retaining catch (i.e., 1-X).

As before, commercial diving, which contributed ~1.5% of current F, is excluded from the projections. Successful rebuilding of red snapper was gauged by achieving at least a 50% chance of stock recovery by the beginning of 2045.

Projection Results

Projected recovery success for the various scenarios is summarized in Table 1. (The Appendix shows details of select individual runs: Scenarios 30-0, 70-0, 80-0, 30-10, 40-10, 0-20). In summary, if the other (discard-only) sectors killed no red snapper, stock recovery was predicted to occur, with 0.5 probability, when the headboat fishery operated at 70% capacity for red snapper, but not at 80%. If other sectors operated at 10% capacity for red snapper, stock recovery was predicted to occur when the headboat fishery operated at 30% capacity for red snapper, but not at 40%. If other sectors operated at 20–100% capacity, stock recovery was not predicted to occur, even if the headboat fishery killed no red snapper. Total landings and dead discards, in 1000s of fish, for the first year of rebuilding (2010) are shown in Table 2.

Taken together, these projections demonstrate a steep trade-off between fishing mortality of the headboat fishery and that of other sectors, in terms of red snapper recovery. That is, without other sectors operating on red snapper, the headboat sector can operate at 70% of its current red snapper capacity. However, the headboat fishery would need to be scaled back to 30%, if other sectors operate at only 10% of their red snapper capacities. This result occurs because headboat fishing mortality rate of red snapper represents a relatively small proportion of total fishing mortality rate (as described in item 2 above).

Table 1. Success of red snapper recovery under various allowances (0%, 10%, …, 100%) of current fishing rates. Y denotes successful stock recovery, and N otherwise. In these projections, headboat retained landings according to the percent of F indicated, and other sectors were treated as discard-only fisheries. The discard-only fisheries included the percent of headboat F that did not go toward landings (e.g., if 30% of headboat F went toward landings, 70% went toward the discard-only component, at the rate indicated in columns).

		Commercial and general recreational sectors		
	Percent	0	10	20−100
Headboat	10	Y	Y	N
	20	Y	Y	N
	30	Y	Y	N
	40	Y	N	N
	50	Y	N	N
	60	Y	N	N
	70	Y	N	N
	80	N	N	N
	90	N	N	N
	100	N	N	N

Table 2. Landings/dead discards (units 1000 fish) of red snapper in the first year of rebuilding (2010), under various allowances (0%, 10%, …, 100%) of current fishing rates. In these projections, headboat retained landings according to the percent of F indicated, and other sectors were treated as discard-only fisheries. The discard-only fisheries included the percent of headboat F that did not go toward landings (e.g., if 30% of headboat F went toward landings, 70% went toward the discard-only component, at the rate indicated in columns).

		Discard-only sectors		
	Percent	0	10	20
Headboat	10	1.08/2.24	1.06/18.83	1.05/34.91
	20	2.15/4.47	2.12/20.93	2.08/36.9
	30	3.22/6.68	3.16/23.03	3.11/38.87
	40	4.27/8.88	4.2/25.11	4.13/40.84
	50	5.31/11.08	5.23/27.18	5.14/42.79
	60	6.35/13.26	6.24/29.24	6.14/44.74
	70	7.37/15.43	7.25/31.29	7.14/46.67
	80	8.39/17.58	8.26/33.33	8.13/48.6
	90	9.39/19.73	9.25/35.35	9.1/50.51
	100	10.39/21.87	10.23/37.37	10.07/52.42

1 Appendix—Select projections scenarios

*Table 1.1. Projection results under Scenario 30-0 (HB-others). Fnow is F_{current}; all fisheries but headboat are assumed to be discard-only (commercial diving not included). F = fishing mortality rate applied given Scenario 30-0 proportions of Fnow, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), L.hb = landings from headboat (1000* lb *whole weight), L.cr = landings from commercial and general recreational (1000* lb *whole weight), Csum L = cumulative landings from all sectors (1000* lb*), D.hb = discard mortalities from headboat (1000* fish), and D.cr = discard mortalities from commercial and recreational (1000 *fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104 and* $\text{SSB}_{F_{40\%}}$ = 8102.5 mt.

Year	Fnow	F	Pr(recover)	SSB(mt)	L.hb(1000 lb)	L.cr(1000 lb)	Csum L(1000 lb)	D.hb(1000)	D.cr(1000)
2007	0.930	0.930	0.00	203	58	395	453	17	84
2008	1.220	1.220	0.00	204	70	480	1004	22	108
2009	0.974	0.974	0.00	164	50	355	1408	18	91
2010	0.958	0.045	0.00	185	20	0	1429	7	0
2011	0.958	0.045	0.00	425	39	0	1467	8	0
2012	0.958	0.045	0.00	661	67	0	1534	9	0
2013	0.958	0.045	0.00	962	100	0	1633	12	0
2014	0.958	0.045	0.00	1341	141	0	1775	14	0
2015	0.958	0.045	0.00	1795	194	0	1969	16	0
2016	0.958	0.045	0.00	2311	256	0	2224	17	0
2017	0.958	0.045	0.00	2874	323	0	2548	17	0
2018	0.958	0.045	0.00	3469	396	0	2943	18	0
2019	0.958	0.045	0.00	4081	470	0	3413	18	0
2020	0.958	0.045	0.01	4696	545	0	3958	19	0
2021	0.958	0.045	0.03	5304	619	0	4577	19	0
2022	0.958	0.045	0.06	5896	692	0	5269	19	0
2023	0.958	0.045	0.12	6465	761	0	6030	19	0
2024	0.958	0.045	0.22	7007	828	0	6858	19	0
2025	0.958	0.045	0.33	7518	890	0	7748	19	0
2026	0.958	0.045	0.45	7999	949	0	8697	19	0
2027	0.958	0.045	0.57	8447	1004	0	9701	19	0
2028	0.958	0.045	0.67	8863	1055	0	10,756	19	0
2029	0.958	0.045	0.76	9248	1102	0	11,858	19	0
2030	0.958	0.045	0.82	9603	1146	0	13,004	19	0
2031	0.958	0.045	0.88	9929	1186	0	14,189	19	0
2032	0.958	0.045	0.92	10,228	1222	0	15,412	19	0
2033	0.958	0.045	0.94	10,501	1256	0	16,667	19	0
2034	0.958	0.045	0.96	10,751	1286	0	17,954	19	0
2035	0.958	0.045	0.97	10,979	1314	0	19,268	19	0
2036	0.958	0.045	0.98	11,187	1340	0	20,608	19	0
2037	0.958	0.045	0.99	11,376	1363	0	21,971	19	0
2038	0.958	0.045	0.99	11,548	1384	0	23,356	19	0
2039	0.958	0.045	0.99	11,705	1403	0	24,759	19	0
2040	0.958	0.045	0.99	11,848	1421	0	26,180	19	0
2041	0.958	0.045	1.00	11,977	1437	0	27,617	19	0
2042	0.958	0.045	1.00	12,095	1451	0	29,068	19	0
2043	0.958	0.045	1.00	12,202	1464	0	30,532	19	0
2044	0.958	0.045	1.00	12,299	1476	0	32,009	19	0
2045	0.958	0.045	1.00	12,388	1487	0	33,496	19	0

