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Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the South Atlantic and Gulf of Mexico in 1981-1985 with For Hire Survey estimates with application to Spanish mackerel and cobia landings

by

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INTRODUCTION

The Marine Recreational Fishery Statistics Survey (MRFSS) was implemented to provide regional based catch and effort estimates of marine finfish in the U.S. recreational fishery (http://www.st.nmfs.gov/st1/recreational/survey/overview.html). Fishing pressure (effort) data are collected by a telephone survey of households in coastal counties and by interviewing anglers at fishing access sites. MRFSS acknowledged that the estimation of effort for the charterboat sector is difficult due to the low incidence of this type of fishing trips by households contacted in the telephone survey. To reduce the effect of small sample sizes on charterboat effort estimation, data from a 5 year period are combined for estimates using the traditional MRFSS method. Pooling data across years provides a larger data set to produce more reliable estimates of effort. However, this approach tends to mask effort trends in the fishery, annual weather patterns, etc.

To improve the effort estimation procedure for the charterboat mode, in 1995 MRFSS started testing a new survey protocol named For Hire Survey (FHS) (http://www.st.nmfs.gov/st1/recreational/pubs/charter_method.pdf). To implement the new FHS, charterboat vessel directories were created by NMFS and participating state agencies and are maintained by the Gulf States Marine Fisheries Commission. Approximately 10% of the charterboat operators in the directory are randomly contacted by phone and asked relevant information regarding their fishing activities (e.g., number of trips and anglers, area of fishing, etc.). MRFSS concluded that the FHS produced significantly ‘more efficient, precise, and credible charter angler effort estimates than the traditional MRFSS method’ (http://www.st.nmfs.noaa.gov/st1/recreational/queries/charter_method_test.html).

Previous Catch and Effort Calibration Analyses

Conversion factors exist to calibrate the traditional MRFSS charterboat estimates with the FHS in the Gulf of Mexico (SEDAR7-AW-03, Diaz and Phares, 2004) and the South Atlantic (SEDAR25-Data Workshop Report, 2011). For the years 1986+, the methods used in both regions are consistent and are based on effort calibrations. The period of 1981-1985 could not be calibrated with the same ratios developed for 1986+ because in the earlier 1981-1985 time period, MRFSS considered charterboat and headboat as a single combined mode in both regions. Thus, in order to properly calibrate the estimates from 1981-1985, headboat data from the Southeast Region Headboat Survey (SRHS) must be included in the analysis. In the Gulf of Mexico, the calibration analysis for 1981-1985 was based on effort estimates from both surveys (SRHS and MRFSS) and assumed that angler trips and angler days are equivalent (SEDAR7-AW-03). In the South Atlantic, a different approach based on landings estimates from both surveys (SRHS and MRFSS) was used (SEDAR 16- Data Workshop Report, 2008). The landings for each species in number of fish were used to generate ratios, resulting in species-specific calibration factors.

METHODS

The following text outlines the approach used to develop calibration factors for 1981-1985 for both the South Atlantic and the Gulf of Mexico. These calibration factors are based on equivalent units of effort and consistent methodologies across both sub regions.

The SRHS uses angler days as the official measure of fishing effort in the headboat fishery. Vessel personnel provide the number of anglers for each trip on the logbook form. These numbers are standardized, by trip type (length in hours), by converting number of anglers to “angler days” (e.g., 40 anglers on a half-day trip would yield 40 * 0.5 = 20 angler days, or a full day 40 * 1.0 = 40 angler days). Angler days are then totaled by month for individual vessels.

In order to use SRHS effort in the calibration work, a measure of angler trips is required in order to properly match the effort units used in the MRFSS, which are angler trips. Staff of the SRHS calculated estimated angler trips for 1986 to 1990 for the South Atlantic and Gulf of Mexico. An angler trip is defined as the number of anglers participating in a single headboat trip (e.g., 40 anglers on a trip = 40 angler trips). The estimated number of total trips were summed by month and then divided by total reported trips by month, which results in a correction factor. The correction factor was multiplied by the reported number of anglers by month, which generates the monthly estimated angler trips. These new angler trip estimates were used as the SRHS effort data in the new calibration work.

To calibrate the MRFSS combined charterboat and headboat mode effort estimates in 1981-1985, conversion factors were estimated using 1986-1990 effort estimates from both modes, in equivalent effort units, an angler trip. SRHS and traditional MRFSS charterboat effort estimates were combined (summed) into one estimate for each year, wave, and state. The same procedure was done with the same headboat estimates and the calibrated (FHS) charterboat estimates (estimates obtained after applying currently approved conversion factors- SEDAR28-DW-14). The same modeling approach as used by Diaz and Phares (2004) was used to identify significant factors and to estimate predicted ratios. The factors included in the model were year, wave, state and the interaction terms. If a factor was found non-significant (Pr > 0.05), it was removed and the regression re-run until all (highest order) model terms were significant (Hocking 1976, Draper and Smith 1981). The predicted ratios are then used as the conversion factors.

