Modeling the Combined Effects of Gulf Reef Fish Amendment 35 Proposed Management Measures for Greater Amberjack

LAPP/DM Branch
NOAA Fisheries Service
Southeast Regional Office

Introduction

The first formal assessment of greater amberjack (*Seriola dumerili*) stocks in the Gulf of Mexico indicated that the stock was overfished and undergoing overfishing as of 1998 (Turner et al. 2000). Management measures to reduce the recreational bag limit from three to one fish were implemented in January 1997 and a commercial seasonal closure from March through May was implemented in January 1998; however, these closures were not incorporated into the Turner et al. (2000) assessment. The projected effects of these management measures were expected to eliminate overfishing; therefore, no new management measures were implemented under the rebuilding plan approved by Secretarial Amendment 2 in 2003 (NMFS 2003).

In 2006, a new stock assessment was completed and determined the greater amberjack stock was overfished, undergoing overfishing, and not recovering at the rate previously projected (SEDAR 9 2006). In response to these assessment results, the Gulf of Mexico Fishery Management Council (Gulf Council) and the National Marine Fisheries Service (NMFS) developed Amendment 30A to the Reef Fish FMP to end overfishing and rebuild the stock (GMFMC 2008). Upon implementation in August 2008, Amendment 30A required a reduction of fishing mortality and implemented a total allowable catch of 1.871 million pounds whole weight (mp ww) (GMFMC 2008). Amendment 30A also established annual catch limits (ACLs) for the recreational and commercial sectors at 1.368 mp and 0.503 mp ww, respectively. In addition to establishing quotas, Amendment 30A also increased the recreational size limit to 30-inches FL, eliminated the bag limit for captain and crew of for-hire vessels, and implemented sector accountability measures (AMs). Under the AMs, if a sector's ACL is met or projected to be met during the fishing year, harvest and retention of greater amberjack by that sector is prohibited for the remainder of the year. Additionally, if a sector exceeds its ACL, the overage is deducted from the sector's ACL for the subsequent fishing year.

In 2009, the recreational fishing season for Gulf of Mexico greater amberjack was closed on October 24, 2009, because the recreational ACL was projected to be exceeded in-season. The total 2009 recreational landings exceeded the ACL by 0.125 mp despite the in-season closure. The AMs required the length of the recreational fishing season in 2010 to be reduced by the amount necessary to recover the overage that occurred during the 2009 fishing year. The 2010 recreational ACL was set at 1.243 mp. Recreational harvest in 2010 was slowed by fishery closures associated with the Deepwater Horizon oil spill, and the 2010 recreational fishing season remained open through the end of the fishing year. The 2010 recreational ACL was exceeded by 0.053 mp. The 2011 recreational ACL was set at 1.315 mp to adjust for the 2010 overage. The Gulf Council also approved a regulatory amendment that prohibits recreational greater amberjack harvest and retention from June 1-July 31. This closure is intended to slow

the rate of harvest and reduce the likelihood of an early end of year closure, and it was first implemented during the 2011 fishing year.

In 2009, the commercial greater amberjack sector was closed on November 7, 2009 because the commercial ACL was projected to be exceeded in-season. The total 2009 commercial landings exceeded the ACL by 0.130 mp despite this in-season closure. The 2010 commercial ACL was subsequently reduced to 0.373 mp. This ACL was exceeded by 0.189 mp despite an in-season closure on October 28, 2010. The 2011 commercial ACL was set at 0.3139 mp and was projected to be met on June 17, 2011. The season was closed for the remainder of the year and will reopen on January 1, 2012.

In March 2011, the Gulf Council's Scientific and Statistical Committee (SSC) reviewed the 2011 greater amberjack update assessment and recommended an acceptable biological catch (ABC) of 1.78 mp ww; a 4.8% reduction from the ABC established by Amendment 30A. In response to the SSC's recommendation, the Gulf Council began drafting Amendment 35. Amendment 35 will adjust the greater amberjack rebuilding plan and implement management measures to constrain recreational and commercial harvest to the reduced ACL levels. This amendment considers recreational ACLs ranging from 1.368 mp to 0 lb, and commercial ACLs ranging from 0.503 mp to 0 lb. In August 2011, the Gulf Council selected a preferred recreational ACL alternative of 1.13 mp and a preferred commercial ACL alternative of 0.409 mp. This report presents the development of a recreational decision tool (RDT) and a commercial decision tool (CDT) to simulate the impacts of various combinations of proposed management measures to support Amendment 35.

Current Management Regulations

The following regulations currently apply to the Gulf of Mexico greater amberjack fishery:

1) One greater amberjack recreational bag limit (implemented January 1997).
2) 30-inch FL recreational minimum size limit (implemented August 2008).
3) 36-inch FL commercial minimum size limit (implemented February 1990).
4) June 1 through July 31 recreational closed season (implemented June 2011).
5) March 1 through May 31 commercial closed season (implemented January 1998).

Methods

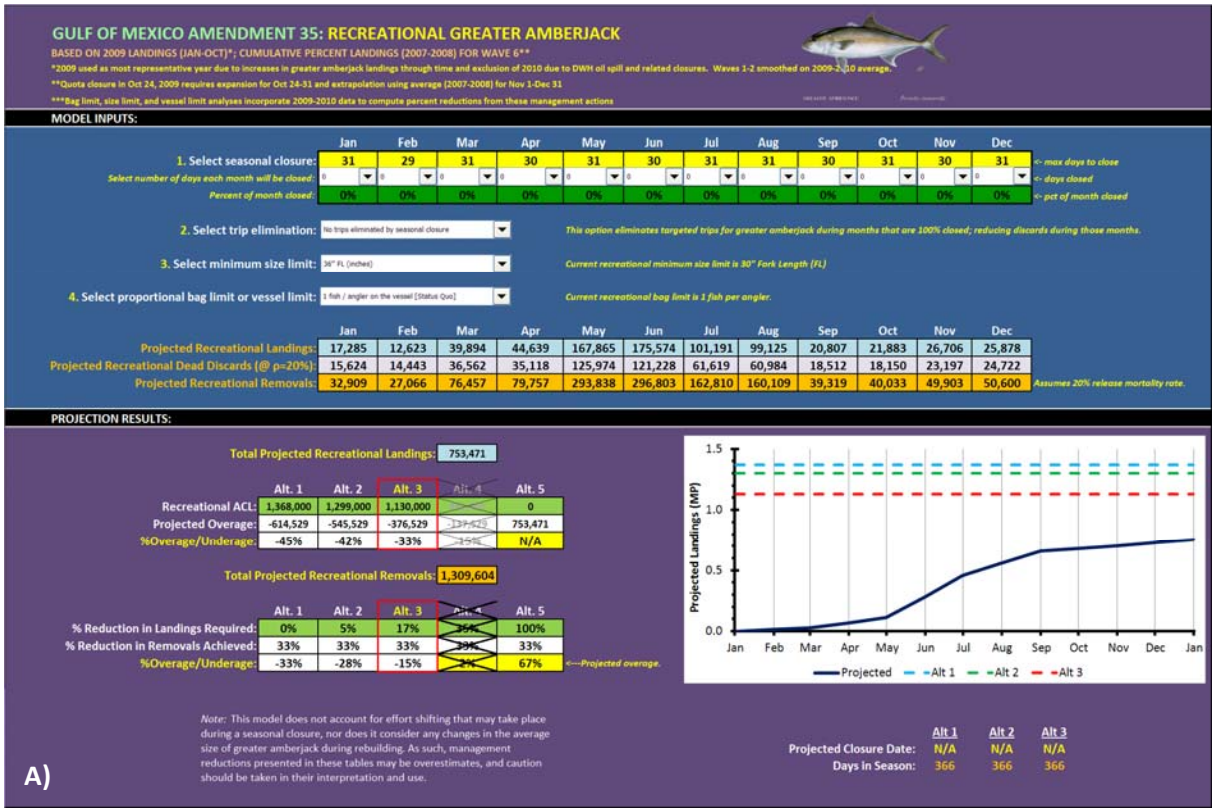
The RDT and CDT were implemented in Microsoft Excel using drop-down menus to obtain user inputs regarding desired management measures (Figure 1). Excel was chosen because it is widely available for constituent use. Impacts of management measures were simulated using programs written in SAS (SAS Institute, Cary, NC). The following management options were evaluated in this report:

