

**SEDAR**

**Southeast Data, Assessment, and Review**

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**SEDAR 42**

**Gulf of Mexico Red Grouper**

**SECTION II: Data Workshop Report**

**February 2015**

**SEDAR**  
4055 Faber Place Drive, Suite 201  
North Charleston, SC 29405

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**Table of Contents**

1 INTRODUCTION ..... 6

    1.1 WORKSHOP TIME AND PLACE ..... 6

    1.2 TERMS OF REFERENCE..... 6

    1.3 LIST OF PARTICIPANTS..... 8

    1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERENCE DOCUMENTS .. 9

2 LIFE HISTORY ..... 11

    2.1 OVERVIEW ..... 11

        2.1.1 Life History Workgroup (LHW) members ..... 11

        2.1.2 LHW Topics addressed..... 12

    2.2 REVIEW OF WORKING PAPERS..... 12

    2.3 STOCK STRUCTURE ..... 13

        2.3.1 Population genetics, larval transport, and connectivity ..... 13

        2.3.2 Habitat Requirements..... 14

        2.3.3 Tagging, movements, and migrations..... 15

    2.4 AGE AND GROWTH DATA..... 17

        2.4.1 Source of samples ..... 17

        2.4.2 Age Reader Precision..... 18

        2.4.3 Year Class progressions..... 18

        2.4.4 Age and Length data ..... 18

        2.4.5 Modeling Growth..... 19

    2.5 MORTALITY ..... 20

        2.5.1 Natural Mortality ..... 20

        2.5.2 Total Mortality ..... 22

        2.5.3 Discard Mortality ..... 22

    2.6 REPRODUCTION..... 25

        2.6.1 Maturity..... 25

        2.6.2 Sexual Transition ..... 27

        2.6.3 Fecundity and spawning frequency ..... 29

    2.7 MERISTIC CONVERSIONS..... 30

    2.8 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES ..... 30

    2.9 RESEARCH RECOMMENDATIONS..... 31

2.9.1 Stock Structure..... 31

2.9.2 Age and Growth..... 32

2.9.3 Mortality ..... 33

2.9.4 Reproduction..... 34

2.9.5 Meristic & Conversion factors..... 35

2.10 LITERATURE CITED ..... 35

2.11 TABLES ..... 41

2.12 FIGURES..... 56

3 COMMERCIAL FISHERY STATISTICS ..... 74

3.1 OVERVIEW ..... 74

3.2 REVIEW OF WORKING PAPERS..... 76

3.3 COMMERCIAL LANDINGS..... 76

3.3.1 Boundaries ..... 78

3.3.2 Gears ..... 78

3.3.3 Unclassified Groupers..... 79

3.3.4 IFQ Landings ..... 79

3.3.5 Historical Landings..... 80

3.4 DISCARDS AND BYCATCH..... 81

3.5 COMMERCIAL EFFORT..... 83

3.6 BIOLOGICAL SAMPLING..... 83

3.6.1 TIP Samples ..... 84

3.6.2 Size frequency data from commercial fisheries observers ..... 85

3.7 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES ..... 86

3.8 RESEARCH RECOMMENDATIONS..... 87

3.9 LITERATURE CITED ..... 88

3.10 TABLES ..... 90

3.11 FIGURES..... 100

3.12 APPENDIX A..... 120

3.13 APPENDIX B..... 125

4 RECREATIONAL FISHERY STATISTICS ..... 129

4.1 OVERVIEW ..... 129

4.1.1 Recreational Workgroup (RWG) Members..... 129

4.1.2 Issues Discussed at the Data Workshop..... 129

4.1.3 Gulf of Mexico Fishery Management Council Jurisdictional Boundaries ..... 130

4.2 REVIEW OF WORKING PAPERS..... 130

4.3 RECREATIONAL LANDINGS ..... 132

4.3.1 Marine Recreational Fisheries Statistics Survey (MRFSS) and Marine Recreational Information Program (MRIP) ..... 132

4.3.2 Southeast Region Headboat Survey..... 138

4.3.3 Estimating Historical Recreational Landings ..... 140

4.4 RECREATIONAL DISCARDS ..... 142

4.4.1 MRFSS/MRIP discards..... 142

4.4.2 Headboat Logbook Discards..... 143

4.4.3 Headboat At-Sea Observer Survey Discards ..... 144

4.5 BIOLOGICAL SAMPLING..... 145

4.5.1 Sampling Intensity ..... 145

4.5.2 Length Distributions ..... 146

4.5.3 Age Distribution..... 147

4.6 RECREATIONAL EFFORT ..... 147

4.6.1 MRFSS/MRIP Effort ..... 147

4.6.2 Headboat Effort..... 147

4.7 LITERATURE CITED ..... 148

4.8 TABLES ..... 152

4.9 FIGURES..... 172

5 MEASURES OF POPULATION ABUNDANCE..... 196

5.1 OVERVIEW ..... 196

5.1.1 Group Membership..... 196

5.2 REVIEW OF WORKING PAPERS..... 197

5.3 FISHERY INDEPENDENT SURVEYS..... 197

5.3.1 SEAMAP Summer Groundfish..... 197

5.3.2 NMFS Bottom Longline ..... 200

5.3.3 SEAMAP Video..... 202

5.3.4 Panama City Video ..... 206

5.3.5 Panama City Trap Survey ..... 210

5.3.6 FWRI Video..... 214

5.3.7 FWRI Trap Survey..... 216

5.3.8 Combined Video ..... 220

5.3.9 Dry Tortugas RVC ..... 221

5.4 FISHERY-DEPENDENT MEASURES..... 223

5.4.1 Headboat Survey..... 223

5.4.2 MRFSS..... 226

5.4.3 Commercial Longline ..... 228

5.4.4 Commercial Vertical Line..... 232

5.4.5 Headboat Observer Discard ..... 236

5.5 CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS..... 239

5.6 RESEARCH RECOMMENDATIONS ..... 239

5.7 LITERATURE CITED ..... 240

5.8 TABLES ..... 242

5.9 FIGURES ..... 254

6 INTEGRATED ECOSYSTEM ASSESSMENT AD-HOC WORKING GROUP ..... 273

6.1 OVERVIEW ..... 274

6.1.1 IEA Working Group Participants..... 276

6.2 CONTRIBUTED MODELING ENVIRONMENTS ..... 276

6.2.1 Spatiotemporal overlap of red grouper distribution with red tide events ..... 276

6.2.2 OSMOSE ..... 277

6.2.3 CMS ..... 278

6.3 INTEGRATION OF ECOSYSTEM PRODUCTS INTO STOCK SYNTHESIS ..... 279

6.4 RESEARCH RECOMMENDATIONS ..... 280

6.5 LITERATURE CITED ..... 284

## 1 INTRODUCTION

### 1.1 WORKSHOP TIME AND PLACE

The SEDAR 42 Data Workshop was held November 17-21, 2014 in St. Petersburg, Florida.

### 1.2 TERMS OF REFERENCE

1. Review stock structure and unit stock definitions and consider whether changes are required.
2. Review, discuss, and tabulate available life history information.
  - Evaluate age, growth, natural mortality, and reproductive characteristics
  - Provide appropriate models to describe growth, maturation, and fecundity by age, sex, hermaphroditism including age and size at transition, and/or length as applicable.
  - Evaluate the adequacy of available life history information for conducting stock assessments and recommend life history information for use in population modeling.
  - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models<sup>1</sup>.
3. Recommend discard mortality rates.
  - Review available research and published literature
  - Consider research directed at red grouper as well as similar species from the southeastern United States and other areas.
  - Provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata.
  - Include thorough rationale for recommended discard mortality rates.
  - Provide justification for any recommendations that deviate from the range of discard mortality provided in the last benchmark or other prior assessment.
  - Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models<sup>1</sup>.
4. Provide measures of population abundance that are appropriate for stock assessment.
  - Consider and discuss all available and relevant fishery-dependent and -independent data sources.
  - Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
  - Provide maps of fishery and survey coverage.
  - Develop fishery and survey CPUE indices by appropriate strata (e.g., age, size, area, and fishery) and include measures of precision and accuracy.
  - Discuss the degree to which available indices adequately represent fishery and population conditions.

- Recommend which data sources adequately and reliably represent population abundance for use in assessment modeling.
  - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models<sup>1</sup>.
  - Complete the SEDAR index evaluation worksheet for each index considered.
  - Rank the available indices with regard to their reliability and suitability for use in assessment modeling.
5. Identify and describe ecosystem, climate, species interactions, habitat considerations, and/or episodic events that would be reasonably expected to affect population dynamics.
  6. Incorporate socioeconomic information into considerations of environmental events that affect stock status and related fishing effort and catch levels as practicable.
  7. Provide commercial catch statistics, including both landings and discards in both pounds and number.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
    - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models<sup>1</sup>.
    - Provide length and age distributions for both landings and discards if feasible.
    - Provide maps of fishery effort and harvest by species and fishery sector or gear.
  8. Provide recreational catch statistics, including both landings and discards in both pounds and number.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
    - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models<sup>1</sup>.
    - Provide length and age distributions for both landings and discards if feasible.
    - Provide maps of fishery effort and harvest by species and fishery sector or gear.
  9. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.
  10. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section II of the SEDAR assessment report).

<sup>1</sup> In providing ranges for uncertain or incomplete information, data workshop groups should consider and distinguish between those ranges and bounds that represent probable values (i.e., likely alternative states) to be included in structured uncertainty analyses, and those that represent extreme values to be considered in evaluating model performance through sensitivity analyses.

1.3 LIST OF PARTICIPANTS

**Workshop Panel**

|                                   |                    |
|-----------------------------------|--------------------|
| Meaghan Bryan, Lead Analyst ..... | NMFS Miami         |
| Neil Baertlein .....              | NMFS Miami         |
| Ken Brennan .....                 | NMFS Beaufort      |
| Shannon Cass-Calay .....          | NMFS Miami         |
| Matt Campbell .....               | NMFS Pascagoula    |
| Mary Christman .....              | MCC Consulting     |
| Jason Delacruz .....              | RFSHA              |
| Doug Devries .....                | NMFS Panama City   |
| Jon Dondrill .....                | FWC Tallahassee    |
| Jim Eliason.....                  | RFAP               |
| Martin Fisher.....                | RFAP               |
| Gary Fitzhugh .....               | NMFS Panama City   |
| Arnaud Gruss .....                | NMFS Miami         |
| Chad Hanson.....                  | PEW                |
| Bill Harford.....                 | NMFS Miami         |
| Walter Ingram .....               | NMFS Pascagoula    |
| Linda Lombardi .....              | NMFS Panama City   |
| Susan Lowerre-Barbieri .....      | FWC                |
| Patrick Lynch .....               | NMFS Silver Spring |
| John Mareska .....                | ADMR               |
| Vivian Matter .....               | NMFS Miami         |
| Kevin McCarthy.....               | NMFS Miami         |
| Adam Pollack.....                 | NMFS Pascagoula    |
| Jeff Pulver .....                 | NMFS Galveston     |
| Adyan Rios.....                   | NMFS Miami         |
| Skyler Sagarese.....              | UM                 |
| Beverly Sauls .....               | FL FWC             |
| Bob Spaeth .....                  | RFAP               |
| Jessica Stephen.....              | NMFS SERO St. Pete |
| John Ward .....                   | SSC                |

**Attendees**

|                       |                   |
|-----------------------|-------------------|
| Aimee Adams.....      | FL FWC            |
| Oscar Ayala.....      | FL FWC            |
| Steve Brown.....      | FL FWC            |
| Bridget Cermark.....  | FL FWC            |
| Tiffany Cross .....   | FL FWC            |
| Michael Drexler ..... | Ocean Conservancy |
| Alisha Gray .....     | FL FWC            |
| Joshua Kilborn .....  | USF               |
| Kelly Kowal .....     | FL FWC            |
| Ted Switzer .....     | FL FWC            |

**Staff**

Julie Neer ..... SEDAR  
 Partrick Giles ..... NMFS Miami  
 Ryan Rindone.....GMFMC  
 Charlotte Schiaffo .....GMFMC

**Additional Participants via Webinar**

Ching-ping Chih..... NMFS Miami  
 Chris Gardner..... NMFS Panama City  
 Chris Kelble ..... NOAA AOML  
 Michael Schirripa..... NMFS Miami  
 Elizabeth Scott-Denton ..... NMFS Galveston  
 John Walter ..... NMFS Miami  
 Jason Whitaker..... Private Angler

1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERENCE DOCUMENTS

| Document #                                             | Title                                                                                                                                                                                                                             | Authors                                                                                                                                  | Date Submitted                     |
|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>Angler Documents Prepared for the Data Workshop</b> |                                                                                                                                                                                                                                   |                                                                                                                                          |                                    |
| SEDAR42-DW-01                                          | Summary of commercial red grouper ( <i>Epinephelus morio</i> ) catch data based on fishery observer coverage of the Gulf of Mexico reef fish fishery                                                                              | Jeffrey R. Pulver, Linda Lombardi, and Elizabeth Scott-Denton                                                                            | 27 Oct 2014                        |
| SEDAR42-DW-02                                          | Evaluation of the natural mortality rates of red grouper ( <i>Epinephelus morio</i> ) in the West Florida Shelf ecosystem using the individual-based, multi-species model OSMOSE-WFS                                              | A. Grüss, M. J. Schirripa, D. Chagaris, P. Verley, Y.-J. Shin, L. Velez, C. H. Ainsworth, S. R. Sagarese, and M. Karnauskas <sup>2</sup> | 1 Nov 2014                         |
| SEDAR42-DW-03                                          | Use of the Connectivity Modeling System to estimate the larval dispersal, settlement patterns and annual recruitment anomalies due to oceanographic factors of red grouper ( <i>Epinephelus morio</i> ) on the West Florida Shelf | A. Grüss, M. Karnauskas, S. R. Sagarese, C.B. Paris, G. Zapfe, J.F. Walter III, W. Ingram, and M. J. Schirripa                           | 2 Nov 2014<br>Updated: 14 Nov 2014 |
| SEDAR42-DW-04                                          | Ontogenetic spatial distributions of red grouper ( <i>Epinephelus morio</i> ) within the northeastern Gulf of                                                                                                                     | S. R. Sagarese, A. Grüss, M. Karnauskas, J.F.                                                                                            | 3 Nov 2014                         |

|               |                                                                                                                                                                              |                                                                                                                                     |                                     |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|               | Mexico and spatio-temporal overlap with red tide events                                                                                                                      | Walter III                                                                                                                          |                                     |
| SEDAR42-DW-05 | Red Grouper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico                                                                                  | Adam G. Pollack and G. Walter Ingram, Jr.                                                                                           | 7 Nov 2014<br>Updated: 26 Nov 2014  |
| SEDAR42-DW-06 | Red Grouper Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico                                                                               | Adam G. Pollack and G. Walter Ingram, Jr.                                                                                           | 19 Nov 2014                         |
| SEDAR42-DW-07 | Maturity, sexual transition, and spawning seasonality in the protogynous red grouper on the West Florida Shelf                                                               | Susan Lowerre-Barbieri, Laura Crabtree, Theodore S. Switzer, and Robert H. McMichael, Jr.                                           | 17 Nov 2014<br>Updated: 21 Nov 2014 |
| SEDAR42-DW-08 | Indices of abundance for Red Grouper ( <i>Epinephelus morio</i> ) from the Florida Fish and Wildlife Research Institute (FWRI) video survey on the West Florida Shelf        | Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.                                              | 12 Nov 2014                         |
| SEDAR42-DW-09 | Indices of abundance for Red Grouper ( <i>Epinephelus morio</i> ) from the Florida Fish and Wildlife Research Institute (FWRI) chevron trap survey on the West Florida Shelf | Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.                                              | 12 Nov 2014                         |
| SEDAR42-DW-10 | An age and growth description of Red Grouper ( <i>Epinephelus morio</i> ) from the northeastern Gulf of Mexico: 1978-2013 for SEDAR42                                        | Linda Lombardi-Carlson                                                                                                              | 13 Nov 2014<br>Updated: 10 Dec 2014 |
| SEDAR42-DW-11 | SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Red Grouper                                                                                                  | Matthew D. Campbell, Kevin R. Rademacher, Michael Hendon, Paul Felts, Brandi Noble, Michael Felts, Joseph Salisbury, and John Moser | 13 Nov 2014                         |
| SEDAR42-DW-12 | Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of                                                                   | Ching-Ping Chih                                                                                                                     | 14 Nov 2014                         |

|               |                                                                                                                                                   |                                                     |                                     |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-------------------------------------|
|               | Mexico                                                                                                                                            |                                                     |                                     |
| SEDAR42-DW-13 | The use of Otolith Reference Collections to Determine Ageing Precision of Red Grouper ( <i>Epinephelus morio</i> ) Between Fisheries Laboratories | Palmer, C.L., L. Lombardi, J. Carroll, and E. Crow  | 18 Nov 2014<br>Updated: 16 Dec 2014 |
| SEDAR42-DW-14 | Size Distribution of Red Grouper Observed in For-Hire Recreational Fisheries in the Gulf of Mexico                                                | Alisha Gray and Beverly Sauls                       | 20 Nov 2014<br>Updated: 15 Dec 2014 |
| SEDAR42-DW-15 | Red Grouper <i>Epinephelus morio</i> Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2014           | D.A. DeVries, C.L. Gardner, P. Raley, and W. Ingram | 5 Dec 2014                          |
| SEDAR42-DW-16 | Estimates of Historical Private/Charterboat and Headboat Fishery Red Grouper Angler Catch in the Gulf of Mexico 19xx-1980                         | Jeff Isely, Nancie Cummings and Adyan Rios          | 9 Dec 2014                          |
| SEDAR42-DW-17 | Discards of red grouper ( <i>Epinephelus morio</i> ) for the headboat fishery in the US Gulf of Mexico                                            | Fisheries Ecosystems Branch, Beaufort, NC           | 21 Nov 2014<br>Updated: 10 Dec 2014 |
| SEDAR42-DW-18 | Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984 to 2013                                         | Ching-Ping Chih                                     | 11 Dec 2014                         |
| SEDAR42-DW-19 | Index report cards                                                                                                                                | Indices Working Group                               | 17 Dec 2014                         |

## 2 LIFE HISTORY

### 2.1 OVERVIEW

The life history workgroup (LHW) reviewed and discussed data collected since the last Gulf of Mexico red grouper stock assessment in 2006 and the update assessment in 2009 (SEDAR 2006, SEFSC 2009). Updated information was examined and new studies were reviewed regarding age, growth, reproduction, mortality, habitat and movement. A summary of the data presented, discussions and recommendations made during SEDAR42 Data Workshop are presented below.

#### 2.1.1 Life History Workgroup (LHW) members

| Member Name                           | Affiliation                           |
|---------------------------------------|---------------------------------------|
| Linda Lombardi-Carlson (group leader) | SEFSC/NMFS Panama City, FL            |
| Gary Fitzhugh                         | SEFSC/NMFS Panama City, FL            |
| John Mareska                          | Alabama Marine Resources, Mobile, AL  |
| Sue Lowerre-Barbieri                  | FL FWCC/FWRI St. Petersburg, FL       |
| Jon Dodrill                           | FL FWCC Tallahassee, FL               |
| Mike Drexler (observer)               | Ocean Conservancy, St. Petersburg, FL |

### 2.1.2 LHW Topics addressed

Attributes of stock structure and unit stock definition, age and length data and aging error, growth, mortality, reproductive characteristics including maturity, alternative forms of reproductive potential (spawning stock biomass and fecundity), sex transition, sex ratio and meristic conversions.

## 2.2 REVIEW OF WORKING PAPERS

These SEDAR42 Data Workshop Working Papers were taken into consideration within the corresponding life history topics discussed below.

Chih, C-P. 2014a. Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of Mexico. SEDAR42-DW-12. SEDAR, North Charleston, SC. 26 pp.

Chih, C-P. 2014b. Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984-2013. SEDAR42-DW-18. SEDAR, North Charleston, SC. 42 pp.

Grüss, A., M. Karnauskas, S. R. Sagarese, C.B. Paris, G. Zapfe, J.F. Walter III, W. Ingram, and M. J. Schirripa. 2014. Use of the Connectivity Modeling System to estimate the larval dispersal, settlement patterns and annual recruitment anomalies due to oceanographic factors of red grouper (*Epinephelus morio*) on the West Florida Shelf. SEDAR42-DW-03. SEDAR, North Charleston, SC. 24 pp.

Lombardi-Carlson, L. 2014. An age and growth description of Red Grouper (*Epinephelus morio*) from the northeastern Gulf of Mexico: 1978-2013 for SEDAR42. SEDAR42-DW-10. SEDAR, North Charleston, SC. 37 pp.

Lowerre-Barbieri, S., L. Crabtree, T.S. Switzer, and R.H. McMichael, Jr. 2014. Maturity, sexual transition, and spawning seasonality in the protogynous red grouper on the West Florida Shelf. SEDAR42-DW-07. SEDAR, North Charleston, SC. 20 pp.

Palmer, C.L., L. Lombardi, J. Carroll, and E. Crow. 2014. The use of otolith reference collections to determine ageing precision of Red Grouper (*Epinephelus morio*) between fisheries laboratories. SEDAR42-DW-13. SEDAR, North Charleston, SC. 10 pp.

### 2.3 STOCK STRUCTURE

The red grouper fishery has been managed as separate Gulf and Atlantic stock units with the boundary being U.S. Highway 1 in the Florida Keys. The life history workgroup (LHW) discussed and reviewed the available stock structure information and inquired about new evidence to suggest changing stock management units. Many researchers have indicated due to red grouper's high site fidelity that over an evolutionary scale, sub-populations may emerge throughout red groupers range.

#### ***Recommendation***

Given that no new information was presented related to the mixing of the Atlantic and Gulf of Mexico stock units, the LHW recommends that the red grouper fishery be managed as a separate stock within the Gulf of Mexico, until further studies may suggest otherwise.

#### *2.3.1 Population genetics, larval transport, and connectivity*

Genetic studies have not revealed any separate stock structure or reproductive isolation among southeastern U.S. Atlantic, northeastern Gulf of Mexico, and southwestern Mexico, Gulf of Mexico (Yucatan peninsula) collections of red grouper based on mitochondrial DNA (Richardson and Gold 1997) or microsatellite genetic markers (Zatcoff et al. 2004). Based on recent biophysical modeling of transport from the Campeche Banks of red snapper and Gag, it is hypothesized that little connectivity exists for red grouper mixing of Mexico and US stocks as well (unpublished data, M. Karnauskas, SEFSC/NMFS Miami, FL). Red grouper may have a more complex stock structure based on possible separated distributions and evidence of little movement but a longer timescale of generations may be needed to detect genetic differences (Zatcoff et al. 2004).

Red grouper spend their larval phase in the plankton carried across the Florida shelf or in some cases are self-recruiting (Grüss et al. 2014). Wallace et al. (2014) analyzed stable isotopes from eye lenses of red snapper (n=8), red grouper (n=4) and Gag (n=3) from the west Florida shelf. Samples sizes (n) were small and groups across the shelf were detected for red snapper and Gag. No clear grouping emerged for red grouper. Juvenile red grouper are found settling and residing on a variety of suitable habitat at ages 0-2 predominantly out to 30m depth contour (Figure 2.1).

Based on recent biophysical modeling of transport from the Campeche Banks of red snapper and Gag, it is hypothesized that little connectivity exists for red grouper mixing of Mexico and US stocks as well (unpublished data, M. Karnauskas, SEFSC/NMFS Miami, FL).

### 2.3.2 *Habitat Requirements*

Juvenile red grouper are generally characterized as inhabiting shallow water habitats, but some are found in waters deeper than 30m. Florida Fish and Wildlife Conservation Commission (personal communication, T. Switzer, FL FWCC/FWRI, St. Petersburg, FL) has reported numerous sub-legal ( $\leq 508$  mm TL) size red grouper in association with natural and artificial structures in the 6 to 30m depth ranges. Juveniles utilize spaces between structures, as well as, create holes beneath. Red grouper are associated with the low relief artificial patch reefs deployed for Gag (personal communication, B. Lindberg, UF/SFRC/FAS Gainesville, FL). For the patch reefs along the 12m and 21m depth contours, red grouper were approximately 1% and 6% of Gag abundance, respectively.

Coleman et al. (2011) list low relief, hard bottom covered with a thin veneer of sand as essential habitat for adult red grouper. Within the depths of the study area, 60 to 100m, red grouper were abundant from 60 to 73m in Steamboat Lumps and Madison Swanson marine reserves. Red grouper were characterized as either few or none for depths out to 100m. Burns and Robbins (2006) collected red grouper from Tampa Bay to Florida Keys predominantly at 40-60m and 80-90m. Sites within the marine reserves were mostly characterized as low relief, with some large cobble to boulders size rocks with less than 2m in vertical relief. Sponges, seafans, corkscrew sea whips and small clusters of stony coral are other characteristics of habitat that may hold red grouper. Areas that contain red grouper are indicated by conical depressions 2m in depth by 5 to 6.8m in width. These depressions are the result of excavation activities by red grouper that clean

rocky surfaces and provide attachment sites for sessile invertebrates and other species such as vermilion snapper and spiny lobster (Coleman et al. 2010).

In general, red grouper are hypothesized to have high site fidelity due to the investment they make in excavating and creating habitat (Coleman et al. 2010, Coleman et al. 2011, Wall et al. 2011). Wall et al. (2011) studying red grouper holes in the Steamboat Lumps Marine Reserve indicated that hole density was increasing over time (2006-2009) and, in response to increasing density, individual hole depth and slope increased. In addition, red grouper were collected from depths ranging from 6.5 to 94m and mature red grouper inhabited a preferred range (30-80m) as indicated by females collected while in spawning condition (unpublished data, S. Lowerre-Barbieri, FL FWCC/FWRI, St. Petersburg, FL), however, spawning females were found in deeper depths (Figure 2.2). These depths also are representative of immature and mature males (Figure 2.3).

### 2.3.3 Tagging, movements, and migrations

Tagging at artificial reef sites (2005-2007) off the western Florida panhandle indicated collective groupers (Gag [n=101], Scamp [n=20], red grouper [n=34]) had high site fidelity with 33% being recaptured at the tagging site (Addis et al. 2007). A high percentage of the tagged grouper were below the minimum size limit and authors acknowledged that off shore movement in these shallow grouper species increases ontogenetically.

Extensive tagging of snapper and grouper species (n=15,000+) in the northeastern Gulf, centered off Manatee and Sarasota counties, by Mote Marine Laboratory strongly suggested that red grouper (age 2-4 yr) move very little. No verifiable recaptures were made in the Atlantic Ocean. Of the 243 recaptured red grouper, 89% of these moved less than 1.9 km (Burns et al. 2008). Coleman et al. (2011) were able to tag and recapture 9 red grouper and after 100 to 300 days at liberty 8 red grouper had shown no movement.

Movement by recaptured red grouper (n=388) indicated that approximately 63% moved less than 1 kilometer and 16% moved between 2-5 km (Burns et al. 2008). A plot of length tagged as sub-adults by recaptured length, 43-1200 days later, at distance from shore, shows that overall fish length increased with distance. Sub-adults were tagged and released at depths ranging 6 to 30m

and recaptured at depths ranging from 30 to 85m (Burns et al. 2008). These data agree with those of Bullock and Smith (1991) who reported that smaller red grouper usually occur in shallow water (3-18m) off southwest Florida, and then following several years, are found in commercial catches at depths greater than 36m. The maximum distance moved was 375 km (Burns et al. 2008). Recaptures of larger red grouper were either recaptured at the original site or a few kilometers away (Burns and Robbins 2006). Koenig and Coleman (2006) reported that older red grouper exhibit high site fidelity upon reaching mid- to outer shelf depths, which they attributed to the species habitat-structuring and harem mating behavior. None of their tagged fish moved more than 1.2nm. Thus, in general, tagging data reveal that most red grouper exhibit limited movements throughout their life span, which could give rise to complex sub-stock structure.

Rare fish do exhibit long distance movements and it is postulated that some of these movements are the result of hurricane forces (Burns and Robbins 2006). One individual was recaptured 375 km from the release site (Burns et al. 2008). There have been some reports of movements in red grouper that do not appear related to ontogeny. Some onshore/offshore movements have been explained by anglers as inshore summer feeding migrations (personal communication, M. Fischer, stakeholder representative). Commercial fishers have also noted seasonal movements of adult red grouper offshore (27-91m) in the Florida Keys (Bullock and Smith 1991). Moe (1972) reported 22 tagged red grouper traveled 16ml within 50 days. The Mote tagging data also revealed that groups of similar sized fish caught together on the same date at the same location were recaptured together on the same date at some other same site. This type of pattern has been characterized as “cohort movement” (personal communication, K. Burns, Mote Marine Laboratory, Sarasota, FL). These cohort movements (recapture groups of 2-5 fish) have occurred during all months of various years, however it is unknown how common or widespread these might be due to the nature of fishery-dependent recaptures. There is further information that red grouper movements occur after spawning, possibly following prey to shallower depths (Moe 1969; personal communication, W. Ward, commercial fisher). Perhaps similar to “cohort movement”, red grouper may move in large numbers in response to events such as hurricanes. Following Hurricane Lili in (2002), juvenile and adult red grouper were commonly caught on artificial reefs and petroleum platforms off Mississippi (Franks 2003). After Hurricane Ivan

(2004) juvenile and adult red grouper were commonly caught within Alabama's artificial reef zone (personal communication, J. Mareska, Alabama Marine Resources, Mobile, AL).

## 2.4 AGE AND GROWTH DATA

### 2.4.1 Source of samples

Age data were provided to the LHW by NMFS Panama City with data from the Gulf of Mexico commercial and recreational fisheries, and fishery independent surveys (1978-2013, n=95,343; Lombardi-Carlson 2014). Age data were collected by multiple sources (Table 2.1), incorporating a variety of fishing modes and gears (Table 2.2). Of the 95,343 otoliths collected, 39,857 were aged (Table 2.3). Due to an increase in otolith sampling that has occurred in the commercial hand-line and long-line sectors, records (minimum n = 500) from each year and gear were randomly sub-sampled based on the percentage of commercial landings by National Marine Fisheries Service (NMFS) Shrimp Grids (see Lombardi-Carlson 2014 for further information).

### **Recommendation**

The LHW recommends the use of all age and growth data from multiple sources for SEDAR42.

### *Adequacy of the data*

- Sample sizes of red grouper intercepted by commercial sector were low prior to 2000 and currently (2009-2013) there is over sampling of this sector.
- The recreational sector is still being under sampling for biological samples (e.g., hard parts, n<100/year, all years). It is recommended that an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS occurs in the future and for a higher percentage of the intercepts include collecting biological samples (length, weight, and hard parts).
- In the past 4 years, only 166 trips (on average, 2010-2013; Table 4.8.11) intercepted included collecting biological samples (e.g., length, hard parts) by MRFSS/MRIP port agents and there was an estimated 22 million recreational trips made by recreational anglers in the more recent years (2010-2013; Table 4.8.17). Biological data collected at such a low percentage (< 0.0001%), provide very minimal information regarding age and growth of red grouper. An

increase in the number of fish intercepted for biological samples will increase our knowledge of the size and age structure being intercepted by recreational anglers.

#### *2.4.2 Age Reader Precision*

Two ageing facilities provided red grouper ages to SEDAR42 (NMFS Panama City and FL FWCC/FWRI St. Pete), involving 11 individual readers over the entire time series of data collection (Palmer et al. 2014). Indices of precision (APE = Average Percent Error, CV = Coefficient of Variation and D = Index of Precision) were calculated to determine the agreement among readers for specific time periods. Overall reader agreement values show high precision among all five groupings of readers (APE, range 3.21-5.10; CV, 4.23-6.50; D, 2.12-3.25). Standard deviations at age among readers showed little bias, up to age 12 (Figure 2.4).

#### ***Recommendation***

Apply the ageing error matrix, if warranted, given the models predictions of annual age frequencies.

#### *2.4.3 Year Class progressions*

Red grouper year-class trends are apparent for the Gulf of Mexico due to the ease of aging red grouper otoliths and the availability of a continuous series of age structure sampling from 1991 to 2013 from the Gulf. Strong year classes were evident in the Gulf of Mexico 1989, 1990, 1991, 1996, 1999, 2002, 2006 and 2007 (Lombardi-Carlson 2014).

#### *2.4.4 Age and Length data*

Red grouper for SEDAR42 were represented from a wide range of fork lengths (116-1010 mm,  $540 \pm 114$  mm, mean  $\pm$  std dev) with most lengths from the 500 – 600 mm length bin. The ages of these fish also encompassed a wide distribution (range = 0-29 yrs,  $6.8 \pm 3$  yr) (Lombardi-Carlson 2014). There was more variation in the modal age (than length) given the presence/absence of a strong cohort in a specific year. In more recent years, there seems to be fewer (<10) fish older than 20 years collected but is uncertain if this is due to a decline in older

fish in the population or due to recent changes in the fishery management regulations (Table 2.4).

#### 2.4.5 Modeling Growth

A growth curve, based on fractional ages and observed fork lengths at capture, was modeled using the von Bertalanffy growth model and was executed in ADMB (Auto Differentiate Model Builder). The size-modified growth model takes into account the non-random sampling due to minimum size restrictions (Diaz et al. 2004) used in this assessment has structural similarities with the model applied in the previous assessments (Lombardi-Carlson et al. 2006, Lombardi-Carlson et al. 2009), but now the size-modified growth model is compiled in ADMB with alternative variance structures. Since not all species have the same variability in the variations of sizes-at-age, it is valuable to model growth with the variance structure most representative of the species. The model choices of the variance structures in the size-at-age data are: constant standard deviation (SD) with age, constant coefficient of variation (CV) with age, variance proportion to the mean, coefficient of variation (CV) increase linearly with age, and coefficient of variation (CV) increases linearly with size. Multiple model compilations were examined using three difference variance structures (constant SD with age, constant CV with age, and CV increases linearly with age) in the size-at-age data. Model convergence was based on value of the model objective function (minimal log-likelihood) and Akaike Information Criteria (AIC).

Red grouper displayed a constant CV with age (Figure 2.5b). The growth models using the variance structure of constant CV with age and CV increases linearly with age had similar objective functions, as well as, similar predicted growth parameters (Table 2.5 and 2.6). Model diagnostic plots showed similar residual patterns for each variance structure: normally distributed residuals, reasonable distribution of residuals by age, and probability plots showed divergence (see Figure 9, Lombardi-Carlson 2014). The LHW recommends the growth model using the same variance structure as observed in red grouper, constant CV with age. The SEDAR42 growth model was very similar to those of previous assessments (Table 2.5, Figure 2.6), with slightly smaller asymptotic fork lengths, similar growth coefficients (as update in 2009), and similar sizes at time zero.

#### **Recommendation**

The LHW recommends using the predicted growth parameters from the growth model using a constant CV at age variance structure as priors in the stock synthesis assessment model, providing growth will be predicted internally in the stock synthesis assessment model.

## 2.5 MORTALITY

### 2.5.1 Natural Mortality

There are multiple methods to calculate estimates of natural mortality (M) and these methods use a variety of life history parameters (e.g., von Bertalanffy growth parameters, maximum age, age at 50% maturity, Table 2.7) and environmental parameters (water temperature). A constant natural mortality for the lifetime of a species is unrealistic but an estimate of M is necessary for the calculation of an age-specific vector of natural mortality (Lorenzen 2005).

#### Point estimates of M

Multiple life history parameters (asymptotic length, growth coefficient, maximum age, age at 50% mature) and water temperature were used to calculate various point estimates of M (Table 2.7 and 2.8). As reported during SEDAR12, the maximum estimated age of red grouper in the Gulf of Mexico is 29 years (Lombardi-Carlson et al. 2006). This red grouper was caught during a fishery independent survey using hook-and-line gear in 1992. During SEDAR12, the Assessment Panel recommended not to use the oldest aged red grouper to calculate natural mortality but to use the next, more frequent age class (age 25, n = 13, Table 2.4); however, this decision was reversed during the Review Panel (SEDAR 2006).

Using the multiple methods to calculate natural mortality, M ranged from 0.10 – 0.82 (Table 2.8). The minimum M was calculated using the Hewitt and Hoenig (2005) method that divides the maximum age by a constant and the maximum M was calculated using Beverton and Holt (1956) that uses both the predicted von Bertalanffy growth coefficient and the age at 50% maturity (Table 2.7 and Table 2.8). The natural mortality methods that utilize the von Bertalanffy growth parameters (Linf and/or k) estimated similar M values (0.19-0.31). Likewise, those natural mortality methods that took in consideration maximum age had similar M values (0.10-0.16).

#### **Recommendation**

As was recommended during SEDAR12 and the update assessment in 2009, LHW recommends using the maximum age fish of 29 years to calculate natural mortality by applying Hoenig's regression for teleosts ( $M = 0.14$ ) as the target  $M$  used to calculate an age-specific vector of  $M$ .

### Age-Specific vector of $M$

An age-specific vector of  $M$  was developed during the red grouper SEDAR12 assessment workshop (SEDAR 2006, following Lorenzen 2005). This vector was re-estimated using the resulting von Bertalanffy growth parameters for SEDAR42 (Table 2.9, Figure 2.7). This vector takes into the consideration the first age at vulnerability into the fishery (age 5), the target  $M$  of 0.14 (Hoenig<sub>teleost</sub>, maximum age of 29 years) and the von Bertalanffy growth parameters. The resulting age-specific natural mortality vector was compared to the previous vectors from the update assessment in 2009 and SEDAR12 (SEDAR 2006, SEFSC 2009). The only difference among the age-specific natural mortality vectors were the predicted von Bertalanffy growth parameters used in the estimations.

### ***Recommendation***

The LWH recommends applying the age-specific natural mortality vector using Lorenzen 2005 (as was used in previous assessments) adjusted for the newly predicted von Bertalanffy growth parameters.

### Assessment model sensitivities for $M$

In previous assessments, model sensitivities for natural mortality have been quite arbitrary (age-specific natural mortality vector increased and decreased by 10%) (SEDAR 2006, SEFSC 2009).

LHW presented 5 different options for model sensitivities for  $M$ :

1. Apply the same sensitivities as in the update assessment in 2009 and SEDAR12 (10% increase/decrease in the age-specific natural mortality vector).
2. Apply a range of  $M$  (upper:  $M = 0.20$  (corresponds to a maximum age of 21); lower:  $M = 0.10$  (corresponds to a maximum age of 40)).
3. Apply the average  $\pm$  standard deviation ( $0.19 \pm 0.07$ ) of the point estimates of  $M$  (except for the Beverton and Holt outlier) (Table 2.8).

4. Apply the average  $\pm$  standard deviation ( $0.13 \pm 0.02$ ) of the point estimates of  $M$  (only for those regressions that incorporate maximum age) (Table 2.8).
5. Apply the resulting standard deviation ( $\pm 5$ ) for the maximum aged red grouper. Three readers interpreted this otolith (readings: 29, 21, 19; average age 23 yrs, standard deviation 5 yrs).

### ***Recommendation***

The LHW recommends applying option 5 as the sensitivities for the age-specific natural mortality vector based on the variation around the maximum aged red grouper (age  $29 \pm 5$  yrs) (Table 2.10, Figure 2.8).

#### *2.5.2 Total Mortality*

A catch curve estimated the instantaneous total mortality ( $Z$ ) using data summarized in Lombardi-Carlson 2014. Age 5 fish were considered fully recruited to the fishery. Combining all cohorts for the 5-18 year age intervals, an overall  $Z$  of 0.39 was observed (Figure 2.9a). A catch curve was also developed for all strong cohorts (1989, 1990, 1991, 1996, 1999, 2002, 2006, 2007), an overall  $Z$  of 0.49 was observed (Figure 2.9b).

### ***Recommendation***

The LHW recommends the use of the catch-curve derived total mortality estimates ( $Z$ ) as a check on stock synthesis assessment model results.

#### *2.5.3 Discard Mortality*

An ad-hoc panel (led by Beverly Sauls, FL FWCC/FWRI, St. Petersburg, FL) convened during the Data Workshop to specifically discuss discard mortality. Participants included data providers, analysts, and professionals from the fishing industry representing both commercial and private recreational sectors. The task for this panel was to review new data and results from studies that have become available since SEDAR12, and formulate recommended mortality percentages to apply to estimated discards. Previous assessments in 1999 and 2002 assumed 10% discard mortality for recreational discards (based on Wilson and Burns 1996) and 33%

discard mortality for commercial discards. For SEDAR12, 10% discard mortality was recommended for both recreational hook-and-line gear and commercial vertical line gear, and 40% discard mortality was recommended for commercial bottom long-line gear. Two new data sources since SEDAR 12 were identified and are summarized here.

Since 2009, Florida FWCC/FWRI (FWC) has worked cooperatively with for-hire vessels that offer recreational fishing trips from the west coast of Florida. FWC biologists are allowed to board vessels and directly observe discarding practices during recreational hook-and-line bottom fishing trips. A detailed description of methods and results is provided in Sauls et al. 2014. For each red grouper not harvested by anglers, fishery observers recorded the length and capture depth, as well as capture and release condition variables. Discards were marked with conventional tags prior to release. Mark-recapture data were used to model the relative survival of fish released in different conditions and estimate overall discard mortality under conditions measured directly in the recreational hook-and-line fishery. Red grouper that re-submerged with assistance from venting (fair condition), and that demonstrated difficulty re-submerging or suffered internal hook injuries or gill injuries (poor condition) survived at lower rates (survival 82.7% and 60.9%, respectively) compared to fish that were re-submerged immediately without the need for venting (good condition). Point estimates for overall discard mortality across all depths fished were 10.4% and 12.9% in the charter fishery (for areas fished adjacent to Tampa Bay and the northwestern panhandle, respectively), and were comparable to the headboat fishery (9.7% to 13.8%, respectively per area). Confidence intervals for all four point estimates overlapped, and a single mean value may be applied across fleets and areas.

Since 2006, National Marine Fisheries Service has placed fishery observers on commercial vessels fishing with vertical line and bottom long-line gears. A detailed description of methods and results are provided in Pulver et al. 2014. Size, capture depth, release condition, and final dispositions were recorded for red grouper discards. Retention rates increased after initiation of the Individual Fishing Quota (IFQ) program in 2010 most likely due to the lowering of the commercial size limit to 18in TL. Immediate discard mortality was estimated by combining fish that were dead on arrival or that were unable to re-submerge following release as a percentage of overall fish discarded (not including discards with unknown conditions; Figure 2.10). In the vertical line fishery, the mean immediate discard mortality rate (weighted based on the number

of fishing sets for each depth bin) was 13.8%. Immediate discard mortality was higher in the bottom longline fishery (27.0% and 29.5% of discards observed pre- and post-IFQ, respectively), but these vessels typically fished in deeper depths than the vertical line fishery.

### ***Recommendations***

Based on new data available since SEDAR12, the following recommendations were made:

1. For recreational discards, the ad-hoc panel recommended the mean overall depth-integrated estimate of 11.6% (95% C.I. = 5.8% to 14.5%) from the FWC study be applied to live discards in the recreational fishery. This estimate includes all sources of latent discard mortality for fish that were able to re-submerge and those that were alive and floating after release. Dead discards are included in recreational landings estimates, and no immediate mortality should be applied to recreational discards.
2. For vertical line gear used in the commercial sector, the panel recommended an estimate of 19% latent discard mortality as the base value for all discards that re-submerged or floated. This value is based on the recreational hook-and-line gear depth-dependent discard mortality function from the FWC study for live red grouper discarded in fishing depths between 41 meters and 50 meters (Table 2.11, Figure 2.11), where the vertical line fishery primarily operates. This recommendation is based on the assumption that vertical line gear is fished similar to recreational hook-and-line gear (with regards to retrieval and handling time), and commercial observer data were used to select the mean fishing depth range for vertical line gear that is representative of the Gulf-wide fishery. Therefore, this single mortality percentage may be applied to estimated discards across regions in the Gulf. The same method was used to estimate discard mortality for gag in SEDAR33 (SEDAR 2014a). For sensitivity, the panel recommended a range between 10% and 31%. The lower value is based on the previous percentage used in SEDAR12. The upper value assumes that 100% of discards observed to be floating upon release in the vertical line fishery suffer immediate mortality, and the remaining live discards that are able to re-submerge suffer 20% latent discard mortality.
3. For the bottom long-line fishery, the panel agreed that retrieval and handling times for this gear are longer compared to vertical line and recreational gears. Therefore, a more conservative approach was recommended. Commercial observer data also indicated differences

in discarding practices between pre- and post-IFQ years that may influence mortality. The panel recommended base values of 41.5% discard mortality during pre-IFQ years, and 43.6% post-IFQ. These values assume that 100% of floaters suffer immediate mortality, and 20% latent mortality for discards that re-submerge for each 10-m depth bin. The discard mortality rates for each depth bin were combined using the weighted mean average based on the number of fishing sets in each bin. For sensitivity, the panel recommends using the base value of 20% latent mortality plus and minus 10% for fish that re-submerge with these values (Tables 2.12 and 2.13, Figures 2.12 and 2.13).

## 2.6 REPRODUCTION

There have been several studies on the reproductive biology of red grouper (see references within SEDAR12, including Fitzhugh et al. 2006). The LHW reviewed the size and age-based data in regards to maturity, sexual transition and fecundity. New references pertaining to reproduction include Freitas et al. (2011) and Lowerre-Barbieri et al. (2014).

### 2.6.1 Maturity

As red grouper have been found to be protogynous hermaphrodites (female first, then male), all transitional and male fish were considered to be mature (see sexual transition below). Comparison of earlier work (e.g. Moe 1969) was conducted during SEDAR12 and records were examined for the period 1991-2005. As in earlier assessments, histological staging techniques were used. New maturity information was provided by NMFS PC and FL FWCC/FWRI for years 2008-2013 for SEDAR42.

Issues regarding assignment of maturity status were discussed during SEDAR12. Similar challenging issues regarding interpretation of some histological traits persisted and were discussed during SEDAR42. Red grouper females exhibit a high degree of parasitism that may result in atresia or in some cases be confused with degenerating follicles. Additionally, a relatively high proportion of females are not developing (vitellogenic) during the spawning season and are of a size or exhibit traits that otherwise suggests they have previously spawned. This indicates some females are either skip spawning or exhibiting asynchronous reproductive seasonality.

### Comments on maturity data

As NMFS PC and FL FWCC/FWRI biologists were preparing for SEDAR42, histological images were exchanged during the summer of 2014 for the purposes of discussing these characteristics.

During the SEDAR42 DW, the LHW made the following decisions:

- 1) To combine maturity results for NMFS PC and FL FWCC/FWRI.
  - a) NMFS PC reproductive samples were typically obtained from the commercial fleet (via observers or cooperative projects) and thus represented largest and oldest components of the stock.
  - b) FL FWCC/FWRI sampling filled a gap noted during SEDAR12 wherein small and younger red grouper were under-represented and which previously made it difficult to fit ogives describing the onset of maturity.
- 2) To retain maturity data only from the reproductive period (March, April, May and June). This was done to minimize uncertainty between resting or regenerating females and immature females.
- 3) Both NMFS PC and FL FWCC/FWRI further censored females considered to be “uncertain” in histological staging in addition to retaining data for spawning months. NMFS PC retained females exhibiting developing (CA or V) oocytes and spawning females (bearing POFs or maturing oocytes) as “active” mature. FL FWCC/FWRI did the same but took further steps, via consultation with parasitologists, to distinguish regressing mature females from females bearing parasites. Females designated as immature bore no traits that may be associated with prior spawning (Lowerre-Barbieri et al. 2014). Thus similar to the maturity fit recommended for SEDAR12, active mature and clearly regressing mature females are the numerator of a proportion of total active, regressing and immature females (Figure 2.14).

### *Adequacy of the data for age and size at maturity*

The combination of NMFS PC and FL FWCC/FWRI data increased the size and age ranges for maturity analysis and improved resolution of the onset of maturity.

### ***Recommendation for age and size at maturity***

The age range of females with spawning markers (postovulatory follicles and hydrated oocytes) overlapped the age range of females deemed “mature” and supports the identification of the age and size range of mature females (Figure 2.14). The logistic fit via Gompertz equation predicts age at 50% maturity to be 2.8 years (Figure 2.15a) and length at 50% maturity at 292 mm FL (Figure 2.15b).

These maturity results are consistent with recent findings and are intermediate between values determined in SEDAR12 and values determined by FL FWCC/FWRI investigation:

SEDAR12: 50% mature at age 2.0 years and 271 mm FL (Fitzhugh et al. 2006; “definitely” mature, original length 280 mm TL)

FL FWCC/FWRI data only: 50% mature at age 2.96 years and 310 mm FL (Lowerre-Barbieri et al. 2014, original length, 258 mm SL).

While the raw data and details of sample sources are not known from Moe (1969), this early classic work indicated that maturity of females occurred between ages 4-6 years with active mature females important after age 6, at much larger sizes (Moe 1969, Table 8, mean sizes > 500 mm SL for mature females) than are observed in recent years. This comparison supports the conclusion that size and age at maturity has declined since the 1960s. Comparisons with the collections made in Brazil also indicate red grouper can obtain larger sizes before becoming mature (L50 = 380 mm SL, Freitas et al. 2011).

### ***2.6.2 Sexual Transition***

As with maturity, NMFS PC and FL FWCC/FWRI data regarding histological determination of sex were combined (Figure 2.16). There is broad overlap of the size and age range of males and female red grouper; transition to male occurs as young as age 3. This is somewhat different than observations for gag wherein males, --individuals with “copperbelly” pigmentation, are noted to be large in size and relatively old (SEDAR 2014a). Of greater distinction, the numbers of sampled red grouper that are male (thus sex ratio) are much greater among young age classes

than is observed in gag (Figure 2.16). The overall ratio of red grouper male = 28% (Figure 2.16) while ratios for gag are about 2 to 5% male in recent years (SEDAR 2014a).

As reported during the previous red grouper SEDAR (Fitzhugh et al. 2006, Moe 1969, Burgos 2001 and Koenig reported in Schirripa et al. 1999) and more recently by (Lowerre-Barbieri et al. 2014), reduced age at transition for red grouper is observed in the 1990s and 2000s compared to the 1960s. This is similar to the issue for maturity. While sources of Moe's 1960s samples are not well described, Moe's study using data from the eastern Gulf showed an older age at transition (50% by age 15-16). Moe (1969) noted males do not exceed 10% until after age 9. By visual inspection of the age histogram, males now exceed 10% by age 5 (Figure 2.16). The most recent logistical model fits presented to SEDAR42 indicate that red grouper are 50% male at 793 mm FL (681.9 mm SL) and 12.6 years of age for FL FWCC/FWRI data only (Lowerre-Barbieri et al. 2014).

#### ***Recommendation age and size at transition***

NMFS PC and FL FWCC/FWRI data combined result in a Gompertz logistical fit predicting 50% male at age 11.2 years and size 707 mm FL (Figure 2.17a, 2.17b), similar to findings during SEDAR12.

The LHW noted that at oldest ages and largest sizes of red grouper, females were still evident (red symbols, Figure 2.17a, 2.17b). During SEDAR12 these old females were considered outliers and due to small numbers at age were discounted during the logistical fit. However, female occurrence among low numbers of oldest red grouper may be biologically relevant. The nature of small and broadly distributed harems, perhaps structured by size, may socially mediate the process of sexual transition. While the LHW did not have advice for alternatives to the logistical fit of sexual transition (Figure 2.17a, 2.17b), there is a research recommendation (below) to improve our understanding of the mating system.

#### ***Comments on comparison to gag grouper mating behavior***

By comparison to red grouper, gag do not show such evidence of change in size or age at sexual transition over time and exhibits overall fewer males except among the largest sizes and ages perhaps because gag typify a lek type of mating system (SEDAR 2014a). As more information

is gathered, the difference between these two protogynous groupers and their mating systems is becoming apparent. Because of broadly distributed harems, red grouper may have more in common with protogynous species such as hogfish. Hogfish exhibit differences in size at transition and reproductive potential among inshore smaller sized components- compared to offshore larger sized components of the stock (Collins and McBride 2011, 2014 and SEDAR 2014b). Thus, managers of red grouper may ultimately need to map the harem pattern and account for regional differences in fishing intensity similar to hogfish.

### *2.6.3 Fecundity and spawning frequency*

As presented in SEDAR12, red grouper exhibit asynchronous oocyte development and an indeterminate fecundity pattern. Previously batch fecundity and spawning frequency data were considered limited thus gonad weight (of ovaries with vitellogenic and maturing oocytes) were used as the form of reproductive potential. An examination of ovary weight suggests reproductive potential of older and larger females greater than would be predicted by a proportional increase in average weight at age (spawning stock biomass or SSB females) (Figure 2.18).

However, the variation in gonad weight, even when classified by stage of development is quite large due to the temporal changes in oocyte size affecting gonad weight (Figure 2.18).

#### ***Recommendation for fecundity***

As the LHW noted that more batch fecundity data were available (Figure 2.19), the recommendation is to use the power function fit of the batch data as the form of female reproductive potential.

Other assessments of protogynous hermaphrodites, particularly those conducted in the South Atlantic have used male and female combined SSB when data are limited (Shepherd et al. 2013). This is thought to confer some conservation advantage (e.g., result in a more conservative benchmark) by inclusion of males, assuming males are larger and older yet comprise a small amount of stock biomass (Brooks et al. 2008). However, the LHW discussed that while this

approach may hold true for gag, the situation for red grouper may be very different due to greater biomass of males, particularly among younger ages.

### ***Recommendation for model sensitivities for fecundity***

Thus, the recommendation is to conduct sensitivity model runs using female SSB and male and female combined SSB. A further recommendation to the Assessment Panel is to define the per capita fecundity as the product of proportion female, batch fecundity, and maturity by age directly and secondarily by size (transformed to age within age-based model), if constrained by inputs to the stock synthesis model.

The LHW noted that more information regarding spawning fraction (which can be used to derive spawning frequency and number of batches) is available compared to earlier assessments (Figure 2.20). The increased data indicates that spawning fraction is greater among larger females supporting the assertion that larger/older females spawn more batches. This could further amplify the non-proportional reproductive contribution of older females than would be expected based on body mass. New approaches for modeling egg production of indeterminate species are being developed but they need to incorporate temporal variation in reproductive traits—and may incorporate spatial variation as well (see Porch 2004, Collins and McBride 2014).

## 2.7 MERISTIC CONVERSIONS

Meristic relationships were calculated for red grouper in the northeastern Gulf of Mexico for length types (total, fork, and standard) and body weights (whole and gutted) (Table 2.14). Data were combined from all data sources, both fishery independent and dependent and all years (1978-2013).

### ***Recommendation***

The LWH recommends applying the meristic conversions provided for SEDAR42.

## 2.8 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

For stock assessments to provide meaningful results to inform management policies, these stock assessments must use the best available data and the assessment scientists should be

knowledgeable on data limitations. The life history data provided for SEDAR42 used the combined efforts of fishery dependent and fishery independent sources (Table 2.1).

Fishery dependent data can be advantageous in that it is more generally available for more species (all that have a management plan), inexpensive, and often routinely collected covering a broad geographic area (Begg 2005). There are several caveats to fishery dependent data. One caveat of fishery dependent data is the size-selective nature of fisheries. A fishery can be size-selective due to a variety of fishery regulations of minimum size limit, an upper slot limit, gear restriction (e.g., hook size, bait type), area and seasonal closures, or depth restrictions. Another caveat of fishery dependent data is how port agents collect biological samples from the landed catch. Most port agents' guidelines for biological sampling are to attempt to purposely sample landings of multiple species from one or many fishing vessels at one time, which has led to some species being under sampled while other more economically important species are oversampled. A third caveat of fishery dependent data is the behavior of commercial fishers. A fishers behavior can be affected by the current economics (i.e., cost per pound, fuel price, boat slip price), as well as technological advances (i.e., vessel electronics, changes in gear), which can alter the species being fished and the location of fishing.

Fishery independent surveys provide an opportunity to collect data without the influences of the dynamics of a fishery (see caveats above). Red grouper were collected by several fishery independent surveys both at the state and federal level, as well as, special projects such as Cooperative Research Projects, Expanded Annual Stock Assessment Survey. Since the last full red grouper assessment in 2006, these surveys have increased their sampling frequency and provided an enormous amount of biological samples (otoliths,  $n = 6748$ ; gonads,  $n = 3034$ ) from standardized methodologies (Table 2.2).

The LHW agrees there were periods of low sampling effort from all data sources (pre-2000, fishery dependent; pre-2007, fishery independent) but with the increase in sampling in all sectors, there is an increase in the resolution of the analysis from such data.

## 2.9 RESEARCH RECOMMENDATIONS

### 2.9.1 Stock Structure

Population genetics - LHW recommends a study using next-generation sequencing of single nucleotide polymorphisms to generate a genetic map that may elucidate sub-populations and refine the stock structure of red grouper.

Larval transport and connectivity - Implement a survey to identify red grouper Age 0's locations for an index of recruitment and identify nearshore habitats that provide recruitment to offshore areas.

Habitat Requirements - Given the expected high site fidelity of red grouper, an acoustic array around a harem may provide essential information about mating movements, spawning frequency and duration during the spawning season. Anecdotal information about cohort and feeding movements following spawning may guide more targeted tagging studies.

Tagging, movements, and migrations - Gulf wide tag-recapture programs using multiple techniques (dart tags, PIT tags, telemetry, gene tagging) to improve estimates for release mortality and movements among and across regions. Some emphasis concentrated on areas of little known information, the northern and western Gulf of Mexico, as well as the Florida Keys, and should include the time of year as a factor.

### 2.9.2 Age and Growth

#### Sources of Age data

- Conduct further review of current sampling methodologies by sector, including detailed comparison of length data from otolith samples and from more expansive port-based length sampling (via TIP, MRFSS/MRIP, SRHS; see Chih 2014a, 2014b).
- Bring increased attention to the need for strategies improving port sampling (representation of fishery sectors and random sampling)
- It is recommended that an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS occurs in the future and for a higher percentage of the intercepts include collecting biological samples (length, weight, and hard parts).

#### Reader Age Precision

- Continue exchanges of calibration otolith sets and age workshops among state and federal agencies and universities to continue improvements of data comparability and quality control.
- Continue use and development of a reference collection as a means to monitor precision between/among readers.
- Expand the current reference collections to include older age classes (> age 12).

#### Year Class Progressions

- Continue age structure sampling from all fishing sectors on an annual basis.

#### Age and Length Data

- Investigate methods to better collect age structure samples randomly and systematically from all fishing sectors.
- The recreational sector is still under sampling for biological samples (e.g., hard parts,  $n < 100$ /year, all years). It is recommended that there is an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS and that a higher percentages of the intercepts include collecting biological samples (length, weight, and hard parts). In the past 4 years, only 166 trips (on average, 2010-2013; Table 4.8.11) intercepted included collecting biological samples (e.g., length, hard parts) by MRFSS/MRIP port agents and there was an estimated 22 million recreational trips made by recreational anglers in the more recent years (2010-2013; Table 4.8.17). Biological data collected at such a low percentage ( $< 0.0001\%$ ), provide very minimal information regarding age and growth of red grouper. An increase in the number of fish intercepted for biological samples will increase our knowledge of the size and age structure being intercepted by recreational anglers.

#### Modeling Growth

- Explore growth model alternatives that includes both the non-random sampling due to minimum size restrictions (Diaz et al. 2004) and non-random sampling due to biases in over/under sampling specific length bins (Chih 2014a, 2014b).

#### 2.9.3 Mortality

Gulf wide tag-recapture programs using multiple techniques (dart tags, PIT tags, telemetry, gene tagging) to improve estimates for natural, discard, and fishing mortalities.

### Natural Mortality

- Continue the collection of otoliths from all fishing sectors, as well as, fishery independent surveys to monitor any changes in longevity.
- Continue to investigate age-varying M models and their appropriateness.
- LHW recommends further research into mortality rates of juvenile red grouper as they migrate from inshore to the offshore environment.

### Total Mortality

- Continue the annual collection of otoliths from all fishing sectors, as well as, fishery independent surveys to monitor any changes in annual catch by age.

### Discard Mortality

- Direct estimates of latent discard mortality are needed for the commercial sector for both bottom long line and vertical line gears. Apply innovative tag-recapture programs to the observed discards to estimate discard and other types of mortality.

#### 2.9.4 *Reproduction*

Improve our understanding of the spatio-temporal aspects of the reproductive strategy. An example may be screen for a spatial- or depth dependence in male transition. Conduct surveys for metapopulation structure in demographics and reproduction (example hogfish assessment, SEDAR 2014b).

As in SEDAR12, the LHW recommends continued work to better understand and discriminate between annual asynchrony in spawning (skipped spawning) and seasonal asynchrony in spawning. Results of aquaculture rearing trials, review of histology, and new information or metadata regarding temperature and the development and duration of oocytes and follicles may increase our understanding.

Age and Size at Maturity - Continue to monitor changes in maturation schedules – evidence of earlier maturity since Moe 1969.

Age and Size at Transition - Continue to monitor changes in transition schedules, evidence of earlier transition since Moe 1969.

Mating Systems - Utilize new approaches to characterize the mating system such as measurement of the amount of androgen across species and across size within species (Shepherd et al. 2013).

Develop full egg production model by accounting for temporal changes in batch fecundity and intensity of spawning and incorporate spawning frequency by size and/or age.

#### 2.9.5 Meristic & Conversion factors

Continue to communicate the need to standardize length (natural total length, maximum total length, fork length, and standard length), weight (whole and gutted) measurements and the units (metric –e.g., millimeters, kilograms) used in collecting data among all sampling programs to minimize measurement errors.

#### 2.10 LITERATURE CITED

- Addis, D. T., W.F. Patterson, III and M.A. Dance. 2007. Site fidelity of reef fishes tagged at unreported artificial reef sites off northwest Florida. *Gulf and Caribbean Fisheries Institute* 60:297-304.
- Alagaraja, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian Journal of Fisheries* 31: 177-208.
- Begg, G.A. 2005. Life history parameters. Pages 119-150 in S. X. Cadrin, K. D. Friedland, and J. R. Waldman, editors. *Stock Identification Methods, Applications in Fishery Science*. Elsevier Academic Press, Amsterdam.
- Beverton, R.J.H., and S.J. Holt. 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. *Rapp. Proc.-Verb. Réun. International Council for the Exploration of the Sea* 140:67–83.
- Brooks, E.N., K.W. Shertzer, T. Gedamke, and D.S. Vaughan. 2008. Stock assessment of protogynous fish: evaluating measures of spawning biomass used to estimate biological reference points. *Fishery Bulletin U.S.* 106:12-28.

- Bullock, L.H. and G.B. Smith. 1991. Seabasses (Pisces: Serranidae). In: Memoirs of the Hourglass Cruises. Vol. 8. Florida Marine Research Institute, Department of Natural Resources, St. Petersburg, FL. 243 pp.
- Burgos, J. M. 2001. Life history of the red grouper (*Epinephelus morio*) off the North Carolina and South Carolina coast. Master's Thesis. University of Charleston, South Carolina. 90 pp.
- Burns, K. M. and B. D. Robbins. 2006. Cooperative long-line sampling of the west Florida shelf shallow water grouper complex: characterization of life history, undersized bycatch and targeted habitat. Mote Marine Laboratory Technical report No. 1119.
- Burns, K. M., N.J. Brown-Peterson, R.M. Overstreet, J. Gannon, P. Simmons, J. Sprinkle and C. Weaver. 2008. Evaluation of the efficacy of the current minimum size regulation for selected reef fish based on release mortality and fish physiology. Mote Marine Laboratory Technical Report No. 1176 funded by NOAA under MARFIN Grant # NA17FF2010. 75p.
- Chih, C-P. 2014a. Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of Mexico. SEDAR42-DW-12. SEDAR, North Charleston, SC. 26pp.
- Chih, C-P. 2014b. Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984-2013. SEDAR42-DW-18. SEDAR, North Charleston, SC. 42 pp.
- Coleman F.C., C.C. Koenig, K.M. Scanlon S. Heppell, S. Heppell and M.W. Miller. 2010. Benthic habitat modification through excavation by red grouper, *Epinephelus morio*, in the northeastern Gulf of Mexico. Open Fish Science Journal 3:1-15.
- Coleman F.C., K.M. Scanlon and C.C. Koenig. 2011. Groupers on the edge: shelf edge spawning habitat in and around marine reserve of the northern Gulf of Mexico. Professional Geographer 63(4): 1-19
- Collins, A.B. and R.S. McBride . 2011. Demographics by depth: spatially explicit life-history dynamics of a protogynous reef fish. Fisheries Bulletin 109:232-242.

- Collins, A.B. and R.S. McBride. 2014. Variations in reproductive potential between nearshore and offshore spawning contingents of hogfish in the eastern Gulf of Mexico. *Fisheries Management and Ecology*. DOI:10:1111/fme.12102.
- DeVries, D. A. 2006. The life history, reproductive ecology, and demography of the red porgy, *Pagrus pagrus*, in the northeastern Gulf of Mexico. Doctoral dissertation. Florida State University, Tallahassee, Florida.
- Diaz, G.A., C.E. Porch, and M. Ortiz. 2004. Growth models for red snapper in U.S. Gulf of Mexico waters estimated from landings with minimum size limit restrictions. NMFS/SEFSC/SFD 2004-038, 13 p.
- Fitzhugh, G.R., H.M. Lyon, W.T. Walling, C.F. Levins, and L.A. Lombardi-Carlson. 2006. An update of Gulf of Mexico red grouper reproductive data and parameters for SEDAR12. SEDAR12-DW-04. SEDAR, Charleston, SC. 18 pp.
- Franks, J.S. 2003. First record of goliath grouper, *Epinephelus itajara*, in Mississippi coastal waters with comments on the first documented occurrence of red grouper, *Epinephelus morio*, off Mississippi. *Gulf and Caribbean Fisheries Institute* 56: 295-306.
- Freitas, M.O, R. L. Moura, R. B. Francini-Filo and C. V. Minte-Vera. 2011. Spawning patterns of commercially important reef fish (Lutjanidae and Serranidae) in the tropical western South Atlantic. *Scientia Marina* 75(1):135-146.
- Grüss, A., M. Karnauskas, S.R. Sagarese, C.B. Paris, G. Zapfe, J.F. Walter III, W. Ingram, and M.J. Schirripa. 2014. Use of the Connectivity Modeling System to estimate the larval dispersal, settlement patterns and annual recruitment anomalies due to oceanographic factors of red grouper (*Epinephelus morio*) on the West Florida Shelf. SEDAR42-DW-03. SEDAR, North Charleston, SC. 24 pp.
- Hewitt, D.A. and J.M. Hoenig. 2005. Comparison of two approaches for estimating natural mortality based on longevity. *Fisheries Bulletin* 103: 433-437.
- Hoenig, J.M. 1983. Empirical use of longevity data to estimate natural mortality rates. *Fisheries Bulletin* 82:898-903.

- Jensen, A. L. 1996. Beverton and Holt life history invariants result from optimal tradeoff of reproduction and survival. *Canadian Journal of Fisheries and Aquatic Sciences* 53:820-822.
- Johnson, A. G., L. A. Collins, J. Dahl, and M. S. Baker. 1995. Age, growth, and mortality of lane snapper from the northern Gulf of Mexico. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 49:178-186.
- Koenig, C.C. and F. C. Coleman. 2006. Demographics, density, and seasonal movement patterns of reef fish in the northeastern Gulf of Mexico associated with marine reserves. MARFIN Grant NA17FF2876 final report. 62 p.
- Lombardi-Carlson, L., C. Palmer, C. Gardner, and B. Farsky. 2006. Temporal and spatial trends in red grouper (*Epinephelus morio*) age and growth from the northeastern Gulf of Mexico: 1979-2005. SEDAR 12-DW-03. SEDAR, Charleston, SC. 43 p..
- Lombardi-Carlson, L., G. Fitzhugh, C. Palmer, B. Barnett, L. Goetz, and C. Fioramonti. 2009. Summary of gag and red grouper age data from the northeastern Gulf of Mexico for SEDAR (10/12) update: 2006-2008. 31 p. NMFS/SEFSC Panama City Laboratory Contribution 2009-06. SEDAR update.
- Lombardi-Carlson, L. 2014. An age and growth description of red grouper (*Epinephelus morio*) from the northeastern Gulf of Mexico: 1978-2013 for SEDAR42. SEDAR42-DW-10. SEDAR, North Charleston, SC. 37 pp.
- Lowerre-Barbieri, S., L. Crabtree, T.S. Switzer, R.H. McMichael. 2014. Size at maturity and at 50% male based upon histological analysis of the protogynous red grouper on the West Florida Shelf. SEDAR42-DW-07. SEDAR, North Charleston, SC. 21 pp.
- Lorenzen, K. 2005. Population dynamics and potential of fisheries stock enhancement: practical theory for assessment and policy analysis. *Philosophical Transactions of the Royal Society of London. Biological Sciences.* 360: 171-189.
- Moe, M. A., Jr. 1969. Biology of the red grouper *Epinephelus morio* (Valenciennes) from the eastern Gulf of Mexico. Florida Department of Natural Resources Marine Resources Laboratory Professional Paper No. 10, 95 p.

- Moe, M. A., Jr. 1972. Movement and migration of south Florida fishes. Florida Department of Natural Resources Marine Research Laboratory Technical Series. No. 69: 1- 25.
- Palmer, C.L., L. Lombardi, J. Carroll, and E. Crow. 2014. The use of otolith reference collections to determine ageing precision of red grouper (*Epinephelus morio*) between fisheries laboratories. SEDAR42-DW-13. SEDAR, North Charleston, SC. 10 pp.
- Pauly, D., and C. Binohlan. 1996. FishBase and AUXIM as tools for comparing the life history patterns, growth and natural mortality of fish: applications to snappers and groupers. Pages 218-243 in F. Arreguín-Sánchez, J.L. Munro, M.C. Balgos and D. Pauly, editors. Biology, Fisheries and Culture of Tropical Groupers and Snappers. International Center for Living Aquatic Resources Management Conference Proceedings. Makati City, Philippines.
- Porch, C.E. 2004. Batch-fecundity and maturity estimates for the 2004 assessment of red snapper in the Gulf of Mexico. SEDAR07-AW-05. SEDAR, Charleston, SC. 15 pp.
- Pulver, J.R., L. Lombardi, and E. Scott-Denton. 2014. Summary of commercial red grouper (*Epinephelus morio*) catch data based on fishery observer coverage of the Gulf of Mexico reef fish fishery. SEDAR42-DW-01. SEDAR, North Charleston, SC. 40 pp.
- Quinn, T.J., and R.B. Deriso. 1999. Quantitative Fish Dynamics. Oxford University Press, Inc., New York.
- Ralston, S. 1987. Mortality rates of snappers and groupers. Pages 375-404 in J. J. Polovina and S. Ralston, editors. Tropical Snappers and Groupers: Biology and fisheries management. Westview Press, Boulder.
- Richardson, L.R., and J.R. Gold. 1997. Mitochondrial DNA diversity in and population structure of red grouper, *Epinephelus morio*, from the Gulf of Mexico. Fisheries Bulletin 95:174-179.
- Sauls, B., O. Ayala, and R. Cody. 2014. A directed study of the recreational red snapper fisheries in the Gulf of Mexico along the west Florida shelf – Final Project Report. SEDAR42-RD-01. 100 pp.
- SEDAR. 2006. SEDAR12. Stock Assessment Report for Gulf of Mexico Red Grouper. SEDAR, Charleston, SC. 358 pp.

- SEDAR. 2014a. SEDAR33. Stock Assessment Report for Gulf of Mexico Gag. SEDAR, North Charleston, SC. 609 pp.
- SEDAR. 2014b. SEDAR37. The 2013 Stock Assessment Report for Hogfish in the South Atlantic and Gulf of Mexico. FL FWCC/FWRI, St. Petersburg, FL. 573 pp.
- SEFSC. 2009. SEDAR Update Assessment. Stock Assessment of the Red Grouper in the Gulf of Mexico. SEFSC. Miami, FL. 143 pp.
- Shepherd, G., K. Shertzer, J. Coakley and M. Caldwell (Eds.). 2013. Modeling protogynous hermaphrodite fishes workshop. SEDAR33-RD-19. SEDAR, North Charleston, SC. 35 pp.
- Schirripa, M.J., C.M. Legault, and M. Ortiz. 1999. The red grouper fishery of the Gulf of Mexico: assessment 3.0. SEFSC, SFD. Contribution No. SFD – 98/99- 56.
- Wall, C.C., B.T. Donahue, D.F. Naar, and D.A. Mann. 2011. Spatial and temporal variability of red grouper within Steamboat Lumps Marine reserve, Gulf of Mexico. Marine Ecology Progress Series 431: 243-254.
- Wallace, A.A., D.J. Hollander and E.B. Peebles. 2014. Stable isotope in fish eye lenses as potential recorders of geographic history. ONE 9(10): e108935.  
doi:10.1371/journal.pone.0108935.
- Wilson, R. R. and K. M. Burns. 1996. Potential survival of released groupers caught deeper than 40m based on shipboard and in-situ observations, and tag-recapture data. Bulletin of Marine Science 58:234-247.
- Zatcoff, M.S., A.O. Ball, and G.R. Sedberry. 2004. Population genetic analysis of red grouper, *Epinephelus morio*, and scamp, *Mycteroperca phenax*, from the southeastern U.S. Atlantic and Gulf of Mexico. Marine Biology. 144:769-777.

## 2.11 TABLES

Table 2.1. Summary of the number of red grouper otoliths collected by source (TIP - Trip Interview Program, FWRI - Florida Fish and Wildlife Research Institute, HB – Southeast Recreational Headboat Survey, MRFSS - Marine Recreational Fisheries Statistical Survey, RECFIN - Recreational Fisheries Information Network, MSLAB -NMFS Pascagoula MS; PCLAB - NMFS Panama City, FL; CRP - Cooperative Research Proposals, EASA – Expanded Annual Stock Assessment Survey, NMFS Pascagoula, MS; Obs – NMFS Reef Fish Observer Program, Galveston, TX; NMFS Shark Bottom Long-line Observer Program, Panama City, FL; Other - ALLIANCE – expanded vertical line survey from MSLAB, DISL – Dauphin Island Sea Lab, Fishery Independent Survey; FIN – Gulf States Marine Fisheries Commission, Fisheries Information Network, samples from Alabama only; SEAMAP – Fishery Independent Survey, state of Alabama; US Geological Survey, Unknown).

| Year | TIP   | FWRI | HB | MRFSS | RECFIN | MSLAB | PCLAB | CRP | EASA | Obs | Other | Total |
|------|-------|------|----|-------|--------|-------|-------|-----|------|-----|-------|-------|
| 1978 |       |      |    |       |        | 1     |       |     |      |     |       | 1     |
| 1979 |       |      |    |       |        |       | 75    |     |      |     |       | 75    |
| 1980 |       |      | 5  |       |        |       |       |     |      |     | 3     | 8     |
| 1981 |       |      | 14 |       |        | 80    |       |     |      |     | 215   | 309   |
| 1985 |       |      | 1  |       |        |       |       |     |      |     |       | 1     |
| 1986 |       |      | 9  |       |        |       |       |     |      |     |       | 9     |
| 1987 |       |      | 11 |       |        |       |       |     |      |     |       | 11    |
| 1988 |       |      | 10 |       |        |       |       |     |      |     |       | 10    |
| 1989 |       |      | 11 |       |        |       |       |     |      |     |       | 11    |
| 1991 | 102   |      | 32 |       |        |       |       |     |      |     |       | 134   |
| 1992 | 252   |      | 31 |       |        | 5     |       |     |      |     | 2     | 290   |
| 1993 | 479   |      | 18 |       |        |       |       |     |      |     |       | 497   |
| 1994 | 490   |      | 23 |       |        | 6     | 7     |     |      |     |       | 526   |
| 1995 | 522   |      | 34 |       |        | 25    |       |     |      |     |       | 581   |
| 1996 | 436   |      | 34 |       |        |       |       |     |      |     |       | 470   |
| 1997 | 165   |      | 10 |       |        | 1     |       |     |      |     |       | 176   |
| 1998 | 283   | 13   |    |       |        | 7     | 3     |     |      |     |       | 306   |
| 1999 | 850   |      | 2  | 33    |        | 11    | 9     |     |      |     |       | 905   |
| 2000 | 697   |      | 11 | 12    |        | 1     | 88    |     |      |     |       | 809   |
| 2001 | 1,852 |      |    | 31    |        | 83    | 100   | 2   |      |     | 1     | 2,069 |
| 2002 | 2,190 | 18   | 1  | 69    | 44     | 30    | 216   | 310 |      |     | 6     | 2,884 |
| 2003 | 3,026 | 28   | 29 | 121   |        | 62    | 48    | 54  |      |     | 6     | 3,374 |
| 2004 | 2,982 | 63   | 41 | 68    | 87     | 170   | 186   | 478 |      |     | 14    | 4,089 |

February 2015

Gulf of Mexico Red Grouper

|         |        |       |     |     |       |       |       |       |       |       |        |        |
|---------|--------|-------|-----|-----|-------|-------|-------|-------|-------|-------|--------|--------|
| 2005    | 3,623  | 21    | 29  | 18  | 67    | 50    | 127   | 458   |       | 3     | 4,396  |        |
| 2006    | 4,282  | 122   | 21  |     | 33    | 58    | 32    |       |       | 5     | 4,553  |        |
| 2007    | 3,625  | 305   | 22  | 7   | 32    | 51    | 24    |       | 105   | 2     | 4,173  |        |
| 2008    | 2,853  | 182   | 9   | 18  | 113   | 42    | 92    |       | 9     |       | 3,318  |        |
| 2009    | 6,047  | 1,007 | 9   | 8   | 190   | 96    | 132   | 2,235 | 10    | 1     | 9,735  |        |
| 2010    | 5,583  | 1,021 | 18  | 35  | 353   | 197   | 100   |       | 145   | 25    | 7,477  |        |
| 2011    | 10,679 | 968   | 35  | 68  | 439   | 147   | 139   |       | 1,014 | 19    | 13,508 |        |
| 2012    | 14,460 | 644   | 34  | 18  | 199   | 140   | 95    | 162   |       | 463   | 11     | 16,226 |
| 2013    | 12,595 | 833   | 16  |     | 274   | 56    | 23    |       |       | 613   | 2      | 14,412 |
| Total   | 78,073 | 5,225 | 520 | 506 | 1,831 | 1,319 | 1,496 | 3,699 | 1,014 | 1,345 | 315    | 95,343 |
| Percent | 81.9   | 5.5   | 0.5 | 0.5 | 1.9   | 1.4   | 1.6   | 3.9   | 1.1   | 1.4   | 0.3    |        |

Table 2.2. Summary of the number of red grouper otoliths collected by sector (CM - Commercial, CP - Charter Party, HB – Headboat, PR - Private, SS - Scientific Survey, Other Modes – Tournament, Unknown) and gear (LL - Long-Line, HL - Hand-Line, VLL – Vertical Long-line, TR - Trap, TRW – Trawl, Other – kali pole, seine net, spear, unknown and undersized fish from CRP in 2009 and recreational vessels in 2009-2011). The recreational (REC) sector composed of otoliths intercepted from charter boats (CP), head boats (HB), and private vessels (PR) from HL in 1979-1980 and spears in other years.

| Year | CM<br>LL | CM<br>HL | CM<br>VLL | CM<br>TR | CM<br>Other | CP<br>HL | HB<br>HL | PR<br>HL | REC<br>Other | SS<br>HL | SS<br>LL | SS<br>TR | SS<br>TRW | SS<br>VLL | SS<br>Other | Other | Total |
|------|----------|----------|-----------|----------|-------------|----------|----------|----------|--------------|----------|----------|----------|-----------|-----------|-------------|-------|-------|
| 1978 |          |          |           |          |             |          |          |          |              | 1        |          |          |           |           |             |       | 1     |
| 1979 |          |          |           |          |             |          |          |          | 75           |          |          |          |           |           |             |       | 75    |
| 1980 |          | 1        |           |          |             |          | 5        |          | 2            |          |          |          |           |           |             |       | 8     |
| 1981 |          | 215      |           |          |             |          | 14       |          |              | 11       | 4        | 64       |           |           | 1           |       | 309   |
| 1985 |          |          |           |          |             |          | 1        |          |              |          |          |          |           |           |             |       | 1     |
| 1986 |          |          |           |          |             |          | 9        |          |              |          |          |          |           |           |             |       | 9     |
| 1987 |          |          |           |          |             |          | 11       |          |              |          |          |          |           |           |             |       | 11    |
| 1988 |          |          |           |          |             |          | 10       |          |              |          |          |          |           |           |             |       | 10    |
| 1989 |          |          |           |          |             |          | 11       |          |              |          |          |          |           |           |             |       | 11    |
| 1991 | 48       | 46       |           | 2        |             | 1        | 37       |          |              |          |          |          |           |           |             |       | 134   |
| 1992 | 156      | 44       |           | 16       |             | 25       | 33       | 1        |              | 5        |          |          |           |           |             | 10    | 290   |
| 1993 | 201      | 94       |           | 84       |             | 61       | 21       | 2        |              |          |          | 5        |           |           |             | 29    | 497   |
| 1994 | 88       | 242      |           | 29       |             | 75       | 29       |          |              | 7        |          | 6        |           |           |             | 50    | 526   |
| 1995 | 151      | 202      |           | 41       |             | 99       | 61       |          |              | 21       |          | 4        |           |           |             | 2     | 581   |
| 1996 | 103      | 152      |           | 9        | 6           | 151      | 44       |          |              | 5        |          |          |           |           |             |       | 470   |
| 1997 | 8        | 41       |           | 17       | 1           | 69       | 30       | 9        |              | 1        |          |          |           |           |             |       | 176   |
| 1998 | 124      | 42       |           | 33       |             | 74       | 21       | 4        |              | 8        |          |          |           |           |             |       | 306   |
| 1999 | 662      | 77       |           | 31       |             | 104      | 9        | 2        |              | 20       |          |          |           |           |             |       | 905   |

|         |        |        |       |     |     |       |       |     |     |       |       |       |     |     |       |       |        |
|---------|--------|--------|-------|-----|-----|-------|-------|-----|-----|-------|-------|-------|-----|-----|-------|-------|--------|
| 2000    | 412    | 213    |       | 38  | 6   | 59    | 12    |     |     | 68    |       | 1     |     |     |       |       | 809    |
| 2001    | 1,238  | 583    |       | 40  | 3   | 48    | 1     | 2   |     | 71    | 80    | 3     |     |     |       |       | 2,069  |
| 2002    | 1,809  | 573    |       | 89  | 1   | 287   | 50    | 7   | 6   | 9     | 16    | 18    |     |     | 19    |       | 2,884  |
| 2003    | 2,422  | 567    |       | 65  | 4   | 101   | 30    | 64  | 4   | 25    | 62    | 14    | 9   |     | 7     |       | 3,374  |
| 2004    | 2,340  | 1,070  |       | 38  | 1   | 144   | 43    | 39  | 2   | 139   | 168   | 52    | 52  | 1   |       |       | 4,089  |
| 2005    | 3,442  | 630    |       |     | 4   | 64    | 52    | 1   |     | 72    | 32    | 88    | 5   | 1   | 5     |       | 4,396  |
| 2006    | 3,465  | 633    |       | 174 |     | 38    | 33    | 6   |     | 5     | 98    | 55    | 28  | 14  | 4     |       | 4,553  |
| 2007    | 2,553  | 1,139  |       |     | 2   | 46    | 29    | 10  | 6   | 74    | 80    | 59    | 107 | 60  | 8     |       | 4,173  |
| 2008    | 2,065  | 755    |       |     | 11  | 64    | 44    | 25  | 17  | 33    | 30    | 154   | 97  | 2   | 21    |       | 3,318  |
| 2009    | 2,704  | 3,840  | 180   |     | 17  | 89    | 104   | 16  | 14  | 400   | 64    | 490   | 261 |     | 1,556 |       | 9,735  |
| 2010    | 2,481  | 1,776  | 1,341 |     | 149 | 263   | 86    | 31  | 18  | 705   | 93    | 341   | 98  | 80  | 15    |       | 7,477  |
| 2011    | 4,613  | 5,892  | 115   |     | 24  | 391   | 114   | 15  | 1   | 198   | 1,090 | 534   | 76  | 15  | 431   |       | 13,508 |
| 2012    | 5,898  | 8,943  | 188   |     | 40  | 225   | 40    | 12  | 2   | 181   | 116   | 435   | 116 | 6   | 24    |       | 16,226 |
| 2013    | 5,607  | 7,479  | 32    |     | 80  | 216   | 45    | 17  | 8   | 295   | 111   | 359   | 65  | 71  | 1     | 26    | 14,412 |
| Total   | 42,590 | 35,249 | 1,856 | 706 | 349 | 2,694 | 1,029 | 263 | 155 | 2,354 | 2,044 | 2,682 | 914 | 172 | 80    | 2,207 | 95,343 |
| Percent | 44.7   | 37.0   | 1.9   | 0.7 | 0.4 | 2.8   | 1.1   | 0.3 | 0.2 | 2.5   | 2.1   | 2.8   | 1.0 | 0.2 | 0.1   | 2.3   |        |

Table 2.3. Summary of the number of red grouper otoliths collected, read, and determined unreadable (1978-2001) or sub-sampled to be aged (2002-2013). \*These totals also include those otoliths and ages provided by other ageing facilities. The only fish sub-sampled were those collected by Trip Interview Program port agents from the commercial industry (see Lombardi-Carlson 2014, further information on sub-sampling).

| Year  | Otoliths<br>collected | Otoliths<br>sub-sampled* | Otoliths<br>read | Otoliths<br>not readable | Otoliths<br>not readable (%) |
|-------|-----------------------|--------------------------|------------------|--------------------------|------------------------------|
| 1978  | 1                     |                          | 1                | 1                        | 100                          |
| 1979  | 75                    |                          | 75               | 4                        | 5                            |
| 1980  | 8                     |                          | 8                | 0                        | 0                            |
| 1981  | 309                   |                          | 309              | 8                        | 3                            |
| 1985  | 1                     |                          | 1                | 0                        | 0                            |
| 1986  | 9                     |                          | 9                | 1                        | 11                           |
| 1987  | 11                    |                          | 11               | 0                        | 0                            |
| 1988  | 10                    |                          | 10               | 0                        | 0                            |
| 1989  | 11                    |                          | 11               | 0                        | 0                            |
| 1991  | 134                   |                          | 134              | 15                       | 11                           |
| 1992  | 290                   |                          | 290              | 18                       | 6                            |
| 1993  | 497                   |                          | 497              | 3                        | 1                            |
| 1994  | 526                   |                          | 526              | 7                        | 1                            |
| 1995  | 581                   |                          | 581              | 53                       | 9                            |
| 1996  | 470                   |                          | 470              | 39                       | 8                            |
| 1997  | 176                   |                          | 176              | 17                       | 10                           |
| 1998  | 306                   |                          | 306              | 7                        | 2                            |
| 1999  | 905                   |                          | 905              | 20                       | 2                            |
| 2000  | 809                   |                          | 809              | 15                       | 2                            |
| 2001  | 2,069                 |                          | 2,069            | 41                       | 2                            |
| 2002  | 2,884                 | 2,150                    | 2,150            | 9                        | 0                            |
| 2003  | 3,374                 | 2,036                    | 2,036            | 14                       | 1                            |
| 2004  | 4,089                 | 2,910                    | 2,910            | 20                       | 1                            |
| 2005  | 4,396                 | 2,424                    | 2,424            | 20                       | 1                            |
| 2006  | 4,553                 | 1,624                    | 1,624            | 13                       | 1                            |
| 2007  | 4,173                 | 1,577                    | 1,577            | 19                       | 1                            |
| 2008  | 3,318                 | 1,499                    | 1,499            | 6                        | 0                            |
| 2009  | 9,735                 | 4,901                    | 4,901            | 44                       | 1                            |
| 2010  | 7,477                 | 3,447                    | 3,447            | 45                       | 1                            |
| 2011  | 13,508                | 3,989                    | 3,989            | 38                       | 1                            |
| 2012  | 16,226                | 3,109                    | 3,109            | 60                       | 2                            |
| 2013  | 14,412                | 2,993                    | 2,993            | 54                       | 2                            |
| Total | 95,343                | 32,659                   | 39,857           | 591                      | 1                            |

Table 2.4. Annual observed numbers at age for red grouper sampled from the northeastern Gulf of Mexico for 1991-2013. Data combined from fishery dependent (commercial and recreational) and independent sources.

