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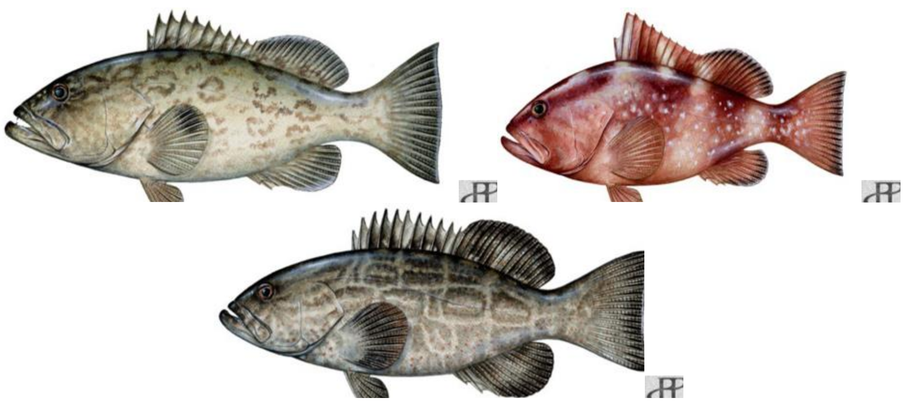

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
Miami Laboratory
75 Virginia Beach Drive
Miami, Florida 33149

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JUAN J. AGAR AND DAVID W. CARTER
National Marine Fisheries Service
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75 Virginia Beach Drive
Miami, Florida 33149

U. S. DEPARTMENT OF COMMERCE
Penny Pritzker, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Kathryn D. Sullivan, Under Secretary for Oceans and Atmosphere

NATIONAL MARINE FISHERIES SERVICE
Eileen Sobeck, Assistant Administrator for Fisheries

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Copies may be obtained by writing:
David W. Carter
NOAA Fisheries
75 Virginia Beach Drive
Miami, Florida 33149
David.W.Carter@noaa.gov

National Technical Information Center
5825 Port Royal Road
Springfield, VA 22161
(800) 553-6847 or
(703) 605- 6000
http://www.ntis.gov/numbers.htm

Are the 2012 allocations of gag, red, and black grouper in the Gulf of Mexico economically efficient?

Abstract

This report investigates the economic efficiency of the current allocation of red, gag and black grouper between the commercial and recreational fishing sectors in the Gulf of Mexico. Our results suggest that the 2012 allocations are not economically efficient because the willingness to pay for an additional unit of quota differs between these sectors. However, the magnitude of the reallocation and the extent to which societal benefits can be increased can only be confidently determined with additional research, improvements in the quality of existing data collections and new data collections.

Note

This document was originally distributed in 2012 in support of the Gag, Red, and Black Grouper Allocation Options Paper for Amendment 28 to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico

Contents

1. Introduction

The fundamental tenet of economic efficiency requires that the net benefits of the existing quota allocation must be equal at the margin. If they are not equal, then society is not maximizing the economic benefits from those scarce resources. In other words, society's economic well-being can be improved by reallocating the quota until these margins are equal. Hence, a fishery management body who wants to maximize the economic benefits of a stock must consider each sector's willingness to pay for an additional unit of quota when making allocation decisions. Perusal of the economic literature on the issue of resource allocation shows that most studies dealing with this issue are theoretical (see, McConnell and Sutinen, 1979; Bishop and Samples, 1980; Edwards, 1990; Edwards, 1991), there are few empirical applications (Campbell and Nichol, 1995; Carter et al., 2008; Gentner et al., 2010).

The objective of this report is to assess the economic efficiency of the present commercial recreational allocation split for the Gulf of Mexico red, gag and black grouper species. The information provided is intended to assist decision-makers who many want to revisit existing allocation formulas. The paper is organized as follows. Section 2 provides a brief overview of the commercial fishery and describes the commercial sector analysis. Section 3 describes the recreational sector analysis. The last section presents the main conclusions of this work.

2. Commercial sector analysis

A. Recent management history

Red, gag and black groupers are commercially valuable species of the shallow-water grouper complex, which are primarily prosecuted by vessels with longlines or vertical lines. In 2011, red grouper landings were around 4.8 million pounds (MP) valued at $ 15 million, gag landings were about 0.32 MP valued at $ 1.5 million, and black grouper landings were about 0.035 MP valued at $ 0.14 million. Figure 1 shows the evolution of red, gag and black grouper landings over time.

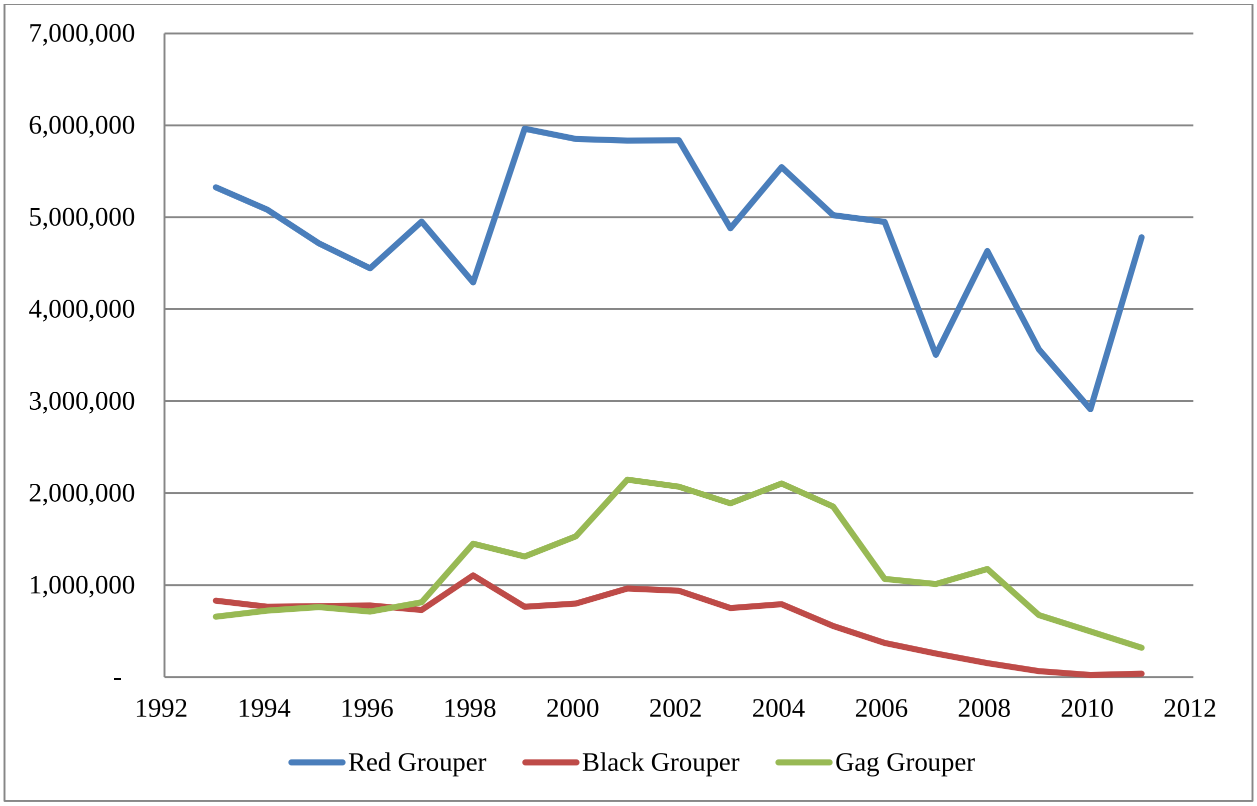

Figure 1. Gulf of Mexico grouper landings

In the past decade, the fishery was mainly managed using a two-tiered quota system and a closed season for the harvest of red, gag, and black grouper which ran from February 15 to March 15. Under the tiered quota system, the shallow-water grouper fishery (which includes red grouper) would close when either an aggregate shallow-water grouper quota of 8.8 MP gutted weight (GW) or a red grouper quota of 5.31 MP GW was reached. As fishing seasons for both shallow and deep-water groupers became shorter, increasingly tighter trip limits were also put in place.

On May 18, 2009, the Council implemented Amendment 30B. This amendment, among other things, established annual catch limits (ACLs) and accountability measures (AMs) for gag, red grouper, and other shallow-water groupers, established a commercial quota for gag of 1.32 MP in 2009, 1.41 MP in 2010, and 1.49 MP in 2011. It also increased the commercial quota for red grouper from 5.31 to 5.75 MP and set shallow-water grouper quota equal to the sum of the gag and red grouper quotas with an additional 0.41 MP allowance for other SWG species (7.48 MP). Amendment 30B also phased out the February 15 to March 15 season closure in favor of a four month closure of "The Edges", which would extend from January 1 through April 30.