Recreational Sector

1) Seasonal closures
2) Size limits
3) Vessel limits
4) Fractional bag limits

Commercial Sector

1) Seasonal closures
2) Trip limits



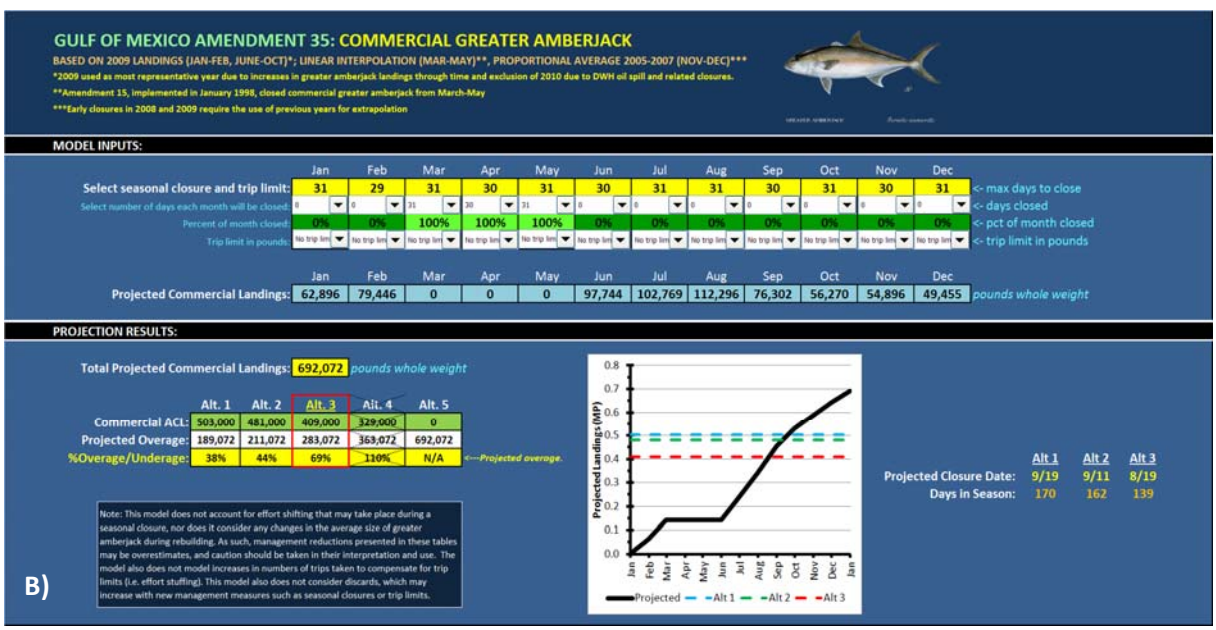


Figure 1. Screenshots for A) recreational and B) commercial decision tools, showing dropdown menus for user-specified management measures.

Data Sources

Recreational landings data for Gulf of Mexico greater amberjack were obtained from the Southeast Fisheries Science Center's (SEFSC) ACL Dataset (accessed September 2011), which provided aggregated landings data from the Marine Recreational Fisheries Statistics Survey (MRFSS), the SEFSC's Headboat Survey (HBS), and the Texas Parks and Wildlife Department (TPWD) Creel Survey. The ACL dataset provides improved quality assurance and quality control (QA/QC) on the raw data generated by the MRFSS and SEFSC headboat survey. The ACL dataset uses MRFSS weight estimates when available. In some cases, MRFSS provides an estimate of numbers landed but no weight estimate, due to missing weights in the intercept data. In these cases, the SEFSC uses weight substitutions to provide a weight estimate in the ACL data. MRFSS intercepts collect data on port agent observed landings ('A' catch) and angler reported landings ('B1' catch) and discards ('B2' catch) in numbers by species, two-month 'wave' (e.g., Wave 1 = Jan/Feb, …, Wave 6 = Nov/Dec), area fished (inland, state, and federal waters), mode of fishing (charter, private/rental, shore), and state (west Florida, Alabama, Mississippi, and Louisiana). HBS landings are generated after the end of each calendar year, at which time they are included in the ACL dataset. HBS landings in weight are calculated using a combination of logbook reports and dockside sampling, and adjustments to landings are made based on underreporting and misreporting determined through dockside validation by port agents. HBS records contain trip-level information on number of anglers, trip duration, date, area fished, landings (number of fish) and releases (number fish) by species. TPWD generates estimates of landings for private/rental boats and charter vessels fishing off Texas. TPWD landings are reported in numbers by 'high-use' (May 15-November 20) and 'low-use' time periods (November 21-May 14), area fished (state and federal waters), and mode (charter, private/rental). TPWD high and low use landings estimates can be re-estimated to correspond to MRFSS two-month waves. Landings, biological data (size of catch), and catch-effort information from each of these surveys were used to evaluate reductions in landings and discards (when available) associated with various greater amberjack closed seasons, vessel limits, fractional bag limits, and size limits. Following approaches used in the most recent stock assessment, MRFSS data from Monroe County were post-stratified and removed west Florida landing and discard estimates.

Typically, projected impacts of management measures are modeled as compared to a two- or three-year baseline; however, as evidenced by quota closures and overages in 2009 and 2010, fishing pressure on the greater amberjack stock in the Gulf appears to be increasing within both the recreational and commercial sectors. Thus, for projection purposes, 2009 was selected as the year most closely approximating future harvest patterns. Harvest data for 2010 was mostly excluded from this baseline because landings after April 2010 were deemed inappropriate for projections due to the confounding effects of fishery closures associated with the Deepwater Horizon oil spill.

To establish a recreational landings baseline, the three recreational datasets (i.e. MRFSS, HBS, and TPWD) were broken into monthly landings assuming a uniform distribution of landings within waves. The baseline was formed primarily from 2009 landings but gap filling was done in some months to smooth irregularities and backfill for quota closures. Landings from January to April came directly from the Headboat and TPWD 2009 datasets. MRFSS landings of greater

amberjack typically follow a dome-shaped seasonal pattern, but showed an uncharacteristic pattern in 2009, with landings higher in January and February (~11% of annual projected) than in March and April (~4% of annual projected). Wave 1 landings historically (2000-2008) have accounted for 8 ± 1% (mean ± SE) of annual landings, as compared to 16 ± 2% % from Wave 2. To avoid overestimating reductions in future harvest in January or February, this 2009 irregularity was smoothed by redistributing MRFSS 2009 Wave 1-2 landings using the average percent landings within Waves 1-2 from MRFSS 2009-2010 data. This redistribution placed 9% of the 2009 MRFSS annual landings into Wave 1 and 13% into Wave 2.

Recreational baseline data from all three datasets for May to September were derived directly from 2009 landings without modification. October 2009 landings following the October 24 quota closure were extrapolated by expanding the reported October landings by 29.2% to account for the percentage of closed days. As November and December were closed in 2009 and 2010, baseline landings for these months were derived by expanding 2009 landings by average percent cumulative landings for November and December 2007-2008 (+7% MRFSS-Charter, +8% MRFSS-Private, +3% HBS). No greater amberjack landings were reported by TPWD for Wave 6 2007-2009. Baseline recreational landings by month and mode are presented in Table 1A. Because the baseline predicts landings during periods in 2009 that were closed to prevent quota overages (i.e. Oct 24-Dec 31), the projected baseline of 1.68 mp in the absence of any closures is higher than the 1.493 mp ww landed in 2009. Baseline discards (in numbers) by month and mode were also developed in similar fashion, and converted to weights using 2009 discard average weight data from the update assessment (SEDAR-9 Update 2011).

Commercial landings data for Gulf of Mexico greater amberjack were obtained from the SEFSC's commercial ACL dataset (accessed June 2011), and the SEFSC's commercial logbook program (accessed May 2011). The SEFSC commercial ACL dataset provides additional QA/QC for data collected by the SEFSC via the Accumulated Landings System and state trip ticket programs. Landings data are provided in pounds ww, and logbook records summarize landings on a trip level, with information for each species encountered including landings (in lbs), primary gear used, and primary area and depth of capture. Monthly commercial logbook landings for open months in 2009 were converted to a percentage of the total annual landings. Commercial harvest of greater amberjack has been prohibited in March, April, and May since January 1998. To predict what landings trends might be if these months were re-opened, linear interpolation was used to estimate percent annual landings between February and June. Re-opening March-May is projected to increase annual landings by 44%, assuming no quota closure. Quota closures for commercial greater amberjack were implemented in November-December of 2009 and 2010; these months were back-filled using average percent of annual landings (2006-2008) for November (9%) and December (8%). The commercial logbook provides incomplete landings information due to noncompliance and failure to include state-licensed commercial fishermen. Monthly percentages of annual landings derived from logbook records were scaled to the 601,446 lb annual total (Source: SEFSC ACL Dataset 2011). The baseline commercial landings by month are presented in Table 1B. Because the baseline predicts landings during months in 2009 that were closed (i.e. Mar-May; Nov-Dec), the projected baseline of 0.958 mp landed in the absence of any closures is substantially higher than the 0.601 mp landed in 2009.