| Age   | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| 0     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 3    | 10   |      | 1    | 1    |      | 1    |      | 16    |
| 1     |      |      |      |      |      |      |      |      |      |      |      |      | 4    | 4    |      | 6    | 91   | 94   | 19   | 4    | 7    | 15   | 11   | 255   |
| 2     |      |      | 1    |      |      |      |      |      |      |      | 7    |      | 3    | 53   | 4    | 22   | 11   | 132  | 280  | 27   | 31   | 53   | 28   | 652   |
| 3     | 2    | 1    | 3    | 8    |      | 1    | 1    | 2    | 3    | 8    | 6    | 24   | 21   | 13   | 51   | 17   | 17   | 3    | 1257 | 408  | 97   | 48   | 35   | 2026  |
| 4     | 7    | 5    | 46   | 79   | 16   | 8    | 9    | 20   | 10   | 142  | 71   | 70   | 208  | 129  | 22   | 69   | 16   | 48   | 242  | 1044 | 1002 | 92   | 54   | 3409  |
| 5     | 19   | 48   | 52   | 125  | 92   | 86   | 19   | 48   | 86   | 67   | 740  | 198  | 131  | 877  | 231  | 52   | 279  | 87   | 364  | 140  | 1682 | 701  | 195  | 6319  |
| 6     | 17   | 54   | 114  | 71   | 159  | 138  | 42   | 61   | 104  | 139  | 236  | 640  | 268  | 221  | 1048 | 245  | 153  | 361  | 366  | 251  | 187  | 1336 | 993  | 7204  |
| 7     | 14   | 63   | 120  | 89   | 97   | 97   | 51   | 73   | 130  | 95   | 339  | 307  | 439  | 382  | 178  | 643  | 248  | 148  | 1081 | 360  | 222  | 183  | 1022 | 6381  |
| 8     | 9    | 43   | 86   | 58   | 65   | 32   | 21   | 42   | 211  | 90   | 164  | 261  | 221  | 408  | 250  | 237  | 411  | 227  | 403  | 550  | 168  | 147  | 164  | 4268  |
| 9     | 16   | 20   | 35   | 36   | 40   | 42   | 3    | 25   | 165  | 84   | 81   | 169  | 199  | 218  | 248  | 102  | 124  | 233  | 397  | 248  | 266  | 102  | 111  | 2964  |
| 10    | 15   | 16   | 15   | 23   | 23   | 18   | 2    | 10   | 79   | 59   | 134  | 97   | 121  | 180  | 135  | 77   | 60   | 59   | 294  | 211  | 94   | 155  | 92   | 1969  |
| 11    | 3    | 7    | 9    | 9    | 11   | 3    | 3    | 8    | 46   | 52   | 92   | 101  | 88   | 103  | 72   | 46   | 55   | 38   | 74   | 82   | 95   | 79   | 105  | 1181  |
| 12    | 5    | 8    | 3    | 6    | 8    | 2    | 1    | 5    | 23   | 21   | 50   | 87   | 88   | 70   | 49   | 30   | 26   | 23   | 19   | 14   | 53   | 60   | 31   | 682   |
| 13    | 3    | 3    | 3    | 7    | 6    | 1    | 3    | 1    | 13   | 13   | 31   | 61   | 68   | 56   | 29   | 20   | 15   | 12   | 17   | 21   | 13   | 46   | 41   | 483   |
| 14    |      |      | 1    | 3    | 4    |      | 1    | 2    | 6    | 7    | 24   | 33   | 40   | 57   | 24   | 12   | 18   | 7    | 11   | 14   | 8    | 9    | 38   | 319   |
| 15    | 1    |      | 1    | 1    |      | 1    | 1    | 2    | 3    | 6    | 16   | 26   | 37   | 36   | 14   | 9    | 7    | 4    | 9    | 8    | 8    | 14   | 6    | 210   |
| 16    | 2    |      | 1    |      | 2    |      | 2    |      | 2    | 3    | 13   | 18   | 21   | 18   | 14   | 8    | 5    | 4    | 5    | 7    | 6    | 1    | 5    | 137   |
| 17    |      | 2    |      |      |      | 1    |      |      | 1    | 1    | 9    | 10   | 23   | 17   | 7    | 5    | 4    | 4    | 4    | 4    | 1    | 2    | 1    | 96    |
| 18    |      | 1    | 2    |      |      |      |      |      | 1    | 1    | 3    | 12   | 14   | 18   | 6    | 2    | 3    | 4    | 3    | 3    | 1    |      | 3    | 77    |
| 19    | 2    |      |      |      |      |      |      |      |      | 2    | 3    | 5    | 10   | 10   | 4    | 1    | 3    | 3    | 2    | 4    | 5    | 3    | 1    | 58    |
| 20    |      |      |      |      |      |      |      |      | 1    | 2    | 4    | 2    | 5    | 9    | 5    | 4    | 2    |      | 2    |      | 2    | 2    | 1    | 41    |
| 21    | 1    |      |      | 1    | 2    |      |      |      |      | 1    | 2    | 7    | 2    | 3    | 7    |      |      | 1    | 2    |      | 1    |      | 1    | 31    |
| 22    |      |      |      |      | 1    |      |      |      |      |      |      |      | 2    | 2    | 1    | 1    |      | 1    | 2    |      | 1    | 1    | 1    | 13    |
| 23    | 1    |      |      |      | 1    |      |      |      |      | 1    |      | 1    | 1    | 2    | 2    |      |      |      |      | 1    |      |      |      | 10    |
| 24    | 2    |      | 1    | 1    |      | 1    |      |      |      |      | 2    | 4    | 5    | 1    |      |      |      |      | 1    |      | 1    |      |      | 19    |
| 25    |      |      | 1    | 1    | 1    |      |      |      |      |      |      | 3    | 3    | 1    | 3    |      |      |      | 1    |      |      |      |      | 14    |
| 26    |      |      |      |      |      |      |      |      |      |      |      | 2    |      |      |      |      |      |      | 1    |      |      |      |      | 3     |
| 27    |      |      |      | 1    |      |      |      |      |      | 1    | 2    |      |      | 2    |      |      |      |      |      |      |      |      |      | 6     |
| 28    |      |      |      |      |      |      |      |      | 1    |      | 1    |      |      |      |      |      |      |      |      |      |      |      |      | 2     |
| 29    |      | 1    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1     |
| Total | 119  | 272  | 494  | 519  | 528  | 431  | 159  | 299  | 885  | 794  | 2028 | 2141 | 2022 | 2890 | 2404 | 1611 | 1558 | 1493 | 4857 | 3402 | 3951 | 3050 | 2939 | 38846 |

Table 2.5. Growth curve parameters  $\pm$  standard deviation ( $L_{\infty}$  - asymptotic length,  $k$  – growth coefficient,  $t_0$  – size at time zero, sigma – standard deviation, CV – coefficient of variation) for red grouper from the northeastern Gulf of Mexico for fractional ages and observed fork lengths at capture provided for the current (1991-2013) and previous size-modified growth curves (SEDAR12, years:1991-2005, Lombardi-Carlson et al. 2006; update, years:1991-2008, Lombardi-Carlson et al. 2009). \*Suggested growth model to use.

| Model                | n     | $L_{\infty}$                     | k                                   | $t_0$                                | Sigma            | CV                                                                         |
|----------------------|-------|----------------------------------|-------------------------------------|--------------------------------------|------------------|----------------------------------------------------------------------------|
| Constant CV*         | 38813 | 829 $\pm$ 5.50 (FL)              | 0.1251 $\pm$ 2.0 x 10 <sup>-3</sup> | -1.2022 $\pm$ 3.4 x 10 <sup>-2</sup> |                  | 0.1548 $\pm$ 7.7 x 10 <sup>-4</sup>                                        |
| Constant std dev     | 38813 | 841 $\pm$ 5.37 (FL)              | 0.1248 $\pm$ 2.2 x 10 <sup>-3</sup> | -1.0590 $\pm$ 5.3 x 10 <sup>-2</sup> | 79.59 $\pm$ 0.46 |                                                                            |
| CV increase with age | 38813 | 830 $\pm$ 5.83 (FL)              | 0.1249 $\pm$ 2.0 x 10 <sup>-3</sup> | -1.2027 $\pm$ 3.5 x 10 <sup>-2</sup> |                  | 0.1559 $\pm$ 2.2 x 10 <sup>-3</sup><br>0.1510 $\pm$ 6.9 x 10 <sup>-3</sup> |
| update               | 20143 | 884 (TL), 845 ( <sup>1</sup> FL) | 0.13                                | -1.01                                | 83.37            |                                                                            |
| SEDAR12              | 15953 | 854 (TL), 817 ( <sup>1</sup> FL) | 0.16                                | -0.19                                | 82.83            |                                                                            |

<sup>1</sup> Fork length predicted from total length, using  $FL = 5.35 + TL * 0.95$

Table 2.6 The resulting model objective functions (negative log likelihood), the change in the objective function, and resulting Akaike Information Criteria for each phase of the model for the minimum-size corrected von Bertalanffy growth model using three types of the variance structure (std dev – standard deviation, CV – coefficient of variation). \*Suggested growth model to use.

| Variance Structure   | Phase | # parameters | Objective              | Change                  | AIC                    | AICc                   | Delta AICc              |
|----------------------|-------|--------------|------------------------|-------------------------|------------------------|------------------------|-------------------------|
|                      |       |              | Function (nLL)         | Obj. function           |                        |                        |                         |
| Constant CV*         | 1     | 3            | $2.07 \times 10^{+05}$ |                         | $4.13 \times 10^{+05}$ | $4.13 \times 10^{+05}$ |                         |
|                      | 2     | 3            | $2.07 \times 10^{+05}$ |                         | $4.13 \times 10^{+05}$ | $4.13 \times 10^{+05}$ | $-1.92 \times 10^{-09}$ |
|                      | 3     | 4            | $2.01 \times 10^{+05}$ | $-5.72 \times 10^{+03}$ | $4.02 \times 10^{+05}$ | $4.02 \times 10^{+05}$ | $-1.14 \times 10^{+04}$ |
| Constant std dev     | 1     | 3            | $1.08 \times 10^{+06}$ |                         | $2.15 \times 10^{+06}$ | $2.15 \times 10^{+06}$ |                         |
|                      | 2     | 3            | $1.08 \times 10^{+06}$ |                         | $2.15 \times 10^{+06}$ | $2.15 \times 10^{+06}$ | $-2.33 \times 10^{-09}$ |
|                      | 3     | 4            | $2.02 \times 10^{+05}$ | $-8.73 \times 10^{+05}$ | $4.05 \times 10^{+05}$ | $4.05 \times 10^{+05}$ | $-1.75 \times 10^{+06}$ |
| CV increase with age | 1     | 3            | $2.06 \times 10^{+05}$ |                         | $4.12 \times 10^{+05}$ | $4.12 \times 10^{+05}$ |                         |
|                      | 2     | 3            | $2.06 \times 10^{+05}$ |                         | $4.12 \times 10^{+05}$ | $4.12 \times 10^{+05}$ | $-3.09 \times 10^{-09}$ |
|                      | 3     | 5            | $2.01 \times 10^{+05}$ | $-2.53 \times 10^{+03}$ | $4.02 \times 10^{+05}$ | $4.02 \times 10^{+05}$ | $-1.01 \times 10^{+04}$ |

Table 2.7. Multiple methods used to estimate natural mortality (M). Definitions of parameters: Linf = von Bertalanffy asymptotic length (FL, mm), k = von Bertalanffy growth coefficient, Amax = maximum age (yr), A50 = age at 50% mature, Lat = length at age (t), Temp = average water temperature (°C), S = survivorship. Water temperature based on annual mean estimate at bottom from the U.S. Gulf shelf (Johnson et al. 1995, DeVries 2006).

| Method                                     | Parameters              | Citation                  | Equation                                                                                                                                                   |
|--------------------------------------------|-------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alverson & Carney                          | k, Amax                 | Quinn & Deriso (1999)     | $M = 3k/(\exp(0.38 \cdot A_{\max} \cdot k) - 1)$                                                                                                           |
| Beverton & Holt                            | k, A50                  | Beverton and Holt (1956)  | $M = 3k/(\exp(A_{50} \cdot k) - 1)$                                                                                                                        |
| Hoening <sub>teleosts</sub>                | Amax                    | Hoening (1983)            | $M = \exp(1.46 - 1.01 \cdot \ln(A_{\max}))$                                                                                                                |
| Hoening <sub>all taxa</sub>                | Amax                    | Hoening (1983)            | $M = \exp(1.44 - 0.982 \cdot \ln(A_{\max}))$                                                                                                               |
| Pauly                                      | Linf, k, Temp           | Quinn & Deriso (1999)     | $M = 10^{(-0.0066 - 0.279 \cdot (\log(\text{Linf})) + 0.6543 \cdot \log(k) + 0.4634 \cdot \log(\text{Temp}))}$                                             |
| Pauly Method II<br>(snappers and groupers) | Linf, k, Temp           | Pauly and Binohlan (1996) | $M = 10^{(-0.0636 - 0.279 \cdot (\log(\text{Linf})) + 0.6543 \cdot \log(k) + 0.4634 \cdot \log(\text{Temp}))}$                                             |
| Ralston                                    | k                       | Ralston (1987)            | $M = 0.0189 + 2.06 \cdot k$                                                                                                                                |
| Ralston (geometric mean)                   | k                       | Ralston (1987)            | $M = -0.0666 + 2.52 \cdot k$                                                                                                                               |
| Ralston Method II                          | k                       | Pauly and Binohlan (1996) | $M = -0.1778 + 3.1687 \cdot k$                                                                                                                             |
| Lorenzen Age-Specific                      | M, Linf, k              | Lorenzen (2005)           | $\text{Survival} = \exp(-M \cdot t)$<br>$= \exp(\ln((\text{Lat}/(\text{Lat} + \text{Linf} \cdot (\exp(k \cdot t) - 1))) \cdot (M/(\text{Linf} \cdot K))))$ |
| Jensen                                     | k<br>Amax,              | Jensen (1996)             | $M = 1.5 \cdot k$                                                                                                                                          |
| Alagaraja                                  | Survivorship to<br>Amax | Alagaraja (1984)          | $M = -\ln[S(A_{\max})]/A_{\max}$ ; derived from $S(A_{\max}) = \exp(-M \cdot A_{\max})$                                                                    |
| Rule of Thumb                              | Amax                    | Hewitt and Hoening (2005) | $M = 2.996/A_{\max}$                                                                                                                                       |

Table 2.8. List of parameter values used to estimate natural mortality (M) and resulting natural mortalities (M) for each method described in Table 2.7.

| Parameter                                  | Value     |
|--------------------------------------------|-----------|
| Data Source                                | 1991-2013 |
| Maximum age (A <sub>max</sub> )            | 29        |
| Number of fish aged                        | 38,813    |
| von Bertalanffy (L <sub>inf</sub> , FL mm) | 829       |
| von Bertalanffy (k)                        | 0.1251    |
| Age at 50% maturity (A <sub>50</sub> )     | 3         |

| Method                      | M      |
|-----------------------------|--------|
| Alverson & Carney           | 0.1264 |
| Beverton & Holt             | 0.8240 |
| Hoening <sub>teleosts</sub> | 0.1436 |
| Hoening <sub>all taxa</sub> | 0.1546 |
| Pauly                       | 0.3088 |
| Pauly Method II             | 0.2708 |
| Ralston                     | 0.2767 |
| Ralston (geo mean)          | 0.2488 |
| Ralston Method II           | 0.2187 |
| Jensen                      | 0.1877 |
| Hewitt & Hoening            | 0.1033 |
| Alagaraja, S = 0.01         | 0.1588 |
| Alagaraja, S = 0.02         | 0.1209 |
| Alagaraja, S = 0.05         | 0.1033 |

Table 2.9 Resulting age-specific natural mortality (M) vectors for SEDAR42, update assessment 2009 and SEDAR12. Each vector was calculated using the same regression (Lorenzen 2005), age 5 as the first age at vulnerability, with a target M of 0.14 ( $M_{\text{Hoenig}_{\text{teleost}}}$ , maximum age of 29 years). The only difference among the age-specific natural mortality vectors were the predicted von Bertalanffy growth parameters used in the estimations.

| Age | SEDAR42 | 2009 update | SEDAR12 |
|-----|---------|-------------|---------|
| 0   | 0.5837  | 0.6309      | 1.0000  |
| 1   | 0.3952  | 0.4092      | 0.4943  |
| 2   | 0.3082  | 0.3137      | 0.3391  |
| 3   | 0.2583  | 0.2606      | 0.2681  |
| 4   | 0.2261  | 0.2269      | 0.2277  |
| 5   | 0.2036  | 0.2038      | 0.2018  |
| 6   | 0.1873  | 0.1871      | 0.1840  |
| 7   | 0.1749  | 0.1745      | 0.1712  |
| 8   | 0.1652  | 0.1648      | 0.1616  |
| 9   | 0.1576  | 0.1571      | 0.1542  |
| 10  | 0.1514  | 0.1510      | 0.1484  |
| 11  | 0.1463  | 0.1459      | 0.1438  |
| 12  | 0.1421  | 0.1418      | 0.1401  |
| 13  | 0.1386  | 0.1383      | 0.1371  |
| 14  | 0.1356  | 0.1354      | 0.1347  |
| 15  | 0.1331  | 0.1330      | 0.1327  |
| 16  | 0.1310  | 0.1309      | 0.1310  |
| 17  | 0.1291  | 0.1291      | 0.1296  |
| 18  | 0.1276  | 0.1276      | 0.1284  |
| 19  | 0.1262  | 0.1263      | 0.1274  |
| 20  | 0.1250  | 0.1252      | 0.1266  |
| 21  | 0.1240  | 0.1242      | 0.1259  |
| 22  | 0.1231  | 0.1234      | 0.1254  |
| 23  | 0.1224  | 0.1227      | 0.1249  |
| 24  | 0.1217  | 0.1220      | 0.1244  |
| 25  | 0.1211  | 0.1215      | 0.1241  |
| 26  | 0.1206  | 0.1210      | 0.1238  |
| 27  | 0.1202  | 0.1206      | 0.1235  |
| 28  | 0.1198  | 0.1202      | 0.1233  |
| 29  | 0.1194  | 0.1199      | 0.1231  |

Table 2.10. LHW recommended model sensitivities for age-specific natural mortality (M). Apply the standard deviation ( $\pm 5$  yrs) at age for the maximum aged (29 yrs) red grouper to calculate an upper and lower range for natural mortality.

| Age | SEDAR42 | Lower  | Upper  |
|-----|---------|--------|--------|
| 0   | 0.5837  | 0.5053 | 0.7336 |
| 1   | 0.3952  | 0.3421 | 0.4967 |
| 2   | 0.3082  | 0.2669 | 0.3874 |
| 3   | 0.2583  | 0.2236 | 0.3247 |
| 4   | 0.2261  | 0.1957 | 0.2841 |
| 5   | 0.2036  | 0.1763 | 0.2560 |
| 6   | 0.1873  | 0.1621 | 0.2354 |
| 7   | 0.1749  | 0.1514 | 0.2198 |
| 8   | 0.1652  | 0.1431 | 0.2077 |
| 9   | 0.1576  | 0.1364 | 0.1980 |
| 10  | 0.1514  | 0.1311 | 0.1903 |
| 11  | 0.1463  | 0.1267 | 0.1839 |
| 12  | 0.1421  | 0.1230 | 0.1786 |
| 13  | 0.1386  | 0.1200 | 0.1742 |
| 14  | 0.1356  | 0.1174 | 0.1705 |
| 15  | 0.1331  | 0.1152 | 0.1673 |
| 16  | 0.1310  | 0.1134 | 0.1646 |
| 17  | 0.1291  | 0.1118 | 0.1623 |
| 18  | 0.1276  | 0.1105 | 0.1603 |
| 19  | 0.1262  | 0.1093 | 0.1586 |
| 20  | 0.1250  | 0.1083 | 0.1572 |
| 21  | 0.1240  | 0.1074 | 0.1559 |
| 22  | 0.1231  | 0.1066 | 0.1548 |
| 23  | 0.1224  | 0.1060 | 0.1538 |
| 24  | 0.1217  | 0.1054 | 0.1530 |
| 25  | 0.1211  | 0.1049 | 0.1522 |
| 26  | 0.1206  | 0.1044 | 0.1516 |
| 27  | 0.1202  | 0.1040 | 0.1510 |
| 28  | 0.1198  | 0.1037 | 0.1505 |
| 29  | 0.1194  | 0.1034 | 0.1501 |

Table 2.11 Depth-dependent discard mortality values for live red grouper discards caught with recreational hook-and-line gear (see Figure 2.11).

| Depth Range (m) | Lower 95% CL | Point Estimate | Upper 95% CL |
|-----------------|--------------|----------------|--------------|
| 1-10            | 0.010        | 0.089          | 0.166        |
| 11-20           | 0.015        | 0.096          | 0.174        |
| 21-30           | 0.020        | 0.109          | 0.194        |
| 31-40           | 0.040        | 0.157          | 0.260        |
| 41-50           | 0.057        | 0.190          | 0.304        |
| 51-60           | 0.054        | 0.187          | 0.301        |
| 61-70           | 0.058        | 0.203          | 0.325        |
| 71-80           | 0.117        | 0.266          | 0.390        |
| 81-90           | 0.132        | 0.282          | 0.406        |

Table 2.12. Pre-IFQ bottom longline discard mortality rates assuming latent mortality of 0%, 10%, 20%, and 30% for fish that re-submerge for each depth bin (see Figure 2.12).

| Depth Range (m)        | 30 -<br>39.99 | 40 -<br>49.99 | 50 -<br>59.99 | 60 -<br>69.99 | 70 -<br>79.99 | 80 -<br>89.99 | 90 -<br>99.99 | 100 -<br>109.99 |
|------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|-----------------|
| Number of Fishing Sets | 94            | 356           | 117           | 93            | 55            | 14            | 19            | 5               |
| Discarded Alive        | 1659          | 6747          | 1322          | 347           | 226           | 16            | 18            | 0               |
| Discarded Dead         | 422           | 1880          | 387           | 198           | 193           | 20            | 19            | 1               |
| Discard Mortality (0%) | 20.3%         | 21.8%         | 22.6%         | 36.3%         | 46.1%         | 55.6%         | 51.4%         | 100.0%          |
| Recommended (20%)      | 36.2%         | 37.4%         | 38.1%         | 49.1%         | 56.8%         | 64.4%         | 61.1%         | 100.0%          |
| Low Sensitivity (10%)  | 28.3%         | 29.6%         | 30.4%         | 42.7%         | 51.5%         | 60.0%         | 56.2%         | 100.0%          |
| High Sensitivity (30%) | 44.2%         | 45.3%         | 45.9%         | 55.4%         | 62.2%         | 68.9%         | 65.9%         | 100.0%          |

Table 2.13. Post-IFQ bottom longline discard mortality rates assuming latent mortality of 0%, 10%, 20%, and 30% for fish that re-submerge for each depth bin (see Figure 2.13).

| Depth Range (m)        | 30 -<br>39.99 | 40 -<br>49.99 | 50 -<br>59.99 | 60 -<br>69.99 | 70 -<br>79.99 | 80 -<br>89.99 | 90 -<br>99.99 | 100 -<br>109.99 |
|------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|-----------------|
| Number of Fishing Sets | 494           | 1626          | 806           | 836           | 913           | 267           | 32            | 9               |
| Discarded Alive        | 9088          | 31450         | 11936         | 6015          | 6490          | 1763          | 23            | 6               |
| Discarded Dead         | 2651          | 10060         | 5107          | 2957          | 3733          | 1027          | 18            | 7               |
| Discard Mortality (0%) | 22.6%         | 24.2%         | 30.0%         | 33.0%         | 36.5%         | 36.8%         | 43.9%         | 53.8%           |
| Recommended (20%)      | 38.1%         | 39.4%         | 44.0%         | 46.4%         | 49.2%         | 49.4%         | 55.1%         | 63.1%           |
| Low Sensitivity (10%)  | 30.3%         | 31.8%         | 37.0%         | 39.7%         | 42.9%         | 43.1%         | 49.5%         | 58.5%           |
| High Sensitivity (30%) | 45.8%         | 47.0%         | 51.0%         | 53.1%         | 55.6%         | 55.8%         | 60.7%         | 67.7%           |

Table 2.14. Meristic regressions for red grouper (1978-2013) from the Gulf of Mexico. Data combined from all data sources, both fishery independent and dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length, SL – Standard Length. Weight Type: G Wt – Guttled Weight, W Wt – Whole Weight. Units: length (mm) and weight (kg). Linear and non-linear regressions calculated using R (lm and nls functions, respectively).

| Regression     | Equation                                                | statistic    | N     | Data Range                            |
|----------------|---------------------------------------------------------|--------------|-------|---------------------------------------|
| Max TL to FL   | $FL = 5.35 + \text{max\_TL} * 0.95$                     | $r^2=0.9963$ | 5818  | Max TL: 120 – 954; FL: 116 – 910      |
| Nat TL to FL   | $FL = 5.71 + \text{nat\_TL} * 0.95$                     | $r^2=0.9909$ | 3901  | Nat TL: 151 – 957; FL: 149 – 910      |
| SL to FL       | $FL = 15.90 + SL * 1.14$                                | $r^2=0.9938$ | 985   | SL: 130 – 686; FL: 159 – 830          |
| SL to Max TL   | $\text{Max\_TL} = 9.19 + SL * 1.21$                     | $r^2=0.9944$ | 3399  | SL: 130 – 720; Max TL: 161 – 876      |
| SL to Nat TL   | $\text{Nat\_TL} = -51.18 + SL * 1.32$                   | $r^2=0.9791$ | 7     | SL: 404 – 670; Nat TL: 484 – 860      |
| Max TL to G Wt | $G\ WT = 4.33 \times 10^{-8} * (\text{max\_TL}^{2.83})$ | RSE = 0.7421 | 633   | Max TL: 458 – 980; G WT: 0.82 – 15.05 |
| Max TL to W Wt | $WWT = 5.21 \times 10^{-9} * (\text{max\_TL}^{3.16})$   | RSE = 0.5152 | 3725  | Max TL: 127 – 954; W WT: 0.03 – 16.96 |
| Nat TL to G Wt | $GWT = 5.70 \times 10^{-8} * (\text{nat\_TL}^{2.78})$   | RSE = 0.6398 | 34    | Nat TL: 490 – 802; G WT: 1.28 – 7.17  |
| Nat TL to W Wt | $WWT = 7.58 \times 10^{-9} * (\text{nat\_TL}^{3.10})$   | RSE = 0.3482 | 3912  | Nat TL: 120 – 957; W WT: 0.02 – 14.00 |
| FL to G Wt     | $GWT = 3.37 \times 10^{-9} * (FL^{3.25})$               | RSE = 0.3499 | 37414 | FL: 230 – 935; G WT: 0.26 – 16.96     |
| FL to W Wt     | $WWT = 5.46 \times 10^{-9} * (FL^{3.18})$               | RSE = 0.4667 | 7361  | FL: 123 – 965; W WT: 0.05 – 16.96     |
| SL to W Wt     | $WWT = 2.32 \times 10^{-8} * (SL^{3.03})$               | RSE = 0.1825 | 483   | SL: 147 – 670; W WT: 0.10 – 9.00      |

2.12 FIGURES

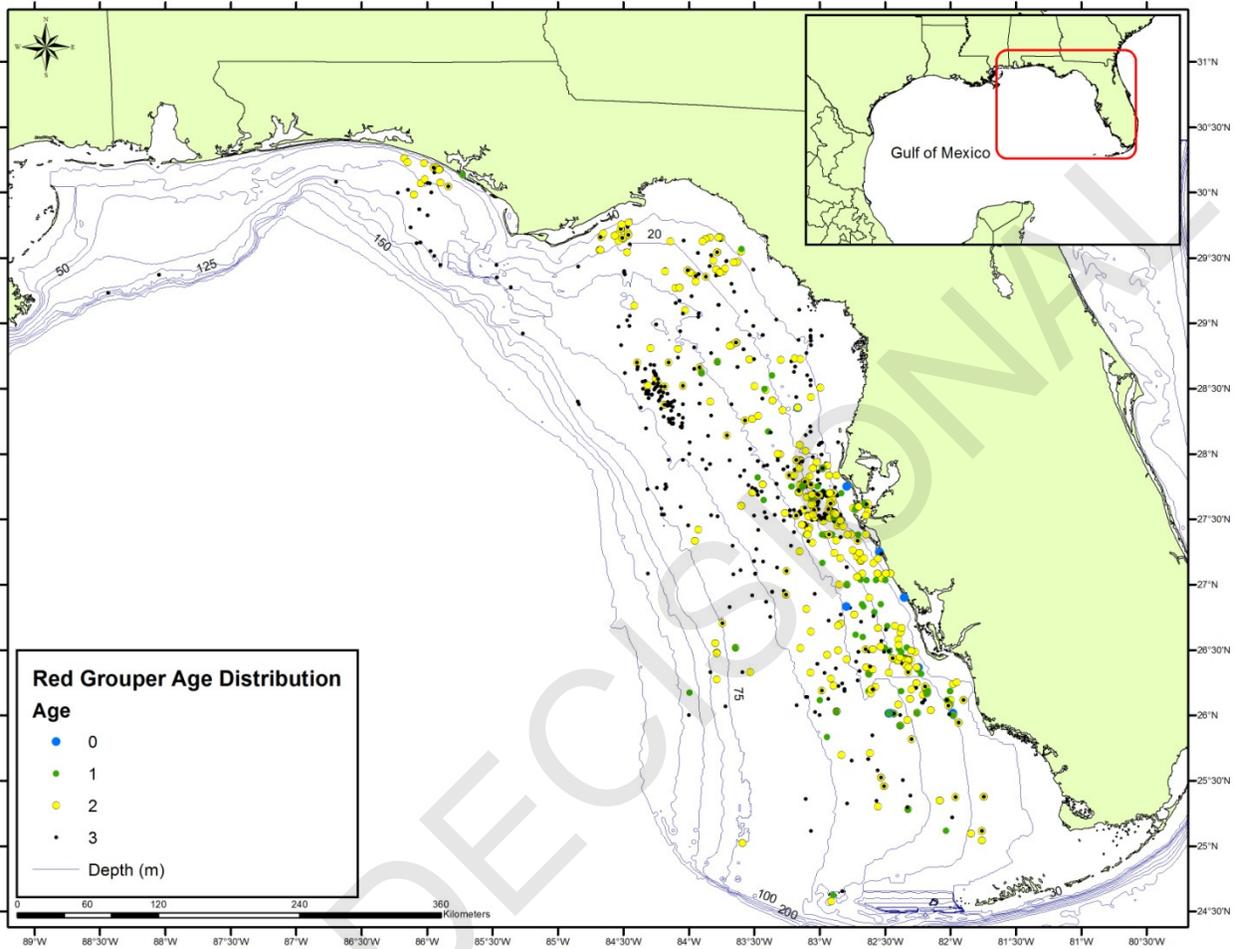


Figure 2.1. Locations of juvenile (age 0 – 3 yr) red grouper collected by state and federal fishery independent surveys along the west Florida shelf.

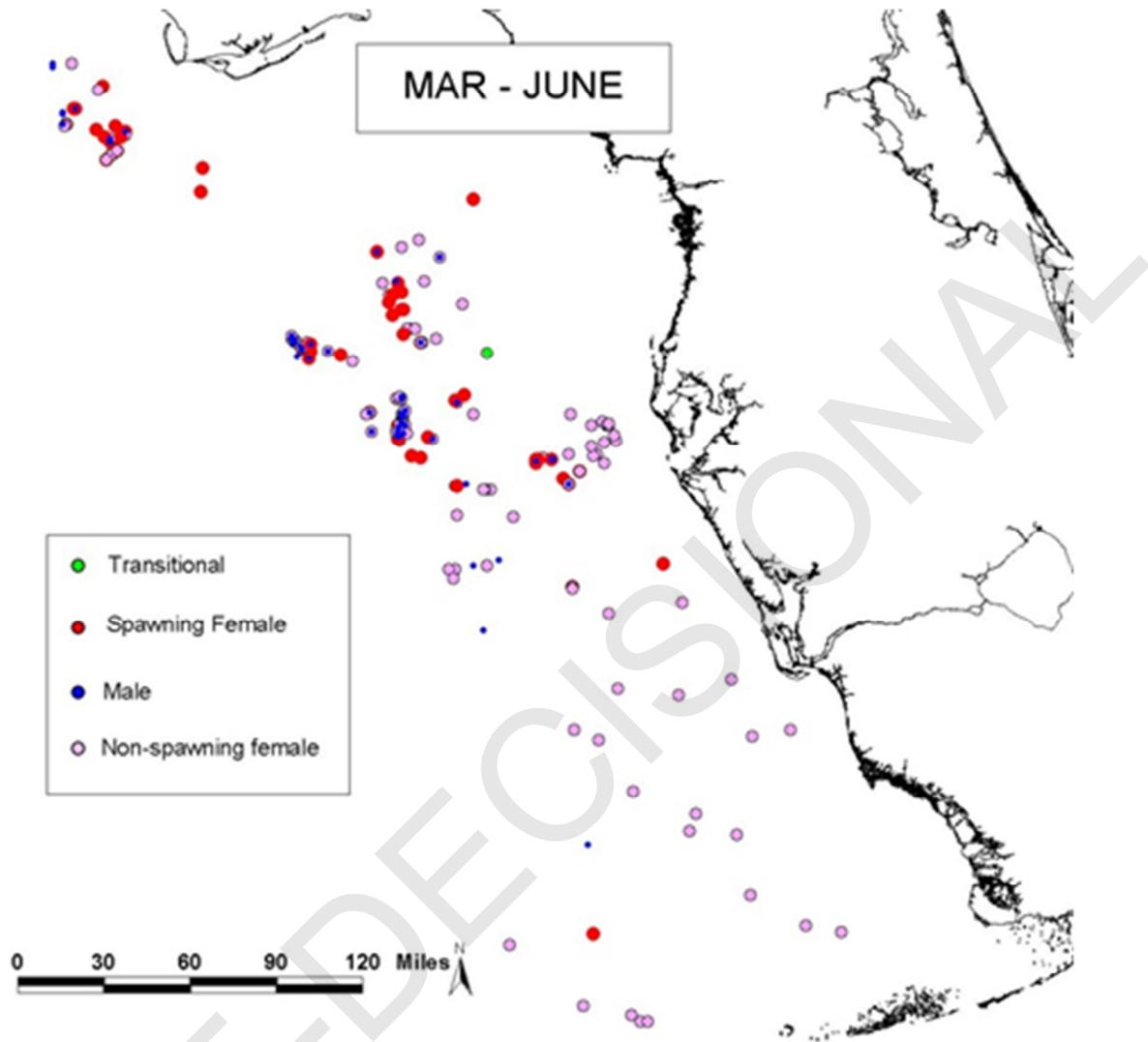


Figure 2.2. Locations of red grouper of various spawning condition (non-spawning female, spawning females, males and transitional fish) collected by FL FWCC/FWRI during red grouper spawning season (March – June 2008-2013) (original figure, Lowerre-Barbieri et al. 2014).

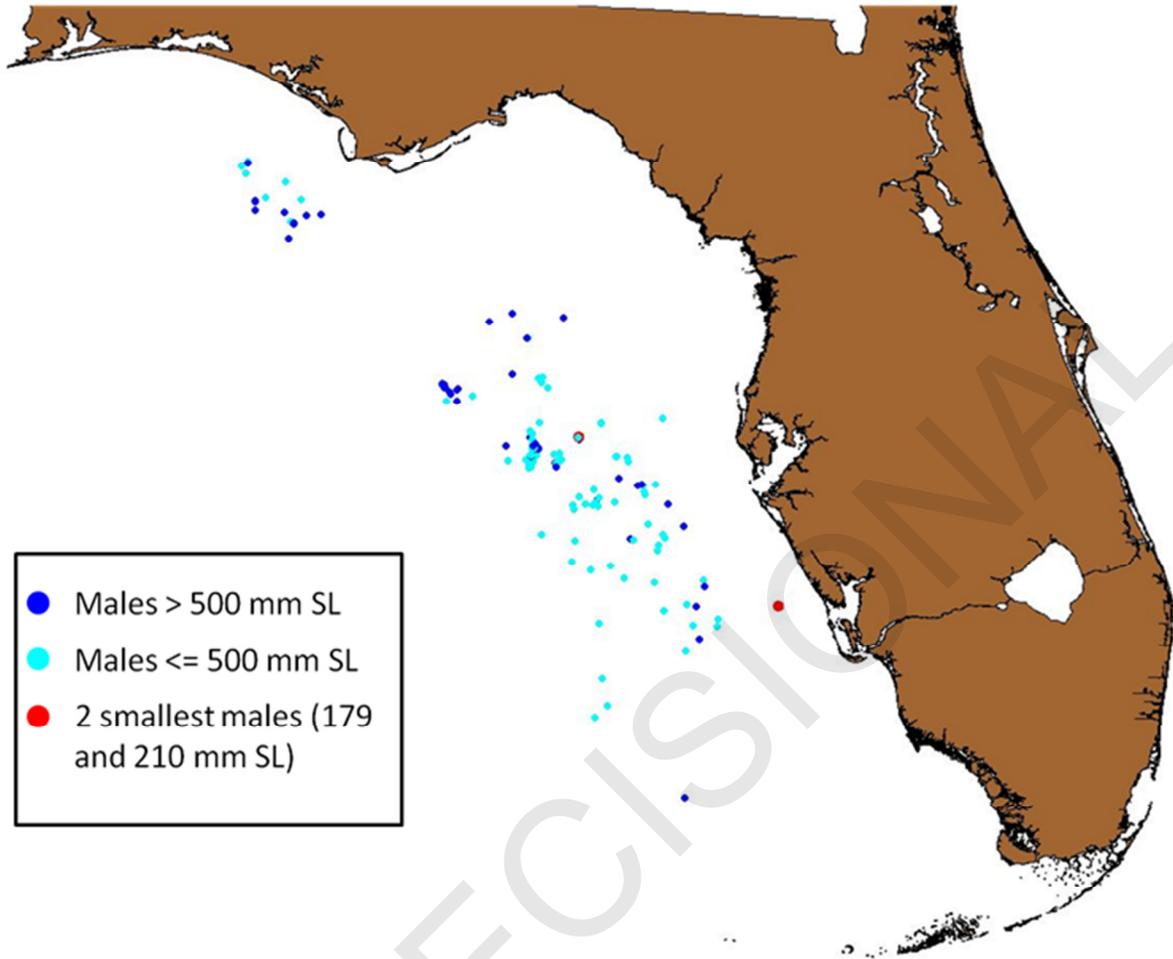


Figure 2.3. Locations of male red grouper by length groups (large  $\geq 500$  mm SL, small  $\leq 500$  mm SL), collected by FL FWCC/FWRI during (original figure, Lowerre-Barbieri et al. 2014).



Figure 2.4 Standard deviations at age among readers calculated from the use of two reference collections to determine precision among readers throughout the time series (NMFS Panama City Laboratory and FFWCC/FWRI). The numbers above and below the data points are the sample size per age per reference collection.

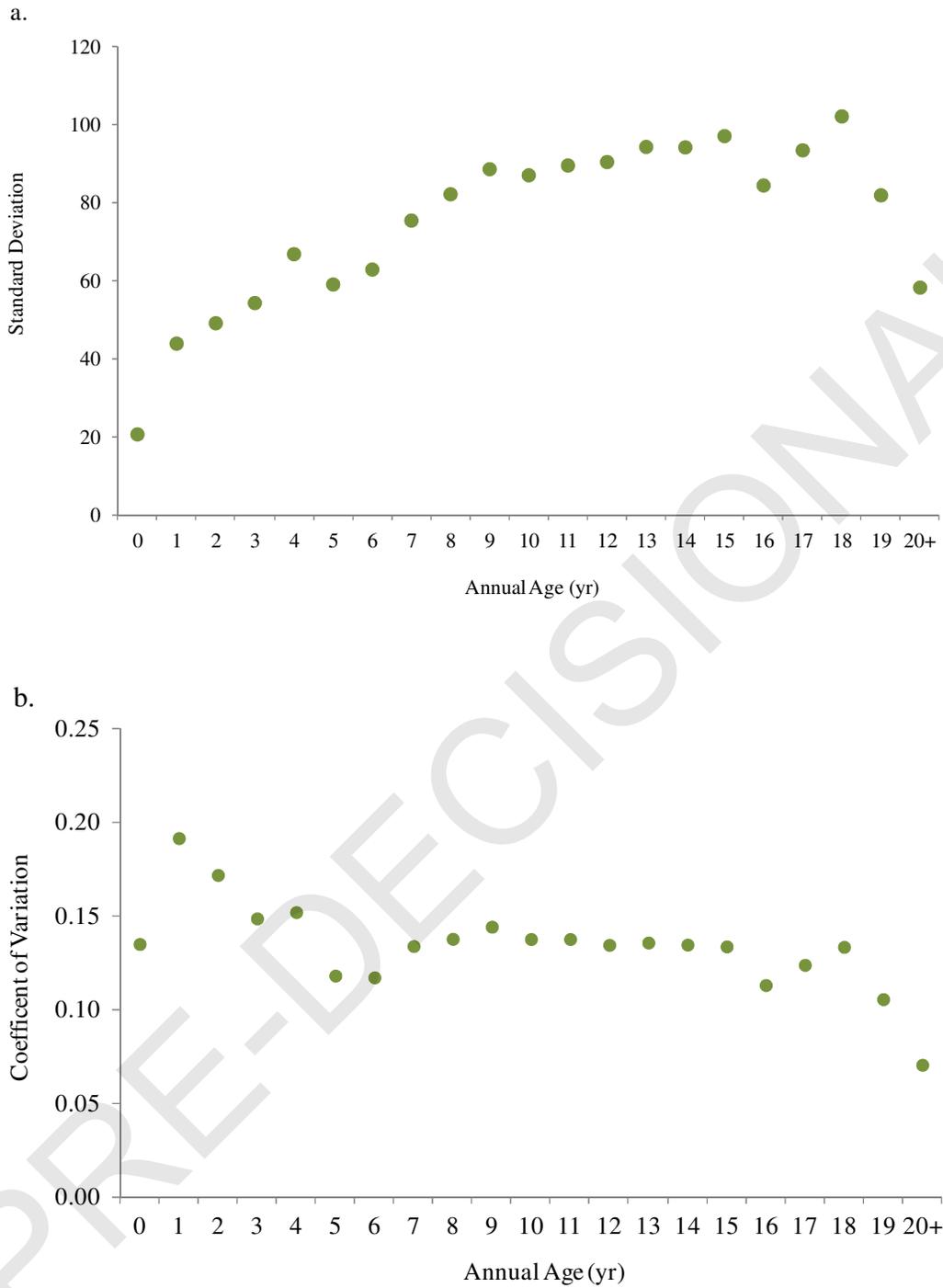


Figure 2.5 Variance structure for observed size-at-age data for red grouper from the northeastern Gulf of Mexico (1991-2013) (a) standard deviation and (b) coefficient of variation at length for each age group.

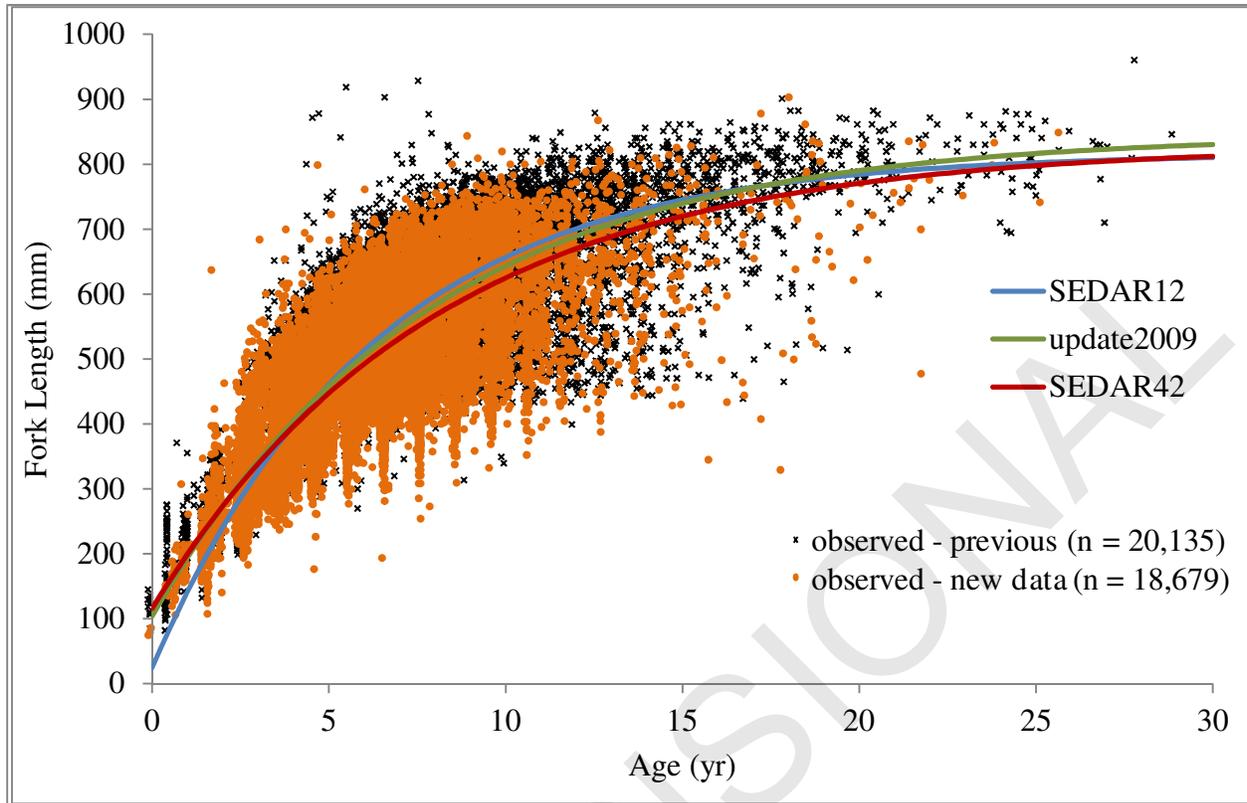


Figure 2.6 Comparison of size-modified von Bertalanffy growth models fit to fractional ages and fork lengths for red grouper from the northeastern Gulf of Mexico for SEDAR42: 1991-2013,  $n = 38,813$ ; update 2009: 1991-2008,  $n = 20,143$  and SEDAR12: 1991-2005,  $n = 15,953$ . SEDAR42 growth model fit the data using a constant coefficient of variation at age variance structure. The update assessment in 2009 and SEDAR12 growth models used a constant standard deviation at age variance structures.

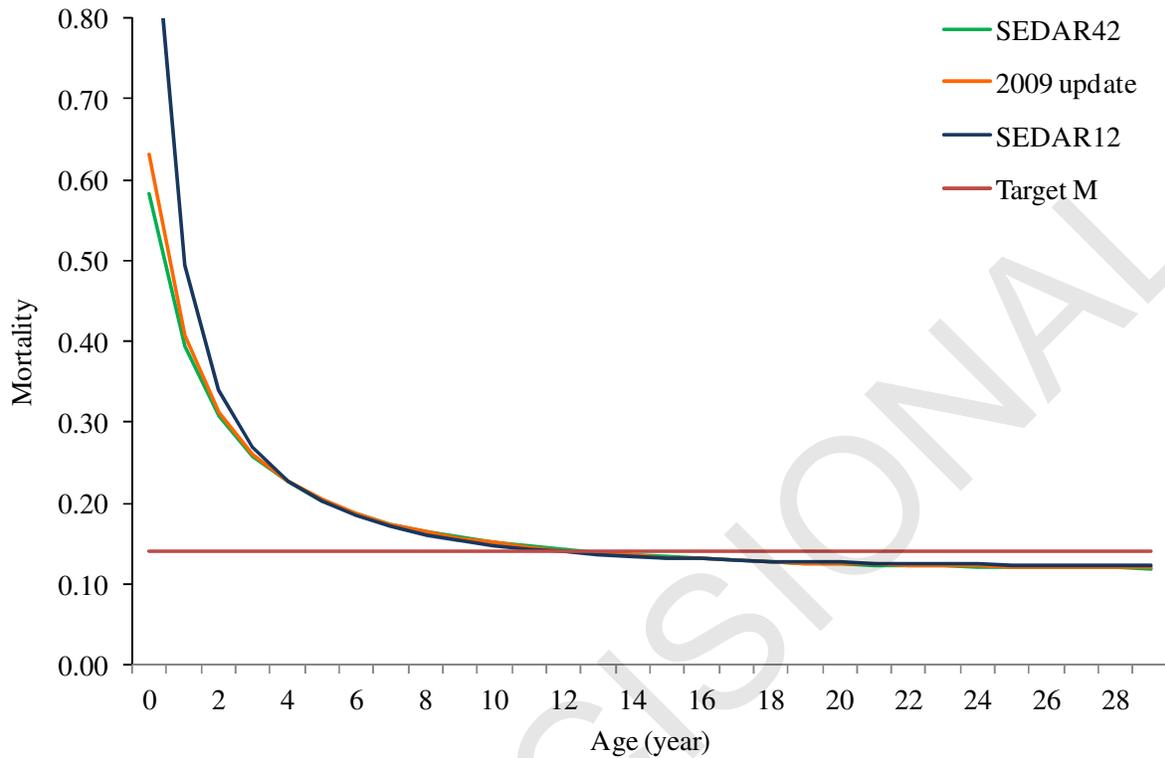


Figure 2.7 Comparison of age-specific natural mortality (M) vectors for red grouper from the northeastern Gulf of Mexico. Each vector was calculated using the same regression (Lorenzen 2005), age 5 as the first age at vulnerability, with a target M of 0.14 (Hoenig<sub>teleost</sub>, maximum age of 29 years). The only difference among the age-specific natural mortality vectors were the predicted von Bertalanffy growth parameters used in the estimations.

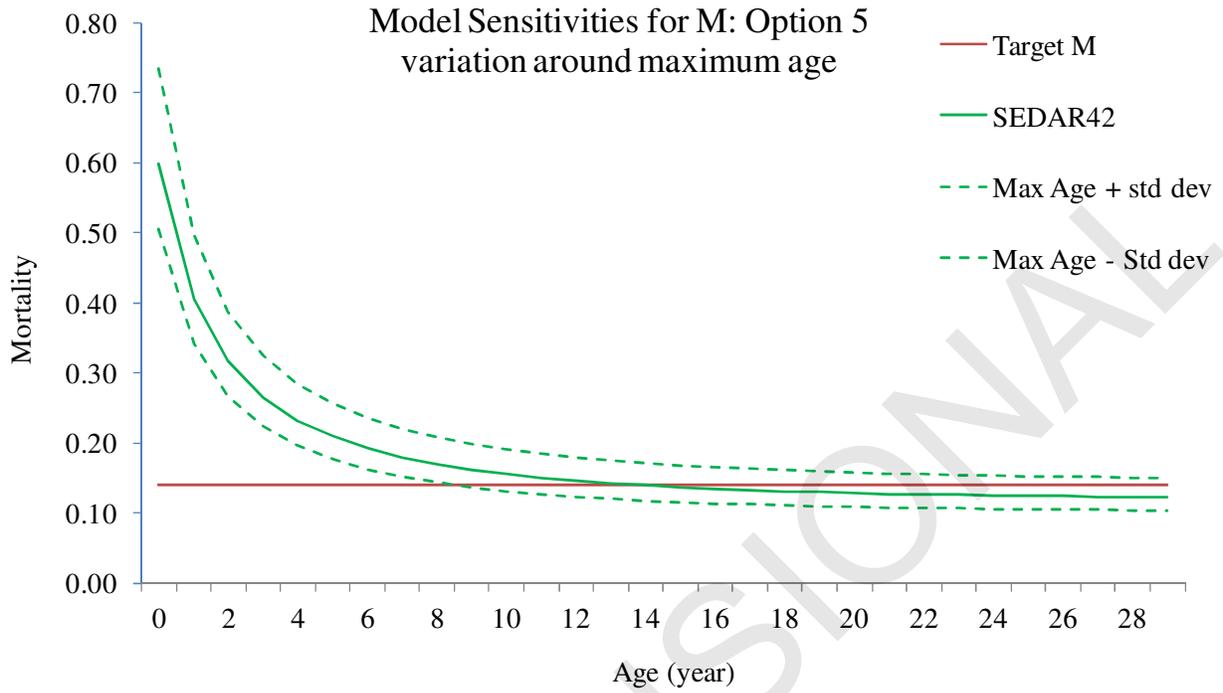


Figure 2.8 Recommended model sensitivities for age-specific natural mortality (M) vector. LWH suggests using the standard deviation at age of the maximum aged red grouper to calculate an upper and lower age-specific mortality vector.

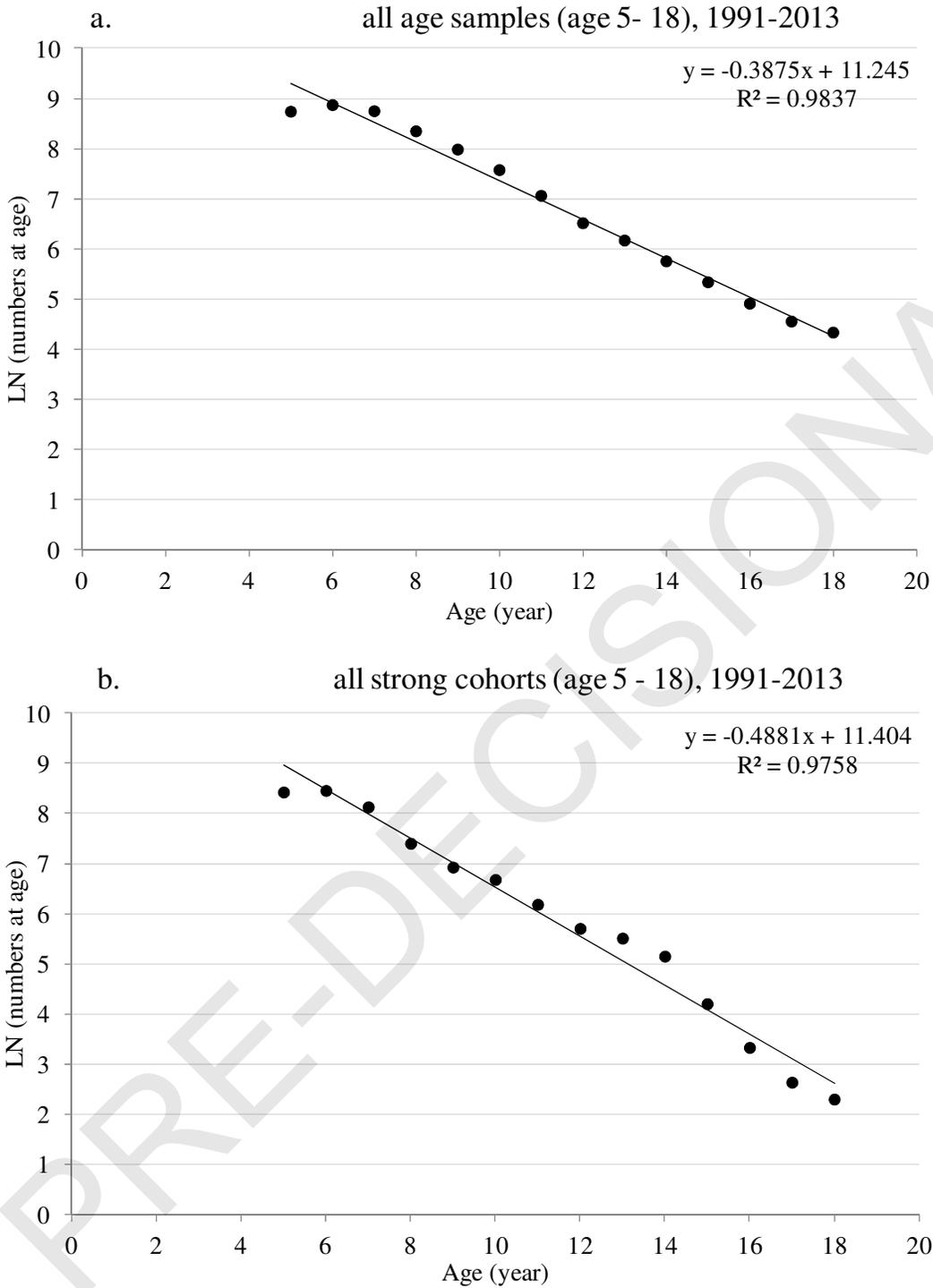


Figure 2.9. Total mortality estimates (Z) using catch curves for (a) all data, 1991-2013, n = 38,813 and (b) all strong cohorts, 1991-2013, n = 22,529 Red grouper were fully vulnerable at age 5 yrs.

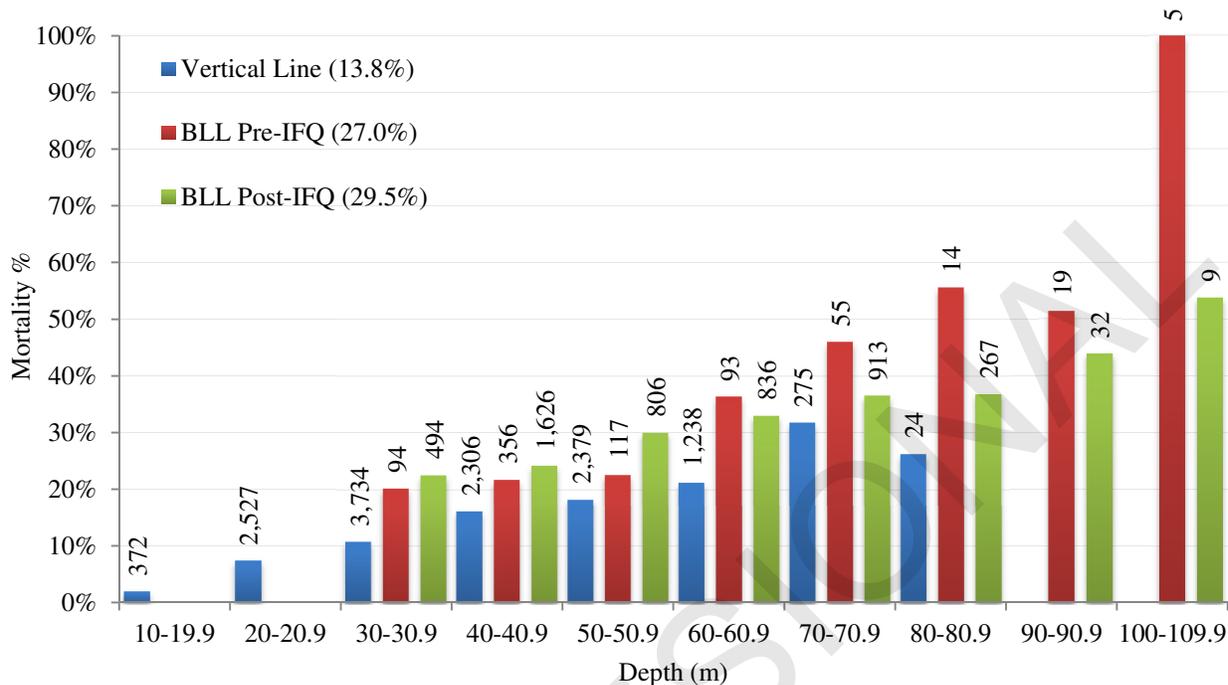


Figure 2.10. Percentage of red grouper discards that were dead on arrival or floating after release observed for each depth bin (n = the number of fishing sets observed per depth bin by gear). The legend values in parenthesis are the weighted mean average discard mortality per gear type and time period for all depths. Red grouper with an unknown discard fate were not used in deriving these percentages. Vertical line – manual or electronic hook and line, BLL – bottom longline, IFQ – Individual Fishing Quota (commenced in 2010 for the shallow-water grouper complex in the Gulf of Mexico).

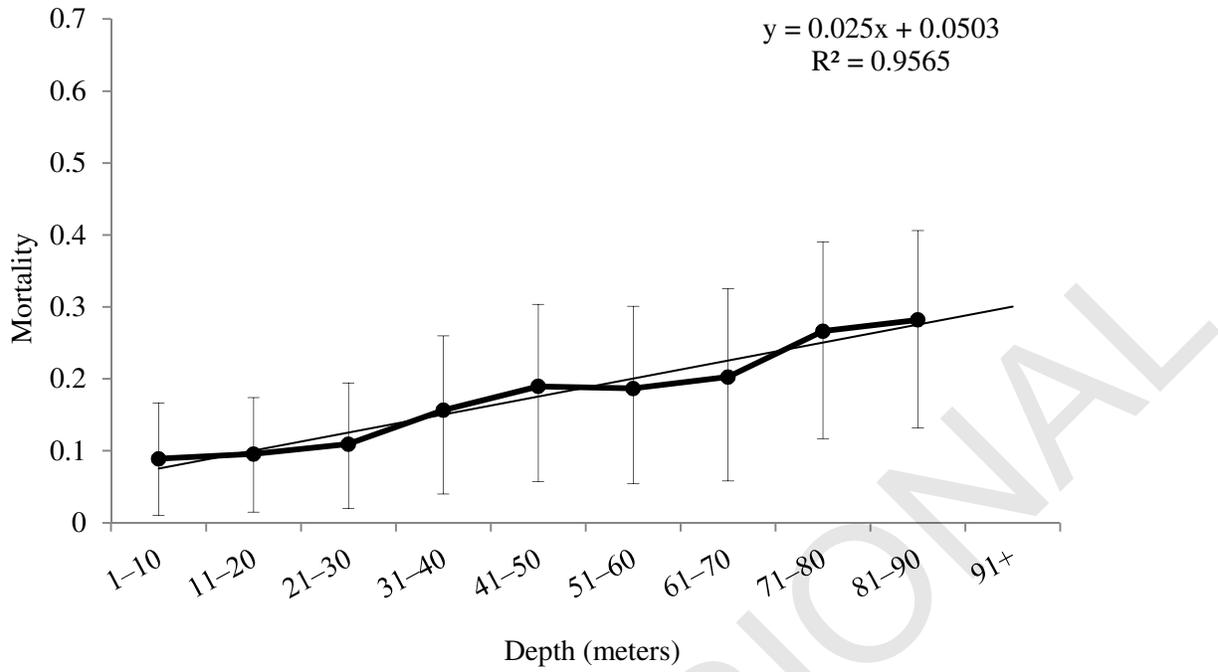


Figure 2.11: Depth-dependent discard mortality estimates with 95% confidence intervals and the fitted regression for live red grouper discards caught with recreational hook-and-line gear (Sauls et al. 2014) (see Table 2.11).

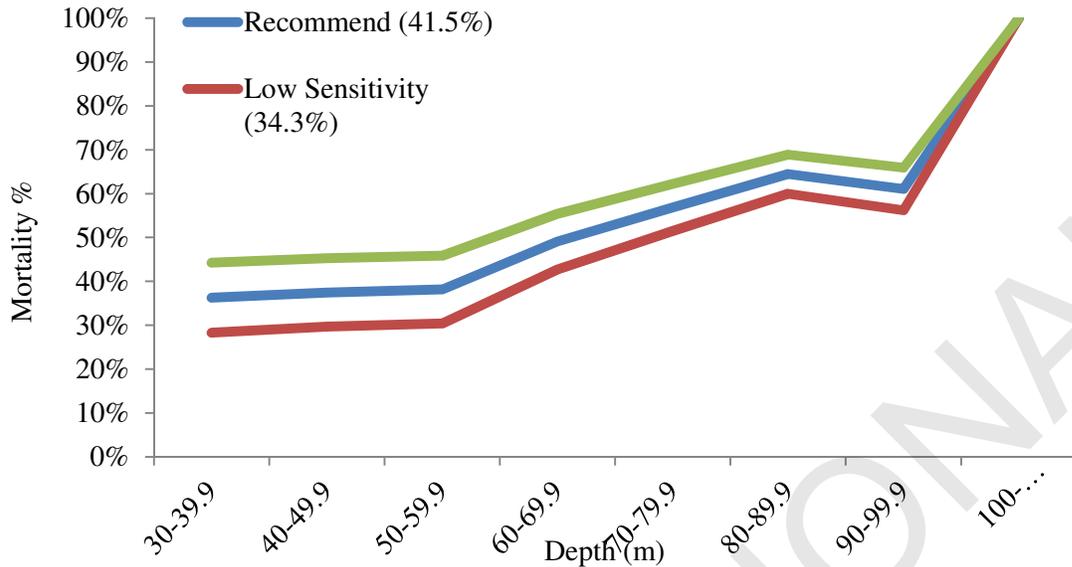


Figure 2.12: Bottom longline recommended discard mortality pre-IFQ based on weighted mean average for each depth bin from 758 fishing sets (see Table 2.12). Discard mortality estimates in the legend in parenthesis represent the base values per latent mortality (recommended = 20%, low sensitivity = 10%, high sensitivity = 30%).

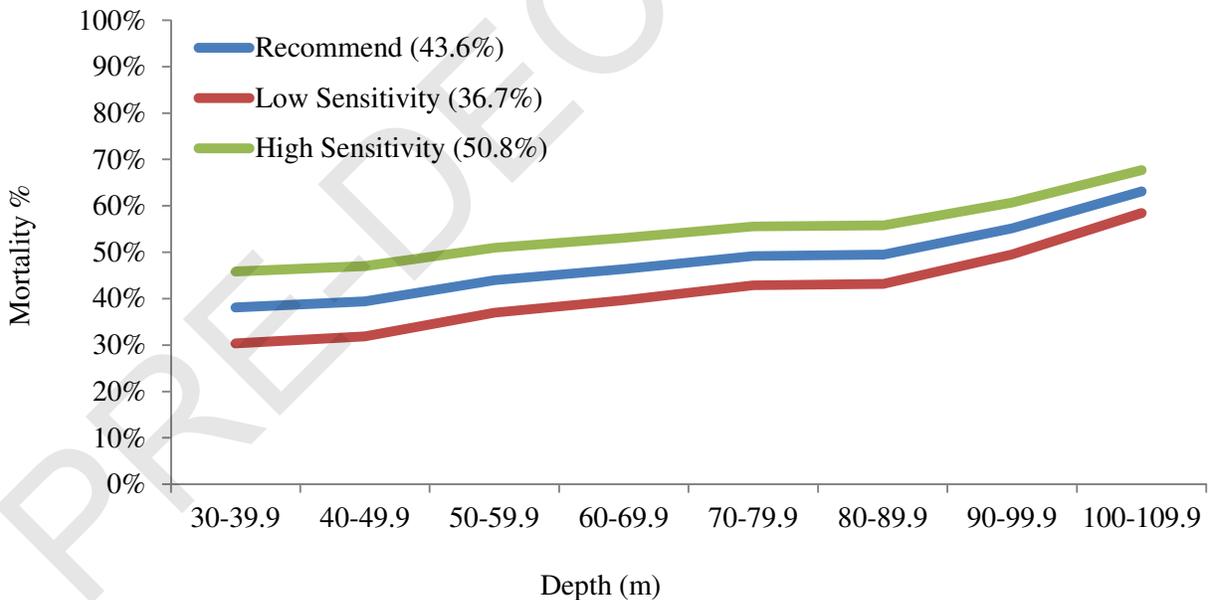


Figure 2.13. Bottom longline recommended discard mortality post-IFQ based on weighted mean average for each depth bin from 4,995 fishing sets (see Table 2.13). Discard mortality estimates in the legend in parenthesis represent the base values per latent mortality (recommended = 20%, low sensitivity = 10%, high sensitivity = 30%).

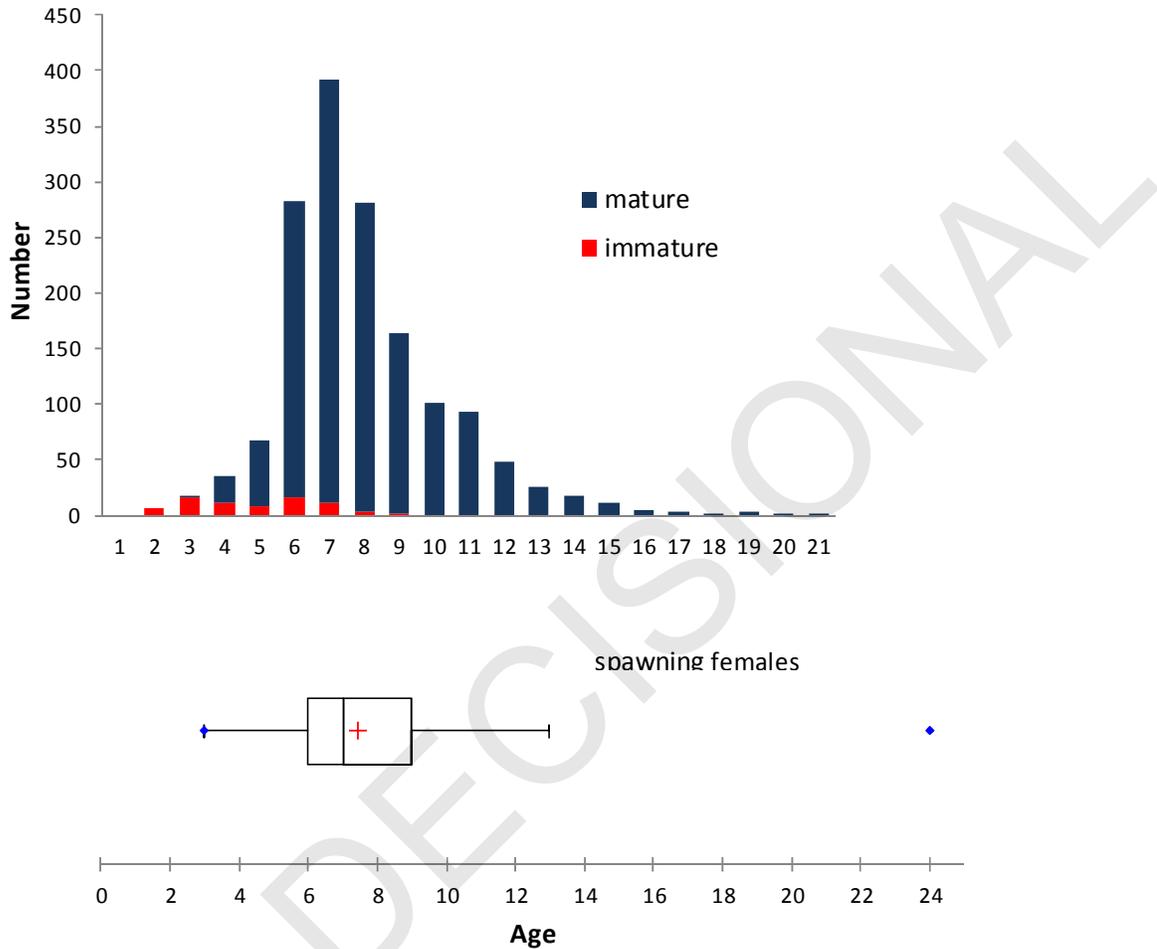


Figure 2.14. Top panel: histogram of mature and immature females by age, n = 1559, NMFS PC and FL FWCC/FWRI data combined. Females are represented from all years (1991-2013) for months March, April, May and June.

Bottom panel: boxplot of age distribution of females with spawning markers (postovulatory follicles and hydrated oocytes). The mean (red cross), median, 25%, 75% quantiles and range (blue symbols) are shown.

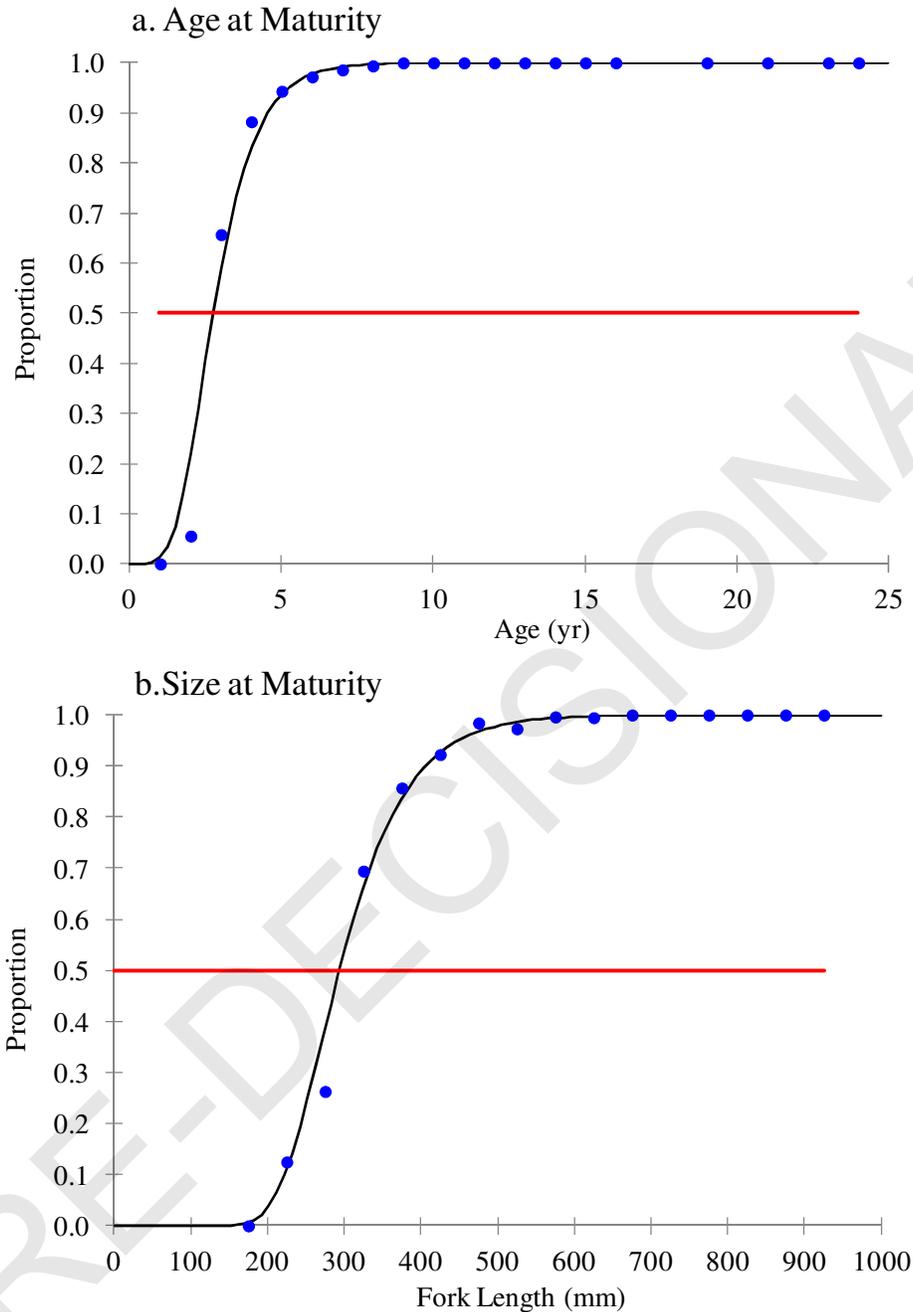


Figure 2.15. Logistic fit of (a) age at maturity (Gompertz model:  $\text{proportion mature} = \exp(-\exp(-(-2.5493+1.0517*\text{age})))$ ,  $r^2$  (McFadden) = 0.4, n= 1559, A50 maturity = 2.8 years) and (b) length at maturity (Gompertz model:  $\text{proportion mature} = \exp(-\exp(-(-4.5622+0.0168*\text{length})))$ ,  $r^2$  (McFadden) = 0.4, n= 1677, L50 maturity = 292 mm FL). Logistic regression analysis conducted using XLSTAT software v2012.4.03 based upon weighted sums of binary data.

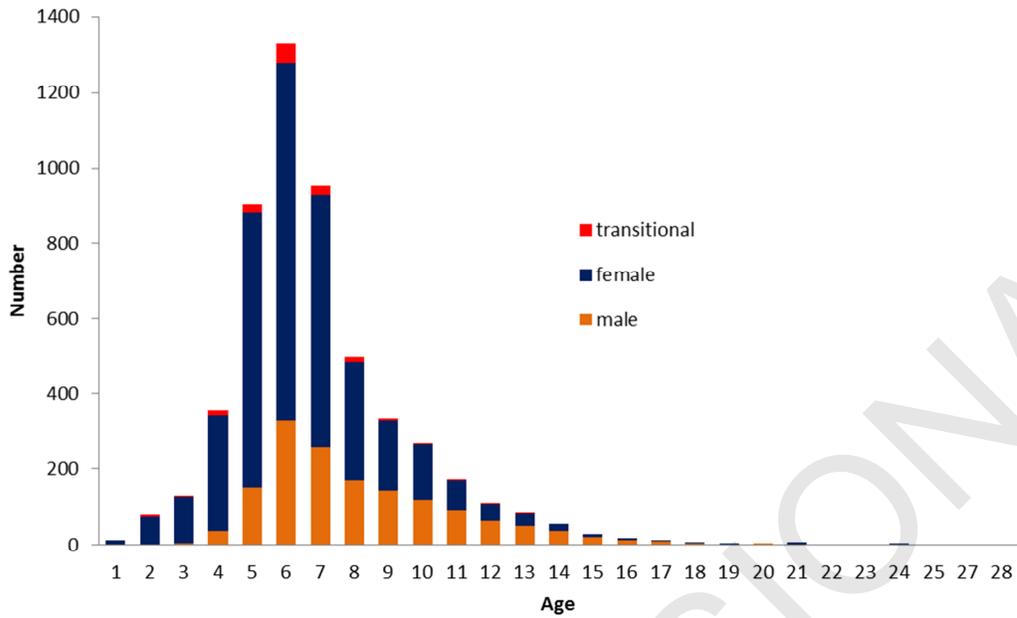


Figure 2.16. Histogram of numbers of red grouper sampled and identified by sex and by age (n = 5381). NMFS PC and FL FWCC/FWRI data combined, years 1991-2013, all months represented.

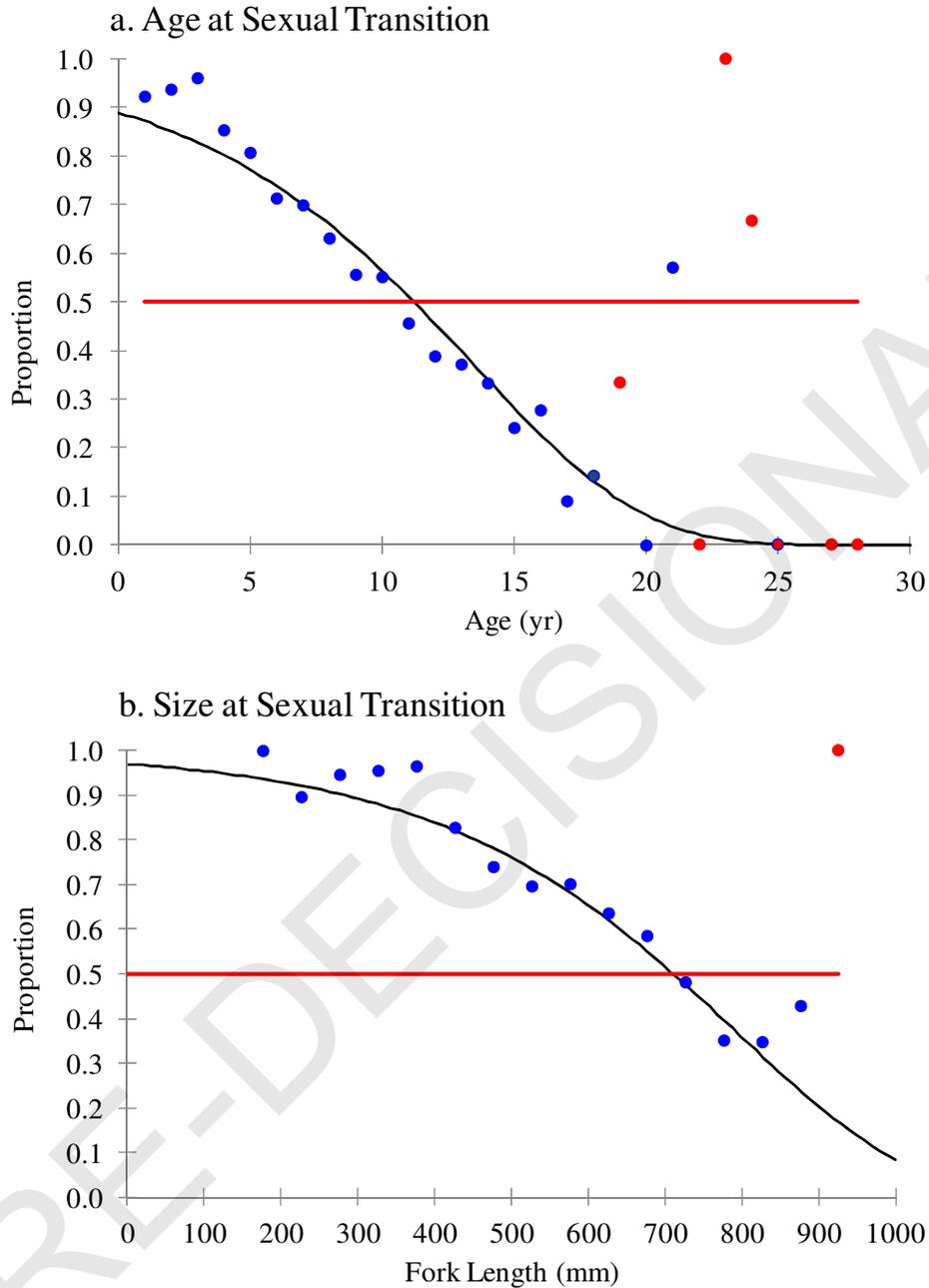


Figure 2.17. Logistic fit of (a) age of sexual transition (Gompertz model: proportion female =  $\exp(-\exp(-(-2.142-0.1585*\text{age})))$ ,  $r^2$  (McFaden) = 0.6,  $n= 5381$ , A50 transition = 11.2 yr) and (b) length at sexual transition (Gompertz model: proportion female =  $\exp(-\exp(-(-3.5002-0.0044*\text{length})))$ ,  $r^2$  (McFaden) = 0.06,  $n=5775$ , L50 transition = 707 mm FL), NMFS PC and FL FWCC/FWRI data combined. Red symbols indicate ages with  $n < 4$ . After age 21, four females and seven males were observed. Logistic regression analysis conducted using XLSTAT software v2012.4.03 based on weighted sums of binary data.

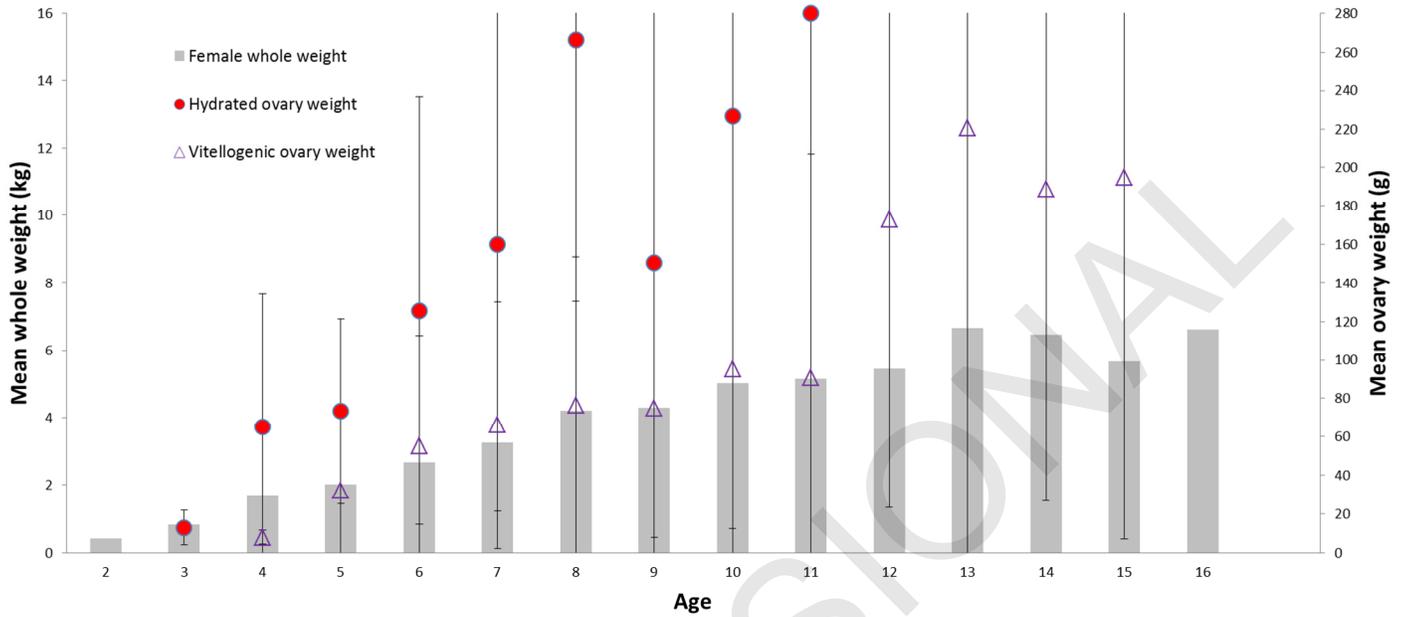
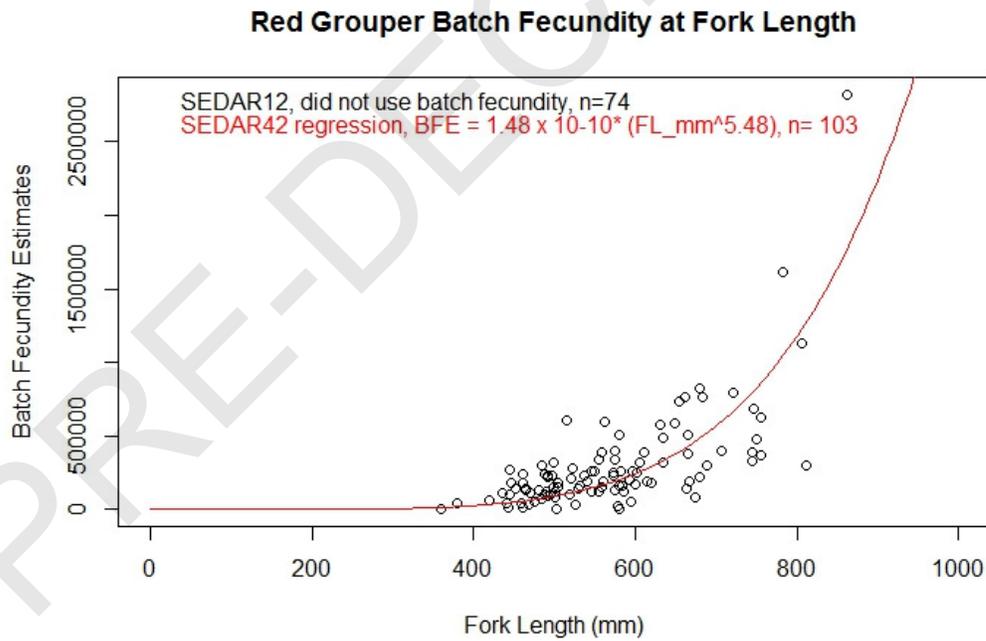
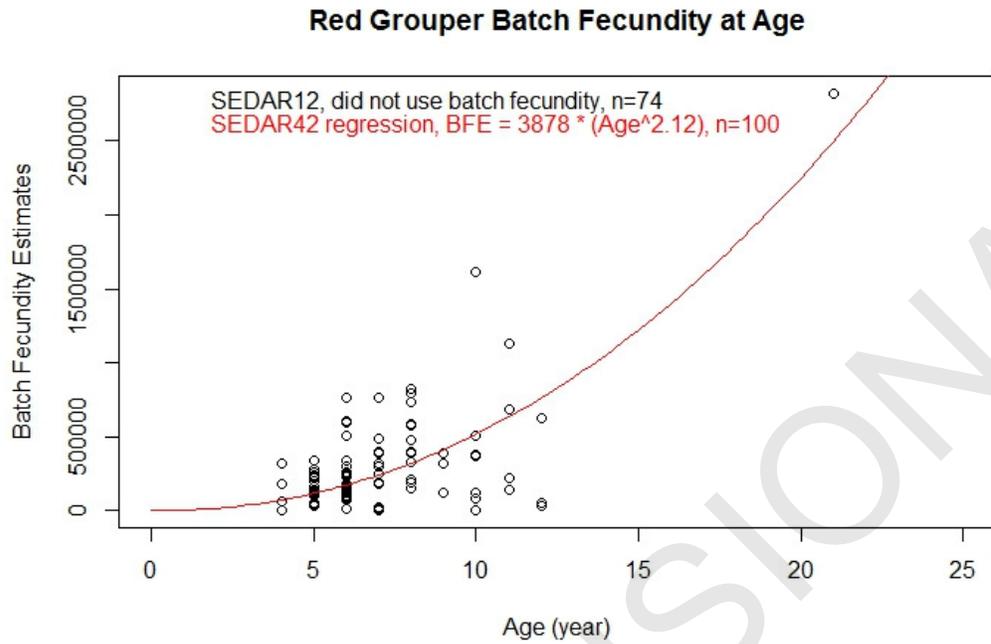


Figure 2.18. Comparison of average female whole weight at age (grey bars, n = 2864) with ovary weights by stage of development. Triangle symbols indicate mean ( $\pm 1$  SD) weight of ovaries with vitellogenic oocytes (n= 820) and round red symbols indicate mean ( $\pm 1$  SD) weight of ovaries with hydrated oocytes (n=148). Ovary weight (and thus one aspect of reproductive output) increases with age in a manner that is non-proportional to increase in female body weight.

a.



b.

Figure 2.19. Elements of annual fecundity: a) batch fecundity by age and b) batch fecundity by fork length. Data fit in R (nlms).

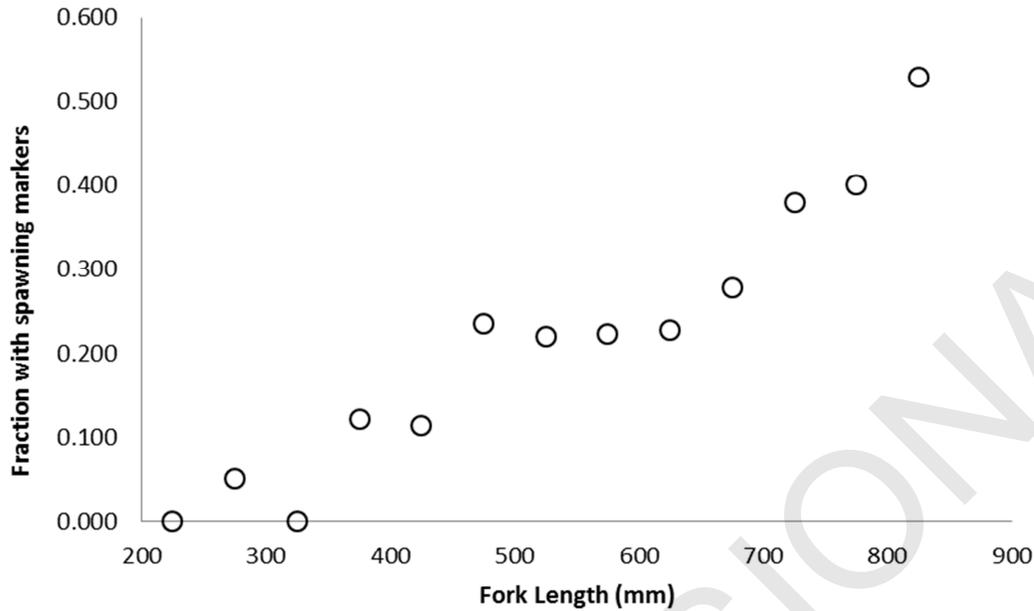


Figure 2.20. Elements of annual fecundity: Fraction of females bearing histological spawning markers (postovulatory follicles and/or hydrated oocytes) out of the total sampled by length during March-June, all years (n=1937).

### 3 COMMERCIAL FISHERY STATISTICS

#### 3.1 OVERVIEW

Commercial landings of red grouper for the U.S. Gulf of Mexico were constructed primarily using data housed in the NOAA’s Southeast Fisheries Science Center’s Accumulated Landings System (ALS) from 1963 through 2013. Florida landings from 1986 through 2013 were obtained from the Florida Trip Ticket program and were preferred over ALS due to the data’s finer resolution. For historical landings between 1880 and 1962, landings were obtained from Saul (2006). Cuban landings from U.S. waters were also provided from Saul (2006). Overall the methodologies used to produce landings were the same as those used in SEDAR 12. One addition to those methods was the introduction of landings from the Individual Fishing Quota

(IFQ) program for 2011-2013. Final landings were then provided by year and gear (handline, longline, trap, and other).

Discards were calculated for the directed fishery using data from the reef fish observer program. Data were available from 2007 through 2013. Data were stratified to produce discard rates. Some strata had insufficient sample size so mean rates were used. Mean discard rates were used for 1993-2006. All discard rates were applied to total effort from the Coastal Fisheries Logbook Program.

Red grouper length samples were reviewed for the years 1984-2013 using available TIP length data. Commercial landings length frequency distributions will be provided by year, and gear (handline, longline, and trap). Commercial discard lengths from observer data were provided for 2006-2012. Commercial landings ages were weighted by the length frequency distributions and will be provided by year and gear.

### 3.1.1. Commercial Workgroup Participants

|                         |                          |                |
|-------------------------|--------------------------|----------------|
| Neil Baertlein          | Workgroup leader         | NMFS Miami     |
| Ching-Ping Chih*        | Data provider            | NMFS Miami     |
| Donna Bellais*          | Data provider            | GulfFIN        |
| Steve Brown             | Data provider            | FL FWC         |
| Jason Delacruz          | Commercial               | Florida        |
| Martin Fisher           | Commercial               | Florida        |
| Kevin McCarthy          | Data provider            | NMFS Miami     |
| Refik Orhun*            | Data provider            | NMFS Miami     |
| Jeff Pulver             | Data provider            | NMFS Galveston |
| Elizabeth Scott-Denton* | Data provider            | NMFS Galveston |
| Bob Spaeth              | Commercial               | Florida        |
| Jessica Stephen         | Rapporteur/Data provider | NMFS SERO      |
| John Ward               |                          |                |

\*Did not attend workshop

### 3.1.2 Issues Discussed at the Data Workshop

Commercial landings issues the workgroup addressed included historical landings, gears, Florida trip ticket data, and IFQ reported landings. Methodologies from SEDAR 12 were largely used for the production of landings. Incorporation of vessels' allocation for construction discard

estimates is ongoing. Length and age samples were also reviewed and weightings of each for the development of length/age frequency distributions were discussed.