On May 18, 2009 NOAA Fisheries Service implemented an Emergency Rule (ER) to reduce the sea turtle bycatch in the Gulf of Mexico. The ER ran through October 28, 2009. The ER prohibited bottom longlining for Gulf reef fish east of the 50-fathom depth contour. On October 16, 2009 another ER to protect sea turtles prohibited bottom longlining shoreward of the line approximating the 35-fathom depth contour with a restriction of 1,000 hooks per vessel with no more than 750 hooks being fished or rigged for fishing at any given time.

On January 1, 2010 the Grouper-Tilefish individual fishing quota (IFQ) was implemented to reduce overcapacity, and eliminate to the extent possible derby like fishing conditions. On May 26, 2010, Amendment 31 banned the use of bottom longline gear shoreward of a line approximating the 35-fathom depth contour from June through August. It also required an endorsement to harvest reef fish using bottom longline gear in the eastern Gulf of Mexico, and restricted the number of hooks that may be possessed onboard each reef fish bottom longline vessel operating in the eastern Gulf of Mexico to 1,000 hooks total, only 750 of which may be fished or rigged for fishing at any given time.[1] Throughout the second part of 2010, there were large areas of the Gulf closed due to the Deep-water Horizon (DWH) event.

Table 1. Description of allocation transactions

Year		Red grouper	Gag grouper	Shallow-water grouper
2010	Commercial Quota (lbs.)	5,750,000	1,410,000	410,000
2010	Landings (lbs.)	2,910,970	496,826	176,773
2010	Landings to Quota Ratio (%)	50.6	35.2	43.1
2010	Allocation traded (lbs.)[1]	3,217,048	743,266	315,042
2010	Allocation to Quota Ratio (%)	55.9	52.7	76.8
2010	Number of transactions	1,065	945	616
2010	Average allocation traded (lbs.)	3021	786	511
2010	Median allocation traded (lbs.)	926	300	186
2010	Minimum allocation traded (lbs.)	1	1	1
2010	Maximum allocation traded (lbs.)	100,000	26,043	10,000
2011	Commercial Quota (lbs.)	5,230,000 Nov 2 (4,320,000)	430,000 May 27 (100,000)	410,000
2011	Landings (lbs.)	4,782,255	317,895	186,951
2011	Landings to Quota Ratio (%)	91.4	73.9	45.6
2011	Allocation traded (lbs.)	4,260,483	332,049	272,816
2011	Allocation to Quota Ratio (%)	81.5	77.2	66.5
2011	Number of transactions	1,550	1,250	568
2011	Average allocation traded (lbs.)	2,749	266	480
2011	Median allocation traded (lbs.)	1,000	108.5	200
2011	Minimum allocation traded (lbs.)	1	1	1
2011	Maximum allocation traded (lbs.)	60,000	4,770	9,939

Source: NOAA IFQ Database

[1] In estimating allocation transactions, multiple transactions of a single allocation are not tracked separately.

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[1] Only federally-permitted vessels with demonstrated average annual landings of 40,000 pounds of reef fish taken by fish traps or longlines during 1999-2007 qualify for an endorsement

On January 1, 2011 the red grouper commercial quota was reduced from 5.75 MP to 4.32 MP and the gag commercial quota from 1.4 MP to100,000 pounds to protect these stocks, particularly gag grouper. On May 27, 2011 following a revision of the gag stock assessment, the gag commercial quota was increased to 430,000 pounds. On November 2, 2011 the red grouper commercial quota was raised from 4.32 MP to 5.23 MP. Following the adoption of the Grouper-Tilefish IFQ program in 2010, the commercial landings to commercial quota ratios increased notably. The landings to quota ratio for red grouper increased from 51% in 2010 to 91% in 2011, for gag grouper increased from 35% in 2010 to 74% in 2011, and for other shallow-water groupers increased from 43% in 2010 to 45% in 2011 (Table 1).

B. The Commercial Model

Most of the applied economic work dealing with allocation has either relied on general or partial equilibrium approaches. General equilibrium approaches examine changes in supply, demand and prices in multiple interacting markets whereas partial equilibrium approaches examine the behavior of supply, demand and prices in the confines of a single market. Thurman and Easley (1992), for example, used a general equilibrium approach to examine the impact of harvest restrictions on red drum. Their analysis used retail level data to model general equilibrium derived demand curves. In contrast, Carter et al. (2008) and Gentner et al. (2010) used a partial equilibrium approach to analyze an *ex-ante* potential redistribution of Gulf of Mexico red grouper and New England summer flounder quota, respectively. Their choice of partial equilibrium approach was partly based on the absence of retail data and also rested on the assumption that the quota was binding (i.e., *ex-ante* partial equilibrium derived demand curves intersected the perfectly inelastic supply curve).

We are not aware of empirical applications that use IFQ lease (allocation) prices for allocation decisions; however, these prices (theoretically) convey the marginal net benefit to commercial sector given the existing quota level.[2] In well-behaved IFQ fisheries, leasing (allocation) prices reflect the annual maximum willingness to pay for an additional unit of quota because a profit-maximizing fisherman will only purchase additional units of leased quota (allocation) as long as the marginal net benefit from that last unit bought is equal to the marginal increase in net revenue (Clark, 1990). The annual maximum willingness to pay for each unit of quota leased is given by the difference between the dockside price and the marginal cost of production.

To examine the economic efficiency of the current allocation, we model the price of the leased quota (allocation) rather than estimate partial equilibrium derived demands as previously done for the Gulf of Mexico red grouper allocation analysis (see, Carter et al, 2008). Partial equilibrium derived demand was not estimated because quotas were not bidding due to, among other things, significant changes in the ACLs, the fleet's adjustment to the new IFQ program and the DWH event. The adjustment of the commercial fleet to a cost-efficient configuration can be protracted because fishermen cannot readily match their landings to their share portfolio and also because they cannot easily adjust their capital stock.

i. Data and specification

Data on allocation traded, allocation prices, landings, and dockside prices were obtained from the Southeast Regional Office (SERO) IFQ Database. Prices were adjusted by the consumer price index (2012=100). The consumer and fuel price indices were obtained from the U.S. Bureau of Labor Statistics. The analysis focused on the 2010-2011 period because the IFQ

[2] There have been only a handful of studies examining the determinants of share and lease prices; however, not in the context of allocation (see, Newell et al., 2005).

program was in force which allowed us to use lease (allocation) prices. Because of the large number of observations of lease prices equal or less than one penny, we were forced create a monthly average using those observations with values greater than one penny and less than $5. The descriptive statistics of those variables used in the analysis are found in

Table **2**.

Table 2. Descriptive statistics of the variables used in regression analysis

Variable	Mean	Median	Std. dev.	Min	Max
Red grouper monthly lease price ($/lb.)	0.73	0.63	0.34	0.40	1.94
Gag grouper monthly lease price ($/lb.)	1.40	1.31	0.50	0.65	2.37
Other sw grouper monthly lease price ($/lb.)	1.24	1.26	0.26	0.78	1.63
Red grouper monthly dockside price ($/lb.)	3.26	3.23	0.13	3.10	3.55
Gag grouper monthly dockside price ($/lb.)	4.45	4.50	0.10	4.29	4.60
Other sw monthly dockside grouper price ($/lb.)	4.23	4.21	0.07	4.10	4.35
Red grouper monthly landings (lbs)	319,544	324,994	115,464	152,594	591,441
Gag grouper monthly landings (lbs)	33,149.21	27,178.50	18,349.15	5,972	76,515
Black grouper monthly landings (lbs)	14,340.5	13,969.5	4,745.4	5,880.0	21,907.0
Red grouper monthly allocation sold (lbs)	92,178.08	70,802	73,669.56	5,601	277,863
Gag grouper monthly allocation sold (lbs)	9,223.54	5,100.50	11,705.11	524.00	52,125.00
Black grouper monthly allocation sold (lbs)	5,170.0	3,038.5	6,129.0	415.0	29,416.0
Red grouper cumulative landings (lbs.)	1,965,693.3	1,804,813.5	1,268,206.9	192,548	4,780,862
Gag grouper cumulative landings (lbs.)	207,126.3	188,455.5	139,287.5	23,789	486,064
Other sw grouper e landings (lbs.)	103,524.33	109,219.50	49,319.10	13,712	185,978
Red grouper cumulative allocation (lbs.)	677,816.6	632,457	274,031.7	247,805	1,388,463
Gag grouper cumulative allocation (lbs.)	70,326.3	75,630	41,575.1	6,027	126,975
Other sw grouper allocation (lbs.)	44,466.25	43,181	16,968.93	11,801	75,931
DWH event dummy	0.50	0.50	0.51	0	1

Source: NOAA IFQ Database, N=24, All prices are real (2012=100).
Allocation prices used in the analysis were limited to those greater than$ 0.01 and less or equal to $5.5.
Dockside prices used in the analysis were limited to those greater than $0.01 and less or equal to $10.