General results regarding factor significance for the 1981-1985 analyses were:
1) T-tests carried out on each separate state and wave stratum (Appendices 1-2 for GOM; Appendices 5-6 for SATL) for both regions indicated that states were significant in the regression. Therefore, states were retained as separate for developing the calibration factors.
2) Results of Duncan analyses conducted for wave variables in both regions (Appendix 3 for GOM; Appendix 7 for SATL). Gulf of Mexico, indicated that waves 1, 2, 5, and 6 could be pooled together to form a new wave grouping for these winter months (newwave=win). Waves 3 and 4 could be pooled together to form a new wave grouping for these summer months (newwave=sum). South Atlantic, indicated that wave 2 was found not to be significant from waves 3 and 4, however, waves 3 and 4 were found to be significant from each other. No pooling was able to be done.

Final GLM outputs showing predicted ratios and standard errors are found in Appendix 4 for GOM and Appendix 8 for SATL. The South Atlantic and Gulf of Mexico sub-regions were treated separately. For each region, ratios of the combined MRFSS charterboat and headboat estimates to FHS charterboat and headboat were calculated for each year, wave, and state. A similar approach using a generalized linear model analysis as conducted for the South Atlantic data (SEDAR16-DW-15) was used to identify significant variables and to estimate predicted ratios (GLM procedure, lsmeans, SAS Inst.). The factors included in the model were year, wave, and state. The analysis of the charterboat and headboat angler trips estimates (1986-

1990) showed that only wave and state had significant effects on the ratios (Pr<0.0001). Some states needed to be combined (Georgia and East Florida; Alabama and West Florida) due to the geographic areas defined in the headboat data set. In addition there were no HBS estimates for Mississippi in these years.

RESULTS AND DISCUSSION

A ratio greater than 1, the result of the FHS effort estimate being higher than the MRFSS estimate, indicates that the MRFSS effort was underestimated in that particular stratum. Conversely, a ratio less than 1 indicates that the MRFSS effort was overestimated.

Tables 1 and 2 show the estimated ratios and associated standard errors for the South Atlantic and Gulf of Mexico sub regions, respectively.

	WAVE					
STATE	1	2	3	4	5	6
NC	-	2.151 (0.12)	2.294 (0.12)	1.444 (0.12)	1.763 (0.12)	0.857 (0.12)
SC	-	1.035 (0.04)	1.085 (0.04)	1.437 (0.04)	0.891 (0.04)	0.750 (0.04)
GFE	0.845 (0.02)	0.951 (0.02)	0.985 (0.02)	1.016 (0.02)	0.811 (0.02)	0.696 (0.02)

Table 1) South Atlantic predicted ratios and standard errors (in parenthesis) between FHS and traditional MRFSS effort estimates for the combined charterboat and headboat mode. Apply to 1981 – 1985 charterboat/headboat mode in the South Atlantic.

	WAVE					
STATE	1	2	3	4	5	6
AFW	0.883 (0.03)	0.883 (0.03)	1.104 (0.05)	1.104 (0.05)	0.883 (0.03)	0.883 (0.03)
MS	1.155 (0.11)	1.155 (0.11)	2.245 (0.11)	2.245 (0.11)	1.155 (0.11)	1.155 (0.11)
LA	0.962 (0.09)	0.962 (0.09)	2.260 (0.13)	2.260 (0.13)	0.962 (0.09)	0.962 (0.09)

Table 2) Gulf of Mexico predicted ratios and standard errors (in parenthesis) between FHS and traditional MRFSS effort estimates for the combined charterboat and headboat mode. Apply to 1981 – 1985 charterboat/headboat mode in the Gulf of Mexico.

Cobia and spanish mackerel traditional MRFSS charterboat/headboat landings (A+B1) were calibrated into the corresponding FHS levels by multiplying the original landings by the predicted FHS/MRFSS effort ratios from Tables 1 and 2. These results are shown in tables 3 (cobia) and 4 (spanish mackerel). The underestimation of effort by the traditional MRFSS (most notibly in LA and MS during the summer months in the Gulf of Mexico and in NC in the South Atlantic) for the combined charterboat/ headboat mode translated into larger landings when the estimated ratios in tables 1 and 2 were applied.

COBIA			Cbt/Hbt	
YEAR	new_st	new_sta	Sum of ab1	Sum of oldab1
1981	2	LA	14,810	6,553
	3	MS	869	387
	4	AL	28	25
	5	FLW	558	505
1981 Total			16,264	7,470
1982	2	LA	6,647	2,941
	3	MS	2,111	940
	4	AL	2,874	2,604
	5	FLW	3,666	4,152
1982 Total			15,299	10,637
1983	2	LA	15,051	9,065
	3	MS	1,368	1,185
	4	AL	3,353	3,225
	6	FLE	587	596
1983 Total			20,359	14,070
1984	2	LA	13,558	7,157
	3	MS	0	0
	5	FLW	953	1,011
	6	FLE	1,590	1,648
	8	SC	663	628
1984 Total			16,764	10,445
1985	2	LA	5,654	3,415
	3	MS	0	0
	4	AL	720	652
	5	FLW	5,008	5,465
	6	FLE	1,192	1,264
	8	SC	1,725	1,882
1985 Total			14,298	12,677

Table 3) Cobia landings (number of fish) for the South Atlantic and Gulf of Mexico 1981-1985 by state. ‘oldab1’ is the traditional MRFSS estimate and ‘ab1’ is the newly calibrated FHS estimate using the ratios in tables 1 and 2.