Table 1.2. Projection results under Scenario 70-0 (HB-others). Fnow is $F_{current}$; all fisheries but headboat are assumed to be discard-only (commercial diving not included). F = fishing mortality rate applied given Scenario 70-0 proportions of Fnow, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (mt)*, L.hb = landings from headboat (1000* lb *whole weight), L.cr = landings from commercial and general recreational (1000* lb *whole weight), Csum L = cumulative landings from all sectors (1000* lb*), D.hb = discard mortalities from headboat (1000* fish), and D.cr = discard mortalities from commercial and recreational (1000 *fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104 and* $SSB_{F_{40\%}}$ = 8102.5 mt.

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2009	0.974	0.974	0.00	164	50	355	1408	18	91
2010	0.958	0.106	0.00	185	46	0	1455	15	0
2011	0.958	0.106	0.00	406	86	0	1540	18	0
2012	0.958	0.106	0.00	614	143	0	1684	21	0
2013	0.958	0.106	0.00	873	209	0	1893	27	0
2014	0.958	0.106	0.00	1192	289	0	2182	32	0
2015	0.958	0.106	0.00	1564	391	0	2572	35	0
2016	0.958	0.106	0.00	1979	505	0	3077	37	0
2017	0.958	0.106	0.00	2420	628	0	3706	39	0
2018	0.958	0.106	0.00	2875	757	0	4462	40	0
2019	0.958	0.106	0.00	3331	886	0	5348	41	0
2020	0.958	0.106	0.00	3778	1013	0	6361	42	0
2021	0.958	0.106	0.00	4208	1135	0	7496	42	0
2022	0.958	0.106	0.01	4616	1251	0	8747	42	0
2023	0.958	0.106	0.01	4997	1360	0	10,106	43	0
2024	0.958	0.106	0.02	5351	1461	0	11,567	43	0
2025	0.958	0.106	0.03	5675	1553	0	13,120	43	0
2026	0.958	0.106	0.05	5970	1638	0	14,758	43	0
2027	0.958	0.106	0.07	6238	1714	0	16,472	43	0
2028	0.958	0.106	0.10	6480	1783	0	18,255	43	0
2029	0.958	0.106	0.14	6697	1845	0	20,100	43	0
2030	0.958	0.106	0.18	6890	1901	0	22,001	43	0
2031	0.958	0.106	0.21	7063	1950	0	23,951	44	0
2032	0.958	0.106	0.24	7217	1994	0	25,945	44	0
2033	0.958	0.106	0.28	7354	2033	0	27,978	44	0
2034	0.958	0.106	0.30	7474	2068	0	30,046	44	0
2035	0.958	0.106	0.34	7581	2098	0	32,144	44	0
2036	0.958	0.106	0.36	7676	2125	0	34,269	44	0
2037	0.958	0.106	0.39	7759	2149	0	36,418	44	0
2038	0.958	0.106	0.41	7833	2170	0	38,588	44	0
2039	0.958	0.106	0.43	7898	2189	0	40,776	44	0
2040	0.958	0.106	0.46	7955	2205	0	42,981	44	0
2041	0.958	0.106	0.47	8005	2219	0	45,201	44	0
2042	0.958	0.106	0.48	8049	2232	0	47,433	44	0
2043	0.958	0.106	0.49	8088	2243	0	49,676	44	0
2044	0.958	0.106	0.50	8123	2253	0	51,929	44	0
2045	0.958	0.106	0.51	8153	2262	0	54,191	44	0

*Table 1.3. Projection results under Scenario 80-0 (HB-others). Fnow is F_{current}; all fisheries but headboat are assumed to be discard-only (commercial diving not included). F = fishing mortality rate applied given Scenario 80-0 proportions of Fnow, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), L.hb = landings from headboat (1000* lb *whole weight), L.cr = landings from commercial and general recreational (1000* lb *whole weight), Csum L = cumulative landings from all sectors (1000* lb*), D.hb = discard mortalities from headboat (1000* fish), and D.cr = discard mortalities from commercial and recreational (1000 *fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104 and* $\text{SSB}_{F_{40\%}}$ = 8102.5 mt.

