SEDAR

Southeast Data, Assessment, and Review

SEDAR 31
Section II: Data Workshop Report

Gulf of Mexico Red Snapper

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SEDAR
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1. Introduction

1.1 Workshop Time and Place

The SEDAR 31 Data Workshop for Gulf of Mexico Red Snapper (*Lutjanus campechanus*) was held August 20-24, 2012 in Pensacola, Florida.

1.2 Terms of Reference

1. Review stock structure and unit stock definitions, considering 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, 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, with particular emphasis on density-dependence
3. Recommend discard mortality rates.
   - Review available research and published literature
   - Consider research directed at red snapper as well as similar species from 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
4. Provide measures of population abundance that are appropriate for stock assessment.
   - Consider and discuss all applicable 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; rank indices with regard to their suitability for use in assessment modeling
   - Discuss the degree to which available indices adequately represent fishery and population conditions
   - Recommend which data sources are considered appropriate for use in assessment modeling
   - Complete the SEDAR index evaluation worksheet for each index considered
5. Characterize commercial and recreational catch, 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 fishery sector or gear
   - Provide length and age distributions if feasible, and maps of fishery effort and harvest

- Provide maps of fishery effort and harvest

6. Evaluate the mortality rate of red snapper due to explosive rig removals, and whether such mortality is significant for inclusion in the assessment.
7. Describe any environmental covariates or episodic events that would be reasonably expected to affect population abundance.
8. Provide any information available about demographics and socioeconomics of fishermen, especially as they may relate to fishing effort.
9. Provide recommendations for future research, including guidance on sampling design, intensity, and appropriate strata and coverage.
10. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions (Section II of the SEDAR assessment report).
    - Develop a list of tasks to be completed following the workshop
    - Review and describe any ecosystem consideration(s) that should be included in the stock assessment report

1.3 List of Participants

Data Workshop Panel

Jason Adriance	LDWF	Robert Allman	NMFS
Neil Baertlein	SEFSC	Beverly Barnett	NMFS
Nancy Brown-Peterson	USM	Matthew Campbell	NMFS
Ching-Ping Chih	SEFSC	Dave Donaldson	GSMFC
Barbara Dorf	TPWD	Gary Fitzhugh	NMFS
Claudia Friess	OC	Benny Gallaway	LGL Consulting
Adyan Rios	SEFSC	Gary Graham	Texas Sea Grant
Wade Griffin	TAMU	John Ward	Economist
Walter Ingram	NMFS	David Krebs	Fisherman
Brian Linton	SEFSC	Joanne Lyczkowski-Shultz	NMFS
John Mareska	AL DNR	Kevin McCarthy	SEFSC
James Nance	NMFS	Mike Thierry	Fisherman
Adam Pollack	NMFS	Clay Porch	SEFSC
Steven Saul	SEFSC	Beverly Sauls	FWRI
Stephen Szedlmayer	Auburn	Vivian Matter	SEFSC

Council and Agency Staff

Ryan Rindone	SEDAR	Charlotte Schiaffo	GMFMC
Jessica Stephen	SERO	Patrick Davis	SEFSC

Data Workshop Observers

Helen Takade-Hammacher	EDF	Ted Switzer	FWRI
Matthew Vincent	Virginia Tech	John Winter	SEFSC
Bob McMichael	FWRI	Will Patterson	DISL
Shannon Cass-Calay	SEFSC	Marcus Drymon	DISL

Sean Powers	DISL	Doug DeVries	NMFS
Stephanie Freed	FWRI	Joe Powers	LSU
Donnie Waters	Fisherman	Wayne Werner	Fisherman
Bob Zales II	Fisherman	Dave Gloeckner	SEFSC
Hannah Trowbridge	NMFS	David Walker	Fisherman
Russell Underwood	Fisherman	Mike Whitfield	Fisherman
Brian Gauvin	Photographer	Kerry Hurst	KC Fisheries Inc
Glenn Brooks	Fisherman	Glenn Brooks, Jr.	Fisherman
Carlos Llull	FWC	Terri Menzel	FWC
Jill Broome	FWC	Ian Rehrig	FWC
Troy Frady	Fisherman		

1.4 List of Data Workshop Working Papers

Document Number	Title	Authors
Data Workshop Documents		
SEDAR31-DW01	Relative abundance of juvenile red snapper, *Lutjanus campechanus* in the northern Gulf of Mexico	Parsons
SEDAR31-DW02	Brief overview on Gulf of Mexico Red Snapper IFQ Program	Stephen
SEDAR31-DW03	Working Paper for Red Snapper Data Workshop (SEDAR 31)	Cowan, Boswell, Simonsen, Saari, and Kulaw
SEDAR31-DW04	Recreational Survey Data for Red snapper in the Gulf of Mexico	Matter
SEDAR31-DW05	Red snapper (*Lutjanus campechanus*) otolith ageing summary for collection years 2009-2011	Allman, Barnett, Trowbridge, Goetz, and Evou
SEDAR31-DW06	An Update to the Age Composition, Growth, and Density-Dependent Mortality in Juvenile Red Snapper Estimated from Observer Data from the Gulf of Mexico Penaeid Shrimp Fishery	Gazey, Gallaway, and Cole
SEDAR31-DW07	Expanded Annual Stock Assessment Survey 2011: Red Snapper Reproduction	Fitzhugh, Lang, and Lyon
SEDAR31-DW08	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Red Snapper	Campbell, Rademacher, Felts, Noble, Felts, and Salisbury
SEDAR31-DW09	Index of Abundance for Pre-Fishery Recruit Red Snapper from Florida Headboat Observer Data	O'Hop and Sauls
SEDAR31-DW10	Length frequency distributions for red snappers in the Gulf of Mexico from 1984-2011	Chih
SEDAR31-DW11	A Summary of Data on the Size Distribution and Release Condition of Red Snapper Discards from Recreational Fishery Surveys in the Gulf of	Sauls