SPANISH MACKEREL			Cbt/Hbt	
YEAR	new_st	new_sta	Sum of ab1	Sum of oldab1
1981	3	MS	861,577	403,815
	4	AL	34,835	31,553
	5	FLW	45,759	47,322
	6	FLE	19,351	27,803
	8	SC	16,668	11,599
1981 Total			978,189	522,092
1982	3	MS	1,541,752	723,264
	4	AL	22,930	25,940
	5	FLW	4,807	5,444
	6	FLE	2,444	3,511
	8	SC	6,730	6,202
	9	NC	240,253	163,364
1982 Total			1,818,915	927,725
1983	2	LA	277	122
	3	MS	538,684	256,773
	4	AL	19,260	17,446
	5	FLW	24,333	22,041
	6	FLE	5,283	5,411
	7	GA	274	270
	8	SC	3,995	3,279
	9	NC	1,313	745
1983 Total			593,420	306,086
1984	2	LA	629	471
	3	MS	341,034	177,855
	4	AL	22,001	21,037
	5	FLW	21,473	23,585
	6	FLE	3,984	4,338
	7	GA	1,449	1,563
	8	SC	40,307	31,176
	9	NC	3,846	2,663
1984 Total			434,723	262,690
1985	2	LA	9,861	4,363
	3	MS	338,831	165,725
	4	AL	19,927	18,207
	5	FLW	19,433	22,008
	6	FLE	4,389	4,456
	7	GA	392	391
	8	SC	12,718	10,527
	9	NC	79,874	42,941
1985 Total			485,426	268,618

Table 4) Spanish mackerel landings (number of fish) for the South Atlantic and Gulf of Mexico 1981-1985 by state. ‘oldab1’ is the traditional MRFSS estimate and ‘ab1’ is the newly calibrated FHS estimate using the ratios in tables 1 and 2.

Appendix 1: Gulf of Mexico region output showing T-tests on state variable (GLM, lsmeans, means (lsd), SAS Inst.)

```
Proc GLM for Ratio = HBS+MRFSSnewcbt/HBS+MRFSSoldcbt 1986-90                57
                          GULF OF MEXICO SUB-REGION      10:52 Friday, February 3, 2012

                              The GLM Procedure

                              Class Level Information

                        Class         Levels    Values

                        new_sta            3    AFW LA MS

                        wave               6    1 2 3 4 5 6


                       Number of Observations Read          85
                       Number of Observations Used          81
             Proc GLM for Ratio = HBS+MRFSSnewcbt/HBS+MRFSSoldcbt 1986-90                58
                          GULF OF MEXICO SUB-REGION      10:52 Friday, February 3, 2012

                              The GLM Procedure

Dependent Variable: ratio

       Source                       DF          Sum of Squares     Mean Square    F Value    Pr > F

       Model                        16      25.56612027      1.59788252      15.52    <.0001

       Error                        64       6.58918736      0.10295605

       Corrected Total              80      32.15530763


                     R-Square     Coeff Var      Root MSE    ratio Mean

                     0.795082      24.58736      0.320868      1.305011


       Source                       DF       Type I SS     Mean Square    F Value    Pr > F

       new_sta                       2       6.75660514      3.37830257      32.81    <.0001
       wave                          5      13.83109669      2.76621934      26.87    <.0001
       new_sta*wave                  9       4.97841844      0.55315760       5.37    <.0001


       Source                       DF     Type III SS     Mean Square    F Value    Pr > F

       new_sta                       2       4.32774393      2.16387196      21.02    <.0001
       wave                          5      13.59857379      2.71971476      26.42    <.0001
       new_sta*wave                  9       4.97841844      0.55315760       5.37    <.0001
             Proc GLM for Ratio = HBS+MRFSSnewcbt/HBS+MRFSSoldcbt 1986-90                59
                          GULF OF MEXICO SUB-REGION      10:52 Friday, February 3, 2012

                              The GLM Procedure
                             Least Squares Means

                                                    Standard
```

new_sta	ratio LSMEAN	Error	Pr > |t|
AFW	0.95635098	0.05858215	<.0001
LA	1.39504921	0.05858215	<.0001
MS	Non-est	.	.

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	Non-est	.	.
2	1.03854660	0.12655191	<.0001
3	1.88377302	0.08284767	<.0001
4	1.85607323	0.08284767	<.0001
5	1.09112949	0.08284767	<.0001
6	0.90254113	0.08284767	<.0001

new_sta	wave	ratio LSMEAN	Standard Error	Pr > |t|
AFW	1	0.84642210	0.14349638	<.0001
AFW	2	0.99260100	0.14349638	<.0001
AFW	3	1.17683202	0.14349638	<.0001
AFW	4	1.03103229	0.14349638	<.0001
AFW	5	0.74424611	0.14349638	<.0001
AFW	6	0.94697238	0.14349638	<.0001
LA	1	0.93149209	0.14349638	<.0001
LA	2	0.93187214	0.14349638	<.0001
LA	3	2.26001393	0.14349638	<.0001
LA	4	2.26082171	0.14349638	<.0001
LA	5	1.15209490	0.14349638	<.0001
LA	6	0.83400052	0.14349638	<.0001
MS	2	1.19116667	0.32086766	0.0004
MS	3	2.21447311	0.14349638	<.0001
MS	4	2.27636569	0.14349638	<.0001
MS	5	1.37704746	0.14349638	<.0001
MS	6	0.92665050	0.14349638	<.0001