### 3.2 REVIEW OF WORKING PAPERS

The workgroup considered data and analyses presented from the following workshop working paper.

**SEDAR42-DW-01:** This document provided a summary of observer data from the reef fish observer program out of NMFS Galveston.

**SEDAR42-DW-12:** This document provided an analysis of commercial length and age compositions in the Gulf of Mexico. Sample sizes by year, gear, and region were reviewed and found to be sufficient for most strata. Length and age frequency distributions, and age length keys were also discussed.

**SEDAR12-DW-11.** This document provided historic and Cuban landings of red grouper. These landings were also provided for and used in SEDAR12.

### 3.3 COMMERCIAL LANDINGS

#### Accumulated Landings System (ALS)

Most of the commercial landings were compiled from the ALS from 1963-2012. Red grouper landings are provided in Table 3.1 and Figure 3.3 by year and gear (handline, longline, trap, and other). There are several situations where the landings data may not have the desired level of resolution. The following issues were identified:

1. Only annual data are available for 1963 – 1977
2. In 1963, some landings are only reported as water body code 5000 (Gulf of Mexico).
3. For Florida, gear and fishing area are not available for monthly data for 1977 - 1984
4. For Louisiana, gear and fishing area are not available for 1990 - 1999
5. For Texas, gear and fishing area are not available for 1990 - 2011.

There is a lack of resolution for 1962 - 1977, however there was no need to distribute the annual percentages by gear and fishing area by month for this time period.

For the landings on the west coast of Florida during the period 1977 - 1996, data on the allocation of landings gear and fishing area are available from the Florida general canvass data which has annual landings data by gear and water body from 1976 to 1996. Proportions from the annual general canvass were applied to the monthly ALS data to provide the desired resolution for the landings time series. The annual Florida general canvass landings data were used from 1977 – 1985 to allocate gear and statistical area to the landings.

For ALS landings data in Texas, Mississippi, and Alabama, logbook data has been used to assign gear and area information for 1993 forward. The same treatment was applied to the Louisiana landings, but for 1990-1999. The Texas trip ticket program began in 2000.

Further details regarding the data in ALS and General Canvass can be found Appendix A.

#### Florida Trip Ticket

Comparisons were made between Florida's commercial trip ticket data (1986-2013) and NMFS logbook data (1992-2013). Both datasets were very similar in landings trends and level of landings reported for matching years. While no direct comparison was made between Florida trip ticket and NMFS general canvass, it was decided to use the total landings from the Florida trip ticket data over the general canvas and logbook since general canvas data are Florida trip ticket data since 1997, and trip ticket data were more complete and are of a longer time series than the logbook data.

One issue arose with regard to red grouper landings from Florida Gulf of Mexico waters: how to apportion red grouper from unclassified grouper. Since red grouper have been coded to species since 1986, it was decided apportion red grouper from unclassified grouper on trips where only unclassified grouper was reported. The rationale was that if grouper were coded to species on trips that also included unclassified grouper, the dealer was probably diligent in reporting major grouper species correctly. To apportion red grouper from unclassified only grouper, Florida trip ticket data were used to calculate the ratio of red grouper to total identified grouper which was then applied to unclassified only grouper landings by year and gear from 1992-2013.

The amount of Gulf red grouper from Florida trip ticket was determined by calculating the proportion of annual Gulf red grouper stratified by area and gear from the logbook data. The decision to use logbook data for proportions was based on the general acceptance that effort and location data are more accurate on fisher reported logbook records than on dealer reported trip tickets. Proportions were calculated by dividing the amount of Gulf red grouper by area and gear into total red grouper for each year from 1992-2013. Since reliable logbook data were not available prior to 1993, gear and area data were retained from the FL general canvass (as described earlier) but were scaled to the Florida trip ticket total.

**Decision 1:** It was the workgroup's recommendation to use Florida trip ticket data when available (1986-2013).

**Decision 2:** It was the workgroup's recommendation to use logbook data to apportion annual state landings to gear and area.

### 3.3.1 Boundaries

Gulf of Mexico landings are spatially distributed using the statistical areas 1 to 21, reaching from statistical area 1 in the Florida Keys to statistical area 21 bordering Mexico, see Figure 3.1.

The CFLP landings are reported by statistical area 1-21. ALS landings are reported by water body. When available, water body code is converted to statistical areas using the first two digits of the water body codes. When ALS water body is not available, county of landing was used.

The Gulf of Mexico and South Atlantic stock boundary lays in areas 1 and 2. The Gulf of Mexico landings from areas 1 and 2 are taken from water bodies north of highway U.S. 1 in the Florida Keys and north of the boundary line that extends from Key West to the Dry Tortugas. Waters west of the Dry Tortugas are considered to be the Gulf of Mexico (Figure 3.2).

**Decision 3:** The workgroup's recommendation was to maintain the region boundaries as defined by the Gulf of Mexico Council boundaries between statistical grid areas 1 and 21.

### 3.3.2 Gears

The workgroup investigated reported gears landing red grouper from various data sources (ALS, CFLP, and Florida Trip Ticket) and determined the predominate gears to be handline, longline, and trap. In agreement with SEDAR 12, it was the workgroup's recommendation to then categorize landings into four gear groups: handline, longline, trap, and other. A list of gears included in the handline, longline, and trap categories can be found in Table 3.2.

**Decision 4:** The workgroup suggested four gear groupings to characterize the red grouper fishery (handlines, longlines, trap, and other). Handlines include hook and line, electric/hydraulic bandit reels, and trolling.

### 3.3.3 *Unclassified Groupers*

Prior to 1986 all grouper landings, with the exception of goliath and warsaw, were reported as unclassified grouper. After this time unclassified grouper can still be found to varying degrees depending on the state of reporting. To apportion these landings to red grouper, a proportion of red grouper to the total identified grouper { (red grouper)/(all identified grouper species) } was developed for each year and state. The proportions were then applied to all unclassified grouper landings with the corresponding year and state. Prior to 1986 a mean red grouper proportion was created for each state using data for 1986-1989.

**Decision 5:** The workgroup recommended using a mean red grouper proportion from 1986 through 1989 for grouper landings prior to 1986. This methodology remains consistent to that used in SEDAR12.

### 3.3.4 *IFQ Landings*

The red grouper Individual Fishing Quota program (IFQ) is an online system where all transactions (share, allocation, and landing transfers) are recorded immediately upon entry by red grouper-IFQ participants. Landing transactions contain the following information: shareholder, vessel, and dealer name, landing date/time, landing location, species and pounds landed, and a landing confirmation number. Landings transactions cannot be completed for more pounds than are allocated to the vessel at the time of the landing and are not completed until approved by both the dealer and shareholder. The red grouper-IFQ program records all weights in gutted pounds.

Individual landings were summed for annual total pounds landed. Additional information concerning the IFQ program can be found in Appendix B.

Landings from IFQ and ALS were compared for 2010 through 2013. Total IFQ landings of red grouper were 98.9% to 100.8% of the calculated ALS landings. 2010 was the only year in which IFQ landings were less than those found in ALS (98.9%). It was discussed that the lower IFQ landings may be attributed to unreported IFQ landings by some fishers as there was likely a period of adjustment to the then new IFQ program. The possibility of unreported IFQ landings in 2010 was corroborated when comparing logbook trip reports to IFQ transactions. It is for this reason the workgroup felt that landings from ALS most accurately reflected landings of red grouper. For 2011- 2013, the workgroup felt the IFQ landings reported were more likely to be accurate as fishers were more aware and accustomed to reporting to the IFQ program and no unclassified grouper can be reported. For the assessment, ALS data are assigned to gear and statistical area (and thereby region) using logbook proportions of the landings (rather than dealer information). To maintain this resolution in ALS data, ALS landings were adjusted across strata using the percent difference between ALS and IFQ landings (Table 3.3). The resulting total ALS landings for 2011 through 2013 would then reflect that of IFQ.

**Decision 6:** Use total IFQ landings from 2011 through 2013. Apply the differences between ALS and IFQ to ALS data across all strata.

### 3.3.5 Historical Landings

Historical landings of red grouper were provided from Saul (2006). Landings provided are for 1880 through 1962 and are consistent with those used in SEDAR12. For historical data, all landings of grouper, with the exception of goliath and warsaw groupers, were reported as unclassified grouper. The unclassified grouper data available were by year and state. Of the 83 years of unclassified grouper landings available, only 26 years had data for all states (TX, LA, MS, AL, west FL), 12 years had data for at least one of the states, and 45 years had no data available. To fill in missing years of data, linear interpolations of unclassified grouper landings were made by state. Data were further apportioned to U.S. caught red grouper based on findings from an “exhaustive literature search” (Saul, 2006) and anecdotal evidence. Saul (2006) apportioned 90% of unclassified to red grouper. Landings were further apportioned to U.S.

caught fish based on fleet reports of smaller near shore vessels (“chings”), and larger vessels (“smacks”).

The workgroup discussed the possibility of dropping landings during World War II as prior SEDAR discussions mentioned that ports were closed due to the war. Further investigation however, found no substantive evidence that no fishing was occurring (Cortez 2014), (Smith 1948, (Baughman 1943) (Tarbox, National Fisherman 1970 vol 50, no 13) (Carpenter 1965). It is possible that fishing decreased during the war due to labor shortages, but not to the point where no landings were made. While landings levels remain uncertain for the 1940’s it was the workgroup’s recommendation to keep the calculated values provided by Saul (2006). Historic red grouper landings can be seen in Table 3.4 and Figure 3.4.

**Decision 7:** Use historic landings as produced by Saul (2006) for SEDAR12.

As with historical US landings of red grouper, Cuban landed red grouper were provided from Saul (2006). These landings represent red grouper landed in Cuba, but were taken from US waters. Landings are from 1937 through 1977. Missing landings in 1959-1962 were likely attributed to the Cuban revolution. The Cuban landings series ends in 1977 due to the expansion of the US EEZ to 200 miles and the expulsion of Cuban vessels. Cuban landings can be found in Table 3.5 and a comparison to US landings in Figure 3.5.

**Decision 8:** Use Cuban landings as produced by Saul (2006) for SEDAR12.

### 3.4 DISCARDS AND BYCATCH

#### Commercial Discards Preliminary Analyses

Commercial red grouper discards were calculated using discard rates as reported by fisheries observers. The discard rates were multiplied by year-specific total effort reported to the coastal logbook program to estimate total discards. Analytical methods used are briefly described here.

#### *Red grouper discard calculations*

Data available for the calculation of red grouper discards from the commercial fishery included vertical line (handline and electric/hydraulic reel) and bottom longline observer data in addition

to fisher reported effort data from the coastal logbook program. Complete years of observer data included the years 2007-2013. Coastal logbook data were available for the years 1990-2013; however, during the period 1990-92 only 20% of Florida vessels were selected to report landings and effort data. Beginning in 1993 all vessels with federal fishing permits were required to report to the coastal logbook program. Discards were calculated for the years with full reporting, 1993-2013.

To calculate discard rates of red grouper, observer and coastal logbook effort data were stratified by:

| <b>Gear</b>                         | <b>Vertical line/bottom longline</b>                                                               |
|-------------------------------------|----------------------------------------------------------------------------------------------------|
| <b>Region</b>                       | Statistical areas 1-8 (FL Keys to Cape San Blas), 9-21 (west of Cape San Blas to TX/Mexico border) |
| <b>Size limit</b>                   | 20 inch (1993-2009), 18 inch (2010-2013)                                                           |
| <b>Shallow water grouper season</b> | Open, closed (applies to 1993-2009)                                                                |
| <b>Allocation</b>                   | 0, 1+ pounds (applies to 2010-2013)                                                                |
| <b>Year</b>                         | Year specific stratification, 2007-2013                                                            |
| <b>Seasonal depth restriction</b>   | 20 fathoms, 35 fathoms*                                                                            |

\*Bottom longline vessels were restricted to fishing in depths 35 fathoms or deeper during June-August beginning in 2010. That restriction did not apply to vertical line vessels.

For the years 1993-2006, mean discard rates within strata across the years 2007-2009 (pre-IFQ, 20 inch minimum size data) were used. Effort data from the coastal logbook program were summed within each stratum.

Yearly discards were calculated for the years 2007-2013 (years with observer data) as:

$$\text{Year/stratum-specific discard rate} * \text{year/stratum-specific total effort}$$

For the years 1993-2006 (years with effort data, but no observer data available), discards were calculated as:

$$\text{mean stratum-specific discard rate} \times \text{year} / \text{stratum-specific total effort}$$

Mean discard rates were also used for the years 2007-2013 in cases where a stratum had few (<10) or no observer reports.

Discards were calculated as number of red grouper discarded summed across all strata within a year (Figures 3.6 and 3.7). Discard rates were in number of fish discarded per hook hour fished (vertical line) or per hook fished (bottom longline). High discards from the vertical line fishery in 2011-12 were associated with increased fishing effort and high discard rates in the eastern Gulf of Mexico among vessels with red grouper IFQ allocation. Decreased discards in the bottom longline fishery were likely due to reduced effort in the fishery (Figure 3.8). The fishery was restricted to 50 fathoms or deeper (from the usual 20 fathoms) in May, 2009. Beginning in 2010, depth restrictions were 35 fathoms or deeper during June-August and 20 fathoms or deeper during the remainder of the year. In addition, the bottom longline fishery became a limited entry fishery in 2010. Bottom longline gear was limited to 750 hooks per set, also beginning in 2010. The increase in discards from bottom longline vessels in 2011-12 was due to higher discard rates in the eastern Gulf of Mexico.

### **Recommendation:**

Use calculated discards from both commercial vertical line and bottom longline as data inputs for the Gulf of Mexico red grouper assessment.

## 3.5 COMMERCIAL EFFORT

The distribution of directed commercial effort in trips by year was compiled from the Coastal Fisheries Logbook Program (CFLP) for 1993-2013 and supplied here for information purposes. These data are presented in Figure 3.9. The distribution of harvest, as reported to the CFLP, is also displayed in Figure 3.10.

## 3.6 BIOLOGICAL SAMPLING

Biological sample data were obtained from the TIP sample data at NMFS/SEFSC and from the reef fish observer program at SEFSC's Galveston laboratory. Data were filtered to eliminate those records that included a size or effort bias, non-random collection of length data, were not from commercial trips, fish were selected by quota sampling, or the data were not collected shore-side. These data were further limited to those that could be assigned a year, gear, and state. Data that had an unknown sampling year, gear, or sampling state were deleted from the file.

### 3.6.1 TIP Samples

Commercial length samples are available for handline, longline, and trap gear groups between 1984 and 2013. The number of fish measured appears relatively adequate throughout the time series. The majority of samples are from the longline fishery in the southern Gulf of Mexico (areas 1 through 5), with well over 1,000 samples for most years (except 1988 when there were 0) and over 35,000 in 1999. The number of handline samples was generally above 1,000 for most years in both the north and south categories. Handline samples in the north were below 100 for five years between 1985 and 1990. Aggregation across regions may be necessary for these years. Trap samples were absent in the southern region until 1991. Other years were absent or low so aggregation of northern and southern trap samples may be necessary. The number of measured fish can be found in Table 3.6.

Age samples for handline and longline are available for 1991-2013. Prior to 2000, most years had fewer than 100 handline samples across regions. The number of longline age samples was greater with only four years having fewer than 100 samples prior to 2000. From 2000 forward, both handline and longline appear to have adequate sampling with over 100 ages collected for both gears and regions. A table of age samples can be found in Table 3.7.

There were some concerns about potential differences in size and age between the northern and southern Gulf. As expressed by Chih (2014b) it was recommended that handline and longline samples be weighted by landings and region (north and south Gulf). Length frequency distributions will then be provided by year and gear. There were also concerns about the representativeness of the age samples. It was therefore recommended that, in agreement with

Chih (2014b), ages be weighted by length frequencies for handline and longline by region. Final age frequencies will be provided by year and gear for handline and longline.

**Decision 9:** Weight length distributions for handline and longline by landings and region. Region is defined as north (areas 6 – 11) and south (areas 1 – 5) Gulf of Mexico.

**Decision 10:** Weight age distributions for handline and longline by length frequencies and region. Region is defined as north (areas 6 – 11) and south (areas 1 – 5) Gulf of Mexico.

Following these recommendations, length frequency distributions (LFDs) and age frequency distributions (AFDs) were developed for handline and longline, and were presented in Chih (2014a). The methods for estimating LFDs and AFDs for red groupers differ from those used in SEDAR 12 in several ways: (1) LFDs for handline and long line strata were stratified into north and south regions due to apparent differences in LFDs between the two regions (Chih, 2014b), (2) AFDs were reweighted by LFDs due to non-random sampling of some otolith samples, and (3) AFDs for handline and longline strata were also stratified into north and south regions due to apparent differences in ALKs between the two regions (Chih,2014b). All length and age samples collected from trips with Exempted Fishing Permits were also removed. Final sample sizes of lengths and ages can be found in tables 3.8 and 3.9. The resulting LFDs and AFDs can be found in Figures 3.11 – 3.16.

### *3.6.2 Size frequency data from commercial fisheries observers*

Fishery observer data collected on bottom longline and vertical line (handline and electric/hydraulic reels) from the Gulf of Mexico reef fish fishery from July 2006 through December 2013 were used for length frequency distributions. Vessels were randomly selected for observer coverage within gear type, region, and season strata. Strata with the highest effort received greater observer coverage (days at sea) than those strata with lower reported effort. Additionally, increased coverage was directed at either gear type (bottom longline or vertical line) based on enhanced coverage funding levels during various time periods. Data from 2007 and 2008 bottom longline gear were pooled to maintain confidentiality under NOAA Administrative Order 216-100.

Fishery observers record detailed information on both kept and discarded fish for each recorded fishing set; where set was defined as fishing at a specific location. Observers record lengths, weights, barotrauma stress indicators, and dispositions (kept, discarded alive, discarded dead, unknown discard, used for bait, and unknown if kept or discarded) for each fish captured. A total of 314,551 red grouper were recorded as captured by the observer program for bottom longline and vertical line gear types with 98.9% of these measured. For red grouper recorded as kept or discarded, 99.7% of kept and 97.7% of discarded red grouper had length information recorded. The majority (77.5%) of length measurements recorded were on vessels using bottom longline gear. Most (>99%) of the red grouper length measurements were fork length to the nearest mm, but a small amount (1,955) were recorded as stretched total length and converted using  $\text{Fork Length (mm)} = (\text{Total Length (mm)} + 5.95) / 1.05$ .

For length frequency distributions, histograms were produced for longline (Figure 3.17) and handline (Figure 3.18) by year for the proportion of red grouper kept and discarded in 1-cm bins. Further characterization of discarded sizes was explored. To explore the possibility of size selectivity based on available red grouper IFQ allocation, length frequency distributions were developed for longline (Figure 3.19), and handline (Figures 3.20 and 3.21). Sample sizes for each year are provided within each figure.

### 3.7 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

Overall the workgroup felt the landings were adequate for assessment analyses. The landings time series ran from 1880-2013. There was much uncertainty in the landings provided for 1880-1962 as reported landings of grouper were missing for the majority of years and assumptions on species apportionment and US caught fish remain. Landings post-1962 are felt to be relatively accurate. Landings after 1986 should be considered most accurate as this is when trip tickets went into place and landings were generally reported to species (i.e. reported as red grouper instead of 'unclassified' grouper). Total IFQ landings used for 2011 through 2013 were also agreed upon as being the most accurate.

There was some uncertainty in the discard estimations due to relatively low sample size when dividing observer data into various strata for discard rate calculation. This is most evident when dealing with longline trips. To address low or missing samples size, mean discard rates were

used. There is also a greater amount of uncertainty in the discard estimates prior to 2007. Since no observer data were available, a mean discard rate was applied back to 1993. Other than when using mean discards rates, it is felt that discard estimates should be fairly adequate since the observer program is the best source of data available.

The workgroup felt the commercial landings length samples should be adequate for assessment analyses. There appears to be an adequate number of samples for most years for all gears, especially handline and longline. There were fewer age samples, but the workgroup felt those data were adequate and should be weighted by length frequency distributions.

### 3.8 RESEARCH RECOMMENDATIONS

#### Landings

-Improve data quality of CFLP Logbook VTR number to state trip ticket for data reconciliation.

#### IFQ

-Investigate dealer influence on IFQ allocation usage through dealer IFQ surveys.

-Explore fishermen behavior in relation to allocation available.

-Add CFLP Logbook VTR number to IFQ landing transaction form for data reconciliation.

-Translate IFQ allocation activity ledger into a useable data set for daily allocation balances.

-Add actual landing date to IFQ reporting form.

-Improved enforcement of IFQ reporting infractions.

-Improve real time seizure reporting from states law enforcements agents. Need vessel, species, pounds, price per pound, dealer, and enforcement agent.

#### Discard

-Most appropriate method for incorporation of IFQ data into discard estimations.

-Most appropriate method for incorporation of IFQ data into discard size compositions.

-Increased observer funding and coverage.

-More representative observer coverage.

-Assess reliability of effort data in logbook data.

### Overall

Meet with fishermen prior to data workshops to provide supplementary information relevant to fishery dependent data.

### 3.9 LITERATURE CITED

Baughman, J. L. 1943. The Lutjanid Fishes of Texas. *Copeia* 1943(4):212-215.

Carpenter, J.S. 1965. A review of the Gulf of Mexico red snapper fishery. United States Fish and Wildlife Service, Circ. 208, Pages 1-35.

Chih, Ching-Ping. 2014(a). Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984 to 2013. SEDAR42-DW-18. SEDAR, North Charleston, SC. 42 pp.

Chih, C-P. 2014(b). Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of Mexico. SEDAR42-DW-12. SEDAR, North Charleston, SC. 26 pp.

Cortez. 2014. Retrieved from <http://www.freshfromflorida.com/Divisions-Offices/Marketing-and-Development/Consumer-Resources/Recreation/Florida-s-Waterfront-Communities-and-Commercial-Fishing-Heritage/Cortez>

Pulver, J.R., L. Lombardi, and E. Scott-Denton. 2014. Summary of commercial red grouper (*Epinephelus morio*) catch data based on fishery observer coverage of the Gulf of Mexico reef fish fishery. SEDAR42-DW-01. SEDAR, North Charleston, SC. 40 pp.

Saul, S. 2006. Quantitative Historical Analysis of the United States and Cuban Gulf of Mexico Red Grouper Commercial Fishery. SEDAR12-DW-11. SEDAR, North Charleston, SC. 27 pp.

Smith, R.O. 1948. Experimental fishing for red snapper, parts one and two. Commercial Fisheries Review 10(2):1-10 and 10(3):6-7.

Tarbox, L.H. 1970. The red snapper fleet of the Gulf Coast. National Fisherman. Yearbook. 50(13), pp 129-132.

PRE-DECISIONAL

## 3.10 TABLES

**Table 3.1** Annual red grouper landings in gutted pounds for 1963-2013

| Year | Handline  | Longline  | Trap      | Other  | Total     |
|------|-----------|-----------|-----------|--------|-----------|
| 1963 | 3,564,592 |           |           | 2,884  | 3,567,476 |
| 1964 | 4,140,338 |           | 4,628     | 13,769 | 4,158,735 |
| 1965 | 4,616,945 |           | 5,053     |        | 4,621,998 |
| 1966 | 4,433,396 |           | 6,553     | 1,093  | 4,441,042 |
| 1967 | 3,583,388 |           | 7,404     | 15,447 | 3,606,239 |
| 1968 | 3,942,688 |           | 13,511    | 3,205  | 3,959,403 |
| 1969 | 4,587,309 |           | 7,804     | 2,056  | 4,597,170 |
| 1970 | 4,469,105 |           | 12,160    |        | 4,481,264 |
| 1971 | 3,812,225 |           | 12,149    |        | 3,824,374 |
| 1972 | 3,963,622 |           | 2,277     | 10     | 3,965,908 |
| 1973 | 3,059,028 |           |           | 530    | 3,059,558 |
| 1974 | 3,568,782 |           |           | 827    | 3,569,609 |
| 1975 | 4,312,414 |           | 12,426    | 163    | 4,325,003 |
| 1976 | 3,727,297 |           | 11,404    |        | 3,738,701 |
| 1977 | 2,977,567 |           | 41,873    | 4,514  | 3,023,954 |
| 1978 | 2,731,138 |           | 88,893    | 5,628  | 2,825,658 |
| 1979 | 3,778,962 |           | 70,135    |        | 3,849,096 |
| 1980 | 3,847,616 |           | 44,773    | 10,672 | 3,903,060 |
| 1981 | 3,324,172 | 3         | 66,685    | 9,827  | 3,400,688 |
| 1982 | 3,074,037 | 815,663   | 50,020    | 12,994 | 3,952,714 |
| 1983 | 2,907,533 | 3,064,216 | 1,109     | 12,650 | 5,985,509 |
| 1984 | 2,947,579 | 2,487,094 | 311,570   | 3,349  | 5,749,592 |
| 1985 | 3,647,830 | 2,073,122 | 640,413   | 7,282  | 6,368,646 |
| 1986 | 3,134,859 | 2,505,832 | 721,461   | 11,217 | 6,373,369 |
| 1987 | 2,542,122 | 3,774,849 | 448,081   | 11,082 | 6,776,135 |
| 1988 | 2,049,120 | 2,192,793 | 540,228   | 5,228  | 4,787,369 |
| 1989 | 3,814,892 | 3,118,201 | 592,772   | 11,051 | 7,536,916 |
| 1990 | 2,460,952 | 2,025,693 | 340,896   | 5,346  | 4,832,887 |
| 1991 | 2,093,837 | 2,583,586 | 373,747   | 33,887 | 5,085,058 |
| 1992 | 1,444,966 | 2,409,550 | 602,185   | 8,636  | 4,465,337 |
| 1993 | 1,300,324 | 4,274,356 | 711,086   | 43,275 | 6,329,042 |
| 1994 | 1,241,427 | 2,699,085 | 913,825   | 37,682 | 4,892,020 |
| 1995 | 1,171,250 | 2,429,416 | 1,056,993 | 16,044 | 4,673,703 |
| 1996 | 865,153   | 2,907,190 | 539,359   | 10,161 | 4,321,863 |
| 1997 | 948,379   | 3,024,185 | 685,831   | 6,839  | 4,665,234 |
| 1998 | 741,613   | 2,662,645 | 297,548   | 5,128  | 3,706,934 |
| 1999 | 1,212,757 | 3,815,403 | 751,819   | 17,430 | 5,797,409 |
| 2000 | 1,720,988 | 2,909,341 | 1,024,809 | 30,399 | 5,685,537 |

|      |           |           |         |         |           |
|------|-----------|-----------|---------|---------|-----------|
| 2001 | 1,555,714 | 3,399,634 | 743,289 | 21,255  | 5,719,892 |
| 2002 | 1,628,178 | 3,130,561 | 980,293 | 18,484  | 5,757,516 |
| 2003 | 1,118,263 | 2,964,737 | 701,668 | 12,313  | 4,796,981 |
| 2004 | 1,376,656 | 3,383,468 | 745,209 | 14,130  | 5,519,462 |
| 2005 | 1,404,245 | 3,211,570 | 612,717 | 12,402  | 5,240,934 |
| 2006 | 1,375,688 | 3,012,663 | 586,847 | 8,956   | 4,984,154 |
| 2007 | 1,561,080 | 1,984,386 | 24,476  | 13,097  | 3,583,039 |
| 2008 | 1,888,224 | 2,804,144 |         | 24,773  | 4,717,142 |
| 2009 | 2,445,139 | 1,124,827 |         | 121,721 | 3,691,687 |
| 2010 | 1,353,711 | 1,314,422 |         | 275,596 | 2,943,729 |
| 2011 | 1,688,279 | 3,045,086 | 15      | 50,289  | 4,783,668 |
| 2012 | 2,229,535 | 2,940,062 |         | 49,537  | 5,219,133 |
| 2013 | 1,540,493 | 3,017,605 |         | 40,902  | 4,599,001 |

**Table 3.2** ALS gear code grouping.

| NMFS Code | Description                   | Group    |
|-----------|-------------------------------|----------|
| 600       | Troll & Hand Lines Cmb        | Handline |
| 610       | Lines Hand, Other             | Handline |
| 611       | Rod and Reel                  | Handline |
| 612       | Reel, Manual                  | Handline |
| 613       | Reel, Electric or Hydraulic   | Handline |
| 614       | Long Line, Vertical           | Handline |
| 616       | Rod and Reel, Electric (Hand) | Handline |
| 675       | Lines Long Set With Hooks     | Longline |
| 676       | Lines Long, Reef Fish         | Longline |
| 677       | Lines Long, Shark             | Longline |
| 345       | Pots and Traps, Fish          | Trap     |
| 355       | Pots and Traps, Spiny Lobster | Trap     |
| *         | All other codes               | Other    |

**Table 3.3** Annual IFQ correction factors.

| Year | IFQ landings | ALS + FTT landings | IFQ correction factor |
|------|--------------|--------------------|-----------------------|
| 2011 | 4,783,668    | 4,746,990          | 1.00773               |
| 2012 | 5,219,133    | 5,203,521          | 1.00300               |
| 2013 | 4,599,001    | 4,564,933          | 1.00746               |

**Table 3.4** Historic red grouper landings from Gulf of Mexico states.

| Year | Texas | Louisiana | Mississippi | Alabama | Florida | Total |
|------|-------|-----------|-------------|---------|---------|-------|
|------|-------|-----------|-------------|---------|---------|-------|

|      |        |        |        |         |           |           |
|------|--------|--------|--------|---------|-----------|-----------|
| 1880 | 0      | 0      | 0      | 0       | 1,514,570 | 1,514,570 |
| 1881 | 491    | 0      | 0      | 954     | 1,366,462 | 1,367,907 |
| 1882 | 981    | 0      | 0      | 1,908   | 1,218,353 | 1,221,243 |
| 1883 | 1,472  | 0      | 0      | 2,862   | 1,070,245 | 1,074,579 |
| 1884 | 1,963  | 0      | 0      | 3,816   | 922,136   | 927,915   |
| 1885 | 2,453  | 0      | 0      | 4,770   | 774,028   | 781,251   |
| 1886 | 2,944  | 0      | 0      | 5,724   | 625,919   | 634,587   |
| 1887 | 3,434  | 0      | 0      | 6,678   | 477,811   | 487,923   |
| 1888 | 6,010  | 7,727  | 0      | 7,632   | 329,702   | 351,072   |
| 1889 | 0      | 15,455 | 0      | 8,586   | 358,895   | 382,936   |
| 1890 | 0      | 15,455 | 0      | 9,445   | 342,581   | 367,481   |
| 1891 | 425    | 13,247 | 0      | 16,559  | 389,455   | 419,686   |
| 1892 | 850    | 11,039 | 0      | 23,673  | 436,329   | 471,891   |
| 1893 | 1,274  | 8,831  | 0      | 30,787  | 483,204   | 524,096   |
| 1894 | 1,699  | 6,623  | 0      | 37,901  | 530,078   | 576,301   |
| 1895 | 2,018  | 4,416  | 0      | 42,764  | 554,849   | 604,047   |
| 1896 | 2,319  | 2,208  | 0      | 47,438  | 581,263   | 633,228   |
| 1897 | 2,557  | 0      | 0      | 50,949  | 597,236   | 650,743   |
| 1898 | 7,514  | 818    | 1,008  | 126,714 | 501,739   | 637,792   |
| 1899 | 11,996 | 1,635  | 2,016  | 195,295 | 416,974   | 627,917   |
| 1900 | 15,756 | 2,453  | 3,024  | 252,593 | 334,242   | 608,068   |
| 1901 | 18,885 | 3,271  | 4,032  | 300,172 | 257,371   | 583,730   |
| 1902 | 21,728 | 4,089  | 5,040  | 343,483 | 283,508   | 657,848   |
| 1903 | 19,402 | 4,906  | 6,048  | 296,220 | 353,401   | 679,978   |
| 1904 | 17,180 | 5,724  | 7,057  | 252,406 | 415,956   | 698,322   |
| 1905 | 15,061 | 6,542  | 8,065  | 212,040 | 471,209   | 712,916   |
| 1906 | 13,350 | 7,359  | 9,073  | 179,196 | 524,646   | 733,623   |
| 1907 | 11,428 | 8,177  | 10,081 | 145,382 | 566,143   | 741,211   |
| 1908 | 9,610  | 8,995  | 11,089 | 115,018 | 600,448   | 745,160   |
| 1909 | 8,169  | 9,813  | 12,097 | 97,623  | 778,394   | 906,095   |
| 1910 | 6,548  | 10,630 | 13,105 | 78,133  | 925,503   | 1,033,919 |
| 1911 | 6,288  | 11,448 | 14,113 | 74,913  | 1,120,083 | 1,226,845 |
| 1912 | 6,029  | 12,266 | 15,121 | 71,693  | 1,315,282 | 1,420,391 |
| 1913 | 5,770  | 13,083 | 16,129 | 68,473  | 1,511,099 | 1,614,555 |
| 1914 | 5,511  | 13,901 | 17,137 | 65,254  | 1,707,536 | 1,809,339 |
| 1915 | 5,251  | 14,719 | 18,145 | 62,034  | 1,904,591 | 2,004,741 |
| 1916 | 4,992  | 15,537 | 19,153 | 58,814  | 2,102,266 | 2,200,762 |
| 1917 | 4,733  | 16,354 | 20,162 | 55,594  | 2,300,559 | 2,397,402 |
| 1918 | 4,473  | 17,172 | 21,170 | 52,375  | 2,499,471 | 2,594,660 |
| 1919 | 4,984  | 15,455 | 21,424 | 54,976  | 2,382,338 | 2,479,176 |
| 1920 | 5,494  | 13,738 | 21,678 | 57,578  | 2,264,822 | 2,363,309 |
| 1921 | 6,004  | 12,020 | 21,933 | 60,179  | 2,146,923 | 2,247,059 |
| 1922 | 6,514  | 10,303 | 22,187 | 62,781  | 2,028,640 | 2,130,425 |

|      |        |        |         |        |           |           |
|------|--------|--------|---------|--------|-----------|-----------|
| 1923 | 7,024  | 8,586  | 22,441  | 65,382 | 1,909,975 | 2,013,409 |
| 1924 | 7,267  | 9,874  | 25,027  | 56,774 | 1,873,771 | 1,972,714 |
| 1925 | 7,510  | 11,162 | 27,613  | 48,166 | 1,835,998 | 1,930,450 |
| 1926 | 7,753  | 12,450 | 30,200  | 39,558 | 1,796,656 | 1,886,616 |
| 1927 | 7,996  | 13,738 | 32,786  | 34,785 | 1,755,744 | 1,845,048 |
| 1928 | 5,230  | 429    | 42,329  | 83,271 | 1,761,198 | 1,892,457 |
| 1929 | 4,857  | 3,434  | 21,405  | 37,814 | 2,020,038 | 2,087,548 |
| 1930 | 6,814  | 3,005  | 61,040  | 52,403 | 1,273,484 | 1,396,746 |
| 1931 | 11,930 | 3,580  | 20,685  | 25,380 | 1,174,304 | 1,235,880 |
| 1932 | 8,372  | 2,919  | 13,838  | 25,281 | 1,545,659 | 1,596,069 |
| 1933 | 6,517  | 9,359  | 30,531  | 57,112 | 1,984,501 | 2,088,019 |
| 1934 | 2,054  | 15,798 | 47,223  | 28,563 | 1,918,300 | 2,011,938 |
| 1935 | 10,694 | 9,616  | 88,006  | 34,234 | 2,384,720 | 2,527,271 |
| 1936 | 19,839 | 3,434  | 128,790 | 40,271 | 2,889,396 | 3,081,730 |
| 1937 | 11,612 | 5,237  | 110,416 | 46,714 | 3,165,300 | 3,339,280 |
| 1938 | 20,067 | 5,152  | 135,315 | 47,375 | 2,863,585 | 3,071,494 |
| 1939 | 43,161 | 8,844  | 18,288  | 50,051 | 4,473,796 | 4,594,140 |
| 1940 | 53,723 | 3,434  | 15,541  | 52,140 | 3,133,444 | 3,258,282 |
| 1941 | 41,755 | 3,263  | 13,686  | 48,354 | 3,379,013 | 3,486,070 |
| 1942 | 34,762 | 3,091  | 11,832  | 50,045 | 3,931,818 | 4,031,547 |
| 1943 | 24,751 | 2,919  | 9,977   | 40,782 | 4,122,729 | 4,201,159 |
| 1944 | 17,686 | 2,748  | 8,122   | 35,481 | 4,679,268 | 4,743,304 |
| 1945 | 9,457  | 2,576  | 6,268   | 29,129 | 4,918,990 | 4,966,420 |
| 1946 | 27,540 | 2,948  | 14,196  | 51,799 | 5,300,728 | 5,397,211 |
| 1947 | 45,397 | 3,320  | 22,123  | 55,834 | 5,298,183 | 5,424,857 |
| 1948 | 61,152 | 3,692  | 30,051  | 67,212 | 5,090,963 | 5,253,070 |
| 1949 | 81,861 | 4,465  | 25,071  | 45,622 | 5,205,622 | 5,362,641 |
| 1950 | 58,769 | 6,525  | 12,962  | 28,910 | 3,480,371 | 3,587,538 |
| 1951 | 25,280 | 15,196 | 268     | 70,807 | 3,929,321 | 4,040,872 |
| 1952 | 42,499 | 179    | 3,710   | 58,629 | 2,452,656 | 2,557,673 |
| 1953 | 26,769 | 626    | 7,151   | 35,225 | 1,911,275 | 1,981,046 |
| 1954 | 19,630 | 1,698  | 18,593  | 68,133 | 1,705,939 | 1,813,993 |
| 1955 | 27,019 | 1,788  | 15,017  | 49,611 | 1,576,121 | 1,669,557 |
| 1956 | 4,756  | 0      | 14,839  | 51,463 | 2,258,786 | 2,329,844 |
| 1957 | 18,134 | 268    | 15,116  | 35,817 | 2,781,496 | 2,850,830 |
| 1958 | 18,387 | 0      | 24,999  | 55,350 | 2,822,615 | 2,921,351 |
| 1959 | 63,903 | 10,637 | 45,893  | 74,465 | 3,752,333 | 3,947,231 |
| 1960 | 28,190 | 21,632 | 59,727  | 73,805 | 4,341,318 | 4,524,671 |
| 1961 | 33,097 | 14,124 | 56,886  | 69,237 | 4,270,933 | 4,444,277 |
| 1962 | 71,270 | 47,108 | 81,396  | 74,274 | 4,926,802 | 5,200,851 |

**Table 3.5** Red grouper caught in the U.S. Gulf of Mexico and landed in Cuba.

| Year | Cuban Landings |
|------|----------------|
| 1937 | 6,486,300      |
| 1938 | 6,486,300      |
| 1939 | 6,486,300      |
| 1940 | 6,486,300      |
| 1941 | 6,486,300      |
| 1942 | 2,640,994      |
| 1943 | 2,029,448      |
| 1944 | 2,999,945      |
| 1945 | 1,668,658      |
| 1946 | 1,791,966      |
| 1947 | 1,891,760      |
| 1948 | 1,968,042      |
| 1949 | 2,020,812      |
| 1950 | 2,050,069      |
| 1951 | 2,055,813      |
| 1952 | 2,038,044      |
| 1953 | 1,996,763      |
| 1954 | 1,931,969      |
| 1955 | 1,843,662      |
| 1956 | 1,949,123      |
| 1957 | 2,773,565      |
| 1958 | 2,130,822      |
| 1959 | 0              |
| 1960 | 0              |
| 1961 | 0              |
| 1962 | 0              |
| 1963 | 1,015,863      |
| 1964 | 2,173,199      |
| 1965 | 4,225,336      |
| 1966 | 5,013,435      |
| 1967 | 5,271,405      |
| 1968 | 5,529,375      |
| 1969 | 5,787,345      |
| 1970 | 5,625,305      |
| 1971 | 3,144,358      |
| 1972 | 3,207,059      |
| 1973 | 6,050,765      |
| 1974 | 4,030,210      |

|      |           |
|------|-----------|
| 1975 | 4,030,210 |
| 1976 | 4,030,210 |
| 1977 | 4,030,210 |

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PRE-DECISIONAL

**Table 3.6** Preliminary number of commercial length samples for red grouper.

| Year | North (of 28N) |          |       | South (of 28N) |          |      | Total    |          |       |
|------|----------------|----------|-------|----------------|----------|------|----------|----------|-------|
|      | Handline       | Longline | Trap  | Handline       | Longline | Trap | Handline | Longline | Trap  |
| 1984 | 161            | 107      | 18    | 1,222          | 1,014    |      | 1,383    | 1,121    | 18    |
| 1985 | 39             | 537      | 900   | 2,012          | 1,178    |      | 2,051    | 1,715    | 900   |
| 1986 | 10             | 242      | 1,244 | 510            | 5,519    |      | 520      | 5,761    | 1,244 |
| 1987 | 7              | 75       | 766   | 1,099          | 2,483    |      | 1,106    | 2,558    | 766   |
| 1988 | 1,137          | 1,229    |       | 146            |          |      | 1,283    | 1,229    |       |
| 1989 | 18             | 176      | 341   | 589            | 1,617    |      | 607      | 1,793    | 341   |
| 1990 | 89             | 999      | 359   | 856            | 9,889    |      | 945      | 10,888   | 359   |
| 1991 | 169            | 1,351    | 43    | 1,681          | 10,942   | 367  | 1,850    | 12,293   | 410   |
| 1992 | 447            | 180      | 196   | 1,998          | 8,218    | 647  | 2,445    | 8,398    | 843   |
| 1993 | 1,129          | 1,453    | 4     | 1,387          | 8,232    | 453  | 2,516    | 9,685    | 457   |
| 1994 | 1,072          | 1,081    | 207   | 2,163          | 7,136    |      | 3,235    | 8,217    | 207   |
| 1995 | 1,873          | 2,511    | 342   | 1,425          | 8,586    |      | 3,298    | 11,097   | 342   |
| 1996 | 1,251          | 2,901    | 415   | 1,843          | 6,855    | 287  | 3,094    | 9,756    | 702   |
| 1997 | 1,377          | 4,743    | 1,159 | 1,040          | 8,925    | 363  | 2,417    | 13,668   | 1,522 |
| 1998 | 1,274          | 4,812    | 638   | 2,205          | 24,121   | 422  | 3,479    | 28,933   | 1,060 |
| 1999 | 3,263          | 6,988    | 1,503 | 3,489          | 37,245   | 380  | 6,752    | 44,233   | 1,883 |
| 2000 | 2,884          | 5,038    | 2,185 | 4,869          | 25,125   | 517  | 7,753    | 30,163   | 2,702 |
| 2001 | 3,413          | 3,665    | 3,096 | 3,545          | 16,342   | 866  | 6,958    | 20,007   | 3,962 |
| 2002 | 2,706          | 2,695    | 1,689 | 2,758          | 15,425   | 489  | 5,464    | 18,120   | 2,178 |
| 2003 | 1,565          | 1,402    | 1,209 | 1,412          | 12,261   | 133  | 2,977    | 13,663   | 1,342 |
| 2004 | 1,553          | 1,150    | 20    | 1,299          | 9,823    | 364  | 2,852    | 10,973   | 384   |
| 2005 | 1,298          | 1,839    | 377   | 590            | 5,829    | 207  | 1,888    | 7,668    | 584   |
| 2006 | 700            | 1,441    | 803   | 173            | 3,049    | 186  | 873      | 4,490    | 989   |
| 2007 | 1,340          | 522      |       | 94             | 2,368    |      | 1,434    | 2,890    |       |
| 2008 | 1,178          | 1,154    |       | 305            | 3,499    |      | 1,483    | 4,653    |       |
| 2009 | 2,642          | 314      |       | 1,390          | 1,652    |      | 4,032    | 1,966    |       |
| 2010 | 1,195          | 372      |       | 2,138          | 2,028    |      | 3,333    | 2,400    |       |
| 2011 | 4,759          | 1,387    |       | 1,375          | 3,283    |      | 6,134    | 4,670    |       |
| 2012 | 7,458          | 2,443    |       | 3,270          | 4,697    |      | 10,728   | 7,140    |       |
| 2013 | 6,461          | 1,436    |       | 3,461          | 5,770    |      | 9,922    | 7,206    |       |

**Table 3.7** Preliminary number of commercial age samples for red grouper.

| Year | North    |          | South    |          | Total    |          |
|------|----------|----------|----------|----------|----------|----------|
|      | Handline | Longline | Handline | Longline | Handline | Longline |
| 1991 | 28       | 35       | 15       | 2        | 43       | 37       |
| 1992 | 20       | 1        | 22       | 140      | 42       | 141      |
| 1993 | 81       | 10       | 12       | 190      | 93       | 200      |
| 1994 | 184      | 24       | 55       | 64       | 239      | 88       |
| 1995 | 178      | 14       | 2        | 126      | 180      | 140      |
| 1996 | 135      | 96       | 6        |          | 141      | 96       |
| 1997 | 35       |          | 7        |          | 42       | 0        |
| 1998 | 17       | 37       | 22       | 85       | 39       | 122      |
| 1999 | 53       | 96       | 24       | 547      | 77       | 643      |
| 2000 | 144      | 137      | 62       | 268      | 206      | 405      |
| 2001 | 365      | 872      | 210      | 338      | 575      | 1,210    |
| 2002 | 155      | 607      | 418      | 460      | 573      | 1,067    |
| 2003 | 314      | 234      | 247      | 846      | 561      | 1,080    |
| 2004 | 528      | 200      | 534      | 953      | 1,062    | 1,153    |
| 2005 | 398      | 269      | 228      | 1,186    | 626      | 1,455    |
| 2006 | 299      | 163      | 330      | 375      | 629      | 538      |
| 2007 | 436      | 147      | 61       | 452      | 497      | 599      |
| 2008 | 377      | 143      | 126      | 366      | 503      | 509      |
| 2009 | 801      | 185      | 570      | 1,848    | 1,371    | 2,033    |
| 2010 | 482      | 103      | 548      | 547      | 1,030    | 650      |
| 2011 | 439      | 101      | 190      | 398      | 629      | 499      |
| 2012 | 585      | 192      | 434      | 669      | 1,019    | 861      |
| 2013 | 392      | 275      | 166      | 855      | 558      | 1,130    |

**Table 3.8** Final number of commercial length samples for red grouper. Exempted Fishing Permit samples removed for final analysis.

| Year | Handline | Longline | Trap  | Total  |
|------|----------|----------|-------|--------|
| 1984 | 1,383    | 1,121    | 18    | 2,522  |
| 1985 | 2,051    | 1,715    | 900   | 4,666  |
| 1986 | 520      | 5,761    | 1,244 | 7,525  |
| 1987 | 1,106    | 2,558    | 766   | 4,430  |
| 1988 | 1,137    | 1,375    |       | 2,512  |
| 1989 | 607      | 1,793    | 341   | 2,741  |
| 1990 | 945      | 10,888   | 359   | 12,192 |
| 1991 | 1,850    | 12,293   | 410   | 14,553 |
| 1992 | 2,445    | 8,398    | 843   | 11,686 |
| 1993 | 2,516    | 9,685    | 457   | 12,658 |
| 1994 | 3,235    | 8,217    | 207   | 11,659 |
| 1995 | 3,298    | 11,097   | 342   | 14,737 |
| 1996 | 3,094    | 9,756    | 702   | 13,552 |
| 1997 | 2,417    | 13,668   | 1,522 | 17,607 |
| 1998 | 3,479    | 28,933   | 1,060 | 33,472 |
| 1999 | 6,752    | 44,233   | 1,883 | 52,868 |
| 2000 | 7,753    | 30,163   | 2,702 | 40,618 |
| 2001 | 6,958    | 20,007   | 3,962 | 30,927 |
| 2002 | 5,464    | 18,120   | 2,178 | 25,762 |
| 2003 | 2,977    | 13,663   | 1,342 | 17,982 |
| 2004 | 2,852    | 10,973   | 384   | 14,209 |
| 2005 | 1,888    | 7,668    | 584   | 10,140 |
| 2006 | 873      | 4,487    | 989   | 6,349  |
| 2007 | 1,434    | 2,890    |       | 4,324  |
| 2008 | 1,483    | 4,653    |       | 6,136  |
| 2009 | 4,032    | 1,966    |       | 5,998  |
| 2010 | 3,324    | 2,400    |       | 5,724  |
| 2011 | 6,134    | 4,670    |       | 10,804 |
| 2012 | 10,728   | 7,140    |       | 17,868 |
| 2013 | 9,922    | 7,206    |       | 17,128 |

**Table 3.9** Final number of commercial age samples for red grouper. Exempted Fishing Permit samples removed for final analysis.

| Year | Handline | Longline | Trap | Total |
|------|----------|----------|------|-------|
| 1991 | 43       | 37       | 2    | 82    |
| 1992 | 42       | 143      | 14   | 199   |
| 1993 | 93       | 200      | 84   | 377   |
| 1994 | 239      | 88       | 29   | 356   |
| 1995 | 180      | 140      | 39   | 359   |
| 1996 | 141      | 96       | 8    | 245   |
| 1997 | 35       | 7        | 17   | 59    |
| 1998 | 39       | 122      | 33   | 194   |
| 1999 | 77       | 643      | 31   | 751   |
| 2000 | 206      | 405      | 38   | 649   |
| 2001 | 575      | 1,210    | 39   | 1,824 |
| 2002 | 573      | 1,067    | 89   | 1,729 |
| 2003 | 561      | 1,080    | 65   | 1,706 |
| 2004 | 1,062    | 1,153    | 38   | 2,253 |
| 2005 | 626      | 1,455    |      | 2,081 |
| 2006 | 629      | 538      | 173  | 1,340 |
| 2007 | 497      | 599      |      | 1,096 |
| 2008 | 503      | 509      |      | 1,012 |
| 2009 | 895      | 994      |      | 1,889 |
| 2010 | 1,030    | 650      |      | 1,680 |
| 2011 | 629      | 499      |      | 1,128 |
| 2012 | 1,019    | 861      |      | 1,880 |
| 2013 | 558      | 1,130    |      | 1,688 |

3.11 FIGURES

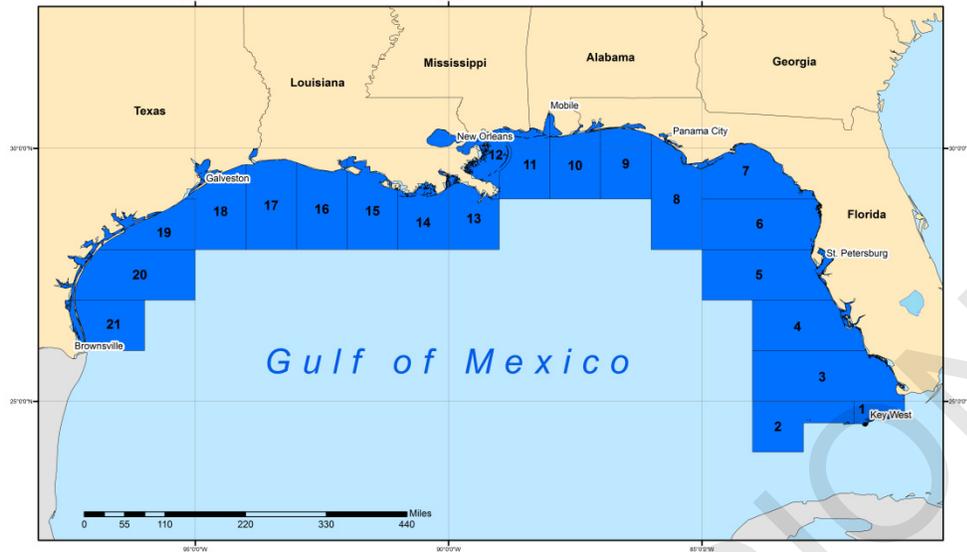


Figure 3.1 Gulf of Mexico region

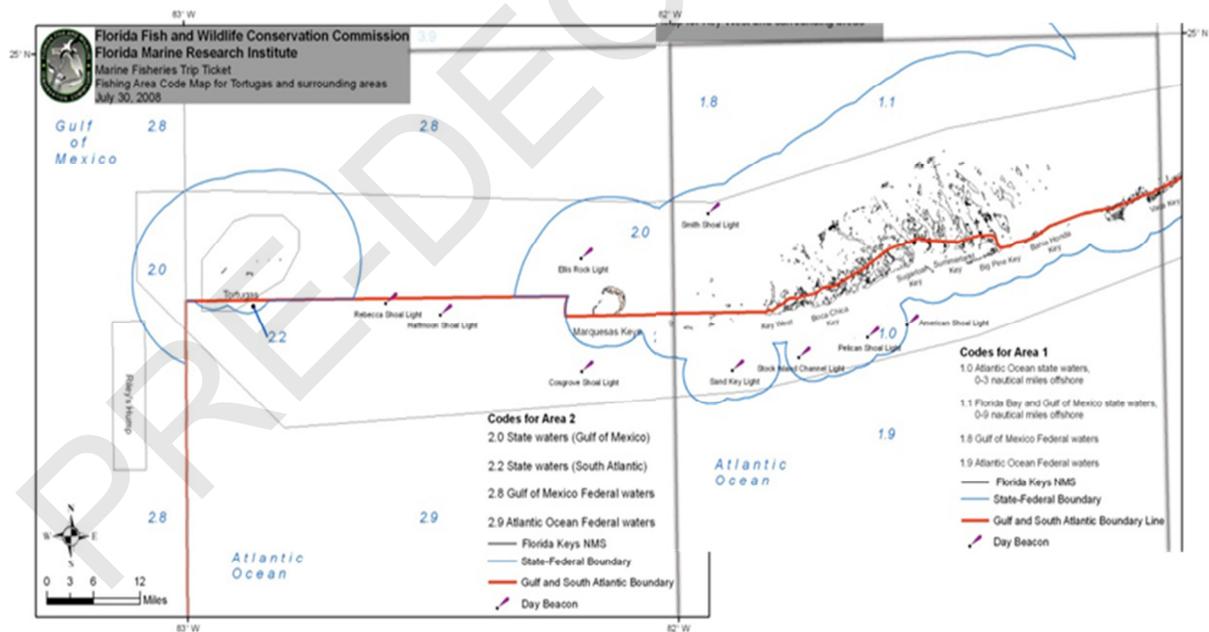


Figure 3.2 Close-up of the southern boundary as defined by the Gulf of Mexico/South Atlantic Council boundary.

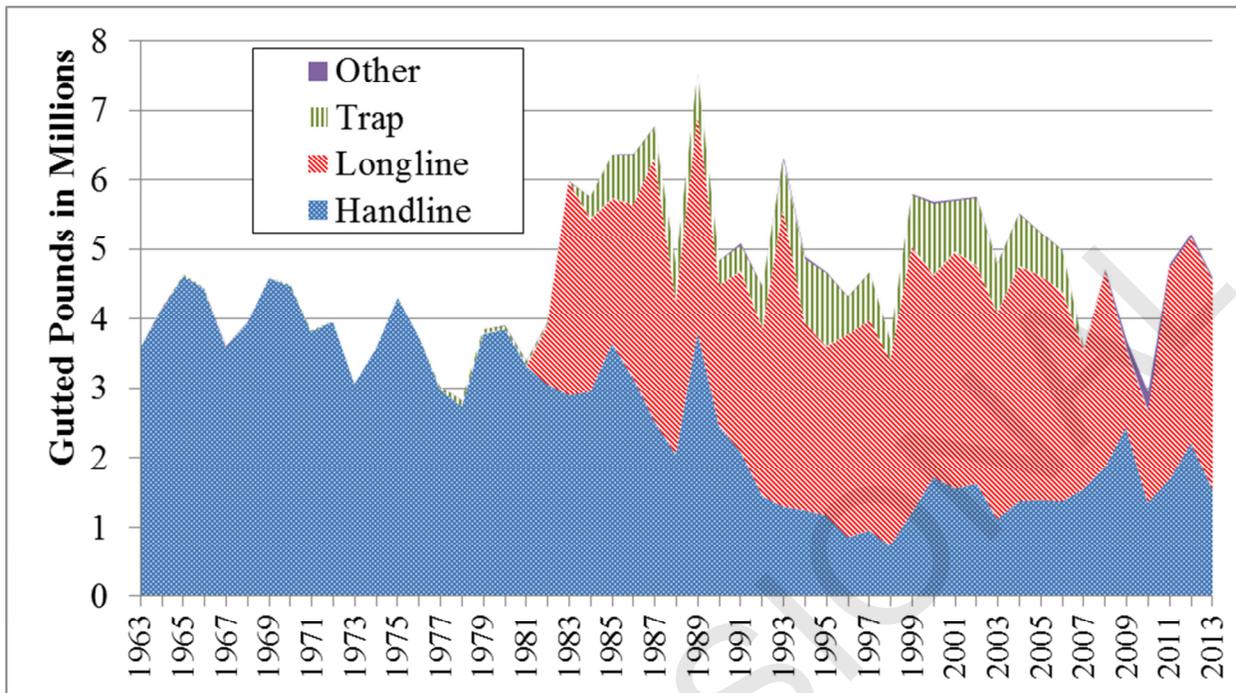


Figure 3.3 Red grouper landings, in gutted weight pounds by gear.

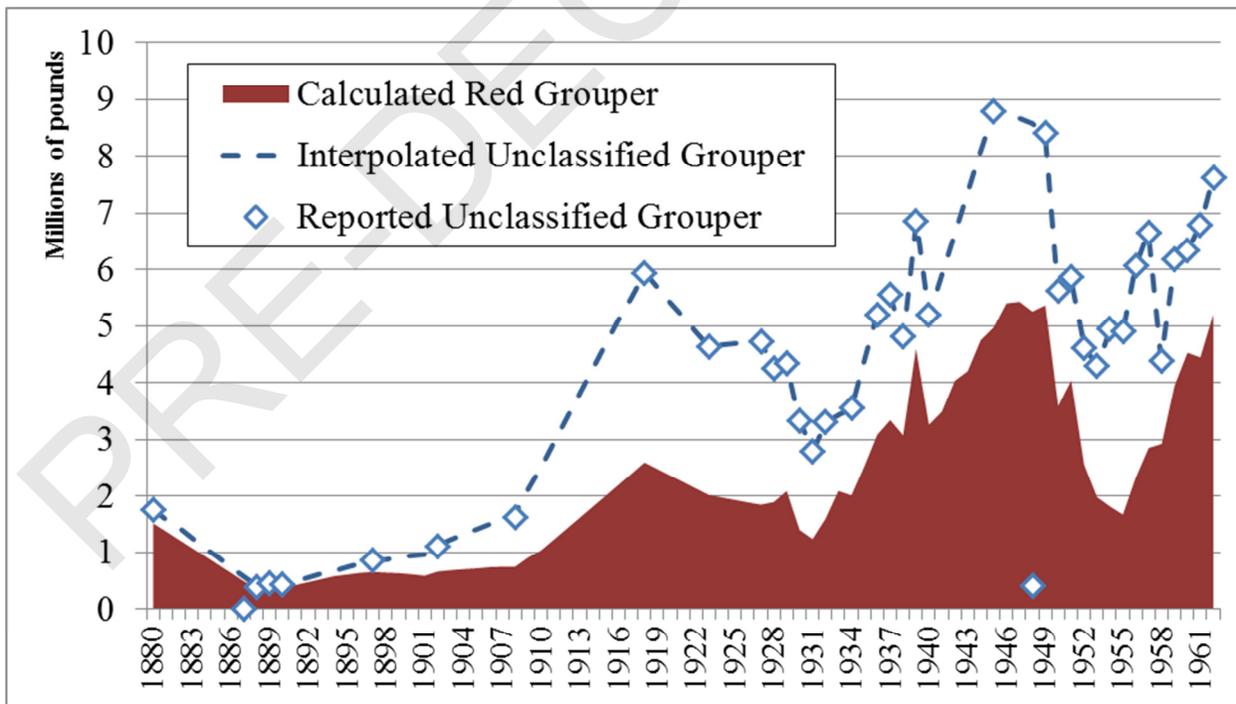


Figure 3.4 Historic red grouper landings as calculated from reported and interpolated unclassified grouper.

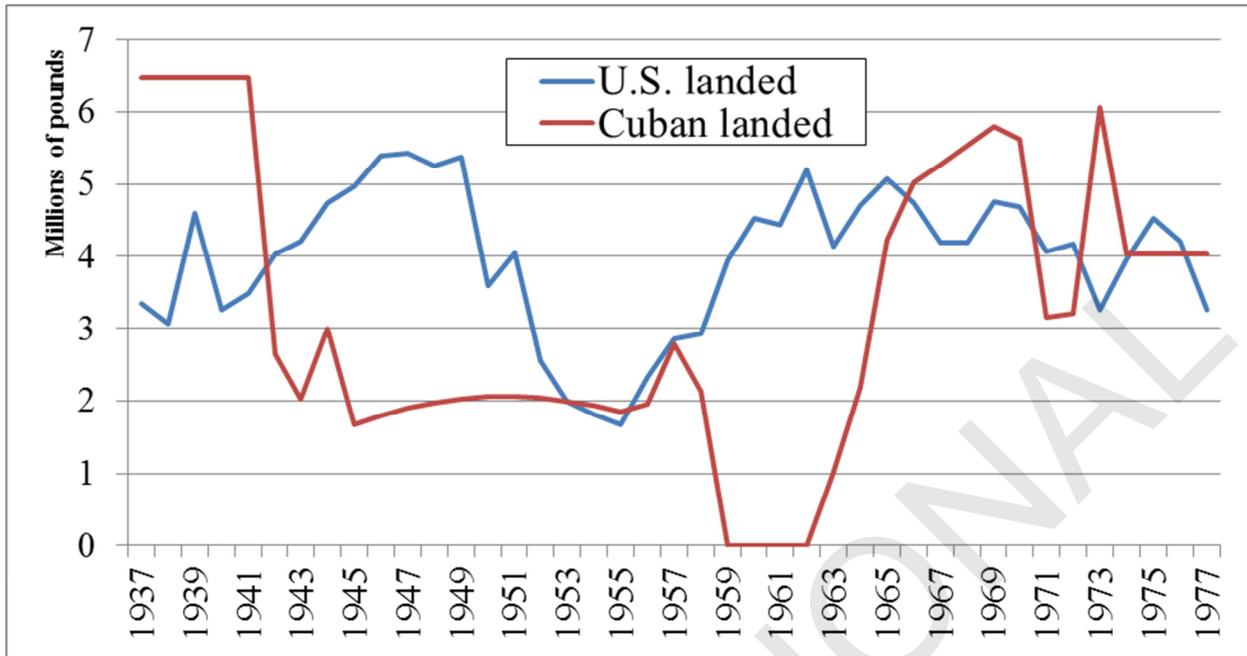


Figure 3.5 A comparison of US and Cuban landed red grouper from the US Gulf of Mexico.

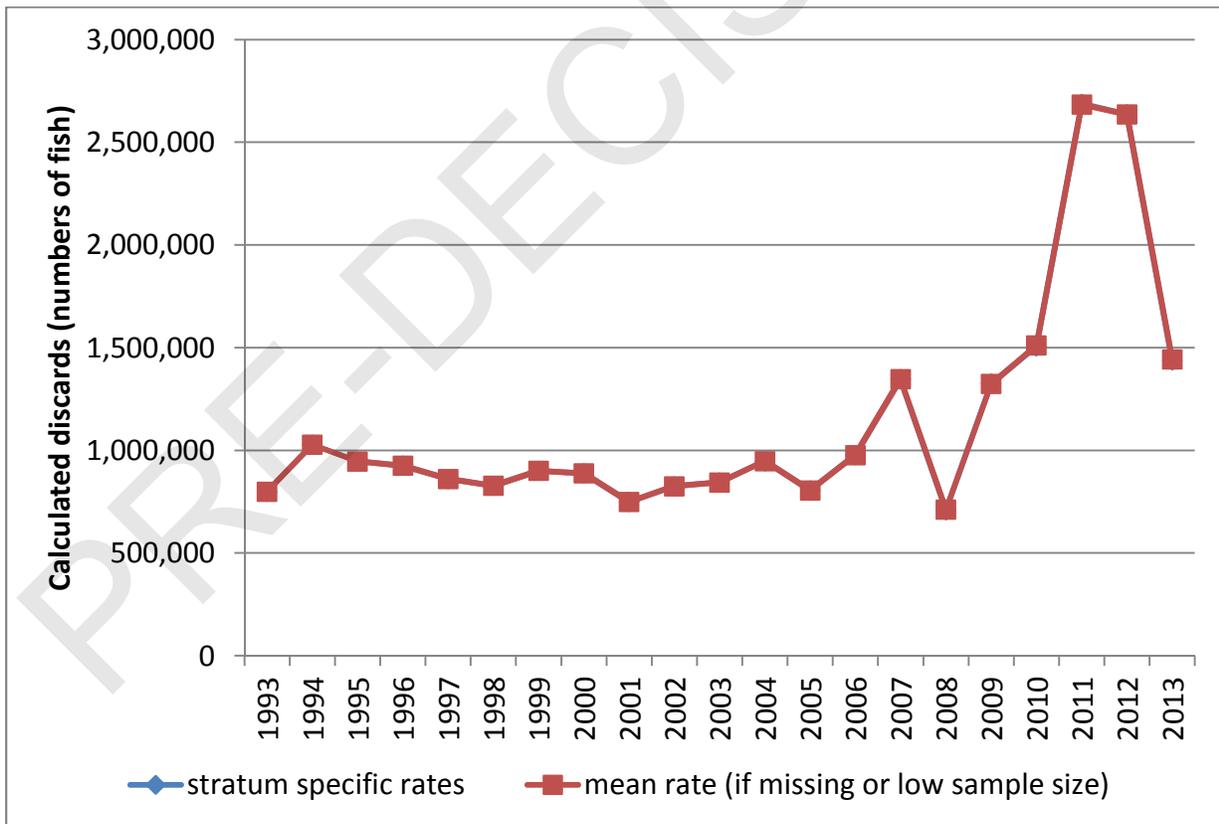
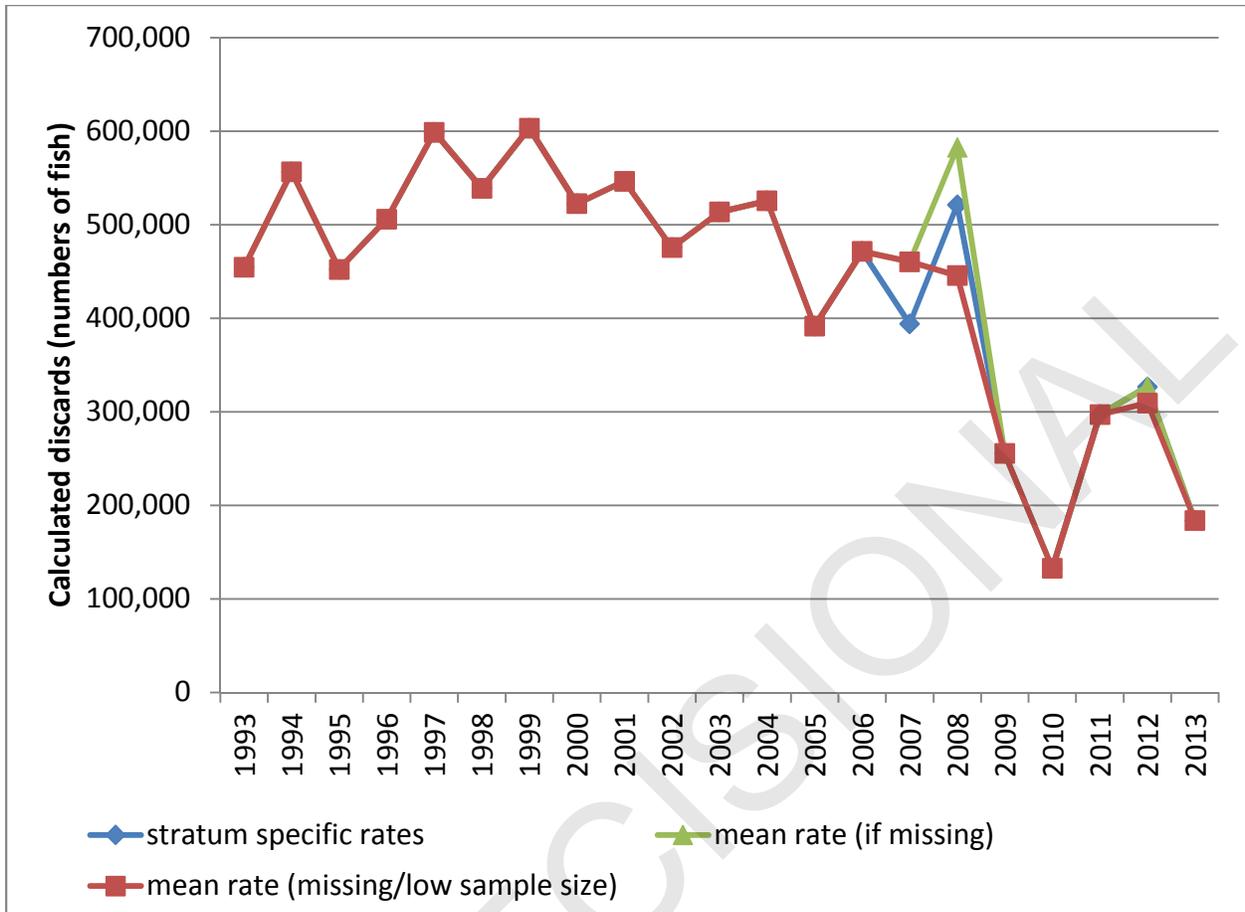
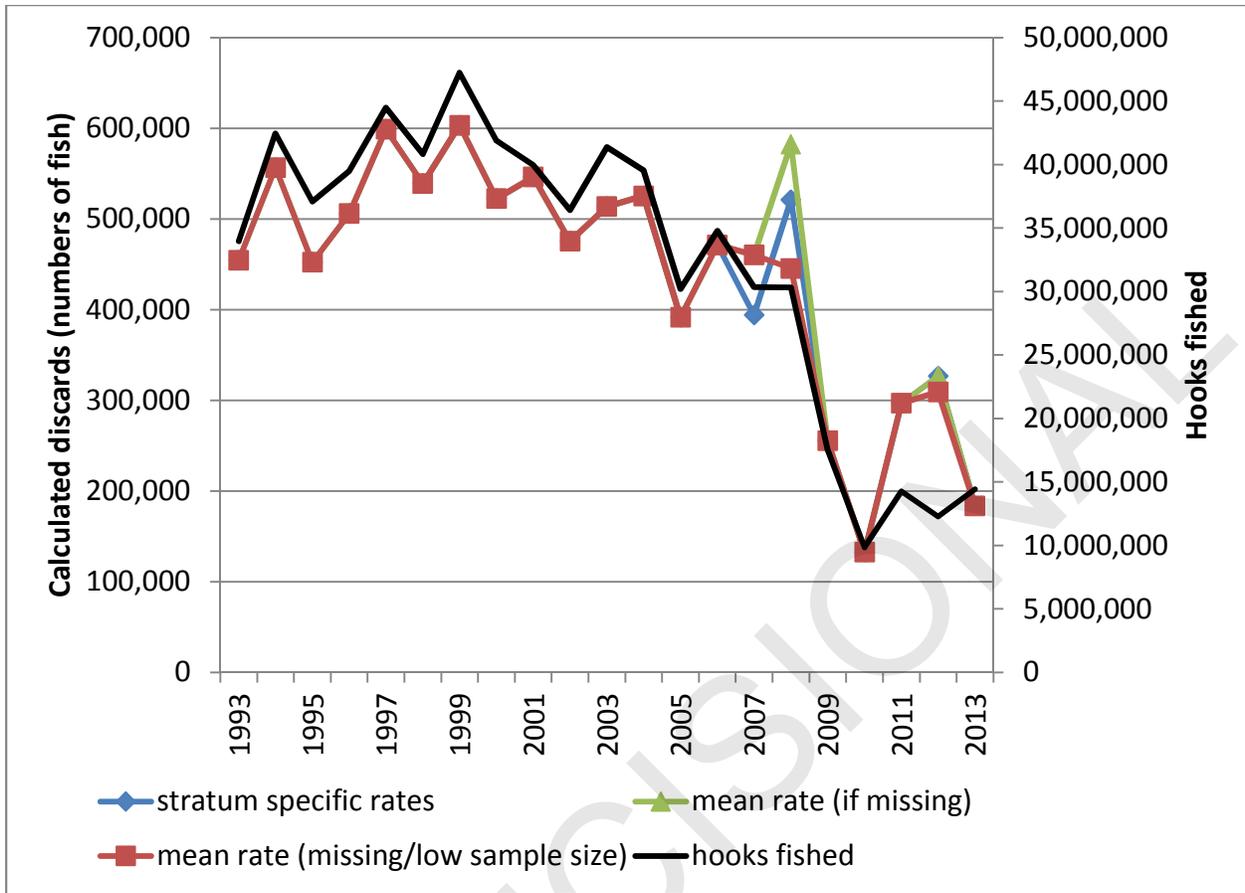


Figure 3.6 Commercial vertical line discards calculated with and without the use of mean discard rates to fill empty or poorly populated (<10 observations) discard rate strata.



**Figure 3.7** Commercial bottom longline discards calculated with and without the use of mean discard rates to fill empty or poorly populated (<10 observations) discard rate strata.



**Figure 3.8** Yearly total commercial bottom longline reported effort and red grouper discards calculated with and without the use of mean discard rates to fill empty or poorly populated (<10 observations) discard rate strata.

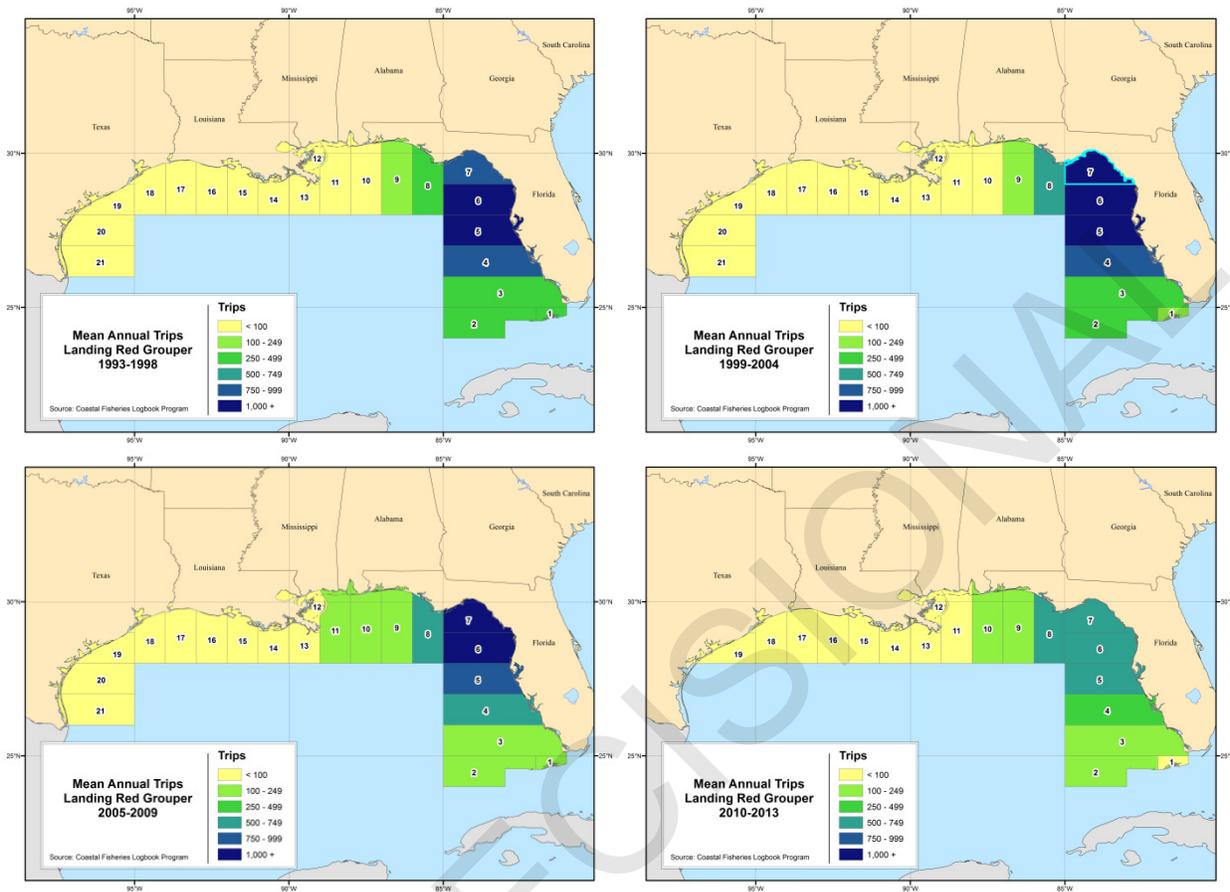


Figure 3.9 Maps of red grouper effort in the Gulf of Mexico as reported to the CFLP

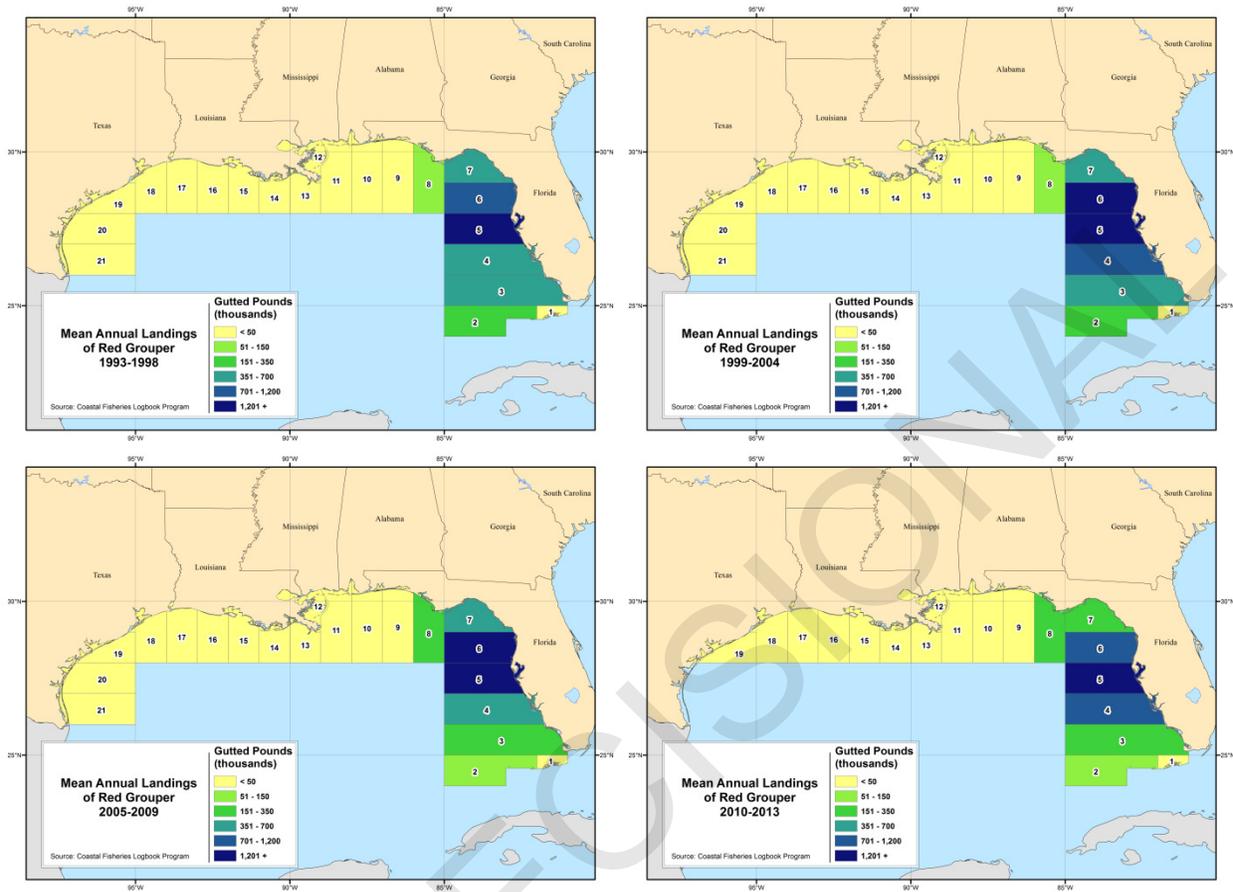
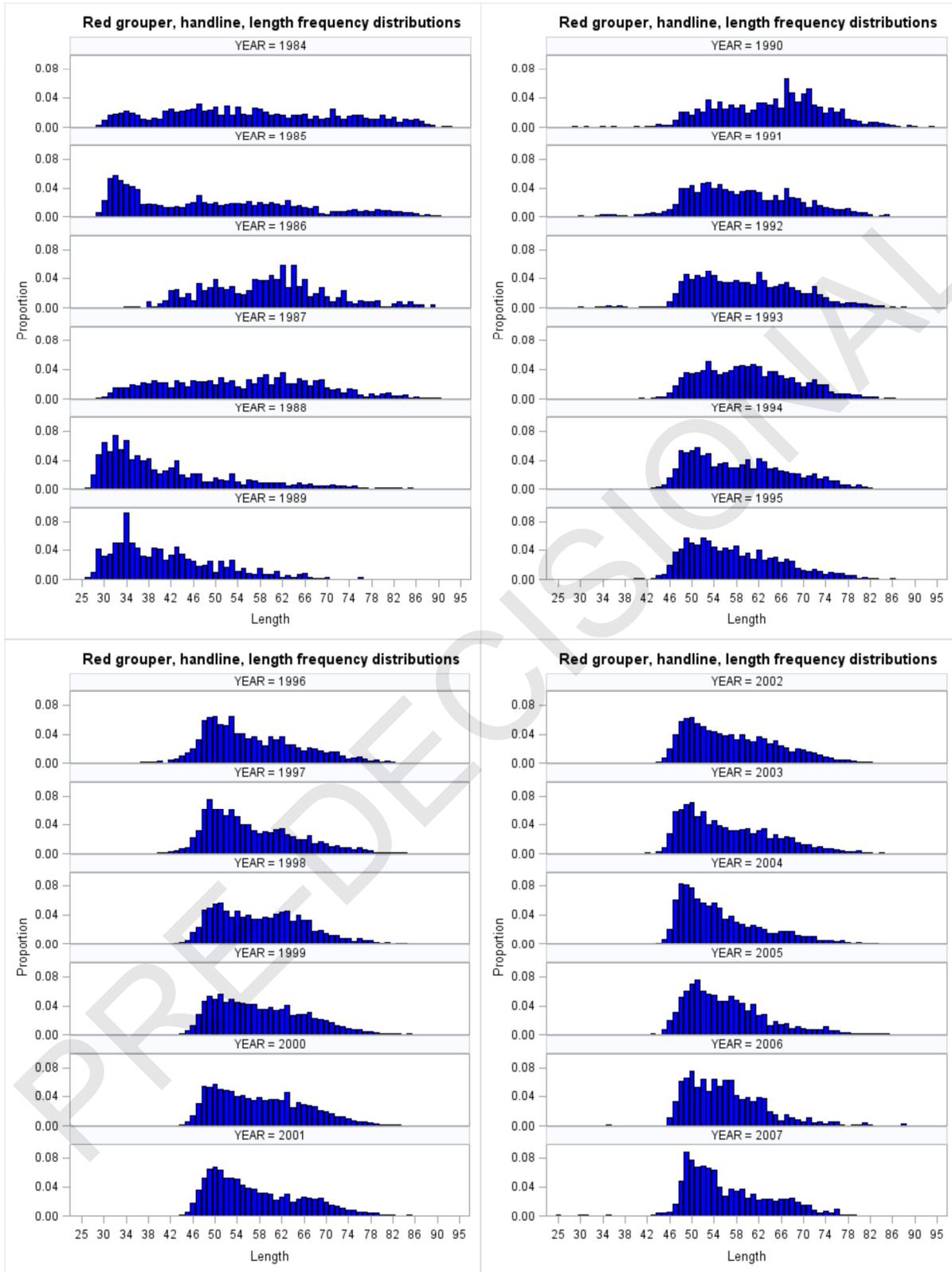
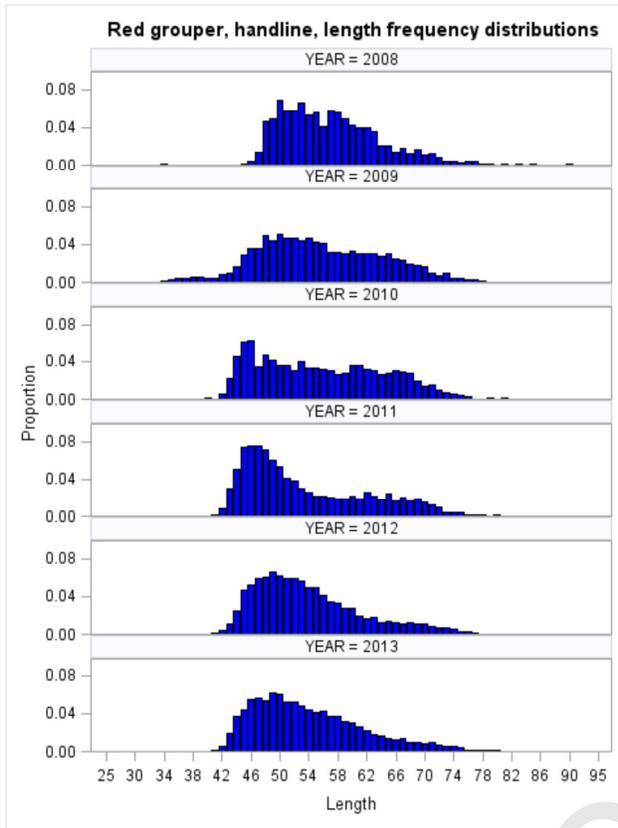


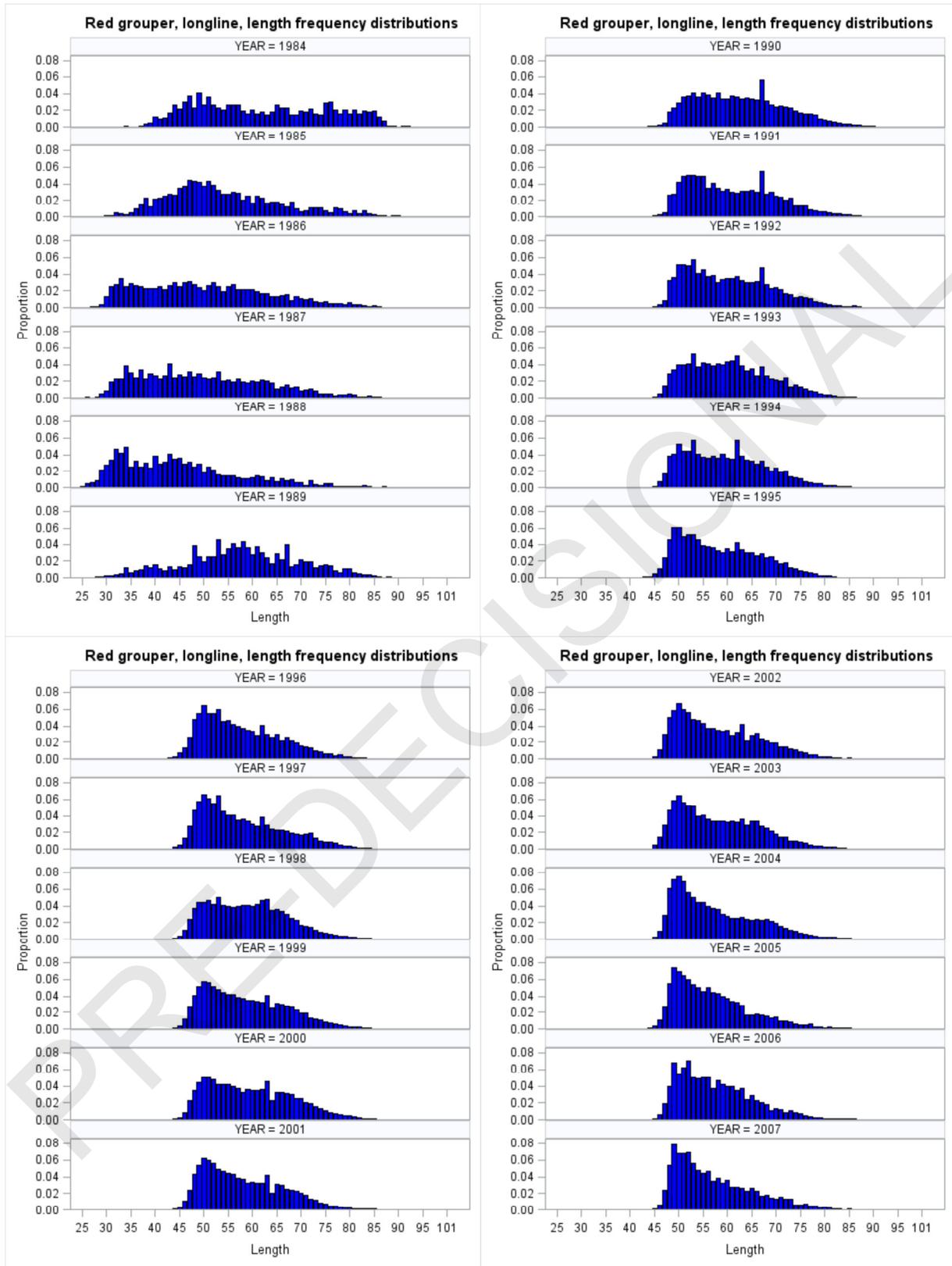
Figure 3.10 Maps of red grouper harvest in the Gulf of Mexico as reported to the CFLP



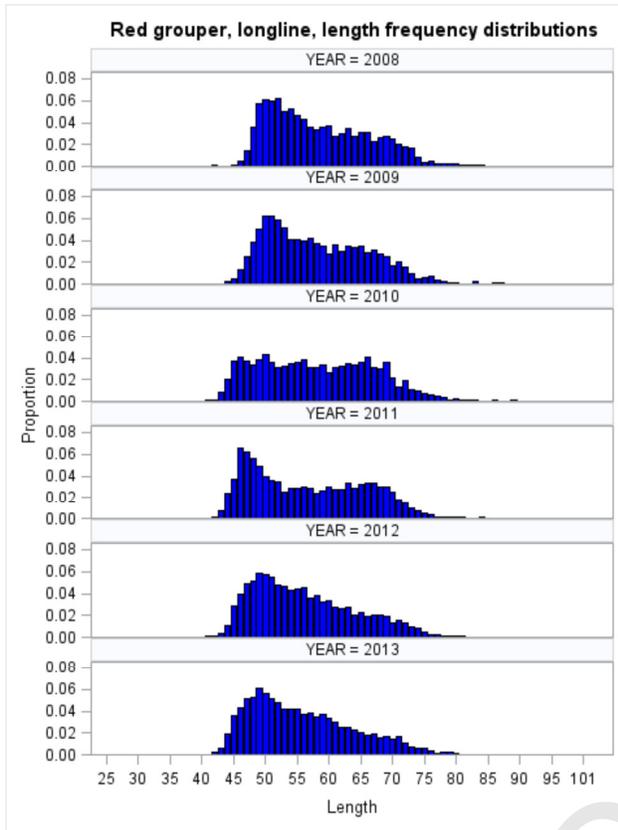
**Figure 3.11 (a)** Length frequency distributions (LFDs) for red grouper length samples collected between 1984 and 2007 from handline fisheries in the Gulf of Mexico.