Year	Fnow	F	Pr(recover)	SSB(mt)	L.hb(1000 lb)	L.cr(1000 lb)	Csum L(1000 lb)	D.hb(1000)	D.cr(1000)
2007	0.930	0.930	0.00	203	58	395	453	17	84
2008	1.220	1.220	0.00	204	70	480	1004	22	108
2009	0.974	0.974	0.00	164	50	355	1408	18	91
2010	0.958	0.121	0.00	185	52	0	1461	18	0
2011	0.958	0.121	0.00	402	97	0	1558	21	0
2012	0.958	0.121	0.00	603	161	0	1718	24	0
2013	0.958	0.121	0.00	852	232	0	1951	31	0
2014	0.958	0.121	0.00	1157	320	0	2271	36	0
2015	0.958	0.121	0.00	1512	430	0	2701	40	0
2016	0.958	0.121	0.00	1904	554	0	3255	42	0
2017	0.958	0.121	0.00	2320	686	0	3941	44	0
2018	0.958	0.121	0.00	2745	823	0	4765	45	0
2019	0.958	0.121	0.00	3170	960	0	5725	46	0
2020	0.958	0.121	0.00	3583	1094	0	6820	47	0
2021	0.958	0.121	0.00	3978	1223	0	8042	48	0
2022	0.958	0.121	0.00	4350	1344	0	9386	48	0
2023	0.958	0.121	0.01	4696	1457	0	10,843	48	0
2024	0.958	0.121	0.01	5014	1560	0	12,403	48	0
2025	0.958	0.121	0.01	5304	1655	0	14,058	49	0
2026	0.958	0.121	0.02	5567	1741	0	15,798	49	0
2027	0.958	0.121	0.04	5803	1818	0	17,616	49	0
2028	0.958	0.121	0.05	6015	1887	0	19,503	49	0
2029	0.958	0.121	0.06	6203	1948	0	21,451	49	0
2030	0.958	0.121	0.09	6371	2003	0	23,455	49	0
2031	0.958	0.121	0.10	6519	2052	0	25,506	49	0
2032	0.958	0.121	0.12	6650	2094	0	27,601	49	0
2033	0.958	0.121	0.14	6766	2132	0	29,733	49	0
2034	0.958	0.121	0.16	6867	2165	0	31,898	49	0
2035	0.958	0.121	0.19	6956	2194	0	34,093	49	0
2036	0.958	0.121	0.20	7034	2220	0	36,313	49	0
2037	0.958	0.121	0.22	7103	2242	0	38,555	50	0
2038	0.958	0.121	0.23	7163	2262	0	40,817	50	0
2039	0.958	0.121	0.25	7215	2279	0	43,096	50	0
2040	0.958	0.121	0.26	7261	2294	0	45,390	50	0
2041	0.958	0.121	0.27	7301	2307	0	47,697	50	0
2042	0.958	0.121	0.27	7336	2319	0	50,016	50	0
2043	0.958	0.121	0.27	7367	2329	0	52,345	50	0
2044	0.958	0.121	0.28	7394	2337	0	54,682	50	0
2045	0.958	0.121	0.28	7417	2345	0	57,027	50	0

Table 1.4. Projection results under Scenario 30-10 (HB-others). Fnow is F_{current}*; all fisheries but headboat are assumed to be discard-only (commercial diving not included). F = fishing mortality rate applied given Scenario 30-10 proportions of Fnow, Pr(recover) = proportion of replicates reaching* $SSB_{F_{40\%}}$*, SSB = mid-year spawning biomass* (mt)*, L.hb = landings from headboat (1000* lb *whole weight), L.cr = landings from commercial and general recreational (1000* lb *whole weight), Csum L = cumulative landings from all sectors (1000* lb*), D.hb = discard mortalities from headboat (1000* fish), and D.cr = discard mortalities from commercial and recreational (1000 *fish). For reference, estimated proxy reference points are* $F_{40\%} = 0.104$ *and* $\text{SSB}_{F_{40\%}} = 8102.5$ mt.

Year	Fnow	F	Pr(recover)	SSB(mt)	L.hb(1000 lb)	L.cr(1000 lb)	Csum L(1000 lb)	D.hb(1000)	D.cr(1000)
2007	0.930	0.930	0.00	203	58	395	453	17	84
2008	1.220	1.220	0.00	204	70	480	1004	22	108
2009	0.974	0.974	0.00	164	50	355	1408	18	91
2010	0.958	0.107	0.00	185	20	0	1428	7	16
2011	0.958	0.107	0.00	405	37	0	1465	8	21
2012	0.958	0.107	0.00	611	61	0	1526	10	27
2013	0.958	0.107	0.00	868	89	0	1615	13	35
2014	0.958	0.107	0.00	1184	123	0	1739	15	43
2015	0.958	0.107	0.00	1554	166	0	1905	17	51
2016	0.958	0.107	0.00	1965	215	0	2120	18	58
2017	0.958	0.107	0.00	2405	268	0	2388	19	64
2018	0.958	0.107	0.00	2860	323	0	2711	20	70
2019	0.958	0.107	0.00	3317	378	0	3089	21	75
2020	0.958	0.107	0.00	3766	433	0	3522	22	80
2021	0.958	0.107	0.00	4200	486	0	4008	22	84
2022	0.958	0.107	0.01	4613	536	0	4544	23	88
2023	0.958	0.107	0.01	5000	583	0	5128	23	91
2024	0.958	0.107	0.02	5360	628	0	5755	23	94
2025	0.958	0.107	0.03	5692	668	0	6423	24	97
2026	0.958	0.107	0.05	5995	705	0	7128	24	99
2027	0.958	0.107	0.08	6271	739	0	7867	24	101
2028	0.958	0.107	0.11	6521	770	0	8637	24	103
2029	0.958	0.107	0.15	6746	797	0	9434	24	104
2030	0.958	0.107	0.19	6948	822	0	10,256	25	106
2031	0.958	0.107	0.22	7128	844	0	11,100	25	107
2032	0.958	0.107	0.26	7290	864	0	11,964	25	108
2033	0.958	0.107	0.30	7434	881	0	12,846	25	109
2034	0.958	0.107	0.33	7561	897	0	13,743	25	110
2035	0.958	0.107	0.37	7675	911	0	14,654	25	111
2036	0.958	0.107	0.39	7775	923	0	15,577	25	111
2037	0.958	0.107	0.42	7865	934	0	16,512	25	112
2038	0.958	0.107	0.44	7944	944	0	17,456	25	112
2039	0.958	0.107	0.47	8013	953	0	18,408	25	113
2040	0.958	0.107	0.49	8075	960	0	19,368	25	113
2041	0.958	0.107	0.51	8130	967	0	20,335	25	114
2042	0.958	0.107	0.52	8178	973	0	21,308	25	114
2043	0.958	0.107	0.53	8221	978	0	22,286	25	114
2044	0.958	0.107	0.55	8258	983	0	23,268	25	114
2045	0.958	0.107	0.56	8292	987	0	24,255	25	115

*Table 1.5. Projection results under Scenario 40-10 (HB-others). Fnow is F_{current}; all fisheries but headboat are assumed to be discard-only (commercial diving not included). F = fishing mortality rate applied given Scenario 40-10 proportions of Fnow, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), L.hb = landings from headboat (1000* lb *whole weight), L.cr = landings from commercial and general recreational (1000* lb *whole weight), Csum L = cumulative landings from all sectors (1000* lb*), D.hb = discard mortalities from headboat (1000* fish), and D.cr = discard mortalities from commercial and recreational (1000 *fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104 and* $\text{SSB}_{F_{40\%}}$ = 8102.5 mt.