Following Newell et al. (2005), we posit that lease (allocation) prices depend on their own dockside price, input costs (e. g., fuel), and the amount of landings or quota leased (allocation). Our specification is considerably more parsimonious than Newell et al.'s (2005) specification because of the limited number of observations available.

$$p^{allocation} = f(p^{dockside}, \cos ts, landings / allocation)$$

Because the allocation price captures the marginal net benefit of holding one unit of allocation, we expect the relationship with dockside prices to be positive and the relationship with costs to be negative. Also, because fishermen have access to real time data on landings (i.e., allocation used), we surmise that this information is used to make quota leasing decisions.

ii. Results

We model the lease (allocation) prices of red, gag and other shallow-water groupers (black grouper) using a log-log specification. We consider two types of monthly models. The first model type uses cumulative monthly landings for that year (which is an indicator of allocation remaining) and/or cumulative allocation traded as explanatory variables. The second model type uses contemporaneous monthly landings and/or allocation traded as explanatory variables. It must be pointed out that because black grouper is part of the shallow-water grouper IFQ unit, the regressions reflect the shallow-water grouper lease price rather than a black grouper specific lease price.[3]

Tables 3 to 5 show the various specifications of the first model type for each grouper species or unit. These models regress monthly lease (allocation) prices against dockside prices,

[3] Scamp accounts for the majority of the shallow water grouper IFQ unit (in excess of 80% of the landings) whereas black grouper only accounts for a small fraction of this IFQ unit (15-19%).

cumulative monthly landings for that year, cumulative allocation traded for that year, fuel index, DWH event dummy and overall commercial quota for that species. In general, the more parsimonious models had better fits. Dockside prices, cumulative landings and cumulative allocation traded were found to be statistically significant whereas the fuel index and the overall quota were not found to be statistically significant.

Tables 6 to 8 show the various specifications for the second model type. These monthly models regress monthly lease (allocation) prices against dockside prices, contemporaneous monthly landings, contemporaneous monthly allocation traded, fuel index, DWH event dummy and overall commercial quota. In general, parsimonious models had better fits, and dockside prices were statistically significant.

After estimating the various statistical models, we estimated the mean expected allocation price by taking the antilog of the predicted estimate assuming the 2011 average real dockside price and the 2012 quota levels as the actual landings. The monthly type one model (i.e., the one that used cumulative monthly landings for that year) yielded a mean lease price per pound of GW of $0.51 for red grouper, $1.32 for gag grouper, and $1.11 for other shallow-water grouper (black grouper) whereas monthly type two model (i.e., the one that used contemporaneous monthly landings) yielded a mean price per pound of GW of $0.60 for red grouper, $1.50 for gag grouper, and $1.44 for other shallow-water grouper (black grouper). These results are also presented on Table 17 (later on the text) as to facilitate the comparison with the recreational willingness to pay estimates.

Table 3. Red grouper marginal net benefit (quota lease price) regressions for the commercial fishing sector

Model results of Allocation Models for Red Grouper								
Dependent Variable: Log of average (monthly) lease price for red grouper (2012=100)								
Regressors								
Log of average (monthly) dockside price	3.60163* (1.98408)	4.38203** (1.84341)	3.78898* (2.01221)	4.67510** (1.92692)	1.81186 (2.22703)	2.48463 (2.04847)	4.01720* (1.99360)	4.81665** (1.91074)
Log of cumulative landings	-0.16493* (0.08843)		-0.20286* (0.10028)		-0.21471** (0.09108)		-0.17913* (0.08831)	
Log of cumulative allocation traded		-0.30476* (0.17009)		-0.35150* (0.18774)		-0.44077** (0.17871)		-0.30421* (0.17076)
Log of fuel index			-0.51509 (0.62448)	-0.38643 (0.61122)				
DWH event dummy					-0.23198 (0.14690)	-0.26999* (0.15070)		
Log of overall commercial quota							-0.59154 (0.49213)	-0.45482 (0.49751)
Intercept	-2.30277 (3.13072)	-1.50094 (3.56203)	-1.92414 (3.18804)	-1.17762 (3.65006)	0.63451 (3.55109)	2.69026 (4.11736)	6.54082 (7.98303)	5.00017 (7.95977)
R Squared	0.38	0.37	0.4	0.38	0.44	0.46	0.42	0.39
Adjusted R Squared	0.32	0.31	0.31	0.29	0.36	0.37	0.33	0.30
F Value	6.30	6.12	4.37	4.10	5.33	5.58	4.77	4.33
Prob.> F	0.0072	0.0080	0.0161	0.0203	0.0073	0.0060	0.0114	0.0166
Number of observations	24	24	24	24	24	24	24	24

***Statistically significant at 1%, ** statistically significant at 5%, *statistically significant at 10%.
All weight units are in gutted weigh.
All prices are in real terms (2012=100).

Table 4. Gag grouper marginal net benefit (quota lease price) regressions for the commercial fishing sector

Model results of Allocation Models for Gag Grouper								
Dependent Variable: Log of average (monthly) lease price for gag grouper (2012=100)								
Regressors								
Log average (monthly) dockside price	9.84193*** (2.28081)	10.37307*** (2.45053)	9.13513*** (3.12650)	10.05222*** (3.27032)	7.28433** (2.71690)	5.68256* (3.10920)	10.82834*** (2.57009)	12.29044*** (2.91696)
Log of cumulative landings	-0.12610* (0.06208)		-0.12290* (0.06413)		-0.13397** (0.06008)		-0.17490* (0.08469)	
Log of cumulative allocation traded		-0.06672 (0.05605)		-0.06302* (0.06227)		-0.12115 ** (0.05724)		-0.24003 (0.15641)
Log of fuel index			-0.19254 (0.56776)	-0.09892 (0.64651)				
DWH event dummy					-0.18795 (0.11717)	-0.28686** (0.13092)		
Log of overall commercial quota							0.06601 (0.07732)	0.19849 (0.16747)
Intercept	-12.91114*** (3.74110)	-14.48891*** (3.94028)	-11.87145** (4.90011)	-14.03823** (4.99584)	-8.90458* (4.38846)	-6.75323 (5.06063)	- 14.67590*** (4.29565)	-18.10728*** (4.95505)
R Squared	0.62	0.57	0.62	057	0.66	0.65	0.63	0.60
Adjusted R Squared	0.58	0.53	0.56	0.51	0.61	0.60	0.57	0.54
F Value	16.82	13.88	10.78	8.83	12.91	12.53	11.31	9.90
Prob.> F	<.0001	0.0001	0.0002	0.0006	<.0001	<.0001	0.0001	0.0003
Number of observations	24	24	24	24	24	24	24	24

***Statistically significant at 1%, ** statistically significant at 5%, *statistically significant at 10%.
All weight units are in gutted weigh.
All prices are in real terms (2012=100).

Table 5. Other shallow-water grouper marginal net benefit (quota lease price) regressions for the commercial fishing sector

Model results of Allocation Models for Other shallow-water grouper						
Dependent Variable: Log of average (monthly) lease price for other shallow-water grouper (2012=100)						
Regressors						
Log average (monthly) dockside price	3.49010 (2.70447)	4.34242 (2.69960)	3.56416 (2.83379)	3.83374 (2.72939)	2.73274 (2.85942)	3.67556 (2.85252)
Log of cumulative landings	-0.12037* (0.06116)		-0.11899* (0.06362)		-0.12522* (0.06179)	
Log of cumulative allocation traded		-0.19618*** (0.09585)		-0.28142** (0.12375)		-0.20012* (0.09686)
Log of fuel index			0.04321 (0.34827)	-0.46497 (0.42956)		
DWH event dummy					-0.07525 (0.08728)	-0.06839 (0.08674)
Log of overall commercial quota						
Intercept	-3.46582 (3.99267)	-3.97973 (3.91488)	-3.59326 (4.21674)	-2.28666 (4.20100)	-2.28166 (4.24559)	-2.94275 (4.16380)
R Squared	0.22	0.23	0.22	0.27	0.24	0.25
Adjusted R Squared	0.14	0.15	0.10	0.16	0.13	0.14
F Value	2.90	3.07	1.85	2.46	2.16	2.22
Prob.> F	0.0771	0.0676	0.1708	0.0928	0.1247	0.1175
Number of observations	24	24	24	24	24	24

***Statistically significant at 1%, ** statistically significant at 5%, *statistically significant at 10%.
All weight units are in gutted weigh.
All prices are in real terms (2012=100).