The GLM Procedure

t Tests (LSD) for ratio

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	64
Error Mean Square	0.102956
Critical Value of t	1.99773

Comparisons significant at the 0.05 level are indicated by ***.

new_sta Comparison	Difference Between Means	95% Confidence Limits

MS	-	LA	0.27942	0.09704	0.46180	***
MS	-	AFW	0.71812	0.53574	0.90050	***
LA	-	MS	-0.27942	-0.46180	-0.09704	***
LA	-	AFW	0.43870	0.27319	0.60421	***
AFW	-	MS	-0.71812	-0.90050	-0.53574	***
AFW	-	LA	-0.43870	-0.60421	-0.27319	***

Appendix 2: Gulf of Mexico region output showing T-tests on wave variable (GLM, lsmeans, means (lsd), SAS Inst.)

The GLM Procedure

Class Level Information

Class	Levels	Values
new_sta	3	AFW LA MS
wave	6	1 2 3 4 5 6

Number of Observations Read 85
Number of Observations Used 81

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	25.56612027	1.59788252	15.52	<.0001
Error	64	6.58918736	0.10295605		
Corrected Total	80	32.15530763			

R-Square	Coeff Var	Root MSE	ratio Mean
0.795082	24.58736	0.320868	1.305011

Source	DF	Type I SS	Mean Square	F Value	Pr > F
new_sta	2	6.75660514	3.37830257	32.81	<.0001
wave	5	13.83109669	2.76621934	26.87	<.0001
new_sta*wave	9	4.97841844	0.55315760	5.37	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
new_sta	2	4.32774393	2.16387196	21.02	<.0001
wave	5	13.59857379	2.71971476	26.42	<.0001
new_sta*wave	9	4.97841844	0.55315760	5.37	<.0001

The GLM Procedure
Least Squares Means

new_sta	ratio LSMEAN	Standard Error	Pr > |t|
AFW	0.95635098	0.05858215	<.0001

LA	1.39504921	0.05858215	<.0001
MS	Non-est	.	.

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	Non-est	.	.
2	1.03854660	0.12655191	<.0001
3	1.88377302	0.08284767	<.0001
4	1.85607323	0.08284767	<.0001
5	1.09112949	0.08284767	<.0001
6	0.90254113	0.08284767	<.0001

new_sta	wave	ratio LSMEAN	Standard Error	Pr > |t|
AFW	1	0.84642210	0.14349638	<.0001
AFW	2	0.99260100	0.14349638	<.0001
AFW	3	1.17683202	0.14349638	<.0001
AFW	4	1.03103229	0.14349638	<.0001
AFW	5	0.74424611	0.14349638	<.0001
AFW	6	0.94697238	0.14349638	<.0001
LA	1	0.93149209	0.14349638	<.0001
LA	2	0.93187214	0.14349638	<.0001
LA	3	2.26001393	0.14349638	<.0001
LA	4	2.26082171	0.14349638	<.0001
LA	5	1.15209490	0.14349638	<.0001
LA	6	0.83400052	0.14349638	<.0001
MS	2	1.19116667	0.32086766	0.0004
MS	3	2.21447311	0.14349638	<.0001
MS	4	2.27636569	0.14349638	<.0001
MS	5	1.37704746	0.14349638	<.0001
MS	6	0.92665050	0.14349638	<.0001

The GLM Procedure

t Tests (LSD) for ratio

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	64
Error Mean Square	0.102956
Critical Value of t	1.99773

Comparisons significant at the 0.05 level are indicated by ***.

wave Comparison	Difference Between Means	95% Confidence Limits		
3 - 4	0.0277	-0.2064	0.2618	
3 - 5	0.7926	0.5586	1.0267	***

3 - 2	0.9007	0.6463	1.1552	***
3 - 6	0.9812	0.7472	1.2153	***
3 - 1	0.9948	0.7331	1.2565	***
4 - 3	-0.0277	-0.2618	0.2064	
4 - 5	0.7649	0.5309	0.9990	***
4 - 2	0.8730	0.6186	1.1275	***
4 - 6	0.9535	0.7195	1.1876	***
4 - 1	0.9671	0.7054	1.2288	***
5 - 3	-0.7926	-1.0267	-0.5586	***
5 - 4	-0.7649	-0.9990	-0.5309	***
5 - 2	0.1081	-0.1464	0.3625	
5 - 6	0.1886	-0.0455	0.4227	
5 - 1	0.2022	-0.0595	0.4639	
2 - 3	-0.9007	-1.1552	-0.6463	***
2 - 4	-0.8730	-1.1275	-0.6186	***
2 - 5	-0.1081	-0.3625	0.1464	
2 - 6	0.0805	-0.1739	0.3350	
2 - 1	0.0941	-0.1860	0.3742	
6 - 3	-0.9812	-1.2153	-0.7472	***
6 - 4	-0.9535	-1.1876	-0.7195	***
6 - 5	-0.1886	-0.4227	0.0455	
6 - 2	-0.0805	-0.3350	0.1739	
6 - 1	0.0136	-0.2481	0.2753	
1 - 3	-0.9948	-1.2565	-0.7331	***
1 - 4	-0.9671	-1.2288	-0.7054	***
1 - 5	-0.2022	-0.4639	0.0595	
1 - 2	-0.0941	-0.3742	0.1860	
1 - 6	-0.0136	-0.2753	0.2481	

Appendix 3: Gulf of Mexico region output showing Duncan Multiple Range Test on wave variable (GLM, lsmeans, means (duncan), SAS Inst.)