Table 1. Projected baseline 2012 monthly A) recreational landings, B) recreational discards, and C) commercial landings in pounds whole weight (lb ww) of Gulf greater amberjack under status quo management measures with no seasonal or quota closures.

A: REC. LANDINGS	Jan*	Feb*	Mar*	Apr*	May	Jun	Jul	Aug	Sep	Oct**	Nov***	Dec***
HBS	4,180	2,438	3,240	7,843	10,158	19,545	21,722	16,208	11,602	7,474	1,498	1,692
TPWD CHARTER	0	0	0	0	0	0	497	497	0	0	0	0
TPWD PRIVATE	305	275	0	0	63	61	456	456	23	24	0	0
MRFSS CHARTER	11,796	10,654	29,259	28,316	128,320	124,181	146,486	146,486	26,659	27,548	23,559	24,344
MRFSS PRIVATE	22,697	20,500	56,300	54,484	220,380	213,271	82,406	82,406	12,154	12,560	31,745	32,803
	38,977	**33,868**	**88,799**	**90,642**	**358,921**	**357,058**	**251,567**	**246,053**	**50,439**	**47,606**	**56,801**	**58,839**

B: REC DISCARDS	Jan*	Feb*	Mar*	Apr*	May	Jun	Jul	Aug	Sep	Oct**	Nov***	Dec***
HBS	4,784	4,321	5,804	5,616	16,723	16,183	16,551	16,822	14,824	15,319	1,899	3,862
TPWD CHARTER	0	0	0	0	0	0	0	0	0	0	0	0
TPWD PRIVATE	0	0	0	0	0	0	0	0	0	0	0	0
MRFSS CHARTER	31,209	28,188	77,413	74,916	152,932	147,999	26,272	26,272	26,499	27,383	29,683	30,672
MRFSS PRIVATE	20,436	18,458	50,691	49,056	269,158	260,475	114,896	114,896	21,606	22,326	54,307	56,117
	56,428	**50,967**	**133,908**	**129,588**	**438,812**	**424,657**	**157,719**	**157,990**	**62,929**	**65,027**	**85,889**	**90,651**

Source: 2009 ACL Data (accessed 9/2011) uniformly distributed within waves. Monroe County MRFSS landings removed.
**MRFSS Waves 1-2 smoothed from 2009-2010 average percent landings by wave.*
***Oct 24-31 extrapolated by expanding Oct landings by 23%.*
****Nov-Dec landings expanded from average (2007-2008) percentage of annual cumulative landings accounted for in Wave 6.*

C: COMM LANDINGS	Jan	Feb	Mar†	Apr†	May†	Jun	Jul	Aug	Sep	Oct	Nov††	Dec††
COMMERCIAL	62,896	79,446	84,020	88,595	93,169	97,744	102,769	112,296	76,302	56,270	54,896	49,455

Source: 2009 commercial logbook data (accessed 9/2011) scaled to 2009 ACL data (accessed 9/2011).
†Based upon linear interpolation between February and June landings.
††Expanded using average (2006-2008) monthly percent annual landings.

Seasonal Closure Analyses

Landings of greater amberjack are highly seasonal in the Gulf of Mexico; thus, reductions associated with seasonal closures differ greatly depending upon the time period selected for closure (Figure 2). To model the effects of a seasonal closure, users of the RDT and CDT models can specify the number of days closed for each month. These choices were converted to a percentage of days closed for a given month. The projected landings during that month under the other user-specified management measures were then reduced by the percentage of the month that was closed. Landings were assumed uniformly distributed within months; no effort shifting or effort compression was modeled. In the RDT, landings that were eliminated by a seasonal closure were converted to dead discards at a release mortality rate of 20%.

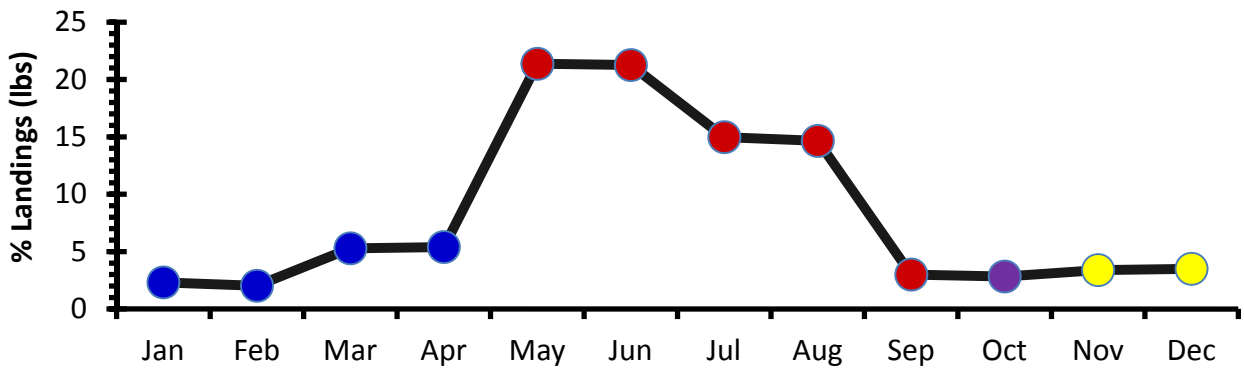


Figure 2A. Distribution by month of simulated 'baseline' Gulf recreational greater amberjack landings from MRFSS, Headboat observer, and Texas Parks and Wildlife datasets. Landings assumed uniformly distributed within waves. MRSS landings from Monroe County were removed following SEDAR-9 (2011). MRFSS landings from Jan-Apr 2009 (blue) were redistributed using 2009-2010 proportional averages by wave. Landings from May-Sept (red) came from 2009 ACL dataset (accessed 9/2011). Landings from Oct (purple) was proportionally expanded to account for quota closure in the last week of the month. Baseline landings for Nov-Dec were derived from average percent cumulative landings for Nov-Dec 2007-2008.

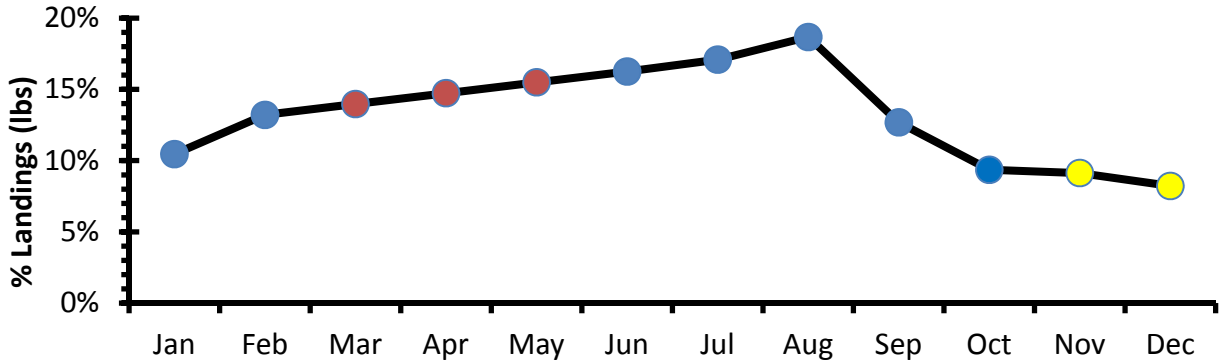


Figure 2B. Distribution by month of simulated 'baseline' Gulf commercial greater amberjack landings from logbook data (accessed 9/2011). Landings from Mar-May (red) predicted via linear extrapolation between February-June. Landings from Nov-Dec (yellow) predicted from the average percent of annual landings (2006-2008) during most recent years without quota closure.

Recreational Target Trip Elimination

A total greater amberjack harvest prohibition during a given month may reduce angler incentive to deliberately target greater amberjack, which may, in turn, reduce encounter rates with the stock during that month. MRFSS intercept records where anglers reported targeting greater amberjack were identified as 'target' trips. In the event of a 100% closure, target trips were assumed to no longer occur. Landings and discards were then re-estimated using a catch estimate program, developed by NMFS Office of Science and Technology, applied to modified intercept records with target trips removed. Reductions predicted for Waves 1 and 2 were pooled because the program predicted an elimination of all greater amberjack encounters during Wave 2, which was deemed unrealistic. Due to the quota closure in Wave 6, Wave 5 reductions were used as a proxy for Wave 6. Percent reductions in landings and discards were then computed relative to the baseline (Table 2). MRFSS Private mode reductions were used as a proxy for encounters that would be eliminated for TPWD Private mode. MRFSS Charter mode reductions were used as a proxy for encounters that would be eliminated for HBS and TPWD Charter. This simulation had no impact upon the predicted landed catch, as it required a 100% closure during a given month (i.e. landed catch = 0 with or without trip elimination). It did have an impact upon total removals, by reducing the formerly landed catch that was converted to dead discards at a release mortality rate of 20% and also by reducing the discarded catch relative to baseline levels. Trip elimination is predicted to have the most substantial impacts during the first four months of the year, and the impacts are more pronounced for the private mode.