	Mexico	
SEDAR31-DW12	A comparison of the size and age of red Snapper, *Lutjanus campechanus*, to the age of artificial reefs in the northern Gulf of Mexico	Syc and Szedlmayer
SEDAR31-DW13	Use of Ultrasonic Telemetry to Estimate Natural and Fishing Mortality of Red Snapper	Topping and Szedlmayer
SEDAR31-DW14	Fine-scale Movements and Home Ranges of Red Snapper *Lutjanus campechanus* Around Artificial Reefs in the Northern Gulf of Mexico	Piraino and Szedlmayer
SEDAR31-DW15	Spatio-temporal dynamics in red snapper reproduction on the West Florida Shelf, 2008-2011	Lowerre-Barbieri, Crabtree, Switzer, and McMichael
SEDAR31-DW16	Spatial distribution and occurrence of red snapper, *Lutjanus campechanus*, sampled off the Louisiana coast during nearshore trawl sampling efforts	Adriance and Sweda
SEDAR31-DW17	Summary report of the red snapper (Lutjanus campechanus) catch during the 2011 congressional supplemental sampling program (CSSP)	Campbell, Pollack, Henwood, Provaznik, and Cook
SEDAR31-DW18	On the comparisons of regional differences in the growth of red snappers from the Gulf of Mexico	Chih
SEDAR31-DW19	Abundance Indices of Red Snapper Collected in NMFS Bottom Longline Surveys in the northern Gulf of Mexico	Ingram and Pollack
SEDAR31-DW20	Red Snapper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Pollack, Ingram, and Foster
SEDAR31-DW21	Examining delayed mortality in barotrauma afflicted red snapper using acoustic telemetry and hyperbaric experimentation	Stunz and Curtis
SEDAR31-DW22	Release mortality in the red snapper fishery: a synopsis of three decades of research	Campbell, Driggers, and Sauls
SEDAR31-DW23	Release Mortality Estimates for Recreational Hook-and-Line Caught Red Snapper Derived from a Large-Scale Tag-Recapture Study in the Eastern Gulf of Mexico	Sauls
SEDAR31-DW24	Fisheries-independent data for red snapper from reef-fish surveys on the West Florida Shelf, 2008-2011	Switzer, Keenan, and McMichael
SEDAR31-DW25	Estimated Conversion Factors for Adjusting MRFSS Gulf of Mexico Red Snapper Catch Estimates and Variances in 1981-2003 to MRIP Estimates and Variances	Rios, Matter, Walter, Farmer, and Turner
SEDAR31-DW26	Developing a survey methodology for sampling	Moser, Pollack,

	red snapper, *Lutjanus campechanus*, at oil and gas platforms in the northern Gulf of Mexico	Ingram, Gledhill, Henwood, and Driggers
SEDAR31-DW27	Red Snapper (*Lutjanus campechanus*) larval indices of relative abundance from SEAMAP fall plankton surveys, 1986 to 2010	Pollack, Hanisko, Lyczkowski- Shultz, Jones, and Ingram
SEDAR31-DW28	Red Snapper Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2011	DeVries, Ingram, Gardner, and Raley
SEDAR31-DW29	Artificial Structure and Hard-Bottom Spatial Coverage in the Gulf of Mexico	Mueller
SEDAR31-DW30	Shrimp Fishery Bycatch Estimates for Gulf of Mexico Red Snapper, 1972-2011	Linton
SEDAR31-DW31	Calculated red snapper discards in the Gulf of Mexico commercial vertical line and bottom longline fisheries: preliminary results	McCarthy
SEDAR31-DW32	Observer reported size distribution of Gulf of Mexico red snapper from the commercial vertical line and bottom longline fisheries	McCarthy
SEDAR31-DW33	Using a Censored Regression Modeling Approach to Standardize Red Snapper Catch per Unit Effort Using Recreational Fishery Data Affected by a Bag Limit	Saul and Walter

Reference Documents		
SEDAR31-RD01	SEDAR 7 Stock Assessment Report	SEDAR
SEDAR31-RD02	2009 SEDAR 7 Update Assessment Report	SEDAR
SEDAR31-RD03	Red Snapper 2011 Projections Update	SEFSC
SEDAR31-RD04	Estimation of Fisheries Impacts Due to Underwater Explosives Used to Sever and Salvage Oil and Gas Platforms in the U.S. Gulf of Mexico	Minerals Management Service
SEDAR31-RD05	Age Composition, Growth, and Density-Dependent Mortality in Juvenile Red Snapper Estimated from Observer Data from the Gulf of Mexico Penaeid Shrimp Fishery	Gazey, Gallaway, Cole, and Fournier
SEDAR31-RD06	A Life History Review for Red Snapper in the Gulf of Mexico with an Evaluation of the Importance of Offshore Petroleum Platforms and Other Artificial Reefs	Gallaway, Szedlmayer, and Gazey
SEDAR31-RD07	Addressing Time-Varying Catchability	SEDAR

SEDAR31-RD08	Fishery-Independent Catch of Young-of-the-Year Red Snapper in the Texas Territorial Sea, 1985–2007	Dorf and Fisher
SEDAR31-RD09	Red Snapper Management History	GMFMC
SEDAR31-RD10	Home range and movement patterns of red snapper (*Lutjanus campechanus*) on artificial reefs	Topping and Szedlmayer
SEDAR31-RD11	Genetic variation and spatial autocorrelation among young-of-the-year red snapper (*Lutjanus campechanus*) in the northern Gulf of Mexico	Saillant, Bradfield, and Gold
SEDAR31-RD12	Determining policy-efficient management strategies in fisheries using data envelopment analysis (DEA)	Griffin and Woodward
SEDAR31-RD13	Red Snapper Larval Transport in the Northern Gulf of Mexico	Johnson, Perry, Lyczkowski-Shultz, and Hanisko
SEDAR31-RD14	Estimation of the Source of Red Snapper Recruits to West Florida and South Texas with Otolith Chemistry: Implications for Stock Structure and Management	Patterson, Cowan, Barnett, and Sluis
SEDAR31-RD15	Trends in Gulf of Mexico Red Snapper Population Dynamics, 1979-85	Parrack and McClellan
SEDAR31-RD16	Effects of habitat complexity and predator exclusion on the abundance of juvenile red snapper	Piko and Szedlmayer
SEDAR31-RD17	Survival and movement of hatchery-reared red snapper on artificial habitats in the northern Gulf of Mexico	Chapin, Szedlmayer, and Phelps
SEDAR31-RD18	A Life History Review for Red Snapper in the Gulf of Mexico with an Evaluation of the Importance of Offshore Petroleum Platforms and Other Artificial Reefs	Gallaway, Szedlmayer, and Gazey
SEDAR31-RD19	The use of otolith shape analysis for ageing juvenile red snapper, *Lutjanus campechanus*	Beyer and Szedlmayer
SEDAR31-RD20	Validation of annual periodicity in otoliths of red snapper, *Lutjanus campechanus*	Szedlmayer and Beyer
SEDAR31-RD21	The Artificial Habitat as an Accessory for Improving Estimates of Juvenile Reef Fish Abundance in Fishery Management	Szedlmayer