The GLM Procedure

Class Level Information

Class	Levels	Values
new_sta	3	AFW LA MS
wave	6	1 2 3 4 5 6

Number of Observations Read 85
Number of Observations Used 81

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	25.56612027	1.59788252	15.52	<.0001
Error	64	6.58918736	0.10295605		
Corrected Total	80	32.15530763			

R-Square	Coeff Var	Root MSE	ratio Mean
0.795082	24.58736	0.320868	1.305011

Source	DF	Type I SS	Mean Square	F Value	Pr > F
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Source	DF	Type III SS	Mean Square	F Value	Pr > F
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wave	5	13.59857379	2.71971476	26.42	<.0001
new_sta*wave	9	4.97841844	0.55315760	5.37	<.0001

The GLM Procedure
Least Squares Means

new_sta	ratio LSMEAN	Standard Error	Pr > |t|
AFW	0.95635098	0.05858215	<.0001
LA	1.39504921	0.05858215	<.0001
MS	Non-est	.	.

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	Non-est	.	.
2	1.03854660	0.12655191	<.0001
3	1.88377302	0.08284767	<.0001
4	1.85607323	0.08284767	<.0001
5	1.09112949	0.08284767	<.0001
6	0.90254113	0.08284767	<.0001

new_sta	wave	ratio LSMEAN	Standard Error	Pr > |t|
AFW	1	0.84642210	0.14349638	<.0001
AFW	2	0.99260100	0.14349638	<.0001
AFW	3	1.17683202	0.14349638	<.0001
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AFW	5	0.74424611	0.14349638	<.0001
AFW	6	0.94697238	0.14349638	<.0001
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LA	5	1.15209490	0.14349638	<.0001
LA	6	0.83400052	0.14349638	<.0001
MS	2	1.19116667	0.32086766	0.0004
MS	3	2.21447311	0.14349638	<.0001
MS	4	2.27636569	0.14349638	<.0001
MS	5	1.37704746	0.14349638	<.0001
MS	6	0.92665050	0.14349638	<.0001

The GLM Procedure

Duncan's Multiple Range Test for ratio

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	64
Error Mean Square	0.102956
Harmonic Mean of Cell Sizes	13.11258

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6
Critical Range	.2503	.2634	.2720	.2782	.2831

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	wave
A	1.8838	15	3
A			
A	1.8561	15	4
B	1.0911	15	5
B			
B	0.9830	11	2
B			
B	0.9025	15	6
B			
B	0.8890	10	1

Appendix 4: Gulf of Mexico region output showing final ratios and standard errors by state and grouped wave variable-newwave (GLM, lsmeans, SAS Inst.)

---------- new_sta=AFW ----------

The GLM Procedure

Class Level Information

Class	Levels	Values
newwave	2	sum win

Number of Observations Read 30
Number of Observations Used 30

---------- new_sta=AFW ----------

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.32670302	0.32670302	16.03	0.0004
Error	28	0.57077129	0.02038469		
Corrected Total	29	0.89747432			

R-Square	Coeff Var	Root MSE	ratio Mean
0.364025	14.92914	0.142775	0.956351

Source	DF	Type I SS	Mean Square	F Value	Pr > F
newwave	1	0.32670302	0.32670302	16.03	0.0004

Source	DF	Type III SS	Mean Square	F Value	Pr > F
newwave	1	0.32670302	0.32670302	16.03	0.0004

---------- new_sta=AFW ----------

The GLM Procedure
Least Squares Means

newwave	ratio LSMEAN	Standard Error	Pr > |t|
sum	1.10393215	0.04514941	<.0001
win	0.88256040	0.03192545	<.0001

---------- new_sta=LA ----------

The GLM Procedure

Class Level Information

Class	Levels	Values
newwave	2	sum win

Number of Observations Read 30
Number of Observations Used 30

---------- new_sta=LA ----------

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	11.23294227	11.23294227	68.99	<.0001
Error	28	4.55919214	0.16282829		
Corrected Total	29	15.79213442			

R-Square	Coeff Var	Root MSE	ratio Mean
0.711300	28.92514	0.403520	1.395049

Source	DF	Type I SS	Mean Square	F Value	Pr > F
newwave	1	11.23294227	11.23294227	68.99	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
newwave	1	11.23294227	11.23294227	68.99	<.0001

---------- new_sta=LA ----------

The GLM Procedure
Least Squares Means

newwave	ratio LSMEAN	Standard Error	Pr > |t|
sum	2.26041782	0.12760419	<.0001
win	0.96236491	0.09022979	<.0001