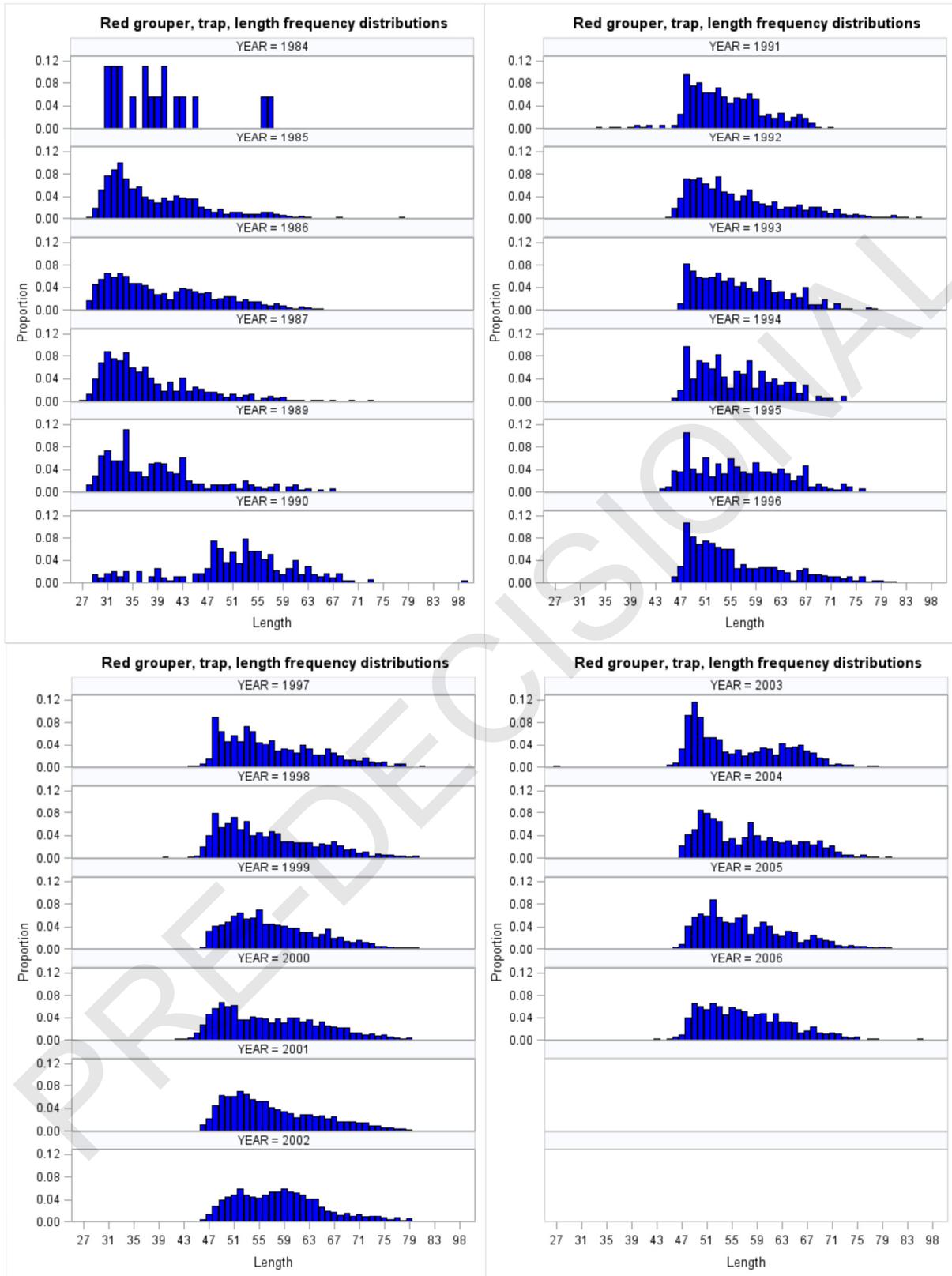
**Figure 3.11 (b)** Length frequency distributions (LFDs) for red grouper length samples collected between 2008 and 2013 from handline fisheries in the Gulf of Mexico.



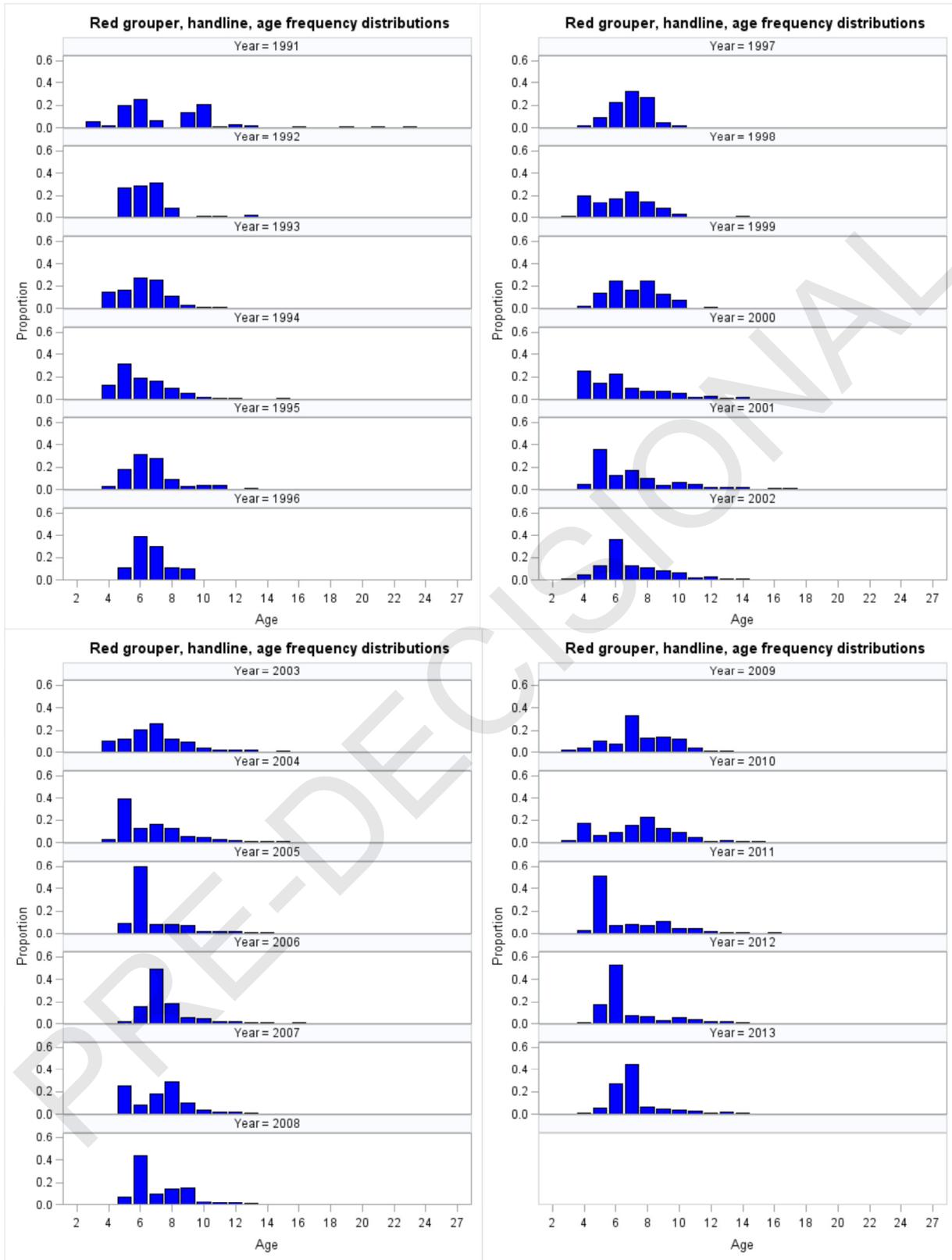
**Figure 3.12 (a)** Length frequency distributions (LFDs) for red grouper length samples collected between 1984 and 2007 from longline fisheries in the Gulf of Mexico.



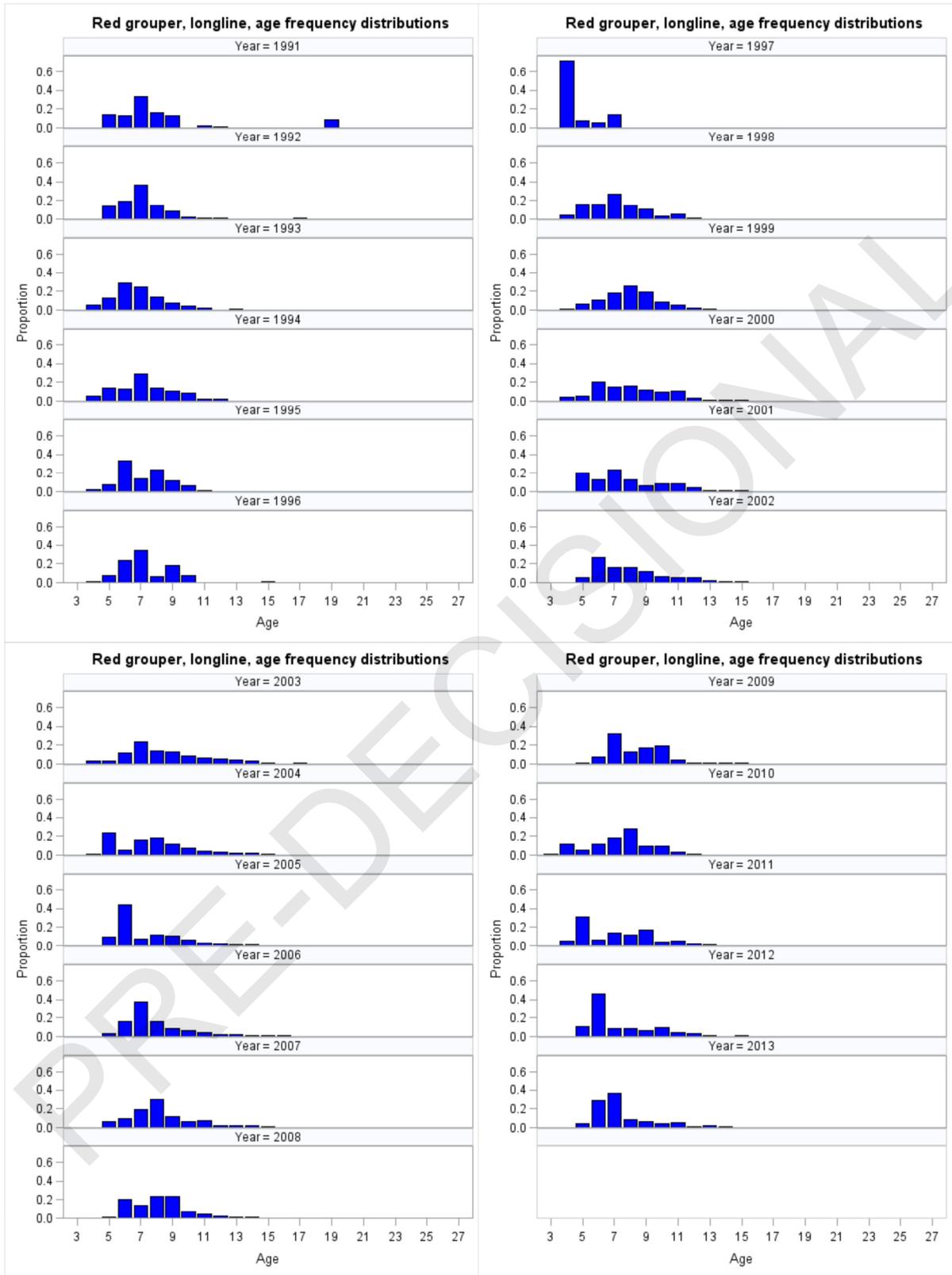
**Figure 3.12 (b)** Length frequency distributions (LFDs) for red grouper length samples collected between 2008 and 2013 from longline fisheries in the Gulf of Mexico.



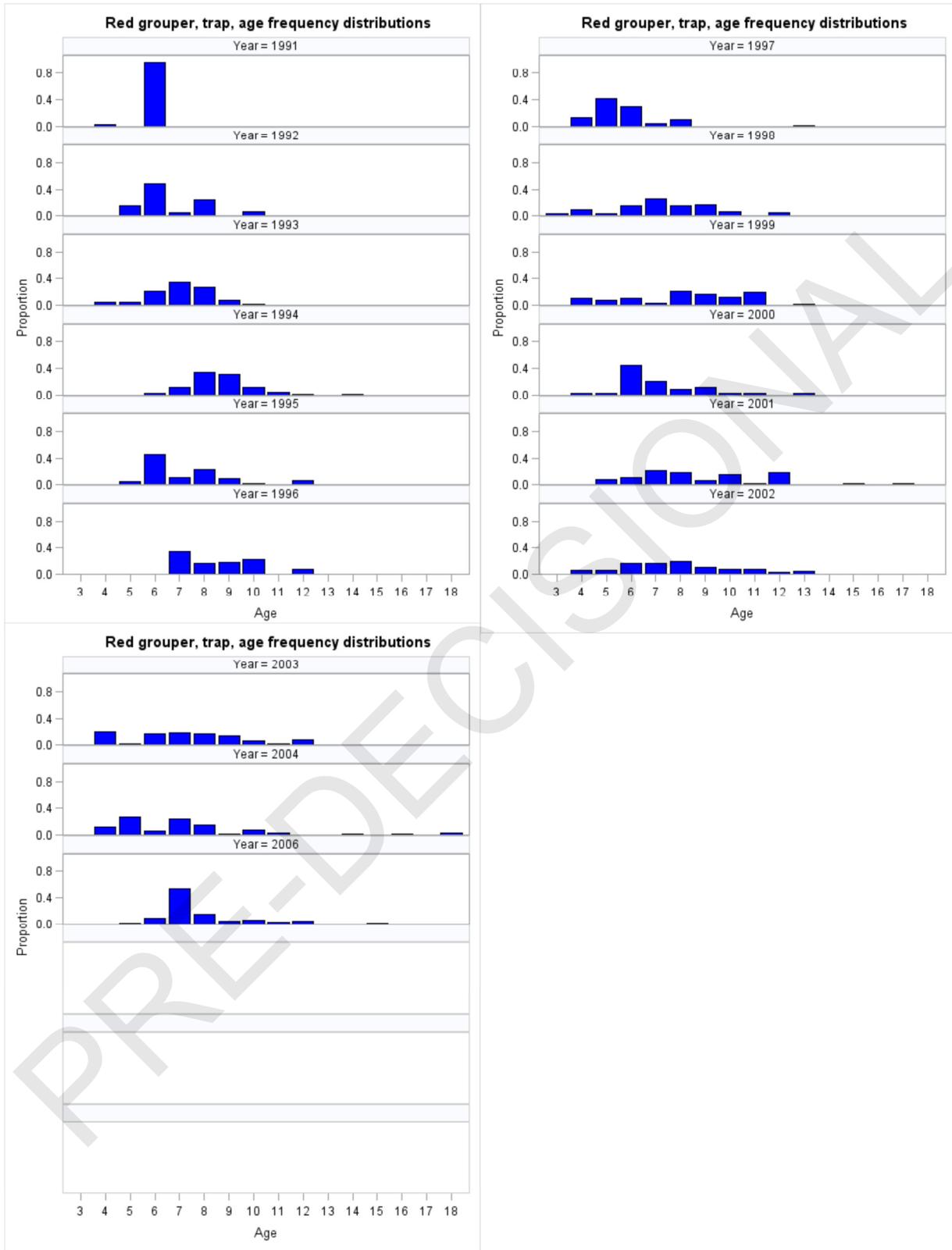
**Figure 3.13** Length frequency distributions (LFDs) for red grouper length samples collected between 1984 and 2006 from trap fisheries in the Gulf of Mexico.



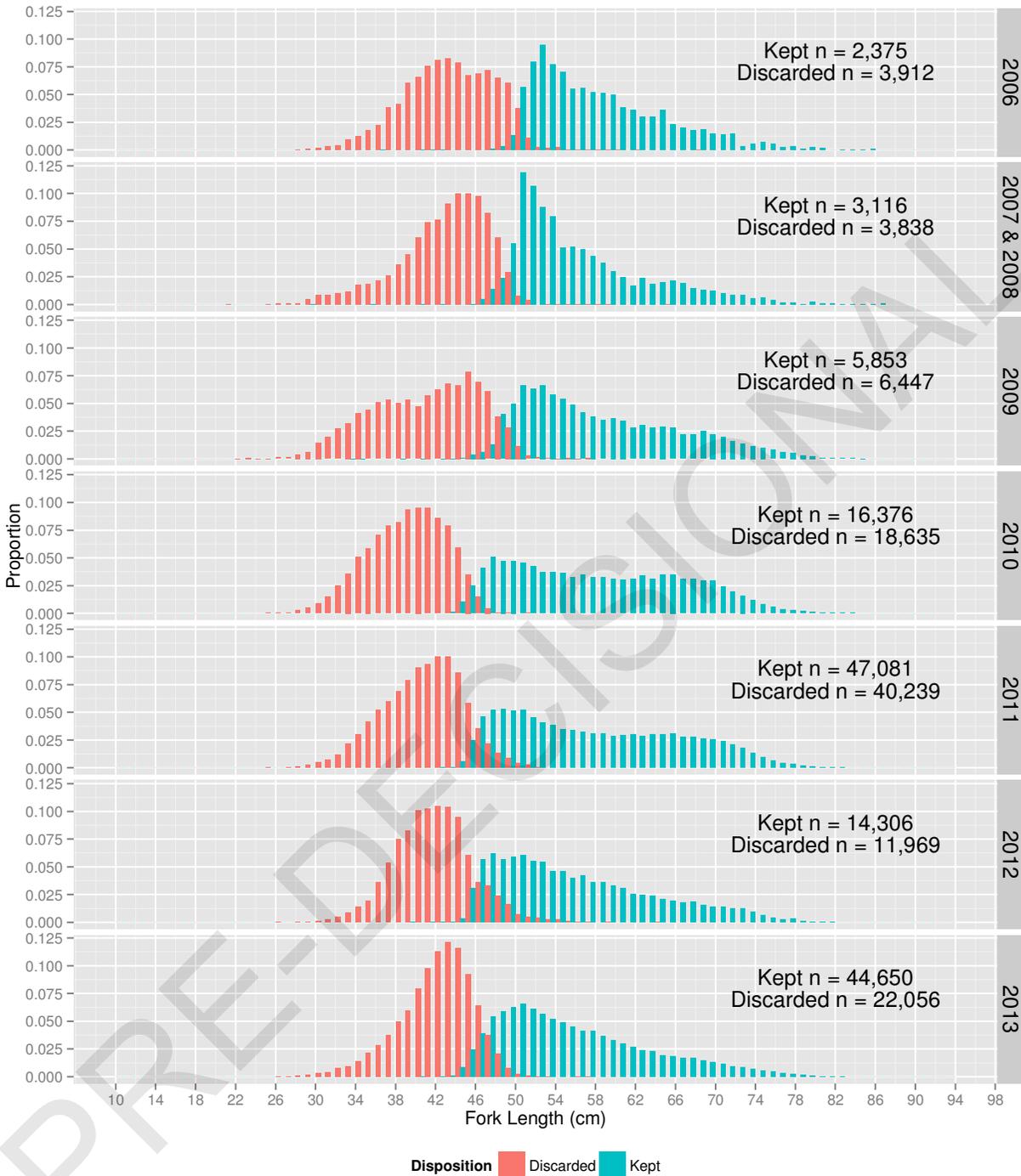
**Figure 3.14** Reweighted age frequency distributions (AFDs) for red grouper age samples between 1991 and 2013 collected from handline fisheries in the Gulf of Mexico.



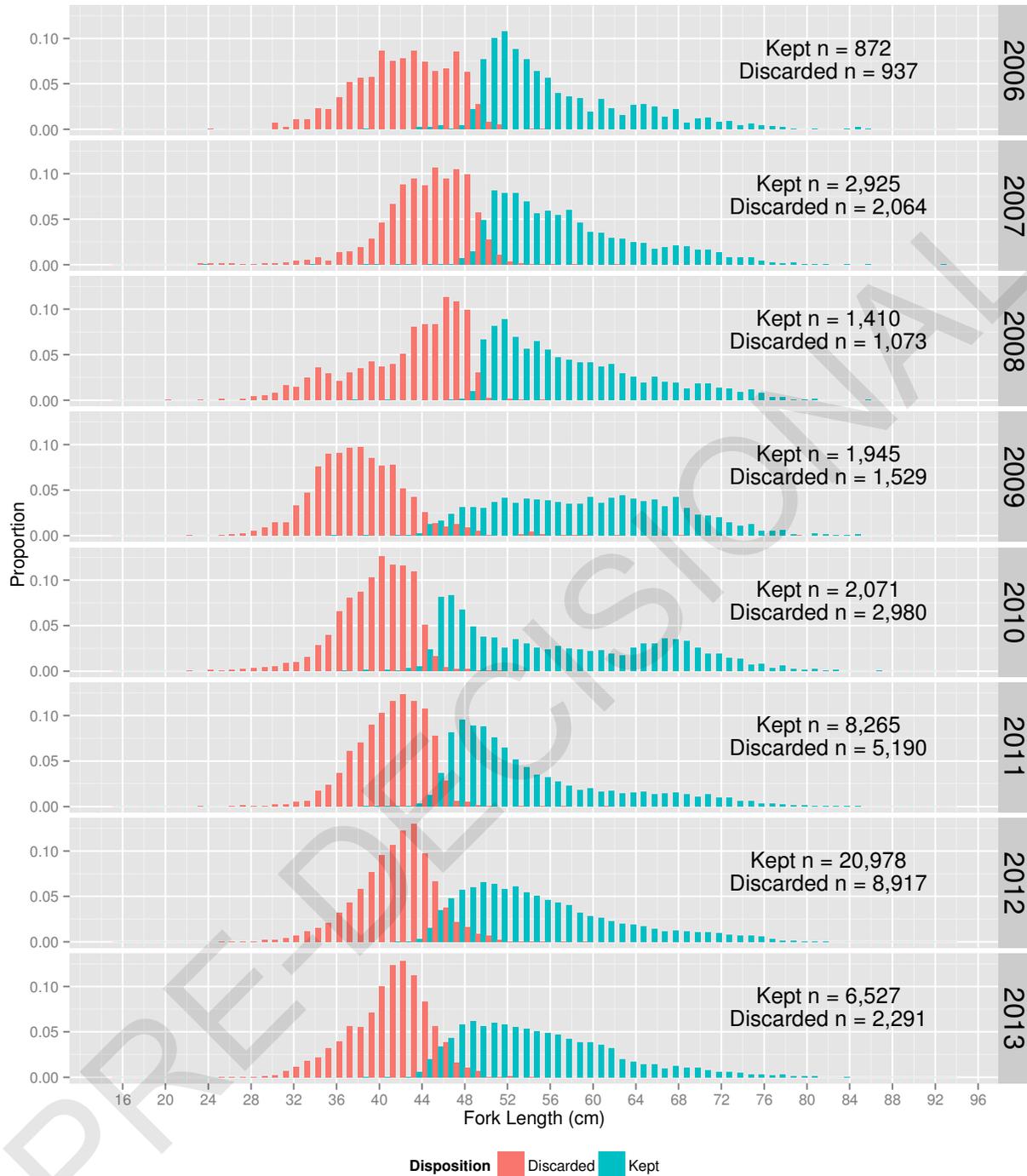
**Figure 3.15** Reweighted age frequency distributions (AFDs) for red grouper age samples between 1991 and 2013 collected from longline fisheries in the Gulf of Mexico.



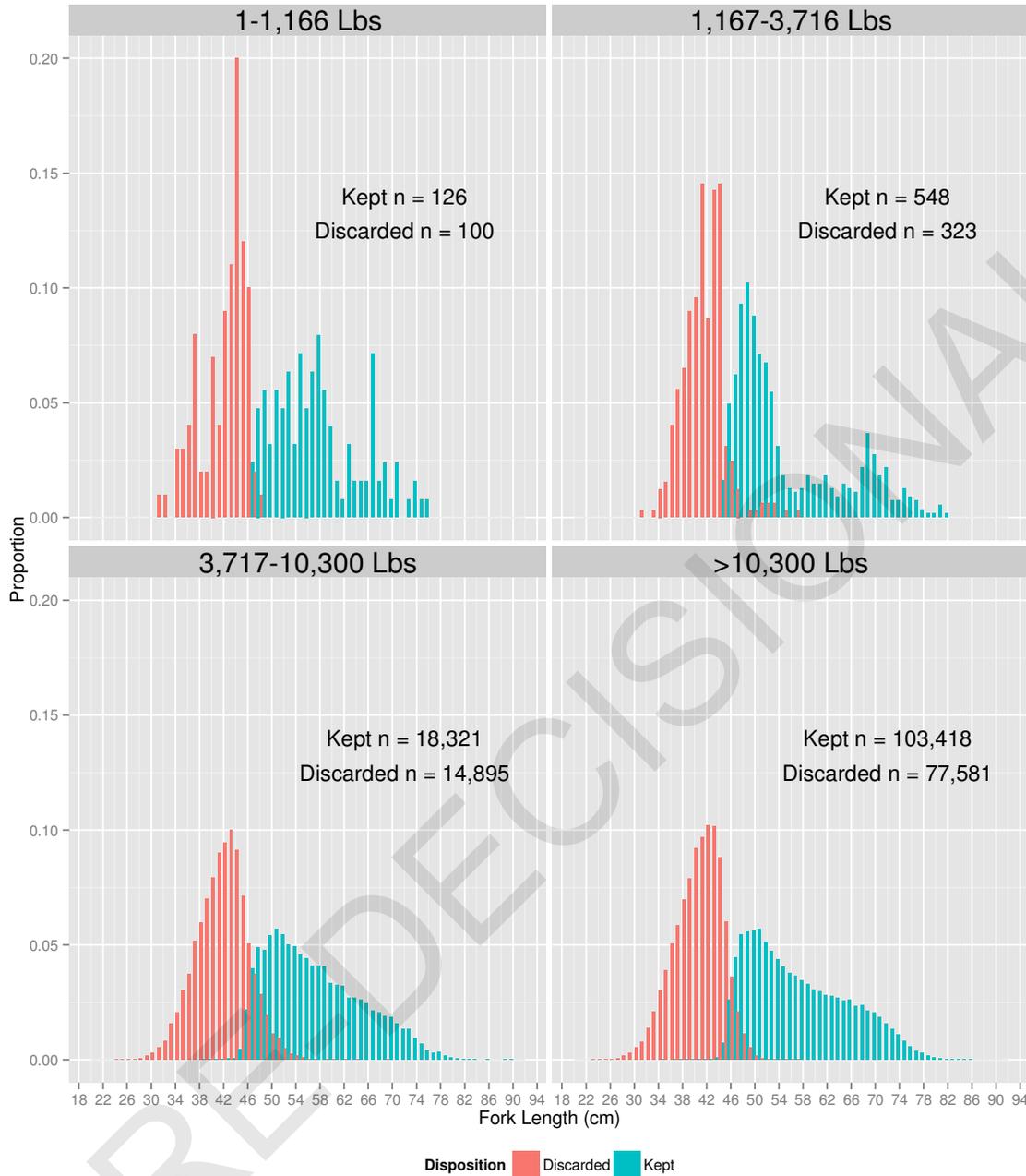
**Figure 3.16** Reweighted age frequency distributions (AFDs) for red grouper age samples between 1991 and 2006 collected from trap fisheries in the Gulf of Mexico.



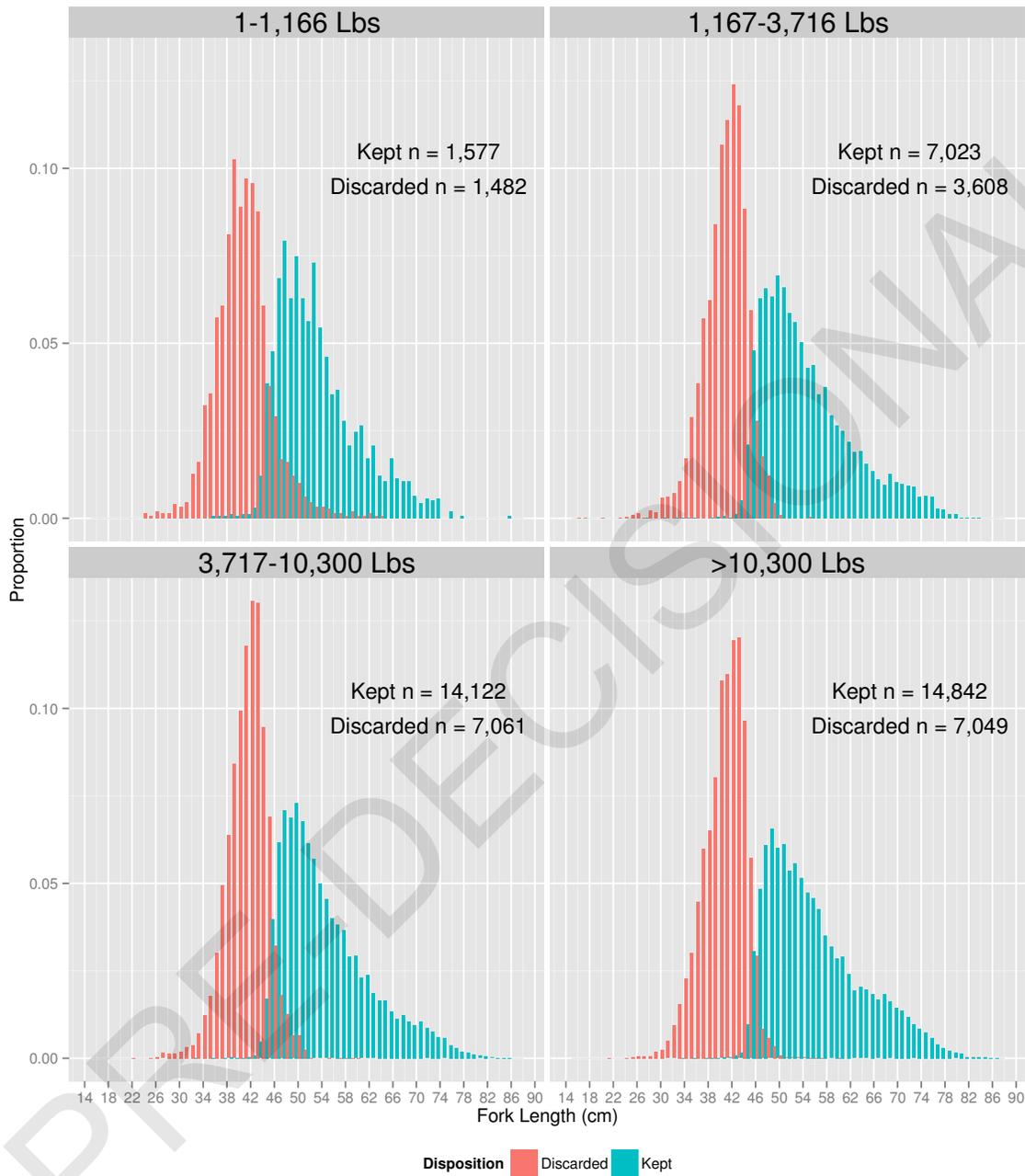
**Figure 3.17** Length frequency distribution by year for all red grouper kept and discarded with bottom longline gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from August 2006 through December 2013. Data from 2007 and 2008 bottom longline gear were combined to conform to data confidentiality rules.



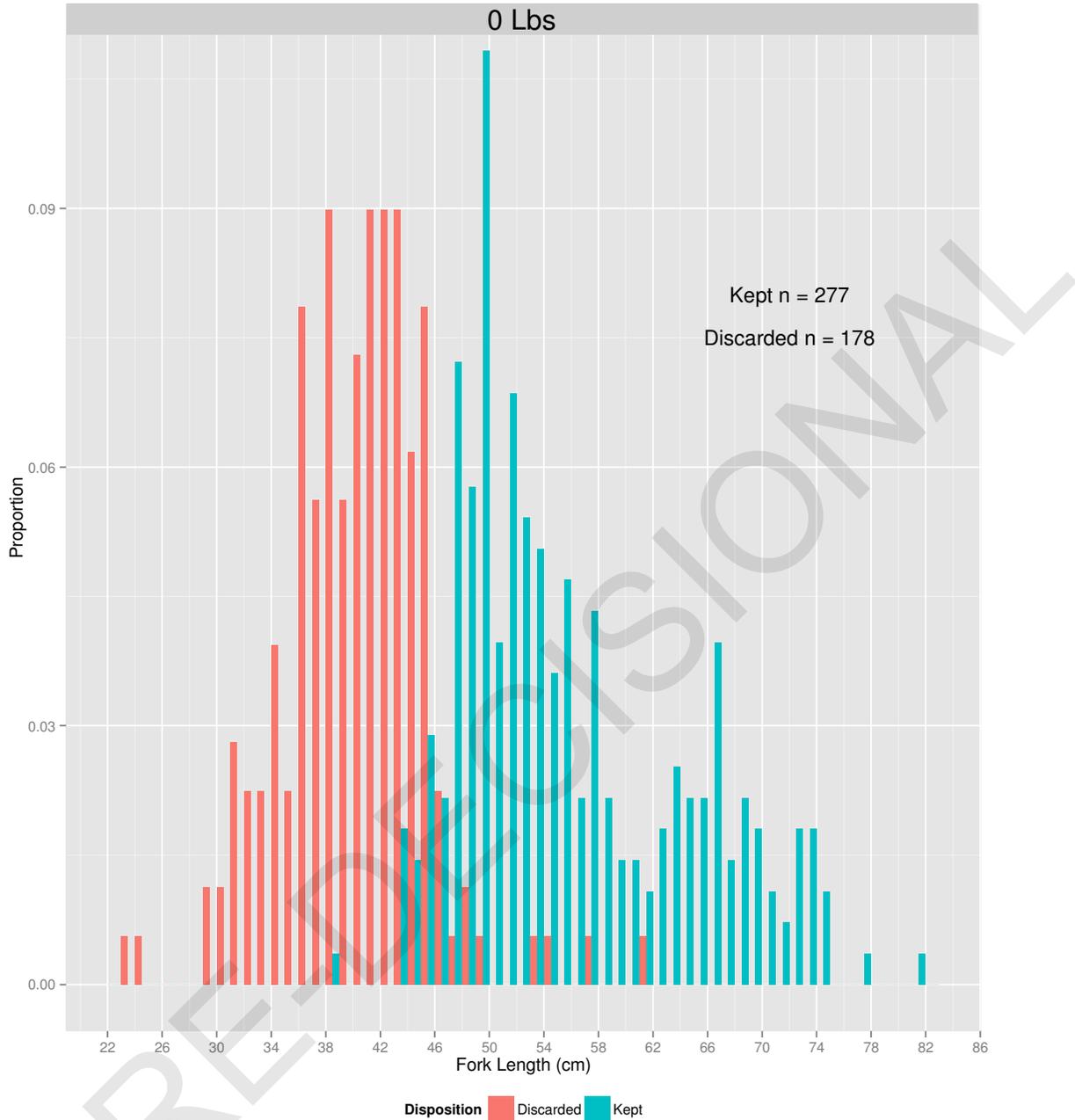
**Figure 3.18** Length frequency distribution by year for all red grouper kept and discarded with vertical line gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from July 2006 through December 2013.



**Figure 3.19** Length frequency distribution by IFQ allocation category for all red grouper kept and discarded with bottom longline gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from January 2010 through December 2013.



**Figure 3.20** Length frequency distribution by IFQ allocation category for all red grouper kept and discarded with vertical line gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from January 2010 through December 2013.



**Figure 3.21** Length frequency distribution for red grouper kept and discarded for handline vessels with no IFQ allocation based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from January 2010 through December 2013.

\* Note some red grouper recorded as kept may have been from vessels failing to comply with the IFQ program for Gulf reef snapper and groupers.

### 3.12 APPENDIX A

#### NMFS SECPR Accumulated Landings System (ALS)

Information on the quantity and value of seafood products caught by fishermen in the U.S. has been collected starting in the late 1800s (inaugural year is species dependent). Fairly serious collection activity began in the 1920s. The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SECPR database management system is a continuous dataset that begins in 1962.

In addition to the quantity and value, information on the gear used to catch the fish, the area where the fishing occurred and the distance from shore are also recorded. Because the quantity and value data are collected from seafood dealers, the information on gear and fishing location are estimated and added to the data by data collection specialists. In some states, this ancillary data are not available.

Commercial landings statistics have been collected and processed by various organizations during the 1962-to-present period that the SECPR data set covers. During the 16 years from 1962 through 1978, these data were collected by port agents employed by the Federal government and stationed at major fishing ports in the southeast. The program was run from the Headquarters Office of the Bureau of Commercial Fisheries in Washington DC until 1970. After 1970 it was run by the newly created National Marine Fisheries Service, which had replaced the Bureau of Commercial Fisheries. Data collection procedures were established by Headquarters and the data were submitted to Washington for processing and computer storage. In 1978, the responsibility for collection and processing was transferred to the SEFSC.

In the early 1980s, the NMFS and the state fishery agencies within the Southeast began to develop a cooperative program for the collection and processing of commercial fisheries statistics. With the exception of two counties, one in Mississippi and one in Alabama, all of the general canvass statistics are collected by the fishery agency in the respective state and provided to the SEFSC under a comprehensive Cooperative Statistics Program (CSP).

The purpose of this documentation is to describe the current collection and processing procedures that are employed for the commercial fisheries statistics maintained in the SECPR database.

1960 - Late 1980s

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Although the data processing and database management responsibilities were transferred from the Headquarters in Washington DC to the SEFSC during this period, the data collection procedures remained essentially the same. Trained data collection personnel, referred to as fishery reporting specialists or port agents, were stationed at major fishing ports throughout the Southeast Region. The data collection procedures for commercial landings included two parts.

The primary task for the port agents was to visit all seafood dealers or fish houses within their assigned areas at least once a month to record the pounds and value for each species or product type that was purchased or handled by the dealer or fish house. The agents summed the landings and value data and submitted these data in monthly reports to their area supervisors. All of the monthly data were submitted in essentially the same form.

The second task was to estimate the quantity of fish that were caught by specific types of gear and the location of the fishing activity. Port agents provided this gear/area information for all of the landings data that they collected. The objective was to have gear and area information assigned to all monthly commercial landings data.

There are two problems with the commercial fishery statistics that were collected from seafood dealers. First, dealers do not always record the specific species that are caught and second, fish or shellfish are not always purchased at the same location where they are unloaded, i.e., landed. Dealers have always recorded fishery products in ways that meet their needs, which sometimes make it ambiguous for scientific uses. Although the port agents can readily identify individual species, they usually were not at the fish house when fish were being unloaded and thus, could not observe and identify the fish.

The second problem is to identify where the fish were landed from the information recorded by the dealers on their sales receipts. The NMFS standard for fisheries statistics is to associate commercial statistics with the location where the product was first unloaded, i.e., landed, at a

shore-based facility. Because some products are unloaded at a dock or fish house and purchased and transported to another dealer, the actual 'landing' location may not be apparent from the dealers' sales receipts. Historically, communications between individual port agents and the area supervisors were the primary source of information that was available to identify the actual unloading location.

Cooperative Statistics Program

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In the early 1980s, it became apparent that the collection of commercial fisheries statistics was an activity that was conducted by both the Federal government and individual state fishery agencies. Plans and negotiations were initiated to develop a program that would provide the fisheries statistics that are needed for management by both Federal and state agencies. By the mid-1980s, formal cooperative agreements had been signed between the NMFS/SEFSC and each of the eight coastal states in the southeast, Puerto Rico and the US Virgin Islands.

Initially, the data collection procedures that were used by the states under the cooperative agreements were essentially the same as the historical NMFS procedures. As the states developed their data collection programs, many of them promulgated legislation that authorized their fishery agencies to collect fishery statistics. Many of the state statutes include mandatory data submission by seafood dealers.

Because the data collection procedures (regulations) are different for each state, the type and detail of data varies throughout the Region. The commercial landings database maintained in SECPR contains a standard set of data that is consistent for all states in the Region.

A description of the data collection procedures and associated data submission requirements for each state follows.

Florida

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Prior to 1986, commercial landings statistics were collected by a combination of monthly mail submissions and port agent visits. These procedures provided quantity and value, but did not provide information on gear, area or distance from shore. Because of the large number of dealers, port agents were not able to provide the gear, area and distance information for monthly

data. This information, however, is provided for annual summaries of the quantity and value and known as the Florida Annual Canvas data (see below).

Beginning in 1986, mandatory reporting by all seafood dealers was implemented by the State of Florida. The State requires that a report (ticket) be completed and submitted to the State for every trip. Dealers have to report the type of gear as well as the quantity (pounds) purchased for each species. Information on the area of catch can also be provided on the tickets for individual trips. As of 1986 the ALS system relies solely on the Florida trip ticket data to create the ALS landings data for all species other than shrimp.

#### Georgia

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Prior to 1977, the National Marine Fisheries Service collected commercial landings data in Georgia. From 1977 to 2001 state port agents visited dealers and docks to collect the information on a regular basis. Compliance was mandatory for the fishing industry. To collect more timely and accurate data, Georgia initiated a trip ticket program in 1999, but the program was not fully implemented to allow complete coverage until 2001. All sales of seafood products landed in Georgia must be recorded on a trip ticket at the time of the sale. Both the seafood dealer and the seafood harvester are responsible for insuring the ticket is completed in full.

#### South Carolina

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Prior to 1972, commercial landings data were collected by various federal fisheries agents based in South Carolina, either U.S. Fish or Wildlife or National Marine Fisheries Service personnel. In 1972, South Carolina began collecting landings data from coastal dealers in cooperation with federal agents. Mandatory monthly landings reports on forms supplied by the Department are required from all licensed wholesale dealers in South Carolina. Until fall of 2003, those monthly reports were summaries collecting species, pounds landed, disposition (gutted or whole) and market category, gear type, and area fished; since September 2003, landings have been reported by a mandatory trip ticket system collecting landings by species, disposition and market category, pounds landed, ex-vessel prices with associated effort data to include gear type and amount, time fished, area fished, along with vessel and fisherman information.

South Carolina began collecting TIP length frequencies in 1983 as part of the Cooperative Statistics Program. Target species and length quotas were supplied by NMFS and sampling targets were established for monthly commercial trips by gear. Sampling was set to collect those species with associated length frequencies. In 2005, SCDNR began collecting age structures (otoliths and spines) in addition to length frequencies, using ACCSP funding to supplement CSP funding. Typically for every four fish measured a single age structure was collected. This sampling periodicity was changed in 2010 to collect both a length and age structure from every fish intercepted as a recommendation from the SEFSC.

#### North Carolina

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The National Marine Fisheries Service prior to 1978 collected commercial landings data for North Carolina. Port agents would conduct monthly surveys of the state's major commercial seafood dealers to determine the commercial landings for the state. Starting in 1978, the North Carolina Division of Marine Fisheries entered into a cooperative program with the National Marine Fisheries Service to maintain the monthly surveys of North Carolina's major commercial seafood dealers and to obtain data from more dealers.

The North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) began on 1 January 1994. The NCTTP was initiated due to a decrease in cooperation in reporting under the voluntary NMFS/North Carolina Cooperative Statistics Program in place prior to 1994, as well as an increase in demand for complete and accurate trip-level commercial harvest statistics by fisheries managers. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e. trips, licenses, participants, vessels) in a given fishery that was not available prior to 1994 and provides a much more detailed record of North Carolina's seafood harvest.

#### NMFS SECPR Annual Canvas Data for Florida

The Florida Annual Data files from 1976–1996 represent annual landings by county (from dealer reports) which are broken out on a percentage estimate by species, gear, area of capture, and distance from shore. These estimates are submitted by Port agents, which were assigned responsibility for the particular county, from interviews and discussions from dealers and fishermen collected throughout the year. The estimates are processed against the annual landings

totals by county on a percentage basis to create the estimated proportions of catch by the gear, area and distance from shore. The sum of percentages for a given Year, State, County, Species combination will equal 100.

Area of capture considerations: ALS is considered to be a commercial landings database which reports where the marine resource was landed. With the advent of some State trip ticket programs, the definition is more loosely applied. As such one cannot assume reports from the ALS by State or county will accurately inform you of Gulf vs. South Atlantic vs. Foreign catch. To make that determination you must consider the area of capture.

### 3.13 APPENDIX B

#### **Brief overview on Gulf of Mexico Grouper-Tilefish IFQ programs**

**Jessica A. Stephen**

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*Date Written: 12/08/2014*

#### **I. Background**

The first year of fishing in the Grouper-Tilefish IFQ (GT-IFQ) program began on January 1, 2010. Initial shares were issued based on the amount of grouper-tilefish logbook landings reported under each entity's qualifying permit during 1999 through 2004, with an allowance for dropping one year of data. Initial shares were issued in five different IFQ categories: deep-water grouper, gag, red grouper, other shallow-water grouper, and tilefish (Table 1). For the first five years of the program, shares and allocation can only be sold to and fished by an entity that owns a valid commercial Gulf reef fish permit and has an active GT-IFQ online account. After January 1, 2015, all U.S. citizens and permanent resident aliens will be eligible to purchase GT-IFQ shares and allocation, although a valid Gulf reef fish permit will still be required to harvest, possess, and land any allocation.

The GT-IFQ program is a multi-species program with five share categories: gag, red grouper, other shallow-water groupers, deep-water groupers, and tilefishes. Each share category has distinct shares and associated allocations. Shares are a percentage of the commercial quota, while allocation refers to the poundage that is possessed, landed, or sold during a given calendar

year. At the beginning of each year, allocation is distributed based on the annual quota and the share percentages held by a GT-IFQ shareholder account. Allocation can then be used to harvest GT-IFQ species or sold to another valid shareholder account. Adjustments in quota can occur if the status of a stock changes as a result of new assessments or through the reallocation of quota between fishing sectors. Adjustments in quota are distributed proportionately among shareholder accounts based on the percentage of shares each account holds at the time of the adjustment. All transactions (share transfers, allocation transfers, landings, and cost recovery fees) in the GT-IFQ program are completed online.

There are three main account roles in the GT-IFQ system: shareholder, vessel, and dealer accounts. All accounts were assigned to users based on the unique entity (single or combination of individuals and/or business) that held either a Gulf of Mexico (Gulf) dealer or reef fish permit. Shareholder accounts with valid Gulf reef fish permits may transfer GT-IFQ shares and allocation to and from their accounts, as well as land GT-IFQ species at an approved dealer. Shareholder accounts that do not have a valid Gulf reef fish permit can only transfer shares and allocation to other accounts, and may not increase their holdings. A list of all accounts that hold shares is available through the NMFS Southeast Regional Office (SERO) Freedom of Information Act website. Vessel accounts, which belong to shareholder accounts, only hold allocation that is debited from the account through landing transactions. Shareholder accounts may have multiple vessel accounts. Dealer accounts were assigned to a unique entity that has a valid Gulf reef fish dealer permit, and functions are limited to completing landing transactions and paying cost recovery fees.

The GT-IFQ program has several built-in flexibility measures to accommodate the multi-species nature of the fishery and reduce bycatch. Two share categories, gag and red grouper, have a multi-use provision that allows a portion of the red grouper to be harvested under the gag allocation, or vice versa. The three remaining categories (shallow-water grouper, deep-water grouper, and tilefish) are multiple-species categories, designed to capture species complexes that are commonly caught together (Table 1). Three grouper species (scamp, Warsaw grouper, and speckled hind) are found in both shallow and deep water. Flexibility measures in the GT-IFQ program allow for these species to be landed under both share categories. Scamp are designated as a shallow-water grouper species and may be landed using deep-water grouper allocation once

all shallow-water grouper allocation in an account has been harvested. Warsaw grouper and speckled hind are designated as deep-water grouper species and may be landed using shallow-water grouper allocation once all deep-water grouper allocation in an account has been harvested. The GT-IFQ program has a built-in flexibility measure to allow a once-per-year allocation overage per share category for any GT-IFQ account that owns shares in that share category. For these accounts, a vessel can land 10% more than their remaining allocation on the vessel. This overage is then deducted from the shareholder's allocation at the start of the following fishing year. Because overages need to be deducted in the following year, GT-IFQ accounts without shares cannot land an excess of their remaining allocation and GT-IFQ accounts with shares are prohibited from selling shares that would reduce the account's shares fewer than the amount needed to repay the overage in the following year.

When harvesting GT-IFQ species, vessels are required to have a GOM reef fish permit, and to hail out before leaving port. While at-sea, vessels are monitored using vessel monitoring systems. When returning to port, vessels landing GT-IFQ species must provide a landing notification indicating the time and location of landing, the intended dealer, and the estimated pounds landed. Landing may occur at any time, but fish may not be offloaded between 6 p.m. and 6 a.m. A landing transaction report is completed by the GT-IFQ dealer and validated by the fisherman. The landing transaction includes the date, time, and location of transaction; weight and actual ex-vessel value of fish landed and sold; and the identity of shareholder account, vessel, and dealer. For current total GT-IFQ landings go to: <https://ifq.sero.nmfs.noaa.gov/> and past landings are recorded under 'Additional Documents'. All current landings data are updated in a real-time basis as the landing transaction is processed.

## **II. Data Description**

The GT-IFQ program is a real-time online system, with all transactions recorded immediately upon entry. Data is entered directly by the GT-IFQ participants for all transactions that occur within the system. The GT-IFQ program directly links to the Southeast Regional Office's Permits database in order to validate all vessel and dealer accounts. There are three types of transactions that occur in the GT-IFQ program: share transfer, allocation transfers, and landing transactions. Share transactions contain the following information: transferor, transferee,

transaction completion date/time, share category, share percentage transferred, and a confirmation number. Share transfers can only occur between shareholder accounts. Allocation transfers contain similar information as share transfers and include: transferor, transferee, transfer date/time, share category, pounds transferred, and confirmation number. Allocation transfers can occur between a shareholder and his vessel, between two shareholder accounts, or from a shareholder account to another shareholder's vessel account. Landing transactions contain the following information: shareholder account, vessel account, dealer account, landing date/time, landing location, species, pounds, and a landing confirmation number. Additional tables in the GT-IFQ program contain address information for each participant in the GT-IFQ program. The primary contact's address information is used when connecting address information to any transaction.

### **III. Database Structure**

The data is stored in a relational database system that is fishermen-vessel based and accounts are based on unique entities associated with the account, where no account contains the exact same entities as another account. Many vessel accounts may be associated with one shareholder account, if the permit holder is the same on each vessel. This allows the GT-IFQ system to link to the Permits database and establish a validity status for each vessel account. Establishing vessel accounts also allowed IFQ program staff and law enforcement to verify that a vessel has sufficient allocation at the time of a landing notification.

### **IV. Data Quality**

The Vessel Monitoring Systems (VMS) staff provides quality control over GT-IFQ data when vessels are out at sea. Vessels are required to notify VMS staff each time they leave dock (hail out) and complete a landing notification (hail in) prior to landing. While at sea, VMS staff is able to monitor vessel locations hourly to determine if the vessel are fishing in approved areas. GT-IFQ landing notifications can be submitted directly from the GT-IFQ system through VMS units.

The online system has a series of built-in quality assurance measures that reduce the possibility of errors within the system. Pre-designed web-based screens direct the GT-IFQ participants

through a detailed process for each transaction. Transactions are not completed until pertinent information has been completed. The system will not allow the completion of any transaction if any of the participating accounts is in a suspended or inactive status. Share transactions are not completed until verified by both the transferor and transferee. Similarly, landing transactions are not completed until the shareholder enters their vessel personal identification number. In 2012, the system was updated to allow for the selection of the associated 3-hour notification for each landing transaction. Dealers can also enter an associated trip ticket number with an IFQ landing transaction, although this is an optional field currently.

IFQ staff provides additional quality control which includes but is not limited to: adjusting landings based on submitted Landing Correction Forms, and auditing landing notifications and transactions. IFQ staff continues to work with system developers to improve data quality and accuracy and ensure that all web-based screen shots capture required information.

## **4 RECREATIONAL FISHERY STATISTICS**

### **4.1 OVERVIEW**

#### *4.1.1 Recreational Workgroup (RWG) Members*

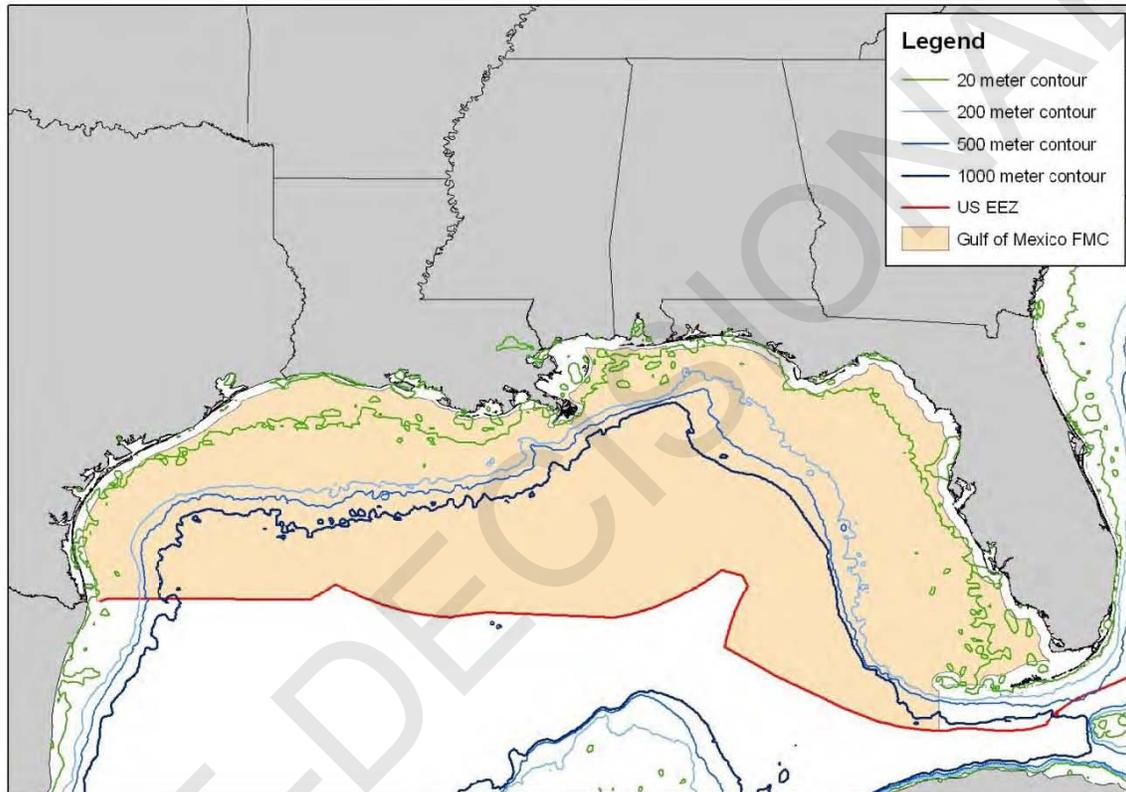
Members- Ken Brennan (NMFS Beaufort, NC), Jim Eliason (SAFMC Panelist, Industry rep FL), \*Kelly Fitzpatrick (NMFS Beaufort, NC), Alisha Gray (FWC, FL), Chad Hanson (Pew Trust), \*Jeff Isely (NMFS SEFSC), Vivian Matter (Leader, NMFS SEFSC), Adyan Rios (NMFS SEFSC), Beverly Sauls (FWC, FL). \*Not present during Data Workshop.

#### *4.1.2 Issues Discussed at the Data Workshop*

- 1) Allocation of Monroe County catches to the Atlantic or the Gulf of Mexico: may vary by data source depending on differing spatial resolutions of the datasets.
- 2) Headboat discards. Data are available from the SRHS since 2004. Review whether they are reliable for use, and determine if there are other sources of data prior to 2004 that could be used as a proxy to estimate headboat discards.
- 3) Calibration of Marine Recreational Fisheries Statistics Survey (MRFSS) to Marine Recreational Information Program (MRIP) 1981-2003.
- 4) Charter boat landings: MRFSS charter survey methods changed in 1998 in the Gulf of Mexico.

- 5) MRIP APAIS adjustment: change in survey protocols starting in 2013.
- 6) Usefulness of historical data sources to generate estimates of landings prior to 1981.  
Review previous methods and other approaches.

#### 4.1.3 Gulf of Mexico Fishery Management Council Jurisdictional Boundaries



## 4.2 REVIEW OF WORKING PAPERS

**SEDAR42-DW-14**, *Size Distribution of Red Grouper Observed in For-Hire Recreational Fisheries in the Gulf of Mexico*. Alisha Gray and Beverly Sauls 2014.

Detailed information on the size of discarded fish is not collected in traditional dockside surveys of recreational fisheries. At-sea observer surveys provide valuable information on the size and condition of discarded fish. Such surveys have been conducted on headboat vessels in the eastern Gulf of Mexico since 2005. Coverage was expanded in June of 2009 to include charter vessels on the east coast of Florida, and this coverage continued through 2013. This report provides a

summary of available information on the size of red grouper collected from headboats and charter boats from the Gulf coast of Florida.

**SEDAR42-DW-16**, *Estimates of Historical Private/Charter boat and Headboat Fishery Red Grouper Angler Catch in the Gulf of Mexico 1945-1980*. Jeff Isely, Nancie Cummings, and Adyan Rios. 2014.

Marine recreational catch and effort data in the Gulf of Mexico have been collected and reported by the National Marine Fisheries Service (NMFS) since 1981. Documenting historic (pre-1981) landings in the recreational sector has been problematic because comprehensive surveys were not conducted consistently prior to 1980. Brennan and Fitzpatrick (2012) developed a method of estimating historic catch and effort based on the National Survey of Fishing, Hunting and Wildlife Associated Recreation (FHWAR 2001). This method has been accepted in recent SEDARs and has been applied to several recently assessed species (SEDAR28-spanish mackerel and cobia; SEDAR33-Gulf of Mexico gag and greater amberjack). However, Brennan and Fitzpatrick (2012) did not develop estimates by separate modes. Rios (2013) partitioned recreational catch and effort into private, charter boat and headboat modes. However, the method relied on assumptions related to the development of the historic headboat and charter boat modes that are not well supported. In this paper, we provide data on the development of the headboat mode in the Atlantic, and provide estimates of historical recreational angler catch for the SEDAR42 assessment of Gulf of Mexico red grouper for the private/charter boat and headboat sectors using a modification of the method proposed by Rios (2013) and Brennan and Fitzpatrick (2012).

**SEDAR42-DW-17**, *Discards of red grouper (Epinephelus morio) for the headboat fishery in the US Gulf of Mexico*. Fisheries Ecosystems Branch, Beaufort, NC 2014.

The Southeast Region Headboat Survey (SRHS) was modified in 2004 to collect self-reported discards for each reported trip. These self-reported data are currently not validated within the SRHS. The SRHS discard rates were compared to the MRFSS/MRIP At-Sea Observer program discard rates for validation purposes and to determine whether the SRHS discard estimates should be used for a full or partial time series (2004-2013). Discard estimates prior to 2004 are calculated using a proxy method. For red grouper, the MRFSS/MRIP CH, MRFSS/MRIP PR,

and MRFSS/MRIP CH:SRHS discard ratio methods were evaluated as proxy methods for calculating discards from the headboat fishery.

**SEDAR42-DW-18**, *Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984 to 2013. Ching-Ping Chih. 2014.*

This report documents changes in the length frequency distributions (LFDs) and age frequency distributions (AFDs) of red groupers collected from the Gulf of Mexico from 1981 to 2013. The methods for estimating LFDs and AFDs for red groupers differ from those used in SEDAR 12 in several ways: (1) LFDs for hand line and long line strata were stratified into north and south regions due to apparent differences in LFDs between the two regions (Chih, 2014), (2) AFDs were reweighted by LFDs due to non-random sampling of some otolith samples, and (3) AFDs for handline and longline strata were also stratified into north and south regions due to apparent differences in ALKs between the two regions (Chih, 2014). For trap samples and recreational fisheries samples, AFDs were reweighted by the corresponding LFDs without stratification into north and south regions because of the small sample sizes of age samples.

#### 4.3 RECREATIONAL LANDINGS

Total recreational landings are summarized below by survey. A map and figures summarizing the total recreational red grouper landings are included in Figure 4.9.1. There are no estimates from the Texas Parks and Wildlife Survey for this species.

##### 4.3.1 *Marine Recreational Fisheries Statistics Survey (MRFSS) and Marine Recreational Information Program (MRIP)*

###### *Introduction*

The Marine Recreational Fisheries Statistics Survey (MRFSS) and the Marine Recreational Information Program (MRIP) provide a long time series of estimated catch per unit effort, total effort, landings, and discards for six two-month periods (waves) each year. MRFSS/MRIP provides estimates for three recreational fishing modes: shore-based fishing (SH), private and rental boat fishing (PR), and for-hire charter and guide fishing (CH). When the survey first began in Wave 2 (Mar/Apr), 1981, headboats were included in the for-hire mode, but were

excluded after 1985 in the South Atlantic and Gulf of Mexico to avoid overlap with the Southeast Region Headboat Survey (SRHS) conducted by the NMFS Beaufort, NC lab.

The MRFSS/MRIP survey covers coastal Gulf of Mexico states from Florida to Louisiana. The state of Texas was included in the survey from 1981-1985, although not all modes and waves were covered. The state of Florida is sampled as two sub-regions. The east Florida sub-region includes counties adjacent to the Atlantic coast from Nassau County south through Miami-Dade County, and the west Florida sub-region includes Monroe County (Florida Keys) and counties adjacent to the Gulf of Mexico. Separate estimates are generated for each Florida sub-region, and those estimates may be post-stratified into smaller regions based on proportional sampling.

The MRFSS/MRIP design incorporates three complementary survey methods for estimating catch and effort. Catch data are collected through angler interviews during dockside intercept surveys of recreational fishing trips after they have been completed. Effort data are collected using two telephone surveys. The Coastal Household Telephone Survey (CHTS) uses random digit dialing of coastal households to obtain detailed information about the previous two months of recreational fishing trips from the anglers. The weekly For-Hire Survey interviews charter boat operators (captains or owners) to obtain the trip information with only one-week recall period. Effort estimates from the two telephone surveys are aggregated to produce total effort estimates by wave. Catch rates from dockside intercept surveys are combined with estimates of effort from telephone interviews to estimate total landings and discards by wave, mode, and area fished (inland, state, and federal waters).

Catch estimates from early years of the survey are highly variable with high proportional standard errors (PSE's), and sample sizes in the dockside intercept portion have been increased over time to improve precision of catch estimates. Several quality assurance and quality control improvements were implemented for the intercept surveys in 1990. Prior to 1990 the contractor did not have regional representatives hired to supervise the samplers in any given area. All samplers were hired as independent sub-contractors and communicated directly with the contractor's home office staff. It is much more likely that the samplers who worked in the 1980's would have varied more in their interpretation of sampling protocols and their ability to identify

at least some of the more difficult-to-recognize species. There were a number of other changes made to enhance consistency in sampling protocols and improve error-checking in the Statement of Work for the 1990-1992 contracts. Improvements have continued over the years, but the biggest changes happened at that time (personal communication, NMFS). Full survey documentation and ongoing efforts to review and improve survey methods are available at: <http://www.st.nmfs.gov/st1/recreational>.

Survey methods for the for-hire fishing mode have seen the most improvement over time. Increased sample quotas and additional sampling (requested and funded by the states) to the intercept portion of the survey has improved catch rate data. It was also recognized that the random household telephone survey was intercepting relatively few anglers in the for-hire fishing mode and the For-Hire Telephone Survey (FHS) was developed to estimate effort in the for-hire mode. The new method draws a random sample of known for-hire charter and guide vessels each week and vessel operators are called and asked directly to report their fishing activity. The FHS was officially adopted in the Gulf states in 2000, in East Florida in 2003, and in Georgia through Maine in 2005. The FHS was pilot tested in the Gulf of Mexico in 1998 and 1999 and in Georgia through Maine in 2004. The FHS does not consider the estimates during pilot years as official estimates; however, FHS data for these years have been used in past SEDARs (e.g. SEDAR 7 red snapper, SEDAR 16 king mackerel, SEDAR 25 black sea bass, etc). As a result of the Deepwater Horizon oil spill in April 2010, the MRFSS/MRIP For-Hire Survey increased sampling rates of charter boat vessel operators from 10% to 40% from May, 2010 through June 2011.

A further improvement in the FHS method was the pre-stratification of Florida into smaller sub-regions for estimating effort. Pre-stratification defines the sample unit on a sub-state level to produce separate effort estimates by these finer geographical regions. The FHS sub-regions include three distinct regions bordering the Atlantic coast: Monroe County (sub-region 3), SE Florida from Dade through Indian River counties (sub-region 4), and NE Florida from Martin through Nassau counties (sub-region 5). The coastal household telephone survey method for the for-hire fishing mode continues to run concurrently with the newer FHS method.

*Calibration of traditional MRFSS charter boat estimates*

Conversion factors have been estimated to calibrate the traditional MRFSS charter boat estimates with the FHS for 1986-1997 in the Gulf of Mexico (SEDAR7-AW-03). The relationship between the old charter boat method estimates of angler trips and the FHS estimates of angler trips was used to estimate the conversion factors. Since these factors are based on effort, they can be applied to all species' landings. In the Gulf of Mexico and the South Atlantic, 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 charter boat and headboat as a single combined mode. Thus, in order to properly calibrate the estimates from 1981-1985, headboat data from the Southeast Region Head-boat Survey (SRHS) were included in the analysis. To calibrate the MRFSS combined charter boat 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 (SEDAR28-DW-12). These 1981-1985 calibration factors were updated since the last assessment of Gulf red grouper (SEDAR 12). The calibration factors were applied to the charter boat estimates and are tabulated in Table 4.8.1.

*MRIP weighted estimates, APAIS changes, and the calibration of MRFSS estimates*

The Marine Recreational Information Program (MRIP) was developed to generate more accurate recreational catch rates by re-designing the MRFSS sampling protocol to address potential biases including port activity and time of day. Revised catch and effort estimates, based on MRIP's improved estimation methodology, were released on January 25, 2012. These estimates are available for the Atlantic and Gulf Coasts starting in 2004.

Starting in 2013, wave 2, the MRIP Access Point Angler Intercept Survey (APAIS) implemented a "revised sampling design that includes an updated sampling frame; eliminates interviewer latitude in selecting interviewing sites; establishes discrete sampling periods of fixed duration, including nighttime sampling; and requires interviewers to collect detailed information about the number of completed boat and angler fishing trips during the sampling period" (MRIP Implementation Plan 2011). Revised catch estimates for red grouper, based on this improved APAIS design, were provided by the Office of Science and Technology for SEDAR 42 (Carmichael 2015). These estimates are provided by state and mode, with all waves and areas

combined. Tables 4.8.2 and 4.8.3 show the differences between the Gulf of Mexico red grouper MRIP APAIS landing and discard estimates and the MRFSS estimates for the time period 2004-2012.

As new MRIP APAIS estimates are available for a portion of the recreational time series that the MRFSS covers, conversion factors between the MRFSS estimates and the MRIP APAIS estimates were developed in order to maintain one consistent time series for the recreational catch estimates. Ratio estimators, based on the ratios of the means, were developed for Gulf of Mexico red grouper to hind-cast catch and variance estimates by fishing mode. In order to apply the charter boat ratio estimator back in time to 1981, charter boat landings were isolated from the combined charter boat /headboat mode for 1981-1985. The MRFSS to MRIP APAIS calibration process is the same as the original MRFSS to MRIP adjustment that has been used since 2012, which is detailed in SEDAR31-DW25 and SEDAR32-DW02. Table 4.8.4 shows the ratio estimators used in the calibration. Figure 4.9.2 shows the MRFSS versus MRIP APAIS adjusted estimates for Gulf of Mexico red grouper from 1981 to 2003. The ratio estimator for shore discards is larger than the other modes. However, since shore mode discards are minor compared to the other modes, this does not greatly affect the overall adjusted discard estimates (see Figure 4.9.2).

### *Monroe County*

Monroe County MRFSS landings from 1981 to 2003 can be post-stratified to separate them from the MRFSS West Florida estimates. Post-stratification proportionally distributes the state-wide (FLE and FLW) effort into finer scale sub-regions and then produces effort estimates at this finer geographical scale. This is needed for the private and shore modes (all years) and charter boat mode (prior to FHS). FHS charter boat mode estimates are already pre-stratified, as discussed above.

Originally, during the first MRIP re-estimation, Monroe County landings (2004+) could be estimated separately from the remaining West Florida estimates using domain estimation. The Monroe County domain includes only intercepted trips returning to that county as identified in the intercept survey data. Estimates are then calculated within this domain using standard design-based estimation which incorporates the MRIP design stratification, clustering, and

sample weights. However, the new MRIP APAIS calibration does not allow for domain estimation at this time. The recommended approach is to use the annual proportions from the original MRIP domain estimates (panhandle and peninsula over total FLW) and apply those proportions to the new West Florida MRIP APAIS estimates in order to remove Monroe County.

Although Monroe County estimates can be separated using these processes, they cannot be partitioned into those from the Atlantic Ocean and those from the Gulf of Mexico. In the previous Gulf of Mexico assessment, SEDAR 12 (2006), Monroe County was included in the Gulf stock. However, in the last South Atlantic assessment for red grouper, SEDAR 19 (2009), Monroe County was included in the South Atlantic stock. The deviation from SEDAR 12 was noted but new information was available that supported that decision. Beginning in 2005, the MRIP intercept survey began collecting information indicating whether an intercept is capturing fishing occurring on the Atlantic side or the Gulf side of the Keys. Figure 4.9.3 shows the allocation of Monroe County trips which caught red grouper and total catch of red grouper between both regions. The recreational workgroup recommends excluding Monroe County estimates from MRIP from the Gulf of Mexico stock. This decision differs from SEDAR 12 but is consistent with SEDAR 19.

### *Shore Estimates*

Shore landings estimates are sporadic and mostly from the earlier years but shore discard estimates consistently appear throughout the time series. It was noted that it is reasonable for red grouper to be caught from shore mode, especially from bridges in some parts of the coast. Shore mode estimates from MRIP were kept as reported by the survey. This is consistent with SEDAR 12.

### *Calculating landings estimates in weight*

The MRFSS and the MRIP surveys use different methodologies to estimate landings in weight. To apply a consistent methodology over the entire recreational time series, the Southeast Fisheries Science Center (SEFSC) implemented a method for calculating average weights for the MRIP (and MRIP adjusted) landings. This method is detailed in SEDAR32-DW-02. The length-weight equation developed by the Life History Working Group ( $W=5.46E-9*(L^{3.18})$ ) was used to convert red grouper sample lengths into weights, when no weight was recorded.  $W$  is whole

weight in kilograms and L is fork length in millimeters. Weight estimates were not provided by the recreational workgroup in SEDAR 12 but this method has been consistently used in SEDARs since 2012.

### *1981, wave 1*

MRFSS began in 1981, wave 2. In the Gulf of Mexico, catch for 1981 wave 1 was estimated by determining the proportion of catch in wave 1 to catch in all other waves for 1982-1984 by fishing mode and area. These proportions were then used to estimate wave 1 in 1981 from the estimated catches in other waves of that year. This methodology is consistent with past SEDARs (e.g., SEDAR 28 Spanish mackerel and cobia).

### *Variances*

Variances are provided by MRFSS/MRIP for their recreational catch estimates. Variances are adjusted to take into account the variance of the conversion factor when an adjustment to the estimate has been made (FHS and MRIP conversions). However, the variance estimates of the charter and headboat modes in 1981-1985 are missing. This is due to the MRIP calibration procedure, which requires the combined charter/headboat mode to be split in order to apply the MRIP adjustment to the charter mode back to 1981. In addition, variance estimates are not available for weight estimates generated through the SEFSC method described above.

Variances for MRIP APAIS estimates from 2004+ were calculated for the entire West Florida coast, including the Florida Keys. As discussed above, Monroe County was removed from the new MRIP APAIS estimates using proportions from the original MRIP domain estimates. There is not enough information to adjust the MRIP APAIS variances to account for the removal of Monroe County.

### *Results*

MRIP landings in numbers of fish and in whole weight in pounds are presented in Table 4.8.5. CVs associated with estimated landings in numbers are also shown. Gulf of Mexico red grouper estimates include Louisiana through West Florida, not including Monroe County, FL.

#### *4.3.2 Southeast Region Headboat Survey*

### *Introduction*

The Southeast Region Headboat Survey (SRHS) estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. The SRHS began in the South Atlantic in 1972 and Gulf of Mexico in 1986 and extends from the North Carolina/Virginia border to the Texas/Mexico border. Mississippi headboats were added to the survey in 2010. The South Atlantic and Gulf of Mexico Headboat Surveys generally include 70-80 vessels participating in each region annually.

The SRHS incorporates two components for estimating catch and effort. 1) Biological information: sizes of the fish landed are collected by port samplers during dockside sampling, where fish are measured to the nearest mm and weighed to the nearest 0.01 kg. These data are used to generate length frequency distributions and mean weights for all species by area and month. Port samplers also collect otoliths and spines for ageing studies during dockside sampling events. 2) Information about total catch and effort are collected via a logbook form that is filled out by vessel personnel for individual trips. These logbooks are summarized by vessel to generate estimated landings by species, area, and time strata. Most recently, the SRHS implemented electronic logbook reporting in the South Atlantic and Gulf of Mexico as of Jan 1, 2013. Headboat personnel now have the ability to report trip information via a website or mobile application. Electronic reporting became mandatory in 2014.

The SRHS was inconsistent in LA in 2002-2005. There were no trip reports collected in LA in 2002. Trip reports from 2001 were used (by the HBS) as a substitute to generate estimates of numbers caught (though there are some minor differences between the resulting estimates for the two years). In 2003, there were only a few trip reports but they were still used to generate the estimates. From 2004 to 2005 there were no trip reports or fish sampled, and no substitutes were used, so there are no estimates or samples from 2004 to 2005 due to funding issues and Hurricane Katrina. However, the MRFSS/MRIP For-Hire Survey included the LA headboats in their charter mode estimates for these years, thereby eliminating this hole in the headboat mode estimates.

### *Variances*

Variance estimates are not currently available for the SRHS catch estimates. Further research is required to develop a suitable method to calculate variance. This task has been prioritized and is currently in the planning stage.

### *Catch Estimates*

Final SRHS landings estimates are shown in Table 4.8.6, by year and state in Figure 4.9.4. SRHS areas 18-29 are included in the Gulf of Mexico red grouper stock.

### *4.3.3 Estimating Historical Recreational Landings*

#### *Introduction*

Historic recreational landings for the charter boat, headboat, private boat, and shore fishing modes are landings prior to the 1981 start of the current recreational surveys (MRIP and SRHS). The Recreational Working Group was tasked with reviewing all available historical sources of red grouper landings to evaluate potential methods to compile landings prior to the available time series of estimated landings.

The sources of historical landings that were reviewed for potential use are as follows:

- Estimates of Historical Red Grouper Angler Catch in the Gulf of Mexico for the Private/Charter boat and Headboat Recreational Fishing Modes, SEDAR42-DW-16.
- Estimating historical recreational angler effort in the Gulf of Mexico for the private, charter, and headboat fishing modes. Southeast Data, Assessment, and Review (SEDAR) 31-AW-11.
- Historical For-Hire Fishing Vessels: South Atlantic Fishery Management Council, 1930's to 1985; SEDAR41-DW-25.
- Backcalculation of recreational catch of red grouper from 1945 to 1985. SEDAR 12-DW15.

The Recreational Data Working Group (RWG) reviewed *Estimates of Historical Red Grouper Angler Catch in the Gulf of Mexico for the Private/Charter boat and Headboat Recreational*

*Fishing Modes* (SEDAR42-DW-16). This paper describes a method that modifies the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) method to include estimates of headboat numbers gleaned from the gray literature and news media accounts of historic headboat fishing. The paper also compares the new method with the previously accepted method. The RWG accepted the methods proposed in SEDAR42-DW-16, but requested a re-analysis of the data to include only the eastern Gulf of Mexico. The RWG concluded that the method used a previously accepted method (FHWAR method; SEDAR41-DW-17) combined with historical archived information that ultimately produced defensible estimates of historical landings.

The RWG reviewed *the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey (FHWAR) census method* (SEDAR41-DW-17). We concluded that the method was sound for the period prior to 1981 for the private/charter sector but the assumption that headboat effort was constant from 1945-1981 was unrealistic.

The RWG reviewed *Historical For-Hire Fishing Vessels: South Atlantic Fishery Management Council, 1930's to 1985* (SEDAR41-DW-25). The RWG concluded that the review was comprehensive for the geographic region surveyed and that the estimates could be used as a proxy for headboat fleet development in the Gulf of Mexico. They also concluded that the charter sector was probably small and indistinguishable from the headboat sector and that charter landings should be combined with the private landings for the purpose of the assessment. This decision is consistent with recent assessments.

The RWG also reviewed *Backcalculation of recreational catch of red grouper from 1945 to 1985* (SEDAR 12-DW15). This paper used the FHWAR method to estimate private landings, point estimates of the numbers of charter boat and catch rates from 1955-1985 for southwest and west central Florida, and from the northwest and panhandle of Florida. The DWG concluded that the methods used to estimate headboat and charter boat effort in the cited studies may not have been similar and that historic effort was likely overestimated.

*Issue:* Available historical red grouper landings prior to 1981.

*Option 1:* Use the *Backcalculation of Recreational Catch of Red Grouper from 1945 to 1985 (SEDAR 12-DW15)* method that relies on boat sales as a proxy for effort.

*Option 2:* Use the *Estimates of Historical Red Grouper Angler Catch in the Gulf of Mexico for the Private/Charter boat and Headboat Recreational Fishing Modes, SEDAR42-DW-16*, which uses the FHWAR census method to estimate red grouper landing 1945-1980 for the combined private/charter modes, and uses the historic headboat fleet size as a proxy for effort for the headboat mode. Use interpolation to complete time series.

*Option 3:* Use available recreational time series for the MRFSS/MRIP 1981 to 2013 for the charter and private modes, and headboat estimates 1972 – 2013 for the headboat mode.

**Decision:** *Option 2.*

Option #2: The FHWAR census method with modifications to estimate red grouper landings back in time will provide estimates consistent with recent assessments. The use of historical fleet size information provides a reasonable proxy for historic headboat effort. As red grouper are restricted to the eastern Gulf of Mexico, the group decided that only effort in Louisiana, Mississippi, Alabama and West Florida would be used to calculate historic landings.

#### *Historical Catch Estimates*

Final historical landings estimates are shown in Table 4.8.7.

#### 4.4 RECREATIONAL DISCARDS

Total recreational discards are summarized below by survey. A map and figures summarizing the total recreational red grouper discards are included in Figure 4.9.5. There are no estimates from the Texas Parks and Wildlife Survey for this species.

##### *4.4.1 MRFSS/MRIP discards*

Discarded live fish are reported by the anglers interviewed by the MRIP/MRFSS. Consequently, neither the identity nor the quantities reported are verified. Lengths and weights of discarded fish are not sampled or estimated by the MRFSS/MRIP.

MRFSS/MRIP estimates of live released fish (B2 fish) were adjusted in the same manner as the landings (i.e., using charter boat calibration factors, MRIP adjustment, substitutions, etc. described above in section 4.3.1).

MRIP discards in numbers of fish and associated CVs are presented in Table 4.8.8. Gulf of Mexico red grouper estimates include Louisiana through West Florida, not including Monroe County, FL.

#### 4.4.2 Headboat Logbook Discards

The Southeast Region Headboat Survey logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered “released alive” if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered “released dead”. As of Jan 1, 2013 the SRHS began collecting logbook data electronically. Changes to the trip report were also made at this time, one of which removed the condition category for discards i.e., released alive vs. released dead. The new form now collects only the total number of fish released regardless of condition.

These self-reported data are currently not validated within the Headboat Survey. However, the At-Sea Observer program data are used to validate the Southeast Region Headboat Survey logbook discard data (SEDAR 42-DW-17, 2014). Based on this validation it was determined that the logbook discard data would be used from 2007-2013. The RWG concluded that a proxy should be used to estimate the headboat red grouper discards for years prior to 2007 in FLW. The three proxy method discard estimates are negligible in all other states, as are the SRHS landings estimates. Therefore it is recommended to assume that the SRHS discards are negligible in the rest of the Gulf of Mexico in 1986-2006. The RWG considered the following three possible data sources to be used as a proxy for estimated headboat discards for 1986-2006 (Figure 4.9.6) in FLW.

- MRIP CH discard ratio proxy method 1986-2006.

- MRIP PR discard ratio proxy method 1986-2006.
- MRIP CH:SRHS discard ratio proxy method 1986-2006 (SEDAR 28-Assessment Workshop Report, 2012).

*Issue: Discard information not available prior to 2006, need a proxy for estimated headboat discards from 1986-2006.*

Option 1: MRIP CH: Apply the yearly MRFSS charter boat discard:landings ratio to estimated headboat landings in order to estimate headboat discards from 1986-2006.

Option 2: MRIP PR: Apply the yearly MRFSS private boat discard:landings ratio to estimated headboat landings in order to estimate headboat discards from 1986-2006.

Option 3: MRIP CH:SRHS Calculate a ratio of the mean ratio of SRHS discard:landings (2007-2013) and MRIP CH discard:landings (2007-2013). Apply this ratio to the yearly MRIP charter boat discard:landings ratio (1986-2006) in order to determine the yearly SRHS discard:landings ratio (1986-2006). This ratio is then applied to the SRHS landings (1986-2006) in order to estimate headboat discards (1986-2006).

**Decision:** Option 3. The MRFSS/MRIP CH discard ratio is much lower than that of the SRHS in 2007-2013 and therefore is not recommended for consideration. The MRFSS/MRIP PR discard ratio proxy agrees well with the SRHS discard ratio in 2007-2013. The MRFSS/MRIP CH:SRHS discard ratio method is closer to the SRHS discard rate in terms of magnitude. Final discard estimates from the SRHS are shown in Table 4.8.9 by year and state and in Figure 4.9.7.

#### 4.4.3 Headboat At-Sea Observer Survey Discards

Observer surveys of recreational headboats provide detailed information of recreational catch, and in particular of recreational discards. In the Gulf of Mexico, observer surveys were conducted in Alabama from 2004 to 2007, and in West Florida from 2005-2007 and 2009-present. For each survey, headboat vessels were randomly selected throughout each year in each state. Trained biologists then boarded the selected vessels, with permission from a vessel's captain, and observed all fishing activity of a sub-sample of anglers as they fished. The data collected included number and species of landed and discarded fish, size of landed and discarded

fish, and the release condition of discarded fish (FL only). Observers also recorded length of the trip, area fished (inland, state, and federal waters) and, in Florida, the minimum and maximum depth fished. As discussed above, the red grouper discard data from the MRFSS At-Sea Observer Headboat program and the Southeast Region Headboat Survey (SRHS) logbook were compared (SEDAR 42-DW-17, 2014). Based on the results of these comparisons, it was determined that the SRHS discard rates were validated by the MRFSS/MRIP At-Sea Observer data starting in 2007.

Total recreational catches (in numbers) from all surveys and all years are presented in Table 4.8.10.

#### 4.5 BIOLOGICAL SAMPLING

Length samples from recreational landings were obtained from the Marine Recreational Fisheries Statistics Survey and the Southeast Region Headboat Survey. Length samples from recreational discards were obtained from the At-sea Observer Program. The recreational sector is under sampled for biological samples (e.g., hard parts,  $n < 100$ /year, all years). It is recommended that there be an increase in the number of trips intercepted by year and that a higher percentage of the intercepts include collecting biological samples (length, weight, and hard parts).

##### 4.5.1 *Sampling Intensity*

###### MRFSS/MRIP Biological Sampling

The MRFSS/MRIP angler intercept survey includes the sampling of fish lengths from the harvested (landed, whole condition) catch. Up to 15 of each species landed per angler interviewed are measured to the nearest mm along a center line (defined as tip of snout to center of tail along a straight line, not curved over body). In those fish with a forked tail, this measure would typically be referred to as a fork length, and in those fish that do not have a forked tail it would typically be referred to as a total length with the exception of some fishes that have a single, or few, caudal fin rays that extend further. Weights are typically collected for the same fish measured although weights are not preferred when time is constrained. Aging structures and other biological samples are not collected during MRFSS/MRIP assignments because of concerns over the introduction of bias to survey data collection.

The number of angler trips with measured red grouper in the Gulf of Mexico (LA to FLW, not including the Keys) in the MRFSS/MRIP by year and mode are summarized in Table 4.8.11. Information on the weights collected (number, mean, minimum, and maximum weights) by year and state from the MRFSS/MRIP is tabulated in Table 4.8.12.

#### *Headboat Survey Biological Sampling*

Lengths were collected from 1972 to 2013 by headboat dockside samplers. From 1972 to 1975, only North Carolina and South Carolina were sampled whereas Georgia and northeast Florida were sampled beginning in 1976. The Southeast Region Headboat Survey conducted dockside sampling for the entire range of Atlantic waters along the southeast portion of the US from the NC-VA border through the Florida Keys beginning in 1978. The Gulf of Mexico, excluding Mississippi, was added to the dockside sampling program in 1986. Mississippi was added in 2010. Weights are typically collected for the same fish measured during dockside sampling. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely and processed for aging, diet studies, and maturity studies.

Annual numbers of red grouper measured for length in the headboat fleet and the number of trips from which red grouper were measured are summarized in Table 4.8.13. Dockside mean weights for the headboat fishery are tabulated for 1972-2013 in Table 4.8.14.

#### *At-sea Observer Program*

Observer surveys were conducted aboard charter vessels from 2009-present and aboard recreational headboats from 2005-2007 and 2009-present. Vessels were randomly selected and a subsample of the anglers onboard was observed. All fish harvested and discarded were recorded for species, length, and condition if released. These surveys provided the detailed information of headboat and charter vessel discards with which length distributions of discards could be made (Figure 4.9.8 and Figure 4.9.9). Results presented here provide the discard length distributions for both headboat and charter vessels. Discard lengths are commonly between 20 and 40cm.

#### *4.5.2 Length Distributions*

Length and age samples (Table 4.8.15 and Table 4.8.16) for recreational fisheries were obtained from the Marine Recreational Fisheries Statistics Survey (i.e., the Marine Recreational

Information Program, MRIP), the Southeast Region Headboat Survey, the Gulf FIN database, and the TIP database. All recreational samples were combined into one stratum. Length frequency distributions for recreational landings are shown in Figure 4.9.10.

#### 4.5.3 Age Distribution

For the estimation of age frequency distributions, age samples were reweighted by length samples (Chih, SEDAR42-DW-18). Reweighted age frequency distributions for recreational landings are shown in Figure 4.9.11.

### 4.6 RECREATIONAL EFFORT

Total recreational effort is summarized below by survey. Effort is summarized for all marine fishing by mode, regardless of what was caught. A map and figures summarizing MRFSS/MRIP effort in angler trips are included in Figure 4.9.12. A map and figures summarizing SRHS effort in angler days are included in Figure 4.9.13.

#### 4.6.1 MRFSS/MRIP Effort

Effort estimates for the recreational fishery survey are produced via telephone surveys of both anglers (private/rental boats and shore fishers) and for-hire boat operators (charter boat anglers, and in early years, party or charter anglers). The methods have changed during the full time series (see section 4.3 for descriptions of survey method changes and adjustments to survey estimates for uniform time-series of catch estimates). An angler-trip is defined as a single day of fishing by a single angler in the specified mode, not to exceed 24 hours. MRFSS effort estimates are presented from 1981 to 2003. MRIP effort estimates are presented starting in 2004. Angler trip estimates are tabulated in Table 4.8.17 by year and mode and include all Gulf of Mexico states from Louisiana to West Florida, not including the Keys.

#### 4.6.2 Headboat Effort

Catch and effort data are reported on logbooks provided to all headboats in the survey. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Data on effort are provided as number of anglers on a given trip. Numbers of

anglers are standardized, depending on the type of trip (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). Angler days are summed by month for individual vessels. Each month, port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is not 100% and is variable by location. To account for non-reporting, a correction factor is developed based on sampler observations, angler numbers from office books and all available information. This information is used to provide estimates of total catch (expanded or corrected for non-reporting) by month and area, along with estimates of effort.

Estimated headboat angler days are tabulated for the Gulf of Mexico in Table 4.8.18 and include SRHS areas 18-29.

Estimated headboat angler days have decreased in the South Atlantic and Gulf of Mexico in recent years. The most obvious factor which impacted the headboat fishery in both the South Atlantic and Gulf of Mexico was the high price of fuel. This, coupled with the economic downturn starting in 2008, has resulted in a marked decline in angler days in the South Atlantic and Gulf of Mexico headboat fishery. Reports from industry staff, captains/owners, and port agents indicated fuel prices, the economy and fishing regulations are the factors that most affected the amount of trips, number of passengers, and overall fishing effort. Also important to note, is the decrease in effort in the South Atlantic and Gulf of Mexico in 2010, the year of the Deepwater Horizon oil spill. However, estimated angler days have risen in recent years (2012-2013).

#### 4.7 LITERATURE CITED

Brennan, K. 2014. SEDAR41-DW-17. Estimates of Historic Recreational Landings of Red Snapper in the South Atlantic Using the FHWAR Census Method. National Marine Fisheries Service Southeast Fisheries Science Center, Fisheries Ecosystems Branch, Beaufort, NC.

Brennan, K. and K. Fitzpatrick. 2012. SEDAR31-RD-25. Estimates of Historic Recreational Landings of Spanish Mackerel in the South Atlantic using the FHWAR Census Method. National Marine Fisheries Service Southeast Fisheries Science Center, Fisheries Ecosystems Branch, Beaufort, NC.

- Carmichael, J. and D. Van Voorhees (editors). 2015. MRIP Calibration Workshop II. Report of a workshop on calibrating MRIP catch estimates, September 8-10, 2014. SAFMC/SEDAR, North Charleston, SC.
- Chih, C.P. 2014. SEDAR42-DW-18. Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984 to 2013. National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division, Miami, FL.
- Diaz, G.A. and P. Phares. 2004. SEDAR7-AW-03. Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the Gulf of Mexico in 1981-1997 with For Hire Survey estimates with application to red snapper landings. National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division (SFD-2004-036), Miami, FL.
- Fisheries Ecosystems Branch. 2014. SEDAR42-DW-17. Discards of red grouper (*Epinephelus morio*) for the headboat fishery in the US Gulf of Mexico. National Marine Fisheries Service Southeast Fisheries Science Center, Fisheries Ecosystems Branch, Beaufort, NC.
- Gray, A. and B. Sauls. 2014. SEDAR42-DW-14. Size Distribution of Red Grouper Observed in For-Hire Recreational Fisheries in the Gulf of Mexico. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Saint Petersburg, FL.
- Hudson, R. H. 2013. SEDAR41-DW-25. Historical For-Hire Fishing Vessels: South Atlantic Fishery Management Council, 1930's to 1985;.
- Isely, J., N. Cummings, and A. Rios. 2014. SEDAR42-DW-16. Estimates of Historical Private/Charter boat and Headboat Fishery Red Grouper Angler Catch in the Gulf of Mexico 1945-1980. National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division, Miami, FL.
- Matter, V.M., N. Cummings, J. J. Isely, K. Brennan and K. Fitzpatrick. 2012. SEDAR28-DW-12. 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. National Marine

Fisheries Service Southeast Fisheries Science Center, Fisheries Statistics Division, Miami, FL, National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division (SFD-2012-003), Miami, FL, and National Marine Fisheries Service Southeast Fisheries Science Center, Fisheries Ecosystems Branch, Beaufort, NC.