Table 6. Red grouper marginal net benefit (quota lease price) regressions for the commercial fishing sector

Model results of Allocation Models for Red grouper								
Dependent Variable: Log of average (monthly) lease price for Red grouper (2012=100)								
Regressors								
Log average (monthly) dockside price	4.95790** (2.21410)	5.31018 *** (1.83936)	4.94066** (2.27166)	4.76451** (2.00317)	3.94581 (2.53507)	5.08992** (2.10413)	4.81661** (2.19149)	5.58144*** (1.94700)
Log of monthly landings	-0.06915 (0.22235)		-0.09583 (0.30601)		-0.12193 (0.23260)		-0.23607 (0.25871)	
Log of monthly allocation traded		0.09402 (0.08004)		0.12515 (0.09138)		0.08413 (0.09216)		0.07894 (0.08671)
Log of fuel index			-0.10655 (0.81639)	0.48237 (0.65758)				
DWH event dummy					-0.13488 (0.16072)	-0.04022 (0.17176)		
Log of commercial quota							-0.75534 (0.61769)	-0.28428 (0.55837)
Intercept	-5.37728 (4.72116)	-7.71077*** (2.34678)	-5.00802 (5.60252)	-7.46931*** (2.39575)	-3.44918 (5.28071)	-7.32053** (2.92298)	8.55540 (12.31224)	-3.47454 (8.65676)
R Squared	0.28	0.32	0.28	0.33	0.30	0.32	0.33	0.32
Adjusted R Squared	0.21	0.25	0.17	0.23	0.19	0.22	0.22	0.22
F Value	3.98	4.86	2.54	3.35	2.85	3.11	3.22	3.21
Prob.> F	0.0342	0.0184	0.0857	0.0395	0.0631	0.0492	0.0448	0.0449
Number of observations	24	24	24	24	24	24	24	24

***Statistically significant at 1%, ** statistically significant at 5%, *statistically significant at 10%.
All weight units are in gutted weigh.
All prices are in real terms (2012=100).

Table 7. Gag grouper marginal net benefit (quota lease price) regressions for the commercial fishing sector

Model results of Allocation Models for Gag grouper								
Dependent Variable: Log of average (monthly) lease price for gag grouper (2012=100)								
Regressors								
Log average (monthly) dockside price	11.41542*** (2.36399)	11.52945*** (2.25859)	10.15467*** (3.42277)	9.47924*** (3.27103)	7.91470** (3.11854)	9.77141*** (3.34533)	10.21538*** (2.96201)	8.54148*** (2.79212)
Log of monthly landings	-0.02168 (0.08347)		0.00097617 (0.09557)		-0.09369 (0.09151)		0.03707 (2.96201)	
Log of monthly allocation traded		0.04992 (0.04558)		0.05927 (0.04708)		0.01551 (0.06642)		0.10224* (0.05349)
Log of fuel index			-0.35592 (0.68719)	-0.52618 (0.60403)				
DWH event dummy					-0.23781 (0.14496)	-0.13507 (0.18773)		
Log of commercial quota							-0.06132 (0.08911)	-0.11989 (0.07078)
Intercept	-16.54546*** (3.79041)	-17.36329*** (3.39397)	-14.85306*** (5.05598)	-14.32011*** (4.88435)	-10.46306* (5.20020)	-14.37750** (5.38610)	-14.54200*** (4.81804)	-11.75892** (4.63945)
R Squared	0.54	0.57	0.55	0.58	0.60	0.58	0.55	0.62
Adjusted R Squared	0.50	0.52	0.48	0.52	0.54	0.51	0.49	0.56
F Value	12.41	13.64	8.08	9.24	9.84	9.06	8.22	10.86
Prob.> F	0.0003	0.0002	0.0010	0.0005	0.0003	0.0005	0.0009	0.0002
Number of observations	24	24	24	24	24	24	24	24

***Statistically significant at 1%, ** statistically significant at 5%, *statistically significant at 10%.
All weight units are in gutted weigh.
All prices are in real terms (2012=100).

Table 8. Other shallow-water grouper marginal net benefit (quota lease price) regressions for the commercial fishing sector

Model results of Allocation Models for Other shallow-water grouper						
Dependent Variable: Log of average (monthly) lease price for other shallow-water grouper (2012=100)						
Regressors						
Log average (monthly) dockside price	1.87897 (2.86386)	3.75263 (2.92618)	2.18125 (2.94353)	4.00466 (3.04712)	1.96165 (2.97722)	3.22167 (3.12652)
Log of monthly landings	0.23537* (0.11955)		0.24235* (0.12176)		0.24459* (0.13515)	
Log of monthly allocation traded		0.01845 (0.04178)		0.01807 (0.04264)		0.01424 (0.04317)
Log of fuel index			0.21759 (0.34101)	0.15324 (0.37017)		
DWH event dummy					0.01574 (0.09765)	-0.05352 (0.09668)
Intercept	-4.75184 (3.89943)	-5.36147 (4.22999)	-5.27939 (4.04115)	-5.73963 (4.41160)	-4.96660 (4.20968)	-4.53577 (4.55292)
R Squared	022	0.08	0.23	0.08	0.22	0.09
Adjusted R Squared	0.14	-0.01	0.12	-0.05	0.10	-0.04
F Value	2.90	0.92	2.02	0.65	1.85	0.70
Prob.> F	0.0770	0.4140	0.1440	0.5944	0.1699	0.5657
Number of observations	24	24	24	24	24	24

***Statistically significant at 1%, ** statistically significant at 5%, *statistically significant at 10%.
All weight units are in gutted weigh.
All prices are in real terms (2012=100).

3. Recreational Sector Analysis

This section describes the methods used to determine the marginal or incremental angler willingness-to-pay (WTP) estimates relevant to the current allocations of red, gag, and black grouper in the Gulf of Mexico. A complete analysis of the marginal WTP at different recreational harvest allocations will account for the following three factors as well as the heterogeneity of anglers (Anderson, 1993; McConnell and Sutinen, 1979):

- the number of anglers,
- the number of trips per angler, and
- the number of fish harvested per angler per trip.

In an earlier allocation analysis of the red grouper fishery we assumed that the first two factors did not change as allocations changed (Carter et al., 2008, hereafter CAW). This is a reasonable assumption when measuring the marginal value of existing allocations or calculating the economic net benefits of relatively small allocation changes. We continue with this operating assumption in calculating the marginal value of harvest at the current allocations of gag, red, and black grouper.[4]

In the CAW analysis of red grouper allocations we also assumed that the marginal value of fish harvested per angler per trip was constant over the number of fish harvested. The previous analysis was further limited because we did not have information on the distribution (heterogeneity) of WTP across anglers, i.e., we only had an estimate of the mean WTP. Both of these assumptions are relaxed in the present work using the results of an analysis of data from a

[4] We also ignore dynamic feedbacks (e.g., congestion or stock effects) because this type of response is unlikely to be significant in the short-term when considering marginal changes in harvest.

stated preference choice survey conducted in 2003 (Carter and Liese 2012, hereafter CL). This analysis estimated equations for the WTP for grouper, red snapper, dolphinfish, and king mackerel harvested per angler per trip in the southeast U.S. The incremental WTP curve for grouper for the average angler in the sample is presented in Figure 2 and the related list of values is shown in Table 9. The table also provides information on the distribution of angler WTP for grouper. CL assumed that the WTP for grouper, red snapper, dolphinfish, and king mackerel per angler per trip were randomly distributed according to a multivariate normal distribution. The incremental values reported for the "average" type angler in Table 9 were evaluated at the mean WTP whereas the "averse" and "avid" type anglers were evaluated at the 5th and 95th percentiles, respectively. Interestingly, there are some (22%) of anglers who would have to be paid to keep any grouper. At the extreme, these "averse" anglers would have to be paid nearly $92 to keep a second grouper. This is still considerably less than the "avid" anglers at the other extreme would pay for the second grouper. Keep in mind, however, that the CL sample consisted of anglers who were intercepted fishing in the Gulf of Mexico *and* the South Atlantic and who had targeted grouper, red snapper, dolphinfish, or king mackerel in the previous year.