---------- new_sta=MS ----------

The GLM Procedure

Class Level Information

Class	Levels	Values
newwave	2	sum win

Number of Observations Read 25
Number of Observations Used 21

---------- new_sta=MS ----------

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	6.22333626	6.22333626	47.57	<.0001
Error	19	2.48575750	0.13082934		
Corrected Total	20	8.70909376			

R-Square	Coeff Var	Root MSE	ratio Mean
0.714579	21.60108	0.361703	1.674469

Source	DF	Type I SS	Mean Square	F Value	Pr > F
newwave	1	6.22333626	6.22333626	47.57	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
newwave	1	6.22333626	6.22333626	47.57	<.0001

---------- new_sta=MS ----------

The GLM Procedure

Least Squares Means

newwave	ratio LSMEAN	Standard Error	Pr > |t|
sum	2.24541940	0.11438065	<.0001
win	1.15542331	0.10905768	<.0001

Appendix 5: South Atlantic region output showing T-tests on state variable (GLM, lsmeans, means (lsd), SAS Inst.)

The GLM Procedure

Class Level Information

Class	Levels	Values
new_sta	3	GFE NC SC
wave	6	1 2 3 4 5 6

Number of Observations Read 90
Number of Observations Used 89

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	18.59665547	1.09392091	43.86	<.0001
Error	71	1.77064499	0.02493866		
Corrected Total	88	20.36730045			

R-Square	Coeff Var	Root MSE	ratio Mean
0.913064	13.50731	0.157920	1.169143

Source	DF	Type I SS	Mean Square	F Value	Pr > F
new_sta	2	8.50950569	4.25475284	170.61	<.0001
wave	5	5.07907013	1.01581403	40.73	<.0001
new_sta*wave	10	5.00807965	0.50080796	20.08	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
new_sta	2	7.97165432	3.98582716	159.83	<.0001
wave	5	5.22998104	1.04599621	41.94	<.0001
new_sta*wave	10	5.00807965	0.50080796	20.08	<.0001

The GLM Procedure
Least Squares Means

Standard

new_sta	ratio LSMEAN	Error	Pr > |t|
GFE	0.88390667	0.02883208	<.0001
NC	1.58494751	0.02942662	<.0001
SC	1.03293750	0.02883208	<.0001

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	0.94829960	0.04243967	<.0001
2	1.37906155	0.04077472	<.0001
3	1.45450877	0.04077472	<.0001
4	1.29875760	0.04077472	<.0001
5	1.15525850	0.04077472	<.0001
6	0.76769731	0.04077472	<.0001

new_sta	wave	ratio LSMEAN	Standard Error	Pr > |t|
GFE	1	0.84489881	0.07062388	<.0001
GFE	2	0.95056019	0.07062388	<.0001
GFE	3	0.98481154	0.07062388	<.0001
GFE	4	1.01574310	0.07062388	<.0001
GFE	5	0.81149804	0.07062388	<.0001
GFE	6	0.69592832	0.07062388	<.0001
NC	1	1.00000000	0.07895990	<.0001
NC	2	2.15118991	0.07062388	<.0001
NC	3	2.29407820	0.07062388	<.0001
NC	4	1.44382760	0.07062388	<.0001
NC	5	1.76341642	0.07062388	<.0001
NC	6	0.85717289	0.07062388	<.0001
SC	1	1.00000000	0.07062388	<.0001
SC	2	1.03543456	0.07062388	<.0001
SC	3	1.08463658	0.07062388	<.0001
SC	4	1.43670208	0.07062388	<.0001
SC	5	0.89086104	0.07062388	<.0001
SC	6	0.74999073	0.07062388	<.0001

The GLM Procedure

t Tests (LSD) for ratio

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	71
Error Mean Square	0.024939
Critical Value of t	1.99394

Comparisons significant at the 0.05 level are indicated by ***.

new_sta	Difference Between	95% Confidence

Comparison	Means	Limits		
NC - SC	0.57218	0.49018	0.65418	***
NC - GFE	0.72121	0.63921	0.80321	***
SC - NC	-0.57218	-0.65418	-0.49018	***
SC - GFE	0.14903	0.06773	0.23033	***
GFE - NC	-0.72121	-0.80321	-0.63921	***
GFE - SC	-0.14903	-0.23033	-0.06773	***

Appendix 6: South Atlantic region output showing T-tests on wave variable (GLM, lsmeans, means (lsd), SAS Inst.)

The GLM Procedure

Class Level Information

Class	Levels	Values
new_sta	3	GFE NC SC
wave	6	1 2 3 4 5 6

Number of Observations Read 90
Number of Observations Used 89

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	18.59665547	1.09392091	43.86	<.0001
Error	71	1.77064499	0.02493866		
Corrected Total	88	20.36730045			

R-Square	Coeff Var	Root MSE	ratio Mean
0.913064	13.50731	0.157920	1.169143

Source	DF	Type I SS	Mean Square	F Value	Pr > F
new_sta	2	8.50950569	4.25475284	170.61	<.0001
wave	5	5.07907013	1.01581403	40.73	<.0001
new_sta*wave	10	5.00807965	0.50080796	20.08	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
new_sta	2	7.97165432	3.98582716	159.83	<.0001
wave	5	5.22998104	1.04599621	41.94	<.0001
new_sta*wave	10	5.00807965	0.50080796	20.08	<.0001