Matter, V. and S. Turner 2010. SEDAR22-DW-16. Estimated Recreational Catch in Weight: Method for Filling in Missing Weight Estimates from the Recreational Surveys with Application to Yellowedge Grouper, Tilefish (golden), and Blueline Tilefish. National Marine Fisheries Service, Southeast Fisheries Science Center, Sustainable Fisheries Division (SFD-2010-003), Miami, FL.

Matter, V.M. and A. Rios. 2013. SEDAR32-DW-02. MRFSS to MRIP Adjustment Ratios and Weight Estimation Procedures for South Atlantic and Gulf of Mexico Managed Species. National Marine Fisheries Service Southeast Fisheries Science Center, Fisheries Statistics Division, Miami, FL and National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division, Miami, FL.

Marine Recreational Information Program. Implementation Plan: 2011/2012 Update. October 2011.

Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division. February 2012.

Rios, A., V.M. Matter, J.F. Walter, N. Farmer, and S. Turner. 2012. SEDAR31-DW-25 Estimated Conversion Factors for Adjusting MRFSS Gulf of Mexico Red Snapper Catch Estimates and Variances in 1981-2003 to MRIP Estimates and Variances. National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division (SFD-2012-016), Miami, FL, National Marine Fisheries Service Southeast Fisheries Science Center, Fisheries Statistics Division, Miami, FL, and National Marine Fisheries Service Southeast Regional Office, Saint Petersburg, FL.

- Rios, A. 2013. SEDAR31-AW-11. Estimating historical recreational angler effort in the Gulf of Mexico for the private, charter, and headboat fishing modes. National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division, Miami, FL.
- SEDAR. 2006. SEDAR 12 – Gulf of Mexico Red Grouper Stock Assessment Report. SEDAR, North Charleston SC. Available online at:  
[http://www.sefsc.noaa.gov/sedar/Sedar\\_Workshops.jsp?WorkshopNum=12](http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=12)
- SEDAR. 2009. SEDAR 19 – South Atlantic Red Grouper Stock Assessment Report. SEDAR, North Charleston SC. Available online at:  
[http://www.sefsc.noaa.gov/sedar/Sedar\\_Workshops.jsp?WorkshopNum=19](http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=19)
- Sauls, B., R. Cody, O. Ayala, B. Cermak. 2013. SEDAR41-RD-16. A directed study of the recreational red snapper fisheries in the Gulf of Mexico along the West Florida Shelf. Federal Grant NA09NMF4720265, Final report submitted to National Marine Fisheries Service, Southeast Regional Office.
- Van Voorhees, D., T. Sminkey, J. Schlechte, D. Donaldson, K. Anson, J. O’Hop, M. Norris, J. Shepherd, T. Van Devender, and B. Zales. 2002. The new Marine Recreational Fisheries Statistics Survey method for estimating charter boat fishing effort. Gulf and Caribbean Fisheries Institute. 53: 332-343.  
[http://research.myfwc.com/publications/publication\\_info.asp?id=41919](http://research.myfwc.com/publications/publication_info.asp?id=41919)
- Walter, J.F. 2006. SEDAR12-DW-15. Backcalculation of recreational catch of red grouper from 1945 to 1985. National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division, Miami, FL.

## 4.8 TABLES

**Table 4.8.1** Gulf of Mexico MRFSS charter boat conversion factors and standard errors (in parentheses).

a) Apply to 1981-1985 charter boat/headboat mode in the South Atlantic and Gulf of Mexico.

|       | WAVE            |                 |                 |                 |                 |                 |
|-------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| STATE | 1               | 2               | 3               | 4               | 5               | 6               |
| NC    | -               | 2.151<br>(0.12) | 2.294<br>(0.12) | 1.444<br>(0.12) | 1.763<br>(0.12) | 0.857<br>(0.12) |
| SC    | -               | 1.035<br>(0.04) | 1.085<br>(0.04) | 1.437<br>(0.04) | 0.891<br>(0.04) | 0.750<br>(0.04) |
| GFE   | 0.845<br>(0.02) | 0.951<br>(0.02) | 0.985<br>(0.02) | 1.016<br>(0.02) | 0.811<br>(0.02) | 0.696<br>(0.02) |
| AFW   | 0.883<br>(0.03) | 0.883<br>(0.03) | 1.104<br>(0.05) | 1.104<br>(0.05) | 0.883<br>(0.03) | 0.883<br>(0.03) |
| MS    | 1.155<br>(0.11) | 1.155<br>(0.11) | 2.245<br>(0.11) | 2.245<br>(0.11) | 1.155<br>(0.11) | 1.155<br>(0.11) |
| LA    | 0.962<br>(0.09) | 0.962<br>(0.09) | 2.260<br>(0.13) | 2.260<br>(0.13) | 0.962<br>(0.09) | 0.962<br>(0.09) |

b) Apply to 1986 – 1997 charter boat mode in LA, MS, and AL

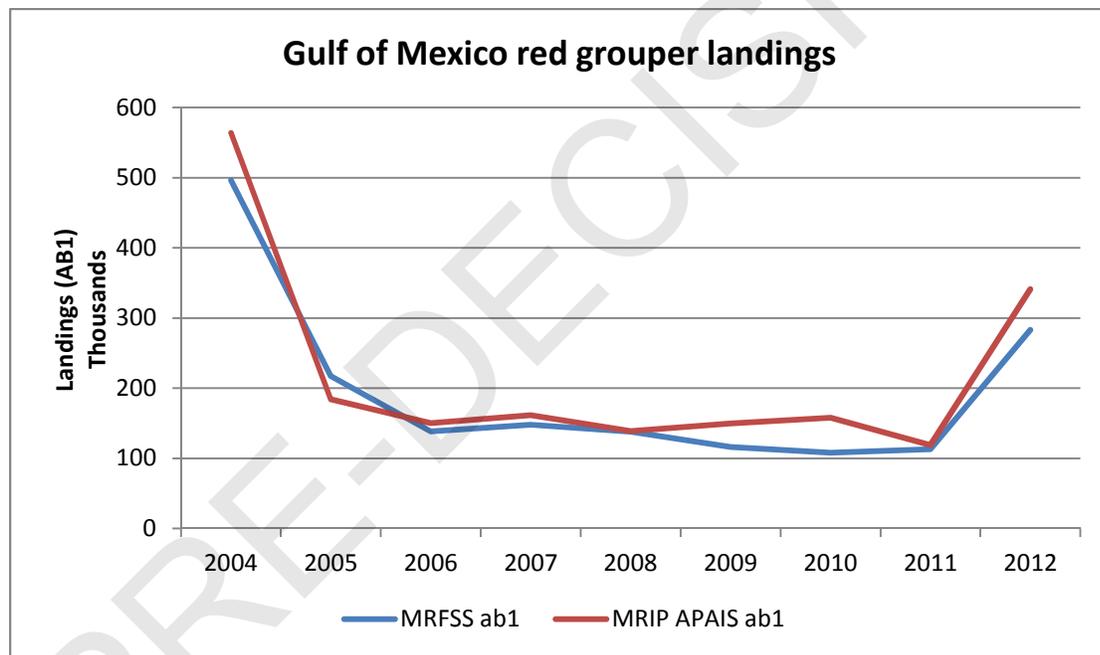
|           | WAVE           |                |                |                |                |                |
|-----------|----------------|----------------|----------------|----------------|----------------|----------------|
| Area      | 1              | 2              | 3              | 4              | 5              | 6              |
| Inshore   | 1.26<br>(1.31) | 1.54<br>(1.27) | 3.82<br>(1.26) | 4.67<br>(1.26) | 3.28<br>(1.27) | 1.48<br>(1.28) |
| < 3 miles | 0.74<br>(1.37) | 0.75<br>(1.26) | 1.49<br>(1.25) | 2.28<br>(1.24) | 0.64<br>(1.28) | 0.52<br>(1.40) |
| > 3 miles | 0.44<br>(1.28) | 0.63<br>(1.24) | 2.23<br>(1.23) | 1.87<br>(1.24) | 1.26<br>(1.23) | 0.53<br>(1.28) |

c) Apply to 1986- 1997 charter boat mode in FLW

|            | WAVE           |                |                |                |                |                |
|------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Area       | 1              | 2              | 3              | 4              | 5              | 6              |
| Inshore    | 3.17<br>(0.16) | 5.31<br>(0.16) | 5.71<br>(0.16) | 5.33<br>(0.16) | 3.49<br>(0.16) | 3.70<br>(0.16) |
| < 10 miles | 0.95<br>(0.16) | 1.10<br>(0.16) | 1.78<br>(0.16) | 0.70<br>(0.16) | 0.48<br>(0.16) | 0.98<br>(0.16) |
| > 10 miles | 0.38<br>(0.16) | 0.58<br>(0.16) | 0.77<br>(0.16) | 0.73<br>(0.16) | 0.59<br>(0.16) | 0.55<br>(0.16) |

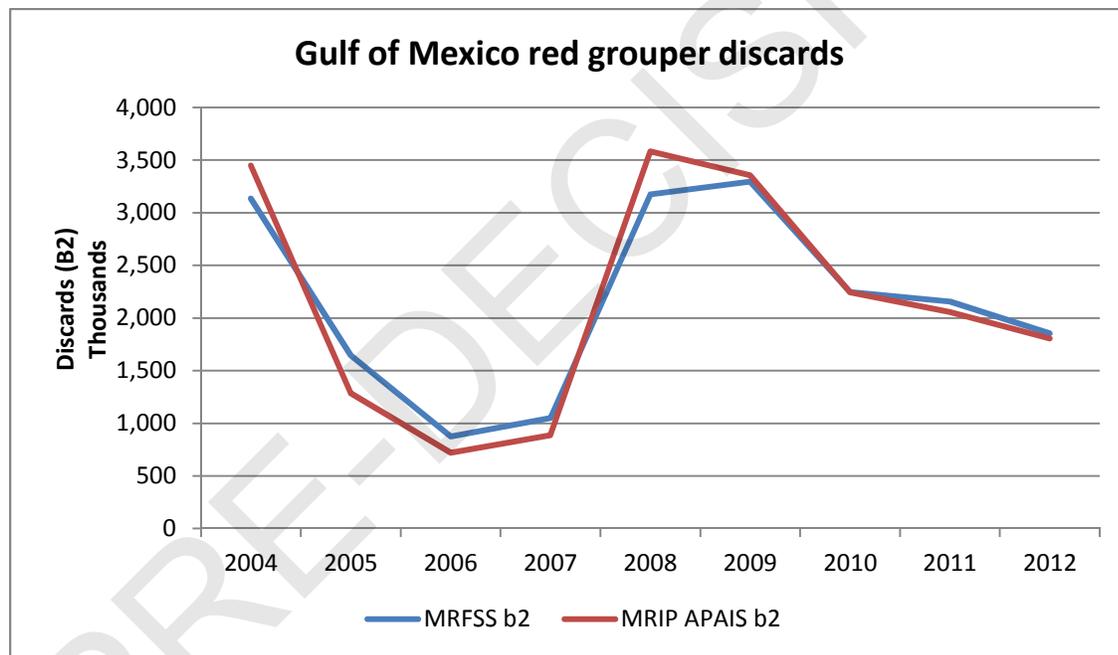
**Table 4.8.2.** Red grouper MRFSS vs MRIP APAIS estimates of landings (number of fish) for the Gulf of Mexico (sub-region 7, including the Keys) 2004-2012. See accompanying graph below table.

| year | MRFSS ab1 | MRFSS CV_ab1 | MRIP APAIS ab1 | MRIP APAIS CV_ab1 |
|------|-----------|--------------|----------------|-------------------|
| 2004 | 495,942   | 0.08         | 563,576        | 0.16              |
| 2005 | 217,464   | 0.09         | 184,447        | 0.15              |
| 2006 | 138,513   | 0.11         | 150,111        | 0.24              |
| 2007 | 147,851   | 0.10         | 161,419        | 0.23              |
| 2008 | 137,920   | 0.10         | 138,779        | 0.16              |
| 2009 | 116,190   | 0.13         | 149,896        | 0.23              |
| 2010 | 107,995   | 0.12         | 157,981        | 0.21              |
| 2011 | 112,871   | 0.10         | 118,887        | 0.16              |
| 2012 | 283,304   | 0.09         | 341,232        | 0.18              |



**Table 4.8.3.** Red grouper MRFSS vs MRIP APAIS estimates of discards (number of fish) for the Gulf of Mexico (sub-region 7, including the Keys) 2004-2012. See accompanying graph below table.

| year | MRFSS b2  | MRFSS CV_b2 | MRIP APAIS b2 | MRIP APAIS CV_b2 |
|------|-----------|-------------|---------------|------------------|
| 2004 | 3,136,801 | 0.05        | 3,449,693     | 0.12             |
| 2005 | 1,644,824 | 0.07        | 1,285,731     | 0.15             |
| 2006 | 874,059   | 0.09        | 719,419       | 0.24             |
| 2007 | 1,050,213 | 0.10        | 887,516       | 0.16             |
| 2008 | 3,174,133 | 0.06        | 3,583,099     | 0.20             |
| 2009 | 3,294,541 | 0.06        | 3,357,560     | 0.13             |
| 2010 | 2,246,179 | 0.06        | 2,242,438     | 0.13             |
| 2011 | 2,156,220 | 0.07        | 2,057,735     | 0.14             |
| 2012 | 1,852,884 | 0.06        | 1,807,062     | 0.11             |



**Table 4.8.4.** Gulf of Mexico red grouper ratio estimators for adjusting MRFSS numbers and variance estimates (AB1 and B2) to MRIP APAIS numbers and variances for 1981-2003. The variances of the numbers ratio estimators are also shown.

| MODE                | Numbers Ratio Estimator |          | Variance Ratio Estimator |          | Variance of Numbers Ratio Estimator |          |
|---------------------|-------------------------|----------|--------------------------|----------|-------------------------------------|----------|
|                     | AB1                     | B2       | AB1                      | B2       | AB1                                 | B2       |
| <b>Charter boat</b> | 1.123337                | 1.234725 | 8.087822                 | 7.746577 | 0.004217                            | 0.001866 |
| <b>Private</b>      | 1.116533                | 0.916223 | 5.138042                 | 4.226388 | 0.003068                            | 0.001189 |
| <b>Shore</b>        | 1.188584                | 6.167641 | 1.417673                 | 849.1178 |                                     | 1.331041 |

**Table 4.8.5.** Gulf of Mexico (LA-FLW, not including the Keys) red grouper landings (numbers of fish and whole weight in pounds) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2004. CH mode adjusted for FHS conversion prior to 2004. \*CVs for CH and HB mode 1981-1985 are unavailable.

| YEAR | Estimated CH Landings |      |         | Estimated HB Landings |     |         | Estimated PR Landings |      |           | Estimated SH Landings |      |         | ALL MODES Landings |       |           |
|------|-----------------------|------|---------|-----------------------|-----|---------|-----------------------|------|-----------|-----------------------|------|---------|--------------------|-------|-----------|
|      | Number                | CV*  | Pounds  | Number                | CV* | Pounds  | Number                | CV   | Pounds    | Number                | CV   | Pounds  | Number             | CV    | Pounds    |
| 1981 | 44,565                |      | 166,524 | 24,813                |     | 92,715  | 77,072                | 0.66 | 286,584   | 0                     | 0.00 | 0       | 146,450            | 0.35* | 545,822   |
| 1982 | 9,413                 |      | 44,545  | 5,241                 |     | 24,801  | 163,825               | 0.41 | 636,825   | 0                     | 0.00 | 0       | 178,480            | 0.38* | 706,172   |
| 1983 | 27,335                |      | 156,106 | 15,219                |     | 120,346 | 351,074               | 0.57 | 1,012,722 | 0                     | 0.00 | 0       | 393,628            | 0.51* | 1,289,175 |
| 1984 | 75,279                |      | 581,335 | 41,913                |     | 169,852 | 118,114               | 0.54 | 615,050   | 28,098                | 1.01 | 146,315 | 263,405            | 0.27* | 1,512,552 |
| 1985 | 107,215               |      | 614,026 | 59,694                |     | 396,035 | 418,989               | 0.70 | 2,399,577 | 0                     | 0.00 | 0       | 585,898            | 0.50* | 3,409,638 |
| 1986 | 79,799                | 0.54 | 211,420 |                       |     |         | 525,519               | 0.35 | 1,482,955 | 6,969                 | 1.01 | 19,032  | 612,286            | 0.31  | 1,713,407 |
| 1987 | 38,279                | 0.82 | 117,460 |                       |     |         | 298,229               | 0.33 | 831,544   | 0                     | 0.00 | 0       | 336,508            | 0.31  | 949,003   |
| 1988 | 51,948                | 0.59 | 192,055 |                       |     |         | 687,306               | 0.31 | 2,359,406 | 9,160                 | 0.77 | 32,682  | 748,415            | 0.29  | 2,584,144 |
| 1989 | 38,012                | 0.77 | 129,960 |                       |     |         | 713,005               | 0.29 | 2,300,517 | 0                     | 0.00 | 0       | 751,017            | 0.28  | 2,430,477 |
| 1990 | 50,212                | 2.06 | 325,496 |                       |     |         | 130,122               | 0.40 | 821,780   | 16,048                | 0.92 | 104,030 | 196,382            | 0.59  | 1,251,306 |
| 1991 | 11,401                | 1.74 | 70,274  |                       |     |         | 284,585               | 0.32 | 1,816,303 | 10,155                | 0.98 | 62,594  | 306,142            | 0.30  | 1,949,171 |
| 1992 | 52,191                | 0.50 | 351,669 |                       |     |         | 419,526               | 0.19 | 2,647,074 | 26,238                | 0.78 | 171,988 | 497,954            | 0.18  | 3,170,731 |
| 1993 | 27,501                | 0.59 | 162,848 |                       |     |         | 331,594               | 0.32 | 2,001,232 | 18,946                | 0.79 | 112,189 | 378,041            | 0.28  | 2,276,269 |
| 1994 | 32,000                | 0.57 | 198,505 |                       |     |         | 279,441               | 0.27 | 1,869,418 | 2,750                 | 0.74 | 17,607  | 314,190            | 0.25  | 2,085,531 |
| 1995 | 59,008                | 0.68 | 441,941 |                       |     |         | 226,726               | 0.27 | 1,500,034 | 0                     | 0.00 | 0       | 285,734            | 0.26  | 1,941,974 |
| 1996 | 22,673                | 0.78 | 151,409 |                       |     |         | 87,205                | 0.31 | 589,392   | 0                     | 0.00 | 0       | 109,879            | 0.29  | 740,801   |
| 1997 | 22,229                | 0.75 | 151,836 |                       |     |         | 55,004                | 0.42 | 358,425   | 0                     | 0.00 | 0       | 77,233             | 0.37  | 510,261   |
| 1998 | 25,665                | 0.36 | 164,507 |                       |     |         | 83,245                | 0.29 | 584,050   | 0                     | 0.00 | 0       | 108,910            | 0.24  | 748,557   |
| 1999 | 34,514                | 0.41 | 236,262 |                       |     |         | 160,692               | 0.22 | 1,040,547 | 0                     | 0.00 | 0       | 195,205            | 0.20  | 1,276,810 |
| 2000 | 126,774               | 0.49 | 957,495 |                       |     |         | 240,164               | 0.23 | 1,581,860 | 0                     | 0.00 | 0       | 366,937            | 0.23  | 2,539,355 |
| 2001 | 63,966                | 0.51 | 427,903 |                       |     |         | 173,124               | 0.23 | 1,161,066 | 0                     | 0.00 | 0       | 237,090            | 0.22  | 1,588,969 |
| 2002 | 49,186                | 0.25 | 356,312 |                       |     |         | 218,694               | 0.31 | 1,529,477 | 0                     | 0.00 | 0       | 267,880            | 0.25  | 1,885,789 |
| 2003 | 53,850                | 0.22 | 323,993 |                       |     |         | 164,178               | 0.21 | 1,019,413 | 0                     | 0.00 | 0       | 218,029            | 0.17  | 1,343,406 |
| 2004 | 91,840                | 0.10 | 576,499 |                       |     |         | 438,051               | 0.20 | 2,846,732 | 0                     | 0.00 | 0       | 529,891            | 0.16  | 3,423,231 |
| 2005 | 86,712                | 0.11 | 536,668 |                       |     |         | 96,952                | 0.27 | 660,950   | 0                     | 0.00 | 0       | 183,664            | 0.15  | 1,197,617 |
| 2006 | 37,001                | 0.18 | 250,814 |                       |     |         | 94,509                | 0.33 | 667,237   | 0                     | 0.00 | 0       | 131,509            | 0.24  | 918,051   |
| 2007 | 26,289                | 0.16 | 193,711 |                       |     |         | 128,452               | 0.27 | 897,602   | 0                     | 0.00 | 0       | 154,741            | 0.23  | 1,091,313 |
| 2008 | 41,527                | 0.17 | 291,058 |                       |     |         | 91,601                | 0.22 | 605,183   | 0                     | 0.00 | 0       | 133,129            | 0.16  | 896,241   |

|      |         |      |         |         |      |           |       |      |        |         |      |           |
|------|---------|------|---------|---------|------|-----------|-------|------|--------|---------|------|-----------|
| 2009 | 28,960  | 0.16 | 209,410 | 95,599  | 0.30 | 733,685   | 1,607 | 1.00 | 11,760 | 126,166 | 0.23 | 954,854   |
| 2010 | 55,165  | 0.36 | 334,920 | 100,922 | 0.25 | 615,491   | 0     | 0.00 | 0      | 156,087 | 0.21 | 950,411   |
| 2011 | 48,798  | 0.22 | 278,039 | 62,111  | 0.22 | 347,762   | 0     | 0.00 | 0      | 110,909 | 0.16 | 625,800   |
| 2012 | 91,304  | 0.30 | 512,928 | 208,979 | 0.23 | 1,286,933 | 0     | 0.00 | 0      | 300,283 | 0.18 | 1,799,861 |
| 2013 | 139,184 | 0.17 | 799,983 | 301,203 | 0.18 | 1,791,279 | 0     | 0.00 | 0      | 440,387 | 0.13 | 2,591,261 |

PRE-DECISIONAL

**Table 4.8.6.** Estimated headboat landings of red grouper in the Gulf of Mexico 1986-2013. Due to headboat area definitions and confidentiality issues, FLW must be combined with AL and MS must be combined with LA.

| Year | Number |       |    | Gulf of Mexico | Pounds  |       |     | Gulf of Mexico |
|------|--------|-------|----|----------------|---------|-------|-----|----------------|
|      | FLW/AL | MS/LA | TX |                | FLW/AL  | MS/LA | TX  |                |
| 1986 | 32,902 | -     | 11 | 32,913         | 118,249 | -     | 82  | 118,331        |
| 1987 | 25,698 | -     | 31 | 25,729         | 88,139  | -     | 281 | 88,420         |
| 1988 | 27,946 | -     | 8  | 27,954         | 103,794 | -     | 85  | 103,879        |
| 1989 | 49,774 | 1     | 2  | 49,777         | 135,003 | 11    | 23  | 135,037        |
| 1990 | 14,578 | -     | 4  | 14,582         | 91,471  | -     | 40  | 91,512         |
| 1991 | 9,504  | -     | 5  | 9,509          | 60,659  | -     | 79  | 60,738         |
| 1992 | 9,047  | 1     | 1  | 9,049          | 52,632  | 10    | 9   | 52,651         |
| 1993 | 8,787  | 5     | 10 | 8,802          | 75,944  | 59    | 118 | 76,120         |
| 1994 | 9,616  | -     | 1  | 9,617          | 55,345  | -     | 6   | 55,351         |
| 1995 | 14,498 | -     | 1  | 14,499         | 94,203  | -     | 8   | 94,210         |
| 1996 | 15,594 | -     | -  | 15,594         | 84,369  | -     | -   | 84,369         |
| 1997 | 4,674  | -     | 2  | 4,676          | 25,093  | -     | 15  | 25,108         |
| 1998 | 4,368  | 9     | 5  | 4,382          | 23,240  | 63    | 35  | 23,339         |
| 1999 | 6,913  | 5     | -  | 6,918          | 47,960  | 49    | -   | 48,010         |
| 2000 | 8,860  | -     | 1  | 8,861          | 51,048  | -     | 7   | 51,056         |
| 2001 | 5,557  | 1     | 2  | 5,560          | 31,613  | 5     | 12  | 31,630         |
| 2002 | 4,399  | 1     | 2  | 4,402          | 24,617  | 6     | 14  | 24,636         |
| 2003 | 7,514  | 4     | 3  | 7,521          | 40,297  | 23    | 17  | 40,337         |
| 2004 | 13,808 | -     | 2  | 13,810         | 68,263  | -     | 9   | 68,272         |
| 2005 | 13,965 | -     | 2  | 13,967         | 78,599  | -     | 12  | 78,610         |
| 2006 | 4,629  | -     | 1  | 4,630          | 26,697  | -     | 6   | 26,703         |
| 2007 | 4,235  | -     | 10 | 4,245          | 25,803  | -     | 55  | 25,858         |
| 2008 | 4,998  | -     | 5  | 5,003          | 39,368  | -     | 41  | 39,409         |
| 2009 | 4,659  | -     | 7  | 4,666          | 30,956  | -     | 47  | 31,003         |
| 2010 | 4,949  | -     | 3  | 4,952          | 27,291  | -     | 24  | 27,315         |
| 2011 | 7,387  | -     | -  | 7,387          | 38,459  | -     | -   | 38,459         |
| 2012 | 13,543 | -     | 1  | 13,544         | 87,316  | -     | 9   | 87,324         |
| 2013 | 14,085 | -     | 4  | 14,089         | 81,230  | -     | 34  | 81,264         |

**Table 4.8.7.** Historic recreational landings of red grouper in the Gulf of Mexico by mode. Private/charter mode uses FHWAR effort estimates referenced to the average of 1981-1985 MRFSS Gulf of Mexico estimates. Headboat mode uses the historic Ponce Inlet headboat fleet size (Hudson 2014) as an effort proxy.

| Year | Recreational Historical Landings (numbers) |          |         |
|------|--------------------------------------------|----------|---------|
|      | private/charter                            | headboat | Total   |
| 1945 | 0                                          | 0        | 0       |
| 1946 | 12,022                                     | 689      | 12,711  |
| 1947 | 24,044                                     | 1,378    | 25,422  |
| 1948 | 36,067                                     | 2,066    | 38,133  |
| 1949 | 48,089                                     | 2,755    | 50,844  |
| 1950 | 60,111                                     | 3,444    | 63,555  |
| 1951 | 72,133                                     | 4,133    | 76,266  |
| 1952 | 84,155                                     | 4,821    | 88,977  |
| 1953 | 96,178                                     | 5,510    | 101,688 |
| 1954 | 108,200                                    | 6,199    | 114,399 |
| 1955 | 120,222                                    | 6,888    | 127,110 |
| 1956 | 127,848                                    | 9,184    | 137,032 |
| 1957 | 135,474                                    | 11,480   | 146,953 |
| 1958 | 143,100                                    | 13,775   | 156,875 |
| 1959 | 150,726                                    | 16,071   | 166,797 |
| 1960 | 158,352                                    | 18,367   | 176,719 |
| 1961 | 158,764                                    | 20,663   | 179,428 |
| 1962 | 159,177                                    | 22,959   | 182,136 |
| 1963 | 159,589                                    | 25,255   | 184,844 |
| 1964 | 160,002                                    | 27,551   | 187,553 |
| 1965 | 160,415                                    | 29,847   | 190,261 |
| 1966 | 164,277                                    | 32,602   | 196,879 |
| 1967 | 168,140                                    | 35,357   | 203,497 |
| 1968 | 172,002                                    | 38,112   | 210,114 |
| 1969 | 175,865                                    | 40,867   | 216,732 |
| 1970 | 179,727                                    | 43,622   | 223,349 |
| 1971 | 186,048                                    | 43,622   | 229,670 |
| 1972 | 192,369                                    | 45,918   | 238,287 |
| 1973 | 198,690                                    | 48,214   | 246,904 |
| 1974 | 205,011                                    | 48,214   | 253,225 |
| 1975 | 211,332                                    | 66,581   | 277,914 |
| 1976 | 223,354                                    | 64,285   | 287,639 |
| 1977 | 235,376                                    | 59,694   | 295,069 |
| 1978 | 247,397                                    | 57,398   | 304,795 |
| 1979 | 259,419                                    | 64,285   | 323,704 |
| 1980 | 271,441                                    | 64,285   | 335,726 |

**Table 4.8.8.** Gulf of Mexico (LA-FLW, not including the Keys) red grouper discards (numbers of fish) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2004. CH mode adjusted for FHS conversion prior to 2004. \*CVs for CH and HB mode 1981-1985 are unavailable.

| YEAR | Estimated CH Discards |      | Estimated HB Discards |     | Estimated PR Discards |      | Estimated SH Discards |       | ALL MODES Discards |      |
|------|-----------------------|------|-----------------------|-----|-----------------------|------|-----------------------|-------|--------------------|------|
|      | Number                | CV*  | Number                | CV* | Number                | CV   | Number                | CV    | Number             | CV   |
| 1981 | 7,906                 |      | 4,005                 |     | 53,292                | 0.89 | 11,623                | 28.63 | 76,825             | 4.37 |
| 1982 | 3,078                 |      | 1,559                 |     | 35,734                | 0.68 | 0                     | 0.00  | 40,372             | 0.60 |
| 1983 | 6,516                 |      | 3,301                 |     | 42,091                | 1.26 | 0                     | 0.00  | 51,907             | 1.02 |
| 1984 | 18,893                |      | 9,570                 |     | 27,223                | 0.96 | 0                     | 0.00  | 55,686             | 0.47 |
| 1985 | 27,212                |      | 13,784                |     | 35,973                | 0.92 | 31,584                | 17.22 | 108,552            | 5.02 |
| 1986 | 75,968                | 0.83 |                       |     | 388,292               | 0.47 | 36,162                | 28.63 | 500,422            | 2.10 |
| 1987 | 55,687                | 0.86 |                       |     | 255,963               | 0.33 | 0                     | 0.00  | 311,651            | 0.31 |
| 1988 | 45,691                | 0.94 |                       |     | 727,407               | 0.33 | 71,741                | 28.63 | 844,838            | 2.45 |
| 1989 | 112,586               | 0.70 |                       |     | 1,718,771             | 0.35 | 11,065                | 28.63 | 1,842,421          | 0.37 |
| 1990 | 217,875               | 1.13 |                       |     | 1,244,607             | 0.28 | 128,784               | 19.45 | 1,591,265          | 1.60 |
| 1991 | 57,281                | 0.62 |                       |     | 2,586,268             | 0.23 | 206,175               | 18.21 | 2,849,724          | 1.33 |
| 1992 | 165,448               | 0.44 |                       |     | 2,115,433             | 0.15 | 505,104               | 10.90 | 2,785,985          | 1.98 |
| 1993 | 133,344               | 0.69 |                       |     | 1,444,787             | 0.21 | 46,668                | 15.34 | 1,624,799          | 0.48 |
| 1994 | 119,009               | 0.69 |                       |     | 1,344,305             | 0.17 | 101,182               | 10.05 | 1,564,497          | 0.67 |
| 1995 | 165,497               | 0.59 |                       |     | 1,295,002             | 0.18 | 2,252                 | 28.63 | 1,462,751          | 0.18 |
| 1996 | 62,371                | 0.87 |                       |     | 705,629               | 0.20 | 20,857                | 16.57 | 788,857            | 0.48 |
| 1997 | 108,861               | 0.51 |                       |     | 703,972               | 0.25 | 33,507                | 14.41 | 846,340            | 0.61 |
| 1998 | 326,922               | 0.35 |                       |     | 1,139,286             | 0.15 | 10,471                | 17.28 | 1,476,679          | 0.18 |
| 1999 | 393,899               | 0.30 |                       |     | 1,572,920             | 0.13 | 21,518                | 14.46 | 1,988,338          | 0.20 |
| 2000 | 634,966               | 0.50 |                       |     | 1,524,541             | 0.17 | 23,009                | 22.08 | 2,182,516          | 0.30 |
| 2001 | 279,996               | 0.37 |                       |     | 1,289,411             | 0.14 | 0                     | 0.00  | 1,569,407          | 0.13 |
| 2002 | 273,975               | 0.27 |                       |     | 1,571,390             | 0.14 | 0                     | 0.00  | 1,845,365          | 0.13 |
| 2003 | 386,452               | 0.21 |                       |     | 1,573,177             | 0.15 | 5,635                 | 28.63 | 1,965,264          | 0.15 |
| 2004 | 452,240               | 0.14 |                       |     | 2,697,519             | 0.14 | 39,812                | 1.04  | 3,189,571          | 0.12 |
| 2005 | 274,709               | 0.13 |                       |     | 999,489               | 0.19 | 7,549                 | 1.00  | 1,281,747          | 0.15 |
| 2006 | 127,967               | 0.24 |                       |     | 503,284               | 0.30 | 0                     | 0.00  | 631,251            | 0.24 |
| 2007 | 133,750               | 0.22 |                       |     | 666,434               | 0.19 | 19,033                | 1.04  | 819,217            | 0.16 |
| 2008 | 425,320               | 0.19 |                       |     | 2,549,796             | 0.14 | 556,633               | 1.05  | 3,531,749          | 0.20 |
| 2009 | 479,498               | 0.20 |                       |     | 2,713,425             | 0.14 | 117,783               | 1.05  | 3,310,706          | 0.13 |
| 2010 | 543,936               | 0.24 |                       |     | 1,667,811             | 0.15 | 6,583                 | 1.03  | 2,218,330          | 0.13 |
| 2011 | 502,370               | 0.21 |                       |     | 1,526,879             | 0.17 | 9,170                 | 1.03  | 2,038,418          | 0.14 |
| 2012 | 539,422               | 0.16 |                       |     | 1,202,880             | 0.15 | 6,982                 | 1.00  | 1,749,284          | 0.11 |
| 2013 | 613,660               | 0.17 |                       |     | 2,036,644             | 0.17 | 1,281                 | 0.66  | 2,651,586          | 0.13 |

**Table 4.8.9.** Estimated Gulf of Mexico red grouper discards for SRHS by year and state. Due to headboat area definitions and confidentiality issues, FLW must be combined with AL and MS must be combined with LA. 1986-2006 HB mode uses the MRIP CH:SRHS discard ratio proxy method, 2007-2013 uses the SRHS discard estimates.

| Year | FLW/AL  | MS/LA | TX | Gulf of Mexico |
|------|---------|-------|----|----------------|
| 1986 | 57,059  | 0     | 0  | 57,059         |
| 1987 | 68,103  | 0     | 0  | 68,103         |
| 1988 | 44,776  | 0     | 0  | 44,776         |
| 1989 | 268,558 | 0     | 0  | 268,558        |
| 1990 | 115,232 | 0     | 0  | 115,232        |
| 1991 | 87,707  | 0     | 0  | 87,707         |
| 1992 | 52,245  | 0     | 0  | 52,245         |
| 1993 | 77,613  | 0     | 0  | 77,613         |
| 1994 | 65,148  | 0     | 0  | 65,148         |
| 1995 | 74,073  | 0     | 0  | 74,073         |
| 1996 | 78,145  | 0     | 0  | 78,145         |
| 1997 | 41,698  | 0     | 0  | 41,698         |
| 1998 | 101,358 | 0     | 0  | 101,358        |
| 1999 | 143,725 | 0     | 0  | 143,725        |
| 2000 | 80,840  | 0     | 0  | 80,840         |
| 2001 | 44,312  | 0     | 0  | 44,312         |
| 2002 | 44,637  | 0     | 0  | 44,637         |
| 2003 | 98,172  | 0     | 0  | 98,172         |
| 2004 | 123,862 | 0     | 0  | 123,862        |
| 2005 | 80,594  | 0     | 0  | 80,594         |
| 2006 | 29,164  | 0     | 0  | 29,164         |
| 2007 | 17,365  | 0     | 0  | 17,365         |
| 2008 | 89,614  | 0     | 1  | 89,615         |
| 2009 | 153,829 | 0     | 0  | 153,829        |
| 2010 | 117,878 | 0     | 1  | 117,879        |
| 2011 | 134,114 | 0     | 0  | 134,114        |
| 2012 | 117,809 | 0     | 0  | 117,809        |
| 2013 | 112,267 | 0     | 0  | 112,267        |

**Table 4.8.10.** Total recreational catch (landings and discards) from all sources and years in numbers of fish.

| Year | Landings | Year | Landings | Discards  | Total Catch |
|------|----------|------|----------|-----------|-------------|
| 1945 | 0        | 1981 | 146,450  | 76,825    | 223,275     |
| 1946 | 12,711   | 1982 | 178,480  | 40,372    | 218,852     |
| 1947 | 25,422   | 1983 | 393,628  | 51,907    | 445,535     |
| 1948 | 38,133   | 1984 | 263,405  | 55,686    | 319,092     |
| 1949 | 50,844   | 1985 | 585,898  | 108,552   | 694,450     |
| 1950 | 63,555   | 1986 | 645,199  | 557,481   | 1,202,681   |
| 1951 | 76,266   | 1987 | 362,237  | 379,754   | 741,991     |
| 1952 | 88,977   | 1988 | 776,369  | 889,614   | 1,665,983   |
| 1953 | 101,688  | 1989 | 800,794  | 2,110,979 | 2,911,774   |
| 1954 | 114,399  | 1990 | 210,964  | 1,706,497 | 1,917,461   |
| 1955 | 127,110  | 1991 | 315,651  | 2,937,431 | 3,253,082   |
| 1956 | 137,032  | 1992 | 507,003  | 2,838,230 | 3,345,234   |
| 1957 | 146,953  | 1993 | 386,843  | 1,702,412 | 2,089,255   |
| 1958 | 156,875  | 1994 | 323,807  | 1,629,644 | 1,953,452   |
| 1959 | 166,797  | 1995 | 300,233  | 1,536,825 | 1,837,058   |
| 1960 | 176,719  | 1996 | 125,473  | 867,002   | 992,475     |
| 1961 | 179,428  | 1997 | 81,909   | 888,039   | 969,947     |
| 1962 | 182,136  | 1998 | 113,292  | 1,578,038 | 1,691,330   |
| 1963 | 184,844  | 1999 | 202,123  | 2,132,062 | 2,334,186   |
| 1964 | 187,553  | 2000 | 375,798  | 2,263,356 | 2,639,155   |
| 1965 | 190,261  | 2001 | 242,650  | 1,613,718 | 1,856,368   |
| 1966 | 196,879  | 2002 | 272,282  | 1,890,002 | 2,162,285   |
| 1967 | 203,497  | 2003 | 225,550  | 2,063,436 | 2,288,986   |
| 1968 | 210,114  | 2004 | 543,701  | 3,313,433 | 3,857,134   |
| 1969 | 216,732  | 2005 | 197,631  | 1,362,341 | 1,559,972   |
| 1970 | 223,349  | 2006 | 136,139  | 660,415   | 796,554     |
| 1971 | 229,670  | 2007 | 158,986  | 836,582   | 995,568     |
| 1972 | 238,287  | 2008 | 138,132  | 3,621,364 | 3,759,495   |
| 1973 | 246,904  | 2009 | 130,832  | 3,464,535 | 3,595,367   |
| 1974 | 253,225  | 2010 | 161,039  | 2,336,209 | 2,497,248   |
| 1975 | 277,914  | 2011 | 118,296  | 2,172,532 | 2,290,828   |
| 1976 | 287,639  | 2012 | 313,827  | 1,867,093 | 2,180,920   |
| 1977 | 295,069  | 2013 | 454,476  | 2,763,853 | 3,218,329   |
| 1978 | 304,795  |      |          |           |             |
| 1979 | 323,704  |      |          |           |             |
| 1980 | 335,726  |      |          |           |             |

**Table 4.8.11.** Number of angler trips with measured red grouper in the Gulf of Mexico (LA-FLW, not including the Florida Keys) in the MRFSS/MRIP by year and mode.

| YEAR | Cbt | Hbt | Priv | Shore | Grand Total |
|------|-----|-----|------|-------|-------------|
| 1981 | 3   | 11  | 5    | 1     | 20          |
| 1982 | 1   | 4   | 21   |       | 26          |
| 1983 | 1   | 31  | 17   |       | 49          |
| 1984 | 8   | 31  | 9    |       | 48          |
| 1985 |     | 26  | 7    |       | 33          |
| 1986 | 24  |     | 12   |       | 36          |
| 1987 | 18  |     | 44   |       | 62          |
| 1988 | 17  |     | 50   | 2     | 69          |
| 1989 | 13  |     | 39   |       | 52          |
| 1990 | 8   |     | 24   |       | 32          |
| 1991 | 3   |     | 37   | 2     | 42          |
| 1992 | 26  |     | 84   | 3     | 113         |
| 1993 | 7   |     | 46   | 1     | 54          |
| 1994 | 9   |     | 47   | 1     | 57          |
| 1995 | 11  |     | 38   |       | 49          |
| 1996 | 6   |     | 23   |       | 29          |
| 1997 | 17  |     | 21   |       | 38          |
| 1998 | 63  |     | 46   |       | 109         |
| 1999 | 99  |     | 72   |       | 171         |
| 2000 | 125 |     | 57   |       | 182         |
| 2001 | 112 |     | 54   |       | 166         |
| 2002 | 164 |     | 58   |       | 222         |
| 2003 | 248 |     | 57   |       | 305         |
| 2004 | 406 |     | 108  |       | 514         |
| 2005 | 334 |     | 61   |       | 395         |
| 2006 | 153 |     | 27   |       | 180         |
| 2007 | 103 |     | 51   |       | 154         |
| 2008 | 82  |     | 43   |       | 125         |
| 2009 | 52  |     | 23   | 1     | 76          |
| 2010 | 79  |     | 41   |       | 120         |
| 2011 | 116 |     | 35   |       | 151         |
| 2012 | 144 |     | 51   |       | 195         |
| 2013 | 102 |     | 96   |       | 198         |

**Table 4.8.12.** Number, mean, minimum, and maximum weights of red grouper in the Gulf of Mexico (LA-FLW, not including the Florida Keys) in the MRFSS/MRIP by year and mode.

| YEAR | CH   |            |           |           | HB |            |           |           | PR  |            |           |           | SH |            |           |           |
|------|------|------------|-----------|-----------|----|------------|-----------|-----------|-----|------------|-----------|-----------|----|------------|-----------|-----------|
|      | N    | Mean (lbs) | Min (lbs) | Max (lbs) | N  | Mean (lbs) | Min (lbs) | Max (lbs) | N   | Mean (lbs) | Min (lbs) | Max (lbs) | N  | Mean (lbs) | Min (lbs) | Max (lbs) |
| 1981 | 12   | 6.63       | 1.54      | 19.18     | 15 | 3.12       | 0.88      | 8.82      | 10  | 5.00       | 1.10      | 14.99     | 8  | 1.98       | 1.10      | 2.87      |
| 1982 | 1    | 1.98       | 1.98      | 1.98      | 5  | 11.55      | 3.09      | 25.35     | 71  | 5.26       | 0.22      | 23.81     |    |            |           |           |
| 1983 | 10   | 10.16      | 3.31      | 18.74     | 35 | 8.48       | 1.10      | 23.15     | 52  | 4.16       | 0.66      | 18.74     |    |            |           |           |
| 1984 | 34   | 5.45       | 1.54      | 11.24     | 46 | 3.74       | 1.10      | 13.89     | 22  | 3.22       | 0.44      | 7.28      |    |            |           |           |
| 1985 |      |            |           |           | 30 | 6.77       | 1.54      | 22.71     | 11  | 2.14       | 0.22      | 3.75      |    |            |           |           |
| 1986 | 38   | 2.66       | 0.88      | 6.17      |    |            |           |           | 21  | 2.41       | 0.88      | 5.95      |    |            |           |           |
| 1987 | 24   | 4.18       | 1.10      | 16.75     |    |            |           |           | 96  | 2.83       | 0.66      | 13.89     |    |            |           |           |
| 1988 | 62   | 3.67       | 1.10      | 13.23     |    |            |           |           | 220 | 3.47       | 0.88      | 13.01     | 4  | 3.69       | 0.44      | 12.79     |
| 1989 | 50   | 3.36       | 0.88      | 9.04      |    |            |           |           | 152 | 2.99       | 0.66      | 10.36     |    |            |           |           |
| 1990 | 13   | 6.27       | 4.41      | 9.26      |    |            |           |           | 37  | 6.42       | 2.87      | 13.89     | 1  | 16.53      | 16.53     | 16.53     |
| 1991 | 13   | 4.27       | 3.31      | 5.07      |    |            |           |           | 90  | 6.36       | 3.53      | 18.74     | 2  | 7.05       | 7.05      | 7.05      |
| 1992 | 115  | 6.84       | 3.53      | 24.03     |    |            |           |           | 222 | 6.36       | 1.76      | 16.31     | 12 | 6.32       | 4.19      | 10.80     |
| 1993 | 19   | 5.40       | 3.75      | 8.60      |    |            |           |           | 119 | 5.95       | 1.54      | 15.43     | 7  | 7.18       | 5.07      | 9.48      |
| 1994 | 56   | 6.21       | 3.75      | 12.79     |    |            |           |           | 86  | 6.45       | 3.09      | 14.55     | 1  | 0.77       | 0.77      | 0.77      |
| 1995 | 68   | 7.06       | 1.54      | 21.61     |    |            |           |           | 96  | 6.54       | 2.65      | 13.23     |    |            |           |           |
| 1996 | 29   | 6.77       | 3.53      | 13.89     |    |            |           |           | 32  | 6.72       | 3.31      | 14.33     |    |            |           |           |
| 1997 | 38   | 6.62       | 3.53      | 14.22     |    |            |           |           | 24  | 6.70       | 3.97      | 9.48      |    |            |           |           |
| 1998 | 112  | 6.10       | 1.54      | 14.33     |    |            |           |           | 77  | 6.70       | 2.65      | 18.74     |    |            |           |           |
| 1999 | 239  | 6.84       | 1.94      | 17.64     |    |            |           |           | 133 | 6.59       | 2.01      | 15.43     |    |            |           |           |
| 2000 | 366  | 6.81       | 3.09      | 24.71     |    |            |           |           | 134 | 6.90       | 1.94      | 17.64     |    |            |           |           |
| 2001 | 331  | 6.50       | 3.13      | 26.46     |    |            |           |           | 110 | 6.56       | 3.40      | 18.65     |    |            |           |           |
| 2002 | 465  | 6.99       | 2.98      | 21.10     |    |            |           |           | 122 | 7.29       | 3.09      | 19.84     |    |            |           |           |
| 2003 | 630  | 5.94       | 0.93      | 22.93     |    |            |           |           | 91  | 6.21       | 2.73      | 19.22     |    |            |           |           |
| 2004 | 1299 | 6.27       | 2.51      | 23.99     |    |            |           |           | 257 | 6.47       | 1.63      | 24.74     |    |            |           |           |
| 2005 | 1103 | 6.17       | 1.87      | 17.46     |    |            |           |           | 103 | 6.81       | 3.62      | 22.64     |    |            |           |           |
| 2006 | 412  | 6.78       | 2.43      | 24.29     |    |            |           |           | 42  | 6.78       | 3.68      | 13.89     |    |            |           |           |
| 2007 | 232  | 7.22       | 1.32      | 18.83     |    |            |           |           | 82  | 6.94       | 3.44      | 14.42     |    |            |           |           |
| 2008 | 211  | 7.01       | 2.91      | 21.69     |    |            |           |           | 60  | 6.74       | 3.53      | 13.78     |    |            |           |           |
| 2009 | 131  | 7.27       | 3.13      | 17.84     |    |            |           |           | 45  | 7.93       | 3.22      | 16.23     | 1  | 0.62       | 0.62      | 0.62      |
| 2010 | 181  | 6.08       | 3.17      | 18.74     |    |            |           |           | 95  | 6.11       | 3.57      | 13.12     |    |            |           |           |
| 2011 | 301  | 5.71       | 2.87      | 17.99     |    |            |           |           | 70  | 5.60       | 2.87      | 14.90     |    |            |           |           |
| 2012 | 544  | 5.62       | 2.95      | 19.93     |    |            |           |           | 144 | 6.08       | 0.66      | 17.28     |    |            |           |           |
| 2013 | 589  | 5.80       | 0.71      | 22.97     |    |            |           |           | 207 | 6.01       | 2.45      | 13.05     |    |            |           |           |

**Table 4.8.13.** Number of red grouper measured and number of trips with measured red grouper in the Gulf of Mexico from the SRHS by year and state 1986-2013. No fish were measured in LA/MS.

| Year | Fish(n) |    |                | Trips(n) |    |                |
|------|---------|----|----------------|----------|----|----------------|
|      | FLW/AL  | TX | Gulf of Mexico | FLW/AL   | TX | Gulf of Mexico |
| 1986 | 366     | 1  | 367            | 145      | 1  | 146            |
| 1987 | 546     |    | 546            | 206      |    | 206            |
| 1988 | 352     | 1  | 353            | 136      | 1  | 137            |
| 1989 | 701     | 1  | 702            | 150      | 1  | 151            |
| 1990 | 241     |    | 241            | 78       |    | 78             |
| 1991 | 103     |    | 103            | 49       |    | 49             |
| 1992 | 54      |    | 54             | 31       |    | 31             |
| 1993 | 33      |    | 33             | 22       |    | 22             |
| 1994 | 37      | 15 | 52             | 29       | 6  | 35             |
| 1995 | 57      |    | 57             | 33       |    | 33             |
| 1996 | 71      |    | 71             | 34       |    | 34             |
| 1997 | 48      |    | 48             | 24       |    | 24             |
| 1998 | 40      |    | 40             | 25       |    | 25             |
| 1999 | 109     |    | 109            | 39       |    | 39             |
| 2000 | 70      |    | 70             | 31       |    | 31             |
| 2001 | 52      |    | 52             | 30       |    | 30             |
| 2002 | 135     |    | 135            | 72       |    | 72             |
| 2003 | 219     |    | 219            | 119      |    | 119            |
| 2004 | 173     |    | 173            | 103      |    | 103            |
| 2005 | 72      |    | 72             | 44       |    | 44             |
| 2006 | 79      |    | 79             | 47       |    | 47             |
| 2007 | 94      |    | 94             | 50       |    | 50             |
| 2008 | 89      |    | 89             | 47       |    | 47             |
| 2009 | 50      |    | 50             | 31       |    | 31             |
| 2010 | 54      |    | 54             | 38       |    | 38             |
| 2011 | 93      |    | 93             | 52       |    | 52             |
| 2012 | 151     |    | 151            | 75       |    | 75             |
| 2013 | 156     |    | 156            | 78       |    | 78             |

**Table 4.8.14.** Mean weight (kg) of red grouper measured in the Gulf of Mexico from the SRHS by year and state, 1986-2013. No fish were measured in MS/LA.

| Year | FLW/AL |           |          | TX       |    |           | Gulf of Mexico |          |     |           |          |          |
|------|--------|-----------|----------|----------|----|-----------|----------------|----------|-----|-----------|----------|----------|
|      | N      | Mean (kg) | Min (kg) | Max (kg) | N  | Mean (kg) | Min (kg)       | Max (kg) | N   | Mean (kg) | Min (kg) | Max (kg) |
| 1986 | 369    | 1.73      | 0.20     | 16.00    | 1  | 0.21      | 0.21           | 0.21     | 370 | 1.93      | 0.41     | 16.21    |
| 1987 | 546    | 1.64      | 0.34     | 11.75    |    |           |                |          | 546 | 1.64      | 0.34     | 11.75    |
| 1988 | 352    | 1.92      | 0.47     | 16.92    | 1  | 0.35      | 0.35           | 0.35     | 353 | 2.27      | 0.82     | 17.27    |
| 1989 | 700    | 1.44      | 0.10     | 12.45    | 1  |           |                |          | 701 | 1.44      | 0.10     | 12.45    |
| 1990 | 241    | 3.06      | 0.44     | 12.11    |    |           |                |          | 241 | 3.06      | 0.44     | 12.11    |
| 1991 | 103    | 3.68      | 1.63     | 12.24    |    |           |                |          | 103 | 3.68      | 1.63     | 12.24    |
| 1992 | 54     | 3.15      | 1.58     | 10.67    |    |           |                |          | 54  | 3.15      | 1.58     | 10.67    |
| 1993 | 33     | 4.12      | 0.33     | 13.56    |    |           |                |          | 33  | 4.12      | 0.33     | 13.56    |
| 1994 | 37     | 2.83      | 0.66     | 10.82    | 15 | 2.64      | 1.94           | 5.00     | 52  | 5.47      | 2.60     | 15.82    |
| 1995 | 57     | 3.09      | 1.69     | 9.04     |    |           |                |          | 57  | 3.09      | 1.69     | 9.04     |
| 1996 | 71     | 2.73      | 0.75     | 8.49     |    |           |                |          | 71  | 2.73      | 0.75     | 8.49     |
| 1997 | 48     | 2.78      | 1.40     | 7.14     |    |           |                |          | 48  | 2.78      | 1.40     | 7.14     |
| 1998 | 40     | 2.36      | 1.48     | 5.84     |    |           |                |          | 40  | 2.36      | 1.48     | 5.84     |
| 1999 | 109    | 2.95      | 0.69     | 12.50    |    |           |                |          | 109 | 2.95      | 0.69     | 12.50    |
| 2000 | 69     | 2.67      | 1.47     | 8.04     |    |           |                |          | 69  | 2.67      | 1.47     | 8.04     |
| 2001 | 52     | 2.72      | 1.50     | 6.57     |    |           |                |          | 52  | 2.72      | 1.50     | 6.57     |
| 2002 | 135    | 2.39      | 0.85     | 4.72     |    |           |                |          | 135 | 2.39      | 0.85     | 4.72     |
| 2003 | 219    | 2.41      | 1.51     | 7.27     |    |           |                |          | 219 | 2.41      | 1.51     | 7.27     |
| 2004 | 173    | 2.29      | 1.49     | 6.00     |    |           |                |          | 173 | 2.29      | 1.49     | 6.00     |
| 2005 | 72     | 2.65      | 1.59     | 4.19     |    |           |                |          | 72  | 2.65      | 1.59     | 4.19     |
| 2006 | 79     | 2.60      | 1.54     | 5.34     |    |           |                |          | 79  | 2.60      | 1.54     | 5.34     |
| 2007 | 94     | 2.71      | 1.52     | 9.27     |    |           |                |          | 94  | 2.71      | 1.52     | 9.27     |
| 2008 | 89     | 3.14      | 1.61     | 8.20     |    |           |                |          | 89  | 3.14      | 1.61     | 8.20     |
| 2009 | 50     | 2.55      | 1.16     | 6.14     |    |           |                |          | 50  | 2.55      | 1.16     | 6.14     |
| 2010 | 54     | 2.70      | 1.18     | 6.77     |    |           |                |          | 54  | 2.70      | 1.18     | 6.77     |
| 2011 | 93     | 2.41      | 1.40     | 6.05     |    |           |                |          | 93  | 2.41      | 1.40     | 6.05     |
| 2012 | 151    | 2.66      | 1.39     | 8.81     |    |           |                |          | 151 | 2.66      | 1.39     | 8.81     |
| 2013 | 156    | 2.35      | 1.48     | 7.31     |    |           |                |          | 156 | 2.35      | 1.48     | 7.31     |

**Table 4.8.15.** Sample sizes for length samples collected between 1981 and 2013 from recreational fisheries in the Gulf of Mexico.

| Year | Charter boat | Private boat | Headboat | Total |
|------|--------------|--------------|----------|-------|
| 1981 | 12           | 10           | 20       | 42    |
| 1982 | 1            | 74           | 5        | 80    |
| 1983 | 10           | 50           | 35       | 95    |
| 1984 | 65           | 22           | 47       | 134   |
| 1985 |              | 11           | 31       | 42    |
| 1986 | 39           | 21           | 367      | 427   |
| 1987 | 26           | 93           | 546      | 665   |
| 1988 | 49           | 182          | 353      | 584   |
| 1989 | 48           | 150          | 699      | 897   |
| 1990 | 13           | 43           | 240      | 296   |
| 1991 | 53           | 91           | 109      | 253   |
| 1992 | 142          | 217          | 56       | 415   |
| 1993 | 78           | 120          | 36       | 234   |
| 1994 | 135          | 103          | 56       | 294   |
| 1995 | 73           | 100          | 57       | 230   |
| 1996 | 123          | 34           | 79       | 236   |
| 1997 | 109          | 32           | 69       | 210   |
| 1998 | 189          | 83           | 49       | 321   |
| 1999 | 261          | 136          | 112      | 509   |
| 2000 | 373          | 143          | 69       | 585   |
| 2001 | 369          | 121          | 55       | 545   |
| 2002 | 535          | 130          | 144      | 809   |
| 2003 | 668          | 102          | 219      | 989   |
| 2004 | 1418         | 279          | 175      | 1872  |
| 2005 | 1178         | 108          | 77       | 1363  |
| 2006 | 447          | 48           | 87       | 582   |
| 2007 | 289          | 90           | 136      | 515   |
| 2008 | 280          | 89           | 124      | 493   |
| 2009 | 222          | 79           | 145      | 446   |
| 2010 | 421          | 135          | 120      | 676   |
| 2011 | 631          | 84           | 168      | 883   |
| 2012 | 721          | 166          | 157      | 1044  |
| 2013 | 831          | 244          | 183      | 1258  |

**Table 4.8.16.** Sample sizes for age samples collected between 1991 and 2013 from recreational fisheries in the Gulf of Mexico.

| Year | Charter boat | Private boat | Headboat | Total |
|------|--------------|--------------|----------|-------|
| 1991 | 1            |              | 36       | 37    |
| 1992 | 24           | 1            | 33       | 58    |
| 1993 | 61           | 1            | 21       | 83    |
| 1994 | 72           |              | 29       | 101   |
| 1995 | 91           |              | 53       | 144   |
| 1996 | 134          |              | 41       | 175   |
| 1997 | 61           | 9            | 28       | 98    |
| 1998 | 72           | 4            | 21       | 97    |
| 1999 | 104          | 2            | 8        | 114   |
| 2000 | 59           |              | 12       | 71    |
| 2001 | 45           | 2            | 1        | 48    |
| 2002 | 292          | 7            | 50       | 349   |
| 2003 | 101          | 68           | 30       | 199   |
| 2004 | 144          | 41           | 43       | 228   |
| 2005 | 64           | 1            | 52       | 117   |
| 2006 | 38           | 6            | 33       | 77    |
| 2007 | 52           | 10           | 28       | 90    |
| 2008 | 73           | 32           | 44       | 149   |
| 2009 | 90           | 27           | 102      | 219   |
| 2010 | 263          | 47           | 85       | 395   |
| 2011 | 391          | 13           | 114      | 518   |
| 2012 | 223          | 14           | 39       | 276   |
| 2013 | 216          | 25           | 45       | 286   |

**Table 4.8.17.** Gulf of Mexico (LA-FLW, not including the Florida Keys) estimated number of angler trips by mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). CH mode adjusted for FHS conversion prior to 2004. \*CVs for CH and HB mode 1981-1985 are unavailable.

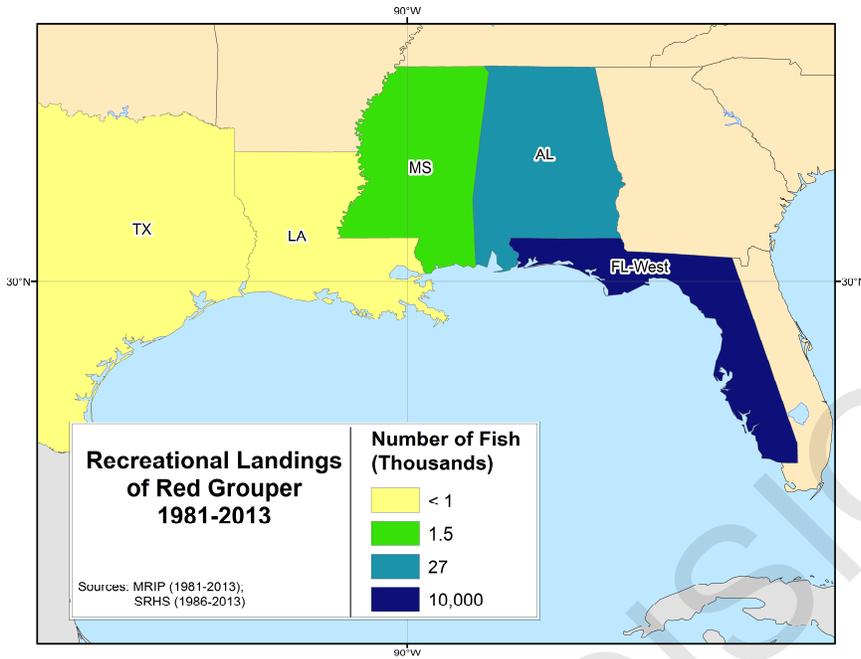
| YEAR | Estimated CH Angler Trips |      | Estimated HB Angler Trips |     | Estimated PR Angler Trips |      | Estimated SH Angler Trips |      | ALL Modes  |       |
|------|---------------------------|------|---------------------------|-----|---------------------------|------|---------------------------|------|------------|-------|
|      | Trips                     | CV*  | Trips                     | CV* | Trips                     | CV   | Trips                     | CV   | Trips      | CV    |
| 1981 | 197,619                   |      | 54,341                    |     | 4,443,552                 | 0.10 | 4,470,098                 | 0.09 | 9,165,610  | 0.07* |
| 1982 | 539,088                   |      | 184,315                   |     | 4,885,774                 | 0.06 | 6,713,660                 | 0.08 | 12,322,837 | 0.05* |
| 1983 | 422,371                   |      | 143,712                   |     | 6,086,649                 | 0.06 | 10,710,328                | 0.11 | 17,363,060 | 0.07* |
| 1984 | 334,652                   |      | 107,449                   |     | 6,315,593                 | 0.06 | 9,689,765                 | 0.09 | 16,447,459 | 0.06* |
| 1985 | 455,274                   |      | 177,691                   |     | 6,383,235                 | 0.07 | 7,528,397                 | 0.10 | 14,544,597 | 0.06* |
| 1986 | 431,334                   | 0.11 |                           |     | 7,844,565                 | 0.04 | 10,152,934                | 0.06 | 18,428,834 | 0.04  |
| 1987 | 489,262                   | 0.13 |                           |     | 7,618,189                 | 0.03 | 5,861,397                 | 0.07 | 13,968,848 | 0.03  |
| 1988 | 500,105                   | 0.10 |                           |     | 10,352,803                | 0.02 | 8,074,692                 | 0.04 | 18,927,600 | 0.02  |
| 1989 | 455,029                   | 0.11 |                           |     | 8,220,154                 | 0.03 | 5,956,223                 | 0.05 | 14,631,406 | 0.03  |
| 1990 | 334,713                   | 0.14 |                           |     | 6,648,049                 | 0.03 | 5,180,294                 | 0.05 | 12,163,056 | 0.03  |
| 1991 | 294,003                   | 0.14 |                           |     | 8,012,939                 | 0.03 | 7,441,416                 | 0.04 | 15,748,358 | 0.03  |
| 1992 | 305,658                   | 0.10 |                           |     | 8,549,108                 | 0.02 | 7,457,773                 | 0.03 | 16,312,539 | 0.02  |
| 1993 | 515,454                   | 0.09 |                           |     | 8,140,262                 | 0.02 | 6,724,100                 | 0.02 | 15,379,816 | 0.01  |
| 1994 | 621,221                   | 0.08 |                           |     | 8,593,115                 | 0.02 | 6,646,637                 | 0.02 | 15,860,973 | 0.01  |
| 1995 | 691,788                   | 0.08 |                           |     | 8,896,938                 | 0.02 | 6,268,982                 | 0.02 | 15,857,708 | 0.01  |
| 1996 | 736,610                   | 0.07 |                           |     | 8,576,163                 | 0.02 | 5,959,794                 | 0.03 | 15,272,567 | 0.01  |
| 1997 | 775,624                   | 0.09 |                           |     | 9,347,283                 | 0.02 | 6,739,975                 | 0.03 | 16,862,882 | 0.02  |
| 1998 | 605,005                   | 0.03 |                           |     | 8,530,035                 | 0.02 | 6,389,504                 | 0.03 | 15,524,545 | 0.02  |
| 1999 | 557,003                   | 0.03 |                           |     | 8,782,785                 | 0.02 | 5,671,528                 | 0.03 | 15,011,316 | 0.01  |
| 2000 | 666,993                   | 0.03 |                           |     | 11,356,651                | 0.02 | 8,312,746                 | 0.03 | 20,336,390 | 0.02  |
| 2001 | 594,585                   | 0.03 |                           |     | 12,068,175                | 0.02 | 9,394,401                 | 0.02 | 22,057,161 | 0.01  |
| 2002 | 592,349                   | 0.03 |                           |     | 11,455,273                | 0.02 | 7,103,284                 | 0.03 | 19,150,906 | 0.01  |
| 2003 | 552,771                   | 0.03 |                           |     | 13,720,239                | 0.02 | 7,927,996                 | 0.03 | 22,201,006 | 0.01  |
| 2004 | 661,243                   | 0.03 |                           |     | 14,901,192                | 0.03 | 9,673,558                 | 0.05 | 25,235,993 | 0.02  |
| 2005 | 577,958                   | 0.04 |                           |     | 13,283,476                | 0.03 | 8,780,857                 | 0.05 | 22,642,292 | 0.03  |
| 2006 | 716,229                   | 0.05 |                           |     | 13,225,412                | 0.03 | 8,767,049                 | 0.06 | 22,708,691 | 0.03  |
| 2007 | 721,891                   | 0.05 |                           |     | 14,275,542                | 0.03 | 8,256,792                 | 0.06 | 23,254,225 | 0.03  |
| 2008 | 695,218                   | 0.05 |                           |     | 14,347,128                | 0.03 | 8,425,076                 | 0.05 | 23,467,421 | 0.03  |
| 2009 | 692,843                   | 0.06 |                           |     | 13,075,467                | 0.03 | 8,202,557                 | 0.06 | 21,970,867 | 0.03  |
| 2010 | 472,209                   | 0.06 |                           |     | 12,286,916                | 0.03 | 7,735,905                 | 0.05 | 20,495,030 | 0.03  |
| 2011 | 617,454                   | 0.04 |                           |     | 12,678,122                | 0.03 | 8,790,961                 | 0.05 | 22,086,537 | 0.02  |
| 2012 | 731,413                   | 0.04 |                           |     | 12,299,016                | 0.02 | 9,329,538                 | 0.05 | 22,359,966 | 0.02  |
| 2013 | 742,631                   | 0.06 |                           |     | 12,712,097                | 0.03 | 10,401,416                | 0.04 | 23,856,144 | 0.02  |

**Table 4.8.18.** Gulf of Mexico headboat estimated angler days by year and state, 1986-2013.

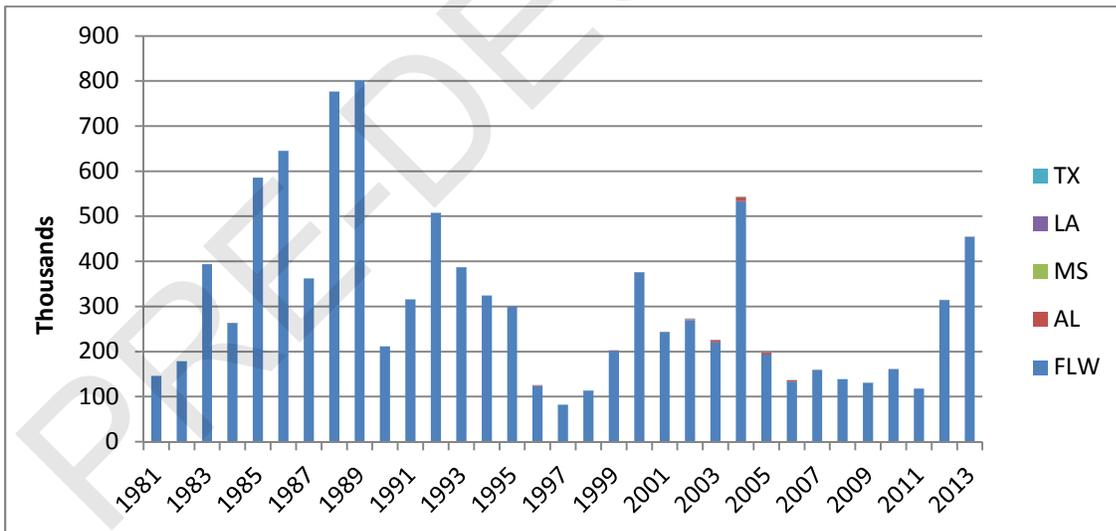
| Year | FLW/AL  | MS/LA  | TX      | Gulf of Mexico |
|------|---------|--------|---------|----------------|
| 1986 | 240,077 | 5,891  | 56,568  | 302,536        |
| 1987 | 217,049 | 6,362  | 63,363  | 286,774        |
| 1988 | 195,948 | 7,691  | 70,396  | 274,035        |
| 1989 | 208,325 | 2,867  | 63,389  | 274,581        |
| 1990 | 213,906 | 6,898  | 58,144  | 278,948        |
| 1991 | 174,312 | 6,373  | 59,969  | 240,654        |
| 1992 | 184,802 | 9,911  | 76,218  | 270,931        |
| 1993 | 207,898 | 11,256 | 80,904  | 300,058        |
| 1994 | 204,562 | 12,651 | 100,778 | 317,991        |
| 1995 | 182,410 | 10,498 | 90,464  | 283,372        |
| 1996 | 154,913 | 10,988 | 91,852  | 257,753        |
| 1997 | 149,442 | 9,008  | 82,207  | 240,657        |
| 1998 | 185,331 | 7,854  | 77,650  | 270,835        |
| 1999 | 176,117 | 8,026  | 58,235  | 242,378        |
| 2000 | 159,331 | 4,952  | 58,395  | 222,678        |
| 2001 | 157,243 | 6,222  | 55,361  | 218,826        |
| 2002 | 141,831 | 6,222  | 66,951  | 215,004        |
| 2003 | 144,211 | 6,636  | 74,432  | 225,279        |
| 2004 | 158,430 |        | 64,990  | 223,420        |
| 2005 | 130,233 |        | 59,857  | 190,090        |
| 2006 | 124,049 | 5,005  | 70,789  | 199,843        |
| 2007 | 136,880 | 2,522  | 63,764  | 203,166        |
| 2008 | 130,176 | 2,945  | 41,188  | 174,309        |
| 2009 | 142,438 | 3,268  | 50,737  | 196,443        |
| 2010 | 111,018 | 715    | 47,154  | 158,887        |
| 2011 | 157,025 | 3,657  | 47,284  | 207,966        |
| 2012 | 161,975 | 3,680  | 51,776  | 217,431        |
| 2013 | 174,800 | 3,406  | 55,749  | 233,955        |

4.9 FIGURES

a) Red Grouper Landings by State 1981-2013

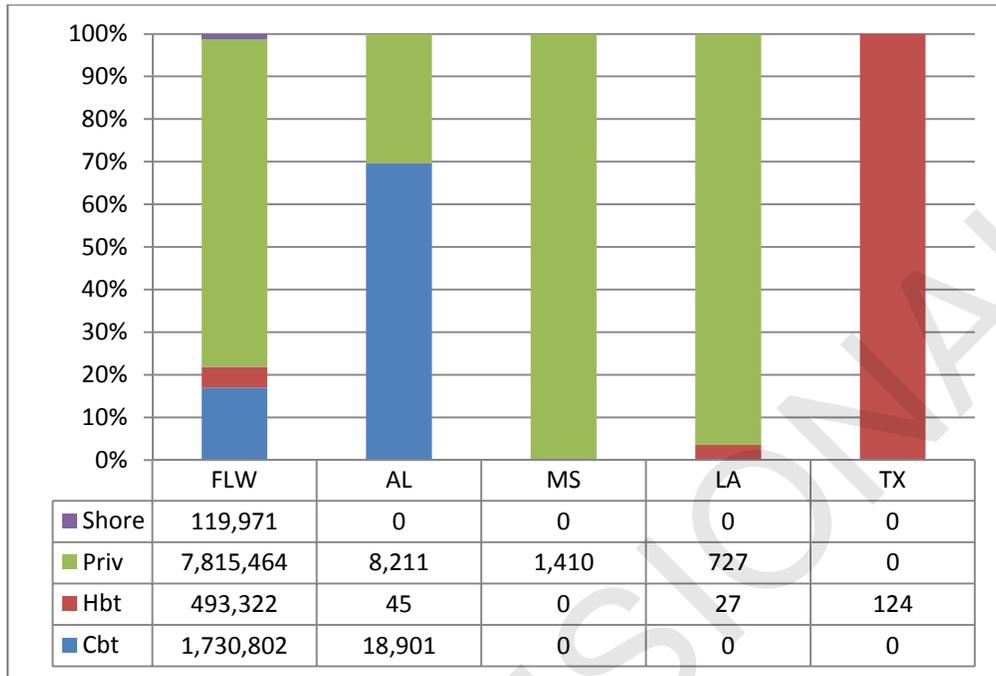


b) Red Grouper Landings by State and Year 1981-2013



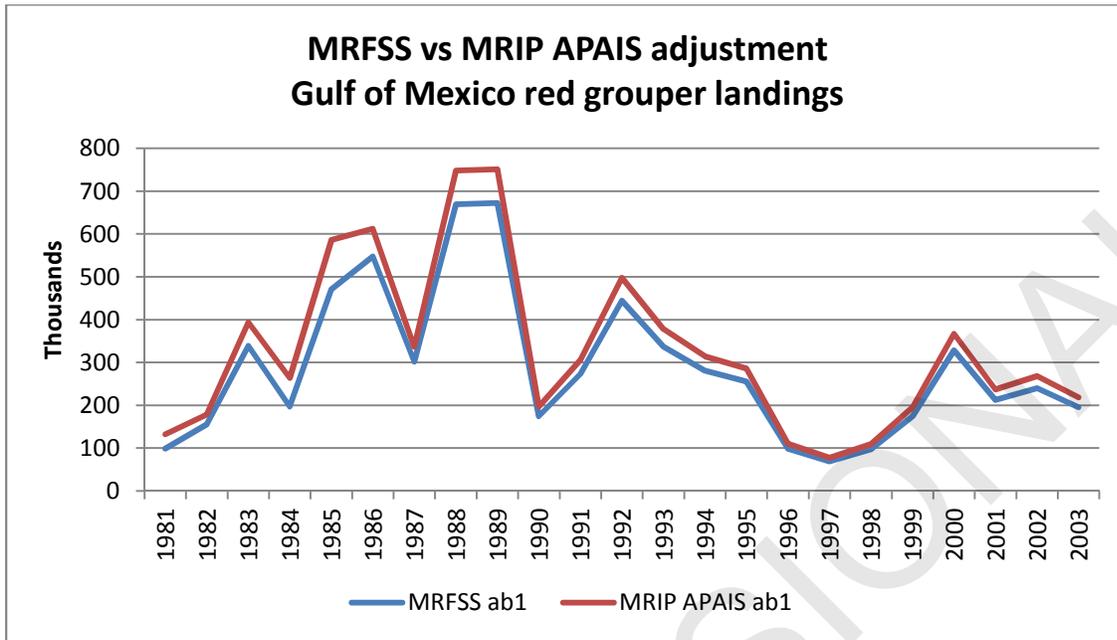
**Figure 4.9.1.** Estimated number of Gulf of Mexico red grouper landings from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

c) **Red Grouper Landings by State and Mode 1981-2013**

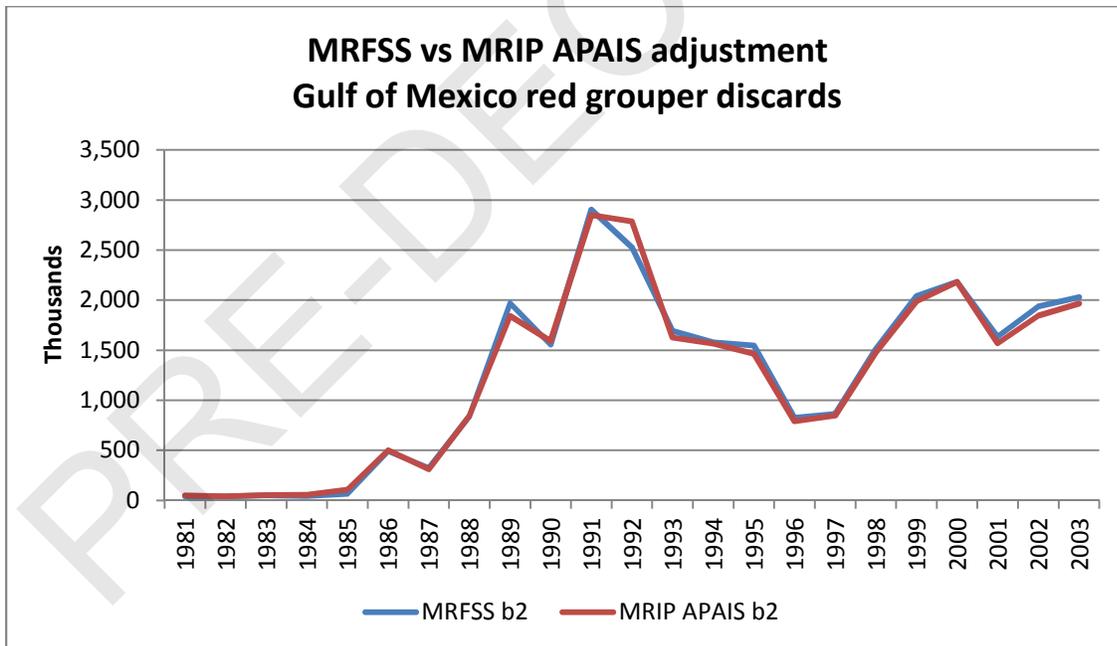


**Figure 4.9.1 (continued).** Estimated number of Gulf of Mexico red grouper landings from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

a) AB1 (number of fish) landed

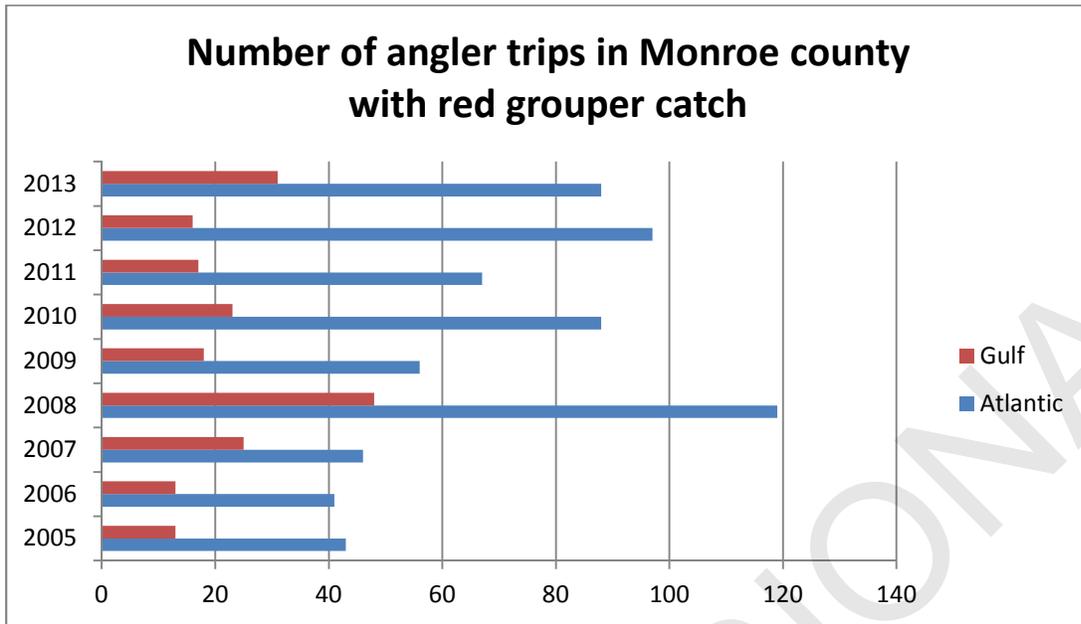


b) B2 (number of fish) discarded alive

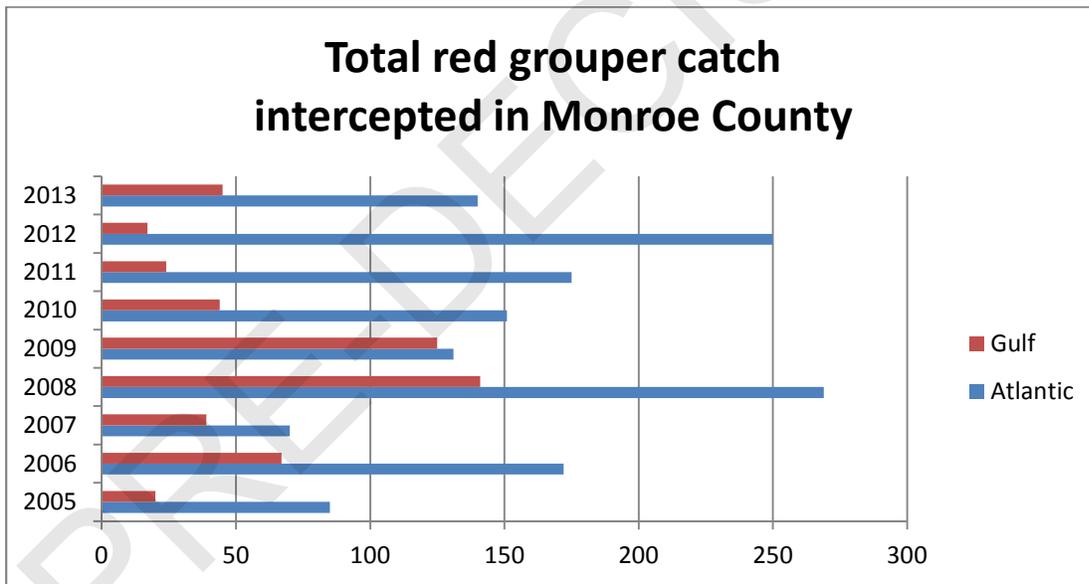


**Figure 4.9.2.** MRFSS estimates versus MRIP adjusted estimates for Gulf of Mexico red grouper 1981-2003.

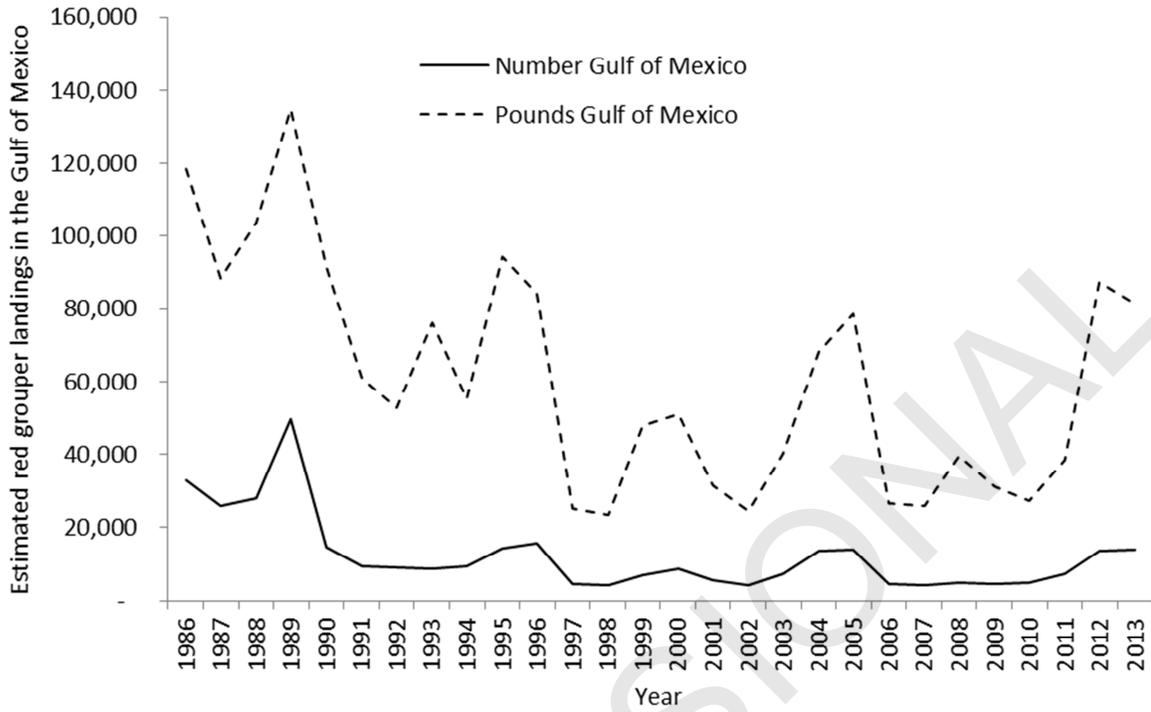
a) Angler trips



b) Total catch

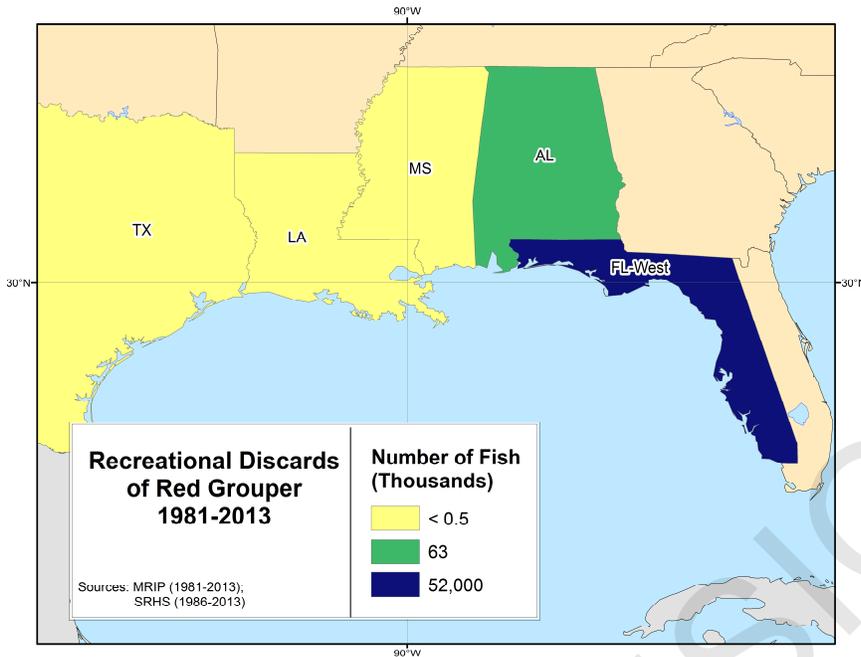


**Figure 4.9.3.** MRFSS intercept data indicating Gulf or Atlantic fishing (2005-2013).

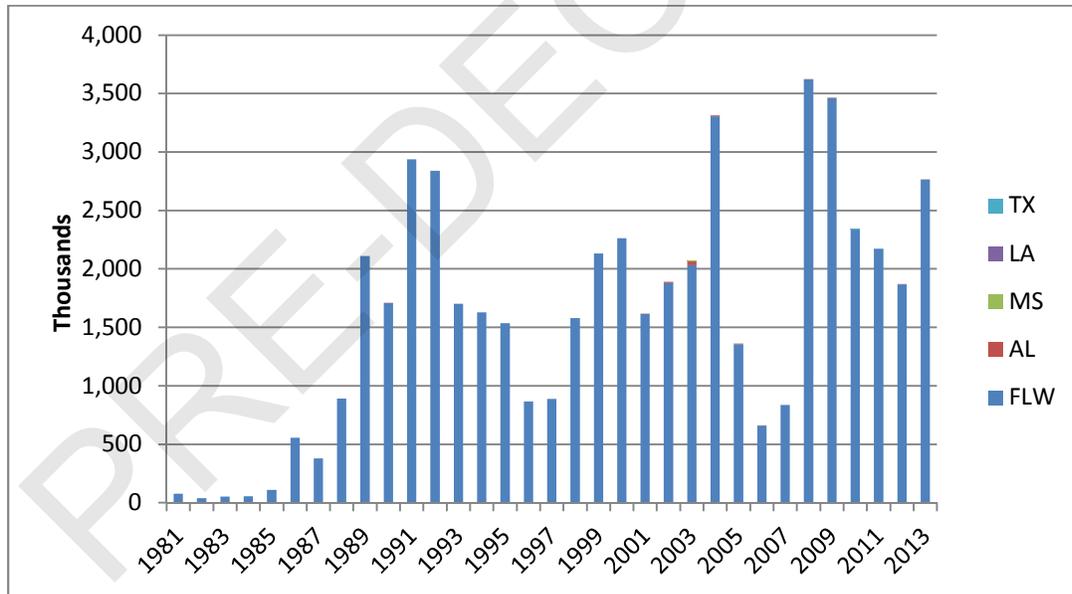


**Figure 4.9.4.** Gulf of Mexico estimated red grouper landings (number and pounds) for the headboat fishery, 1986-2013.

**a) Red Grouper Discards by State 1981-2013**

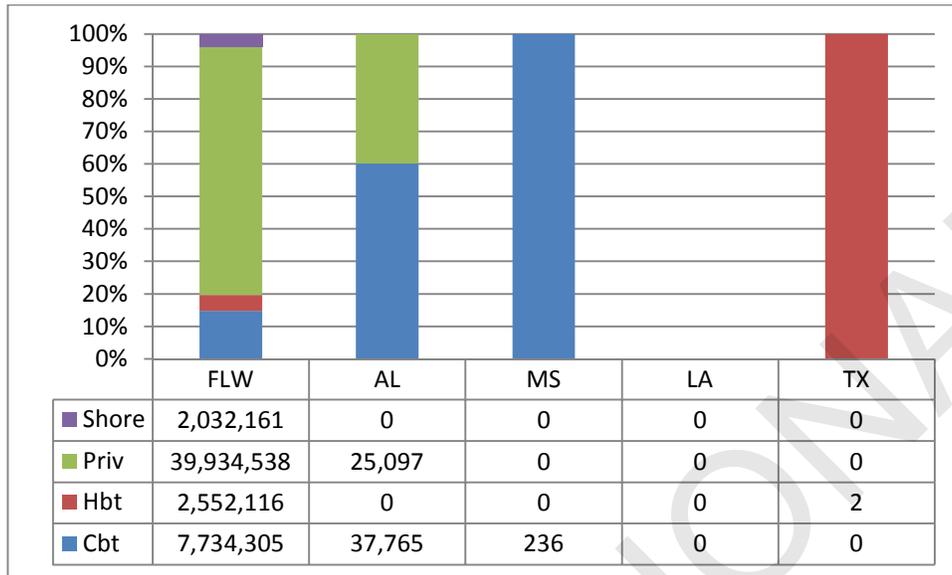


**b) Red Grouper Discards by State and Year 1981-2013**

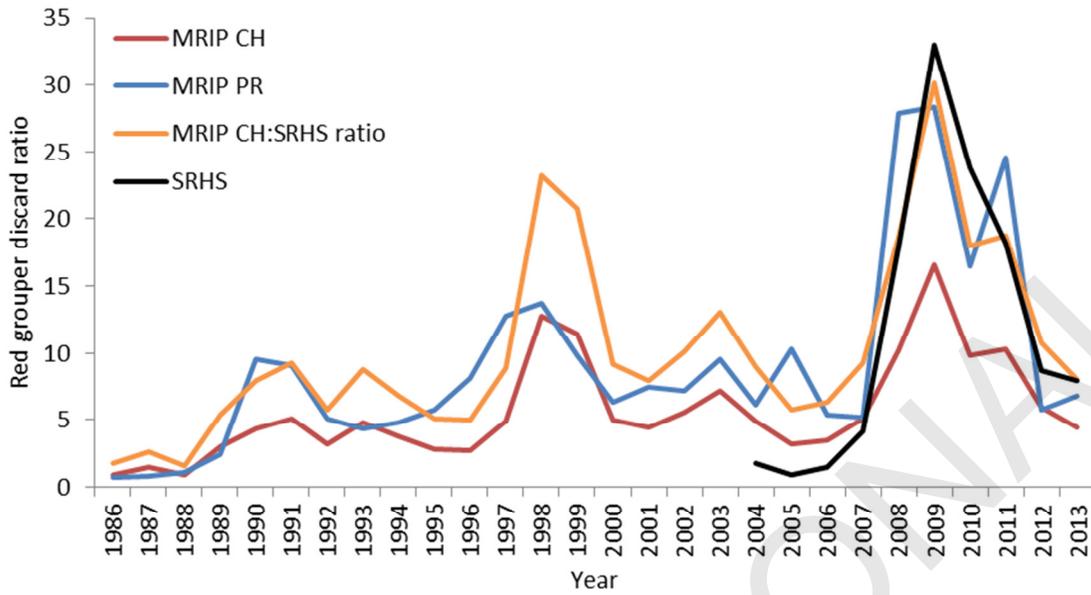


**Figure 4.9.5.** Estimated number of Gulf of Mexico red grouper discards from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

**c) Red Grouper Discards by State and Mode 1981-2013**

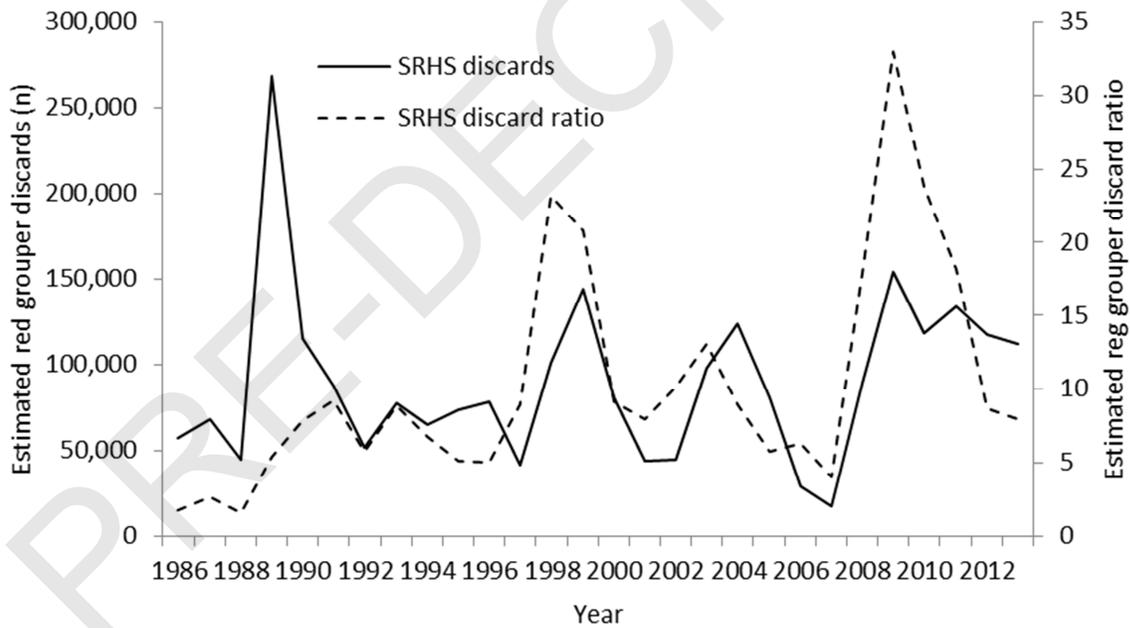


**Figure 4.9.5 (continued).** Estimated number of Gulf of Mexico red grouper discards from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

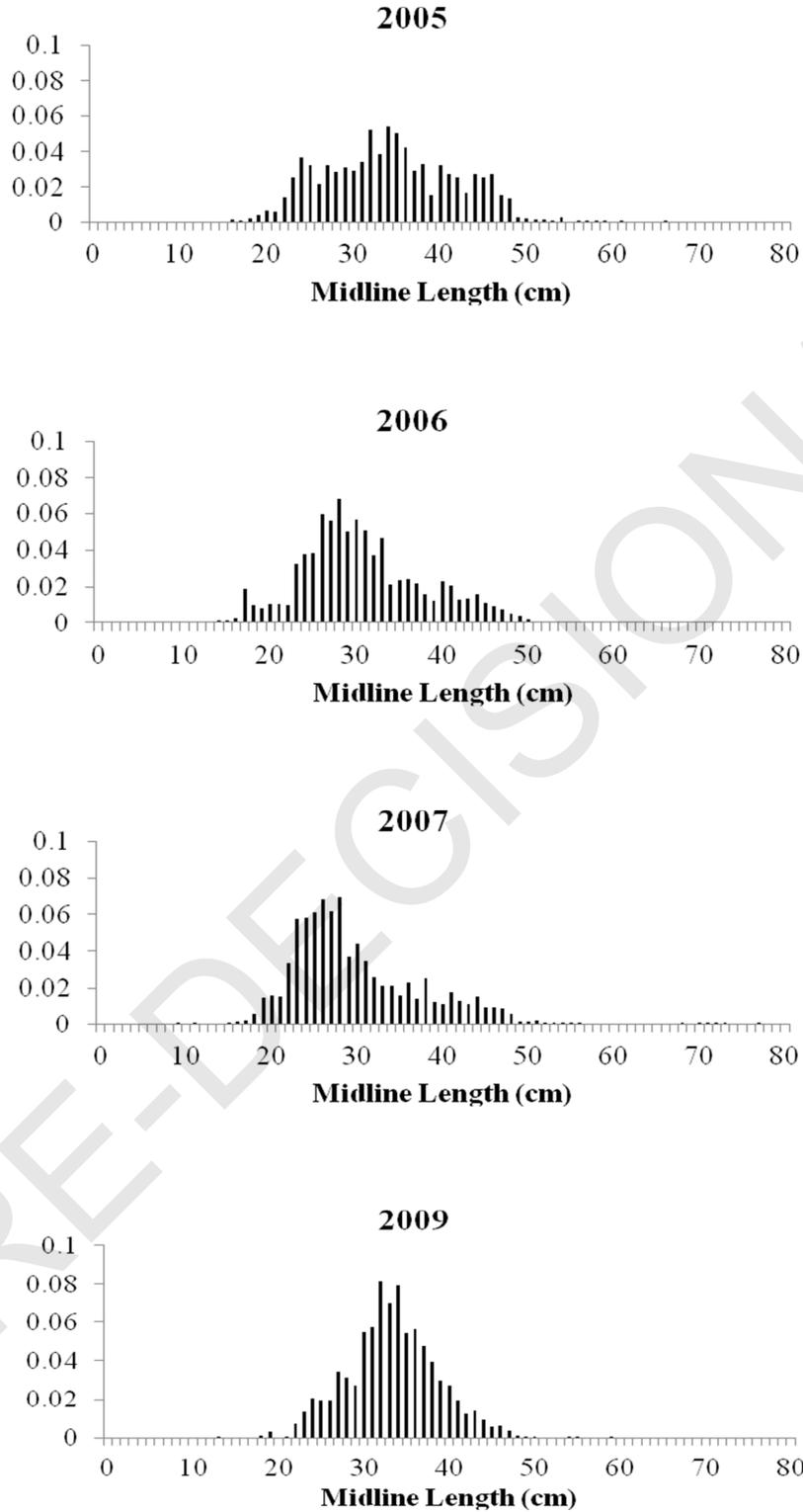


1

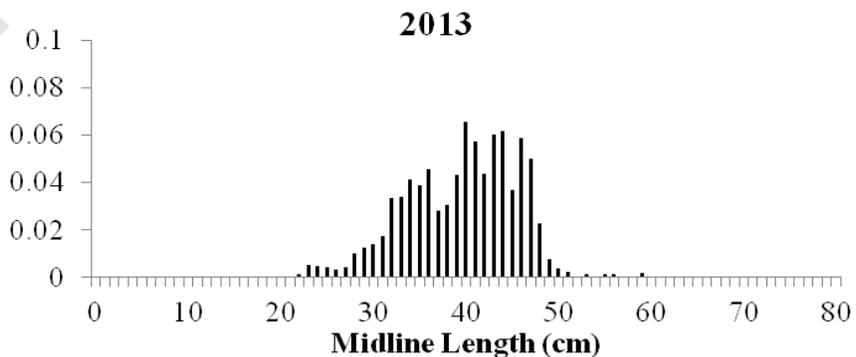
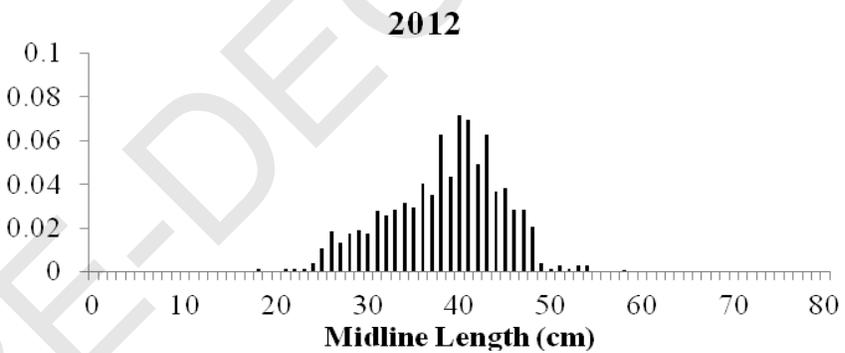
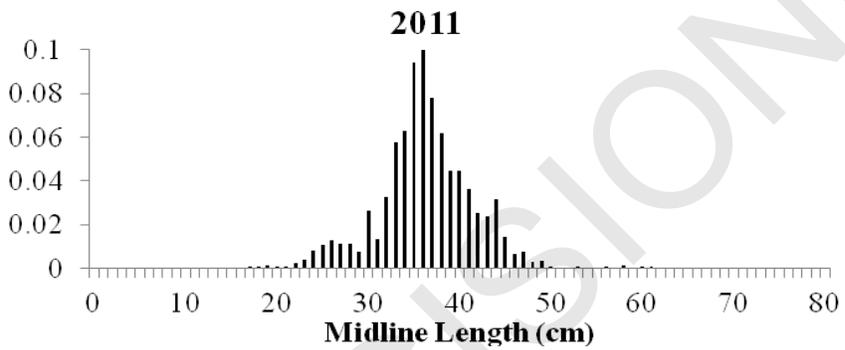
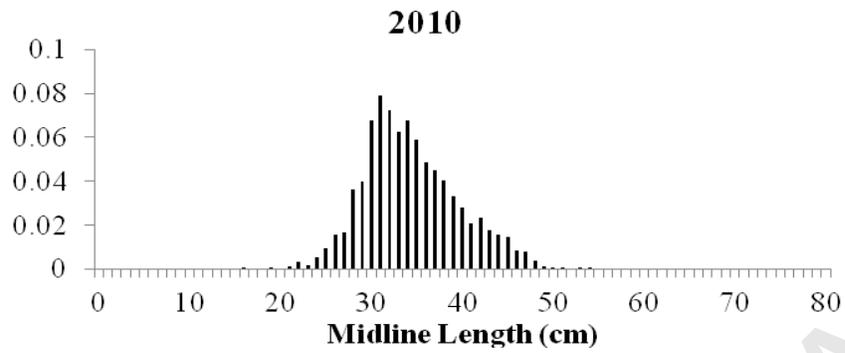
**Figure 4.9.6.** MRIP CH (1986-2013), MRIP PR (1986-2013), MRIP CH:SRHS discard ratio methods (1986-2013), and SRHS discard ratios (2004-2013).