SEDAR31-RD22	Home range and movement patterns of red snapper (*Lutjanus campechanus*) on artificial reefs	Topping and Szedlmayer
SEDAR31-RD23	Site fidelity, residence time and movements of red snapper *Lutjanus campechanus* estimated with long-term acoustic monitoring	Topping and Szedlmayer
SEDAR31-RD24	Proximity Effects of Larger Resident Fishes on Recruitment of Age-0 Red Snapper in the Northern Gulf of Mexico	Mudrak and Szedlmayer
SEDAR31-RD25	Estimates of Historic Recreational Landings of Spanish Mackerel in the South Atlantic Using the FHWAR Census Method	Brennan and Fitzpatrick
SEDAR31-RD26	Declining Size at Age Among Red Snapper in the Northern Gulf of Mexico off Louisiana, USA: Recovery or Collapse?	Nieland, Wilson, and Fischer
SEDAR31-RD27	Examination of Red Snapper Fisheries Ecology on the Northwest Florida Shelf (FWC-08304): Final Report	Patterson, Tarnecki, and Neese
SEDAR31-RD28	Site Fidelity, Movement, and Growth of Red Snapper: Implications for Artificial Reef Management	Strelcheck, Cowan, and Patterson
SEDAR31-RD29	Factors Affecting Catch and Release (CAR) Mortality in Fish: Insight into CAR Mortality in Red Snapper and the Influence of Catastrophic Decompression	Rummer
SEDAR31-RD30	Effect of Circle Hook Size on Reef Fish Catch Rates, Species Composition, and Selectivity in the Northern Gulf of Mexico Recreational Fishery	Patterson, Porch, Tarnecki, and Strelcheck
SEDAR31-RD31	Effect of trawling on juvenile red snapper (*Lutjanus campechanus*) habitat selection and life history parameters	Wells, Cowan, Patterson, and Walters
SEDAR31-RD32	Habitat use and the effect of shrimp trawling on fish and invertebrate communities over the northern Gulf of Mexico continental shelf	Wells, Cowan, and Patterson
SEDAR31-RD33	Site Fidelity and Movement of Reef Fishes Tagged at Unreported Artificial Reef Sites off NW Florida	Addis, Patterson, and Dance
SEDAR31-RD34	Fish Community and Trophic Structure at Artificial Reef Sites in the Northeastern Gulf of Mexico	Dance, Patterson, and Addis

SEDAR31-RD35	A Review of Movement in Gulf of Mexico Red Snapper: Implications for Population Structure	Patterson
SEDAR31-RD36	Size selectivity of sampling gears targeting red snapper in the northern Gulf of Mexico	Wells, Boswell, Cowan, and Patterson
SEDAR31-RD37	Delineating Juvenile Red Snapper Habitat on the Northern Gulf of Mexico Continental Shelf	Patterson, Wilson, Bentley, Cowan, Henwood, Allen, and Dufrene
SEDAR31-RD38	Habitat- and Region-Specific Reproductive Biology of Female Red Snapper (*Lutjanus campechanus*) in the Gulf of Mexico	Kulaw
SEDAR31-RD39	Comparison of the Age and Growth of Red Snapper (*Lutjanus campechanus*) Amongst Habitats and Regions in the Gulf of Mexico	Saari
SEDAR31-RD40	Oil Platforms and Red Snapper Movement and Behavior	McDonough
SEDAR31-RD41	Reconstructed time series of shrimp trawl effort in the Gulf of Mexico and the associated bycatch of red snapper from 1948 to 1972	Porch and Turner
SEDAR31-RD42	Individual-based modeling of an artificial reef fish community: Effects of habitat quantity and degree of refuge	Campbell, Rose, Boswell, and Cowan
SEDAR31-RD43	Literature Search and Data Synthesis of Biological Information for Use in Management Decisions Concerning Decommissioning of Offshore Oil and Gas Structures in the Gulf of Mexico	Versar, Inc.
SEDAR31-RD44	The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts	Keevin and Hempen
SEDAR31-RD45	Connections between Campeche Bank and Red Snapper Populations in the Gulf of Mexico via modeled larval transport	Johnson, Perry, and Lyczkowski-Shultz
SEDAR31-RD46	The commercial landings of red snapper in the Gulf of Mexico from 1872 to 1962	Porch, Turner, and Schirripa
SEDAR31-RD47	Estimates of Historical Red Snapper Recreational Catch Levels Using US Census Data and Recreational Survey Information	Scott
SEDAR31-RD48	MRFSS/MRIP Calibration Workshop: Ad-hoc Working Group Report	Salz, Miller, Williams, Walter, Drew, and Bray

SEDAR31-RD49	Survival of Red Grouper (*Epinephelus morio*) and Red Snapper (*Lutjanus campechanus*) Caught on J-Hooks and Circle Hooks in the Florida Recreational and Recreational-for-Hire Fisheries	Burns and Froeschke
SEDAR31-RD50	Circle Hook Requirements in the Gulf of Mexico: Application in Recreational Fisheries and Effectiveness for Conservation of Reef Fishes	Sauls and Ayala

2 Life History

2.1 Overview

The life history workgroup (LHW) reviewed and discussed data collected since the last Gulf of Mexico red snapper stock assessment in 2004 and offered recommendations. Updated information was examined on age, growth, reproduction, genetics, otolith chemistry, mortality, habitat and movement. A summary of the data presented, discussed and recommendations made is presented below.