Year	Fnow	F	Pr(recover)	SSB(mt)	L.hb(1000 lb)	L.cr(1000 lb)	Csum L(1000 lb)	D.hb(1000)	D.cr(1000)
2007	0.930	0.930	0.00	203	58	395	453	17	84
2008	1.220	1.220	0.00	204	70	480	1004	22	108
2009	0.974	0.974	0.00	164	50	355	1408	18	91
2010	0.958	0.122	0.00	185	26	0	1435	9	16
2011	0.958	0.122	0.00	400	48	0	1483	11	21
2012	0.958	0.122	0.00	600	80	0	1563	13	27
2013	0.958	0.122	0.00	848	116	0	1679	16	35
2014	0.958	0.122	0.00	1151	159	0	1838	19	42
2015	0.958	0.122	0.00	1503	214	0	2052	21	50
2016	0.958	0.122	0.00	1893	276	0	2328	23	56
2017	0.958	0.122	0.00	2308	342	0	2670	24	63
2018	0.958	0.122	0.00	2734	410	0	3080	25	68
2019	0.958	0.122	0.00	3160	479	0	3559	26	73
2020	0.958	0.122	0.00	3576	547	0	4106	27	78
2021	0.958	0.122	0.00	3976	612	0	4717	27	81
2022	0.958	0.122	0.00	4353	673	0	5390	27	85
2023	0.958	0.122	0.01	4705	730	0	6121	28	88
2024	0.958	0.122	0.01	5031	783	0	6904	28	91
2025	0.958	0.122	0.01	5328	832	0	7736	28	93
2026	0.958	0.122	0.02	5599	876	0	8612	29	95
2027	0.958	0.122	0.04	5843	916	0	9528	29	97
2028	0.958	0.122	0.05	6063	952	0	10,480	29	98
2029	0.958	0.122	0.07	6260	984	0	11,464	29	100
2030	0.958	0.122	0.10	6435	1013	0	12,476	29	101
2031	0.958	0.122	0.12	6591	1038	0	13,514	29	102
2032	0.958	0.122	0.13	6729	1061	0	14,575	29	103
2033	0.958	0.122	0.16	6851	1081	0	15,655	30	104
2034	0.958	0.122	0.18	6959	1098	0	16,754	30	105
2035	0.958	0.122	0.21	7054	1114	0	17,867	30	105
2036	0.958	0.122	0.23	7138	1127	0	18,995	30	106
2037	0.958	0.122	0.25	7212	1139	0	20,134	30	106
2038	0.958	0.122	0.26	7276	1150	0	21,284	30	107
2039	0.958	0.122	0.27	7333	1159	0	22,444	30	107
2040	0.958	0.122	0.29	7383	1168	0	23,611	30	108
2041	0.958	0.122	0.30	7427	1175	0	24,786	30	108
2042	0.958	0.122	0.30	7466	1181	0	25,967	30	108
2043	0.958	0.122	0.31	7500	1187	0	27,153	30	108
2044	0.958	0.122	0.32	7529	1191	0	28,345	30	109
2045	0.958	0.122	0.32	7555	1196	0	29,540	30	109

*Table 1.6. Projection results under Scenario 10-20 (HB-others). Fnow is $F_{current}$; all fisheries but headboat are assumed to be discard-only (commercial diving not included). F = fishing mortality rate applied given Scenario 10-20 proportions of Fnow, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), L.hb = landings from headboat (1000* lb *whole weight), L.cr = landings from commercial and general recreational (1000* lb *whole weight), Csum L = cumulative landings from all sectors (1000* lb*), D.hb = discard mortalities from headboat (1000* fish), and D.cr = discard mortalities from commercial and recreational (1000 *fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104 and* $SSB_{F_{40\%}}$ = 8102.5 mt.

Year	Fnow	F	Pr(recover)	SSB(mt)	L.hb(1000 lb)	L.cr(1000 lb)	Csum L(1000 lb)	D.hb(1000)	D.cr(1000)
2007	0.930	0.930	0.00	203	58	395	453	17	84
2008	1.220	1.220	0.00	204	70	480	1004	22	108
2009	0.974	0.974	0.00	164	50	355	1408	18	91
2010	0.958	0.141	0.00	185	7	0	1415	3	32
2011	0.958	0.141	0.00	394	12	0	1427	4	41
2012	0.958	0.141	0.00	585	19	0	1446	5	52
2013	0.958	0.141	0.00	820	28	0	1474	6	67
2014	0.958	0.141	0.00	1106	38	0	1513	8	82
2015	0.958	0.141	0.00	1436	51	0	1564	9	96
2016	0.958	0.141	0.00	1800	65	0	1629	11	109
2017	0.958	0.141	0.00	2185	81	0	1710	12	120
2018	0.958	0.141	0.00	2579	96	0	1806	13	131
2019	0.958	0.141	0.00	2971	112	0	1918	14	140
2020	0.958	0.141	0.00	3353	128	0	2046	15	148
2021	0.958	0.141	0.00	3717	143	0	2189	16	156
2022	0.958	0.141	0.00	4061	157	0	2345	16	162
2023	0.958	0.141	0.00	4379	170	0	2515	17	168
2024	0.958	0.141	0.00	4672	181	0	2696	18	173
2025	0.958	0.141	0.01	4940	192	0	2889	18	177
2026	0.958	0.141	0.01	5181	202	0	3091	18	181
2027	0.958	0.141	0.01	5399	211	0	3302	19	184
2028	0.958	0.141	0.02	5593	219	0	3521	19	187
2029	0.958	0.141	0.03	5766	226	0	3747	19	189
2030	0.958	0.141	0.03	5920	232	0	3979	20	192
2031	0.958	0.141	0.04	6056	238	0	4217	20	194
2032	0.958	0.141	0.06	6176	243	0	4460	20	195
2033	0.958	0.141	0.07	6282	247	0	4707	20	197
2034	0.958	0.141	0.08	6374	251	0	4958	20	198
2035	0.958	0.141	0.09	6456	254	0	5212	20	199
2036	0.958	0.141	0.10	6527	257	0	5469	21	200
2037	0.958	0.141	0.12	6590	260	0	5729	21	201
2038	0.958	0.141	0.13	6644	262	0	5991	21	202
2039	0.958	0.141	0.14	6692	264	0	6255	21	202
2040	0.958	0.141	0.14	6734	266	0	6520	21	203
2041	0.958	0.141	0.15	6770	267	0	6788	21	203
2042	0.958	0.141	0.15	6802	268	0	7056	21	204
2043	0.958	0.141	0.15	6830	269	0	7325	21	204
2044	0.958	0.141	0.15	6854	270	0	7596	21	204
2045	0.958	0.141	0.15	6875	271	0	7867	21	205