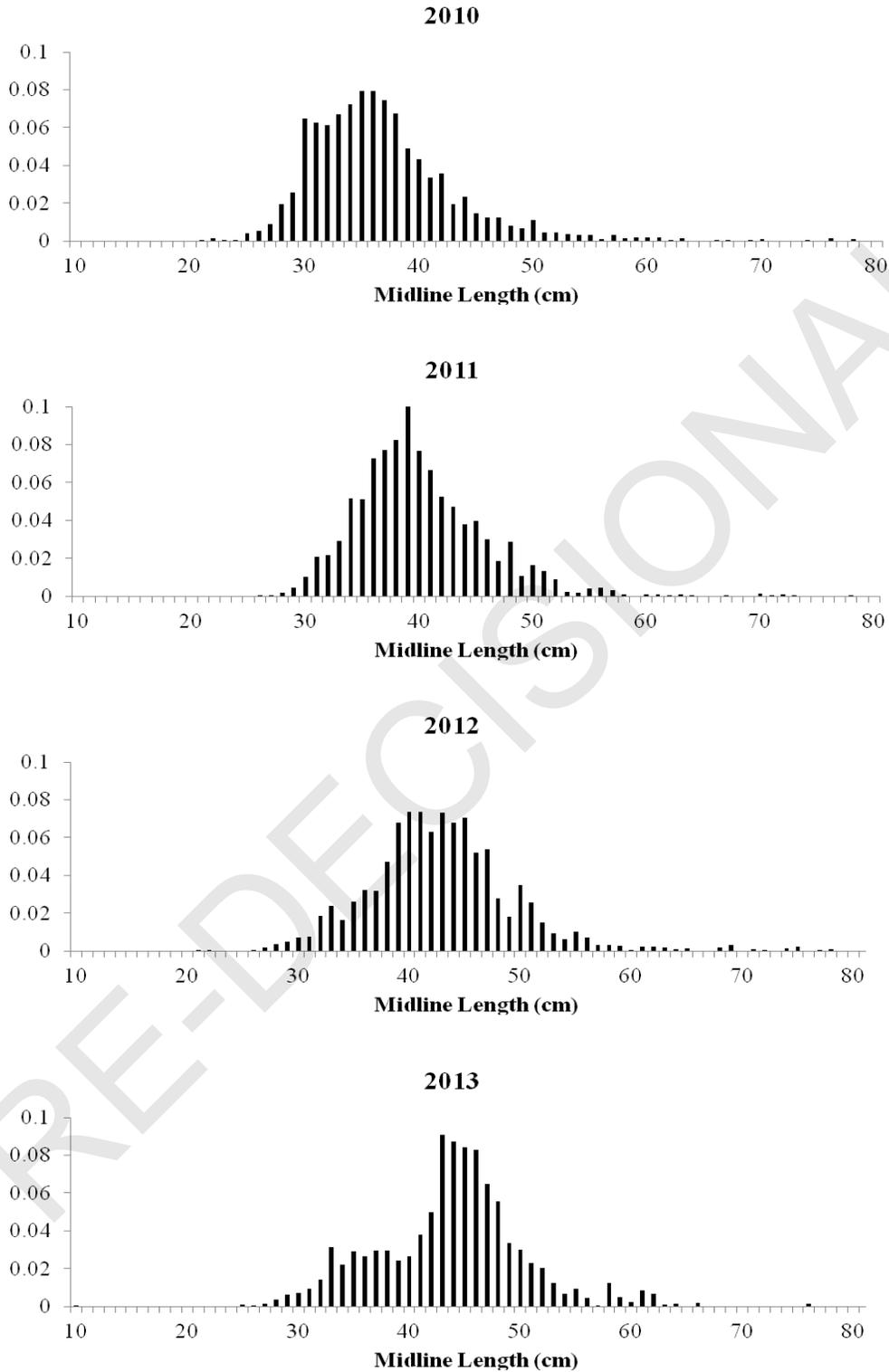
**Figure 4.9.7.** Gulf of Mexico estimated red grouper discards and discard ratio for headboats (MRIP CH:SRHS proxy method 1986-2006; SRHS 2007-2013).



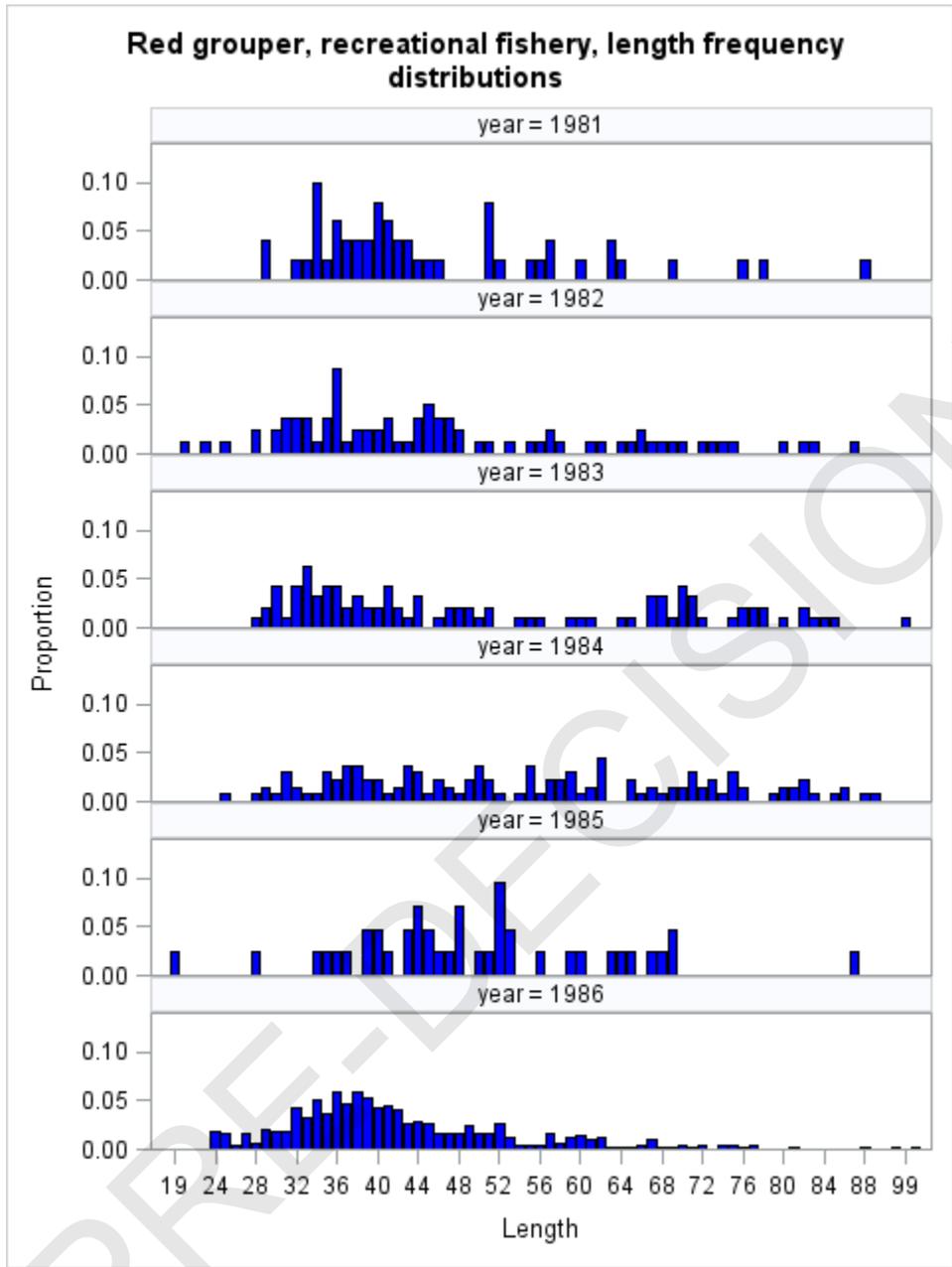
**Figure 4.9.8.** Weighted length frequencies (expressed as proportions) of red grouper discards for headboat vessels. The minimum size limit for harvest is 20" total length (50.8 cm TL).



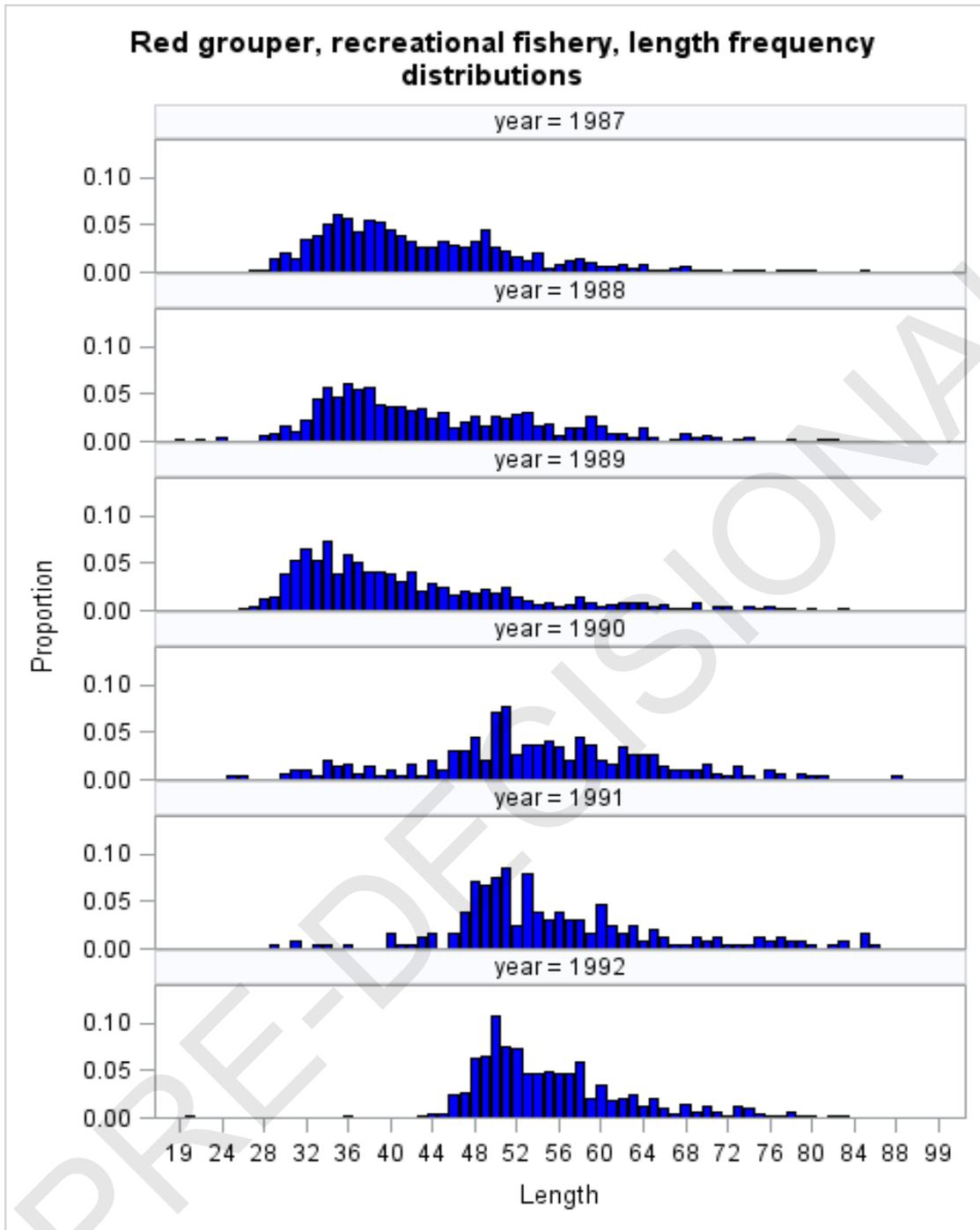
**Figure 4.9.8 (continued).** Weighted length frequencies (expressed as proportions) of red grouper discards for headboat vessels. The minimum size limit for harvest is 20" total length (50.8 cm TL).



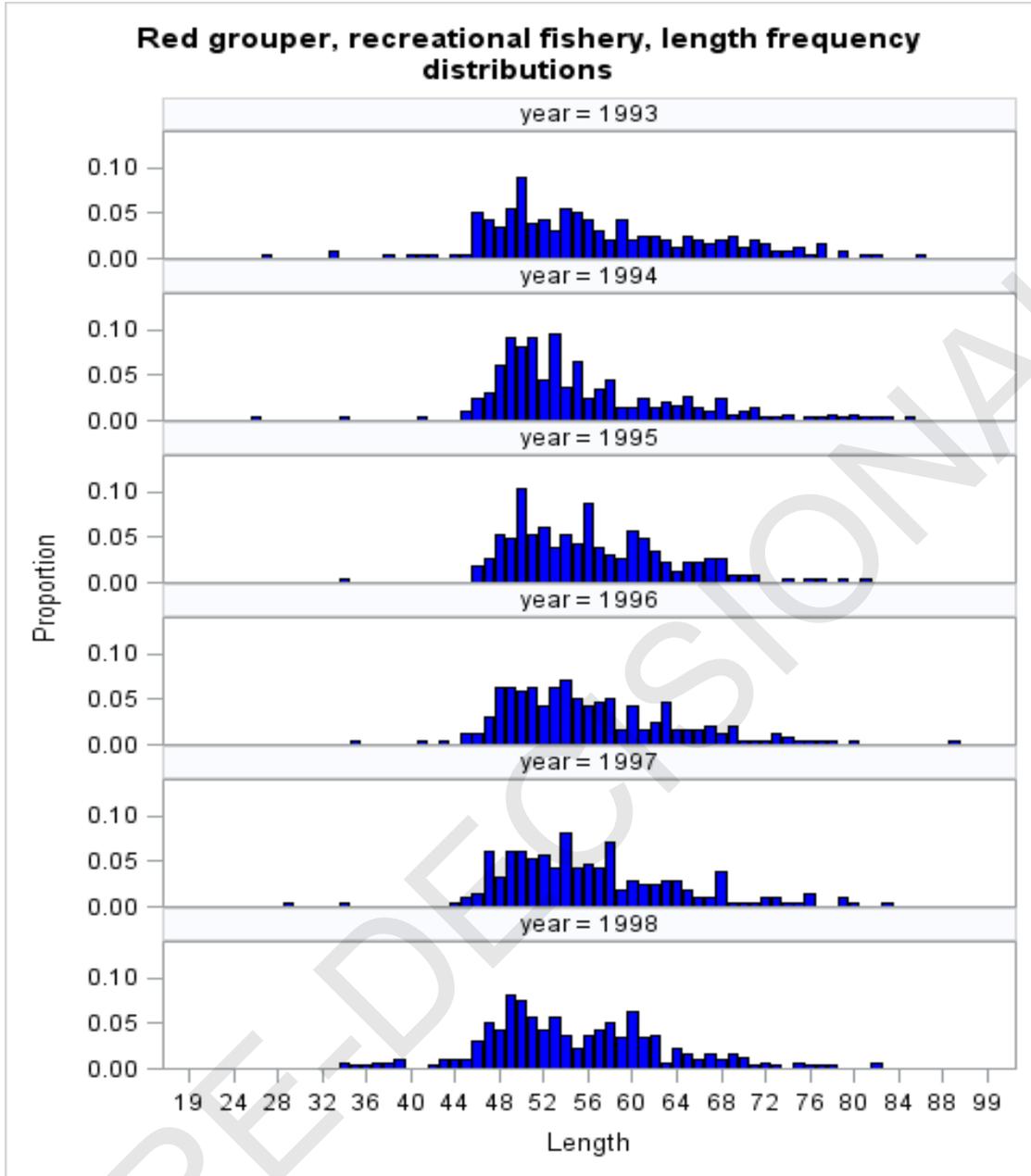
**Figure 4.9.9.** Weighted length frequencies (expressed as proportions) of red grouper discards for charter vessels. The minimum size limit for harvest is 20" total length (50.8 cm TL).



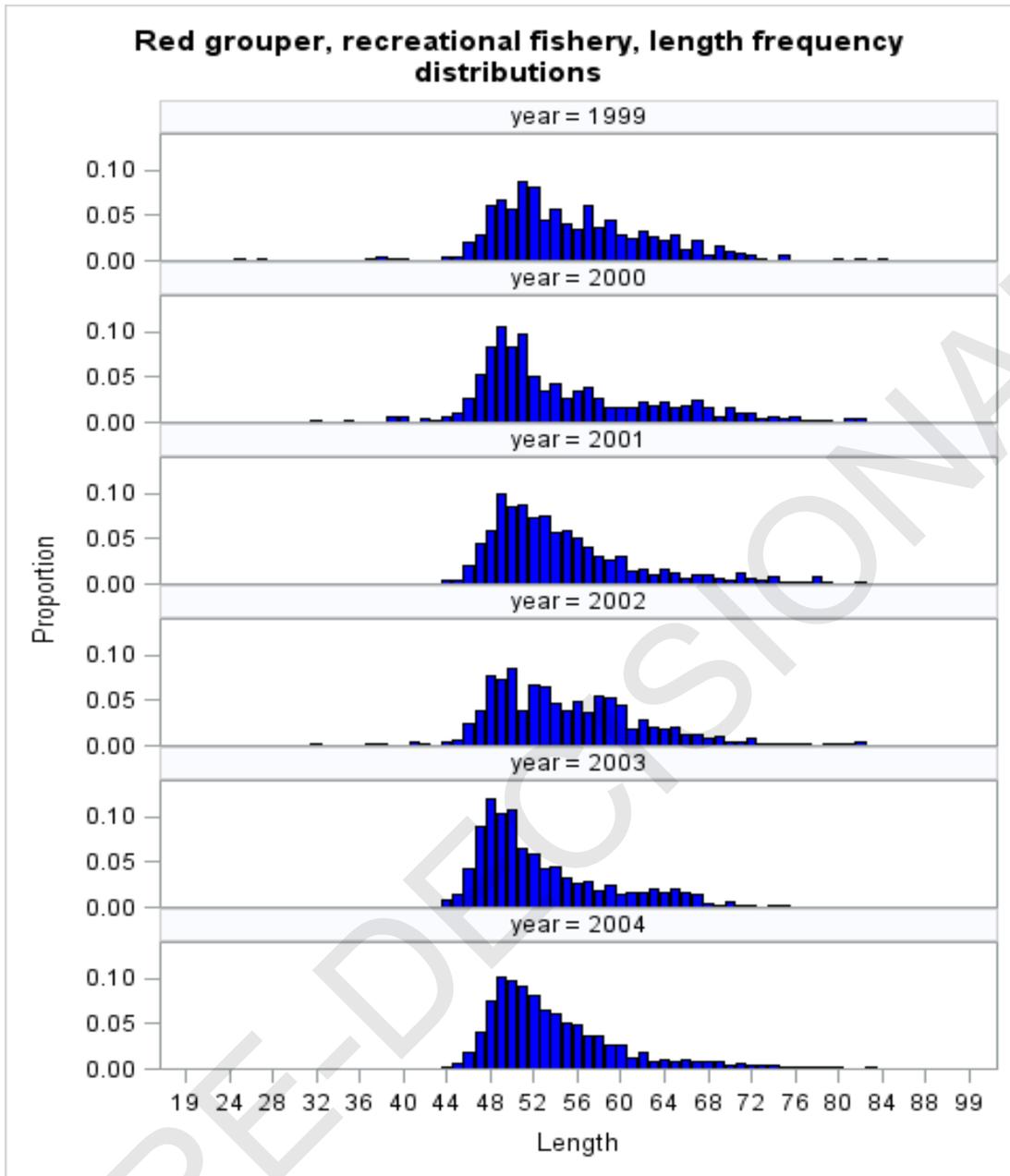
**Figure 4.9.10.** Length frequency distributions (LFDs) for red grouper length samples collected between 1981 and 1986 from recreational fisheries in the Gulf of Mexico.



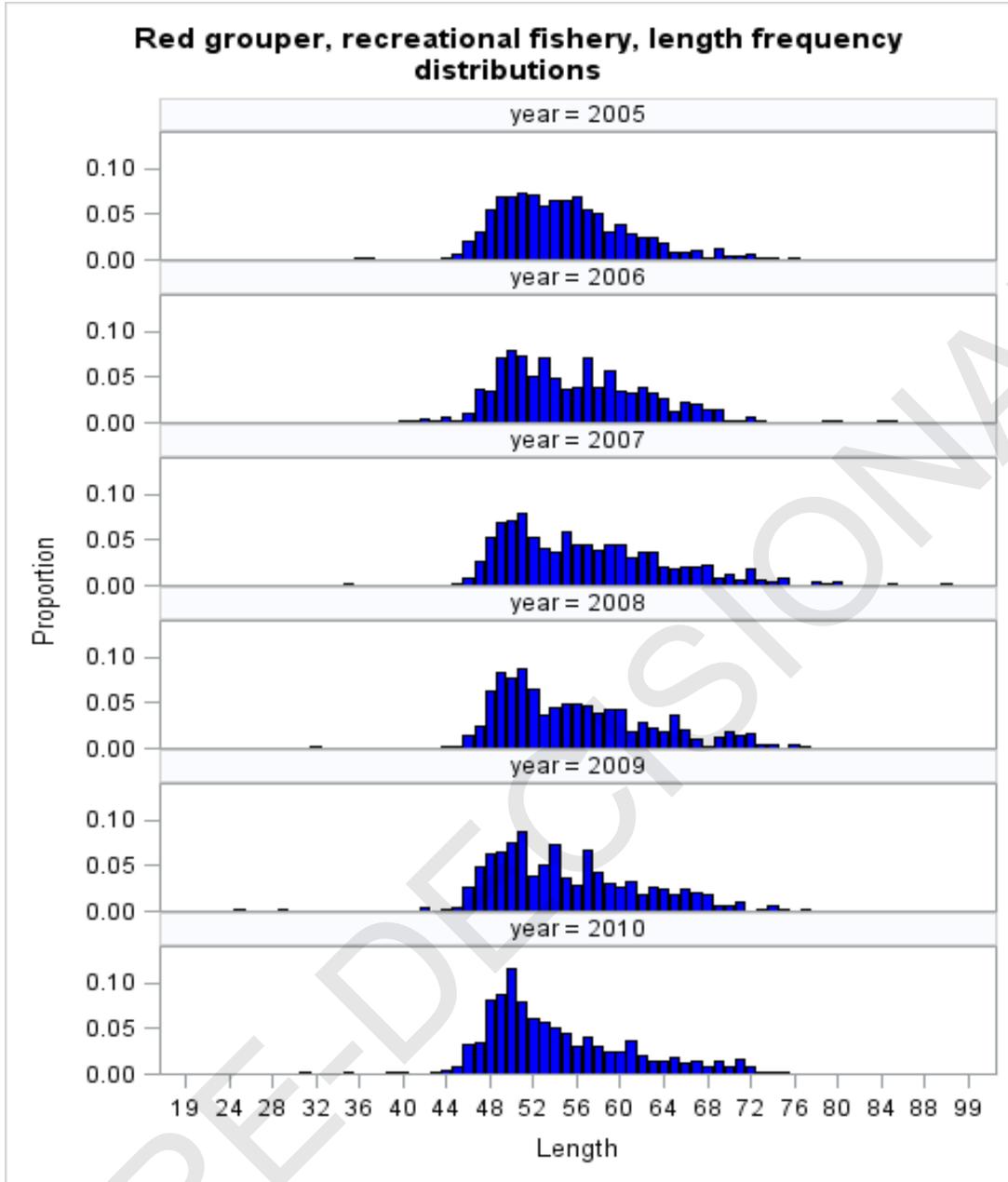
**Figure 4.9.10 (continued).** Length frequency distributions (LFDs) for red grouper length samples collected between 1987 and 1992 from recreational fisheries in the Gulf of Mexico.



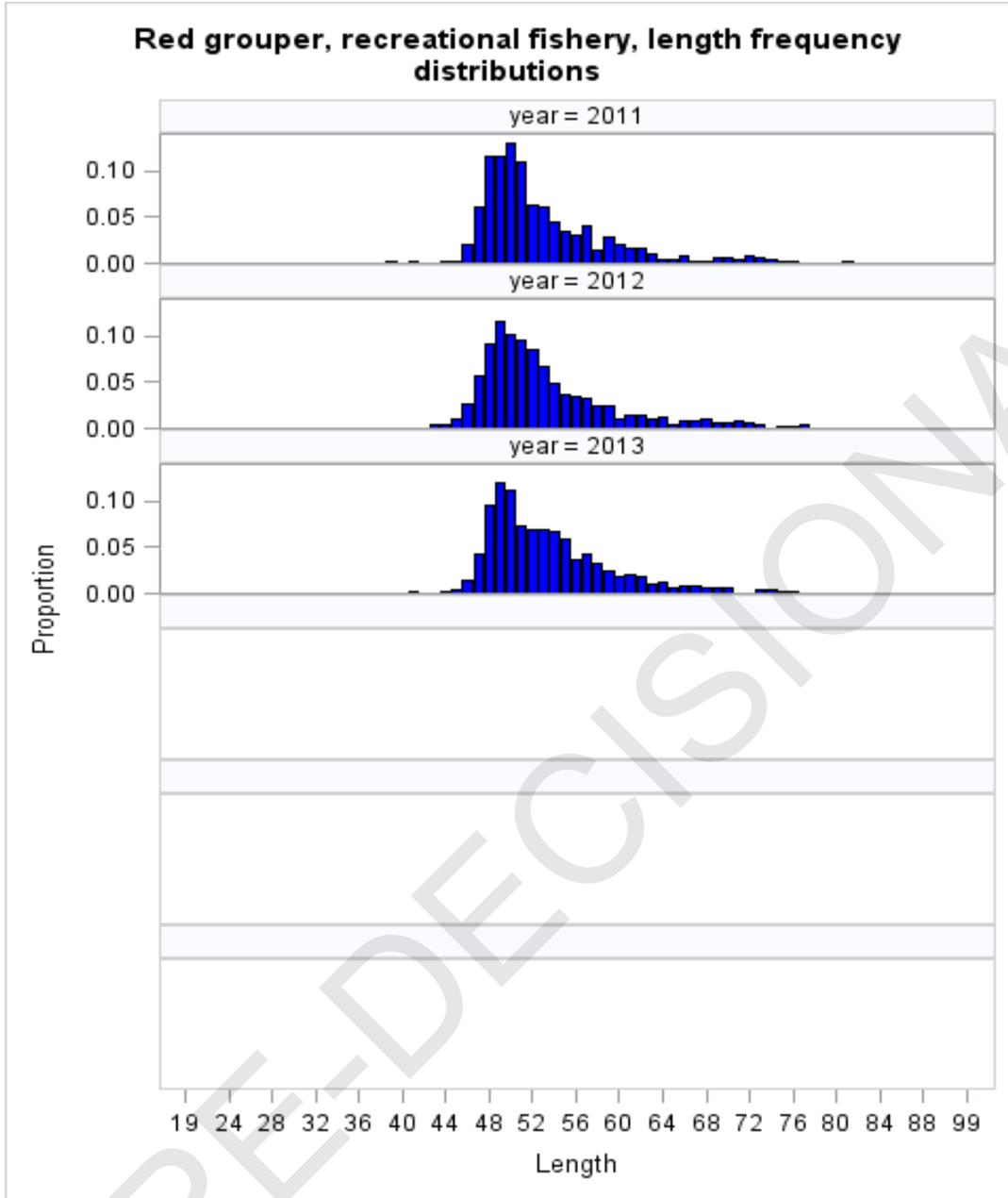
**Figure 4.9.10 (continued).** Length frequency distributions (LFDs) for red grouper length samples collected between 1993 and 1998 from recreational fisheries in the Gulf of Mexico.



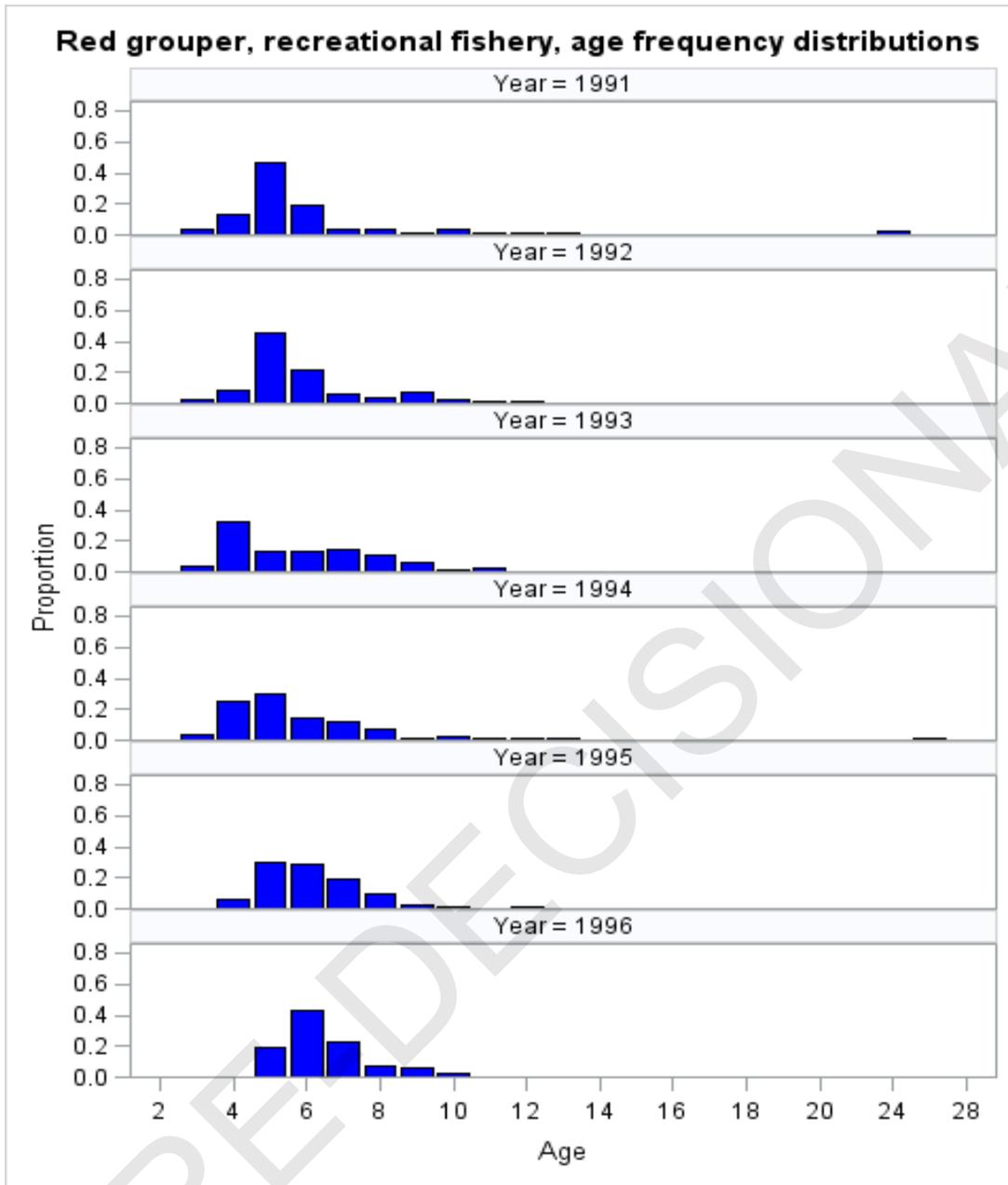
**Figure 4.9.10 (continued).** Length frequency distributions (LFDs) for red grouper length samples collected between 1999 and 2004 from recreational fisheries in the Gulf of Mexico.



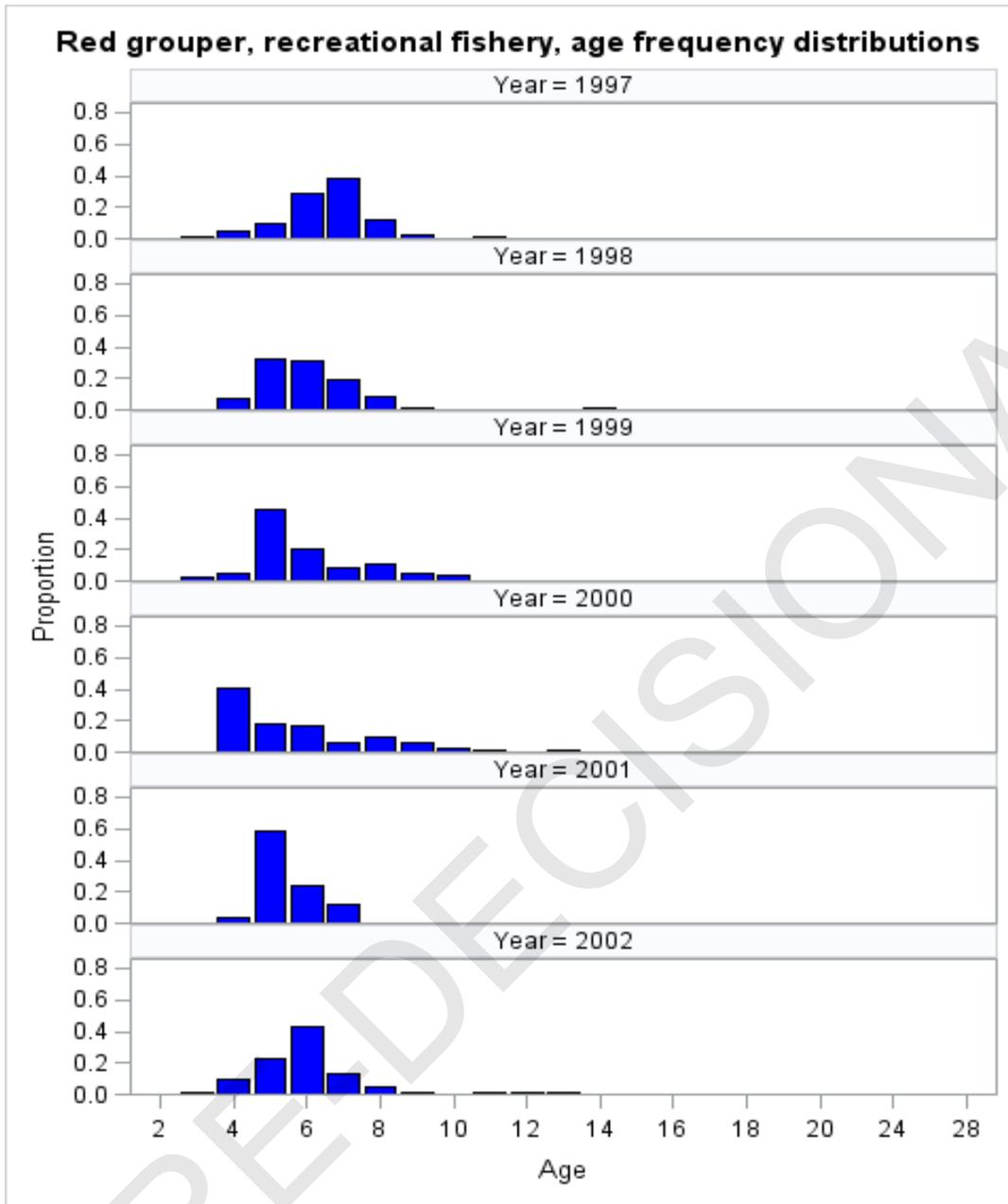
**Figure 4.9.10 (continued).** Length frequency distributions (LFDs) for red grouper length samples collected between 2005 and 2010 from recreational fisheries in the Gulf of Mexico.



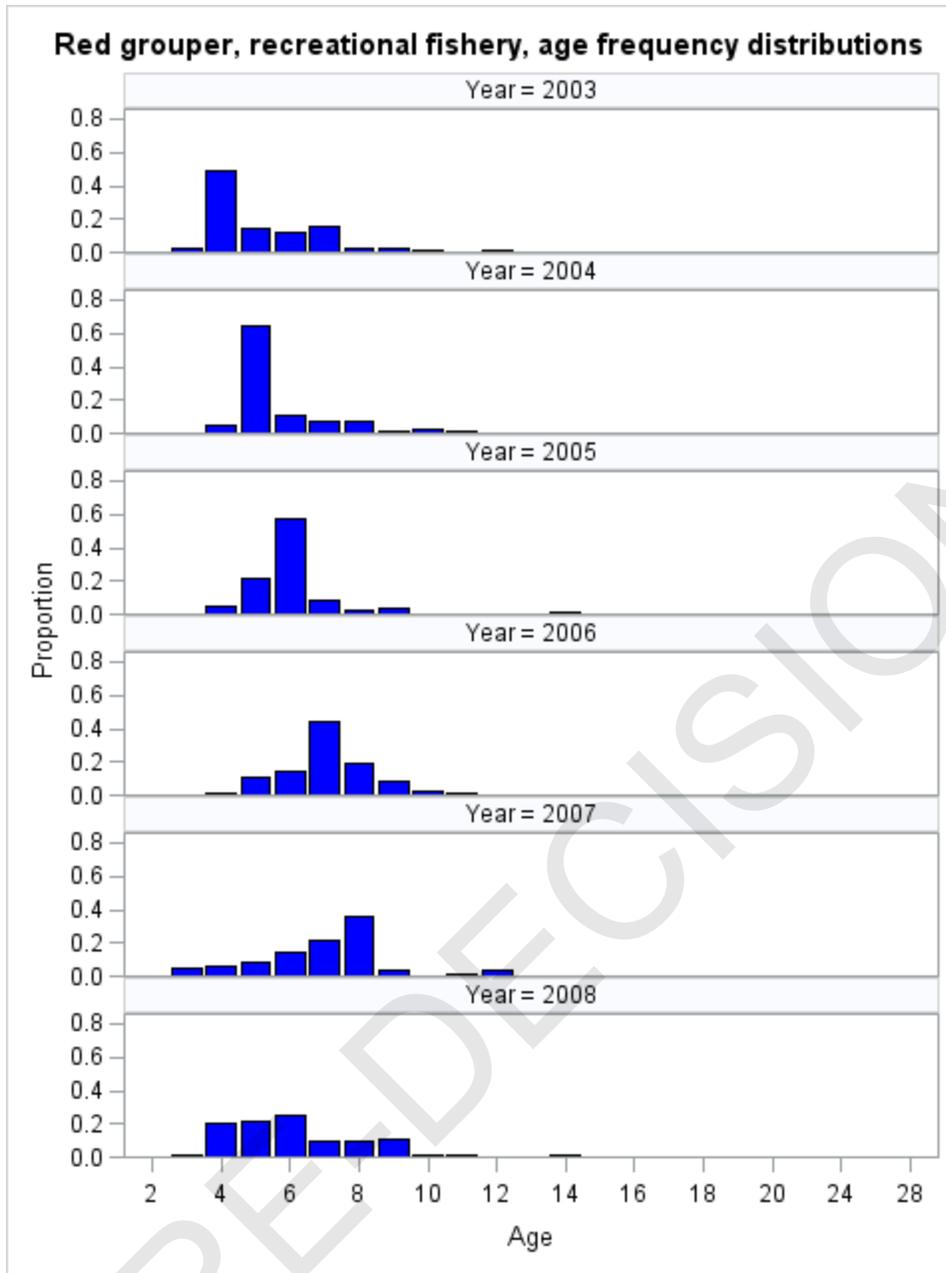
**Figure 4.9.10 (continued).** Length frequency distributions (LFDs) for red grouper length samples collected between 2011 and 2013 from recreational fisheries in the Gulf of Mexico.



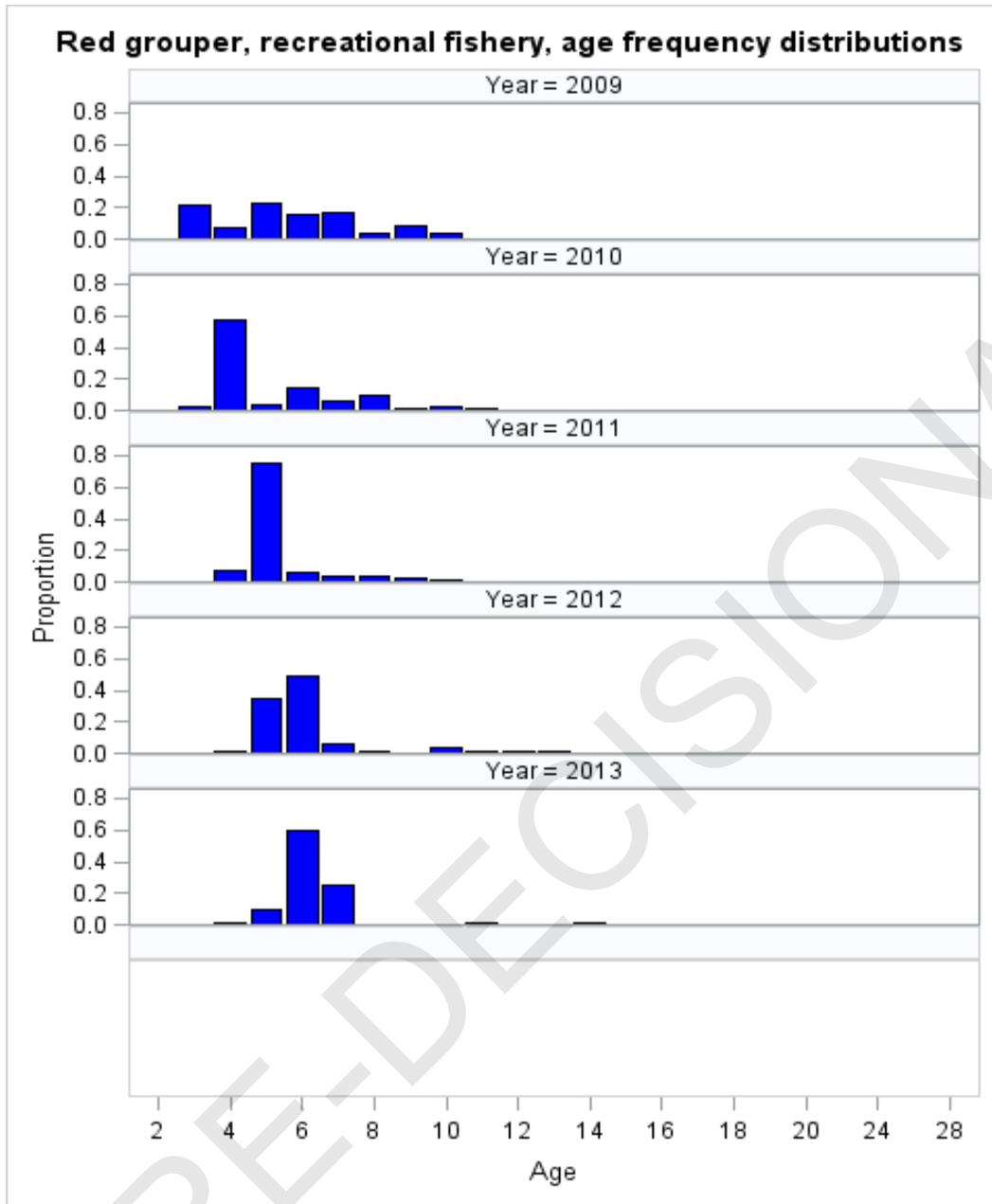
**Figure 4.9.11.** Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 1991 and 1996 from recreational fisheries in the Gulf of Mexico.



**Figure 4.9.11 (continued).** Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 1997 and 2002 from recreational fisheries in the Gulf of Mexico.

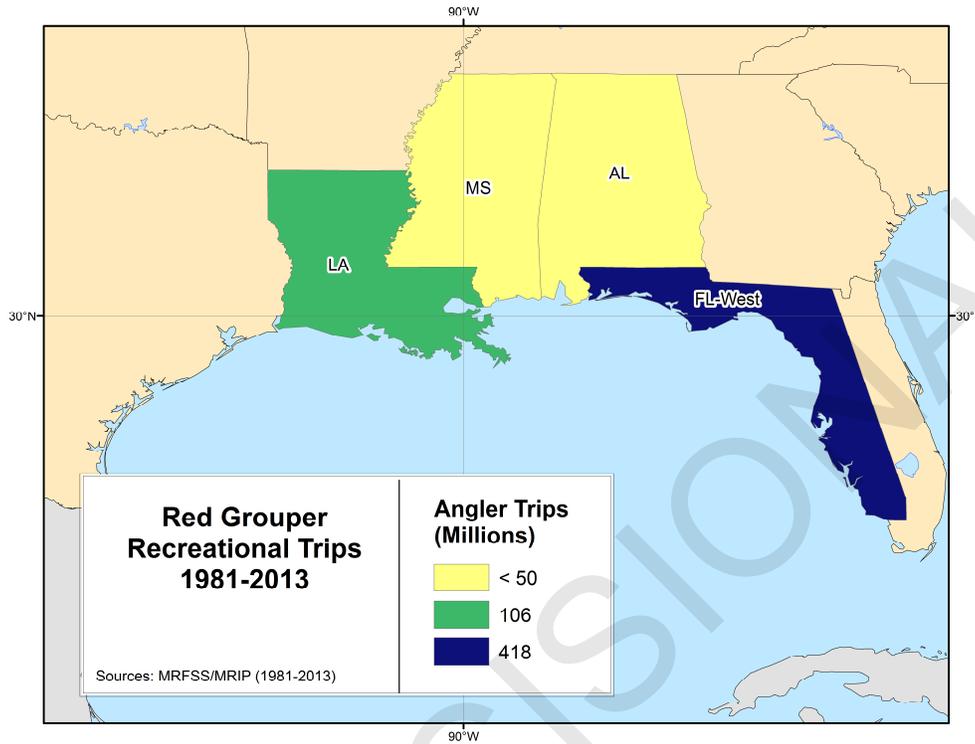


**Figure 4.9.11 (continued).** Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 2003 and 2008 from recreational fisheries in the Gulf of Mexico.

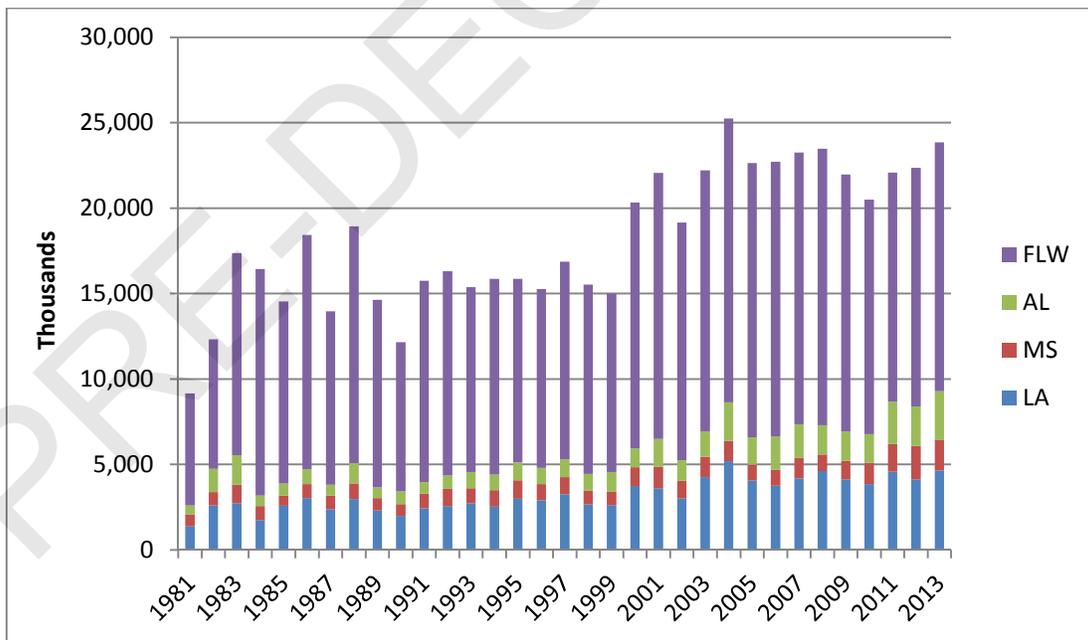


**Figure 4.9.11 (continued).** Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 2009 and 2013 from recreational fisheries in the Gulf of Mexico.

a) **Angler Trips by State 1981-2013**

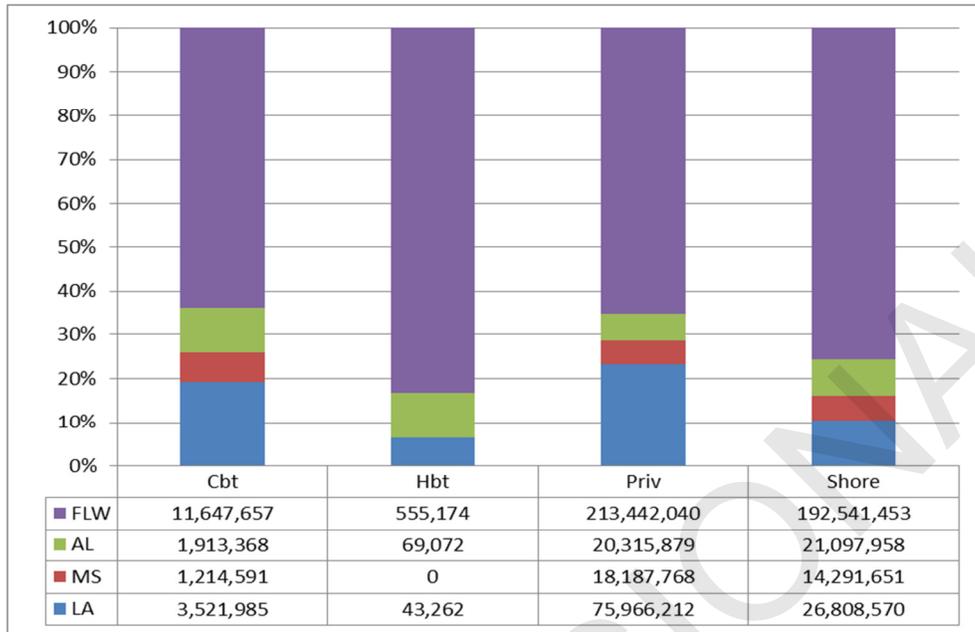


b) **Angler Trips by State and Year 1981-2013**



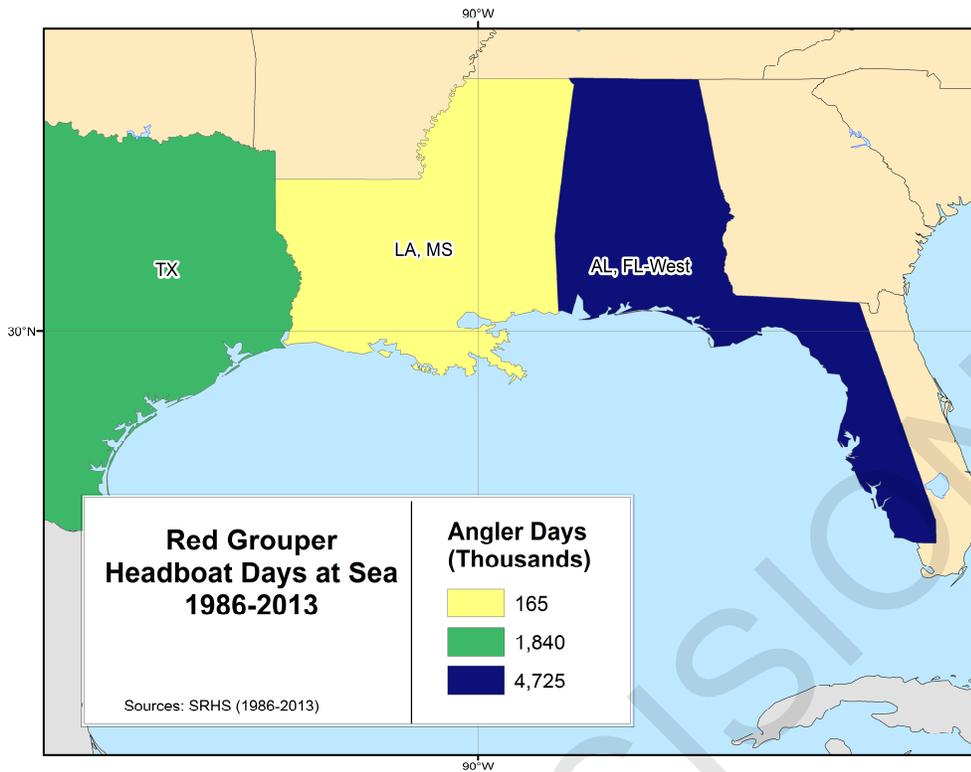
**Figure 4.9.12.** Gulf of Mexico estimated number of angler trips from MRFSS/MRIP (1981-2013) by state (a), by state and year (b), and by state and mode (c). MRFSS/MRIP data from LA to FLW, not including the Keys. Hbt angler trips from 1981 to 1985 only.

c) **Angler Trips by State and Mode 1981-2013**

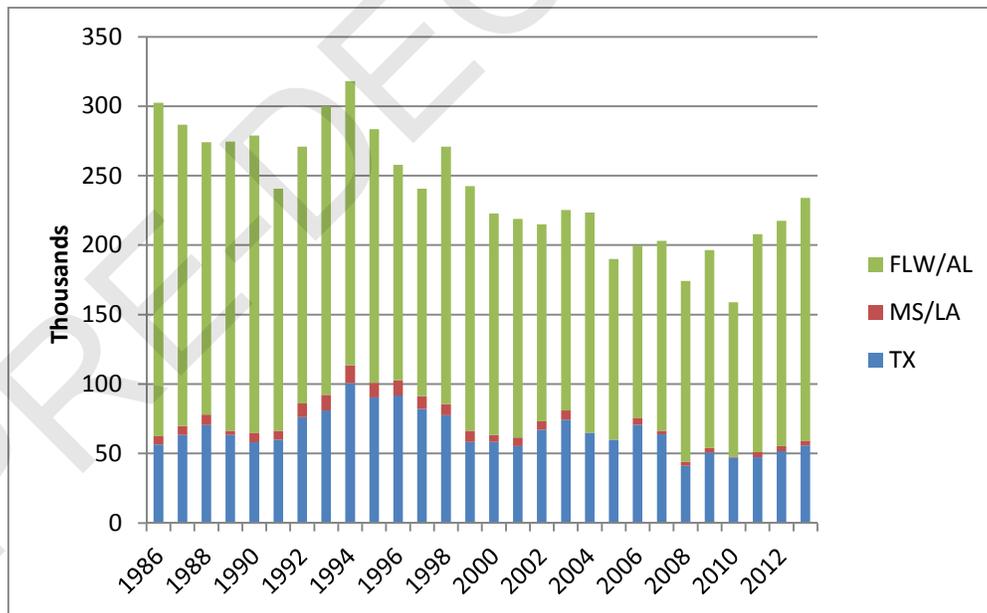


**Figure 4.9.12. (continued).** Gulf of Mexico estimated number of angler trips from MRFSS/MRIP (1981-2013) by state (a), by state and year (b), and by state and mode (c). MRFSS/MRIP data from LA to FLW, not including the Keys. Hbt angler trips from 1981 to 1985 only.

a) **Angler Days by State 1986-2013**



b) **Angler Days by State and Year 1986-2013**



**Figure 4.9.13.** Gulf of Mexico estimated number of headboat angler days from SRHS (1986-2013) by state (a) and by state and year (b). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

## 5 MEASURES OF POPULATION ABUNDANCE

### 5.1 OVERVIEW

Indices and accompanying analyses from 15 fishery-dependent and fishery-independent datasets were presented to the Index Working Group (IWG). The working papers containing full descriptions of the data sets and analytical methods are listed in Section 5.2, and spatial coverage of each is included in Figure 5.9.1. Rationalizations for the recommendation/exclusion of an index are given herein in the ‘Comments on Adequacy for Assessment’ section for each individual index. Diagnostic plots for each index can be found in the individual working papers. Three fishery-independent and four fishery-dependent indices of abundance are recommended for use in the assessment by the IWG and include:

#### Fishery Independent

- SEAMAP Summer Groundfish
- NMFS Bottom Longline
- Combined Video  
(SEAMAP/Panama City/FWRI)

#### Fishery Dependent

- Headboat Survey
- MRFSS
- Commercial Longline
- Commercial Vertical Line

Other indices and/or datasets that were considered and not recommended for use in the assessment by the IWG include:

#### Fishery Independent

- SEAMAP Video
- Panama City Video
- Panama City Trap
- FWRI Video
- FWRI Trap
- Dry Tortugas Visual Census

#### Fishery Dependent

- Commercial Trap
- Everglades National Park Creel Survey
- Headboat Observer Discard

#### 5.1.1 Group Membership

Members of the IWG included: Meaghan Bryan, Matthew Campbell, Shannon Cass-Calay, Mary Christman, Doug DeVries, Walter Ingram, Kevin McCarthy, Adam Pollack (workgroup lead), Adyan Rios and Ted Switzer.

## 5.2 REVIEW OF WORKING PAPERS

The IWG reviewed the following working papers:

| Document #    | Title                                                                                                                                                                        | Authors                                                                                                                             |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| SEDAR42-DW-05 | Red Grouper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico                                                                                  | Adam G. Pollack and G. Walter Ingram, Jr.                                                                                           |
| SEDAR42-DW-06 | Red Grouper Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico                                                                               | Adam G. Pollack and G. Walter Ingram, Jr.                                                                                           |
| SEDAR42-DW-08 | Indices of abundance for Red Grouper ( <i>Epinephelus morio</i> ) from the Florida Fish and Wildlife Research Institute (FWRI) video survey on the West Florida Shelf        | Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.                                              |
| SEDAR42-DW-09 | Indices of abundance for Red Grouper ( <i>Epinephelus morio</i> ) from the Florida Fish and Wildlife Research Institute (FWRI) chevron trap survey on the West Florida Shelf | Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.                                              |
| SEDAR42-DW-11 | SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Red Grouper                                                                                                  | Matthew D. Campbell, Kevin R. Rademacher, Michael Hendon, Paul Felts, Brandi Noble, Michael Felts, Joseph Salisbury, and John Moser |
| SEDAR42-DW-14 | Size Distribution of Red Grouper Observed in For-Hire Recreational Fisheries in the Gulf of Mexico                                                                           | Alisha Gray and Beverly Sauls                                                                                                       |
| SEDAR42-DW-15 | Red Grouper <i>Epinephelus morio</i> Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2014                                      | D.A. DeVries, C.L. Gardner, P. Raley, and W. Ingram                                                                                 |
| SEDAR42-DW-19 | Index report cards                                                                                                                                                           | Indices Working Group                                                                                                               |

## 5.3 FISHERY INDEPENDENT SURVEYS

### 5.3.1 SEAMAP Summer Groundfish

The Southeast Fisheries Science Center Mississippi Laboratories and state partners have conducted standardized groundfish surveys under the Southeast Area Monitoring and Assessment Program (SEAMAP) in the Gulf of Mexico (GOM) since 1987. Prior to 1987, the summer survey was conducted under SEAMAP protocols; however, the fall survey operated independent of SEAMAP and dates back to 1972. SEAMAP is a collaborative effort between federal, state and university programs, designed to collect, manage and distribute fishery independent data throughout the region. The primary objective of this trawl survey is to collect data on the abundance and distribution of demersal organisms in the northern GOM. This survey, which is conducted semi-annually (summer and fall), provides an important source of fisheries independent information on many commercially and recreationally important species throughout the GOM.

#### 5.3.1.1 Methods of Estimation

##### Data Filtering Techniques

The data included in the analysis met the following criteria:

1. No problems with tow (i.e. net torn, doors crossed, etc.).
2. Depths between 5 and 60 fathoms.
3. Within shrimp statistical zones 2 – 8 (east of 86° W) (no catch of red grouper outside of these zones).
4. Sampled with a 40 ft shrimp trawl (Texas uses a 20 ft shrimp trawl and data are not used).
5. Sampled during the summer survey, between 2009 and 2013 (sampling by Florida, which comprises a large percentage of sampling effort in the eastern Gulf of Mexico, has been intermittent in the fall). Earlier years were not included because little or no sampling was done off Florida, the only area where red grouper are normally caught, before 2009.

##### Standardization

The delta-lognormal index of relative abundance ( $I_y$ ) (Lo *et al.* 1992) was estimated as:

$$I_y = c_y p_y,$$

where  $c_y$  is the estimate of mean CPUE for positive catches only for year  $y$ , and  $p_y$  is the estimate of mean probability of occurrence during year  $y$ . Both  $c_y$  and  $p_y$  were estimated using generalized linear models. Data used to estimate abundance for positive catches ( $c$ ) and probability of occurrence ( $p$ ) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

$$\ln(c) = X\beta + \varepsilon$$

and

$$p = \frac{e^{X\beta + \varepsilon}}{1 + e^{X\beta + \varepsilon}},$$

respectively, where  $c$  is a vector of the positive catch data,  $p$  is a vector of the presence/absence data,  $X$  is the design matrix for main effects,  $\beta$  is the parameter vector for main effects, and  $\varepsilon$  is a vector of independent normally distributed errors with expectation zero and variance  $\sigma^2$ .

Therefore,  $c_y$  and  $p_y$  were estimated as least-squares means for each year along with their corresponding standard errors, SE ( $c_y$ ) and SE ( $p_y$ ), respectively. From these estimates,  $I_y$  was calculated, as in equation (1), and its variance calculated using the delta method approximation

$$V(I_y) \approx V(c_y)p_y^2 + c_y^2V(p_y).$$

A covariance term is not included in the variance estimator since there is no correlation between the estimator of the proportion positive and the mean CPUE given presence. The two estimators are derived independently and have been shown to not covary for a given year (Christman, unpublished).

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of  $\alpha = 0.05$ . Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC.

### Submodel Variables

Year: 2009 – 2013

Depth: 5-60 fathoms (continuous)

Shrimp Statistical Zone: Zones 2 - 8

Time of Day: Day, Night

### Annual Abundance Index

Year, depth and shrimp statistical zone were retained in both the binomial submodel and the lognormal submodel.

#### 5.3.1.2 Sampling Intensity and Time Series

There were a total of 676 stations sampled from the Florida Keys, FL to Panama City, FL (between longitudes 81°W and 86°W), during June and July from 2009 – 2013 (Table 5.8.1)

#### 5.3.1.3 Size/Age Data

The average size of red grouper represented in this index was 302 mm (fork length), with the majority of fish being between 2 and 3 years old. Length and age data are presented in Figure 5.9.2.

#### 5.3.1.4 Catch Rates

Standardized catch rates are presented in Table 5.8.1 and Figure 5.9.3.

#### 5.3.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.1.

#### 5.3.1.6 Comments on Adequacy for Assessment

The SEAMAP Summer Groundfish Survey index was recommended for use in the stock assessment. This fishery independent survey has good spatial coverage of the eastern GOM, although the time series is short (5 years). This survey also covers a much greater portion of younger members of the population (1-2 year olds) than covered by other fishery independent indices.

### 5.3.2 NMFS Bottom Longline

The Southeast Fisheries Science Center Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and Western North Atlantic Ocean (Atlantic) since 1995. The objective of these surveys, conducted annually in U.S. waters of the GOM and/or the Atlantic, is to provide fisheries independent data for stock assessment purposes for as many species as possible, and provide considerable information on sharks, snappers and groupers.

In 2011, the Congressional Supplemental Sampling Program (CSSP) enabled high levels of survey effort to be maintained from April through October. This program used the same gear and a similar survey design as the annual bottom longline survey, differing only in the maximum depths sampled – CSSP to 400 m vs annual survey to 366 m.

#### Methods of Estimation

##### Data Filtering Techniques

We used the time series of data between 2001 and 2013 to develop red grouper abundance indices. Data from 1995 – 2000 were not used due to the use of J hooks during those years, resulting in very few red grouper ( $n=53$ ) being captured, with the change to circle-hooks in 2001, red grouper catch increased by an order of magnitude. Survey year 2002 was dropped from analysis because of the limited spatial coverage in the eastern GOM. Data was limited spatially to an area east of  $87^{\circ}\text{W}$ , since no red grouper had been captured west of this point. Data was also limited to stations less than 119 m, since there were no records of red grouper being caught any deeper. In 2005, additional sampling was done in October and November (43 stations) since most of the survey was canceled due to Hurricane Katrina. However, there was little temporal overlap in other years (17 stations in 2004), so all stations done outside of August and September were removed.

##### Standardization

A delta –lognormal index of relative abundance (as described in Section 5.3.1.1) was estimated for red grouper (Lo *et al.* 1992).

##### Submodel Variables

Year: 2001, 2003 – 2013

Depth: 9 – 118 meters (continuous)

Area: Northern (north of 29°N), Central (between 27°N - 29°N), Southern (south of 27°N)

Time of Day: Day, Night

### Annual Abundance Indices

Year, area and depth were retained in the binomial submodel, while year and area were retained in the lognormal submodel.

#### 5.3.2.1 Sampling Intensity and Time Series

There were a total of 837 stations sampled from the Florida Keys, FL to Panama City, FL (between longitudes 81°W and 86°W), during August and September from 2001, 2003 – 2013 (Table 5.8.2)

#### 5.3.2.2 Size/Age Data

The average size of red grouper represented in this index was 508 mm (fork length). Length and age data are presented in Figure 5.9.4.

#### 5.3.2.3 Catch Rates

Standardized catch rates are presented in Table 5.8.2 and Figure 5.9.5.

#### 5.3.2.4 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.2.

#### 5.3.2.5 Comments on Adequacy for Assessment

The IWG recommended that the NMFS Bottom Longline Index be used in the base run of the model. The pros of this index are that it is a fishery independent survey with good spatial and temporal coverage which also samples the entire depth range of red grouper.

### 5.3.3 SEAMAP Video

The primary objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) reef fish video survey is to provide indices of relative abundances for fish species

associated with topographic features such as reefs, banks, and ledges located on the continental shelf of the Gulf of Mexico (GOM) from Brownsville, TX to the Dry Tortugas, FL. Secondary objectives include quantification of habitat types sampled (video and side-scan), and collection of environmental data throughout the survey. Because of the types of topographic features the survey is conducted on, the species assemblages targeted are typically classified as reef fish (e.g. red snapper, *Lutjanus campechanus*), but occasionally fish more commonly associated with pelagic environments are observed (e.g. hammerhead shark, *Sphyrna lewini*).

The survey has been executed from 1992-1997, 2001-2002, and 2004-2013 and historically takes place May – August. The 2001 survey was abbreviated due to ship scheduling, so that the only sites completed were those located in the western Gulf of Mexico. Types of data collected on the survey include diversity, abundance (minimum count), fish length, habitat type, habitat coverage, and bottom topography. The size of fish sampled with the video gear is species specific, however red grouper sampled over the history of the survey ranged from 190 to 971 mm FL, with annual means from 471 to 516 mm FL. Age and reproductive data cannot be collected with the camera gear but beginning in 2012, a vertical line component was added to the video drops to collect hard parts, fin clips, and gonads.

### Sampling design

Total reef area available to select survey sites from is approximately 1771 km<sup>2</sup>, of which 1244 km<sup>2</sup> is in the eastern GOM and 527 km<sup>2</sup> in the western GOM. The large size of the survey area necessitates a two-stage sampling design to minimize travel times between stations. The first-stage uses stratified random sampling to select blocks 10 minutes of latitude by 10 minutes of longitude. The block strata were defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and South Texas), and by total reef habitat area contained in the block ( $\leq 20$  km<sup>2</sup>,  $> 20$  km<sup>2</sup>). There are a total of 7 strata. A 0.1 by 0.1 nm grid is then overlaid onto the reef area contained within a given block and the ultimate sampling sites (second stage units) are randomly selected from that grid.

### Gear and deployment

The SEAMAP reef fish survey has employed several camcorders in underwater housings since 1992. Sony VX2000 DCR digital camcorders mounted in Gates PD150M underwater housings were used from 2002 to 2005 and Sony PD170 camcorders were used during the years 2006 and 2007. In 2008 a stereo video camera system was developed and assembled at the NMFS Mississippi Laboratories Stennis Space Center Facility and has been used in all subsequent surveys. The stereo video unit consists of a digital stereo still camera head, digital video camera, CPU, and hard drive housed in an aluminum casing. All of the camcorder housings are rated to a maximum depth of 150 m while the stereo camera housings are rated to 600 m. Stereo cameras are mounted orthogonally at a height of 50 cm above the bottom of the pod and the array is baited with squid during deployment.

At each sampling site the stereo video unit is deployed for 40 min total, however, the cameras and CPU delay filming for 5 min to allow for descent to the bottom and settling of suspended sediment following impact. Once turned on, the cameras film for approximately 30 min before shutting off prior to retrieval of the array. During camera deployment the vessel drifts away from the site and a CTD cast is executed, collecting water depth, temperature, conductivity, and transmissivity from the surface to the maximum depth. Seabird units are the standard onboard NOAA vessels however the model employed was vessel/cruise dependent.

#### Video tape viewing

One video tape from each station is randomly selected for viewing out of all viewable videos. Videos that have issues with visibility, obstructions or camera malfunction are excluded from randomly selection and are not viewed. Selected videos are viewed for 20 min starting from the time when the view clears from suspended sediment. Viewers identify and enumerate all species to the lowest taxonomic level during the 20 min viewable segment. From 1993-2007 the time when each fish entered and left the field of view was recorded – a procedure referred to as time in - time out (TITO) – and from these data a minimum count was calculated. The minimum count is the maximum number of individuals of a selected taxon in the field of view at one instance. Each video is evaluated to determine the highest minimum count observed during the 20 min analyzed. From 2008 to the present, the digital video allows the viewer to record a frame number or time stamp of the image when the maximum number of individuals of a species

occurred, along with the number of taxon identified in the image, but the TITO method is not used. Both the TITO and current viewing procedure result in the minimum count estimation of abundance (i.e. - mincount). Minimum count methodology is preferred because it prevents counting the same fish multiple times (e.g. if a fish were swimming in circles around the camera).

### Fish length measurement

Beginning in 1995 fish lengths were measured from video using lasers attached on the camera system with known geometry. However, the frequency of hitting targets with the laser is low and precluded estimating size frequency distributions. Additionally, the same fish can be measured more than once at a given station. So, the lengths measured provide the range of sizes observed. The stereo cameras used since 2008 allow size estimation from fish images using Vision Measurement System (Geometrics Inc.) software. Fish measurement is only performed at the point in the video corresponding to the mincount.

#### 5.3.3.1 Methods of Estimation

The IWG recommended that a combined index from the three video surveys (NMFS, Panama City and FWRI) be used rather than having individual indices from each group.

#### 5.3.3.2 Sampling Intensity and Time Series

There were a total of 3025 stations sampled from the Florida Keys, FL to Mobile Bay, AL (between longitudes 81°W and 88°W), from 1993 – 2013 (Table 5.8.3).

#### 5.3.3.3 Size/Age Data

The average size of red grouper represented in this index was 478 mm FL, (Figure 5.9.6).

#### 5.3.3.4 Comments on Adequacy for Assessment

The IWG initially advised that the abundance index from the eastern Gulf of Mexico was appropriate to index adult red grouper. However, evaluation of the positive catch QQ residual plots indicated that fit was poor and it was suggested to explore and evaluate the feasibility of producing indices using other distributions. Code developed by Mary Christman from MCC Statistical Consulting LLC was used to model the indices using Poisson and negative binomial

distributions. Both of these models showed improved fit over the delta-lognormal models historically used to model video survey data and future indices should use these alternative models rather than the delta-lognormal method developed by Lo et al. (1992). Evaluation of the spatial distribution of sampling sites showed spatial gaps in coverage for inshore areas less than 25 m and over all depths in the central portion of the west Florida shelf as well.

Following presentations of video survey indices from the NMFS Panama City and FWRI laboratories, it was shown that coverage could be improved by combining the three indices. Additionally, all three groups have participated in the annual west Florida shelf coordination meetings to discuss methods and ensure that survey methods are standardized (e.g. randomized site selection, camera deployment time, video read procedures, and abundance metrics). Because of the significant amount of effort to standardize these three surveys, it was decided to combine the data sets and develop Poisson and Negative-Binomial indices. The IWG evaluated those models and recommended that the combined Poisson index be used rather than the individual surveys indices by themselves. This combined approach improved spatial coverage without a loss in the temporal length of the longest data series (SEAMAP reef fish video). Those results are presented in Section 5.3.8.

#### 5.3.4 Panama City Video

The Panama City NMFS lab reef fish video survey began in 2005 as an expansion of a trap survey begun in 2004 to provide annual relative abundance estimates on exploited species, including gag, scamp, and red grouper; red, vermilion, gray, and lane snapper; gray triggerfish, red porgy, white grunt, black seabass, and hogfish. Other objectives included examining regional catch, recruitment, demographic, and distribution patterns of these and other common reef fishes, as well as insight on trap selectivity, and more complete information on community structure. Video sampling in 2005 was only done in Apalachee Bay off the Big Bend region of north Florida, but in 2006 was expanded to the area off Panama City. These two regions are separated by Cape San Blas - an established hydrographic and likely zoogeographic boundary (Zieman and Zieman 1989), and include shrimp grids 9 (eastern half), 8, 7, and the northern edge of 6. The survey area is bounded by 86°30' W on the west and 28° 45' N on the southeast.

Through 2009 the survey design was systematic because of a very limited sampling universe. In 2010 the design was changed to 2-stage random after side scan sonar surveys that year yielded an order of magnitude increase in that universe. In the first stage, five by five minute blocks known to contain reef sites, and proportionally allocated by region, sub-region, and depth (10-20, 20-30, 30+ m) to ensure uniform geographic and bathymetric coverage, were randomly chosen. In the second stage, 2 known reef sites a minimum of 300 m apart within each selected block were randomly selected. Individual sites were weighted using a mean value of individual ratings based on measurements of area, relief, rugosity, and proximity to other reefs derived from side scan sonar data. Reefs with higher weighting factors had a higher probability of being selected. The few sites which have not been side scanned were assigned the average rating for the all side scanned sites in the block in which they are located. Alternates were also selected for use when another boat was found to be fishing the site or no hard bottom could be found with sonar at that site.

Depth coverage was ~8-30 m during 2004-07, and then was steadily expanded to deeper depths. Since 2011 it has remained at about 8 to 50 m. All sampling occurred between May and October (with the exception of four sites in November, 2013), but primarily during June through August. A CTD cast was made at each site to collect temperature, salinity, oxygen, and turbidity profiles.

Sampling was conducted only during daytime from 1 hr after sunrise until 1 hr before sunset.

Visual data were collected using a stationary camera array composed of four Hi-8 video cameras (2005 only) or four high definition (HDEF), digital video cameras (2006-08) mounted orthogonally 30 cm above the bottom of an aluminum frame. From 2007 to 2009, parallel lasers (100 mm spacing) mounted above and below each camera were used to estimate the sizes of fish which crossed the field of view perpendicular to the camera. In 2009 and 2010, one of the HDEF cameras was replaced with a stereo imaging system (SIS) consisting of two high resolution black and white still cameras mounted 8 cm apart, one digital video (mpeg) color camera, and a computer to automatically control these cameras as well as store the data. The SIS provides images from which fish measurements can be obtained with the Vision Measurement System (VMS) software. Beginning in 2011, a second SIS facing 180° from the other was added, reducing the number of HDEFs to two; and both SIS's were also upgraded with HDEF, color

mpeg cameras. In 2012 the two HDEFs were replaced with high definition GoPro cameras. The camera array was unbaited 2005-2008, but since 2009 has been freshly baited on each drop with one previously frozen Atlantic mackerel placed in a mesh bag near the center. The switch was made to baiting cameras to standardize methods with the Pascagoula video survey, which had a much longer time series.

Before stereo camera systems were used (prior to 2009), soak time for the array was 30 min to allow sediment stirred up during camera deployment to dissipate and ensure tapes with an unclouded view of at least 20 min duration (Gledhill and David 2003). With the addition of stereo cameras in 2009, soak time was increased to 45 min to allow sufficient time for the SIS to settle on the bottom before starting its hard drive, and to insure the hard drive had time to shut down before retrieval. In 2014, stereo cameras were upgraded with solid state hard drives, enabling soak time to be reduced back to 30 min. Prior to 2009, tapes of the 4 HDEF cameras were scanned, with the one with the best view of the habitat analyzed in detail. If none was obviously better, one was randomly chosen. In 2009 only the 3 HDEF video cameras were scanned and the one with the best view of the reef was analyzed. Starting in 2010, all 4 cameras – the HDEFs and the SIS MPEGs, which have virtually the same fields of view (64 vs 65°) – were scanned, and again, the one with the best view of the habitat was analyzed. Beginning in 2012, when a video from a GoPro camera was selected to be read, because they have a much larger field of view than the SIS MPEGs (122 vs 65°), predetermined, equal portions of each edge of the video monitor were covered so that only the central 65° of the field of view was visible. Twenty min of the tape were viewed, beginning when the cloud of sediment disturbed by the landing of the array had dissipated. All fish captured on videotape were identified to the lowest discernable taxon. Data on habitat type and reef morphometrics were also recorded. If the quality of the mpeg video derived from the SIS was less than desirable (a common problem), fish identifications were confirmed on the much higher quality and concurrent stereo still frames. The estimator of abundance was the maximum number of a given species in the field of view at any time during the 20 min analyzed (= min count; Gledhill and Ingram 2004, or MaxN; Ellis and DeMartini 1995), and VMS measurements were only taken from a still frame showing the min count of a given species to eliminate the possibility of measuring the same fish more than once. Even for deployments where the SIS did not provide a good view of the reef habitat, the

files were examined to obtain fish measurements using VMS, and again, those measurements were only taken from a still frame showing the min count of a given species.

To ensure consistency and identify issues in species id, min counts, and habitat classification within the Panama City lab survey, the first 10 tapes analyzed from a given year are read by both readers. Similarly, to ensure consistency among the 3 labs involved in the West Florida shelf cooperative reef fish video survey (NMFS Panama City, NMFS Pascagoula, FWRI), readers from each lab read a sample of 10 tapes from the other 2 labs. Results from these reader/lab comparisons are presented and discussed at an annual Cooperative Survey workshop.

#### 5.3.4.1 Methods of Estimation

The IWG recommended that a combined index from the three video surveys (NMFS, Panama City and FWRI) be used rather than having individual indices from each group.

#### 5.3.4.2 Sampling Intensity and Time Series

There were a total of 993 stations sampled from the Big Bend Area, FL to Panama City, FL (between longitudes 82°W and 86°30'W and north of 28° 45' N), from 2005 – 2013 (Table 5.8.3)

#### 5.3.4.3 Size/Age Data

Red grouper observed with stereo cameras, 2009-2014, ranged from 274 to 885 mm FL with a modal size of roughly 400-450 mm FL and a mean of 503 mm (Figure 5.9.7). Not surprisingly, a comparison of size data from trap catches with that from stereo images from the same years (2009-13) indicated that the traps do select against most red grouper >750 mm FL, although fish that large were much less common in the survey area based on the few stereo measurements obtained (Figure 5.9.7). The stereo camera gear is also selective, but it tends to select against small (<325 mm FL) red grouper, which tend to be much more cryptic than larger individuals and less likely to be visible to camera gear. Age data were not available from this survey.

#### 5.3.4.4 Comments on Adequacy for Assessment

After determining that the NMFS Pascagoula, NMFS Panama City, and Florida FWRI video surveys: 1) sampled very similar sizes and ages of red grouper, 2) used very similar gear and

video processing methods , 3) have had concurrent sampling since 2008, and 4) together covered a large proportion of the West Florida Shelf, which in turn includes most of the known range and certainly the center of abundance of red grouper in the U.S. Gulf of Mexico, the indices group agreed that combining all three indices into one would provide the best, most comprehensive information on population trends in the NE Gulf. Those results are presented in Section 5.3.8.

For that reason, the group recommended not including a stand-alone Panama City video index in the assessment.