2.1.1 Life History Workgroup Members

Jason Adriance- Gulf Reef fish SSC
Robert Allman-NMFS, Panama City, FL, (leader)
Beverly Barnett-NMFS, Panama City, FL, (rapporteur)
Nancy Brown-Peterson- University of Southern Mississippi
Gary Fitzhugh- NMFS, Panama City, FL
Benny Gallaway- LGL Ecological Research Associates, Inc.
Joanne Lyczkowski-Shultz- NMFS, Pascagoula, MS
John Mareska- Gulf Reef fish SSC
Steve Szedlmayer- Auburn University
Matt Vincent- Virginia Tech University

2.1.2 The LHW group addressed the following topics

1. Stock definitions and any evidence for changes to current east-west stock boundaries
2. Habitat Requirements
3. Natural mortality
4. Age
5. Growth
6. Reproduction
7. Movement and Migration
8. Conversion factors
9. Episodic events
10. Mortality due to oil and natural gas platform removals

2.2 Stock Definitions

The LHW continued to support the two stock model (East and West of the Mississippi River) for Gulf of Mexico red snapper. While there is some evidence that suggests this boundary line should be shifted to the east, the group did not feel there was enough compelling evidence to support moving the boundary line at this time. The LHW noted the recent genetic, otolith chemistry and oceanographic results are advancing our understanding that red snapper is clearly demonstrating metapopulation structure. The LHW emphasized that further studies need to be conducted to

examine critical source populations (likely local) to gain better understanding of the metapopulation structure. Supporting evidence for the two stock model, as well as evidence for existing metapopulation structure, are described below.

2.2.1 Genetic results

Spatial heterogeneity of red snapper was found to exist for two cohorts sampled in 2004 and 2005 (Saillant et al. 2010 SEDAR 31-RD-11). This is a significant result since it provides the first evidence of non-random spatial distribution of red snapper genotypes (Saillant et al. 2010 SEDAR 31-RD11). Significant positive autocorrelation (r) of microsatellite genotypes was found for red snapper collected from geographic scales of ~50 – 100 km indicating significant spatial genetic heterogeneity (Saillant et al. 2010 SEDAR 31-RD-11). These findings provide evidence that red snapper exhibit independent demographic assemblages at small geographic spatial scales (Saillant et al. 2010 SEDAR 31-RD11). Results from this study further support the findings that red snapper demonstrate a metapopulation stock-structure model proposed by Pruett et al. (2005) and Saillant and Gold (2006).

2.2.2 Otolith constituent analysis

Patterson et al. (2010 SEDAR 31-RD-14) expanded on previously conducted otolith chemistry work to address three primary objectives: 1) estimate source(s) recruits to the west Florida shelf; 2) estimate connectivity between south Texas and northeast Mexico; and 3) estimate mixing rates east and west of the Mississippi River. Microconstituent analysis for three cohorts (2005, 2006, and 2007) provided good discrimination among four northern Gulf of Mexico nursery regions (EG = East Gulf; NCG = North Central Gulf; NWG = Northwest Gulf; and SWG = Southwest Gulf) and one region in Mexico (MEX1) (Patterson et al. 2010 SEDAR 31-RD- 14). The boundary used to separate NCG from NWG was longitude 89.0^{o}W and the boundary used to separate NWG from SWG was longitude 94.5^{o}W (Patterson et al. 2008). The boundary between NCG and EG was Cape San Blas, Florida, 85.1^{o}W. There was noted concern about the lack of discrimination between the NWG and NCG nursery regions in all three cohort-specific models. Misclassifications occurred by assigning NWG to NCG, and vice versa (Patterson et al. 2010 SEDAR 31-RD- 14). Sluis et al. (2012) suggested that similarities in chemical signatures may be the result of persistent hydrological and oceanographic processes. It is also important to note that the only regions successfully sampled during each of the three years were the SWG, NWG, and NCG regions (Patterson et al. 2010 SEDAR 31-RD- 14). Samples from EG were collected in 2005 and 2007(Patterson et al. 2010 SEDAR 31-RD- 14). Samples from MEX1 were collected in 2006 and 2007 (Patterson et al. 2010 SEDAR 31-RD- 14). Consequently, the only year for which all five regions were sampled was in 2007 (Patterson et al. 2010 SEDAR 31-RD-14). Patterson et al. (2010 SEDAR 31-RD-14) attempted to jointly model all three year classes to determine if a multi-year class model would allow nursery origins to be estimated for years that all regions had not been successfully sampled. However, the low classification (49%) for this multi-year-class model suggests that this approach would not be feasible (Patterson et al. 2010 SEDAR 31-RD-14). Red snapper age-0 chemical signatures have consistently shown significant differences among year-classes and regions supporting the need for age-0 samples to be collected and analyzed for each year-class and region (Patterson et al. 2010 SEDAR 31-RD-14; Patterson et al. 2008 Sluis et al. 2012).

Nursery region signatures were applied to sub-adult and adult signatures using maximum likelihood estimates (MLE) in order to assign nursery origin. The source of recruits to the EG was estimated as being derived primarily from local recruitment with the secondary source estimated as coming from the NCG and NWG (Patterson et al. 2010 SEDAR 31-RD-14). However, it is unclear as to the contribution, if any, that the NWG may have provided to the EG since the nursery chemical signatures from the NWG were similar to those of the NCG (Patterson et al. 2010 SEDAR 31-RD-14). Interestingly, tagging data further supports the NCG as a source of recruits to the EG and confirms a finding identified during the previous assessment (Addis et al. 2007 SEDAR 31-RD-33). Another trend that was noted was the NWG as a significant source of recruits to the NWG, SWG and NCG regions for the three years examined (Patterson et al. 2010 SEDAR 31-RD-14). Again, uncertainty remains in the connectivity between the NWG and NCG due to the similarities of the chemical signatures from these two regions (Patterson et al. 2010 SEDAR 31-RD-14). Regardless, results found in Patterson et al. (2010 SEDAR 31-RD-14) are consistent with a study conducted by Saillant and Gold (2006) which estimated the NWG as having an effective genetic population size of at least an order of magnitude greater than either the NCG or SWG regions (Saillant and Gold 2006), which further substantiates the importance of the NWG not only as a local source of recruits, but also as a significant source of recruits to other regions.