Report 3. Evaluation of the Southeast Region Headboat Survey CPUE Index for Red Snapper

Indices Evaluation Methods

In this evaluation, we examined effects of data loss to the headboat index of abundance. We started with the original data set evaluated in the SEDAR 15 assessment, then included at random X% of the trips per year, and finally re-computed the index of abundance using a delta-GLM model (as in SEDAR 15). We repeated this process 100 times for each of X=10%, 30%, 50%, and 70%. To summarize resulting variability in the 100 iterations, we computed the ratio of the index in the terminal year to that in the initial year, and report the CV of this ratio. This ratio was chosen because of its role in providing information on stock status.

In computing the indices, areas of the headboat sampling program (Figure 1) were lumped into broader areas, as in the original assessment. The areas were NC (sampling areas 1,2,3,9,10), SC (sampling areas 4,5), north FL and GA (sampling areas 6,7,8), and south FL (sampling areas 11,12,17).

Results

With all data intact, the ratio of the index in the terminal year to that in the initial year is 0.15. The CV of that estimate for X=10% is 0.39, for X=30% is 0.18, for X=50% is 0.12, and for X=70% is 0.07. In other words, as fewer trips are available for analysis, information on current stock status decreases. Results from four randomly selected iterations at each level of X are show in Figures 2−5.

Annual number of red snapper trips (including zero catch), number of positive red snapper trips, and nominal CPUE, are tabulated by area (Table 1), month (Table 2), and trip type (Table 3). These three factors were used in constructing the delta-GLM model.

Table 1. Headboat data used in constructing the abundance index summarized by area (SF=South Florida, SC=South Carolina, NF=North Florida/Georgia, and NC=North Carolina). Values reported are X/Y/Z, where X is total number of trips (including those with zero red snapper landings), Y is number of positive trips (only those with red snapper landings), and Z is mean nominal CPUE of positive trips (number fish per angler-hook-hour).

	SF	SC	NF	NC
1976	0/0/NA	292/108/0.027	394/352/0.091	103/23/0.011
1977	0/0/NA	418/35/0.017	357/284/0.081	37/9/0.024
1978	1/0/NA	551/54/0.013	735/536/0.077	132/26/0.024
1979	30/4/0.035	520/16/0.01	656/490/0.07	58/14/0.023
1980	54/10/0.019	522/20/0.013	673/443/0.044	84/9/0.008
1981	72/29/0.015	417/17/0.017	441/347/0.072	68/20/0.009
1982	44/4/0.007	585/26/0.01	473/333/0.04	180/47/0.009
1983	52/1/0.063	540/48/0.008	681/496/0.052	177/54/0.008
1984	93/0/NA	513/52/0.025	660/498/0.055	74/15/0.013
1985	191/1/0.008	629/99/0.015	712/592/0.058	111/40/0.012
1986	201/1/0.08	742/66/0.01	990/557/0.024	106/36/0.008
1987	182/2/0.016	827/94/0.018	911/535/0.026	128/33/0.025
1988	100/2/0.013	806/136/0.029	878/469/0.026	158/49/0.032
1989	49/1/0.029	502/83/0.044	722/453/0.031	28/9/0.033
1990	23/0/NA	661/125/0.04	631/425/0.024	42/13/0.012
1991	12/0/NA	641/91/0.031	568/324/0.022	163/35/0.007
1992	60/0/NA	671/100/0.023	1108/227/0.01	212/36/0.012
1993	59/0/NA	676/181/0.022	956/243/0.011	171/47/0.012
1994	48/1/0.008	557/92/0.011	758/316/0.019	150/32/0.006
1995	22/0/NA	520/76/0.009	689/339/0.018	164/25/0.027
1996	17/0/NA	423/46/0.005	514/236/0.016	150/18/0.005
1997	10/0/NA	381/26/0.015	329/142/0.015	100/11/0.013
1998	8/0/NA	556/57/0.006	699/332/0.016	202/19/0.011
1999	3/0/NA	512/96/0.016	782/353/0.019	151/39/0.009
2000	14/0/NA	512/61/0.023	596/344/0.022	148/27/0.005
2001	9/0/NA	579/115/0.064	686/427/0.027	186/67/0.011
2002	10/0/NA	522/135/0.074	661/401/0.029	157/69/0.012
2003	10/0/NA	322/48/0.033	532/327/0.024	109/32/0.007
2004	13/0/NA	530/89/0.036	617/472/0.031	208/20/0.005
2005	22/0/NA	441/48/0.055	579/436/0.025	148/8/0.005
2006	31/0/NA	448/23/0.016	540/350/0.022	113/6/0.004

Table 2. Headboat data used in constructing the abundance index summarized by month (1=January, 2=February, …, 12=December). Values reported are X/Y/Z, where X is total number of trips (including those with zero red snapper landings), Y is number of positive trips (only those with red snapper landings), and Z is mean nominal CPUE of positive trips (number fish per angler-hook-hour).