Table 2A. Projected reductions in monthly recreational landings of greater amberjack under 'trip elimination' relative to simulation baseline for for-hire (charter, headboat) and private modes.

LANDINGS	Jan*	Feb*	Mar*	Apr*	May	Jun	Jul	Aug	Sep	Oct	Nov**	Dec**
FOR-HIRE	39%	39%	39%	39%	18%	18%	6%	6%	*0%*	*0%*	*0%*	*0%*
PRIVATE	79%	79%	79%	79%	28%	28%	15%	15%	22%	22%	22%	22%

*Reductions predicted for Waves 1 and 2 were pooled.
**Due to the quota closure in Wave 6, Wave 5 reductions were used as a proxy for Wave 6.

Table 2B. Projected reductions in monthly recreational discards of greater amberjack under 'trip elimination' relative to simulation baseline for for-hire (charter, headboat) and private modes.

DISCARDS	Jan*	Feb*	Mar*	Apr*	May	Jun	Jul	Aug	Sep	Oct	Nov**	Dec**
FOR-HIRE	61%	61%	61%	61%	3%	3%	0%	0%	0%	0%	0%	0%
PRIVATE	76%	76%	76%	76%	24%	24%	3%	3%	*0%*	*0%*	0%	0%

Recreational Vessel Limits

The MRFSS system classifies recreational catch into three categories:

- Type A - Fish that were caught, landed whole, and available for identification and enumeration by the interviewers.
- Type B - Fish that were caught but were either not kept or kept but not available for identification.
    - Type B1 - Fish that were caught and filleted, released dead, given away, or disposed of in some way other than Types A or B2.
    - Type B2 - Fish that were caught and released alive.

Type A and B1 catches were used for vessel limit analyses. Type A catch represents the total catch of all anglers on a fishing trip. However, some or all of the anglers contributing to the A catch are also interviewed to report type B1 catch, and those may be recorded on an individual basis. If the number of people contributing to the A catch was greater than the number of people interviewed to report B1 catch, the following formula was used to account for possible under reporting of the B1 catch:

$$B1 = B1_{interviewed} \times (\#\ people\ in\ fishing\ party / \#\ people\ interviewed\ to\ report\ B1\ catch).$$

The total catch per vessel was then determined by summing the total Type A and Type B1 catches (AB1) for each trip. Percent reductions in harvest were estimated for vessel limits ranging from 1 through 10, 15, 20, 25, 30, 40, 45, and 50 fish per vessel. If AB1 catch per vessel was greater than the vessel limit being analyzed, the value was re-set to the new vessel limit ($AB1_{vessel\ limit}$), otherwise no changes to the vessel's catch were made. Discard mortality was not incorporated into the analysis.

The following formulas were used to estimate reductions in harvest resulting from vessel limits:

$$If\ AB1\ catch <= vessel\ limit,\ then\ harvest = A + B1$$

$$If\ AB1\ catch > vessel\ limit,\ then\ harvest = AB1_{vessel\ limit}$$

Reductions for headboat and TPWD vessel limits were calculated in a similar manner as described above, except no B1 catch data were available. If the catch per vessel trip was greater than the vessel limit being analyzed ($A_{vessel\ limit}$), the value was re-set to the vessel limit, as described above. If the catch per vessel was less than the vessel limit being analyzed, then no change to the catch was made. Percent reductions associated with vessel limits were estimated relative to the status quo of no vessel limit, by mode of fishing (Table 3). Due to concerns about low sample sizes, output was pooled for 2009-2010 data. MRFSS and TPWD output were pooled by mode and outputs for all sources were pooled across nearest months until a sample size of 50 for status quo was achieved. For example, if only 40 greater amberjack were intercepted in January, January samples would be pooled with December and February samples; if this failed to attain the 50 sample target, November and March samples would be included, and so on. The same pattern used to achieve the target sample size in numbers was then applied to

compute reductions in pounds. Vessel limits vary in their impact by mode; headboat is most heavily impacted, followed by charter, with private only impacted by low (<3 fish/vessel) vessel limits.

Table 3A. Projected reduction of headboat greater amberjack landings by month for various vessel limits. Warmer colors denote higher reductions.

Bag Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
45	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
40	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
35	0%	1%	0%	2%	0%	0%	0%	0%	0%	3%	0%	0%
30	2%	2%	0%	3%	0%	0%	0%	3%	0%	3%	6%	0%
25	3%	8%	0%	5%	0%	0%	1%	6%	2%	5%	12%	0%
20	9%	24%	2%	8%	3%	2%	1%	9%	3%	8%	18%	0%
15	17%	30%	4%	17%	11%	6%	5%	13%	10%	11%	24%	9%
10	29%	46%	18%	29%	27%	25%	21%	23%	25%	24%	34%	18%
9	32%	48%	20%	35%	30%	29%	27%	26%	29%	27%	39%	20%
8	36%	51%	22%	39%	35%	33%	32%	29%	32%	31%	43%	21%
7	40%	54%	26%	43%	40%	37%	37%	33%	36%	34%	46%	23%
6	45%	57%	30%	47%	44%	42%	43%	37%	40%	39%	50%	27%
5	52%	61%	36%	52%	49%	47%	49%	42%	45%	43%	54%	32%
4	60%	65%	41%	58%	56%	54%	55%	48%	51%	50%	58%	39%
3	68%	71%	49%	65%	63%	61%	62%	55%	58%	57%	64%	48%
2	77%	78%	58%	74%	71%	70%	71%	64%	66%	67%	72%	61%
1	88%	88%	74%	84%	83%	81%	82%	77%	80%	81%	81%	79%

Table 3B. Projected reduction of MRFSS and TPWD charter greater amberjack landings by month for various vessel limits. Warmer colors denote higher reductions.

Bag Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
45	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
40	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
35	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
30	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
25	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
15	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	2%	0%	0%	0%	1%	1%	0%	3%	2%	2%	3%	2%
9	4%	0%	0%	0%	4%	2%	5%	5%	3%	5%	6%	4%
8	5%	0%	0%	0%	5%	2%	8%	7%	5%	8%	9%	7%
7	8%	0%	0%	1%	7%	4%	11%	8%	7%	12%	13%	10%
6	13%	3%	4%	5%	14%	6%	16%	13%	11%	17%	19%	14%
5	19%	8%	9%	13%	21%	12%	20%	19%	17%	24%	27%	21%
4	25%	13%	15%	22%	30%	20%	31%	28%	25%	32%	34%	28%
3	35%	23%	26%	32%	42%	32%	42%	45%	40%	42%	45%	38%
2	51%	43%	44%	48%	56%	47%	56%	58%	54%	56%	58%	53%
1	69%	62%	67%	71%	74%	69%	70%	75%	72%	74%	75%	69%

Table 3C. Projected reduction of MRFSS and TPWD private greater amberjack landings by month for various vessel limits. Warmer colors denote higher reductions.

Bag Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
45	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
40	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
35	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
30	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
25	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
15	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	1%	2%	2%	1%	1%	3%	2%	2%	1%	1%	2%	2%
3	7%	9%	10%	12%	13%	15%	14%	11%	10%	9%	5%	9%
2	22%	25%	25%	28%	29%	30%	25%	22%	22%	22%	15%	21%
1	48%	54%	55%	53%	54%	49%	41%	38%	38%	38%	38%	45%

Recreational Fractional Bag Limit Analysis

Three fractional bag limits were evaluated: 1) One fish per one angler; 2) One fish per two anglers; and, 2) one fish per three anglers. For trips where the number of anglers was not in multiples of two or three people, anglers were not allowed to keep one additional fish.

Fractional bag limits were calculated in a similar manner as vessel limits, except reductions were determined on a per angler basis rather than a per vessel basis. MRFSS type A + B1 (AB1) catch was divided by the number of people contributing to the catch to estimate the average catch per person. If AB1 catch per person was greater than the fractional bag limit being analyzed, the value was re-set to the fractional bag limit ($AB1_{bag\ limit}$), otherwise no changes to catch were made.