The WTP estimates from CL that we use are for grouper in general because we do not have viable estimates for specific grouper species. This was also the case in the CAW red grouper study. In fact, the original estimate from that study was for bottom fish species harvested on charter fishing trips. Adjustments were made to "adapt" the bottom fish estimate for red grouper. This adaptation and the looser grouper regulations during the CAW study period could explain the relatively higher estimates reported in Table 9. The CAW study estimated the constant marginal value of a pound of red grouper at $1.51 (+/-$1.13) in 2012 dollars. [5]

[5] The underlying estimate was further described and refined in Carter and Liese (2010).

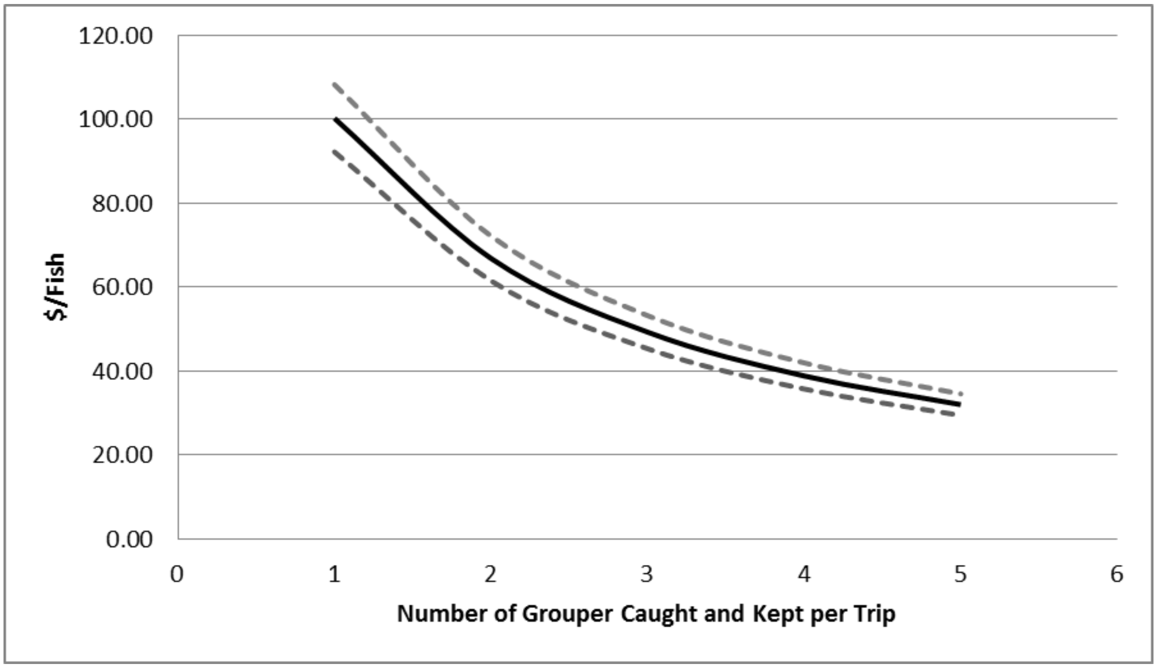

Figure 2. Average Incremental Value of Grouper Caught and Kept per Trip (2012 dollars)
Source: Carter and Liese (2012)

The analysis used data on charter trip prices from 2002-2003 and average harvest rates from 1997 to 2001 when the bag limit for grouper was five fish and there was no separate bag limit for red, gag, or black grouper. This suggests that the most comparable estimate from Table 9 is the value for the sixth fish at $4.38 (+/-0.35) per pound. Furthermore, the less stringent regulations indicate a higher harvest rate and a lower marginal value on average per angler per trip.

The results in Table 9 could also be relatively higher because these are based on stated preferences, whereas the results from the CAW were based on revealed preferences. Research has shown that the value of a recreationally caught fish estimated using stated preferences as in CL can be systematically higher than the value of fish estimated using revealed preferences as in CAW (Johnston et al. 2006). In addition, there is some discussion in CL comparing a few other grouper WTP estimates that appear in the literature. They suggest that the relatively higher estimates in the literature could be due to the limited number of substitute species modeled in these studies.

Table 9. Average Incremental Value of Grouper Caught and Kept per Angler per Trip by Anger Type (2012 dollars)

	WTP for next fish			WTP for next fish/pound (GW)		
Starting # of fish	Averse	Average	Avid	Averse	Average	Avid
1	-\$92.41	\$81.48	\$253.42	-\$15.58	\$13.73	\$42.72
2	-\$61.60	\$54.31	\$168.93	-\$10.38	\$9.16	\$28.48
3	-\$45.40	\$40.03	\$124.52	-\$7.65	\$6.75	\$20.99
4	-\$35.78	\$31.55	\$98.13	-\$6.03	\$5.32	\$16.54
5	-\$29.47	\$25.99	\$80.83	-\$4.97	\$4.38	\$13.63

Source: Carter and Liese (2012, Table 4) adjusted from 2003 to 2012 dollars using the January CPI from series CUSR0000SA0. The three types of anglers are defined according the estimated distribution of WTP for grouper. "Average" anglers are defined at the mean WTP, "averse" anglers are defined at the 5th percentile, and "Avid" anglers are defined 95th percentile. The WTP for next fish per pound is based on a seven pound fish converted to GW with the factor 1/1.18. The confidence interval for all of the WTP estimates in the table is +/- 8%.

Next we offer a brief history of grouper regulations and targeting, followed by two types of estimates of the marginal value of grouper based on the 2012 recreational allocation in the Gulf of Mexico. The first type is measured at the trip-level, is based on bag limits, and is estimated separately for gag, red, and black grouper. The trip-level approach uses the WTP equation estimated in CL directly for the three key grouper species. The second type of marginal value estimate focuses on the total harvest of *all* the grouper species included in the aggregate bag. This approach attempts to construct the aggregate demand schedule for grouper from an estimate of the trip-level grouper demand function. The latter is derived from the WTP equation estimated in CL.

A. Grouper Regulations and Targeted Trips

The groupers included in the aggregate are gag, red, black, yellowfin, scamp, yellowmouth, yellowedge, snowy, speckled hind, and warsaw. Table 10 shows the allocation and harvest of grouper in the Gulf of Mexico and Table 11 shows the historical recreational season length for groupers. The number of days allowed for groupers has decreased since 2008, especially for gag. The bag limit for the grouper aggregate was five fish during 2008 and was decreased to four fish starting on May 18, 2009. The tightening of the grouper regulations is reflected in the decreasing number of anglers targeting the grouper species from 2008 to 2011 shown in Table 12. This decrease is evident for gag which has consistently been the most popular of the grouper species for recreational anglers in the Gulf of Mexico. The current bag limit for gag grouper of two fish has been in place since the middle of 2009. Before the change in 2009, the daily keep of gag grouper during the open season was only constrained by the five fish aggregate grouper bag limit. There is a slight decrease in gag targeting in 2009 and 2010 corresponding with the decreased bag limit and season. The decrease in gag targeting is dramatic in 2011 when the season was severely limited.

Red grouper is the second most popular of the grouper species in the Gulf of Mexico in terms of targeting. The bag limit for red grouper was one fish during 2008 and was increased to two fish starting on May 18, 2009. On November 2, 2011 the bag limit for red grouper was increased to four fish. These increases in the bag limit coincide with increases in the number (and proportion) of trips targeting red grouper, except in 2010 when a considerable amount of the Gulf of Mexico was closed to offshore fishing due to the DWH event.

Relatively few anglers target black grouper in the Gulf of Mexico, especially since 2008. There is no bag limit for black grouper, but it is among the species included in the aggregate grouper bag.

Table 10. Grouper Recreational Allocations and Harvest in the Gulf of Mexico (MP GW)

	Gag			Red			Black		
Year	Allocation	Harvest	%	Allocation	Harvest	%	Allocation	Harvest	%
2008		3.670		1.570	1.942	124%		0.174	
2009	2.060	1.915	93%	1.820	1.184	65%		0.152	
2010	2.140	1.840	86%	1.820	0.734	40%		0.039	
2011	0.781	0.785	101%	1.650	0.708	43%		0.045	
2012	1.031			1.700			0.750		

The allocation of gag is based on the recreational annual catch target (ACT) and the allocation of red is based on the recreational ACL. There is no recreational ACL for black grouper. Blank years indicate that there was no explicit allocation. The harvest percentages are based on information from the SEFSC and include data from the Marine Recreational Statistics Survey (MRFSS), the Headboat Survey, and the Texas Parks and Wildlife Department (TPWD).