	1	2	3	4	5	6	7	8	9	10	11	12
1976	0/0/NA	4/4/0.03	76/75/0.112	113/86/0.077	97/71/0.079	121/66/0.065	126/69/0.04	83/33/0.029	76/22/0.096	53/28/0.041	29/18/0.115	11/11/0.089
1977	13/11/0.104	22/15/0.057	27/17/0.039	66/37/0.064	87/26/0.067	115/41/0.067	141/45/0.062	118/25/0.042	89/32/0.084	57/22/0.129	45/33/0.08	32/24/0.094
1978	24/22/0.08	32/23/0.133	68/32/0.071	105/58/0.082	175/83/0.06	215/84/0.056	215/75/0.057	229/77/0.051	150/60/0.053	110/46/0.073	63/27/0.123	33/29/0.099
1979	54/45/0.107	84/67/0.112	122/85/0.058	139/66/0.048	90/32/0.065	159/47/0.029	216/44/0.039	179/35/0.061	74/33/0.063	65/15/0.067	43/21/0.054	39/34/0.086
1980	34/26/0.05	40/24/0.048	81/41/0.033	138/59/0.024	133/47/0.034	235/51/0.029	221/50/0.019	137/34/0.018	126/51/0.043	94/32/0.049	40/23/0.099	54/44/0.097
1981	40/33/0.092	55/47/0.057	92/56/0.059	153/76/0.07	141/49/0.064	71/10/0.021	137/39/0.022	96/18/0.026	82/22/0.092	52/16/0.06	42/22/0.097	37/25/0.062
1982	50/37/0.035	39/25/0.031	58/23/0.025	88/39/0.052	188/68/0.037	202/46/0.024	242/52/0.013	187/41/0.009	82/15/0.063	61/9/0.058	39/27/0.062	46/28/0.058
1983	58/22/0.092	47/19/0.034	73/48/0.028	119/59/0.029	151/59/0.02	219/75/0.026	198/56/0.016	213/68/0.047	118/46/0.075	136/62/0.07	82/59/0.064	36/26/0.084
1984	46/36/0.068	91/72/0.077	138/86/0.044	183/97/0.035	164/46/0.022	208/52/0.01	151/32/0.024	116/22/0.016	49/20/0.056	74/25/0.092	44/23/0.085	76/54/0.103
1985	54/34/0.104	73/43/0.09	158/94/0.068	180/97/0.048	208/104/0.041	220/75/0.03	187/52/0.024	163/48/0.033	73/21/0.091	106/47/0.033	137/78/0.045	84/39/0.042
1986	76/37/0.039	112/41/0.025	117/38/0.022	201/75/0.014	243/96/0.019	294/84/0.016	283/49/0.012	188/35/0.01	165/42/0.023	138/46/0.035	161/84/0.032	61/33/0.027
1987	91/48/0.037	117/48/0.027	84/31/0.035	232/87/0.027	270/106/0.027	294/94/0.015	246/40/0.013	250/67/0.01	194/43/0.016	87/18/0.026	84/34/0.042	99/48/0.036
1988	66/26/0.019	98/34/0.031	135/42/0.024	207/64/0.015	253/85/0.019	289/83/0.014	229/48/0.018	185/43/0.029	127/54/0.022	136/51/0.047	105/49/0.044	112/77/0.045
1989	93/55/0.039	90/45/0.034	100/41/0.037	132/54/0.029	138/39/0.021	131/42/0.02	140/34/0.023	144/29/0.011	89/43/0.044	81/48/0.036	105/72/0.042	58/44/0.037
1990	81/71/0.033	61/46/0.026	100/57/0.034	129/55/0.032	143/53/0.036	169/50/0.021	142/32/0.01	166/41/0.014	145/45/0.021	83/37/0.03	74/34/0.024	64/42/0.028
1991	66/45/0.027	62/39/0.021	90/39/0.022	140/50/0.015	158/34/0.016	173/35/0.016	210/49/0.018	186/38/0.029	107/21/0.028	77/31/0.029	59/33/0.035	56/36/0.023
1992	83/26/0.027	106/24/0.006	140/25/0.014	192/30/0.01	239/49/0.005	229/31/0.005	275/28/0.011	256/36/0.018	187/21/0.029	171/44/0.02	80/21/0.024	93/28/0.009
1993	102/32/0.01	91/16/0.025	103/20/0.016	173/57/0.019	240/78/0.017	257/63/0.015	272/51/0.014	192/35/0.011	179/43/0.012	116/39/0.008	59/11/0.008	78/26/0.021
1994	58/19/0.02	70/24/0.018	98/47/0.012	177/57/0.012	185/57/0.009	196/58/0.008	124/11/0.015	173/30/0.009	156/35/0.012	102/31/0.028	103/42/0.037	71/30/0.027
1995	63/39/0.019	56/17/0.012	102/35/0.022	197/79/0.016	216/88/0.02	218/51/0.012	174/29/0.013	111/14/0.008	89/25/0.014	80/28/0.022	54/19/0.025	35/16/0.014
1996	32/18/0.02	44/23/0.011	35/12/0.007	99/29/0.011	137/36/0.011	169/40/0.01	140/28/0.009	145/26/0.019	125/36/0.01	96/20/0.023	34/13/0.016	48/19/0.024
1997	25/7/0.017	39/11/0.018	93/35/0.016	111/33/0.022	154/39/0.011	161/25/0.009	166/18/0.007	63/10/0.021	8/1/0.012	0/0/NA	0/0/NA	0/0/NA
1998	48/26/0.02	38/17/0.011	98/40/0.013	123/39/0.012	184/52/0.015	199/37/0.01	138/16/0.006	109/23/0.011	145/27/0.017	175/50/0.019	120/46/0.014	88/35/0.017
1999	87/35/0.009	72/32/0.01	101/35/0.008	129/40/0.03	224/76/0.023	203/53/0.019	207/47/0.01	123/27/0.011	68/19/0.017	81/28/0.023	72/42/0.026	81/54/0.017
2000	60/27/0.016	59/22/0.009	80/31/0.012	109/47/0.018	141/49/0.017	190/44/0.016	139/30/0.014	148/35/0.019	100/28/0.026	113/38/0.027	98/58/0.043	33/23/0.018
2001	29/18/0.024	55/35/0.036	91/42/0.039	180/81/0.036	184/85/0.03	229/79/0.023	205/52/0.021	163/40/0.024	93/42/0.029	73/30/0.03	78/40/0.057	80/65/0.04
2002	57/26/0.04	31/18/0.02	102/49/0.043	135/63/0.021	147/80/0.037	200/94/0.031	201/66/0.028	135/47/0.035	95/39/0.035	116/53/0.063	90/45/0.061	41/25/0.031
2003	17/10/0.011	25/14/0.009	82/41/0.014	134/63/0.024	186/75/0.021	145/45/0.026	89/14/0.023	52/8/0.013	52/19/0.014	102/59/0.033	56/31/0.025	33/28/0.036
2004	26/19/0.027	14/9/0.025	63/30/0.019	165/74/0.025	167/65/0.025	242/83/0.023	224/62/0.025	129/39/0.025	30/6/0.012	156/83/0.053	120/87/0.044	32/24/0.019
2005	28/20/0.022	40/24/0.041	93/54/0.024	102/51/0.028	201/91/0.033	189/55/0.026	190/46/0.018	129/34/0.02	59/22/0.025	70/39/0.034	62/40/0.032	27/16/0.028
2006	24/19/0.024	46/33/0.027	92/46/0.013	115/53/0.015	169/68/0.023	173/41/0.013	157/30/0.014	106/12/0.014	97/28/0.021	81/23/0.034	43/13/0.052	29/13/0.041