Headboat and TPWD bag limit reductions were calculated in a similar manner except only landed (i.e. Type 'A') fish were available for analysis. Catch per person was calculated by dividing the total number of fish landed by the number of anglers. If the catch per angler was greater than the bag limit analyzed ($A_{bag\ limit}$), the value was re-set to the bag limit, as described above. If the catch per angler was less than the bag limit analyzed, then no changes to the catch were made. Percent reductions associated with fractional bag limits were estimated by mode of fishing relative to the status quo of one fish per one angler (Table 4). Due to concerns about low sample sizes, output was pooled for 2009-2010 data. MRFSS and TPWD output were pooled by mode and outputs for all sources were pooled across nearest months until a sample size of 50 for status quo was achieved. The same pattern used to achieve the target sample size in numbers was then applied to compute reductions in pounds. Proportional bag limits are predicted to have the largest impacts upon the private mode, followed by charter, with the least impact upon headboat.

Table 4. Projected reduction of greater amberjack landings by month for various proportional bag limits for A) headboat, B) MRFSS and TPWD charter, and C) MRFSS and TPWD private. Warmer colors denote higher reductions.

A) Headboat

Fract. Bag Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 Fish/1 Angler	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1 Fish/2 Anglers	29%	27%	13%	24%	21%	17%	23%	18%	18%	20%	25%	5%
1 Fish/3 Anglers	43%	39%	23%	38%	32%	28%	35%	30%	27%	31%	37%	21%

B) MRFSS & TPWD Charter

Fract. Bag Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 Fish/1 Angler	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1 Fish/2 Anglers	35%	33%	35%	40%	40%	34%	36%	39%	36%	35%	36%	34%
1 Fish/3 Anglers	56%	55%	56%	62%	56%	55%	56%	60%	56%	54%	54%	53%

C) MRFSS & TWPD Private

Fract. Bag Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 Fish/1 Angler	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1 Fish/2 Anglers	37%	41%	41%	37%	36%	36%	28%	27%	28%	29%	30%	35%
1 Fish/3 Anglers	70%	71%	71%	61%	61%	56%	46%	51%	53%	53%	62%	66%

Recreational Minimum Size Limit Analyses

Length measurements collected during biological sampling associated with HBS, MRFSS, and TPWD were converted to inches FL using standard conversion factors and equations summarized in Table 5 (Figure 3; SEDAR 9 2011). MRFSS weight measurements were recorded in kilograms whole weight (ww) and headboat weight measurements were recorded in grams ww. No weight information was available for TPWD intercepts. All fish weights for TPWD intercepts and some fish weights for MRFSS intercepts were not recorded for greater amberjack so whole weight was estimated from length using the equations summarized in Table 5. All weight measurements were recorded for each intercept in the headboat database.

Table 5. Meristic conversions for Gulf of Mexico greater amberjack. Source: SEDAR-9 (2011).

Conversion	Source	Model	r^2
TL (mm) vs. FL (mm)	FIN	TL = 1.0253(FL) + 70.165	0.91
Whole weight (lbs) vs. FL (in)	TIP	$WW = 0.001(FL)^{2.8078}$	0.99
Gutted weight (lbs) vs. FL (in)	TIP	$GW = 0.0007(FL)^{2.8948}$	0.98

Reductions in harvest (both numbers and weight of fish) were calculated for each mode of fishing (charter, headboat, and private/rental) for minimum size limits (MSL) at 1 inch intervals between 30-36 inches as follows:

Percent reduction = $((C - G) - B)/C$, where:
C = catch in either number of fish or pounds WW
G = number or weight of fish that are greater than or equal to the MSL
B = number or weight of fish smaller than the 30-inch FL MSL (non-compliance or measurement error)

MSL from 30 to 36 inches FL in one-inch increments were evaluated. Percent reductions associated with MSL were estimated by mode of fishing normalized to a 0% reduction at the recreational status quo of 30 inches (Table 6). Due to concerns about low sample sizes, output was pooled for 2009-2010 data. MRFSS and TPWD output were pooled by mode and outputs for all sources were pooled across nearest months until a sample size of 50 fish (in numbers) for status quo was achieved. The same pattern used to achieve the target sample size in numbers was then applied to compute reductions in pounds. Projected MSL impacts vary by month and mode.

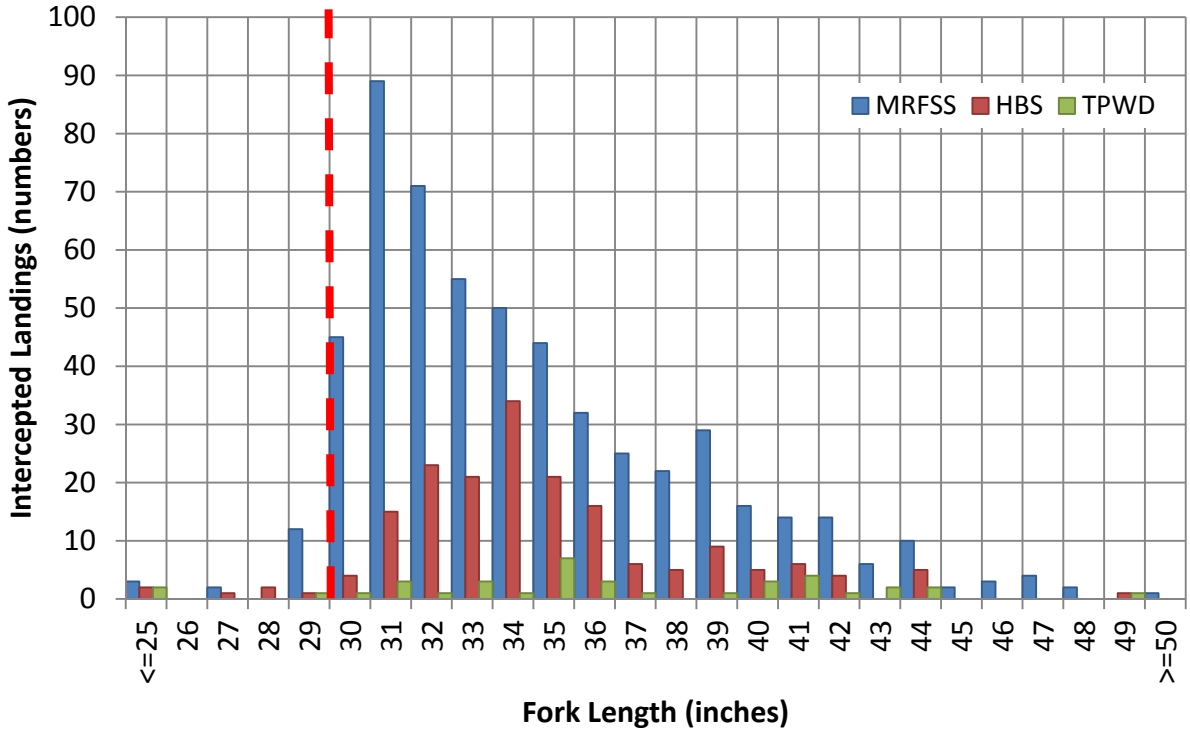


Figure 3. Fork length (FL) distribution for biologically sampled intercepts of recreationally landed greater amberjack in the Gulf of Mexico from MRFSS (blue), headboat survey (HBS; red), and TPWD (green). Red line denotes current recreational minimum size limit of 30 inches FL.

Table 6A. Projected reduction of headboat greater amberjack landings by month for various minimum size limits. Warmer colors denote higher reductions.

Size Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	9%	11%	10%	11%	10%	8%	4%	5%	5%	6%	7%	9%
32	23%	23%	24%	27%	24%	19%	14%	16%	17%	19%	20%	23%
33	42%	47%	50%	47%	43%	32%	18%	20%	20%	21%	27%	33%
34	59%	66%	67%	68%	68%	52%	31%	33%	35%	38%	45%	48%
35	65%	72%	74%	77%	78%	67%	53%	48%	48%	43%	50%	53%
36	70%	77%	79%	82%	82%	77%	71%	62%	61%	49%	57%	59%

Table 6B. Projected reduction of MRFSS and TPWD charter greater amberjack landings by month for various minimum size limits. Warmer colors denote higher reductions.

Size Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	18%	18%	14%	8%	21%	15%	15%	13%	13%	13%	17%	16%
32	24%	27%	22%	15%	34%	39%	31%	25%	23%	24%	24%	23%
33	32%	37%	32%	26%	46%	47%	40%	33%	29%	25%	24%	28%
34	44%	52%	45%	36%	54%	53%	50%	45%	41%	35%	31%	34%
35	57%	65%	54%	43%	62%	57%	56%	54%	48%	45%	40%	49%
36	65%	72%	59%	45%	67%	63%	64%	64%	59%	54%	50%	57%

Table 6C. Projected reduction of MRFSS and TPWD private greater amberjack landings by month for various minimum size limits. Warmer colors denote higher reductions.