Table 11. Days Open in the Recreational Fishing Season for Grouper Species in the Gulf of Mexico by Year

Species	2008	2009	2010	2011
Gag, Red, Black Grouper	337	338	307	307
Gag Grouper	337	307	307	64
Red Grouper	337	338	307	307
Black Grouper	337	338	307	307

Table 12. Distribution of Recreational Fishing Trips in the Gulf of Mexico by Target				
Target	2008	2009	2010	2011
Gag Grouper	436,865	347,363	343,318	178,833
Red Grouper	76,462	89,568	53,366	103,703
Black Grouper	8,985	0	0	2,451
Other Grouper	444,176	245,439	181,171	67,197
Other Target	12,024,050	10,915,796	9,932,796	11,178,256
No Target	11,793,219	10,990,142	10,528,848	10,897,352
Total	24,783,757	22,588,308	21,039,499	22,427,792

Source: MRFSS. The totals may not match the MRFSS estimates because some (charter mode) records are missing the aggregation weights. The estimates for 2011 are preliminary and subject to change.

B. Marginal Value for Specific Grouper Species based on the Bag Limit

When the number of anglers and trips is fixed, the only way to increase aggregate harvest is by increasing harvest per trip.[6] In this case a one fish increment in aggregate harvest occurs when one angler harvests one extra fish on one trip. Assuming that anglers are harvesting the number of fish they prefer from the number that they are able to catch, the primary constraint on harvest per trip is the daily bag limit.[7] In this case the only anglers able to increase their harvest with a bag limit increase are those who currently harvest the bag limit. A one fish increment in aggregate harvest is tantamount to allowing one of these constrained anglers to keep one extra

[6] We also assume that the distribution of trips, spatially and across the year, is also fixed.
[7] The ability to catch and, therefore, harvest fish will also depend on stock effects (Anderson 1983). However, if the number of anglers and trips are fixed, then the change in stock effects should be negligible.

fish on one trip. More precisely, the angler getting the extra fish would be the one with the highest WTP for it out of all of the constrained anglers. The marginal value in this instance is that angler's WTP for the next fish after the bag limit. Presumably, this WTP would be closer to the estimate shown for the "avid" angler shown in Table 9. As more fish are available via further increases in the recreational harvest allocation, the applicable marginal value would depend on how the fish (bag limit increases) are rationed among anglers and trips. However, currently no policy mechanism exists to ration recreational bag limit increases according to WTP.

In reality, the Council cannot change the bag limit for a subset of anglers or trips. Rather, the bag limit would have to be increased for all anglers on trips during the open season.[8] We do not have enough information to determine how a bag limit increase would be distributed among anglers and trips. This is primarily because the bag limits for grouper have been low for so long that the recent data cannot be used to assess latent demand for higher bag limits. However, based on Table 9, we can say something about the *average* WTP for the next fish harvested per trip following a bag limit increase.

i. Gag Grouper

Table 13 shows the distribution of recreational fishing trips in the Gulf of Mexico from 2008 to 2011 by the number of gag grouper harvested per trip. Gag grouper was harvested on less than 1% of all trips during each of these years with slightly more trips harvesting gag grouper in 2008, possibly owing to the higher bag limit. The lower bag limit after 2008 also appears to shift the margin from around five to two fish harvested per trip. Note that the margin

[8] The Council could adjust the aggregate harvest more precisely by changing the season length, effectively changing the number of trips where the higher bag limit is available.

in 2009 is not precise because the bag limit was changed in the middle of the year and it may take time for anglers to adjust.

Table 13. Distribution of Recreational Fishing Trips in the Gulf of Mexico by Number of Gag Grouper Harvested per Angler per Trip

Fish/Angler/Trip	2008	2009	2010	2011
0	24,498,760	22,435,906	20,861,959	22,362,460
1	193,609	116,775	132,302	39,307
2	59,344	35,341	44,092	25,664
3	19,359	285	583	0
4	10,559	0	0	0
5	2,124	0	562	0
>5	0	0	0	360
Total	24,783,756	22,588,307	21,039,498	22,427,792

Source: MRFSS, based on fish kept (A). The totals may not match the MRFSS estimates because some (charter mode) records are missing the aggregation weights. The estimates for 2011 are preliminary and subject to change. The bag limit for gag grouper was five fish during 2008 and was decreased to two fish starting May 18th 2009. The bag limit was temporarily reduced to zero from January 1st to September 15th of 2011.

Assuming that the current distribution of trips is similar to 2009 through 2011, the effective marginal harvest is given by the current bag limit: two gag grouper per trip. Based on Table 9, we can say that the *average* WTP for the third grouper harvested per trip is $54.31 (+/- $4.34) or is $9.16 (+/- $0.73) per pound (GW).

ii. *Red Grouper*

Table 14 shows the distribution of recreational fishing trips in the Gulf of Mexico from 2008 to 2011 by the number of red grouper harvested per trip. Red grouper was harvested on around 0.5% of all trips during each of these years. The effective marginal harvest of red grouper per trip appears to shift in accordance with the bag limit changes. This margin does not move more towards four fish in 2011 because the bag limit was not changed until the beginning of November.

There is limited information in recent years to indicate that the demand for the harvest of red grouper is above the newly established four fish bag limit.[9] Nonetheless, we assume that the effective marginal harvest is given by this bag limit. The *average* WTP for the fifth grouper harvested per trip from Table 9 is $31.55 (+/- $2.52) per fish or $5.32 (+/- $0.43) per pound (GW).

iii. Black Grouper

Table 15 shows the distribution of recreational fishing trips in the Gulf of Mexico from 2008 to 2011 by the number of black grouper harvested per trip. Black grouper was harvested on less than 0.5% of all trips during each of these years, except 2009. The effective marginal harvest of black grouper per trip also remains relatively constant across the years at around two fish. This margin does not appear to be affected by changes in the aggregate grouper bag limit. Given that anglers are legally able to keep four black grouper from 2009 to 2011, yet generally keep less than three fish, we assume that harvest is not constrained by the bag limit. This suggests that the marginal value for a recreationally harvested black grouper in the Gulf of Mexico is negligible. Note, however, that this could change if anglers switch to black grouper when other groupers, most notably gag, are further constrained. The harvest of black grouper could also be constrained by stock abundance such that anglers are harvesting all that is

[9] The two fish bag limit for red grouper was implemented in 2005. Prior to 2005 the recreational harvest of red grouper was nearly double the level observed in recent years.

biologically possible per trip. In this case, the marginal harvest per trip would not be delimited by the bag limit and the marginal value would be positive.

Table 14. Distribution of Recreational Fishing Trips in the Gulf of Mexico by Number of Red Grouper Harvested per Angler per Trip

Fish/Angler/Trip	2008	2009	2010	2011
0	24,670,595	22,491,403	20,945,301	22,353,742
1	110,220	71,380	72,908	52,241
2	2,577	24,181	20,450	20,712
3	364	1,036	0	739
4	0	307	839	358
Total	24,783,756	22,588,307	21,039,498	22,427,792

Source: MRFSS, based on fish kept (A). The totals may not match the MRFSS estimates because some (charter mode) records are missing the aggregation weights. The estimates for 2011 are preliminary and subject to change. The bag limit for red grouper was one fish during 2008 and was increased to two fish starting May 18th of 2009. On November 2nd of 2011 the bag limit for red grouper was increased to four fish.

Table 15. Distribution of Recreational Fishing Trips in the Gulf of Mexico by Number of Black Grouper Harvested per Angler per Trip

Fish/Angler/Trip	2008	2009	2010	2011
0	24,778,930	22,573,368	21,038,857	22,427,158
1	4,723	14,822	641	492
2	104	118	0	0
3	0	0	0	141
Total	24,783,756	22,588,307	21,039,498	22,427,792

Source: MRFSS, based on fish kept (A). The totals may not match the MRFSS estimates because some (charter mode) records are missing the aggregation weights. The estimates for 2011 are preliminary and subject to change. The bag limit for the aggregate grouper group, including black grouper, was five fish during 2008 and was decreased to four fish starting May 18th 2009.

C. Marginal Value for Grouper using the Aggregate Demand for Grouper Harvest

In this section we illustrate how to measure the marginal value for grouper at different harvest allocations using the aggregate demand curve for grouper harvest. This approach cannot be applied for each grouper species separately because we do not know how angler WTP differs, if at all, for these species. Such information is necessary to sort the harvest for these species along the harvest demand curve.