The possibility of recruits coming from Mexico (particularly Campeche Bank) to the US fishery has been an ongoing area of interest and investigation. Results for the contribution of MEX1 (Tamaulipas-Veracruz shelf) fish to south Texas indicate that MEX1 does not provide a significant source of recruits to south Texas or other western US Gulf regions despite the fact that MEX1 had distinct chemical signatures resulting in one of the highest LDF (linear discriminant function) classification accuracies in 2006 and 2007 (Patterson et al. 2010 SEDAR 31-RD-14). Samples were collected from Campeche Bank (MEX2) about three months later than in other regions in 2006 and 2007. Although individual fish were not aged, lengths were larger than age-0 fish collected from other regions suggesting a possible age discrepancy (Patterson et al. 2010 SEDAR 31-RD-14). Furthermore, some element: Ca and stable isotopes resulted in extreme values further suggesting a possible age disparity (Patterson et al. 2010 SEDAR 31-RD-14). As a result, MEX2 was excluded from further analyses (Patterson et al. 2010 SEDAR 31-RD-14). Consequently, the connection between Campeche and south Florida still remains an open question regarding application of otolith chemistry .

2.2.3 Models of Larval Transport

Johnson et al. (2009) shows that there is an oceanographic mechanism to transport red snapper larvae from the western to eastern Gulf during the summer spawning period with eastward flow greatest in July. While there is evidence of a larval transport pathway around the Mississippi delta, the primary pathway is in deeper waters beyond the shelf break raising some uncertainty about successful settlement on the shelf east of the Mississippi River. Conversely, there is evidence for on-shelf exchange from east to west, occurring near the end of the spawning season (September and October). By dropping simulated larvae into locations for 654 SEAMAP stations positive for red snapper larvae, Johnson et al. were able to map drift points (21 d forward, 11 d backward). The result was that most of the continental shelf from DeSoto Canyon westward (primarily western Mississippi Bight and Louisiana-Texas shelf) has the possibility of receiving larvae. The likelihood of transport to the west Florida shelf was much lower. The main topographic impediments to

alongshore flow are the Mississippi River, DeSoto Canyon and the Apalachicola peninsula with the Apalachicola peninsula being most significant (Johnson et al. 2012).

To address the potential Mexican connection, Johnson et al. (2012) modeled possible advection of red snapper larvae from Campeche Bank. They found that retention of simulated larvae was high (67-73%) for model runs based upon 4 years (2003, 2005, 2008, 2010) of oceanographic data. In general there was very little likelihood for recruitment to other regions, although perhaps high enough for genetic homogenization. An estimate of 1.6% of the simulated larvae entered the Florida current with some potential for advection to the SW Florida shelf and Atlantic coast.

A significant synthesis by Johnson et al. (2012) notes that "depleted areas such as peninsular Florida are not likely to be enhanced by larval advection from either the more abundant northwestern population (Johnson et al. 2009) or Campeche Bank."

The LHW noted that while there are a lack of recruits coming from the Tamaulipas-Veracruz shelf (MEX1) to south Texas based on otolith chemistry, there may be a pathway for larval advection if egg production is sufficient. Zavala-Hidalgo (2003) developed a high resolution numerical model of the western Gulf and report an upshelf coastal confluence zone near 26. 5^0 N (Statistical Grid 21) from May-August. The LHW notes this model covers an area of Mexican waters mainly west of investigation by Johnson et al (2012) and may be of interest for future monitoring and investigation.

2.3 Habitat Requirements

Spawning season for red snapper occurs April – October in US Gulf waters with peak fraction in spawning markers noted to occur late June – mid July (Fitzhugh et al. 2012 SEDAR 31-DW-07) Rooker et al. (2004)sampled red snapper larvae at Freeport Rocks Bathymetric High and found that larvae remained in the plankton for approximately 4 weeks . Fish settle out of the plankton about mid-June and continue recruiting to benthic habitat until mid-September (Szedlmayer and Conti 1999). Newly settled recruits can be found on multiple habitat types such as sand, mud, and shell rubble (Rooker et al. 2004). In the Fall, fish recruit to more structured habitats such as shell ridges, rock outcroppings, sand banks and artificial reefs (SEDAR 31-RD01). Parsons (SEDAR31-DW01) reported a significant relationship between relative abundance of juveniles and capture depth in early to late fall with higher catch rates in shallower waters compared to deeper waters. Syc and Szedlmayer (SEDAR 31-DW12) reported juvenile red snapper (approximately age-1) on newly deployed artificial reefs. Changes in diet also occur during the ontogenetic habitat shift resulting in an increase of benthic fauna and fish prey types (McCawley and Cowan 2007; Szedlmayer and Lee 2004). Diet was also reported as varying with diel cycles (Ouzts and Szedlmayer 2003). NMFS long-line surveys suggest that larger, older red snapper become more independent of structured habitat, being found more often on the open continental shelf (SEDAR31-RD01). Furthermore, landings from large, tournament-winning fish in Texas caught on mud bottoms with very small (< 1 m^2) structured relief (< 0.5 m) support this same conclusion (Landre, personal observation).

2.4 Natural Mortality

The models to be used for analysis of red snapper in SEDAR 31 will be CATCHEM_AD and Stock Synthesis (Porch 2007, Methot 2010). These models have the capacity to accept a distribution of informative priors, and estimate M within the model. That capacity reduces some of the need to specify a single estimate for M. However, other analytical methods that are intended to be run in the assessment process do require a specified value of M, or have difficulty in resolving M in some circumstances. Therefore, providing a good estimate of M for those cases will help evaluate the relative performance of the various models.

2.4.1 Age-0 and Age-1

During the 2009 update assessment, natural mortality and means of parameterizing the assessment models were discussed and a decision was made to increase M to 2.0 (age-0) and 1.2 (age-1) (SEDAR31-RD02). New results were reviewed since the 2009 update, including three studies completed in no-trawl zones (Table 1) wherein estimates of Z could be assumed to approximate M (Wells et al. 2008 SEDAR31 RD32, Gallaway et al. 2009 SEDAR31-RD18, Szedlmayer 2011 SEDAR 31-RD21). The LHW noted similar results from these studies which provide further support for increasing estimates of M (particularly for age-0 in the range 2.0-3.4, Table 1) with the caveat that M at age-0 is likely density-dependent (see below).