Table 3. Headboat data used in constructing the abundance index summarized by trip type (half day or full day, where half day trips tend to be in shallower depths). Values reported are X/Y/Z, where X is total number of trips (including those with zero red snapper landings), Y is number of positive trips (only those with red snapper landings), and Z is mean nominal CPUE of positive trips (number fish per angler-hook-hour).

	full	half
1976	670/441/0.065	119/42/0.15
1977	477/276/0.068	335/52/0.095
1978	861/499/0.067	558/117/0.079
1979	615/377/0.069	649/147/0.061
1980	658/361/0.044	675/121/0.036
1981	479/312/0.066	519/101/0.051
1982	590/338/0.031	692/72/0.051
1983	704/473/0.041	746/126/0.058
1984	717/490/0.052	623/75/0.045
1985	828/610/0.048	815/122/0.059
1986	945/552/0.021	1094/108/0.027
1987	1011/602/0.025	1037/62/0.018
1988	1058/602/0.026	884/54/0.034
1989	664/476/0.032	637/70/0.04
1990	714/505/0.027	643/58/0.024
1991	758/412/0.023	626/38/0.015
1992	1234/346/0.013	817/17/0.036
1993	1096/437/0.016	766/34/0.013
1994	904/400/0.016	609/41/0.015
1995	830/375/0.017	565/65/0.018
1996	698/251/0.012	406/49/0.021
1997	457/136/0.014	363/43/0.018
1998	958/342/0.014	507/66/0.016
1999	870/414/0.018	578/74/0.018
2000	784/359/0.021	486/73/0.022
2001	901/501/0.028	559/108/0.053
2002	844/505/0.035	506/100/0.05
2003	593/334/0.025	380/73/0.016
2004	758/455/0.032	610/126/0.028
2005	614/355/0.026	576/137/0.031
2006	552/265/0.02	580/114/0.024

Figure 1. Map of headboat areas as reported in the sampling program.

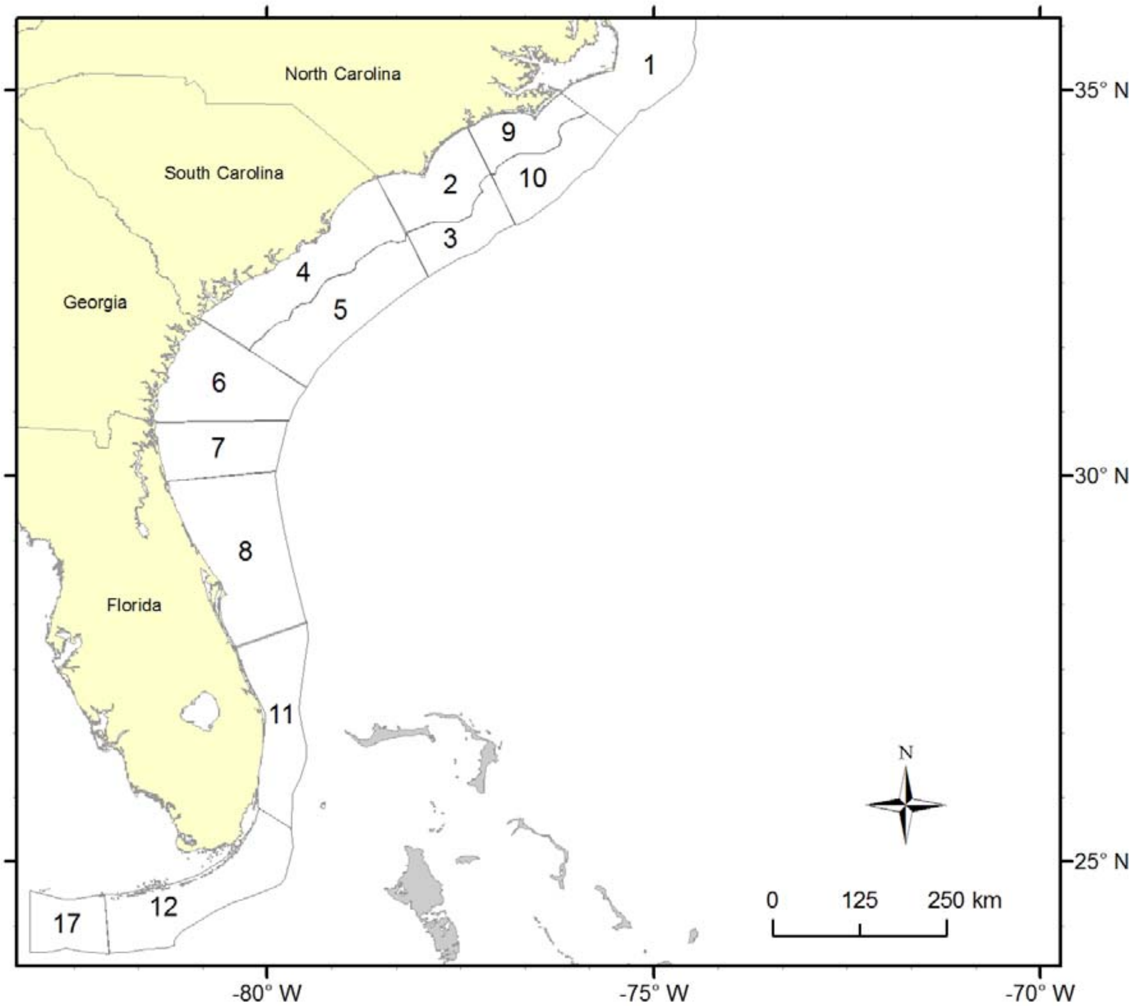

Figure 2. Results from four iterations of randomly selecting 70% red snapper headboat trips per year. Thick line with circles represents the index with all data intact, thin lines represent different iterations.