The aggregate demand curve for grouper is constructed as the sum of the individual angler demands for grouper harvest per trip at each cost per fish. We derive the individual angler demand for harvest per trip using the WTP function for grouper estimated in CL. Specifically, the total WTP for grouper per trip by angler *i* is given by

(2) $$WTP_i(h) = b_i \sinh^{-1} h$$

where *b* is a randomly distributed preference parameter and *h* is the grouper harvest per angler per trip. Taking the derivative of this equation gives the marginal WTP or the inverse demand for harvest per trip for angler *i*

(3) $$MWTP_i(h) = \frac{b}{\sqrt{1+h^2}}.$$

Note that the value of the *b* parameter indicates the WTP for the first fish harvested per trip. Inverting this function gives the demand for harvest per trip for each angler

(4) $$h_i(p) = \frac{\sqrt{(b_i - p)(b_i + p)}}{p}$$

where *p* is the price or cost per fish per angler per trip. In this expression, the *b* parameter approximates the choke price for harvest per trip.

We draw *N* parameters from the distribution of *b*, each corresponding to the preferences of one angler. The *N* parameters are used to create trip harvest demand equations for each angler which can then be summed at each trip cost to create the aggregate demand for grouper harvest

(5) $H(p) = \sum_{i}^{N} \bar{t}\, h_i(p)$

where $\bar{t}$ is average number of trips by the N anglers.

Table 16 shows the distribution of recreational fishing trips in the Gulf of Mexico from 2008 to 2011 by the number of grouper harvested per trip. Grouper was harvested on nearly 2% of all trips in 2008 when the bag limit was five fish and the fishing season was 337 days long. The percent of trips harvesting grouper declines in each of the following years coinciding with a shorter season and lower limits for the aggregate grouper bag and the bag for gag grouper. We use the number of anglers corresponding to the trips that harvested at least one grouper in 2008 as N for our parameter draws. Fishing for grouper during 2008 was the least regulated in recent history and should, all else equal, provide the most reasonable representation of unfettered fishing behavior.

Table 16. Distribution of Recreational Fishing Trips in the Gulf of Mexico by Number of Grouper Harvested per Angler per Trip

Fish/Angler/Trip	2008	2009	2010	2011
0	24,369,224	22,340,602	20,778,057	22,293,498
1	290,243	168,937	164,626	71,663
2	87,450	65,316	86,310	48,802
3	21,873	10,305	6,564	12,723
4	7,451	2,840	3,380	576
5	7,515	0	562	170
>5	0	307	0	360
Total	24,783,756	22,588,307	21,039,498	22,427,792

Source: MRFSS, based on fish kept (A). The totals may not match the MRFSS estimates because some (charter mode) records are missing the aggregation weights. The estimates for 2011 are preliminary and subject to change. The bag limit for the aggregate grouper group was five fish during 2008 and was decreased to four fish starting May 18th 2009.

According to Table 16, there were 414,532 trips that harvested at least one grouper in 2008. The anglers who took these trips went on an average of $\bar{t}$ = 50 trips in the 12 months prior to the interview date (see Appendix A). If we assume that at least one grouper was harvested on each of these trips, then there were *N* = 8,291 anglers who harvested at least one grouper during the year. However, the trips in Table 16 only include anglers interviewed as part of the MRFSS. The trips from the MRFSS typically account for roughly 95% of the grouper harvested in the Gulf of Mexico with the remainder reported in the Head Boat Survey and the Texas Park and Wildlife Survey. Consequently, assuming that the number of trips and anglers are proportional to harvest we increase the number of anglers by 5% to *N* = 8,291/.95 = 8,727.

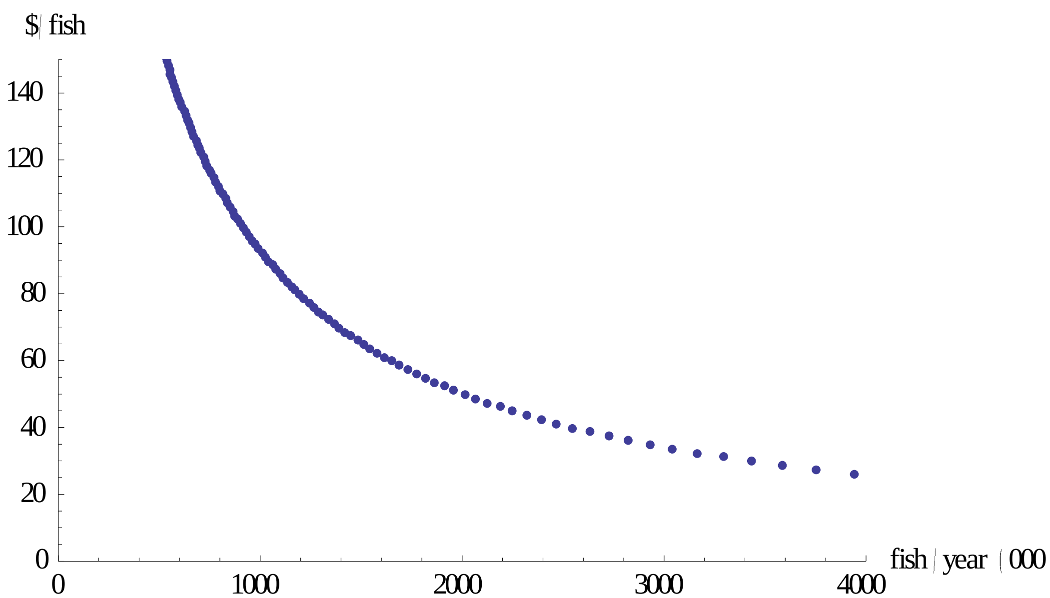

Figure 3. Aggregate Demand for Grouper Caught and Kept (2012 dollars)

The aggregate demand curve for grouper is shown in Figure 3 over the range of $20 to $150 per fish (originally in 2003 dollars).[10] The recreational allocation of red grouper and gag

[10] We evaluated the expression for aggregate harvest demand from p equals 20 to 150. The price (vertical) axis was then scaled from 2003 to 2012 dollars using the January CPI from series

grouper, and black grouper totals 3.48 MP gutted weight (GW) in 2012. There is no explicit recreational allocation for the other shallow-water grouper (scamp, yellowmouth, and yellowfin) in 2012. We assume that the harvest of these other groupers in 2012 will be the same as in 2011: 35,612 lbs. whole weight or 20,048 fish. The gutted weight of red, gag, and black grouper can be converted to whole weight using the factor 1.18 and then converted to fish assuming 7 pounds per fish. After these adjustments, we estimate that the grouper allocation for the recreational sector in 2012 is 586,797 + 20,048 = 606,845 fish. According to the interpolated curve in Figure 3, the marginal value of the next grouper is $135 per fish starting from 606,845 fish. This works out to $23 per pound (GW) using the assumed weight of (7/1.18) pounds per grouper. It is very important to note, however, that this result is sensitive to the number of anglers (N) assumed in the construction of the aggregate harvest demand curve. In fact, the resulting marginal value is almost proportional to the number of anglers. For instance, doubling the number of anglers gives a marginal value of $35 per pound while halving the number of anglers yields a marginal value of $13 per pound.

We can also use this curve to measure the economic benefits of an increase in the allocation to the recreational sector by integrating over the curve between two allocation levels. For example, starting from the allocation of 606,845 fish, the economic benefits of a 1%, 10%, and 25% increase are $0.815 million dollars, $7.903 million, and $18.809 million, respectively. This result is also sensitive, though not strictly proportional, to the number of anglers assumed in the aggregation.

CUSR0000SA0. There are more details regarding the derivation of the aggregate demand curve in Appendix B.

D. Concluding comments on recreational analysis

> The recent experience in modeling marine recreational fishing suggests that considerable progress has been made in empirical descriptions of consumer behavior. But, in our judgment, we are some distance from having an operational basis for implementing the economic framework envisioned in dealing with fishery allocation questions. – Easley, et al. (1989 p. 47)

More than twenty years after Easley et al.'s (1989) thorough economic study we are not much closer to estimating values for recreational harvest that are robust enough to be used in fishery allocations. There are still some fundamental questions that need to be addressed before an adequate economic analysis can be conducted, at least on the recreational side. To quote Easley at al. (p. 47) again: "… the most important question in this process is developing (recreational fishing) quality measures that are consistent with what allocation policies can reasonably address." Specifically, "how do we convert the management policies that are inherent in an allocation plan into their corresponding implications for these measures?" We have suggested two ways that allocation policy translates into changes in the value of recreational fishing at the margin. Both of these take the number of anglers and the number of trips per angler as fixed. The first assumes that the changes in allowable harvest for the recreational sector come about via changes in the bag limit. We presented measures of the average WTP for the next fish across all harvesting anglers. This approach has the advantage of providing measures of marginal value for each species, but it does not account for the sorting of anglers according to the highest WTP for the next fish. Of course, as we noted earlier, there currently is no policy mechanism in place to ration bag limits to the anglers with the highest WTP.