Size Limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	14%	13%	13%	11%	8%	8%	10%	10%	8%	11%	10%	13%
32	21%	23%	21%	17%	14%	11%	16%	19%	20%	22%	22%	24%
33	35%	38%	30%	26%	22%	19%	28%	33%	38%	40%	38%	35%
34	38%	41%	34%	30%	25%	21%	30%	34%	38%	42%	40%	39%
35	47%	52%	46%	43%	39%	36%	44%	48%	50%	53%	50%	52%
36	48%	57%	52%	49%	44%	42%	49%	52%	56%	58%	55%	55%

Commercial Trip Limits

Commercial trip limits are a tool for reducing the rate of commercial harvest to avoid an early closure. For greater amberjack, a relatively small percentage of trips comprise the bulk of the commercial harvest (Figure 4). Trip limits from 250-3,000 lb ww per trip were examined using commercial logbook data. To model trip limits, if total catch per logbook-reported trip was greater than the trip limit being analyzed, the value was re-set to the new trip limit, otherwise no changes to catch were made. Commercial fishermen were assumed to stop targeting amberjack once their trip limit was met. If the CDT user selected a trip limit for a given month, the percent reduction predicted by the trip limit model was applied to baseline monthly landings (Table 7).

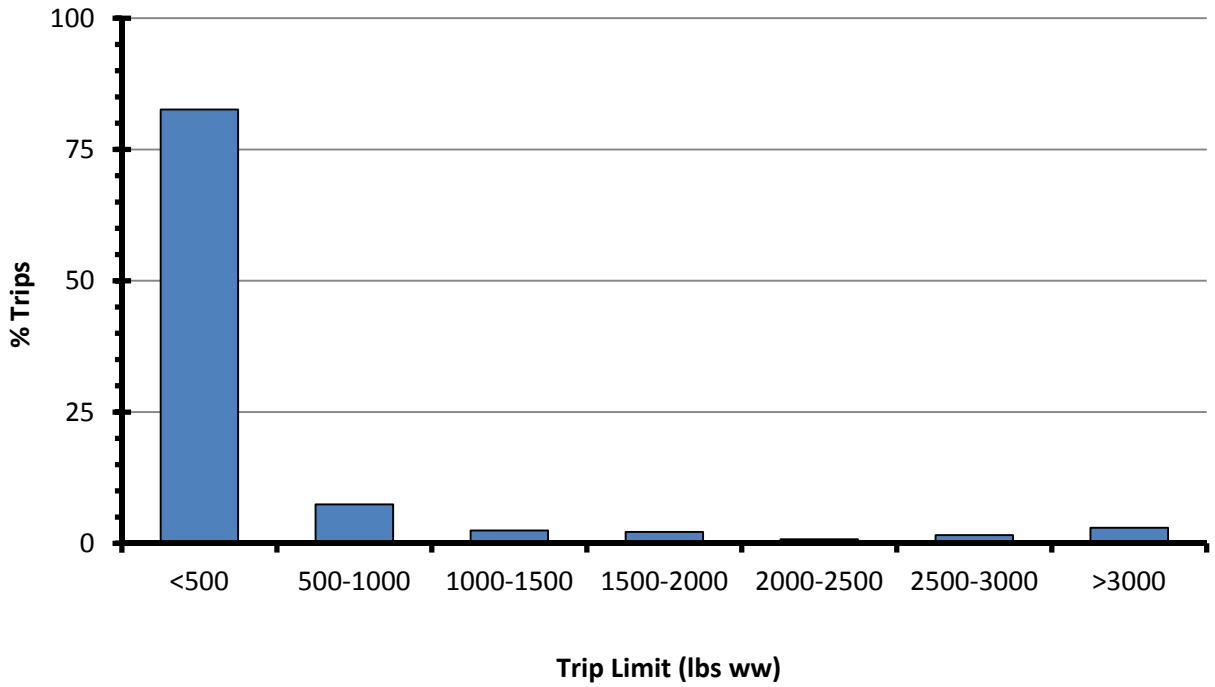


Figure 4. Commercial greater amberjack catch-per-trip as reported to SEFSC logbooks in 2009.

Table 7. Projected monthly commercial greater amberjack landings for various trip limits.

MONTH	NO LIMIT	3000 LB	2500 LB	2000 LB	1500 LB	1000 LB	750 LB	500 LB	250 LB
Jan	62,896	62,151	60,933	59,715	58,497	55,173	52,994	48,187	35,516
Feb	79,446	69,199	66,763	63,615	57,719	48,665	43,097	35,947	24,937
Mar	84,020	69,230	66,442	62,836	56,822	48,357	43,210	36,459	25,729
Apr	88,595	69,262	66,121	62,057	55,924	48,049	43,323	36,972	26,522
May	93,169	69,293	65,800	61,277	55,027	47,740	43,436	37,484	27,314
Jun	97,744	69,324	65,479	60,498	54,129	47,432	43,550	37,996	28,106
Jul	102,769	96,584	91,695	83,857	73,625	59,988	52,244	41,911	27,389
Aug	112,296	91,896	85,119	76,698	66,293	53,249	45,362	36,593	24,193
Sep	76,302	67,993	64,256	59,385	52,683	42,787	37,109	30,256	20,933
Oct	56,270	52,332	49,892	46,519	42,454	36,757	32,711	26,940	18,882
Nov	54,896	47,618	45,663	43,527	40,588	36,433	33,235	28,345	20,235
Dec	49,455	45,736	44,597	42,910	40,406	36,139	32,617	27,751	20,290

Note: Purple shading denotes gaps filled with linear interpolation; orange shading denotes extrapolation from 2006-2008 average percent annual landings.

Combined Effects of User-Defined Management Measures

The projected impacts of the various management measures produced output in pounds of landings (i.e. trip limit) or percent reductions (i.e. vessel limit, proportional bag limit, size limit). These results were incorporated into Microsoft Excel RDT and CDT models. For both models, if month (*m*) was 100% closed, landings were set to zero pounds for all sectors. For the RDT, if a month was partially or fully open, the projected landings (L) were computed as follows:

$$L_{sector,m} = BL_{sector,m} * O_m * \varsigma_{sector,m} * (\beta_{sector,m} \text{ OR } \upsilon_{sector,m})$$

where BL: baseline landings, O: percent of month open to fishing, ς: percent landed catch remaining following size limit implementation, β: percent landed catch remaining following fractional bag limit implementation, and υ: percent landed catch remaining following vessel limit implementation. The RDT does not allow a proportional bag limit and a vessel limit to be modeled simultaneously.

If month (*m*) was 100% closed and the user-defined trip elimination (τ) to be false, projected discards (D) were computed as baseline discards (BD) plus baseline landings (BL). Similarly, if month (*m*) was 100% closed and the user-defined trip elimination (τ) to be true, discards (D) were computed as:

$$D_{sector,m} = BD_{sector,m} * \tau^{D}_{sector,m} + BL_{sector,m} * \tau^{L}_{sector,m}$$

where τ: the percent reduction in landings (L) and discards (D) due to trip elimination. For the RDT, if a month was partially or fully open, the projected discards were computed as follows:

$$D_{sector,m} = \underbrace{BD_{sector,m}}_{\text{baseline discards}} + \underbrace{(BL_{sector,m} - L_{sector,m})}_{\text{new management discards}}.$$

Projected discards were multiplied by a 20% release mortality rate to convert to dead discards. Projected dead discards were added to projected landings to determine total removals.

For the CDT, projected monthly landings were computed as:

$$L_m = T_m * O_m$$

where T_m: projected landings under user-defined trip limit (see Table 7).

For both decision tools, the projected monthly landings were summed across the year for a variety of user-defined management scenarios and compared to the Amendment 35 ACL alternatives. In instances where the management measures were insufficient to constrain harvest below the ACL, the projected quota closure date was computed.

Results

Recreational

Table 8 presents projected recreational landings and quota closure dates under a variety of management alternatives. The RDT predicted that without the recently approved June-July closure or additional management measures, the recreational greater amberjack harvest in 2012 would be 1.68 mp (Figure 5A). Under this scenario, a quota closure would likely be necessary on July 20, limiting the season to just 201 days. Increasing the recreational size limit to 34 inches is projected to constrain harvest below the ACL (Figure 5B), as would the recently approved June-July closure (Figure 5C) or a 1 fish per 2 angler proportional bag limit (Figure 5D).