The GLM Procedure
Least Squares Means

new_sta	ratio LSMEAN	Standard Error	Pr > |t|

GFE	0.88390667	0.02883208	<.0001
NC	1.58494751	0.02942662	<.0001
SC	1.03293750	0.02883208	<.0001

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	0.94829960	0.04243967	<.0001
2	1.37906155	0.04077472	<.0001
3	1.45450877	0.04077472	<.0001
4	1.29875760	0.04077472	<.0001
5	1.15525850	0.04077472	<.0001
6	0.76769731	0.04077472	<.0001

new_sta	wave	ratio LSMEAN	Standard Error	Pr > |t|
GFE	1	0.84489881	0.07062388	<.0001
GFE	2	0.95056019	0.07062388	<.0001
GFE	3	0.98481154	0.07062388	<.0001
GFE	4	1.01574310	0.07062388	<.0001
GFE	5	0.81149804	0.07062388	<.0001
GFE	6	0.69592832	0.07062388	<.0001
NC	1	1.00000000	0.07895990	<.0001
NC	2	2.15118991	0.07062388	<.0001
NC	3	2.29407820	0.07062388	<.0001
NC	4	1.44382760	0.07062388	<.0001
NC	5	1.76341642	0.07062388	<.0001
NC	6	0.85717289	0.07062388	<.0001
SC	1	1.00000000	0.07062388	<.0001
SC	2	1.03543456	0.07062388	<.0001
SC	3	1.08463658	0.07062388	<.0001
SC	4	1.43670208	0.07062388	<.0001
SC	5	0.89086104	0.07062388	<.0001
SC	6	0.74999073	0.07062388	<.0001

The GLM Procedure

t Tests (LSD) for ratio

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	71
Error Mean Square	0.024939
Critical Value of t	1.99394

Comparisons significant at the 0.05 level are indicated by ***.

wave Comparison	Difference Between Means	95% Confidence Limits

3 - 2	0.07545	-0.03953	0.19043	
3 - 4	0.15575	0.04077	0.27073	***
3 - 5	0.29925	0.18427	0.41423	***
3 - 1	0.50990	0.39289	0.62692	***
3 - 6	0.68681	0.57183	0.80179	***
2 - 3	-0.07545	-0.19043	0.03953	
2 - 4	0.08030	-0.03468	0.19528	
2 - 5	0.22380	0.10882	0.33878	***
2 - 1	0.43445	0.31744	0.55147	***
2 - 6	0.61136	0.49639	0.72634	***
4 - 3	-0.15575	-0.27073	-0.04077	***
4 - 2	-0.08030	-0.19528	0.03468	
4 - 5	0.14350	0.02852	0.25848	***
4 - 1	0.35415	0.23714	0.47117	***
4 - 6	0.53106	0.41608	0.64604	***
5 - 3	-0.29925	-0.41423	-0.18427	***
5 - 2	-0.22380	-0.33878	-0.10882	***
5 - 4	-0.14350	-0.25848	-0.02852	***
5 - 1	0.21065	0.09364	0.32767	***
5 - 6	0.38756	0.27258	0.50254	***
1 - 3	-0.50990	-0.62692	-0.39289	***
1 - 2	-0.43445	-0.55147	-0.31744	***
1 - 4	-0.35415	-0.47117	-0.23714	***
1 - 5	-0.21065	-0.32767	-0.09364	***
1 - 6	0.17691	0.05990	0.29392	***
6 - 3	-0.68681	-0.80179	-0.57183	***
6 - 2	-0.61136	-0.72634	-0.49639	***
6 - 4	-0.53106	-0.64604	-0.41608	***
6 - 5	-0.38756	-0.50254	-0.27258	***
6 - 1	-0.17691	-0.29392	-0.05990	***

Appendix 7: South Atlantic region output showing Duncan Multiple Range Test on wave variable (GLM, lsmeans, means (duncan), SAS Inst.)

The GLM Procedure

Class Level Information

Class	Levels	Values
new_sta	3	GFE NC SC
wave	6	1 2 3 4 5 6

Number of Observations Read 90
Number of Observations Used 89

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	18.59665547	1.09392091	43.86	<.0001
Error	71	1.77064499	0.02493866		
Corrected Total	88	20.36730045			

R-Square	Coeff Var	Root MSE	ratio Mean
0.913064	13.50731	0.157920	1.169143

Source	DF	Type I SS	Mean Square	F Value	Pr > F
new_sta	2	8.50950569	4.25475284	170.61	<.0001
wave	5	5.07907013	1.01581403	40.73	<.0001
new_sta*wave	10	5.00807965	0.50080796	20.08	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
new_sta	2	7.97165432	3.98582716	159.83	<.0001
wave	5	5.22998104	1.04599621	41.94	<.0001
new_sta*wave	10	5.00807965	0.50080796	20.08	<.0001

The GLM Procedure
Least Squares Means

new_sta	ratio LSMEAN	Standard Error	Pr > |t|
GFE	0.88390667	0.02883208	<.0001
NC	1.58494751	0.02942662	<.0001
SC	1.03293750	0.02883208	<.0001