### 5.3.5 Panama City Trap Survey

In 2002 the Panama City NMFS lab began development of a fishery-independent trap survey (PC survey) of natural reefs on the inner shelf of the eastern Gulf of Mexico off Panama City, FL, with the primary objective of establishing an age-based annual index of abundance for young (age 0-3), pre-recruit gag, scamp, and red grouper. Secondary objectives included examining regional catch, recruitment, demographic, and distribution patterns of other exploited reef fish species. The chevron trap is efficient at capturing a broad size range of several species of reef fish (Nelson et. al.1982, Collins 1990), and has been used by the South Atlantic MARMAP program for over 20 yr (McGovern et. al. 1998). Initially the PC survey used the same trap configuration and soak time used by MARMAP (McGovern et. al. 1998), but an in-house study indicated that traps with a throat entrance area 50% smaller than that in the MARMAP traps were much more effective at meeting our objective of capturing sufficient numbers of all three species of grouper. Video data from our study and consultations with fishermen suggested that the presence of larger red grouper in a trap tended to deter other species from entering. Beginning in 2004, the 50% trap throat size became the standard. That same year the survey was expanded east of Panama City to Apalachee Bay off the Big Bend region of Florida, an area separated from the shelf off Panama City by Cape San Blas - an established hydrographic and likely zoogeographic boundary (Zieman and Zieman 1989). The survey area is bounded by 86°30' W on the west and 28° 45' N on the southeast, and includes shrimp grids 8 and the eastern half of 9 on the west side of the Cape and grids 7, 8, and the northern edge of 6 on the east side.

In 2005 the target species list was expanded to include other exploited reef fishes common in the survey area, i.e., red, vermilion, gray, and lane snapper; gray triggerfish, red porgy, white grunt, black seabass, and hogfish. From 2005 through 2008 each site was sampled first with a stationary video camera array followed immediately by a single trap. Beginning in 2009 trap effort was reduced ~50%, so that more effort could be devoted to the concurrent video survey. At each site, a CTD cast was made to collect temperature, salinity, oxygen, and turbidity profiles.

Through 2009 the survey design was systematic because of a very limited sampling universe. In 2010 the design was changed to 2-stage random after side scan sonar surveys that year yielded an order of magnitude increase in that universe. In the first stage, five by five minute blocks known to contain reef sites, and proportionally allocated by region, sub-region, and depth (10-20, 20-30, 30+ m) to ensure uniform geographic and bathymetric coverage, were randomly chosen. In the second stage, two known reef sites a minimum of 300 m apart within each selected block were randomly selected. Individual sites were weighted using a mean value of individual ratings based on measurements of area, relief, rugosity, and proximity to other reefs derived from side scan sonar data. Reefs with higher weighting factors had a higher probability of being selected. The few sites which have not been side scanned were assigned the average rating for the all side scanned sites in the block in which they are located. Alternates were also selected for use when another boat was found to be fishing the site or no hard bottom could be found with sonar at that site on the day it was to be sampled.

Depth coverage was ~8-30 m during 2004-07, and then was steadily expanded to deeper depths. Since 2011 it has remained at about 8 to 50 m. Sampling effort also increased during the first few years. All sampling has occurred between May and October (with the exception of four sites in November, 2013), but primarily during June through August.

### Methods

Sampling is conducted only during daytime from 1 hr after sunrise until 1 hr before sunset. Traps are baited each set with 3 previously frozen Atlantic mackerel *Scomber scombrus*, and soaked for 1.5 hr. Traps are fished as close as possible to the exact location sampled by the camera array. All trap-caught fish are identified, counted and measured to maximum total and fork length (FL only for gray triggerfish and TL only for black seabass). Both sagittal otoliths are

collected from 4-5 randomly subsampled specimens of all snappers (gray, lane, red, and vermilion), groupers (gag, red, and scamp), black seabass, red porgy, hogfish, white grunt, and gray triggerfish (first dorsal spine for the latter).

#### 5.3.5.1 Methods of Estimation

##### Data Filtering Techniques

The only data excluded from index calculations were 9 samples in 2004 and 23 in 2005 from sites which had already been sampled in those years, and 8 samples in 2014 from sites located in an ongoing red tide bloom. As a result of this screening, 33 samples from east of Cape San Blas and 7 from the west were excluded.

##### Standardization

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

##### Annual Abundance Indices

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

#### 5.3.5.2 Sampling Intensity and Time Series

Total sample size for 2004-2014 was 791 trap sets — 506 east of and 285 west of Cape San Blas. Annual overall and regional sample sizes, % positive catches, and nominal catch per trap hr with standard errors are shown in Table 5.8.4. Sampling east of Cape San Blas in 2013 was limited (down ~66%) and done later than normal (Oct. and Nov.) because of late receipt of funding, ship mechanical issues, and weather problems.

#### 5.3.5.3 Size/Age Data

Red grouper taken in chevron traps in the Panama City lab survey, 2004-2014, ranged from 211 to 798 mm FL, with a modal size of ~375-400 mm FL and a mean of 448 mm. The survey strongly targets pre-recruit individuals, especially east of Cape San Blas, where mean size was 416 mm FL and 81% were below the minimum legal size limit of 487 mm FL, compared to a

mean size of 509 mm and 44% < 487 mm west of the Cape (Figure 5.9.8). East of the Cape, 20% of the fish were <350 mm and only 4% were >600 mm, while in the west only 6% were <350 mm but 21% were >600 mm. This pattern can also be clearly seen in the annual length composition data from 2005-2009 (Figure 5.9.9), the years when the distribution of depths sampled was quite different east and west of Cape San Blas. Despite small sample sizes in some years, annual size structure data revealed at least two obvious and one probable mode which tracked for a few to several years and steadily shifted to increasingly larger sizes (Figure 5.9.9). The first mode observed, at around 325-350 mm FL, was present in 2004 when the trap survey began, and was clearly identifiable through 2006 when about 400-450 mm. The most persistent modal group appeared in 2007 at ~250 mm FL and was readily identifiable every year through 2014. These patterns suggest different, strong cohorts were moving through the population during those periods.

Not surprisingly, given the regional differences observed in size structure, red grouper were also younger east of the Cape (1- 8 yr, mode 3-4 yr) than west (1-19 yr, mode 5 yr) (Figure 5.9.10). Annual age structure data revealed that the obvious size modes represented the 1999, 2002, 2006, and 2007 cohorts. No new strong year classes have been detected since the 2007 cohort.

#### 5.3.5.4 Catch Rates

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

#### 5.3.5.5 Uncertainty and Measures of Precision

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

#### 5.3.5.6 Comments on Adequacy for Assessment

The Panama City trap survey was carefully considered by the index working group. Though it showed very similar trends in proportions of positive samples and CPUE with the concurrent Panama City video survey, the index group decided not to recommend it for inclusion in the assessment because 1) it covered the same area and time period as the latter and less area and a shorter time period than the combined SEAMAP, Panama City, and FWRI video index, 2) the

trap data were more variable than the video data, and 3) traps were more selective than video gear.

### 5.3.6 FWRI Video

The FWRI reef fish video survey includes a portion of the West Florida Shelf (WFS) bounded by 26° and 28° N latitude and depths from 10 – 110 m. The boundaries of the WFS sampling universe were chosen to compliment ongoing NMFS – Pascagoula and NMFS – Panama City reef-fish surveys. To assure adequate spatial sampling coverage, the WFS survey area was subdivided into four sampling zones comprised of two NMFS statistical zones (Tampa Bay: NMFS statistical zone 5; Charlotte Harbor: NMFS statistical zone 4) and two depth zones (Nearshore: 10 – 37 m; Offshore: 37 – 110 m). Prior to conducting exploratory sampling in 2008, the WFS survey area was subdivided into 1 km x 1 km sampling units. Results from 2008 indicated that the 1 km x 1 km spatial scale was too large in relation to the small-scale habitat features characteristic of the WFS; accordingly, from 2009 onward the WFS survey area was subdivided into 0.1 nm x 0.3 nm sampling units (E/W by N/S). Overall sampling effort (annual goal of 200 sampling units) was proportionally allocated among the four sampling zones (TBN: Tampa Bay Nearshore; TBO: Tampa Bay Offshore; CHN: Charlotte Harbor Nearshore; CHO: Charlotte Harbor Offshore) based on habitat availability, and specific sampling units were selected randomly within each sampling zone.

For the 2008 reef fish survey, the identification of sampling units with an increased probability of containing reef habitat (and inclusion in the sampling frame for the reef-fish survey) was based on bottom rugosity calculated from 100-m-resolution interpolated bathymetry data. An examination of results from the 2008 survey indicated that a high proportion of sampling effort occurred at sites with no reef habitat (i.e., unconsolidated sediment). Accordingly, the sampling universe was updated in 2009 to include habitat information provided by commercial fishermen as well as published literature. Further, we implemented an adaptive strategy where a three-pass acoustic survey was conducted covering an area of 1 nm to the east and west of the pre-selected sampling unit prior to sampling. In 2009 and part of 2010, the acoustic survey was conducted using the research vessel echo sounder, whereas for part of 2010 and 2011 onward the acoustic survey was conducted using an L3- Klein 3900 side scan sonar. If these acoustic surveys

produced evidence of reef habitat in a nearby sampling unit, but not in the pre-selected sampling unit, sampling effort was randomly relocated to the nearby sampling unit.

At each sampling station, 1 – 2 stationary underwater camera arrays (SUCAs) were deployed based on the quantity and distribution of identified reef habitat. All individual gear deployments were spaced a minimum of 100 m apart. In addition to data on the relative abundance of Red Grouper, geographic coordinates, depth, physiochemical conditions (e.g., temperature, salinity, dissolved oxygen, pH), and time of day were recorded at each sampling site. SUCA deployments and collection and processing of field data were identical to those of the NMFS – Pascagoula and NMFS – Panama City surveys. Each SUCA consisted of a pair of stereo imaging system (SIS) units positioned at an angle of 180° from one another to maximize the total field of view. Each SIS unit consisted of an underwater housing containing a digital camcorder to record video and a pair of stereo cameras to capture still images at a rate of one per second. Each SUCA was baited (generally Atlantic Mackerel) and deployed for thirty minutes to assure that twenty minutes of continuous video and stereo images were recorded. Video data from one SIS per SUCA deployment were processed to quantify the relative abundance of Red Grouper (MaxN, or the maximum number of Red Grouper observed on a single video frame). When video conditions allowed, individual Red Grouper were measured to the nearest mm fork length (FL) using stereo still images and Vision Measurement System software (VMS).

#### 5.3.6.1 Methods of Estimation

The IWG recommended that a combined index from the three video surveys (NMFS, Panama City and FWRI) be used rather than having individual indices from each group.

#### 5.3.6.2 Sampling Intensity and Time Series

There were a total of 1078 stations sampled on the west Florida shelf (between latitudes 26°N and 28°N), from 2008 – 2013 (Table 5.8.3).

#### 5.3.6.3 Size/Age Data

Length frequency data are presented in Figure 5.9.11. Length data were aggregated over years because too few length measurements were available per year. Age data are not available.

#### 5.3.6.4 Comments on Adequacy for Assessment

The IWG expressed some concerns with the low proportion positives due to difficulties in identifying reef habitat during the early years of the survey (2008 and 2009). However, the high proportion positives in the later years of the survey, combined with the fact that the spatial footprint was within the heart of Red Grouper distribution, indicated that the index warranted further consideration. After further discussions, the group did not recommend the FWRI video index as a stand-alone index, primarily because it was complementary to other video surveys (NMFS – Pascagoula and NMFS – Panama City), indexing similar portions of the population. Instead, the index working group recommended the development of combined shallow-water (< 50 m) and deep-water ( $\geq 50$  m) indices using data from all three surveys (NMFS – Pascagoula, NMFS – Panama City, and FWRI). Those results are presented in Section 5.3.8.

#### 5.3.7 FWRI Trap Survey

The FWRI reef fish trap survey includes a portion of the West Florida Shelf (WFS) bounded by 26° and 28° N latitude and depths from 10 – 110 m. The boundaries of the WFS sampling universe were chosen to compliment ongoing NMFS – Pascagoula and NMFS – Panama City reef-fish surveys. To assure adequate spatial sampling coverage, the WFS survey area was subdivided into four sampling zones comprised of two NMFS statistical zones (Tampa Bay: NMFS statistical zone 5; Charlotte Harbor: NMFS statistical zone 4) and two depth zones (Nearshore: 10 – 37 m; Offshore: 37 – 110 m). Prior to conducting exploratory sampling in 2008, the WFS survey area was subdivided into 1 km x 1 km sampling units. Results from 2008 indicated that the 1 km x 1 km spatial scale was too large in relation to the small-scale habitat features characteristic of the WFS; accordingly, from 2009 onward the WFS survey area was subdivided into 0.1 nm x 0.3 nm sampling units (E/W by N/S). Overall sampling effort (annual goal of 200 sampling units) was proportionally allocated among the four sampling zones (TBN: Tampa Bay Nearshore; TBO: Tampa Bay Offshore; CHN: Charlotte Harbor Nearshore; CHO: Charlotte Harbor Offshore) based on habitat availability, and specific sampling units were selected randomly within each sampling zone. For the 2008 reef fish survey, the identification of sampling units with an increased probability of containing reef habitat (and inclusion in the sampling frame for the reef-fish survey) was based on bottom rugosity calculated from 100-m-resolution interpolated bathymetry data. An examination of results from the 2008 survey

indicated that a high proportion of sampling effort occurred at sites with no reef habitat (i.e., unconsolidated sediment). Accordingly, the sampling universe was updated in 2009 to include habitat information provided by commercial fishermen as well as published literature. Further, we implemented an adaptive strategy where a three-pass acoustic survey was conducted covering an area of 1 nm to the east and west of the pre-selected sampling unit prior to sampling. In 2009 and part of 2010, the acoustic survey was conducted using the research vessel echo sounder, whereas for part of 2010 and 2011 onward the acoustic survey was conducted using an L3- Klein 3900 side scan sonar. If these acoustic surveys produced evidence of reef habitat in a nearby sampling unit, but not in the pre-selected sampling unit, sampling effort was randomly relocated to the nearby sampling unit.

At each sampling station, 1 – 4 chevron traps were deployed based on the quantity and distribution of identified reef habitat. Each chevron trap (1.76m x 1.52m x 0.61m; 28cm throat diameter; 3.81cm vinyl-clad mesh) was baited with fresh Atlantic Mackerel prior to deployment, and allowed to soak for a target of 90 minutes prior to retrieval. All Red Grouper captured were counted and measured to the nearest mm standard length (SL) and total length (TL); results are summarized by SL. In addition to the total number of Red Grouper captured, geographic coordinates, depth, physiochemical conditions (e.g., temperature, salinity, dissolved oxygen, pH), and time of day were generally recorded at each sampling site. All sampling was conducted from June to October, and although overnight trap sets were conducted during the first two years of the survey, our analyses only included those sets conducted during daylight hours.

#### 5.3.7.1 Methods of Estimation

##### Data Filtering Techniques

Prior to conducting statistical analyses, data from overnight trap sets were removed, as were any trap set exceeding four hours in duration. In total, this excluded 281 traps from subsequent analyses. Overall, 2,186 chevron trap survey deployments were evaluated for developing indices of relative abundance for Red Grouper during the six year sampling period (2008-2013). We excluded any data points where variables of interest were not recorded or standardized sampling methods were not followed. Of the 2,186 trap samples considered for inclusion in the modeling

analysis, only four were removed based on the data subsetting approach described, leaving 2,184 samples available for Red Grouper trap analyses from 2008-2013.

### Standardization

Trap surveys produce count data that do not conform to assumptions of normality. As such distributions of count data are often modeled using Poisson or negative binomial error distributions. Further, there is evidence that our trap data may have a disproportionate number of zero counts that may differ from the standard error distributions used for count data. These data distributions are referred to as “zero-inflated” and are fairly common in ecologically based count data. Zero-inflation is considered a special case of over dispersion that cannot be easily addressed using traditional transformation procedures (Hall 2000). Due to the count nature of the data, and the possibility of inflation of the zero counts, we used four different error distribution models to construct preliminary evaluation models (i.e., Poisson, Negative Binomial, Zero-inflated Poisson and Zero-inflated Negative Binomial). The zero inflated approaches model the zero counts using two different processes, a binomial and a count process (Zuur et al. 2009).

Initially, four null models were considered utilizing both a Poisson (P) and Negative binomial (NB) error distribution (1), and both Zero-inflated Poisson (ZIP) and zero inflated Negative Binomial (ZINB) formulations (2).

$$\text{Total RG} = Y + M + D + \text{Lat} + \text{Eff} + \text{Df}$$

and

$$\text{Total RG} = Y + M + D + \text{Lat} + \text{Eff} + \text{Df} \mid Y + M + D + \text{Lat} + \text{Eff} + \text{Df}$$

We compared the variance structure of each model formulation using likelihood ratio tests (Zuur et al. 2009) and Akaike’s information theoretic criterion (AIC; Zuur et al. 2009) to determine the most appropriate model formulation for the development of a video index for Red Grouper in the Eastern Gulf of Mexico.

A backwards step-wise model selection procedure was used to exclude unnecessary parameters from the null model (2) formulation. The optimum Red Grouper model formulation (3) was determined using a combination of AIC and likelihood ratio tests (Zuur et al. 2009). All data manipulation and analysis was conducted using R version 3.0.2 (R Core Team 2014). Modeling was conducted using the `zeroinfl` function of the `pscl` package (Jackman 2008), available from the Comprehensive R Archive Network (CRAN).

### Submodel Variables

Year: 2008 – 2013

Month: June – October

Depth: 10 – 110 m, converted to a quartile factor

Latitude: 26° - 28° N, converted to a quartile factor

Soak Time: 1 – 4 hours, in decimal hours

Number of Sand Perch: 0 – 22, included as a habitat proxy (more Sand Perch on sand)

### Annual Abundance Indices

Annual abundance indices of the FWRI trap survey are presented in Table 5.8.5.

#### 5.3.7.2 Sampling Intensity and Time Series

From 2008 – 2013, a total of 2,182 sites were sampled. Annually, the number of sites has varied between 291 and 506.

#### 5.3.7.3 Size/Age Data

Length frequency data are presented in Figure 5.9.12. Length data were aggregated over years. Age data were not presented here, but instead were provided to the life history working group.

#### 5.3.7.4 Catch Rates

Nominal and standardized catch rates are presented in Table 5.8.5.

#### 5.3.7.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.5 and Figure 5.9.13. Model diagnostics showed no discernible patterns of association between Pearson residuals and fitted values or the fitted values and the original data. An examination of residuals for the spatial and environmental model parameters showed no clear patterns of association, indicating correspondence to underlying model assumptions (Zuur et al. 2009). Lastly, a comparison of predicted values against original data distribution indicates a good fit between the model and original data. For diagnostic plots, refer to SEDAR 42- DW-09.

#### 5.3.7.6 Comments on Adequacy for Assessment

The index working group expressed some concerns with the low proportion positives due to difficulties in identifying reef habitat during the early years, especially 2008. However, the high proportion positives in the later years of the survey, combined with the fact that the spatial footprint was within the heart of Red Grouper distribution, indicated that the index warranted further consideration. However, because the working group felt that the proportion of the population covered in this survey was also covered by other video surveys, and that traps were more selective than video gear, this index was not recommended for inclusion in the assessment.

#### 5.3.8 Combined Video

The IWG decided to combine all video surveys from the eastern Gulf of Mexico. Summaries for each survey are provided in Sections 5.3.3, 5.3.4, and 5.3.6.

##### 5.3.8.1 Methods of Estimation

#### **Data Filtering Techniques**

All data filtering is described in each surveys respective section.

#### **Standardization**

Initially, a delta-Poisson model was developed. However, there were no significant variables to be included in the Poisson submodel. Therefore, a null Poisson submodel, containing only the intercept was used for the nonzero data (Table 5.8.6). The variables used for the binomial

submodel include year, two depth strata (>25m and <25m depth zones), and three area strata (north, central and south) (see Figure 5.9.14).

#### 5.3.8.2 Sampling Intensity and Time Series

Figure 5.9.14 illustrates the density of samples along the west Florida shelf. The time series data from each source were of different lengths: NMFS-SEAMAP: 1993-1997, 2002 and 2004-2014; PCVideo: 2005-2013; and FWRI: 2008-2013. The terminal year in the combined model was 2013.

#### 5.3.8.3 Size/Age Data

Size data from each survey is presented in Figure 5.9.6 (SEAMAP Video), Figure 5.9.7 (Panama City Video) and Figure 5.9.11 (FWRI Video).

#### 5.3.8.4 Catch Rates

Table 5.8.7 provides the standardized index.

#### 5.3.8.5 Uncertainty and Measures of Precision

Table 5.8.7 provides the list of CVs and confidence limits on the standardized index.

#### 5.3.8.6 Comments on Adequacy for Assessment

The IWG thought it most appropriate to combine all the video survey data from the three mentioned sources, due to the identical sampling methodologies. This index of abundance shows similar trends from other indices in the later years; and being the longest fishery-independent index, the IWG recommends its use in the base model.

### 5.3.9 Dry Tortugas RVC

#### 5.3.9.1 Methods of Estimation

This visual census employs a two stage stratified random sample design. The sampling frame includes all mapped hardbottom habitats that are at depths less than 30m. The sampling frame is divided into primary sample units (PSU), which are 200 m x 200 m grid cells. Two single stage units (SSU) are sampled within each PSU. A SSU is comprised of a diver buddy pair, where

each diver conducts a separate 15m diameter Bohnsack point count. All fish within the survey cylinder are sized and counted. Red grouper individual lengths are reported to the centimeter.

Density and length mean estimates are first made by averaging diver pairs to get SSU abundance and length composition. The two SSUs are then averaged for a PSU estimate with a variance. Strata estimates are made by averaging all PSUs in a stratum. Strata are defined by habitat types and spatial management type (i.e., inside or outside MPAs). A domain wide estimate is made for inside and outside MPAs where the strata are weighted by total area.

While, the RVC program has been collecting data in the Dry Tortugas since 1999, sampling has not been conducted in all years. Figure 5.9.15 shows the spatial distribution of all sampled sites since 1999.

#### Annual Abundance Indices

The red grouper mean density estimates, overall and separated into pre-exploited red grouper (i.e., length < 50cm) and exploited red grouper (i.e., length  $\geq$  50cm) from the Dry Tortugas RVC data are shown in Figure 5.9.16. The trend in the overall mean density declined between 1999 and 2010. In 2012, overall mean density was as high as the mean density observed in 1999 (Table 5.8.8 and Figure 5.9.16a). The trend in the overall mean density is driven by the mean density of the pre-exploited size class (Figure 5.9.16b). The mean density of legal sized red grouper varied from year to year, but increased between 1999 and 2004, declined between 2004 and 2006, and then exhibited a generally increasing trend between 2006 and 2012 (Figure 5.9.16b).

#### 5.3.9.2 Sampling Intensity and Time Series

Sampling intensity and the time-series are summarized in Table 5.8.8.

#### 5.3.9.3 Size/Age Data

Size data are available for pre-exploited and exploited length classes. The mean length of exploited length classes (i.e., greater than 50 cm) are summarized in Table 5.8.9 and Figure 5.9.17. Mean length of legal sized red grouper increased between 1999 and 2004 and has generally declined since 2004.

#### 5.3.9.4 Catch Rates

Catch rates are not available from this survey, however, mean density estimates are available and summarized in Table 5.8.8 and Figure 5.9.16.

#### 5.3.9.5 Uncertainty and Measures of Precision

Estimates of standard error are summarized in Table 5.8.8 and Figure 5.9.16.

#### 5.3.9.6 Comments on Adequacy for Assessment

The index working group did not recommend this index for inclusion in the stock assessment.

### 5.4 FISHERY-DEPENDENT MEASURES

#### 5.4.1 Headboat Survey

Rod and reel catch and effort from party (head) boats in the Gulf of Mexico have been monitored by the NMFS Southeast Region Headboat Survey (conducted by the NMFS Beaufort Laboratory) since 1986. The Headboat Survey collects data on the catch and effort for a vessel trip. Reported information includes landing date and location, vessel identification, the number of anglers, fishing location, trip duration and/or type (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight. These data were used to construct an index of red grouper catch rates in the Gulf of Mexico. The index was constructed using Generalized Linear Mixed Models, and a delta-lognormal approach.

Effort and catch were estimated by vessel trip. CPUE for each trip was defined as the reported number of red grouper landed per angler hour, where the number of angler hours was calculated using the number of reported contributors times the hours fished. To estimate hours fished, the following assumptions were necessary:

$\frac{1}{2}$  day trip = 5 hours fished

$\frac{3}{4}$  day trip = 7 hours fished

Full day trip = 10 hours fished

#### 5.4.1.1 Methods of Estimation

##### Data Filtering Techniques

Data were limited to trips in southwest Florida, northwest Florida, and Alabama. Data were also limited to include only half-day, three-quarter-day and full-day fishing trips that took place during open season for red grouper. Furthermore, trips that were flagged due to possible errors in effort information or catch amount were excluded.

The Stephens and MacCall (2004) approach was used to restrict the dataset to trips that targeted red grouper. This approach uses the species composition of each trip in a logistic regression of species presence/absence to infer if effort on a given trip occurred in habitat similar to that preferred by red grouper.

##### Standardization

A delta-lognormal approach (Lo et al., 1992) was used to develop standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion of trips that observed red grouper and the catch rates on positive trips to construct a single standardized index of abundance. A forward stepwise approach was used during the construction of each GLM. The factors in the table below were examined as possible influences on the proportion of positive trips, and the catch rates on positive trips.

##### Submodel Variables

| Factor     | DF | Details                               |
|------------|----|---------------------------------------|
| Year       | 28 | 1986-2013                             |
| Area       | 2  | NW FL & AL, SW FL                     |
| Season     | 4  | Dec-Feb, Mar-May, Jun-Aug, Sep-Nov    |
| Anglers*   | 5  | 1-10, 11-20, 21-30, 41-50, 51-60      |
| Trip Type* | 3  | Full day, Half day, Three quarter day |

\*Trip type and number of anglers were only explored as factors for modeling the proportion of positive trips.

Once a set of fixed factors was identified, interactions were examined. YEAR\*FACTOR interaction terms were included in the model as random effects. The final delta-lognormal model

was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures by Lo et al. (1992).

The variation in catch rates by vessel was examined using a “repeated measures” approach (Littell et al., 1998). The term ‘repeated measures’ refers to multiple measurements taken over time on the same experimental unit (i.e. vessel). Specifying the repeated measure “VESSEL” and the subject “VESSEL(YEAR)” allows PROC MIXED to model the covariance structure of the data. This is particularly important because catch rates may vary by vessel and because catch rates by a given vessel that are close in time can be more highly correlated than those far apart in time (Littell et al., 1998 )

### Annual Abundance Indices

The final models for the binomial and lognormal components were:

Proportion Positive = YEAR + TRIP TYPE + AREA + YEAR\*AREA

LN(CPUE) = YEAR + AREA + SEASON + YEAR\*AREA + YEAR\*SEASON

#### 5.4.1.2 Sampling Intensity and Time Series

Table 5.8.10 shows the annual number of trips and the number of positive trips that were included in this analysis.

#### 5.4.1.3 Size/Age Data

Recreational size limits for red grouper have been in place since the beginning of the available headboat time series. The size limit in Florida was 18 inches total length (TL) until 1990, when the federal size limit of 20 inches TL was imposed. It is assumed that the size range of red grouper targeted by headboats is comprised of legal sized fish.

#### 5.4.1.4 Catch Rates

Standardized catch rates are presented in Table 5.8.10 and Figure 5.9.18.

#### 5.4.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.10.

#### 5.4.1.6 Comments on Adequacy for Assessment

The headboat index was deemed adequate for use in the assessment by the index working group. This decision was based on the long time series and large spatial coverage associated with the Headboat Survey. The group noted that the Headboat index is associated with high variability and recommended that future investigations should address how to most appropriately model interactions among factors and how to most appropriately calculate the variance associated with the index.

#### 5.4.2 MRFSS

NOAA Fisheries initiated the Marine Recreational Fisheries Statistics Survey (MRFSS) in 1979 in order to obtain standardized estimates of participation, effort and catch by recreational fishermen in U.S. marine waters. Data from the MRFSS dockside interviews were used to construct an index of red grouper catch rates in the Gulf of Mexico. The index was constructed using Generalized Linear Mixed Models, and a delta-lognormal approach.

Effort and catch were estimated by interview. Total numbers of red grouper caught was equal to  $A + B1 + B2$  fish, where  $A$  = fish observed,  $B1$  = dead fish not observed, and  $B2$  = fish released alive. Numbers of  $B1$  and  $B2$  fish were corrected for non-interviewed fishermen. CPUE for each interview was defined as the total red grouper caught per angler hour, where the number of angler hours was calculated using the number of reported contributors times the number of reported hours fished.

##### 5.4.2.1 Methods of Estimation

###### Data Filtering Techniques

Data were limited to interviews that took place in west Florida (excluding Monroe County) from 1986-2013 and that reported at least 30 minutes of fishing time. Data were further filtered to remove the headboat and shore fishing modes, the inshore fishing area, and interviews that occurred before noon or after 6:59pm. Furthermore, interviews that were flagged due to possible errors in group information or catch amount were excluded.

The Stephens and MacCall (2004) approach was used to restrict the dataset to interviews that targeted red grouper. This approach uses the species composition of each interview in a logistic regression of species presence/absence to infer if effort associated with a given interview occurred in similar habitat to red grouper.

### Standardization

A delta-lognormal approach (Lo et al., 1992) was used to develop standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion of trips that observed red grouper and the catch rates on positive trips to construct a single standardized index of abundance. A forward stepwise approach was used during the construction of each GLM. The factors in the table below were examined as possible influences on the proportion of positive trips, and the catch rates on positive trips.

### Submodel Variables

| Factor            | DF | Details                                 |
|-------------------|----|-----------------------------------------|
| Year              | 28 | 1986-2013                               |
| Time of Interview | 5  | 12pm-1pm, 2pm, 3pm, 4pm, 5pm-6pm        |
| Season            | 4  | Dec-Feb, Mar-May, Jun-Aug, Sep-Nov      |
| Reg. Season       | 2  | Open, Closed                            |
| Region            | 3  | SWFL, CWFL, NWFL                        |
| Area              | 2  | <10 miles offshore, > 10 miles offshore |
| Mode              | 2  | Private, Charterboat                    |
| Hours Fished*     | 4  | 1-2, 3-4, 5-6, 7+                       |
| Anglers*          | 7  | 1, 2, 3, 4, 5, 6, 7+                    |

\*Number of hours fished and number of anglers were only explored as factors modeling success

Once a set of fixed factors was identified, interactions were examined. YEAR\*FACTOR interaction terms were included in the model as random effects. The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures by Lo et al. (1992).

### Annual Abundance Indices

The final models for the binomial and lognormal components were:

Proportion Positive = YEAR + AREA + REGION + ANGLERS + YEAR\*REGION

LN(CPUE) = YEAR + REGION + MODE + REGION\*MODE + YEAR\*REGION

#### 5.4.2.2 Sampling Intensity and Time Series

Table 5.8.11 shows the annual number of trips and the number of positive trips that were included in this analysis.

#### 5.4.2.3 Size/Age Data

No size/age data is available.

#### 5.4.2.4 Catch Rates

Standardized catch rates are presented in Table 5.8.11 and Figure 5.9.19.

#### 5.4.2.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.11.

#### 5.4.2.6 Comments on Adequacy for Assessment

The index was deemed adequate for use in the assessment by the index working group. This decision was based on the long time series and large spatial coverage associated with the MRFSS angler intercept data. The group noted that the MRFSS index is associated with high variability and recommended that future investigations should address how to most appropriately model interactions among factors and how to most appropriately calculate the variance associated with the index. An additional research recommendation related to the MRFSS dataset is to explore an index where catch and effort data are summarized for individual trips, as individual trips can be associated with multiple interviews.

### 5.4.3 Commercial Longline

Longline catch and fishing effort of commercial vessels operating in the United States Gulf of Mexico (GOM) have been monitored by the National Marine Fisheries Service (NMFS) through the coastal logbook program. The coastal logbook program in the GOM is conducted by the NMFS Southeast Fisheries Science Center. The program collects catch and effort data by trip

from permitted vessels for a number of fisheries managed by the Gulf of Mexico Fisheries Management Council. The GOM coastal logbook program began in 1990 with the objective of a complete census of reef fish fishery permitted vessel activity. Florida was the exception, where a 20% sample of vessels was targeted. Beginning in 1993, the sampling in Florida was increased to require reports from all vessels permitted in the reef fish fishery.

An index of abundance was developed for the commercial longline fleet. The data available for the analysis started in 1990 and ended in 2013, the terminal year of the assessment. Two indices were developed using these data. One index was developed from the 1990-2009 logbook data. This index represent the time-period prior to implementing the individual fishing quota (IFQ) program (“pre-IFQ”). The second index was developed from the “IFQ years”, 2010 – 2013, data.

#### 5.4.3.1 Methods of Estimation

##### Data Filtering Techniques

The data exclusions made for the analysis were as follows:

1. Multiple areas fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations was not possible; therefore, only trips in which one area fished was reported were included in these analyses.
2. Multiple fishing gears may be recorded for a single fishing trip. In such cases assigning catch and effort to a particular gear type was not possible. Trips fishing multiple gears were excluded in these analyses.
3. Logbook reports submitted 45 days or more after the trip completion data were excluded from these analyses due to the lengthy gap in reporting time.
4. Trips that fell outside the 99<sup>th</sup> percentile were considered to represent misreported data or data entry errors and were excluded from this analysis. The following were excluded from the longline analysis:
  - a) The number of hooks fished per line < 16 and the number of hooks per line > 3000,
  - b) The number of lines fished 96,
  - c) The number of days at sea > 20, and
  - d) The number of crew members > 5.

5. Seasonal closures and regulatory closures have been employed to manage the commercial red grouper fishery. Closures were implemented on the following dates: November 8, 1990 - December 31, 1990; February 15 – March 15, 1999-2008; November 15, 2004 – December 31, 2004; and October 10, 2005 – December 31, 2005. The dataset was restricted to time periods for which fishing on red grouper was allowed.
6. Approximately 99% of the red grouper commercial landings were from shrimp grids 1-10. All other shrimp grids were excluded from the analysis.
7. These indices are essentially Florida indices. Between 1990 and 1992 only 20% of vessels were required to report in Florida; therefore, the years 1990, 1991, and 1992 were excluded from the analysis.
8. Trips fishing more the 24 longline sets per day were excluded from this analysis.

Targeted red grouper trips were identified using the Stephens and MacCall (2004) approach, where trips are subset based upon the reported species composition of the landings. This method is intended to identify trips that fished in locations containing red grouper habitat and, therefore, had the potential of catching red grouper. *This was done for the pre-IFQ index.* Prior to using Stephens-MacCall, the percentage of trips catching red grouper was ~74% on average. After implementing Stephens-MacCall, the percentage of trips catching red grouper was ~94% on average.

Stephens-MacCall was not applied to the IFQ-index. The percentage of trips capturing red grouper ranged between 77% and 87%.

#### Catch rate calculation

Longline catch rates were calculated on a per trip basis. For each trip, catch per unit effort was calculated as:

CPUE = pounds of red grouper/(number of longline sets\*number of hooks per set)

The number of hours fished is an unreliable metric of effort for the longline fleet due to misreporting. Therefore, calculating CPUE by hook-hour could not be done for the longline data, as was done for the commercial handline index.

Standardization

Given the high proportion of positive trips, a GLM assuming a binomial error distribution was inappropriate. A GLM assuming a lognormal error distribution was used to examine the above factors for effects on red grouper CPUE. Factors that significantly affected CPUE were then identified using the GLM assuming lognormal error distribution. The index was fit using the Proc Mixed procedure in SAS. All factors were modeled as fixed effects except two-way interaction terms containing YEAR that were modeled as random effects.

The pre-IFQ index model is as follows:

$$\text{LN}(\text{CPUE}) = \text{INTERCEPT} + \text{AREA} + \text{YEAR}.$$

The IFQ-index model is as follows:

$$\text{LN}(\text{CPUE}) = \text{INTERCEPT} + \text{AREA} + \text{YEAR} + \text{DEPTH\_CLOSURE}.$$

Submodel Variables

The factors that were explored for model development were as follows:

**Pre-IFQ index**

| Factor | Levels | Value                |
|--------|--------|----------------------|
| Year   | 17     | 1993 - 2009          |
| Area   | 10     | Shrimp grids: 1 - 10 |
| Month  | 12     | Month of year        |

**IFQ-index**

| Factor              | Levels | Value                                                                                                                                                                                                                     |
|---------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Year                | 4      | 2010 - 2013                                                                                                                                                                                                               |
| Area                | 10     | Shrimp grids: 1 - 10                                                                                                                                                                                                      |
| Depth closure       | 2      | Open (all months except June, July, and August), Closure (June, July, and August). This corresponds with the management rule that excludes longline fishing at depths less than 35 fathoms during June, July, and August. |
| Allocation category | 3      | Low (1-7237 lbs), mid (7238 – 26302 lbs), and high (26303 – 206249 lbs) allocation                                                                                                                                        |

Annual Abundance Indices

### **Pre-IFQ index**

The pre-IFQ standardized index is summarized in Table 5.8.12 and shown in Figure 5.9.20. After an initial decline between 1993 and 1994, the standardized index had an increasing trend until 2005. The standardized index declined in 2006 and 2007, followed by an increase in 2008. Index values in 2008 and 2009 were similar.

### **IFQ index**

The IFQ standardized index is summarized in Table 5.8.13 and shown in Figure 5.9.21. The lowest catch rate was in 2010 followed by an increase in 2011 and 2012 and a decline in 2013.

#### 5.4.3.2 Sampling Intensity and Time Series

Commercial longline logbook data are available from 1990-2013 for this assessment. As stated in Section 5.4.3.1, only the years 1993-2013 are used in this analysis.

#### 5.4.3.3 Size/Age Data

Size and age data associated with the commercial longline data are available and are summarized in a separate section of this report.

#### 5.4.3.4 Catch Rates

The normalized catch rates for the pre-IFQ and IFQ-indices are summarized in Tables 5.8.12 and 5.8.13 and shown in Figures 5.9.20 and 5.9.21.

#### 5.4.3.5 Uncertainty and Measures of Precision

Estimates of the coefficient of variation associated with each annual CPUE estimate are summarized in Tables 5.8.12 and 5.8.13.

#### 5.4.3.6 Comments on Adequacy for Assessment

The Index Work Group recommended the pre-IFQ index for use in the stock assessment. The IFQ-index was not recommended for use in the stock assessment given that the influence of the IFQ program on fisher behavior is not well understood.

### *5.4.4 Commercial Vertical Line*

Data from the National Marine Fisheries Service (NMFS) coastal logbook program were used to construct abundance indices of red grouper for the eastern Gulf of Mexico (statistical areas 1-11; i.e., Dry Tortugas to Mississippi). Those indices included the years 1993-2009 prior to the implementation of Individual Fishing Quotas (IFQs) for red grouper (the pre-IFQ index) and the years 2010-2013 (IFQ index). Two indices were constructed because the implementation of the IFQ system is believed to have changed fishing behavior and catchability compared to earlier years. Such a change prevents the direct comparison of CPUE during 2010-2013 with CPUE of earlier years.

#### 5.4.4.1 Methods of Estimation

##### Data Filtering Techniques

Coastal logbook data were filtered to remove clearly erroneous data (e.g., fishing more than 24 hours per day), outliers (effort data beyond the 99.5 percentile of the population), and data reported more than 45 days following the completion of the fishing trip. That last filter was used because of low confidence in the accuracy of such late reported data. In addition, data from red grouper closed seasons were also excluded from the analysis. Data from the years 1990-1992 were excluded from the analysis due to partial reporting from Florida during those first three years of the coastal logbook program. Finally, coastal logbook data were subset using the Stephens and MacCall (2004) method for identifying trips with effort in presumptive red grouper habitat.

##### Standardization

The delta lognormal model approach (Lo *et al.* 1992) was used to construct the standardized indices of abundance. Parameterization of each model was accomplished using a GLM analysis (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA). For each GLM analysis of proportion positive trips, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. During the analysis of catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. The linking function selected was “normal”, and the response variable was  $\log(\text{CPUE})$  where  $\log(\text{CPUE}) = \ln(\text{pounds of red$

grouper/hook hours fished). All 2-way interactions among significant main effects were examined. Higher order interaction terms were not examined.

A forward stepwise regression procedure was used to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ( $p < 0.05$ ), and the reduction in deviance per degree of freedom was  $\geq 1\%$ . This model then became the base model, and the process was repeated, adding factors and interactions individually until no factor or interaction met the criteria for incorporation into the final model.

Once a set of fixed factors was identified, the influence of the YEAR\*FACTOR interactions were examined. YEAR\*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike’s Information Criterion (AIC), Schwarz’s Bayesian Criterion (BIC), and a chi-square test of the difference between the – 2 log likelihood statistics between successive model formulations (Littell et al. 1996).

The final delta-lognormal models were fit using the SAS GLIMMIX macro (Russ Wolfinger, SAS Institute). To facilitate visual comparison, relative indices and relative nominal CPUE series were calculated by dividing each value in the series by the mean cpue of the series.

Submodel Variables

For the pre-IFQ index construction, five factors were considered as possible influences on the proportion of trips that landed red grouper and on the catch rate of red grouper. An additional factor, number of hook hours fished, was examined for its effect on the proportion of positive trips. In order to develop a well-balanced sample design it was necessary to define categories within some of the factors examined:

| Factor | Levels | Value                                                |
|--------|--------|------------------------------------------------------|
| YEAR   | 17     | 1993-2009                                            |
| AREA   | 4      | Gulf of Mexico statistical areas 1-5, 6, 7, and 8-11 |
| DAYS   | 3      | 1 day at sea, 2-3 days at sea, 5 or more days at sea |
| MONTH  | 12     | Month of the year                                    |

|                    |   |                                                       |
|--------------------|---|-------------------------------------------------------|
| CREW               | 3 | 1, 2, 3 or more crew members                          |
| Hook hours fished* | 4 | <33, 33-96, 97-294, and 295 or more hook hours fished |

\*Hook hours tested for inclusion in the proportion positive (binominal) model

An additional factor, allocation, was examined when constructing the IFQ index. Total red grouper IFQ allocation was assumed to be the sum of red grouper, red grouper multi, and gag grouper multi allocation available to a vessel on a fishing trip. In cases where vessel owners/IFQ shareholders had multiple IFQ accounts, the sum of all red grouper allocation, as defined above, was assigned to trips reported by vessels owned by that IFQ shareholder. Allocation categories were:

- No allocation
- 1-1,166 pounds of allocation
- 1,167-3,716 pounds of allocation
- 3,717-10,300 pounds of allocation
- 10,301 pounds or more of allocation

#### Annual Abundance Indices

Nominal and standardized abundance indices are provided in Tables 5.8.14 and 5.8.15 and Figures 5.9.22 and 5.9.23.

##### 5.4.4.2 Sampling Intensity and Time Series

Data were available from fisher-reported commercial logbooks for the years 1993-2013. Reporting to the coastal logbook program is mandatory for commercial fishers with federal fishing permits and, therefore, is presumed to be a census of commercial red grouper fishing. Numbers of reported trips per year are provided in Tables 5.8.14 and 5.8.15.

##### 5.4.4.3 Size/Age Data

No size information is directly available in the commercial coastal logbook data set (reports were in pounds landed); however, size composition presumably matches that provided in Trip Interview Program data for commercial vertical line landings.

#### 5.4.4.4 Catch Rates

Nominal and standardized CPUE (pounds landed per hook hour fished) are provided in Tables 5.8.14 and 5.8.15.

#### 5.4.4.5 Uncertainty and Measures of Precision

Coefficients of variation per year for the constructed index are provided in Tables 5.8.14 and 5.8.15.

#### 5.4.4.6 Comments on Adequacy for Assessment

##### Pre-IFQ index

The working group found that the index was properly constructed and recommended its use in the assessment model(s). The group also recommended that alternate methods for calculating variance, modeling of 'success' rather than 'proportion positive', and use of 'proc glimmix' rather than the 'glimmix macro' be explored. That work has begun, but could not be adequately explored and evaluated prior to the data deadline. Those tasks/recommendations require more discussion as to the appropriateness of their adoption as standard methods in constructing indices of abundance.

##### IFQ index

This index was not recommended for use in the assessment because the distribution of the logs of calculated CPUEs were not normally distributed, violating an assumption of the analysis (Figure 5.9.24). The distribution of the logs of trip specific CPUEs varied by the amount of IFQ allocation available to vessels. The distribution of log CPUE from trips by vessels with low amounts of allocation was bimodal (Figure 5.9.25A), but approached a normal distribution for those trips with the highest amounts of red grouper allocation (Figure 5.9.25D). The distribution of log CPUE among vessels with intermediate amounts of allocation was bimodal, but with a secondary peak much lower than the mode (Figure 5.9.25B and C). There was insufficient time prior to the data deadline to investigate alternative data transformations or analyses.

#### 5.4.5 Headboat Observer Discard

#### 5.4.5.1 Methods of Estimation

Harvested red grouper were excluded from this index to avoid overlap with other fisheries-dependent indices that measure abundance of legal-sized harvested fish and provide a longer time series. Only single day headboat trips sampled from the two regions with the most consistent observer coverage throughout the time series were included in this index. Other regions in Florida and Alabama that have had inconsistent observer coverage are not included in this index. Multi-day trips from the Tampa Bay region were also excluded since the majority of red grouper caught during these trips are legal sized.

In the Tampa Bay region, red grouper were present on 89% of trips; therefore, all trips in this region are considered potential red grouper trips. In the Panhandle, no red grouper were observed from the majority of trips sampled, and clustering methods were explored to determine the subset of trips from this region to include in an index. The Stephens and McCall method was explored; however, due to the frequency of false negatives (positive trips with a low estimated probability for red grouper presence), this was not a reliable method for identifying red grouper trips in the region. Hierarchical cluster analysis revealed close association between red grouper and numerous reef associated fishes that are abundant in the panhandle (including vermilion snapper, red snapper, and porgies). The species composition for clustering was sensitive to Morisita and Horn-Morisita aggregation indices, and both methods included the most frequently caught species in the panhandle region (red snapper, vermilion, gray triggerfish, red porgy). So in both cases, no trips were dropped from consideration for a red grouper index. Therefore, all single-day headboat trips sampled from the Tampa Bay and panhandle regions were included in this index, regardless of red grouper presence.

#### Standardization

Separate GLMs were constructed for the binomial presence/absence of red grouper discards and CPUE for positive trips (expressed as the log of discards per observed angler hour). The GLMs were constructed using the GLIMMIX procedure in SAS. A total of 33 unique headboat vessels were sampled repeatedly throughout the time series, and CPUE is likely correlated with the region where individual vessels operate from, patterns in the types of trips offered, locations vessel operators choose to fish, and other potential factors. Correlation within repeated

observations on the same vessels was accounted for with a generalized estimating equation (GEE) using the random statement in GLIMMIX (Stokes et al. 2000). To ensure that similar types of trips were clustered together, clusters were defined by vessel and trip type, with trip types defined as half-day (<6 hours), three-quarter-day (6 to <9 hours), or full day (9 hours or longer). Year and region were included as covariates in the model. One other covariate, depth fished, improved the model fit but was not included due to missing values for a large portion of trips in one year (2007) that impacted sample size.

### Annual Abundance Indices

Results for the standardized index of abundance are provided in Table 5.8.16.

#### 5.4.5.2 Sampling Intensity and Time Series

This index includes headboat trips sampled in northwest Florida and the central west coast of Florida adjacent to Tampa Bay (Figure 5.9.26) from 2005 through 2007 and June 2009 through 2013.

#### 5.4.5.3 Size/Age Data

The majority of red grouper caught from single-day headboat trips are below the legal size limit of 20" TL. Red grouper of harvestable size are more frequently encountered on multi-day trips that take place farther offshore. Only red grouper discards are included in this index to avoid overlap with other fishery-dependent indices.

#### 5.4.5.4 Catch Rates

Nominal (measured as catch per observed angler-hour) and standardized CPUE are present in Table 5.8.16 and Figure 5.9.27.

#### 5.4.5.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.16.

#### 5.4.5.6 Comments on Adequacy for Assessment

The workgroup felt this was a viable index for pre-harvest recruits but did not recommend it for use in the assessment. The size ranges of fish observed in this survey overlap with the combined

NMFS and FWC video index, and the geographic range and length of the time series is shorter for this index. If only one fishery-dependent index may be used in the assessment model to represent the headboat fleet, the workgroup favored use of the headboat logbook index (Southeast Headboat Survey) over this index. It should be noted that this index only measures CPUE for sub-legal sized fish and does not overlap with the headboat logbook index, which only measures CPUE for harvested red grouper.

## 5.5 CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS

After thoroughly reviewing the datasets listed above and their respective indices of abundance, the IWG recommended that the following indices be used in the assessment: SEAMAP Summer Groundfish, NMFS Bottom Longline, Combined Video, MRFSS, Headboat, Commercial Longline and Commercial Vertical Line. Table 5.8.17 contains the index values and CVs for all surveys/datasets recommended for use. Figure 5.9.28 has the indices arranged by portion of the population they represent, overlaid with one another.

Of those datasets/indices not recommended for use, three (SEAMAP Video, Panama City Video, and FWRI Video) were combined into the single Combined Video index. Both the Panama City Trap and FWRI Trap were not recommended because they covered the same portion of the population as the Combined Video Index and the IWG felt the Combined Video was a better index because of the longer time series and more complete spatial coverage.

The Commercial Trap and Everglades National Park Creel Survey were reviewed, however because of the low number of red grouper present in the data and the lack of use in the previous stock assessment these indices were not recommended for use.

Report cards for all the indices can be found in SEDAR42-DW-19.

## 5.6 RESEARCH RECOMMENDATIONS

- The IWG made note that the delta-lognormal index may not be the most appropriate distribution with some of the data presented and that alternative distributions should be considered. In addition, there is some variation in the SAS code used by the various labs to produce the indices. The recommendation is that a best practices workshop be convened to fully investigate different statistical models and produce a standard version

of the appropriate programming code. Further, the use of R in place of SAS should be explored if the workshop warrants such consideration.

- As part of the proposed workshop, the approach to modeling 'success' in binomial portion of the delta models needs investigation. Currently, some labs model the 'proportion positive' rather than 'success' which can be an issue when used improperly.
- A calibration study is needed between the FWRI/NMFS video survey. The standardized reef systems are well suited for rigorous calibration studies, which could also include other sampling methods. In addition, exploration is needed for incorporating standardized video habitat covariates in the models.
- An exploration of the effects of IFQ's on the fishery dependent indices, especially the commercial handline and longline is needed. During the workshop, fishermen indicated that since the implementation of IFQ's, there has been a drastic change in fisheries behavior. There is also the possibility that dealers can directly influence this behavior. There is a need to incorporate these years into the overall time series in the most appropriate manner and to determine the means for doing so.
- The MRFSS data are clustered in the sense that some records represent individuals on the same boat (a cluster). An issue arose where the proper identifier for those clusters was not obvious in the data set. Hence, further investigation into 'party id' and what it represents in the MRFSS data is needed to accurately estimate the variability associated with the indices.
- Expansion of video surveys into Florida Bay
- Development of a YOY survey
- For reef-associated fisheries, the fishery-independent monitoring is based on known distribution of habitat. As side-scan sonar and similar activities increase the list of known habitat, there is a need to ensure that the sampling strategies for the FIM adjust appropriately and are optimized as habitat information becomes available.

## 5.7 LITERATURE CITED

Collins, M.R. 1990. A comparison of three fish trap designs. *Fish. Res.* 9:325-332.

- Ellis, D.M., and DeMartini, E.E. 1995. Evaluation of a video camera technique for indexing abundances of juvenile pink snapper, *Pristipomoides filamentosus*, and other Hawaiian insular shelf fishes. *Fish. Bull.* 93(1): 67–77.
- Gledhill, C., and A. David. 2003. Survey of fish assemblages and habitat within two marine protected areas on the West Florida shelf. NMFS, Southeast Fisheries Science Center. Report to the Gulf of Mexico Fishery Management Council.
- Gledhill, C. and W. Ingram. 2004. SEAMAP Reef Fish survey of Offshore Banks. 14 p. plus appendices. NMFS, Southeast Fisheries Science Center, Mississippi Laboratories. SEDAR 7 –DW 15.
- Hall, D.B. 2000. Zero-Inflated Poisson binomial regression with random effects: a case study. *Biometrics* 56: 1030-1039.
- Jackman, S. 2008. *Pack: Classes and methods for R developed in the political science computational laboratory*, Stanford University. Department of Political Science, Stanford University, Stanford, CA.
- Littell, R.C., P.R. Henry and C.B. Ammerman. 1998. Statistical analysis of repeated measures data using SAS procedures. *J. Anim. Sci.* 76:1216-1231.
- Lo, N.C.H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Canadian Journal of Fisheries and Aquatic Science* 49:2515-2526.
- McGovern, J. C., G.R. Sedberry and P.J. Harris. 1998. The status of reef fish stocks off the southeast United States, 1983-1996. *Gulf and Caribbean Fisheries Institute* 50: 871-895.
- Nelson, W.R., G.M. Russell, and E.J. Gutherz. 1982. Status of reef fish resource survey activities of the Southeast Fisheries Center. A special report for the Southeast Fisheries Science Center's 1982 Stock Assessment Workshop. Mississippi Laboratories, National Marine Fisheries Service. 45 pp.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. <http://www.R-project.org/>.

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. *Fisheries Research* 70:299-310.

Stokes, M.E., Davis, C.S., and Koch, G.G. 2000. *Categorical Data Analysis Using the SASSystem*, 2nd ed. SAS Institute, Inc., Cary, N.C.

Zieman, J.C., and R.T. Zieman. 1989. The ecology of the seagrass meadows of the west coast of Florida: A community profile. *Biological Report* 85(7.25). U.S. Fish and Wildlife Service.

Zuur, A.F., E.N. Ieno, N.J. Walkder, A.A. Saveliev, and G.M. Smith. 2009. *Mixed effects models and extensions in ecology with R*. Spring Science and Business Media, LLC, New York, NY.

## 5.8 TABLES

**Table 5.8.1.** Indices of red grouper abundance developed for SEAMAP Summer Groundfish Survey from 2009-2013. The nominal frequency of occurrence, the number of samples (N), the delta-lognormal (DL) index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| Survey Year | Nominal Frequency | N   | DL Index | Scaled Lo Index | CV      | LCL     | UCL     |
|-------------|-------------------|-----|----------|-----------------|---------|---------|---------|
| 2009        | 0.34711           | 121 | 1.18369  | 1.47025         | 0.26932 | 0.86605 | 2.49597 |
| 2010        | 0.31746           | 126 | 0.76371  | 0.94861         | 0.27511 | 0.55268 | 1.62818 |
| 2011        | 0.24390           | 123 | 0.75150  | 0.93343         | 0.29512 | 0.52369 | 1.66375 |
| 2012        | 0.28090           | 178 | 0.76632  | 0.95184         | 0.25543 | 0.57570 | 1.57374 |
| 2013        | 0.25000           | 128 | 0.56024  | 0.69587         | 0.28890 | 0.39500 | 1.22589 |

**Table 5.8.2.** Indices of red grouper abundance developed for NMFS Bottom Longline Survey 2001-2013. The nominal frequency of occurrence, the number of samples (N), the delta-lognormal (DL) Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| Survey Year | Frequency | N   | DL Index | Scaled Index | CV      | LCL     | UCL     |
|-------------|-----------|-----|----------|--------------|---------|---------|---------|
| 2001        | 0.21505   | 93  | 0.73588  | 0.64446      | 0.29285 | 0.36312 | 1.14380 |
| 2002        |           |     |          |              |         |         |         |
| 2003        | 0.34188   | 117 | 1.01705  | 0.89070      | 0.20235 | 0.59667 | 1.32962 |
| 2004        | 0.41837   | 98  | 1.65489  | 1.44930      | 0.19234 | 0.98994 | 2.12181 |
| 2005        | 0.25000   | 40  | 0.62097  | 0.54383      | 0.40445 | 0.24968 | 1.18452 |
| 2006        | 0.28205   | 39  | 0.56797  | 0.49741      | 0.39043 | 0.23418 | 1.05653 |
| 2007        | 0.19048   | 42  | 0.87920  | 0.76998      | 0.46373 | 0.31852 | 1.86132 |
| 2008        | 0.26667   | 60  | 0.60496  | 0.52980      | 0.32099 | 0.28321 | 0.99110 |
| 2009        | 0.34921   | 63  | 0.93405  | 0.81801      | 0.26314 | 0.48754 | 1.37249 |
| 2010        | 0.32836   | 67  | 1.25711  | 1.10094      | 0.26413 | 0.65494 | 1.85067 |
| 2011        | 0.40164   | 122 | 2.30746  | 2.02080      | 0.18133 | 1.41025 | 2.89570 |
| 2012        | 0.46939   | 49  | 2.14000  | 1.87415      | 0.25422 | 1.13615 | 3.09152 |
| 2013        | 0.34043   | 47  | 0.98270  | 0.86062      | 0.30477 | 0.47418 | 1.56199 |

**Table 5.8.3.** Survey effort for the three video surveys and the combined video totals.

| Year         | SEAMAP V    | PC V       | FWRI V      | Total       |
|--------------|-------------|------------|-------------|-------------|
| 1993         | 114         |            |             | 114         |
| 1994         | 75          |            |             | 75          |
| 1995         | 54          |            |             | 54          |
| 1996         | 125         |            |             | 125         |
| 1997         | 153         |            |             | 153         |
| 1998         |             |            |             |             |
| 1999         |             |            |             |             |
| 2000         |             |            |             |             |
| 2001         |             |            |             |             |
| 2002         | 151         |            |             | 151         |
| 2003         |             |            |             |             |
| 2004         | 148         |            |             | 148         |
| 2005         | 261         | 41         |             | 302         |
| 2006         | 273         | 109        |             | 382         |
| 2007         | 298         | 73         |             | 371         |
| 2008         | 190         | 89         | 109         | 391         |
| 2009         | 249         | 111        | 180         | 541         |
| 2010         | 204         | 148        | 151         | 504         |
| 2011         | 322         | 159        | 221         | 702         |
| 2012         | 261         | 159        | 236         | 657         |
| 2013         | 147         | 104        | 181         | 432         |
| <i>Total</i> | <i>3025</i> | <i>993</i> | <i>1078</i> | <i>5102</i> |

**Table 5.8.4.** Annual trap survey sample sizes, % positive catches, mean catch per trap hour, and standard errors of red grouper east and west of Cape San Blas, 2004-2014, in the Panama City trap survey.

| Year | Total sites sampled |      |       | % Positive catches |      |       | Mean nominal catch/trap hr |       |       | Standard error |       |       |
|------|---------------------|------|-------|--------------------|------|-------|----------------------------|-------|-------|----------------|-------|-------|
|      | East                | West | Total | East               | West | Total | East                       | West  | Total | East           | West  | Total |
| 2004 | 16                  | 18   | 34    | 50.0               | 33.3 | 41.2  | 0.415                      | 0.313 | 0.361 | 0.135          | 0.134 | 0.094 |
| 2005 | 44                  | 18   | 62    | 36.4               | 50.0 | 40.3  | 0.371                      | 0.600 | 0.437 | 0.086          | 0.171 | 0.079 |
| 2006 | 68                  | 23   | 91    | 13.2               | 30.4 | 17.6  | 0.175                      | 0.433 | 0.240 | 0.057          | 0.146 | 0.057 |
| 2007 | 44                  | 20   | 64    | 13.6               | 5.0  | 10.9  | 0.214                      | 0.016 | 0.152 | 0.082          | 0.016 | 0.058 |
| 2008 | 50                  | 31   | 81    | 40.0               | 51.6 | 44.4  | 0.433                      | 0.502 | 0.459 | 0.088          | 0.114 | 0.069 |
| 2009 | 53                  | 29   | 82    | 54.7               | 31.0 | 46.3  | 0.470                      | 0.248 | 0.391 | 0.080          | 0.090 | 0.062 |
| 2010 | 52                  | 17   | 69    | 57.7               | 23.5 | 49.3  | 0.428                      | 0.265 | 0.388 | 0.072          | 0.145 | 0.065 |
| 2011 | 50                  | 30   | 80    | 62.0               | 50.0 | 57.5  | 0.458                      | 0.411 | 0.441 | 0.079          | 0.101 | 0.062 |
| 2012 | 59                  | 30   | 89    | 28.8               | 23.3 | 27.0  | 0.339                      | 0.198 | 0.292 | 0.081          | 0.078 | 0.060 |
| 2013 | 14                  | 37   | 51    | 14.3               | 8.1  | 9.8   | 0.214                      | 0.077 | 0.115 | 0.146          | 0.047 | 0.052 |
| 2014 | 47                  | 33   | 80    | 23.4               | 21.2 | 22.5  | 0.315                      | 0.273 | 0.298 | 0.089          | 0.097 | 0.066 |

**Table 5.8.5.** Model selection results for Zero-Inflated Negative Binomial model of Red Grouper observed during FWRI trap surveys on the West Florida Shelf, 2008-2013.

| Year | Relative Nominal CPUE | N   | Proportion positive | Standardized Index | CV    |
|------|-----------------------|-----|---------------------|--------------------|-------|
| 2008 | 0.138                 | 291 | 0.044               | 0.083              | 0.786 |
| 2009 | 0.492                 | 432 | 0.197               | 0.774              | 0.149 |
| 2010 | 0.667                 | 303 | 0.228               | 0.561              | 0.192 |
| 2011 | 2.600                 | 315 | 0.627               | 2.539              | 0.077 |
| 2012 | 0.993                 | 335 | 0.423               | 0.953              | 0.101 |
| 2013 | 1.111                 | 506 | 0.447               | 1.089              | 0.098 |

**Table 5.8.6.** Submodel development of the delta-Poisson for the combined video index.

| <i>Type III Tests of Fixed Effects for the Binomial Submodel</i> |               |               |                |                  |
|------------------------------------------------------------------|---------------|---------------|----------------|------------------|
| <i>Effect</i>                                                    | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr &gt; F</i> |
| <i>year</i>                                                      | 15            | 5083          | 6.11           | <.0001           |
| <i>area</i>                                                      | 2             | 5083          | 8.89           | 0.0001           |
| <i>depthzone</i>                                                 | 1             | 5083          | 10.04          | 0.0015           |

| <i>Parameter Estimates for Poisson Submodel</i> |                 |                       |           |                |                    |
|-------------------------------------------------|-----------------|-----------------------|-----------|----------------|--------------------|
| <i>Effect</i>                                   | <i>Estimate</i> | <i>Standard Error</i> | <i>DF</i> | <i>t Value</i> | <i>Pr &gt;  t </i> |
| <i>Intercept</i>                                | 0.2848          | 0.02134               | 1650      | 13.34          | <.0001             |

PRE-DECISIONAL

**Table 5.8.7.** Indices of red grouper abundance developed for the Combined Video Survey from 2001-2013. The nominal frequency of occurrence, the number of samples (N), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| Survey Year | Nominal Frequency | N   | Index (mincount units) | Scaled Index | CV      | LCL     | UCL     |
|-------------|-------------------|-----|------------------------|--------------|---------|---------|---------|
| 1993        | 0.25439           | 114 | 0.32903                | 0.76603      | 0.16446 | 0.55253 | 1.06205 |
| 1994        | 0.33333           | 75  | 0.43464                | 1.01191      | 0.16713 | 0.72605 | 1.41030 |
| 1995        | 0.35185           | 54  | 0.44861                | 1.04444      | 0.19073 | 0.71564 | 1.52431 |
| 1996        | 0.30400           | 125 | 0.41926                | 0.97610      | 0.13605 | 0.74450 | 1.27975 |
| 1997        | 0.38562           | 153 | 0.50992                | 1.18718      | 0.10449 | 0.96384 | 1.46228 |
| 1998        |                   |     |                        |              |         |         |         |
| 1999        |                   |     |                        |              |         |         |         |
| 2000        |                   |     |                        |              |         |         |         |
| 2001        |                   |     |                        |              |         |         |         |
| 2002        | 0.36424           | 151 | 0.49702                | 1.15713      | 0.10847 | 0.93205 | 1.43657 |
| 2003        |                   |     |                        |              |         |         |         |
| 2004        | 0.41216           | 148 | 0.56506                | 1.31555      | 0.09810 | 1.08168 | 1.59998 |
| 2005        | 0.34437           | 302 | 0.46718                | 1.08767      | 0.08104 | 0.92517 | 1.27871 |
| 2006        | 0.29843           | 382 | 0.39413                | 0.91759      | 0.08129 | 0.78012 | 1.07929 |
| 2007        | 0.17520           | 371 | 0.24277                | 0.56520      | 0.11356 | 0.45070 | 0.70880 |
| 2008        | 0.23274           | 391 | 0.29837                | 0.69465      | 0.09641 | 0.57308 | 0.84201 |
| 2009        | 0.28835           | 541 | 0.37553                | 0.87430      | 0.07249 | 0.75645 | 1.01051 |
| 2010        | 0.36111           | 504 | 0.47646                | 1.10928      | 0.06322 | 0.97765 | 1.25863 |
| 2011        | 0.40883           | 702 | 0.53536                | 1.24641      | 0.05063 | 1.12646 | 1.37913 |
| 2012        | 0.34094           | 657 | 0.44047                | 1.02549      | 0.06003 | 0.90957 | 1.15618 |
| 2013        | 0.32870           | 432 | 0.43857                | 1.02106      | 0.07425 | 0.88034 | 1.18428 |

**Table 5.8.8.** The number of PSUs, red grouper mean density (overall, pre-exploited, and exploited), and the associated standard error from the Dry Tortugas RVC.

| Year | n   | Overall      |              | Pre-exploited (length < 50cm) |              | Exploited (length >= 50cm) |              |
|------|-----|--------------|--------------|-------------------------------|--------------|----------------------------|--------------|
|      |     | Mean Density | SE (Density) | Mean Density                  | SE (Density) | Mean Density               | SE (Density) |
| 1999 | 169 | 0.74556      | 0.05537      | 0.60297                       | 0.05388      | 0.14724                    | 0.02465      |
| 2000 | 205 | 0.65806      | 0.03739      | 0.48907                       | 0.03918      | 0.18179                    | 0.02166      |
| 2001 | -   | -            | -            |                               |              |                            |              |
| 2002 | -   | -            | -            |                               |              |                            |              |
| 2003 | -   | -            | -            |                               |              |                            |              |
| 2004 | 310 | 0.58172      | 0.07462      | 0.35482                       | 0.03861      | 0.22689                    | 0.04471      |
| 2005 | -   | -            | -            |                               |              |                            |              |
| 2006 | 260 | 0.41299      | 0.04334      | 0.28938                       | 0.03645      | 0.12361                    | 0.01937      |
| 2007 | -   | -            | -            |                               |              |                            |              |
| 2008 | 338 | 0.41000      | 0.06286      | 0.24437                       | 0.03566      | 0.16563                    | 0.03204      |
| 2009 | -   | -            | -            |                               |              |                            |              |
| 2010 | 364 | 0.33129      | 0.02719      | 0.19581                       | 0.01967      | 0.13548                    | 0.01756      |
| 2011 | -   | -            | -            |                               |              |                            |              |
| 2012 | 416 | 0.75750      | 0.04758      | 0.51676                       | 0.04830      | 0.24074                    | 0.02117      |

**Table 5.8.9.** Mean length (Lbar) and standard error of red grouper with lengths greater than or equal to 500mm from the Dry Tortugas RVC.

| Year | n   | mm  | Exploited (Len >=500 mm) |        |
|------|-----|-----|--------------------------|--------|
|      |     |     | Lbar_mm                  | SE_Lmm |
| 1999 | 169 | 305 | 556.43                   | 6.69   |
| 2000 | 205 | 359 | 603.58                   | 11.94  |
| 2001 | -   | -   | -                        | -      |
| 2002 | -   | -   | -                        | -      |
| 2003 | -   | -   | -                        | -      |
| 2004 | 310 | 576 | 602.81                   | 23.11  |
| 2005 | -   | -   | -                        | -      |
| 2006 | 260 | 497 | 596.15                   | 12.01  |
| 2007 | -   | -   | -                        | -      |
| 2008 | 338 | 653 | 587.21                   | 15.89  |
| 2009 | -   | -   | -                        | -      |
| 2010 | 364 | 703 | 570.98                   | 6.27   |
| 2011 | -   | -   | -                        | -      |
| 2012 | 416 | 813 | 575.64                   | 6.54   |

**Table 5.8.10.** Relative nominal CPUE, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the NMFS SE Region headboat survey index.

| YEAR | TRIPS | POSITIVE |       | RELATIVE        |                   | LOWER<br>95% CI | UPPER<br>95% CI | CV     |
|------|-------|----------|-------|-----------------|-------------------|-----------------|-----------------|--------|
|      |       | TRIPS    | PPT   | NOMINAL<br>CPUE | RELATIVE<br>INDEX |                 |                 |        |
| 1986 | 1242  | 809      | 0.651 | 1.8953          | 1.0334            | 0.2845          | 3.7544          | 0.7183 |
| 1987 | 1055  | 788      | 0.747 | 3.1274          | 1.6494            | 0.5133          | 5.3000          | 0.6371 |
| 1988 | 998   | 772      | 0.774 | 3.5868          | 1.6056            | 0.5101          | 5.0544          | 0.6239 |
| 1989 | 1272  | 930      | 0.731 | 3.2024          | 1.5487            | 0.4727          | 5.0744          | 0.6497 |
| 1990 | 2131  | 1206     | 0.566 | 1.1943          | 0.6990            | 0.1831          | 2.6687          | 0.7525 |
| 1991 | 2209  | 1160     | 0.525 | 0.7867          | 0.4941            | 0.1198          | 2.0386          | 0.8076 |
| 1992 | 2058  | 1045     | 0.508 | 0.7488          | 0.4723            | 0.1147          | 1.9451          | 0.8063 |
| 1993 | 1962  | 916      | 0.467 | 0.5862          | 0.6343            | 0.1724          | 2.3336          | 0.7269 |
| 1994 | 1871  | 881      | 0.471 | 0.6115          | 0.5523            | 0.1442          | 2.1152          | 0.7546 |
| 1995 | 1455  | 717      | 0.493 | 2.4753          | 0.8352            | 0.2364          | 2.9504          | 0.6993 |
| 1996 | 1483  | 461      | 0.311 | 0.4419          | 0.4933            | 0.1252          | 1.9436          | 0.7746 |
| 1997 | 1117  | 361      | 0.323 | 0.8408          | 0.4750            | 0.1199          | 1.8820          | 0.7786 |
| 1998 | 1187  | 482      | 0.406 | 0.4631          | 0.5671            | 0.1467          | 2.1927          | 0.7614 |
| 1999 | 1165  | 446      | 0.383 | 0.2368          | 0.4741            | 0.1206          | 1.8641          | 0.7731 |
| 2000 | 1439  | 689      | 0.479 | 0.4683          | 0.5944            | 0.1540          | 2.2946          | 0.7603 |
| 2001 | 1036  | 467      | 0.451 | 0.3499          | 0.8726            | 0.2511          | 3.0328          | 0.6885 |
| 2002 | 923   | 412      | 0.446 | 0.3568          | 0.8929            | 0.2644          | 3.0162          | 0.6696 |
| 2003 | 1218  | 717      | 0.589 | 0.4879          | 1.4145            | 0.4900          | 4.0837          | 0.5696 |
| 2004 | 1473  | 955      | 0.648 | 0.8441          | 2.1247            | 0.7860          | 5.7434          | 0.5296 |
| 2005 | 1536  | 975      | 0.635 | 0.9737          | 2.3719            | 0.8876          | 6.3388          | 0.5227 |
| 2006 | 780   | 287      | 0.368 | 0.2924          | 0.8687            | 0.2482          | 3.0405          | 0.6932 |
| 2007 | 927   | 397      | 0.428 | 0.3731          | 0.9534            | 0.2870          | 3.1670          | 0.6586 |
| 2008 | 1558  | 692      | 0.444 | 0.5589          | 0.8800            | 0.2612          | 2.9648          | 0.6679 |
| 2009 | 1876  | 715      | 0.381 | 0.3773          | 0.6800            | 0.1950          | 2.3709          | 0.6906 |
| 2010 | 1646  | 874      | 0.531 | 0.6013          | 1.1157            | 0.3638          | 3.4216          | 0.6073 |
| 2011 | 1140  | 632      | 0.554 | 0.4965          | 1.0953            | 0.3755          | 3.1950          | 0.5760 |
| 2012 | 1648  | 1018     | 0.618 | 0.6944          | 1.4104            | 0.5122          | 3.8832          | 0.5407 |
| 2013 | 1596  | 1071     | 0.671 | 0.9282          | 1.1915            | 0.3983          | 3.5645          | 0.5917 |

**Table 5.8.11.** Relative nominal CPUE, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the MRFSS index.

| YEAR | TRIPS | POSITIVE |       | RELATIVE        |                   | LOWER<br>95% CI | UPPER<br>95% CI | CV     |
|------|-------|----------|-------|-----------------|-------------------|-----------------|-----------------|--------|
|      |       | TRIPS    | PPT   | NOMINAL<br>CPUE | RELATIVE<br>INDEX |                 |                 |        |
| 1986 | 138   | 108      | 0.783 | 1.0882          | 1.0925            | 0.6301          | 1.8945          | 0.2805 |
| 1987 | 144   | 92       | 0.639 | 0.6915          | 0.8681            | 0.4525          | 1.6653          | 0.3346 |
| 1988 | 138   | 86       | 0.623 | 1.5953          | 1.1339            | 0.5436          | 2.3650          | 0.3803 |
| 1989 | 119   | 87       | 0.731 | 1.7331          | 1.3293            | 0.7039          | 2.5102          | 0.3261 |
| 1990 | 108   | 81       | 0.750 | 1.7736          | 1.5569            | 0.8833          | 2.7441          | 0.2892 |
| 1991 | 112   | 62       | 0.554 | 1.5245          | 1.4756            | 0.7198          | 3.0253          | 0.3708 |
| 1992 | 329   | 229      | 0.696 | 1.3717          | 1.2438            | 0.6673          | 2.3182          | 0.3190 |
| 1993 | 305   | 162      | 0.531 | 0.9688          | 0.7682            | 0.3693          | 1.5979          | 0.3788 |
| 1994 | 336   | 172      | 0.512 | 0.8745          | 0.8707            | 0.4369          | 1.7351          | 0.3553 |
| 1995 | 344   | 184      | 0.535 | 1.0808          | 0.8627            | 0.4374          | 1.7015          | 0.3496 |
| 1996 | 356   | 141      | 0.396 | 0.6581          | 0.5555            | 0.2497          | 1.2359          | 0.4163 |
| 1997 | 357   | 123      | 0.345 | 0.6648          | 0.5467            | 0.2425          | 1.2326          | 0.4238 |
| 1998 | 720   | 340      | 0.472 | 0.6965          | 0.6533            | 0.3191          | 1.3374          | 0.3701 |
| 1999 | 973   | 514      | 0.528 | 0.9575          | 0.7350            | 0.3740          | 1.4446          | 0.3477 |
| 2000 | 729   | 365      | 0.501 | 0.7011          | 0.8305            | 0.4296          | 1.6054          | 0.3387 |
| 2001 | 791   | 388      | 0.491 | 0.5426          | 0.6524            | 0.3332          | 1.2776          | 0.3457 |
| 2002 | 865   | 468      | 0.541 | 0.6371          | 0.7901            | 0.4099          | 1.5228          | 0.3371 |
| 2003 | 1072  | 604      | 0.563 | 0.7479          | 0.9794            | 0.5225          | 1.8358          | 0.3221 |
| 2004 | 1492  | 1007     | 0.675 | 0.8426          | 1.2459            | 0.7184          | 2.1607          | 0.2806 |
| 2005 | 1077  | 651      | 0.604 | 0.4660          | 0.8296            | 0.4463          | 1.5423          | 0.3176 |
| 2006 | 532   | 224      | 0.421 | 0.2531          | 0.4391            | 0.2005          | 0.9617          | 0.4075 |
| 2007 | 540   | 257      | 0.476 | 0.4802          | 0.6953            | 0.3576          | 1.3519          | 0.3419 |
| 2008 | 764   | 462      | 0.605 | 0.9736          | 1.1731            | 0.6716          | 2.0489          | 0.2843 |
| 2009 | 604   | 401      | 0.664 | 1.3996          | 1.5401            | 0.9003          | 2.6346          | 0.2734 |
| 2010 | 505   | 334      | 0.661 | 1.2237          | 1.1744            | 0.6764          | 2.0389          | 0.2812 |
| 2011 | 536   | 341      | 0.636 | 1.2586          | 1.3397            | 0.7743          | 2.3180          | 0.2794 |
| 2012 | 497   | 332      | 0.668 | 1.0868          | 1.1216            | 0.6479          | 1.9416          | 0.2797 |
| 2013 | 355   | 242      | 0.682 | 1.7081          | 1.4966            | 0.8204          | 2.7299          | 0.3075 |

**Table 5.8.12.** The standardized annual commercial longline index and CV for red grouper captured in shrimp grids 1-10 in the Gulf of Mexico from 1993 - 2009. The annual nominal and standardized index (Index) values were normalized to an average value of one.

| Year | Nominal | Index  | CV     |
|------|---------|--------|--------|
| 1993 | 0.8361  | 0.9785 | 0.0535 |
| 1994 | 0.7738  | 0.7235 | 0.0474 |
| 1995 | 0.9213  | 0.7742 | 0.0491 |
| 1996 | 0.8176  | 1.0397 | 0.0513 |
| 1997 | 0.8575  | 0.9069 | 0.0428 |
| 1998 | 1.0451  | 0.9552 | 0.0441 |
| 1999 | 0.9176  | 0.9968 | 0.0438 |
| 2000 | 1.0476  | 0.8980 | 0.0465 |
| 2001 | 0.9860  | 1.0563 | 0.0447 |
| 2002 | 1.5153  | 1.0600 | 0.0471 |
| 2003 | 1.0506  | 0.9284 | 0.0453 |
| 2004 | 1.1543  | 1.1124 | 0.0440 |
| 2005 | 1.3755  | 1.4437 | 0.0455 |
| 2006 | 0.9931  | 1.0927 | 0.0435 |
| 2007 | 0.7466  | 0.7796 | 0.0502 |
| 2008 | 1.0455  | 1.1811 | 0.0496 |
| 2009 | 0.9165  | 1.0731 | 0.0731 |

**Table 5.8.13.** The standardized annual commercial longline index and CV for red grouper captured in shrimp grids 1-10 in the Gulf of Mexico from 2010 - 2013. The annual nominal and standardized index (Index) values were normalized to an average value of one.

| Year | Nominal | Index  | CV     |
|------|---------|--------|--------|
| 2010 | 0.7335  | 0.6282 | 0.0866 |
| 2011 | 1.1028  | 1.0556 | 0.0784 |
| 2012 | 1.1362  | 1.2680 | 0.0823 |
| 2013 | 1.0275  | 1.0481 | 0.0820 |

**Table 5.8.14.** Pre-IFQ index relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for red grouper constructed using commercial vertical line data.

| Year | Normalized Nominal CPUE | Trips | Proportion Successful Trips | Standardized Index | Lower 95% CI (Index) | Upper 95% CI (Index) | CV (Index) |
|------|-------------------------|-------|-----------------------------|--------------------|----------------------|----------------------|------------|
| 1993 | 0.756179                | 1,670 | 0.792                       | 0.731148           | 0.397892             | 1.343525             | 0.311394   |
| 1994 | 0.699744                | 2,239 | 0.771                       | 0.716001           | 0.392517             | 1.306077             | 0.307467   |
| 1995 | 0.780493                | 2,281 | 0.747                       | 0.788638           | 0.429262             | 1.448881             | 0.311289   |
| 1996 | 0.481552                | 2,256 | 0.701                       | 0.490723           | 0.262637             | 0.916886             | 0.320343   |
| 1997 | 0.513838                | 3,318 | 0.681                       | 0.564737           | 0.301849             | 1.056582             | 0.321058   |
| 1998 | 0.467955                | 3,874 | 0.65                        | 0.518547           | 0.277908             | 0.967557             | 0.319611   |
| 1999 | 0.746172                | 4,244 | 0.691                       | 0.739924           | 0.401314             | 1.364237             | 0.3132     |
| 2000 | 0.928729                | 4,210 | 0.738                       | 0.991072           | 0.54536              | 1.801058             | 0.305457   |
| 2001 | 1.003921                | 4,120 | 0.817                       | 1.347042           | 0.753577             | 2.40788              | 0.29665    |
| 2002 | 1.149352                | 4,192 | 0.825                       | 1.387094           | 0.776572             | 2.477593             | 0.296246   |
| 2003 | 0.888259                | 4,068 | 0.841                       | 0.947107           | 0.534658             | 1.67773              | 0.291835   |
| 2004 | 1.295183                | 3,732 | 0.882                       | 1.273959           | 0.726246             | 2.234741             | 0.286637   |
| 2005 | 1.175149                | 3,064 | 0.893                       | 1.416903           | 0.804867             | 2.494341             | 0.288524   |
| 2006 | 1.266166                | 2,768 | 0.874                       | 1.143482           | 0.645103             | 2.026886             | 0.292174   |
| 2007 | 1.550833                | 2,595 | 0.901                       | 1.206628           | 0.684535             | 2.126917             | 0.28921    |
| 2008 | 1.732271                | 2,701 | 0.897                       | 1.530894           | 0.871158             | 2.690253             | 0.287586   |
| 2009 | 1.564206                | 2,606 | 0.898                       | 1.206101           | 0.686788             | 2.118091             | 0.287235   |

**Table 5.8.15.** IFQ index relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for red grouper constructed using commercial vertical line data.

| Year | Normalized Nominal CPUE | Trips | Proportion Successful Trips | Standardized Index | Lower 95% CI (Index) | Upper 95% CI (Index) | CV (Index) |
|------|-------------------------|-------|-----------------------------|--------------------|----------------------|----------------------|------------|
| 2010 | 0.875777                | 2,066 | 0.863                       | 0.672998           | 0.619842             | 0.730713             | 0.041156   |
| 2011 | 1.077042                | 1,898 | 0.903                       | 1.24799            | 1.149515             | 1.354903             | 0.041115   |
| 2012 | 1.115281                | 2,110 | 0.873                       | 1.233445           | 1.140231             | 1.334279             | 0.039305   |
| 2013 | 0.9319                  | 1,773 | 0.897                       | 0.845566           | 0.777091             | 0.920076             | 0.042244   |

**Table 5.8.16.** Indices of red grouper abundance developed for Headboat Observer Discards from 2005-2013. The nominal frequency of occurrence, the number of samples (N), the DL Index, the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| Survey Year | Frequency | N   | DL Index | Scaled Index | CV      | LCL     | UCL     |
|-------------|-----------|-----|----------|--------------|---------|---------|---------|
| 2005        | 0.68889   | 90  | 0.11637  | 0.71381      | 0.17102 | 0.50829 | 1.00244 |
| 2006        | 0.54369   | 103 | 0.03857  | 0.23661      | 0.23070 | 0.15005 | 0.37310 |
| 2007        | 0.56075   | 107 | 0.02143  | 0.13145      | 0.23177 | 0.08319 | 0.20770 |
| 2009        | 0.69355   | 62  | 0.34522  | 2.11753      | 0.17554 | 1.49456 | 3.00016 |
| 2010        | 0.62821   | 78  | 0.27766  | 1.70310      | 0.20465 | 1.13581 | 2.55373 |
| 2011        | 0.57282   | 103 | 0.22606  | 1.38662      | 0.15510 | 1.01869 | 1.88744 |
| 2012        | 0.51087   | 92  | 0.13684  | 0.83936      | 0.17765 | 0.58998 | 1.19414 |
| 2013        | 0.54545   | 88  | 0.14208  | 0.87152      | 0.18340 | 0.60575 | 1.25389 |

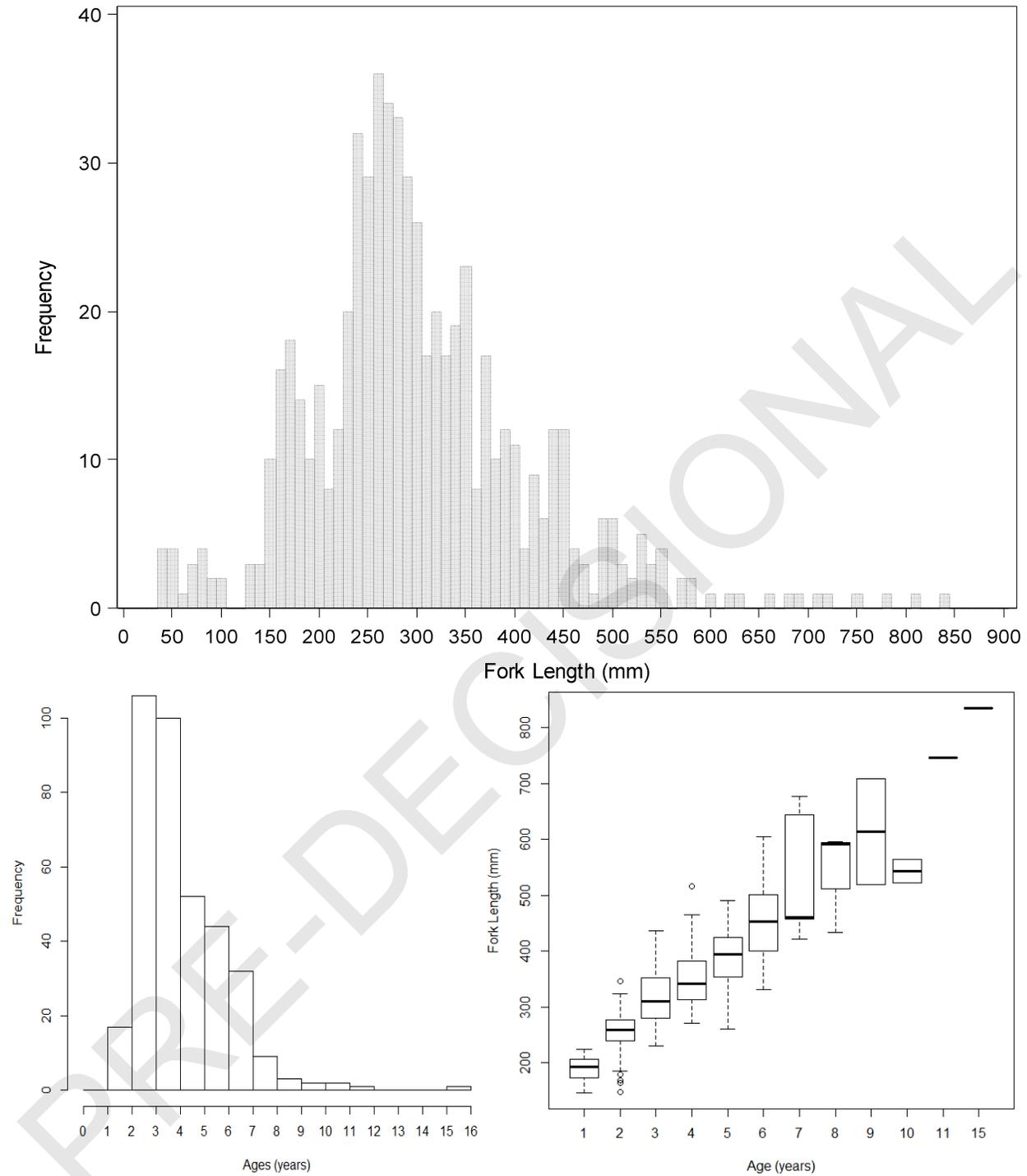
**Table 5.8.17.** Indices recommended for use for red grouper. SEAMAP GF – SEAMAP Summer Groundfish Survey, NMFS BLL – NMFS Bottom Longline Survey, VIDEO – Combined Video Survey, CLL – Commercial Longline, CVL – Commercial Vertical, HEAD – Headboat and MRFSS.

| Year | SEAMAP GF |         | NMFS BLL |         | VIDEO   |         | CLL    |        | CVL      |          | HEADBOAT |        | MRFSS  |        |
|------|-----------|---------|----------|---------|---------|---------|--------|--------|----------|----------|----------|--------|--------|--------|
|      | Index     | CV      | Index    | CV      | Index   | CV      | Index  | CV     | Index    | CV       | Index    | CV     | Index  | CV     |
| 1986 |           |         |          |         |         |         |        |        |          |          | 1.0334   | 0.7183 | 1.0925 | 0.2805 |
| 1987 |           |         |          |         |         |         |        |        |          |          | 1.6494   | 0.6371 | 0.8681 | 0.3346 |
| 1988 |           |         |          |         |         |         |        |        |          |          | 1.6056   | 0.6239 | 1.1339 | 0.3803 |
| 1989 |           |         |          |         |         |         |        |        |          |          | 1.5487   | 0.6497 | 1.3293 | 0.3261 |
| 1990 |           |         |          |         |         |         |        |        |          |          | 0.699    | 0.7525 | 1.5569 | 0.2892 |
| 1991 |           |         |          |         |         |         |        |        |          |          | 0.4941   | 0.8076 | 1.4756 | 0.3708 |
| 1992 |           |         |          |         |         |         |        |        |          |          | 0.4723   | 0.8063 | 1.2438 | 0.319  |
| 1993 |           |         |          |         | 0.76603 | 0.16446 | 0.9785 | 0.0535 | 0.731148 | 0.311394 | 0.6343   | 0.7269 | 0.7682 | 0.3788 |
| 1994 |           |         |          |         | 1.01191 | 0.16713 | 0.7235 | 0.0474 | 0.716001 | 0.307467 | 0.5523   | 0.7546 | 0.8707 | 0.3553 |
| 1995 |           |         |          |         | 1.04444 | 0.19073 | 0.7742 | 0.0491 | 0.788638 | 0.311289 | 0.8352   | 0.6993 | 0.8627 | 0.3496 |
| 1996 |           |         |          |         | 0.9761  | 0.13605 | 1.0397 | 0.0513 | 0.490723 | 0.320343 | 0.4933   | 0.7746 | 0.5555 | 0.4163 |
| 1997 |           |         |          |         | 1.18718 | 0.10449 | 0.9069 | 0.0428 | 0.564737 | 0.321058 | 0.475    | 0.7786 | 0.5467 | 0.4238 |
| 1998 |           |         |          |         |         |         | 0.9552 | 0.0441 | 0.518547 | 0.319611 | 0.5671   | 0.7614 | 0.6533 | 0.3701 |
| 1999 |           |         |          |         |         |         | 0.9968 | 0.0438 | 0.739924 | 0.3132   | 0.4741   | 0.7731 | 0.735  | 0.3477 |
| 2000 |           |         |          |         |         |         | 0.8980 | 0.0465 | 0.991072 | 0.305457 | 0.5944   | 0.7603 | 0.8305 | 0.3387 |
| 2001 |           |         | 0.64446  | 0.29285 |         |         | 1.0563 | 0.0447 | 1.347042 | 0.29665  | 0.8726   | 0.6885 | 0.6524 | 0.3457 |
| 2002 |           |         |          |         | 1.15713 | 0.10847 | 1.0600 | 0.0471 | 1.387094 | 0.296246 | 0.8929   | 0.6696 | 0.7901 | 0.3371 |
| 2003 |           |         | 0.8907   | 0.20235 |         |         | 0.9284 | 0.0453 | 0.947107 | 0.291835 | 1.4145   | 0.5696 | 0.9794 | 0.3221 |
| 2004 |           |         | 1.4493   | 0.19234 | 1.31555 | 0.0981  | 1.1124 | 0.0440 | 1.273959 | 0.286637 | 2.1247   | 0.5296 | 1.2459 | 0.2806 |
| 2005 |           |         | 0.54383  | 0.40445 | 1.08767 | 0.08104 | 1.4437 | 0.0455 | 1.416903 | 0.288524 | 2.3719   | 0.5227 | 0.8296 | 0.3176 |
| 2006 |           |         | 0.49741  | 0.39043 | 0.91759 | 0.08129 | 1.0927 | 0.0435 | 1.143482 | 0.292174 | 0.8687   | 0.6932 | 0.4391 | 0.4075 |
| 2007 |           |         | 0.76998  | 0.46373 | 0.5652  | 0.11356 | 0.7796 | 0.0502 | 1.206628 | 0.28921  | 0.9534   | 0.6586 | 0.6953 | 0.3419 |
| 2008 |           |         | 0.5298   | 0.32099 | 0.69465 | 0.09641 | 1.1811 | 0.0496 | 1.530894 | 0.287586 | 0.88     | 0.6679 | 1.1731 | 0.2843 |
| 2009 | 1.47025   | 0.26932 | 0.81801  | 0.26314 | 0.8743  | 0.07249 | 1.0731 | 0.0731 | 1.206101 | 0.287235 | 0.68     | 0.6906 | 1.5401 | 0.2734 |
| 2010 | 0.94861   | 0.27511 | 1.10094  | 0.26413 | 1.10928 | 0.06322 |        |        |          |          | 1.1157   | 0.6073 | 1.1744 | 0.2812 |
| 2011 | 0.93343   | 0.29512 | 2.0208   | 0.18133 | 1.24641 | 0.05063 |        |        |          |          | 1.0953   | 0.576  | 1.3397 | 0.2794 |
| 2012 | 0.95184   | 0.25543 | 1.87415  | 0.25422 | 1.02549 | 0.06003 |        |        |          |          | 1.4104   | 0.5407 | 1.1216 | 0.2797 |
| 2013 | 0.69587   | 0.2889  | 0.86062  | 0.30477 | 1.02106 | 0.07425 |        |        |          |          | 1.1915   | 0.5917 | 1.4966 | 0.3075 |

5.9 FIGURES



**Figure 5.9.1.** Spatial coverage of fishery-independent (blue text) and fishery-dependent (black text) indices for red grouper recommended for use. Note that all surveys covered roughly the same area, thus only one line is needed to show coverage area.