Table 8. Projected recreational harvest in million pounds whole weight (mp ww) of Gulf greater amberjack under a variety of proposed management measures. Text in bold denote changes from status quo; red text denotes potential quota closure date. Alt 1 ACL = 1.368 mp ww, Alt 2 ACL = 1.299 mp ww, and Alt 3 ACL = 1.130 mp ww.

Closed Season	Size Limit	Bag limit	Vessel limit	Days Open (Alt 1)	Days Open (Alt 2)	Days Open (Alt 3)	Projected Landings w/o Quota Closure (mp ww)
Jun -Jul	30"	1fish/1angler	N/A	305	305	305	1.071
Jun 1-Jul 15	30"	1fish/1angler	N/A	321	321	283 *(Nov. 24)*	1.201
None	**34"**	1fish/1angler	N/A	366	366	366	1.044
None	30"	N/A	**3fish/vessel**	366	366	299 *(Oct. 26)*	1.226
Mar-May	30"	1fish/1angler	N/A	274	274	267 *(Dec. 25)*	1.142
Jun	30"	**1fish/2anglers**	N/A	336	336	336	0.864
Nov-May	30"	1fish/1angler	N/A	153	153	153	0.953
None	30"	N/A	**2fish/vessel**	366	366	366	0.990
May	30"	**1fish/2anglers**	N/A	335	335	335	0.873
Nov	30"	**1fish/3anglers**	N/A	336	336	336	0.716
May 16-Jul	30"	1fish/1angler	N/A	289	289	289	0.886
Jun 1-Jul 15	30"	**1fish/3anglers**	N/A	321	321	321	0.517
None	30"	N/A	**1fish/vessel**	366	366	366	0.664
Nov-Jun 15	30"	1fish/1angler	N/A	138	138	138	0.774
Jun-Jul	30"	**1fish/2anglers**	N/A	305	305	305	0.694
None	**36"**	1fish/1angler	N/A	366	366	366	0.754

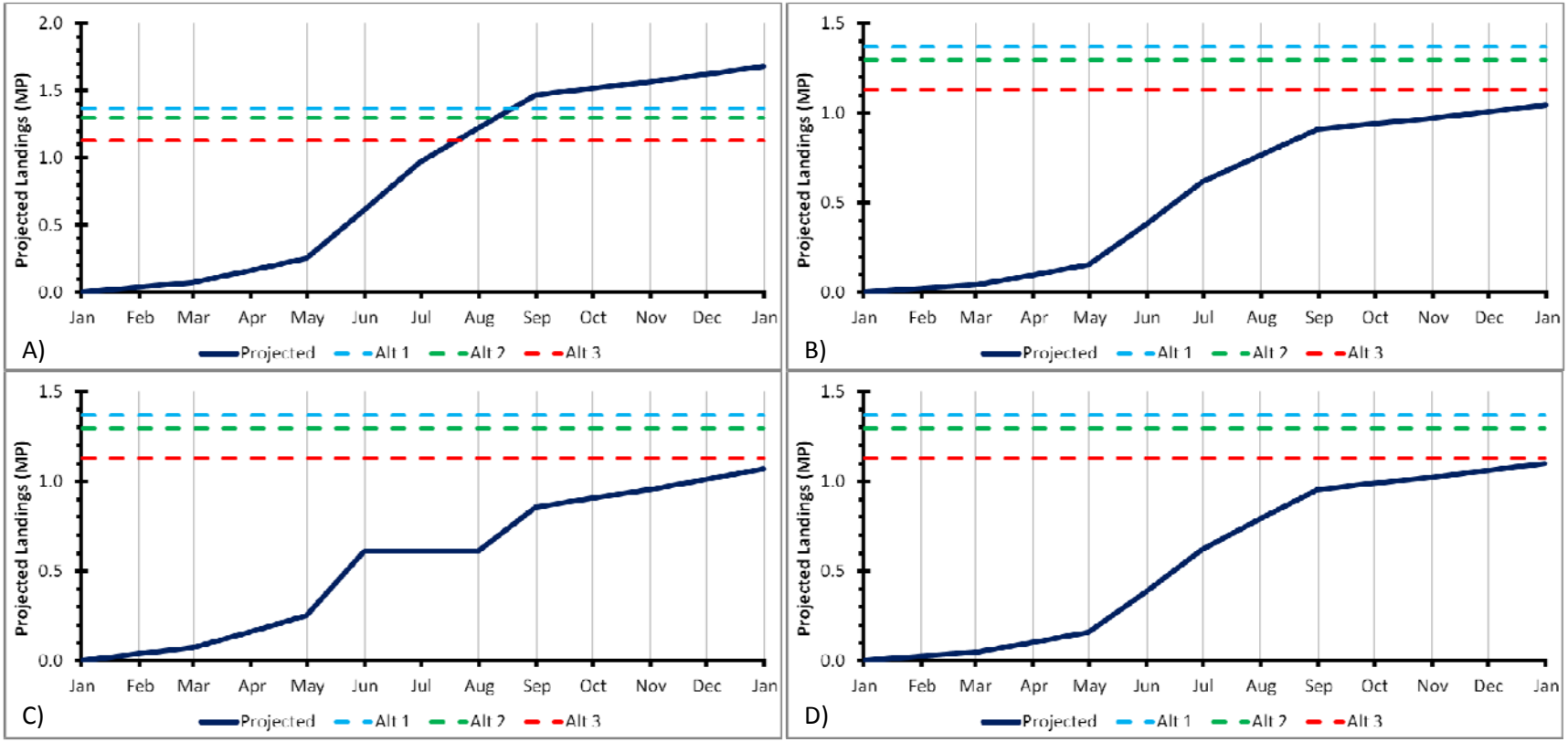


Figure 5. Projected recreational harvest in million pounds whole weight (MP) under A) no seasonal closure or additional management measures, B) a 34 inch size limit, C) a June-July seasonal closure, and D) a 1 fish per 2 angler proportional bag limit for annual catch limit (ACL) alternatives 1 (blue; 1.368 MP), 2 (green; 1.299 MP), and 3 (red; 1.130 MP) in Amendment 35.

Commercial

Table 9 presents projected commercial landings and quota closure dates under a variety of management alternatives. The CDT predicted that without additional management measures, including closing the commercial sector when the quota is met, the commercial greater amberjack harvest in 2012 would be 0.692 mp (Figure 6A). Under this scenario, a quota closure would likely be necessary on August 19, limiting the season to just 139 days. Reducing the trip limit to 1,000 lb ww is projected to nearly constrain harvest below the ACL (Figure 6B); a quota closure might be required on December 25. Harvest would likely be constrained below the ACL by a Jan-Jun 15 closure coupled with a 1,500 lb trip limit (Figure 6C) or a 750 lb trip limit (Figure 6D).

Table 9. Projected commercial harvest in million pounds whole weight (mp ww) of Gulf greater amberjack under a variety of proposed management measures. Text in bold denote changes from status quo; red text denotes potential quota closure date.

Closed Season	Trip Limit	Days Open (Alt 1)	Days Open (Alt 2)	Days Open (Alt 3)	Projected Landings w/o Quota Closure (mp ww)
Mar-May	None	170 *(Sept. 19)*	162 *(Sept. 11)*	139 *(Aug. 19)*	0.692
Mar-May	**2000 lb**	249 *(Dec. 7)*	234 *(Nov. 22)*	185 *(Oct. 4)*	0.537
Mar-May	**1500 lb**	274	269 *(Dec. 27)*	215 *(Nov. 3)*	0.486
Mar-May	**1500 lb (Jan-Feb, June-Aug); 1000 lb (Sept-Dec)**	274	274	228 *(Nov. 16)*	0.462
Mar-May	**1500 lb (Jan-Feb, June-Sept); 1000 lb (Oct-Dec)**	274	274	220 *(Nov. 8)*	0.472
Mar-May	**1000 lb**	274	274	267 *(Dec. 25)*	0.417
Mar-May	**750 lb**	274	274	274	0.381
Mar-May	**1000 lb (Jan-Feb, June-Oct); 500 lb (Nov-Dec)**	274	274	274	0.400
Mar-May	**1500 lb (Jan-Feb, June-July); 500 lb (Aug-Dec)**	274	274	274	0.394
Mar-June	None	190 *(Nov. 8)*	178 *(Oct. 27)*	142 *(Sept. 21)*	0.594
Jan-June 15	**1500 lb**	199	199	199	0.365
Mar-July	None	213	206 *(Dec. 25)*	163 *(Nov. 12)*	0.492