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	0.94829960	0.04243967	<.0001
2	1.37906155	0.04077472	<.0001
3	1.45450877	0.04077472	<.0001
4	1.29875760	0.04077472	<.0001
5	1.15525850	0.04077472	<.0001
6	0.76769731	0.04077472	<.0001

new_sta	wave	ratio LSMEAN	Standard Error	Pr > |t|
GFE	1	0.84489881	0.07062388	<.0001
GFE	2	0.95056019	0.07062388	<.0001
GFE	3	0.98481154	0.07062388	<.0001
GFE	4	1.01574310	0.07062388	<.0001
GFE	5	0.81149804	0.07062388	<.0001
GFE	6	0.69592832	0.07062388	<.0001
NC	1	1.00000000	0.07895990	<.0001
NC	2	2.15118991	0.07062388	<.0001
NC	3	2.29407820	0.07062388	<.0001
NC	4	1.44382760	0.07062388	<.0001
NC	5	1.76341642	0.07062388	<.0001
NC	6	0.85717289	0.07062388	<.0001
SC	1	1.00000000	0.07062388	<.0001
SC	2	1.03543456	0.07062388	<.0001
SC	3	1.08463658	0.07062388	<.0001
SC	4	1.43670208	0.07062388	<.0001
SC	5	0.89086104	0.07062388	<.0001
SC	6	0.74999073	0.07062388	<.0001

The GLM Procedure

Duncan's Multiple Range Test for ratio

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	71
Error Mean Square	0.024939
Harmonic Mean of Cell Sizes	14.82353

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6
Critical Range	.1157	.1217	.1257	.1286	.1308

Means with the same letter are not significantly different.

Duncan Grouping		Mean	N	wave
	A	1.45451	15	3
	A			
B	A	1.37906	15	2
B				
B		1.29876	15	4
	C	1.15526	15	5
	D	0.94461	14	1
	E	0.76770	15	6

Appendix 8: South Atlantic region output showing final ratios and standard errors by state and wave (GLM, lsmeans, SAS Inst.)

---------- new_sta=GFE ----------

The GLM Procedure

Class Level Information

Class	Levels	Values
wave	6	1 2 3 4 5 6

Number of Observations Read 30
Number of Observations Used 30

---------- new_sta=GFE ----------

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.37052905	0.07410581	43.24	<.0001
Error	24	0.04113226	0.00171384		
Corrected Total	29	0.41166131			

R-Square	Coeff Var	Root MSE	ratio Mean
0.900082	4.683594	0.041399	0.883907

Source	DF	Type I SS	Mean Square	F Value	Pr > F
wave	5	0.37052905	0.07410581	43.24	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
wave	5	0.37052905	0.07410581	43.24	<.0001

---------- new_sta=GFE ----------

The GLM Procedure
Least Squares Means

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	0.84489881	0.01851402	<.0001
2	0.95056019	0.01851402	<.0001
3	0.98481154	0.01851402	<.0001
4	1.01574310	0.01851402	<.0001
5	0.81149804	0.01851402	<.0001
6	0.69592832	0.01851402	<.0001

---------- new_sta=NC ----------

The GLM Procedure

Class Level Information

Class	Levels	Values
wave	6	1 2 3 4 5 6

Number of Observations Read 30
Number of Observations Used 29

---------- new_sta=NC ----------

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	8.38144903	1.67628981	24.93	<.0001
Error	23	1.54671197	0.06724835		
Corrected Total	28	9.92816101			

R-Square	Coeff Var	Root MSE	ratio Mean
0.844210	16.15600	0.259323	1.605118

Source	DF	Type I SS	Mean Square	F Value	Pr > F
wave	5	8.38144903	1.67628981	24.93	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
wave	5	8.38144903	1.67628981	24.93	<.0001

---------- new_sta=NC ----------

The GLM Procedure
Least Squares Means

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	1.00000000	0.12966143	<.0001
2	2.15118991	0.11597271	<.0001
3	2.29407820	0.11597271	<.0001
4	1.44382760	0.11597271	<.0001
5	1.76341642	0.11597271	<.0001
6	0.85717289	0.11597271	<.0001

---------- new_sta=SC ----------

The GLM Procedure

Class Level Information

Class	Levels	Values
wave	6	1 2 3 4 5 6

Number of Observations Read 30
Number of Observations Used 30

---------- new_sta=SC ----------

The GLM Procedure

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.33517170	0.26703434	35.06	<.0001
Error	24	0.18280075	0.00761670		
Corrected Total	29	1.51797245			

R-Square	Coeff Var	Root MSE	ratio Mean
0.879576	8.449078	0.087274	1.032937

Source	DF	Type I SS	Mean Square	F Value	Pr > F
wave	5	1.33517170	0.26703434	35.06	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F

---------- new_sta=SC ----------

The GLM Procedure
Least Squares Means

wave	ratio LSMEAN	Standard Error	Pr > |t|
1	1.00000000	0.03902998	<.0001
2	1.03543456	0.03902998	<.0001
3	1.08463658	0.03902998	<.0001
4	1.43670208	0.03902998	<.0001
5	0.89086104	0.03902998	<.0001
6	0.74999073	0.03902998	<.0001