Two presentations to the LHW on natural mortality in the juvenile stage were based upon broad regional results of trawl surveys and observer data. B. Gallaway presented a density dependent model of growth and survival applied to observer estimates of red snapper bycatch in the western Gulf shrimp fishery (introduced in Gazey et al. 2008 SEDAR31-RD05). Best fit results were age-0 Z = 2.2, and age-1 Z = 1.3 (Table 1). J. Walter presented preliminary new results of an earlier analysis in 2009 (Brooks et al. SEDAR31-RD02): Mortality was estimated via decline in numbers at age (based on size modes) between summer and fall SEAMAP surveys. Estimation accounted for survey trawl size-selectivity in age-0 and age-1 fish. Preliminary early estimates for age-0 M ranged from 2.65-5.6 and age-1 M from 2.01-3.6. This analysis will continue to be refined for the Assessment Workshop.

While the reviewed studies collectively suggest convergence of estimates and an increase in the age-0 estimate of M, the study authors generally acknowledged the potential for biased high estimates in some cases due to unaccounted emigration at particular sizes or juvenile stages. Szedlmayer (2011 SEDAR31-RD21) suggested emigration may be discounted in an Alabama study given a lack of correlation between diver estimates of age-0 red snapper density on artificial reefs and broad scale trawling results. That is, no spill-over effect was detected via trawling which suggests any emigration from reefs is minimal. The LHW noted this is challenging research and there is a need to expand studies to more habitats and regions and better understand survival in early life history as a function of habitat type and density (see recommendations).

2.4.2 Older age classes

The LHW reviewed estimates of total disappearance (Z) and natural mortality (M) from catch curves and various equations (Table 2). From these functions the LHW developed a table of

estimated M values as informative priors for the assessment (Table 3). Natural mortality (M) estimates ranged from 0.05 to 1.29. Calculated values of M fall into three groups based upon selected life history correlates. As expected, lowest values were generated from equations utilizing longevity of red snapper (>50 years; Alverson and Carney, Hoenig, and Hewitt and Hoenig). Equations that accounted for productivity in early life history (fast initial growth, relative early age of maturation) return higher estimates of M (Beverton and Holt, Pauly, Ralston, and Jensen) (Table 3, Figure 1).

Disappearance rates (Z) were obtained through catch curve analysis following Murphy (1997) for regression and Chapman-Robson approaches assuming steady state conditions. Numbers at age data from various fishing sectors for the period 2009-2011 were examined using peak-age and right truncation criteria (Murphy 1997, Table 4). Estimates of Z ranged from 0.1222 to 1.064. Values of Z were highest (> 1.0) among handline sectors (commercial and recreational) in the eastern Gulf. Higher values have been recently reported by Patterson et al. 2010 from the northeastern Gulf (1.24 – 1.31; artificial and natural reef respectively) which reflect a large degree of fishing mortality and possible emigration (e.g. ontogenetic movement to deeper water).

Lowest values of Z (about 0.1) were evident from long-line gear (fishery-dependent and – independent sources) from the western Gulf which is in accordance with older red snapper age structure in the west and susceptibility of oldest ages at deepest depths to longline gear. The true value of Z should be considered as an upper limit of M, since with no fishing and no emigration Z=M. The true value of M is rarely determined because it should be calculated from an unfished population, which requires sampling a population before the onset of fishing. However, the LHW learned that some areas of the Gulf outer shelf may have experienced relatively low fishing effort historically (e.g., shrimp grids 20 and 21; Kit Doncaster and Gary Graham Pers. Comm.). These areas have high proportions of red snapper aged > 20 years (see Age section) and would likely return the lowest values of Z which approach longevity-based estimates of M. Given the longline results, estimates of M based upon longevity (e.g. Hoenig regression based estimate for fish = 0.075) may be a reasonable prior for oldest ages (Figure 1).

Notwithstanding low natural maturity rate in red snapper due to longevity >50 years, and high rates in ages-0 and -1, there is evidence that M may be of some intermediate value in ages > 1 consistent with the idea that M declines rapidly with age. Topping and Szedlmayer (2011 SEDAR31-10) provide some direct evidence for this. Using telemetry, M for red snapper >500 mm TL (predominately thought to be age 3), was estimated at 0.12 to 0.22 when catch (F) was accounted for (Table 1).

The Data Workshop panel supported the approach to incorporate declining natural mortality rate with age as in the previous assessment (Figure 2). However, there is more information that natural mortality is higher among earlier ages (particularly age-0 but also ages 1-3) than previously estimated. Conversely, M may be lower at oldest ages (<0.1) due to longevity estimates. The panel noted that while the Lorenzen approach (1996) for age-variable mortality has been used in assessments of other species (an example for red snapper is shown in Figure 2) another type of function may be appropriate to account for higher expected mortality of age-1 to age 3+ red snapper. This analysis will continue going forward to the Assessment Workshop.

2.4.3 Density Dependence in Mortality

The potential for density dependence in mortality of juvenile red snapper was raised in SEDAR-7 (update 2009) and was also recently presented as a greater issue for fisheries in general (Lorenzen 2008). Therefore, one of the terms of reference for SEDAR 31 was to further examine the evidence for density dependent mortality in early life history.

B. Gallaway presented the Gazey et al. (2008 SEDAR 31-RD5) modeling approach to the LHW updated to July 2012. The model incorporates growth and mortality to explain observed size red snapper juvenile distributions over time from the shrimp fishery observer data. Despite a 74% reduction in shrimp effort to date, there is no evidence for an increase in the red snapper recruitment index (based on standardized by-catch abundance). This provides strong inference that some other population regulatory mechanism is in effect. The most parsimonious model fit incorporated VBGF and density-dependent mortality.

J. Walter presented preliminary results to the LHW of an updated analysis of SEAMAP trawl survey data which similarly models changes in numbers at length (hence age) (Brooks et al. SEDAR31-RD02). In this approach, the most parsimonious model fits also included density-dependence modeled as a power function of abundance.

Given the evidence highlighted by the modeling efforts, the Data Workshop panel recommends incorporation of density dependence in age-0 mortality into assessment model runs. Notably, a paper is in press which outlines a modeling approach to simultaneously account for density-dependent mortality and bycatch in age-0 red snapper (Forrest et al. in press). The panel recognized this work will continue through the Assessment Workshop.