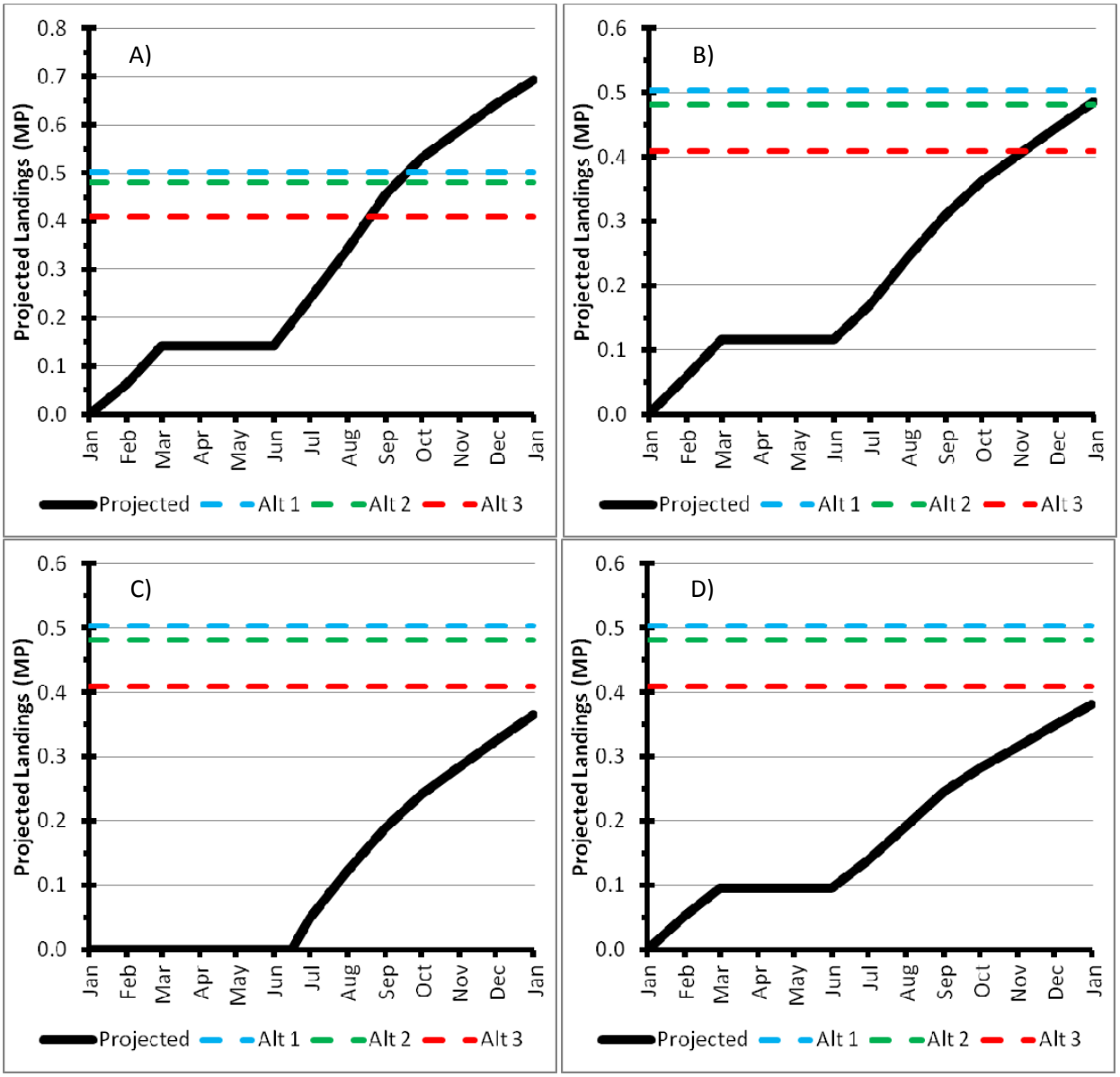


Figure 6. Projected commercial harvest in million pounds whole weight (MP) under A) Mar-May seasonal closure with no additional management measures, B) Mar-May seasonal closure with a 1,000 lb trip limit, C) a Jan-June 15 seasonal closure and a 1,500 lb trip limit, and D) Mar-May seasonal closure with a 750 lb trip limit for annual catch limit (ACL) alternatives 1 (blue; 0.503 MP), 2 (green; 0.481 MP), and 3 (red; 0.409 MP) in Amendment 35.

Discussion

As with most projection models, the reliability of the RDT and CDT results are dependent upon the accuracy of their underlying data and input assumptions. We have attempted to create a realistic baseline as a foundation for comparisons, under the assumption that 2009 is the most representative year for future trends. Uncertainty exists in this baseline, as economic conditions, weather events, changes in catch-per-unit effort (CPUE), fisher response to management regulations, and a variety of other factors may cause departures from this assumption. The bounds of this uncertainty are not captured by the model as currently configured; as such, it should be used with caution as a 'best guess' for future dynamics. In addition to the aforementioned sources of uncertainty, the modeled reductions associated with management measures assume that past performance in the fishery is a good predictor of future dynamics. We have attempted to constrain the range of data considered to recent years to reduce the unreliability of this assumption; however, due to the long-standing commercial spawning closure and quota closures in previous years, we have been forced to fill gaps in recent data when establishing a baseline. Greater uncertainty exists in our predictions during these extrapolated time periods relative to months where greater amberjack was open in 2009.

Neither model accounts for effort shifting that may take place during a seasonal closure. Effort shifting may lead to increased removal rates before and after a closure that partially offset the reductions expected from the closure. The models also do not consider non-compliance with various proposed regulations, which would similarly offset the projected reductions. Neither model considers any changes in the average size of greater amberjack during rebuilding. An increased average size would lead to fishermen capturing their quota more rapidly relative to previous years under similar effort levels. All of these factors would result in more pessimistic projections. As such, management reductions presented in this report may be overestimates, and caution should be taken in their interpretation and use. By contrast, continued adverse economic conditions and rising fuel prices may reduce effort, which would counter these other trends.

In general, the models suggest additional management regulations are necessary to rebuild greater amberjack within the allowable time frame and constrain harvest below the ACL. For the recreational sector, the recently approved June-July seasonal closure would accomplish this objective. However, increasing the recreational size limit to 34 inches fork length (FL) would accomplish this objective without a seasonal closure and may be more biologically advantageous. Murie and Parkyn (2008) determined the size of 50% maturity to be about 35 inches fork length and spawning potential ratio (SPR) would be greatly enhanced by increasing the size limit (SERO 2011). Although greater amberjack release mortality rate is poorly quantified, it is estimated to be around 20% (SEDAR-9 Update 2011); thus, a high percentage of fish released due to an increased size limit may survive to spawn and promote recovery of the stock.

For the commercial sector, retaining or extending the current March-May spawning closure and coupling it with a trip limit appears to be necessary to constrain harvest and extend the length of the commercial fishing season. The most straightforward management alternative explored that reduced projected landings below the Alt 3 (Preferred) ACL was a 750 lb trip limit during all open months. This projection is limited by the assumption that fishermen will not make

additional trips to partially offset their losses due to a severely restrictive trip limit. This dynamic would result in the CDT overestimating the reductions associated with the trip limit. Higher trip limits would extend the length of the commercial fishing season, but will not likely be sufficient to prevent quota closures.

References

GMFMC (2008) Reef Fish Amendement 30A. Gulf of Mexico Fisheries Management Council, Tampa, FL. 346 pp.

Murie, D.J. and D.C. Parkyn (2008) Age, growth, and sex maturity of greater amberjack (*Seriola dumerili*) in the Gulf of Mexico. MARFIN Final Report: NA05NMF4331071. 52 pp.

NMFS (2003) Secretarial Amendment 2 to the Reef Fish Fishery Management Plan to set greater amberjack Sustainable Fisheries Act targets and thresholds and to set a rebuilding plan. National Marine Fisheries Service, St. Petersburg, FL. 105 pp.

SEDAR-9 (2006) SEDAR 9 Stock Assessment Report: Gulf of Mexico Greater Amberjack. SEDAR, North Charleston, SC. 178 pp.

SEDAR-9 Update (2011) SEDAR 9 Stock Assessment Update Report: Gulf of Mexico Greater Amberjack. SEDAR, North Charleston, SC. 167 pp.

SERO (2011) Greater ambjerack yield-per-Recruit (YPR) and spawning potential ratio analysis for the Gulf of Mexico. NOAA Fisheries Service, Southeast Regional Office, St. Petersburg, Florida. 10 pp.

Turner, S.C., N.J. Cummings, and C.P. Porch. (2000) Stock assessment of Gulf of Mexico greater amberjack using data through 1998. NOAA-NMFS-SEFSC, Miami, FL. SFD-99/00-00. 27 pp.