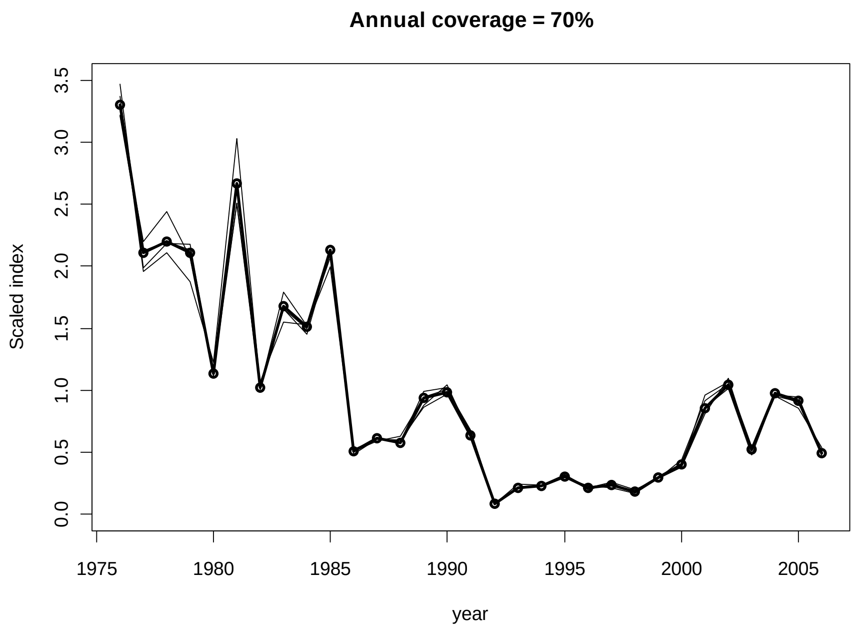

Figure 3. Results from four iterations of randomly selecting 50% red snapper headboat trips per year. Thick line with circles represents the index with all data intact, thin lines represent different iterations.

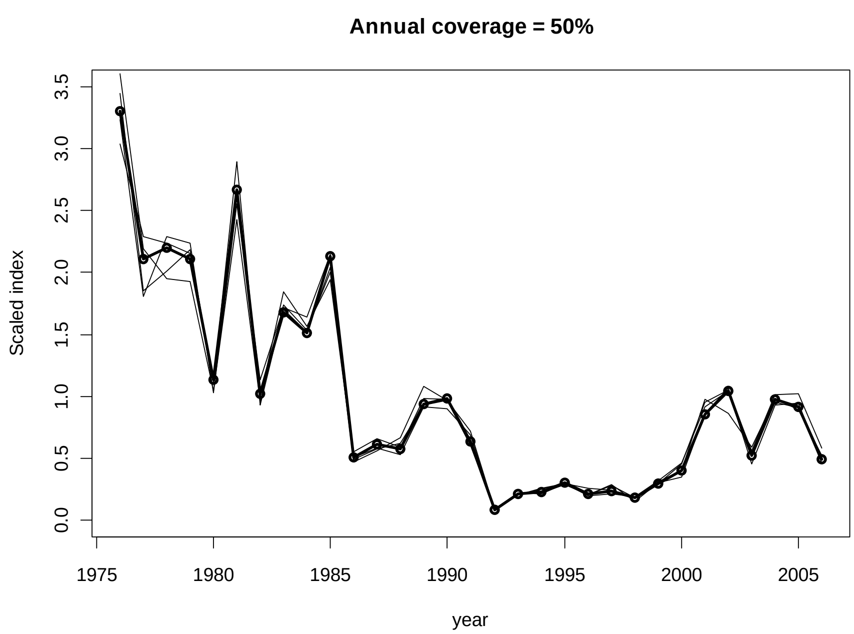

Figure 4. Results from four iterations of randomly selecting 30% red snapper headboat trips per year. Thick line with circles represents the index with all data intact, thin lines represent different iterations.

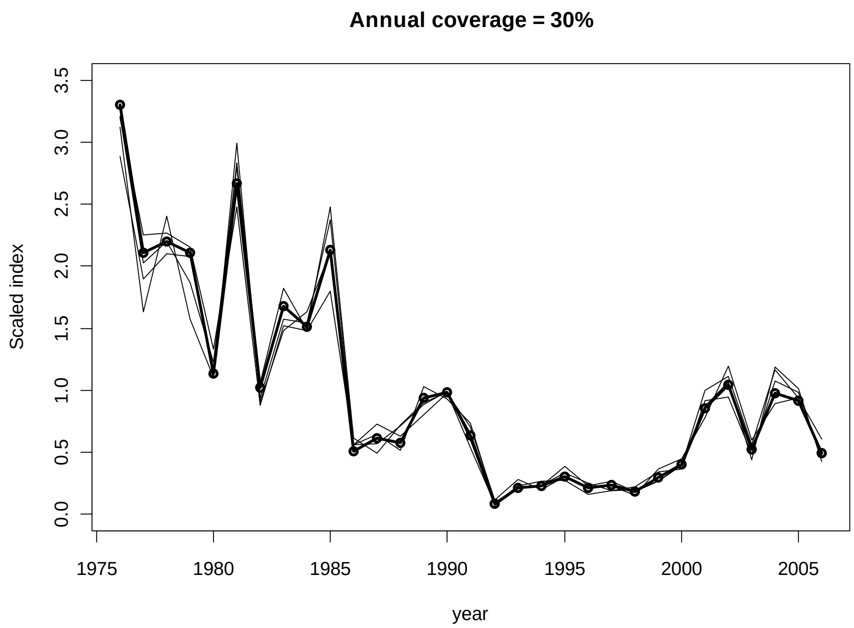

Figure 5. Results from four iterations of randomly selecting 10% red snapper headboat trips per year. Thick line with circles represents the index with all data intact, thin lines represent different iterations.