The LHW also discussed alternative interpretations of an apparent density dependent effect in early mortality. These included the possibility of density-independent increases in M and the possibility of supplemental recruitment to account for the lack of a significant stock-recruit signal (see stock delineation section). Further investigation (modeling, research) into possible alternatives are recommended (below).

2.4.4 Comments on Adequacy of Data for Assessment Analyses

Natural Mortality: The LHW recommends model sensitivity runs using M as age-fixed values (age-0 and age-1, age>1) and as an age-variable value (Lorenzen M or other approach). As in earlier SEDARs, the LHW believes an age-variable approach is more realistic and thus the preferred approach.

Review the data for bycatch reduction (BRD) efficiency. Point estimates of efficiency may better inform model fit of density dependence by accounting for possible confounding BRD effect (e.g. Gallaway and Cole 1999).

2.4.5 Recommendations

1. Review the evidence for density dependence in older ages (e.g. ages 2-3). Incorporate full age model of recruitment to examine density-dependent effect.

2. Site and habitat specific comparisons from more regions of the Gulf are needed for estimation of age-0 and age-1 mortality, accounting for shelf characteristics (e.g., width, slope, depth) in tests of density-dependent variation in M and emigration.

3. Broader understanding of habitat value and areal estimates of habitat (distribution—areas of trawlable vs. untrawlable bottom; more refined maps Gulf-wide etc) are needed to further inform the habitat limitation hypothesis for density dependence.

4. Assess the impact of potential predation/competition for taxa of particular interest (lionfish, marine catfish, sciaenids, and red grouper). As well, investigate alternative population regulatory mechanisms including potential sources of density-independent increases in mortality and distant sources of recruitment (but see stock delineation section).

5. Evaluate the potential for sea-bottom restoration or other means to expand habitat and increase survival for post-settlement red snapper.

2.5 Age

Numerous studies have used otoliths to age red snapper and provide basic information on growth and annulus formation (Futch and Bruger, 1976; Bortone and Hollingsworth, 1980; Nelson and Manooch, 1982; Wilson and Nieland, 2001; Manooch and Potts, 1997; Patterson et al., 2001). The age of red snapper has been directly validated to at least 38 years using bomb radio carbon ^{14}C and longevity estimates exceed 50 years (Baker and Wilson, 2001). Additionally, red snapper otolith reader interpretation and the repeatability of age estimates (i.e., precision) have been examined (Allman et al., 2005).

A total of 24,669 red snapper otoliths were aged for SEDAR 31 by NOAA Fisheries Panama City laboratory (N= 17,305; Allman et al. 2012 SEDAR31-DW05) and Gulf States Marine Fisheries Commission (N= 7,364). Otoliths were from fishery dependent and independent sources covering sampling years 2009 through 2011 and covered all gulf states (Table 5 & 6). The Gulf States Marine Fisheries Commission held annual otolith workshops to standardize ageing methods and estimates of reader precision were determined from a red snapper otolith reference collection which was aged annually by all gulf state ageing red snapper and NOAA Fisheries Panama City. We considered an average percent reader error (APE) of 5% as a reference point for a moderately long-lived difficult species to age species such as red snapper (Morison et al. 1998; Campana et al. 2001). APE's for Gulf of Mexico laboratories ageing the red snapper reference collection ranged from 2.2% to 5.6%.

A comparison of age distributions by fishing mode indicated differences by fishing mode and by sampling year. Red snapper collected from 2009 through 2011 ranged from young-of-the-year (<1

year) to 55 years. The smallest youngest individuals were collected from fishery independent survey trawls (mean 1.9 yr) and traps (mean 3.7), while the largest, oldest individuals were collected from the commercial and fishery independent long-lines (mean 5.6 and 8.9 yr. respectively). Age distributions were similar between the eastern and western gulf for commercial hand-line, fishery independent hand-line and the recreational fishery. However, the commercial long-line and fishery independent long-line survey yielded older fish in the western gulf. Saari (2011 SEDAR31-RD39) also noted differences in the age structure of the recreational fishery with the eastern gulf consisting of younger individuals compared to the central and western gulf.

There was some indication of strong year-classes in the directed fisheries and fishery-independent surveys. The commercial hand-line fishery and fishery-independent hand-line survey showed evidence of a strong 2006 year-class with a relatively large percentage of 3 year olds in 2009 (31% and43%, respectively) followed by 4 year olds in 2010 (34% and 34% respectively) and 5 year olds in 2011 (30% and 29% respectively; Fig. 3) This pattern was consistent in the eastern and western gulf in the commercial hand-line fishery, but there were too few data points in the western gulf for fishery-independent hand-line survey for comparison. To a lesser degree there was also some evidence in the recreational and commercial long-line fisheries and was consistent in the eastern and western gulf (Fig. 4). Both the recreational and commercial long-line fisheries also showed some evidence of a strong 2005 year class. Generally, the influence of these strong year classes can be followed for 2 or 3 consecutive years. Saari (2011 SEDAR31-RD39) also found evidence of consistent gulf-wide strong year- classes (2004, 2005 and 2006) in the recreational fishery.

The LHW also examined the frequency of older red snapper (20+ years) from the entire Panama City dataset (1991-2011) by statistical grid (Kutkuhn 1962; Figure 5). We noted a higher frequency of older red snapper in grid 3 (SW Florida) and grids 20 and 21(South Texas) (Fig. 6). This was somewhat independent of gear type, that is, other regions of the gulf with similar or lower percentages of long-line sampled fish did not have the high number of older red snapper (Table 7). These results highlight the need for fishery independent surveys (e.g. long-line survey) to cover the edges of the U.S. fishery (South Texas, South Florida), as well as the northern gulf. The LHW discussed potential differences in the periodicity of opaque zone formation in otoliths. Szedlmayer and Beyer (2011 SEDAR31-RD20) found that opaque zone formation occurred later (late summer to early winter) in OTC marked mark-recapture fish compared to studies which used marginal increment analysis (late winter to early summer; Patterson et al. (2001); Wilson and Nieland (2001); Allman et al. (2005)). It was noted that this could affect the ageing macro used to advance ages by 1 year. Szedlmayer and Beyer (2011 SEDAR31-RD20) posited that the later opaque zone formation could be related to spawning and not slower winter growth. The LHW group discussed that differences may be due to interpretation of otolith edge type and that late formation of the opaque zone was sometimes noted in marginal increment analysis. Additionally, the Szedlmayer laboratory found that 27% of laboratory reared age 1 fish (<200 mm) had 2 opaque zones. The LHW discussed whether the choice of section to age affected interpretation; Gulf States and NOAA primarily use the dorsal side (Vanderkooy and Guindon-Tisdel 2003). The LHW noted 2 papers have measured the distance from the core to the first annulus in red snapper and both used the dorsal side and found similar results (Allman et al. 2005; Fischer et al. 2010).