**Figure 5.9.2.** Length (top) and age (bottom) distribution of red grouper from SEAMAP Summer Groundfish Survey.

SEAMAP Summer Groundfish Red Grouper Gulf of Mexico 2009 to 2013  
Observed and Standardized CPUE (95% CI)

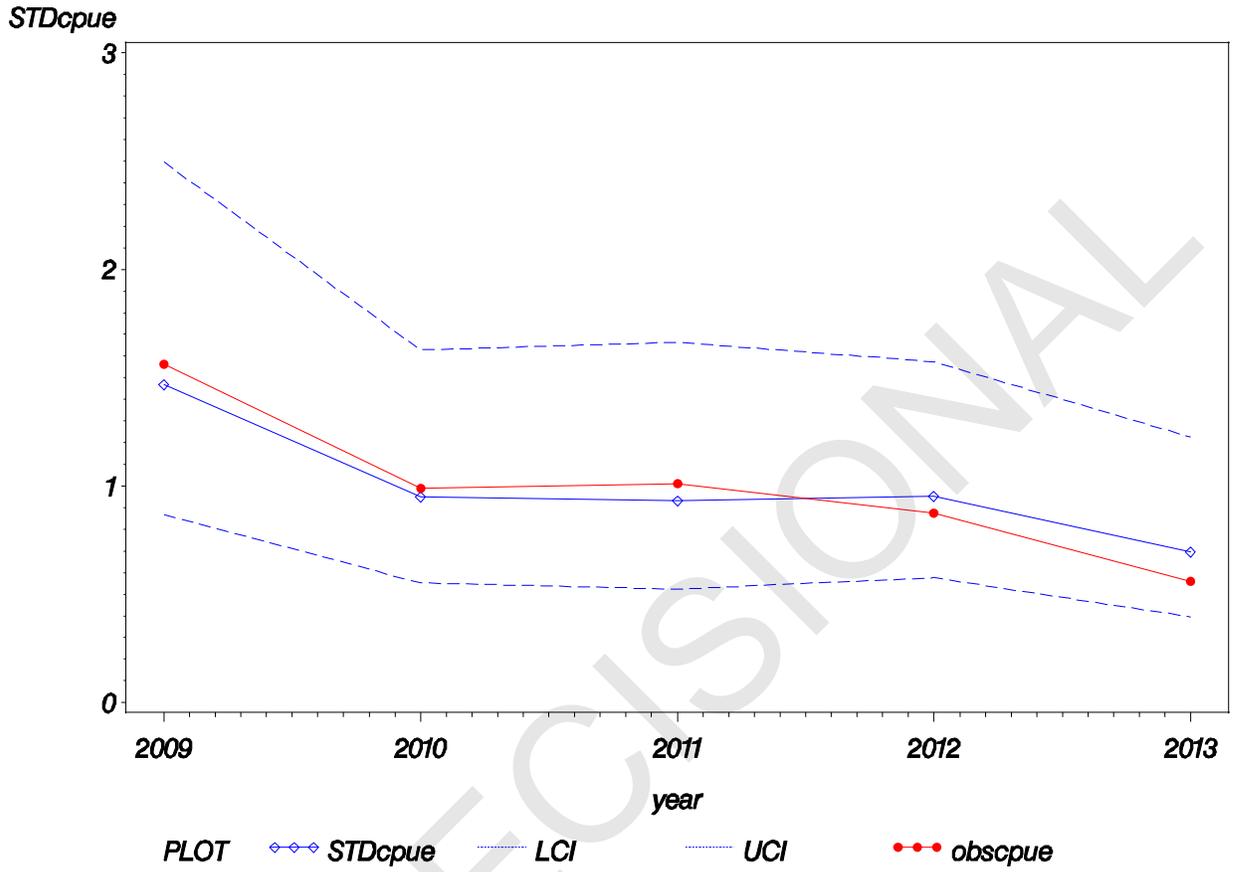
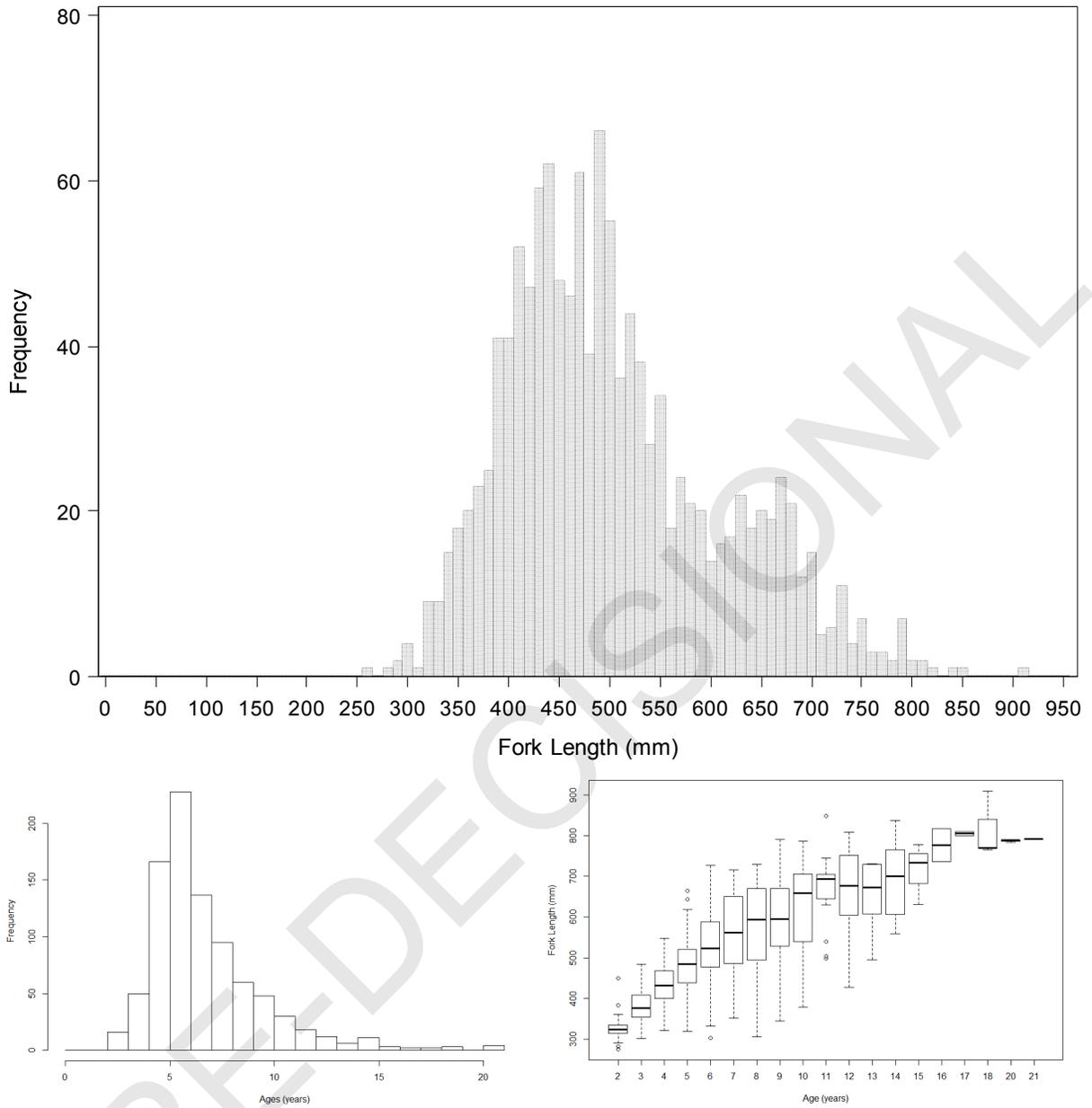


Figure 5.9.3. Annual index of abundance for red grouper from the SEAMAP Summer Groundfish Survey from 2009 – 2013.



**Figure 5.9.4.** Length (top) and age (bottom) distribution of red grouper from NMFS Bottom Longline Survey.

NMFS Bottom Longline Red Grouper Gulf of Mexico 2001 to 2013  
Observed and Standardized CPUE (95% CI)

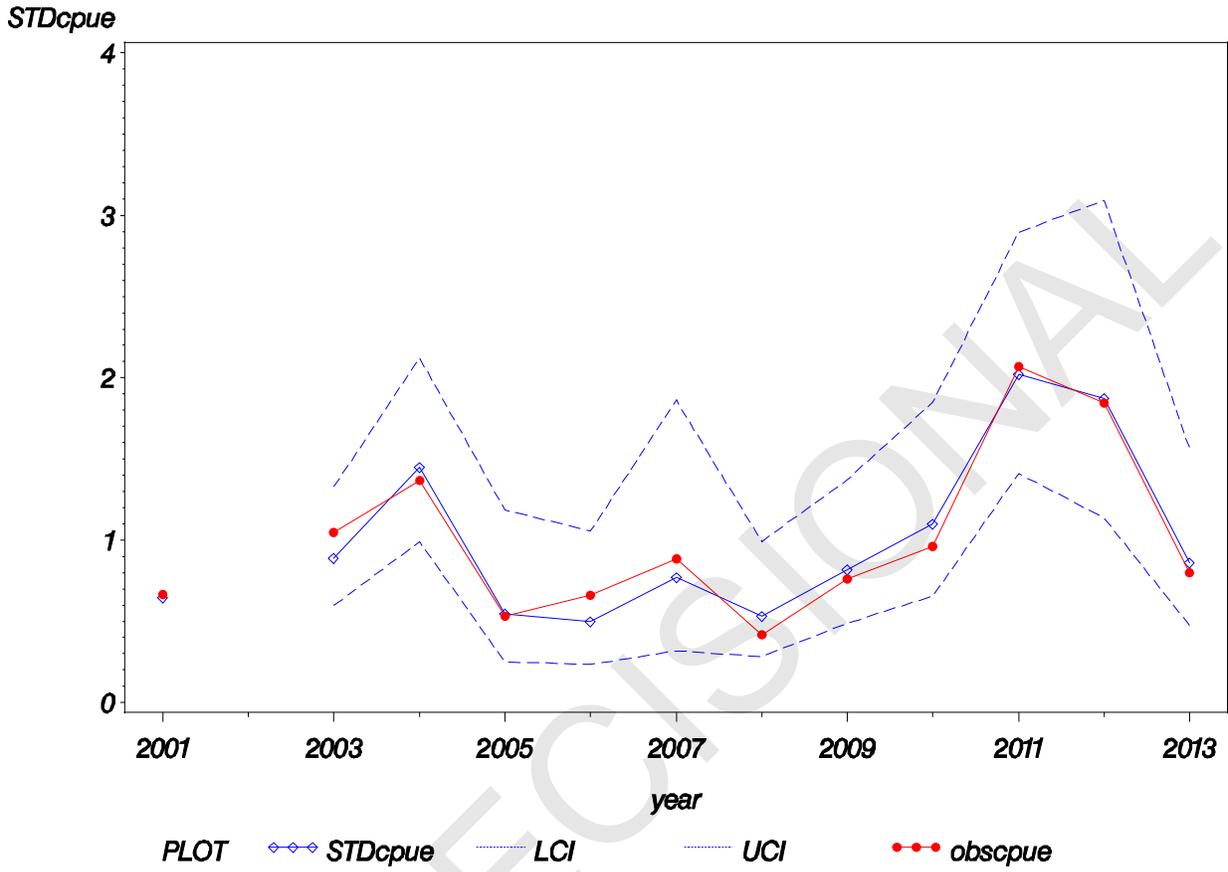
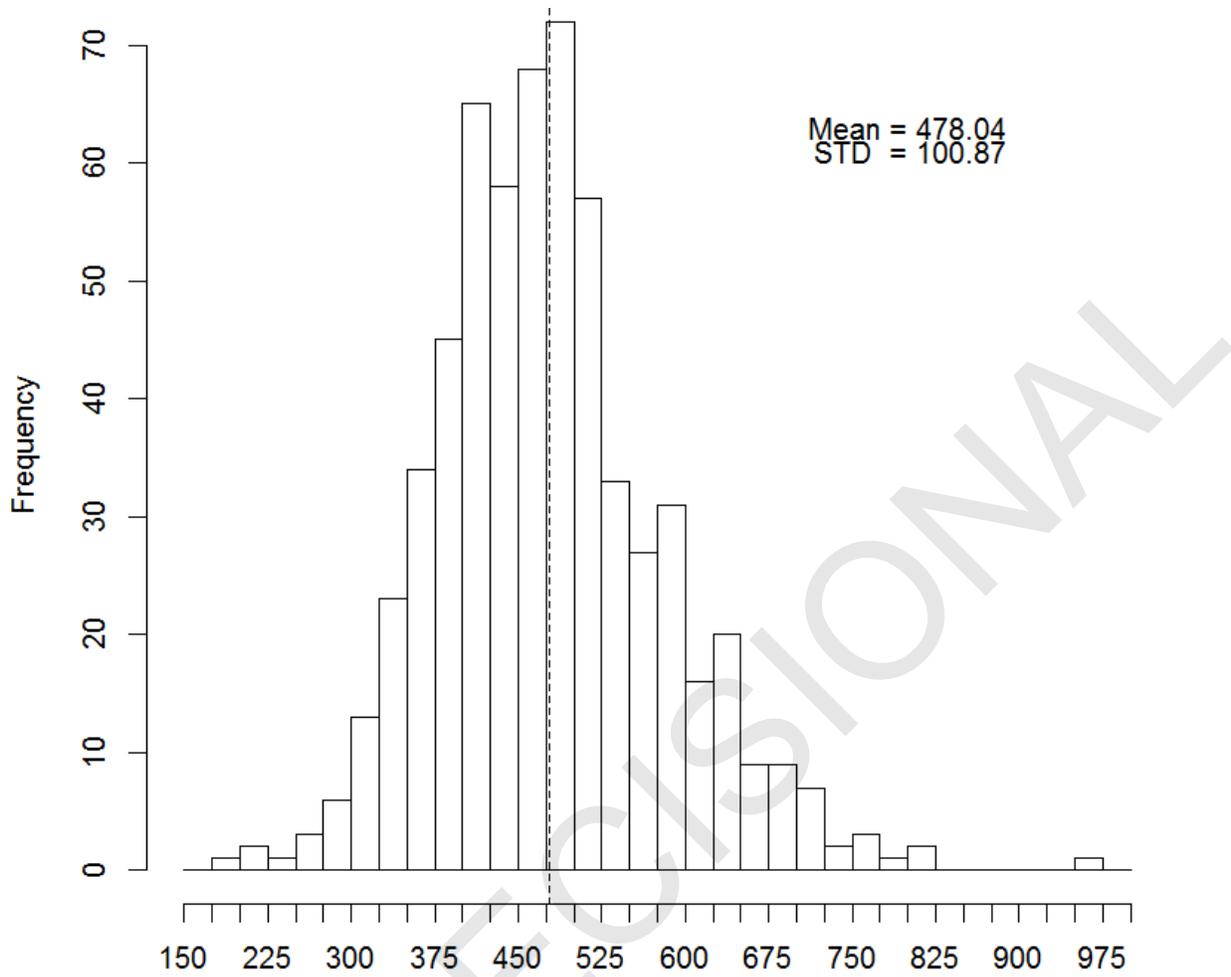
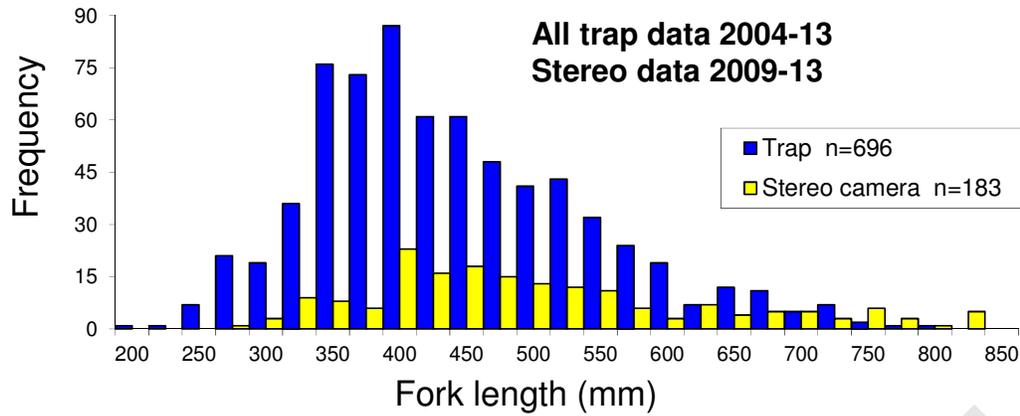


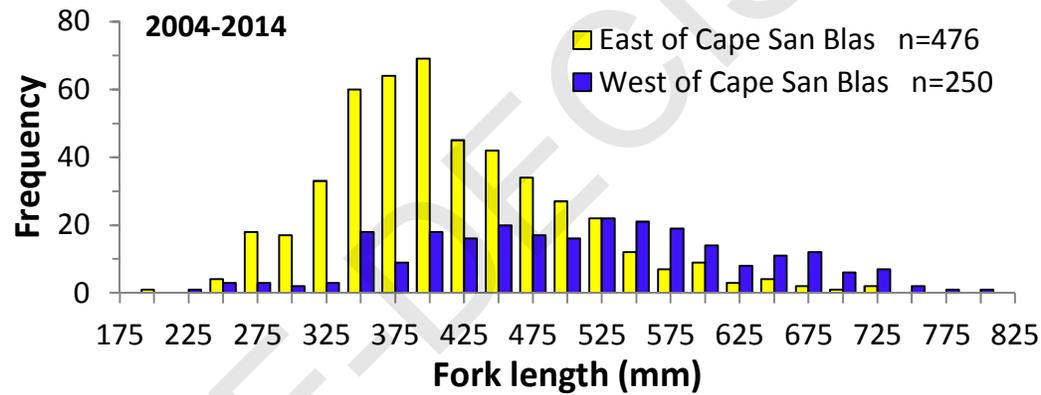
Figure 5.9.5. Annual index of abundance for red grouper from the NMFS Bottom Longline Survey from 2001 – 2013.



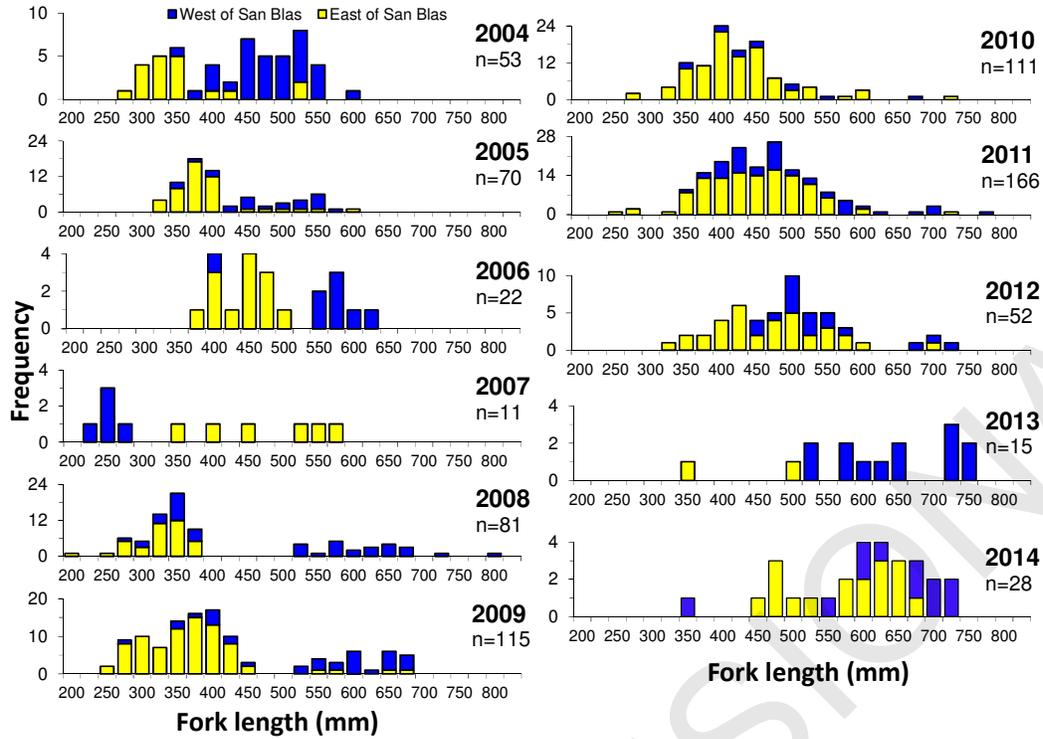
**Figure 5.9.6.** Red grouper length-frequency histograms (fork length - 25 mm bins) measured using parallel lasers from 1993-2009 and stereo-cameras from 2008-2013 (combined data set, N=609) from the Panama City reef fish survey.



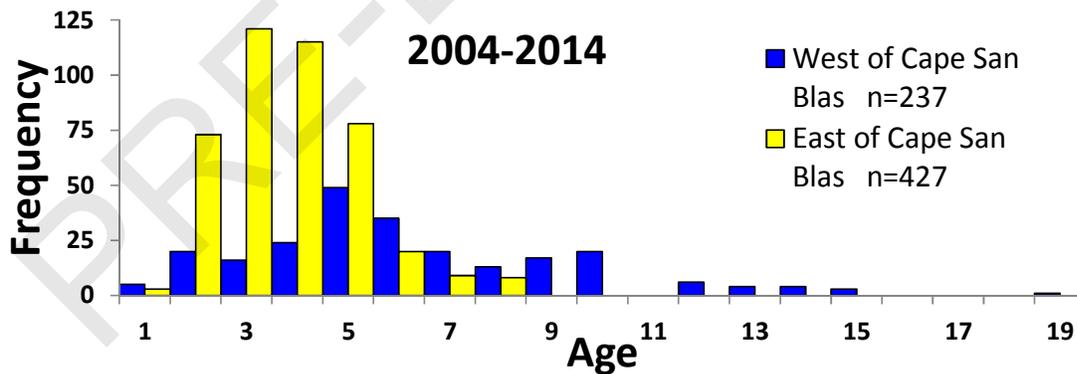
**Figure 5.9.7.** Overall size distributions of red grouper measured from stereo camera images, 2009-2013 and captured in chevron traps, 2004-2013, in the Panama City reef fish survey.



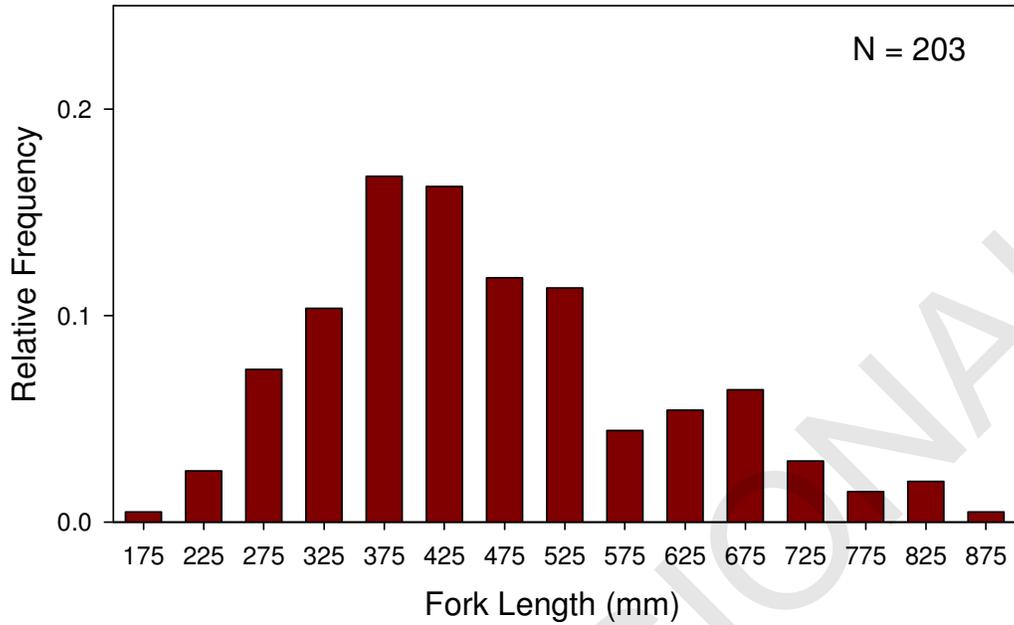
**Figure 5.9.8.** Overall size distributions of trap-caught red grouper by region, 2004-2014, from the Panama City reef fish survey.



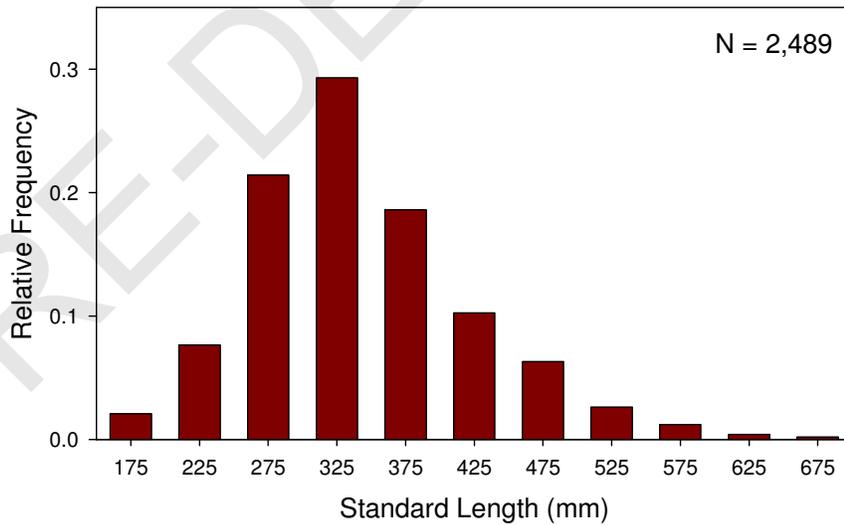
**Figure 5.9.9.** Annual size distributions of red grouper collected in chevron traps, 2004-2014, east and west of Cape San Blas from the Panama City reef fish survey.



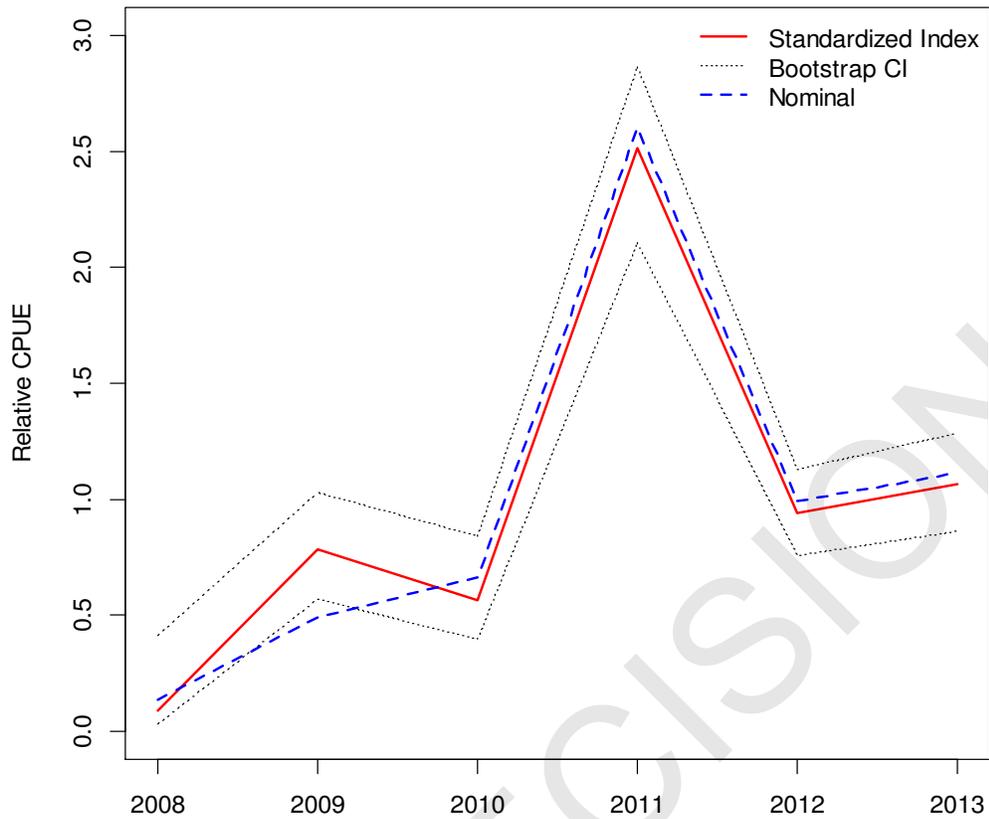
**Figure 5.9.10.** Overall age structure of trap-caught red grouper, 2004-2014, east and west of Cape San Blas from the Panama City reef fish survey.



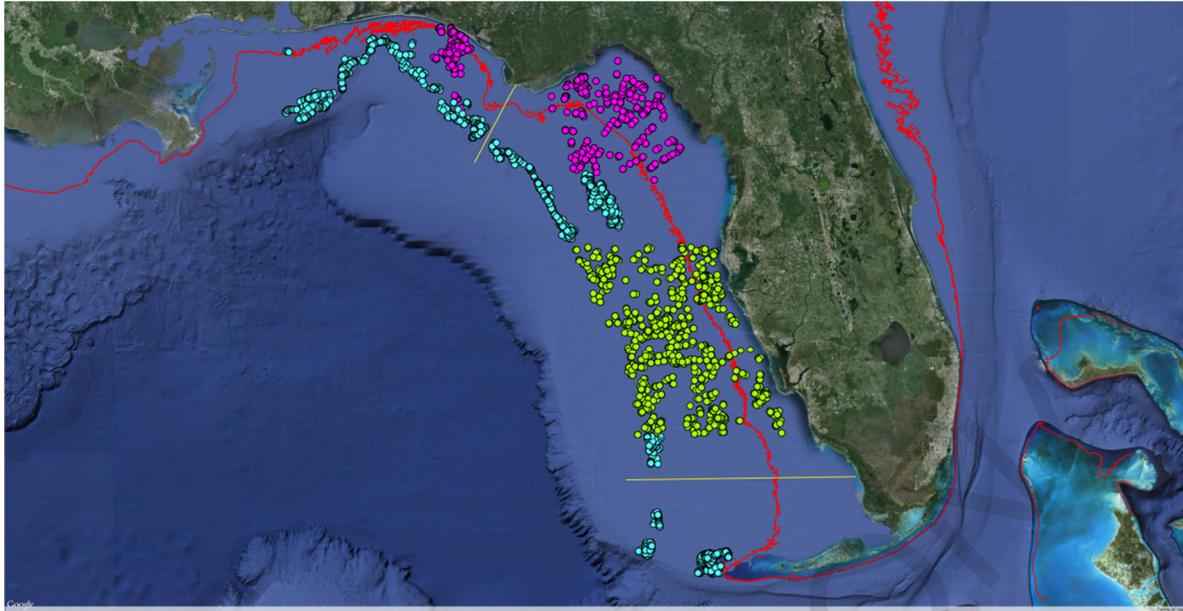
**Figure 5.9.11.** Length frequency distribution of red grouper observed in the FWRI video survey on stationary underwater camera arrays and measured using Vision Measurement System software.



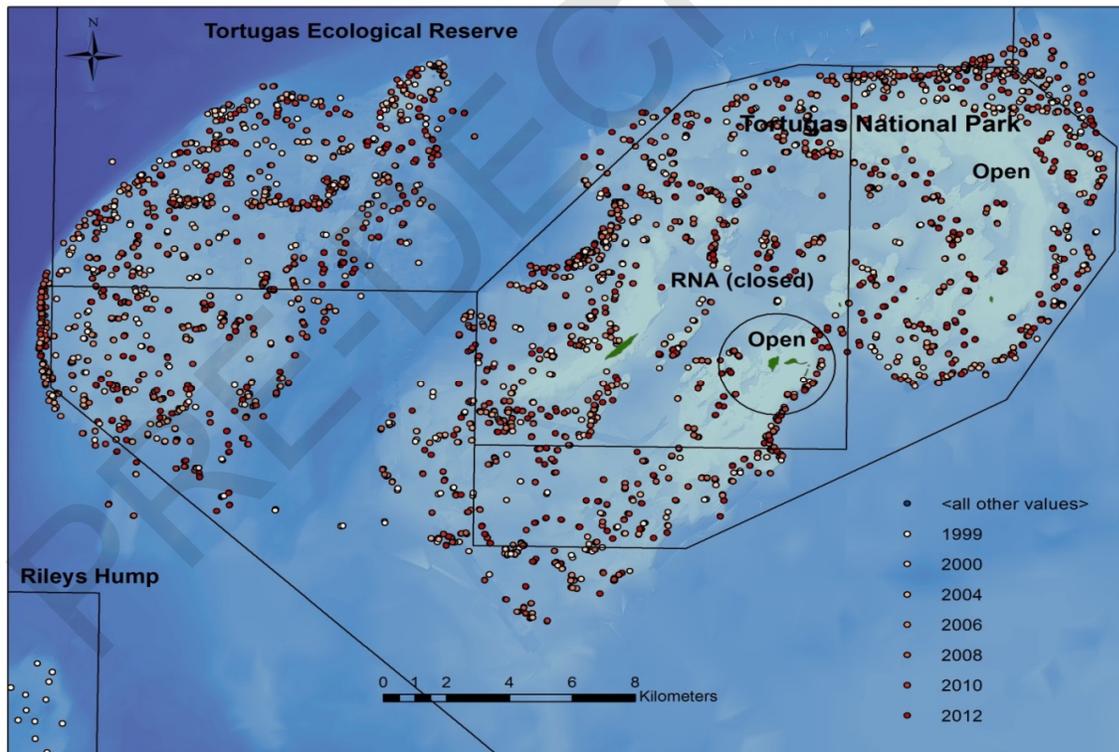
**Figure 5.9.12.** Length frequency distribution of red grouper captured in chevron traps in the FWRI trap survey.



**Figure 5.9.13.** Relative standardized index (solid red line) with 2.5% and 97.5% confidence intervals (black dotted lines) and the relative nominal index (blue hashed line) for red grouper CPUE in the FWRI West Florida Shelf trap survey.

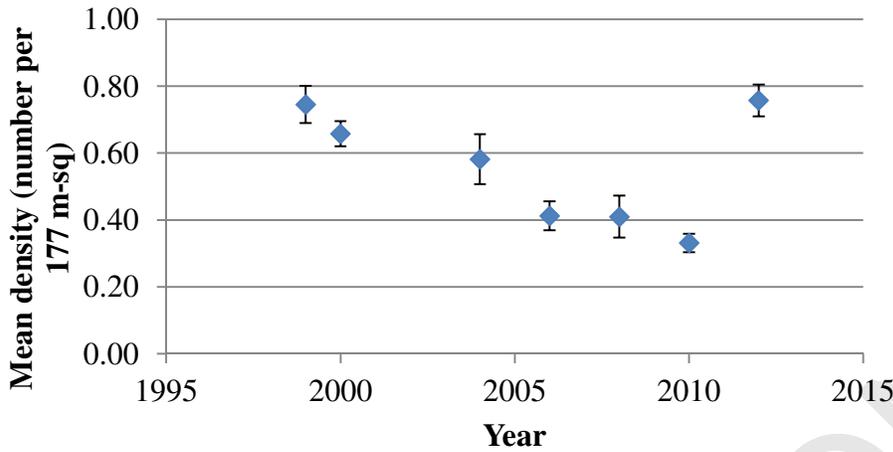


**Figure 5.9.14.** Video survey effort for NMFS-SEAMAP (light blue circles), PCVideo (pink circles), and FWRI (green circles) video surveys, and division of that effort into two depth strata (red 25 m isobath) and three geographic strata (straight tan lines).

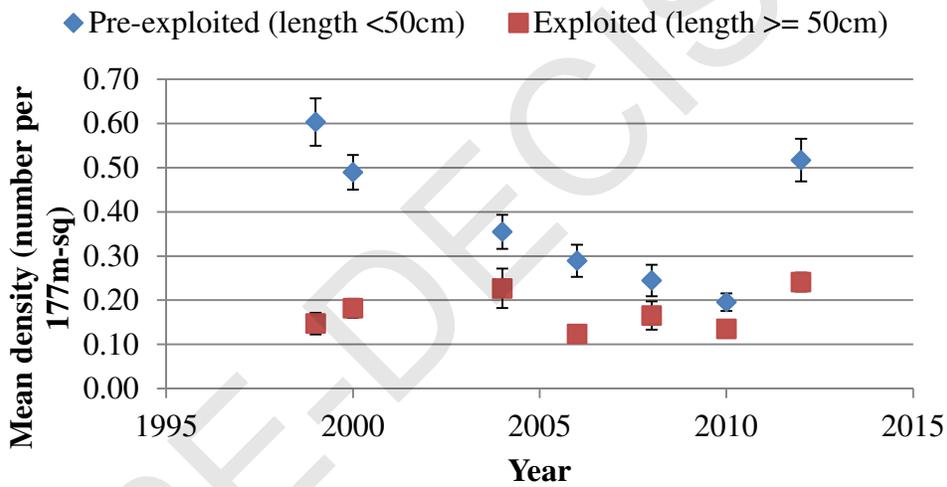


**Figure 5.9.15.** Map of the RVC sampling sites in the Dry Tortugas.

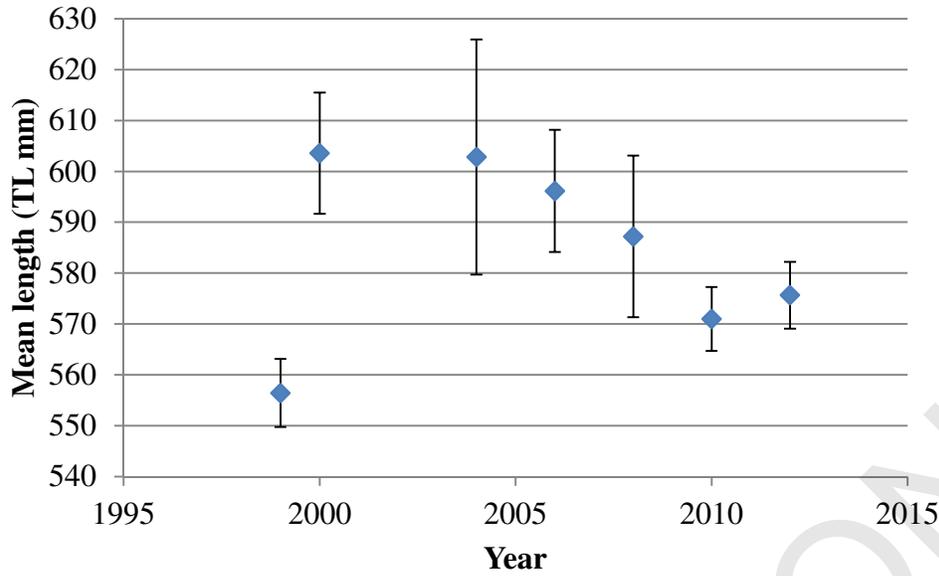
a)



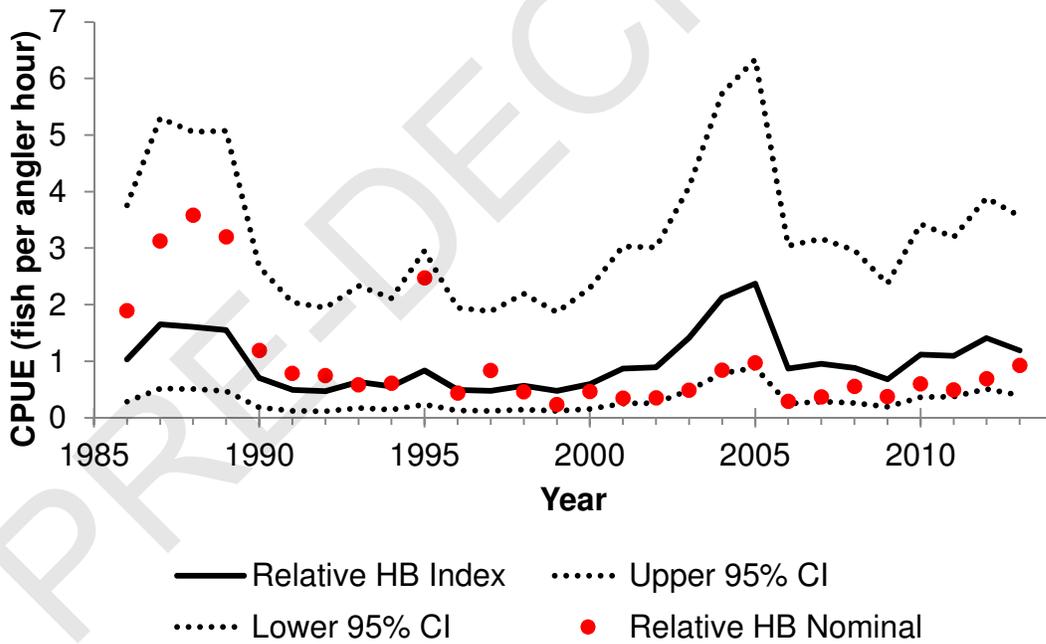
b)



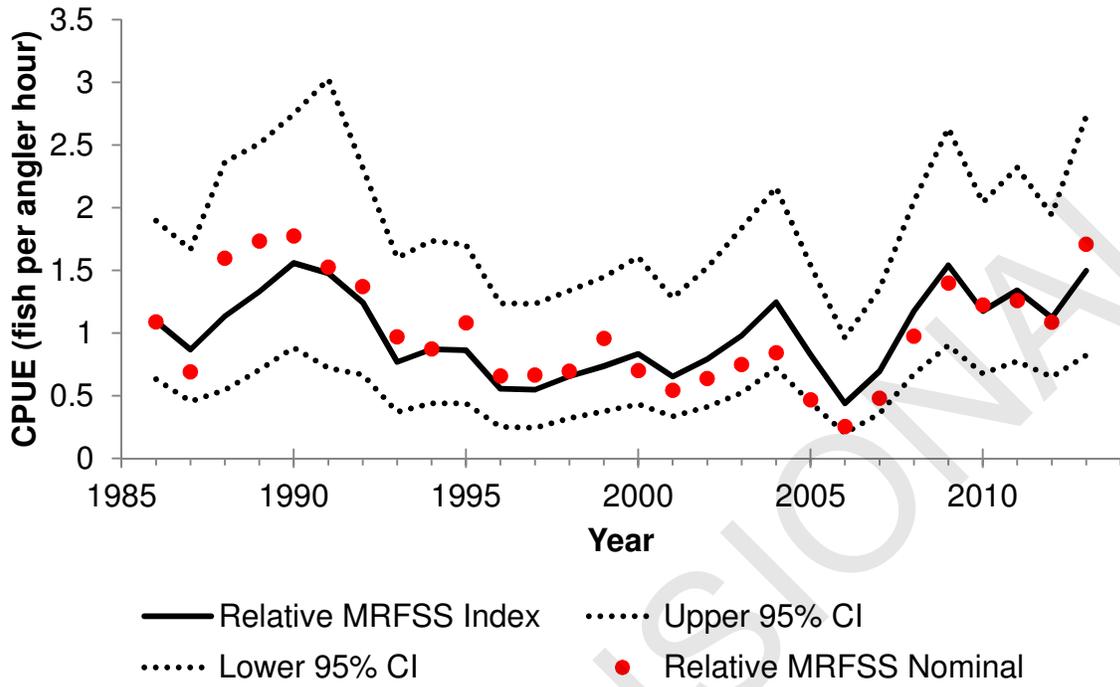
**Figure 5.9.16.** a) Red grouper overall mean density from the Dry Tortugas RVC project, b) the mean density of pre-exploited red grouper (i.e., length < 50cm) and the mean density of exploited red grouper (i.e., length > = 50cm). The points represent the mean density and the bars represent the standard error.



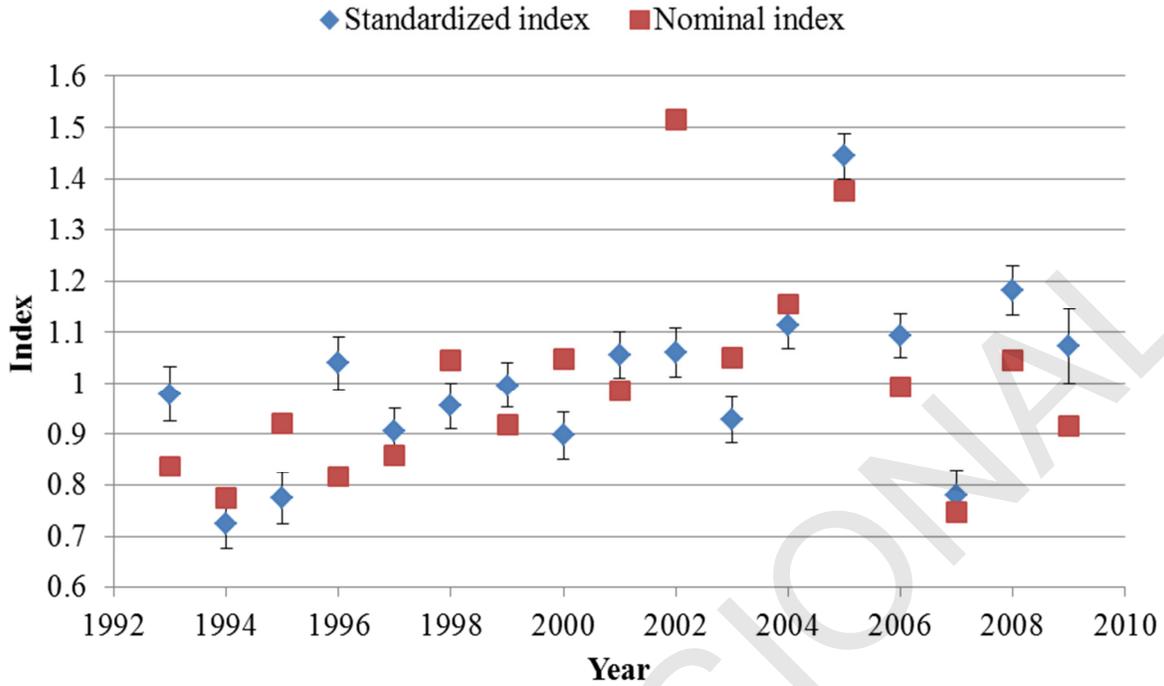
**Figure 5.9.17.** Mean length (TL mm) of legal red grouper (length  $\geq$  50cm TL), from the Dry Tortugas RVC project, 1999 - 2012.



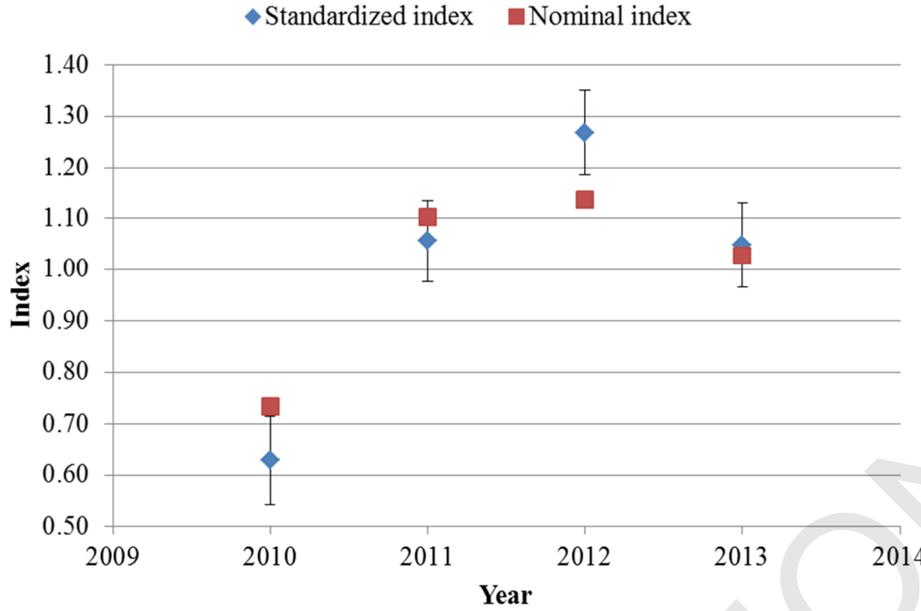
**Figure 5.9.18.** Standardized indices with 95% confidence intervals and nominal CPUE for the headboat index.



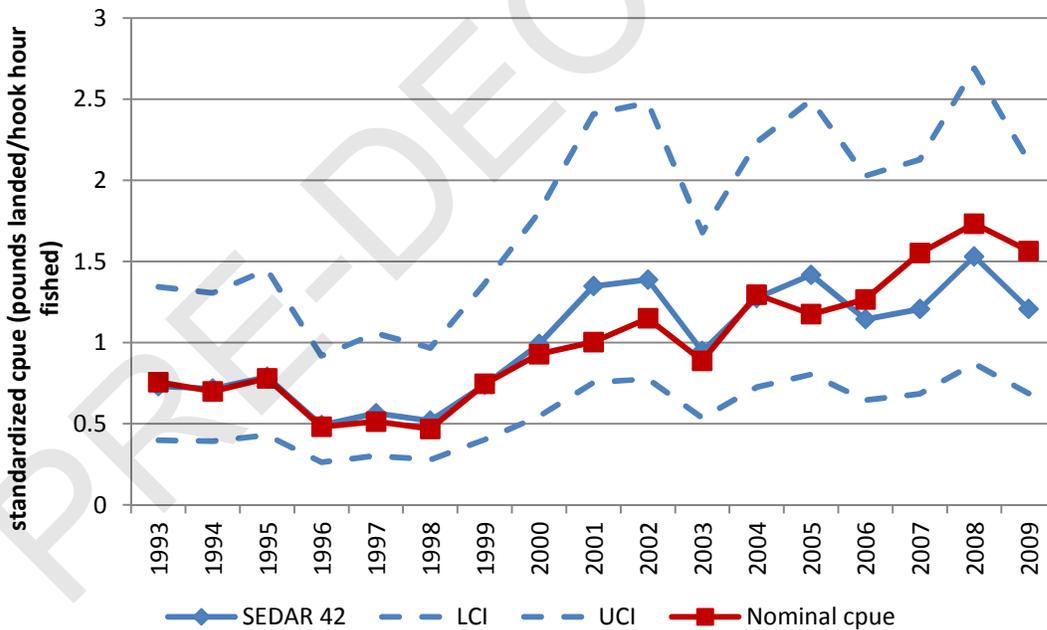
**Figure 5.9.19.** Standardized indices with 95% confidence intervals and nominal CPUE for the MRFSS index.



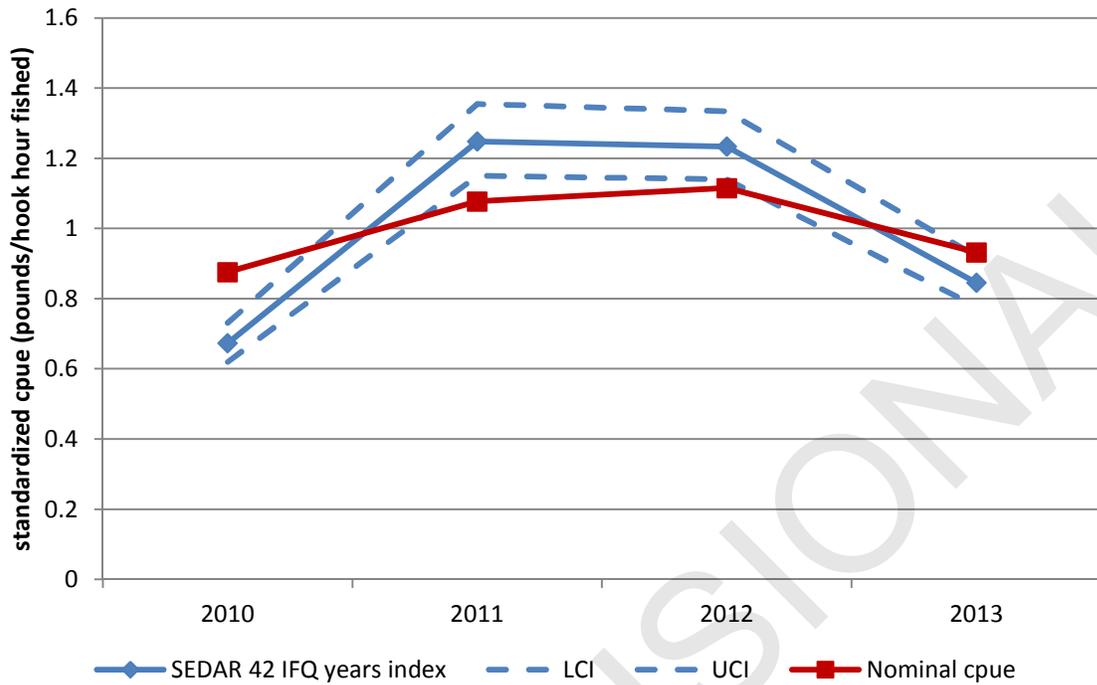
**Figure 5.9.20.** The standardized red grouper commercial longline index for shrimp grids 1-10 in the Gulf of Mexico from 1993 until 2009 (years before the implementation of IFQ). The points represent the catch rates normalized to an average of one. The bars represent the CV. See Table 5.8.12 for values.



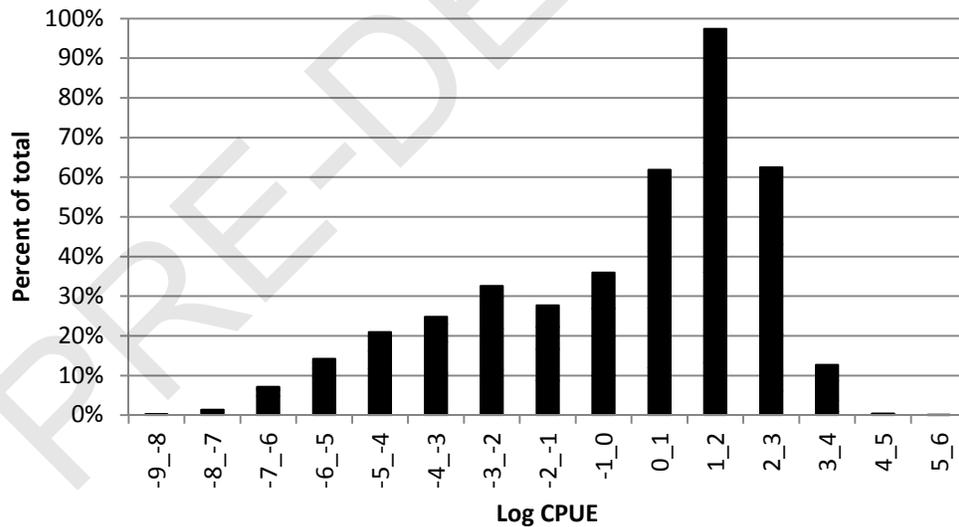
**Figure 5.9.21.** The standardized red grouper commercial longline index for shrimp grids 1-10 in the Gulf of Mexico from 2010 until 2013 (years of IFQ program). The points represent the catch rates normalized to an average of one. The bars represent the CV. See Table 5.8.13 for values.



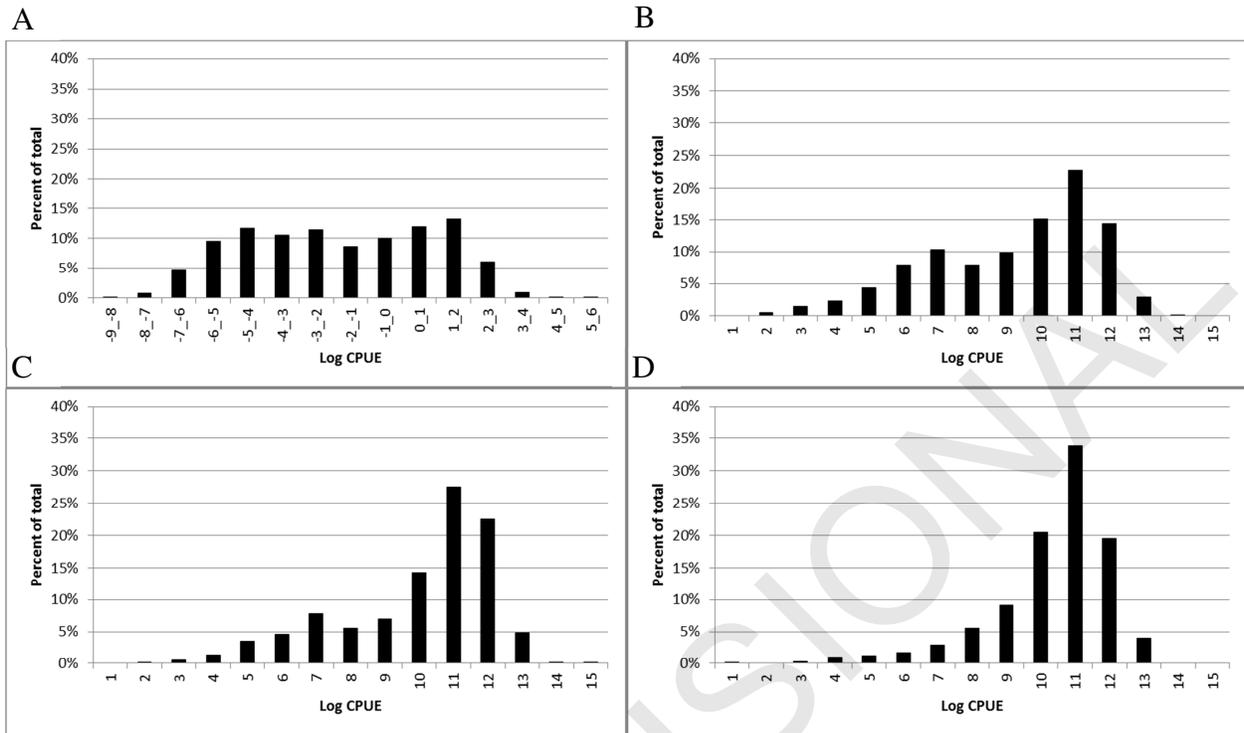
**Figure 5.9.22.** Pre-IFQ commercial vertical line standardized index of abundance (pounds landed/hook hour fished) of red grouper with 95% confidence intervals.



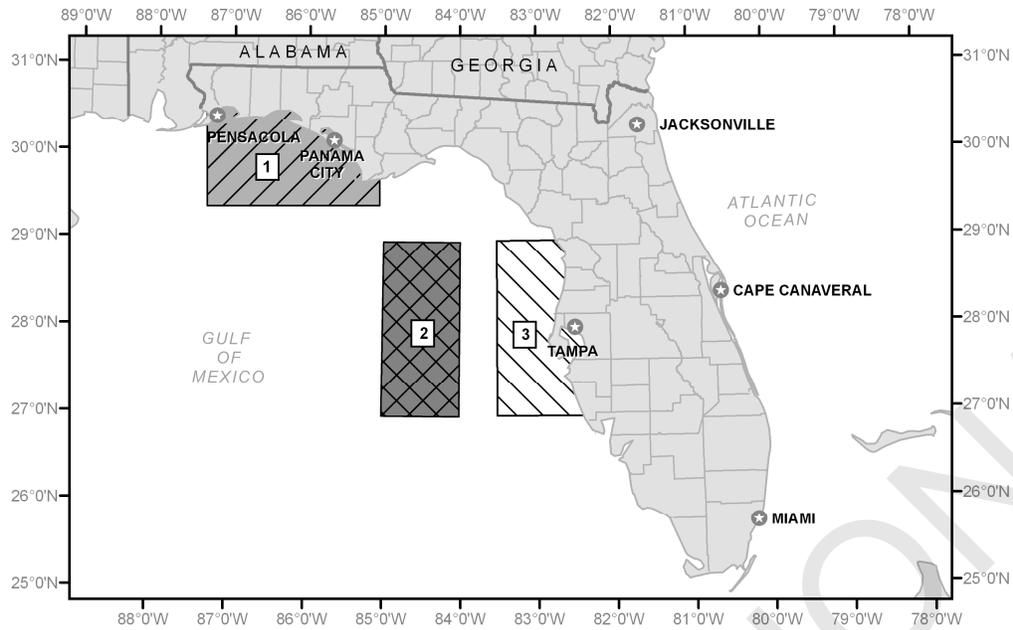
**Figure 5.9.23.** IFQ commercial vertical line standardized index of abundance (pounds landed/hook hour fished) of red grouper with 95% confidence intervals.



**Figure 5.9.24.** Commercial vertical line percent frequency of the log of red grouper CPUE, all 2010-2013 positive trips included. Log CPUE bins are: -9 to -8, -8 to -7, etc.



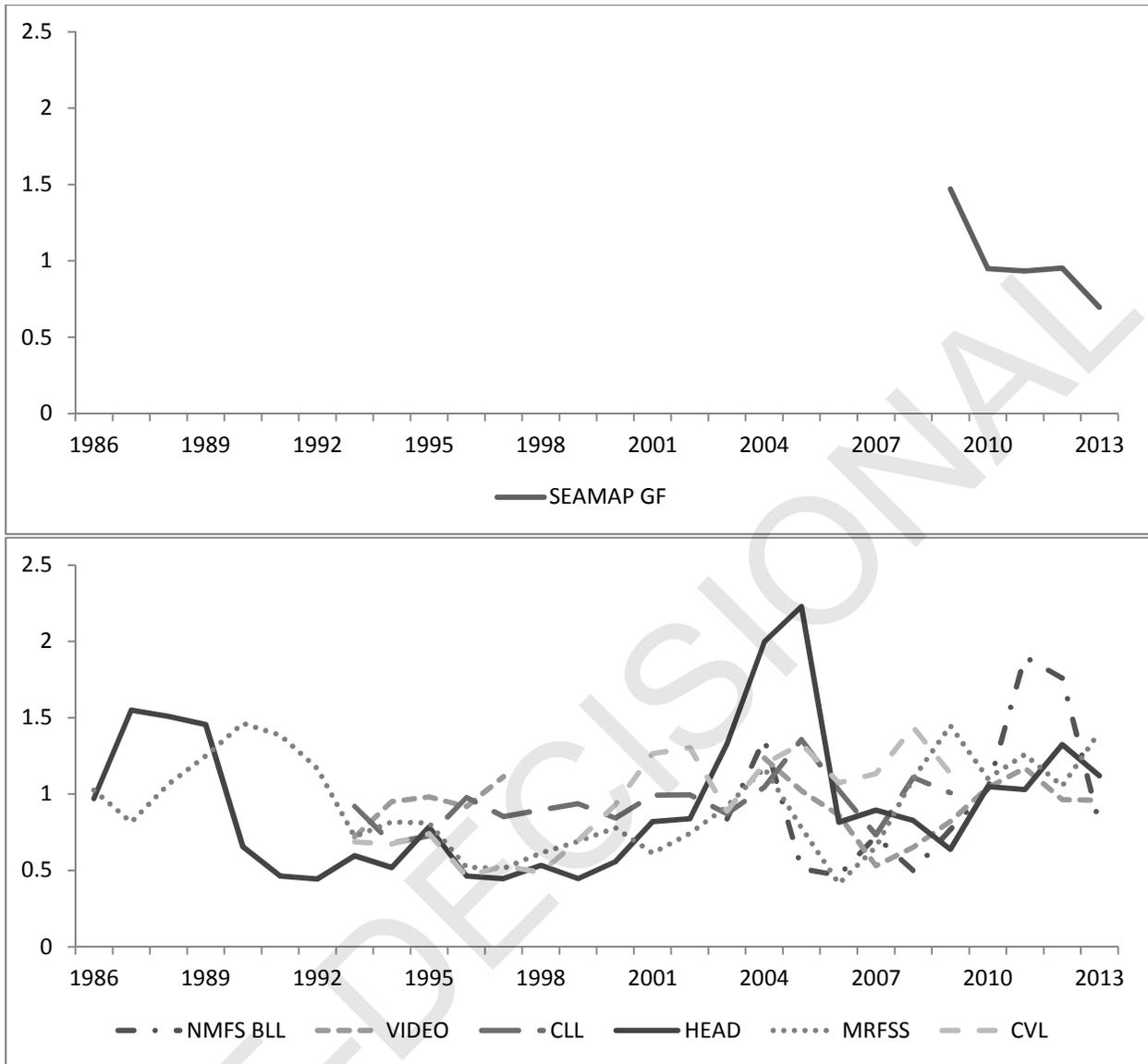
**Figure 5.9.25.** Commercial vertical line percent frequency of the log of red grouper CPUE by amount of red grouper allocation A. 1-1,166 pounds. B. 1,167-3,716 pounds. C. 3,717-10,300 pounds. D. 10,300 or more pounds.



**Figure 5.9.26.** Areas 1 and 3 represent the two regions where fishing trips included in the headboat observer discard index took place. Multi-day trips in region 2 were excluded from this index since the majority of red grouper caught offshore are legal to harvest.



**Figure 5.9.27.** Annual index of abundance for red grouper from the Headboat Observer Discards from 2005 – 2013.



**Figure 5.9.28.** Plot of all recommended indices (normalized to the common years), grouped by sampled portion of the population (top – juveniles, bottom – adults). SEAMAP GF – SEAMAP Summer Groundfish Survey, NMFS BLL – NMFS Bottom Longline Survey, VIDEO – Combined Video Survey, CLL – Commercial Longline, CVL – Commercial Vertical Line, HEAD – Headboat and MRFSS.

**6 INTEGRATED ECOSYSTEM ASSESSMENT AD-HOC WORKING GROUP**

## 6.1 OVERVIEW

The Integrated Ecosystem Assessment (IEA) group sought to develop three products for SEDAR 42. The first product provides quantitative insight into how red tide events are distributed in relation to red grouper, so as to highlight the importance of considering natural mortality due to red tide events in the stock assessment model of red grouper. The other products delivered by the IEA group are intended for integration into the red grouper Stock Synthesis assessment model: (1) estimates of age-specific natural mortality due to predation and other causes (e.g., red tide events); and (2) estimates of recruitment anomalies due to oceanographic factors that are independent of spawning stock biomass. The integration of these two ecosystem products developed by the IEA group will allow the linkage of natural mortality and recruitment to ecosystem processes including predation, red tide events, and oceanographic conditions.

The effects of environmental forces on red grouper and other commercial stocks have been well-established. One of the primary concerns for red grouper in the northern Gulf of Mexico is the presence of sporadic red tide events, which are thought to cause increased mortality in some years. This issue in particular was noted because of a well-observed severe red tide event in 2005, and an associated large decline in multiple abundance indices for red grouper and other species thought to be susceptible to mortality from red tide events. It is unknown whether mortality occurs via absorption of toxins across gill membranes (Abbott et al. 1975, Baden 1988), ingestion of toxic biota (Landsberg 2002), or from some indirect effect of red tide such as hypoxia (Walter et al. 2013). A statistical study conducted within the Gulf of Mexico IEA program evaluated the impacts of including time-varying red tide mortality in the Gulf of Mexico gag grouper (*Mycteroperca microlepis*) Stock Synthesis assessment model configured for SEDAR 33 (Sagarese et al. 2014b). Consideration of red tide mortality in the Stock Synthesis assessment model improved model fit, and was incorporated into the base stock assessment. The inclusion of red tide mortality within the base assessment model better explained historical trends in abundance and accounted for interannual variation resulting from environmental influence otherwise viewed by the model as random deviates.

Other environmental perturbations in addition to red tide events have the potential to affect populations of demersal fishes. The passage of hurricanes, for example, appears to affect

movement and site-fidelity of red snapper (Patterson et al. 2001). The presence of red grouper west of the Florida-Alabama line has been suggested to relate to displacement of individuals by hurricanes (Franks 2005). Periodic upwelling events and associated reductions in temperature and increases in nutrients have been documented to contribute to mass mortality of fishes and macroinvertebrates, potentially in association with the development of near-anoxic conditions (Collard & Lugo-Fernández 1999, Collard et al. 2000). Within the Florida Fish and Wildlife Research Institute's (FWRI) fish kill database (<http://research.myfwc.com/fishkill/>), red grouper fish kills have been documented due to cold weather events. During SEDAR 33 in 2013, a member of the life history group noted that physical conditions in the northeastern Gulf of Mexico were displaying similar patterns to those observed in the spring and summer of 1998, when an extended period of stratification led to hypoxia in this region. Incorporation of this and other sporadic events should be a focus of IEA efforts in future assessments.

It is well-known that factors besides spawning stock biomass can affect recruitment strength. Typically, such factors are not included in assessment models, and therefore manifest themselves as anomalies from the stock-recruitment relationship. The accuracy and/or precision of the assessment can be improved by explaining some of this variation with a suitable index, representing external environmental forces hypothesized as drivers of recruitment. Typically, this is done by looking for correlations between recruitment deviations, and environmental variables such as climate indices (e.g., Atlantic Multidecadal Oscillation), sea surface temperature, or wind strength. Rather than relying on correlational models, which produce relationships which may or may not hold true in future years, the IEA working group has taken a more mechanistic approach to describing anomalies in the stock recruitment relationship. This is done via a hydrodynamic model, the Connectivity Modeling System (CMS) (Paris et al. 2013), which simulates the transport of larvae, and allows us to calculate expected recruitment anomalies based on the oceanographic conditions observed for each year. Estimates of annual recruitment deviations produced using the CMS (Karnauskas et al. 2013) were incorporated in the SEDAR 33 gag grouper Stock Synthesis assessment model as a sensitivity run. These estimates explained about one-third of the variation in the stock-recruitment deviates from the gag grouper assessment model, and their consideration in the Stock Synthesis assessment model informed the recent years of the assessment where cohort strength is poorly estimated. The IEA group estimated

annual recruitment anomalies of red grouper due to oceanographic factors over the period 2003–2013, and plans to devise scenarios based on methods for inclusion of the recruitment anomaly index in the red grouper Stock Synthesis assessment model.

### 6.1.1 IEA Working Group Participants

|                    |                  |
|--------------------|------------------|
| Michael Schirripa* | NMFS SEFSC Miami |
| Mandy Karnauskas*  | NMFS SEFSC Miami |
| Meaghan Bryan      | NMFS SEFSC Miami |
| Arnaud Grüss       | RSMAS            |
| Skyler Sagarese    | RSMAS            |
| William Harford    | RSMAS            |
| Walter Ingram      | NMFS Pascagoula  |

\*Not present at data workshop.

## 6.2 CONTRIBUTED MODELING ENVIRONMENTS

The contributed modeling environments for SEDAR 42 include:

1. Spatiotemporal overlap of juvenile and adult red grouper distribution with red tide events in the northeastern Gulf of Mexico
2. An individual-based, multi-species OSMOSE model for the West Florida Shelf
3. The Connectivity Modeling System, a Lagrangian particle-tracking model (Paris et al. 2013)

Each of the modeling efforts is briefly presented below.

### 6.2.1 Spatiotemporal overlap of red grouper distribution with red tide events

#### Methods

Generalized linear models were developed to quantify ontogenetic spatial distributions of red grouper and to enable an assessment of the spatiotemporal overlap between juvenile and adult red groupers and red tide events. The aggregation of fishery-independent (SEAMAP trawl survey, 2011 expanded annual stock assessment survey, NMFS bottom longline survey) and

fishery-dependent data (Shark bottom longline observer program, Observer longline, Observer vertical line) was necessary to provide sufficient data and resolution for rigorous model evaluation. Using the parameters estimated by the optimal binomial GLM, the expected probability of occurrence of each life-history stage was predicted across space. The resulting spatial distribution maps for juvenile and adult red groupers were used to investigate overlap with red tide events.

The predicted presence of red tide throughout the West Florida Shelf was available from 1998 through 2010 and was based on statistical models developed during SEDAR 33 (Walter et al. 2013). Generalized additive models predicted the probability of a red tide bloom using a suite of satellite derived remote sensing products from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the FWRI's harmful algal bloom cell counts (Walter et al. 2013). Monthly estimates of the predicted probability of red tide occurrence were averaged to obtain annual estimates of predicted probability of red tide throughout the WFS. Annual estimates of spatiotemporal overlap between red grouper distribution and red tide distribution served as a proxy of the exposure of each life-history stage to red tide events. Further details on methods used for this study are outlined in Sagarese et al. (2014a).

### Assessment Contributions

Spatial overlap analyses reinforced the importance of considering the influence of red tide events on red grouper dynamics. Peak overlap between predicted red grouper distribution and red tide occurred in 2005 for both juvenile (ages 1-3) and adult (ages 3+) red groupers.

### 6.2.2 OSMOSE

#### Methods

An ecosystem simulation model, OSMOSE-WFS, was developed to describe the trophic structure of the West Florida Shelf (WFS) ecosystem in the 2000s. This model was used to produce estimates of natural mortality rates for different life stages of gag grouper (younger juveniles, older juveniles and adults) for SEDAR 33. OSMOSE-WFS is an individual-based, multi-species model, which explicitly represents major processes in the life cycle of a number of

high trophic level groups of species. OSMOSE-WFS builds on WFS Reef fish Ecopath, an Ecopath model for the WFS. However, OSMOSE-WFS and WFS Reef fish Ecopath differ greatly in both their structure and assumptions. In particular, predation mortality and diet compositions emerge from model simulations in OSMOSE-WFS, whereas they are determined *a priori* in WFS Reef fish Ecopath. The use of OSMOSE-WFS, WFS Reef fish Ecopath and other ecosystem models developed within the Gulf of Mexico IEA program through a multi-model approach allows us to have different perspectives on the same research questions, while being able to identify from where discrepancies between the different ecosystem models may originate. Further details on the construction, parameterization, calibration and validation can be found in Grüss et al. (2014b).

In OSMOSE-WFS, we recently switched from the ‘iterative mortality algorithm’ used in Grüss et al. (2014b) to the better-performing ‘stochastic mortality algorithm’, which assumes that all types of mortalities are continuous processes that compete with each other, and that there is competition and stochasticity in the predation process (<http://www.osmose-model.org/>). This update of OSMOSE-WFS entailed a recalibration of the model, which is described in detail in Grüss et al. (2014b).

### Assessment Contributions

Once OSMOSE-WFS was recalibrated, the model was used to produce estimates of natural mortality for different stanzas (younger juveniles, older juveniles and adults) and age classes (0-1 year old, 1-2 years old, ..., 8-9 years old and 9+ years old individuals) of red grouper. Estimates of natural mortality rates for age classes of red grouper could be used in the Stock Synthesis assessment model employed for SEDAR 42. Several methods have been proposed for incorporating estimates of instantaneous natural mortality into a single-species stock assessment model, each with advantages and disadvantages. The best method depends on the specifics of the assessment model being used, and which is most appropriate for Gulf of Mexico red grouper needs to be evaluated and discussed. Note that the definition of age classes of red grouper presented in SEDAR42-DW-02 can be altered if necessary.

### 6.2.3 CMS

### Methods

The Connectivity Modeling System (CMS) is a biophysical modeling system based on a Lagrangian framework, and was developed to study complex larval migrations (Paris et al. 2013). The CMS uses outputs from hydrodynamic models and tracks the three-dimensional movements of advected particles through time, given a specified set of release points and particle behaviors. Optional modules are provided to allow for complex behaviors and movements, simulating observed biological phenomena such as egg buoyancy and ontogenetic vertical migration. The specific model set up used for SEDAR 42 is outlined in detail in Grüss et al. (2014a).

### Assessment Contributions

The CMS modeling effort produced an index of recruitment anomalies due to oceanographic factors for red grouper by year, for the years 2003 – 2013. This index represents the expected recruitment strength due to oceanographic conditions alone, without the influence of spawning stock biomass. The recruitment anomalies index produced with the CMS can be directly input as an environmental covariate into the Stock Synthesis assessment model used for SEDAR 42.

### 6.3 INTEGRATION OF ECOSYSTEM PRODUCTS INTO STOCK SYNTHESIS

The IEA working group agreed that both estimates of natural mortality and recruitment anomalies would be worthy of consideration for inclusion in the stock assessment process. Schirripa et al. (2013) provided a detailed outline of various methods for incorporating estimates of natural mortality and recruitment anomalies into Stock Synthesis. IEA products could either be incorporated directly into the base model if justified or tested as sensitivities.

Two studies provided estimates of natural mortality. First, the statistical model of the probability of red tide severity (Walter et al. 2013) could be directly input into the stock assessment model as a regulator of natural mortality for red grouper. Although this study was first presented for gag grouper, the results also apply to red grouper since it focused on critical habitat for both grouper species. Secondly, Grüss et al. (2014b) presented a vector of natural mortality estimates for age classes obtained from their OSMOSE model.

Within Stock Synthesis, various methods exist for linking ecosystem products to processes including natural mortality and recruitment. Natural mortality can deviate as a time-varying function of an environmental index, such as red tide severity Walter et al. (2013). Scenarios based on combinations of potential red tide indices and methods for inclusion can be devised to test whether the plausibility of the stock assessment model increases with environmental consideration. The first method termed the ‘*model method*’ requires estimation of an additional parameter which relates the environmental time-series to deviations in natural mortality (Maunder & Watters 2003). This approach also works for recruitment and allows indices of natural mortality and/or recruitment anomalies to be incorporated as an index with a variance, which the stock assessment model then attempts to fit. For recruitment anomalies, the ‘*data method*’ treats environmental data as a survey of annual recruitment deviations (i.e., age-0 survey) with an associated variance. For natural mortality, the ‘*modified data method*’ can be used to link natural mortality to a block design where environmental index values are used as Bayesian priors (with standard deviation) within the Stock Synthesis assessment model. This method is encouraged for situations where episodic events (such as red tides) drive natural mortality (Schirripa & Methot 2013) and allows for annual observation error (Schirripa et al. 2009).

Another avenue for incorporating red tide into natural mortality is through the creation of a discard-only red tide fishing fleet to drive natural mortality. In this pseudo-fishery, all fish encountered are discarded with 100% mortality. Selectivity of the red tide fishing fleet can either be assumed constant at age if data on size-specific red tide mortality is lacking or can be specified based on field collections of individuals in red tide fish kills.

Only one estimate of recruitment anomalies was put forward by the IEA working group (based on the Connectivity Modeling System), and it was agreed that this index would be put forth for recommended inclusion in the assessment. This index could be incorporated via the ‘*model method*’ or via the ‘*data method*’ discussed above.

#### 6.4 RESEARCH RECOMMENDATIONS

##### **Recommendation 1: Time varying natural mortality**

Research is required to incorporate interannual variation in red grouper natural mortality within the assessment process. In particular, elevated mortality rates in fishes, including members of the shallow-water grouper complex, can be caused by severe red tide events (Flaherty & Landsberg 2011). A red tide severity index (Walter et al. 2013) was previously included in the base stock assessment model for Gulf of Mexico gag grouper, which improved model fits to indices of abundance (Sagarese et al. 2014b). In the Gulf of Mexico gag grouper assessment (SEDAR 33), fluctuations in red tide mortality varied more than 10-fold through time, and were estimated to be commensurate with fishing mortality rates in several “severe” years (Sagarese et al. 2014b). Like the gag grouper SEDAR assessment, red tide severity should be considered as a source of mortality for red grouper. This recommendation requires at least four research steps.

*First, length/age composition data are needed to determining lengths/ages susceptibility to red tide severity.*

Collections of fish during red tide events would allow for the size/age selectivity of mortality to be determined, and might also allow for some minimum estimates of total mortality. Preliminary data were distributed by the NMFS Panama City lab containing red grouper lengths and estimated ages for 16 individuals collected from the Big Bend region during August 1<sup>st</sup> and 3<sup>rd</sup> of 2014. During plenary, various participants noted that collection of samples during the NMFS bottom longline survey was complicated by the decomposed nature of many fish encountered, which also prevented length estimates. In addition, otoliths were often difficult to recover from some specimens because they were missing anterior portions of their body.

*Second, existing indices of red tide severity should be updated.*

The IEA group recommends research to produce candidate indices of red tide severity and to devise scenarios based on red tide indices and methods for inclusion in the red grouper Stock Synthesis assessment model. Updating red tide indices is difficult because the original red tide indices (Walter et al. 2013) were created using SeaWiFS (operational 1998 – December 2010) satellite sensors. More recently, MODIS (Moderate Resolution Imaging Spectrometer) satellite sensors (July 2002 – present) have been used to detect and track harmful algal blooms (Stumpf et al. 2003, Hu et al. 2005). Thus, steps need to be taken to (i) calibrate SeaWiFS and MODIS

satellite data during overlap periods; (ii) extend the red tide index through the present period (2014); and (iii) automate compilation of satellite data, and calculation and reporting of index values.

*Third, procedures for incorporating red tide indices into Stock Synthesis should be critically evaluated.*

Simulations should be conducted to evaluate the consequences of assuming constant or size specific natural mortality, when mortality actually fluctuates according to episodic temporal events. Further, approaches to incorporating environmental indices in stock assessment tuning procedures should be compared through simulated datasets to evaluate the effects of assessment model misspecification.

*Fourth, the statistical properties of red tide indices should be characterized for use in simulations and assessment projections.*

Evaluate whether all levels of red tide severity are equally likely in near-term future events, or whether information is contained in red tide indices that can be used to generate ‘forecast distributions’. Time series decomposition can be used to statistically characterize red tide indices (Stumpf et al. 2003). By quantifying periodicity, trends, and stochasticity, ‘forecast distributions’ may enable plausible future scenarios to be considered in assessment projections.

### **Recommendation 2: Index of red tide mortality derived from Ecopath with Ecosim**

The IEA working group agreed that additional efforts deriving natural mortality values from the WFS Red tide Ecopath with Ecosim model would be helpful as presented for gag grouper during SEDAR 33 (Gray et al. 2013). These modeling efforts would allow red tide events to affect multiple components of the West Florida Shelf ecosystem and to assess the overall effect of red tide and predator/prey dynamics on the mortality rates of Gulf of Mexico red grouper.

### **Recommendation 3: Elucidating the response of red grouper to red tide events**

Future modeling efforts should aim to address whether groupers move in response to red tide events or if they experience elevated natural mortality during these episodic events.

**Recommendation 4: Modifications to the CMS modeling framework**

Additional fisheries-independent data (e.g., PCLAB data) will be incorporated in the datasets used for habitat modeling of red grouper. This will allow us to improve the predictions made by the binomial GLMs described in SEDAR42-DW-04. Thus, we will be able to better predict the probability of presence of adult red grouper on the West Florida Shelf and, therefore, to better simulate the production of red grouper eggs over space in the CMS.

The life history working group brought up concerns regarding the aggregated use of all adult red groupers in determining the number of eggs released at red grouper spawning sites. There is evidence in red grouper that the fecundity of large adult females is considerably higher than that of small adult females. To account for this, the IEA group will use data compiled by the life history group to calculate mean age at depth for red grouper. This information will be useful to estimate the number of eggs released at each red grouper spawning site based on (1) the probability of presence of adult red grouper at that site; and (2) the relative fecundity at that site. The relative fecundity at each spawning site will be determined from: (1) the depth at that site; (2) the mean age at depth profile; and (3) the fecundity-at-age (number of eggs released during a spawning event at age) profile.

The CMS index should be extended to cover 2014 to provide insight into potential recruitment for the first year of projections.

***Recommendation 5: Enhance fish kill reporting, particularly in offshore regions***

Current understanding of fish killed by red tide events largely originates from the Florida Fish and Wildlife Conservation Commission and Fish and Wildlife Research Institute fish kill database, which is informed by a statewide fish kill hotline (<http://research.myfwc.com/fishkill/>). Many of the observations are based on fish that washed ashore following red tide events. Enhanced reporting of red tides, in addition to observations from offshore waters by recreational and commercial fishermen, could increase understanding of how red tide events impact offshore species. This could be achieved through the creation of a national program or increased citizen

science through outreach educating fishermen and other Gulf patrons on their ability to improve fish kill reporting.

## 6.5 LITERATURE CITED

- Abbott B, Siger A, Spiegelstein M (1975) Toxins from the blooms of *Gymnodinium breve*. In: LoCicero VR (ed). Proc Proceedings of the First International Conference on Toxic Dinoflagellate Blooms. Massachusetts Science and Technology Foundation, Wakefield, Massachusetts
- Baden D (1988) Public health problems of red tides. In: Tu AT (ed) Handbook of Natural Toxins, Book 3. Marcel Dekker, New York, p 259–277
- Collard S, Lugo-Fernandez A, Fitzhugh G, Brusher J, Shaffer R (2000) A Mass Mortality Event in Coastal Waters of the Central Florida Panhandle During Spring and Summer 1998. *Gulf of Mexico Science* 18(1):68-71
- Collard SB, Lugo-Fernández A (1999) Coastal Upwelling and Mass Mortalities of Fishes and Invertebrates in the Northeastern Gulf of Mexico During Spring and Summer 1998: Final Report. US Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region
- Flaherty KE, Landsberg JH (2011) Effects of a persistent red tide (*Karenia brevis*) bloom on community structure and species-specific relative abundance of nekton in a Gulf of Mexico estuary. *Estuaries and Coasts* 34(2):417-439
- Franks J (2005) First record of goliath grouper, *Epinephelus itajara* in Mississippi coastal waters with comments on the first documented occurrence of red grouper: *Epinephelus morio*, off Mississippi. *Gulf and Caribbean Fisheries Institute* 56:295-306
- Grüss A, Karnauskas M, Sagarese SR, Paris CB, Zapfe G, Walter JF, Ingram W, Schirippa MJ (2014a) Use of the Connectivity Modeling System to estimate the larval dispersal, settlement patterns and annual recruitment anomalies due to oceanographic factors of red

- grouper (*Epinephelus morio*) on the West Florida Shelf. SEDAR42-DW-03. SEDAR, North Charleston, SC, 24 pp.
- Grüss A, Schirripa MJ, Chagaris D, Verley P, Shin Y-J, Velez L, Ainsworth CH, Sagarese SR, Karnauskas M (2014b) Evaluation of the natural mortality rates of red grouper (*Epinephelus morio*) in the West Florida Shelf ecosystem using the individual-based, multi-species model OSMOSE-WFS. SEDAR42-DW-02. SEDAR, North Charleston, SC, 70 pp.
- Hu C, Muller-Karger FE, Taylor C, Carder KL, Kelble C, Johns E, Heil CA (2005) Red tide detection and tracing using MODIS fluorescence data: A regional example in SW Florida coastal waters. *Remote Sensing of Environment* 97(3):311-321
- Karnauskas M, Paris CB, Zapfe G, Grüss A, Walter JF, Schirripa MJ (2013) Use of the Connectivity Modeling System to estimate movements of gag grouper (*Mycteroperca microlepis*) recruits in the northern Gulf of Mexico. SEDAR33-DW18. SEDAR, North Charleston, SC, 12 pp.
- Landsberg JH (2002) The effects of harmful algal blooms on aquatic organisms. *Reviews in Fisheries Science* 10(2):113-390
- Maunder MN, Watters GM (2003) A general framework for integrating environmental time series into stock assessment models: model description, simulation testing, and example. *Fishery Bulletin* 101:89-99
- Paris CB, Helgers J, Van Sebille E, Srinivasan A (2013) Connectivity Modeling System: A probabilistic modeling tool for the multi-scale tracking of biotic and abiotic variability in the ocean. *Environmental Modelling & Software* 42:47-54
- Patterson WF, Watterson JC, Shipp RL, Cowan Jr JH (2001) Movement of tagged red snapper in the northern Gulf of Mexico. *Transactions of the American Fisheries Society* 130(4):533-545

- Sagarese SR, Grüss A, Karnauskas M, Walter JF (2014a) Ontogenetic spatial distributions of red grouper (*Epinephelus morio*) within the northeastern Gulf of Mexico and spatio-temporal overlap with red tide events. SEDAR42-DW-04. SEDAR, North Charleston, SC, 32 pp.
- Sagarese SR, Tetzlaff JC, Bryan MD, Walter JF, Schirripa MJ (2014b) Linking an environmental index to natural mortality within the stock synthesis integrated assessment model framework: A case study for Gulf of Mexico gag grouper (*Mycteroperca microlepis*) and red tide. SEDAR33-RW01. SEDAR, North Charleston, SC, 29 pp.
- Schirripa MJ, Goodyear CP, Methot RM (2009) Testing different methods of incorporating climate data into the assessment of US West Coast sablefish. ICES Journal of Marine Science 66(7):1605-1613
- Schirripa MJ, Methot RD, et al. (2013) Incorporating various Gulf of Mexico Integrated Ecosystem Assessment products into the Stock Synthesis Integrated Assessment Model framework. SEDAR33-DW10. SEDAR, North Charleston, SC, 17 pp.
- Stumpf R, Culver M, Tester P, Tomlinson M, Kirkpatrick GJ, Pederson BA, Truby E, Ransibrahmanakul V, Soracco M (2003) Monitoring *Karenia brevis* blooms in the Gulf of Mexico using satellite ocean color imagery and other data. Harmful Algae 2(2):147-160
- Walter J, Christman MC, Landsberg JH, Linton B, Steidinger K, Stumpf R, Tustison J (2013) Satellite derived indices of red tide severity for input for Gulf of Mexico Gag grouper stock assessment. SEDAR33-DW08. SEDAR, North Charleston, SC, 43 pp.