The second way we suggested to measure the marginal value of recreationally harvested fish at the current allocation is based on the aggregate demand curve for grouper harvest. We estimated this demand curve and then found the marginal value at the current allocation. This approach accounts for the sorting of anglers according to WTP for grouper harvest, but does not provide separate estimates for each grouper species.

There is a more fundamental difficulty related to assessing the marginal value of recreational harvest for use in fishery allocations. Unlike commercial fishing there is no market price for recreationally harvested fish. Furthermore, most recreational fishing trips are not purchased in the market. This is important because in the recreational context there is no market price that can be used to bound the marginal value of harvest. Randall (1994) made this observation for the travel cost approach to non-market valuation, but the problem is more general. As noted by Easley et al. (1989 p. 47), “it seems reasonable that the values for improvement measured per trip to a given recreation site cannot exceed the value of a typical trip to that site.” This upper bound is not very useful in decisions about fishery allocations. Carter et al (2008) attempted to overcome this issue by using the market prices of charter trips to derive the relevant marginal values. However, their approach is of limited use in the absence of good data on the market prices for for-hire services.

Even if we had accurate, cardinal measures of the marginal value of recreationally harvested fish there is still much work to be done before we can calculate and predict the economic effects of fishery allocation decisions on the recreational sector. The most recent review of recreational economic data at NMFS (McConnell 2006 p. 10) concluded that “allocation decisions will have to answer the conceptual issues of how regulations affect catch, effort and economic value and how changes in fish stocks influence recreational behavior and value.” NMFS continues to work on answers to address these important issues.

4. Study Results and Conclusions

This study finds that the 2012 Gulf of Mexico grouper allocations for the commercial and recreational sectors are not economically efficient because the willingness to pay for an additional unit of quota differs. Table 17 shows that the magnitude of the red and gag grouper estimates are higher for the recreational sector relative to the commercial sector. This suggests that societal benefits could be increased by modifying the current allocation. However, we cannot confidently determine the economically optimal allocation level with existing methods and data.

On the commercial side, improving the quality of allocation and share prices is critical since they provide valuable information on the willingness to pay for an additional unit of quota as the commercial sector adjusts to the current IFQ regime. The majority of the allocation and share prices encountered in the analysis were very low (i.e., less or equal to one penny). While there may be reasons for some of these low transaction prices (e.g., in kind services) it is vital to ensure that the correct transactions prices are reported, if these data are to be used in economic analyses.

A second consideration for the commercial analysis is the recognition that this sector may have not fully adjusted to the new IFQ program and to the significant changes in ACLs, particularly for gag grouper. The Grouper Tilefish IFQ program was instituted to generate incentives to balance the harvesting capacity of fleets with the productivity of fish stocks. The presence of excessive harvesting capacity was undesirable because it signaled the presence of unwarranted investment levels, which have adverse consequences on the efficiency and profitability of the fleet as well as on the sustainability of the stocks. Under an IFQ program, fishers are not only expected to use capital and labor more judiciously, but also are anticipated to adjust the scale and scope of their operations by trading allocation or shares. Although, allocation and shares are expected to gravitate towards the most efficient producers (thereby shedding excess harvesting capacity as marginal producers exit the fishery) this process is not instantaneous because of the non-malleable nature of capital. Share and allocation prices are likely to increase as the commercial fleet settles into a profitable configuration.

A third concern with the commercial analysis is that it does not include consumer surplus estimates because of the absence of retail data. However, it is likely that these values are relatively low because of the wide availability of substitutes such as grouper imports.

The recreational analysis assumed that the number of anglers and the number of trips across time and space would not change as the allocation to the recreational sector changed. This assumption was used in our previous analysis of red grouper allocations in the Gulf of Mexico (Carter et al. 2008) and is acceptable for measuring the economic value of harvest at the margin or the change in economic value for relatively small allocation changes.

Two alternative approaches were used to measure the marginal value of 2012 allocation of harvest to the recreational sector. The preferred approach allowed for a different marginal value for each species based on the relevant bag limit. However, this approach measured the *average* incremental value of a *grouper* harvested per angler per trip and did not explicitly address the sorting of anglers along the aggregate harvest demand schedule for the recreational sector. The outcome of this sorting will ultimately determine the incremental value relevant for changes in aggregate harvest. We need more information on the economic value of the *different* grouper species to analyze the sorting behavior. There is typically not enough data on the harvest of each grouper species in existing data collections to generate statistically reliable estimates of economic value for each species. Therefore, specialized data collections may be required if there is interest in this level of detail.

We also have general concerns regarding the usefulness of existing recreational valuation techniques for measuring the economic value of changes in harvest in the recreational sector. These approaches are useful for measuring changes in economic value within the sector. However, these methods should be used with caution when comparing economic values with the commercial sector due to the lack of a relevant market price to bound the estimates in the recreational sector. Our previous work attempted to use charter trip prices to address this concern, but there are no current data on charter prices to update this analysis.

Table 17. Summary of study findings

	Gag	Red	OSWG (Black)
2012 Allocation, C : R (MP)	0.43 : 0.78	5.37 : 1.70	0.20 : 0.75
Commercial MWTP/lb. (type 1 model: cumulative monthly Landings for that year)	$1.32 (0.66-2.66)	$0.51 (0.25-1.04)	$1.11 (0.55-2.24)
Commercial MWTP/lb. (type 2 model: contemporaneous monthly landings)	$1.50	$0.60	$1.44
Recreational MWTP/lb.	$9.16 (8.42-9.89)	$5.32 (4.89-5.75)	Negligible
Is current allocation economically efficient?	No	No	?

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6. Appendix A: Calculation of the mean number of trips taken by the anglers who harvested at least one grouper in 2008 (as indicated by agk=1)

The SURVEYMEANS Procedure

Data Summary	
Number of Strata	324
Number of Clusters	3226
Number of Observations	36637
Number of Observations Used	33562
Number of Obs with Nonpositive Weights	3075
Sum of Weights	24783756.1

Variance Estimation	
Method	Taylor Series
Missing Values	NOMCAR

Statistics

Variable	Label	N	Mean	Std Error of Mean	95% CL for Mean	
FFDAYS2	DYS SALWAT.FINFIS.(LAST 2 MON.)	33562	6.500106	0.155480	6.1952445	6.8049677
FFDAYS12	DYS SALWAT.FINFIS.(LAST 12 MON.)	33562	47.158480	1.570946	44.0781983	50.2387614

Domain Analysis: agk

agk	Variable	Label	N	Mean	Std Error of Mean	95% CL for Mean	
0	FFDAYS2	DYS SALWAT.FINFIS.(LAST 2 MON.)	32404	6.513871	0.157580	6.2048907	6.8228520
	FFDAYS12	DYS SALWAT.FINFIS.(LAST 12 MON.)	32404	47.107879	1.585553	43.9989544	50.2168029
1	FFDAYS2	DYS SALWAT.FINFIS.(LAST 2 MON.)	1158	5.690884	0.973773	3.7815279	7.6002404
	FFDAYS12	DYS SALWAT.FINFIS.(LAST 12 MON.)	1158	50.133192	11.614540	27.3596131	72.9067701

7. Appendix B: Mathematic Notebook for the Derivation of Aggregate Grouper Demand

<<DOUBLE-CLICK THE IMAGE BELOW TO OPEN THE PDF FILE>>

Aggregate Demand for Sportfishing Harvest of Grouper in the Gulf of Mexico based on the 2003 Sportfishing Stated Preference Choice Experiment

David W. Carter

NOAA SEFSC

03/23/2012

Individual angler

- **Behavioral equations**

Total willingness-to-pay (WTP) function

```
twtp = b ArcSinh[h];
```

Marginal WTP function. Note that the b parameter is the marginal WTP for an infinitesimal change starting from zero fish.

```
mwtp = D[twtp, h]
```

$$\frac{b}{\sqrt{1+h^2}}$$

WTP function for a discrete change from h0 to h1

```
dwtp = Integrate[mwtp, {h, h0, h1}, Assumptions → {h ≥ 0, h0 ≥ 0, h1 ≥ 0, h1 ≥ h0}]
```

```
b (-ArcSinh[h0] + ArcSinh[h1])
```

Demand (Inverse WTP) function and choke price. Note that the choke price is the b parameter and it can be negative (i.e., where you would have to pay the angler to keep the fish).

```
hq = h /. FullSimplify[Solve[mwtp == p, h]][[2]]
Refine[Solve[hq == 0, p], p ≥ 0]
```

$$\frac{\sqrt{(b-p)\ (b+p)}}{p}$$

```
{{p → -b}, {p → b}}
```