2.5.1 Recommendations

1. Cross-reference trip tickets and log book data to Biological Sampling Database to complete spatial records (depth, grid, etc.) to allow for increased analysis of spatial demographics.

2. The LHW recommended that existing otolith archives (e.g., NOAA) be used to further investigate interpretation of increment formation based on section orientation, sample source (location), season and year. This could be conducted as a graduate student project in collaboration with agency personnel.

3. Interested Academic representatives (e.g. Auburn University, University of S. Florida) should be included at Gulf States Marine Fisheries Commission sponsored otolith workshops (e.g., May 2013) to review age determinations and promote standardization.

4. Based upon the results of Szedlmayer and Beyer (2011 SEDAR31-RD20), further investigation of longevity is warranted. More recent catches of older fish should allow a direct comparison to ^{14}C coral chronologies established during the nuclear testing period and extend the age that can be directly validated (beyond 38 years in the earlier study by Baker and Wilson 2001).

2.6 Growth

Several studies addressing red snapper growth between differing habitat types and regions have been completed in the Gulf of Mexico since the last benchmark assessment. While not a universal finding, there is evidence of increased growth on artificial habitats for young adults, but size or complexity of the habitat may be an important factor. Cowan et al. (2012 SEDAR31-DW03) noted significant differences in TL and TW von Bertalanffy growth models between shelf-edge banks and standing oil and gas platforms off Louisiana with a significantly larger estimate of $L\infty$ for the standing platforms, but no difference in growth coefficients (k) observed between habitats. Saari (2011 SEDAR31-RD39) also reported that red snapper sampled from shelf-edge banks were significantly smaller at ages 3, 4 and 5 than those from standing and toppled oil and gas platforms. Size-at-age was also significantly different between standing and toppled platforms for ages 3, 4 and 5, but no consistent pattern was found. Saari's (2011 SEDAR31-RD39) analysis included only red snapper from 3 to 6 years old due to insufficient sample size of red snapper above or below those ages. In a 2007 study utilizing conventional tagging methods and subsequent returns, Strelcheck et al. (2007 SEDAR31-RD28) reported faster growth rates at large experimental artificial reefs compared to smaller artificial reefs off of Alabama and slower growth on sites supporting lower reef fish biomass. In a study comparing natural and artificial habitats, Patterson et al. (2010 SEDAR31-RD27), found no significant differences in growth rates between natural reef and artificial reef areas in the northeastern Gulf of Mexico in red snapper ranging from 1 to 9 years of age.

Temporal differences in growth have been examined for red snapper. Neiland et al. (2007 SEDAR31-RD26) demonstrated significant declines in size-at-age for red snapper from the commercial fishery off Louisiana for ages 2-6 over time (1999-2004). They hypothesized that declines in growth over time may to be due to density-dependent effects, possible from the recovery

of an overfished population, or conversely, due to minimum size limits resulting in selection for slower growing individuals. In contrast, Patterson et al. (2010) compared the von Bertalanffy growth function distributions of residuals to those of an earlier study (Patterson et al. 2001) and noted nearly identical residual distributions, thus indicating that growth has not changed in 10 years and that variability in red snapper size-at-age is similar today to what it was estimated to be historically.

Updated age data (from 2009 to 2011, N = 23,785, Table 5, Fig 7) and resulting VBGF analyses were reviewed by the LHW. All von Bertalanffy growth models were size-modified for the effects of minimum size limits (Diaz et al. 2004) and estimates were made by fishery, region, sex, fishery by region and sex by region (Table 8). Comparisons were made using a likelihood ratio test for coincident curves (Kimura 1980; Haddon 2001) (Table 9). All growth curves were significantly different but were informed by high sample sizes ($p < 0.001$). For instance, there is evidence for sexually dimorphic growth and small differences were found in L_{inf} between males (847 mm max TL) and females (889 mm max TL: Fig. 8).

New studies and data sets allowed further examination of regional differences in growth. Saari (2011 SEDAR31-RD39) examined regional growth differences in the recreational fishery and found that small, fast-growing individuals dominated South Texas, Northwest Florida and Central Florida catches and larger, slower-growing individuals dominated Alabama and Louisiana catches. This was consistent with earlier findings that fish from Texas grow faster and reach a smaller maximum size than fish from Alabama and Louisiana (Fischer et al. 2004). Likewise, the 2009-2011 dataset supported a finding of generally higher growth in the eastern Gulf (greater size at age, Fig. 9). However, evidence for reproductive and mortality traits suggest more spatially complex demographic patterns may exist and further examination of sub-regional growth differences is warranted (Table 10). The LHW discussions raised the need for more caution in interpretation of growth based upon opportunistic sampling; often typical of fishery-dependent sources. Appropriate statistical weighting may need to be conducted as part of the analysis (Chih 2012 SEDAR31-DW18; see recommendations).

2.6.1 Recommendations

1. A general recommendation of the LHW is to expand design-based fishery-independent sampling to elucidate regional (i.e., eastern and western GOM) and sub-regional differences in the demographics of red snapper.

2. A further recommendation is to increase random, representative sampling of the catch in order to avoid clustering effects and non-representative sampling which could lead to spurious differences in growth rates. Alternatively, and for localized- or small-scale studies, corrections for length limits and appropriate weighting may need to be utilized to treat data gaps, missing ages and adjust for selectivity (see Chih 2012 SEDAR31-DW18).

2.7 Reproduction

Additional, unpublished data on red snapper reproduction is available since the 2009 red snapper update. Most significantly, the 2011 Congressional Supplemental Sampling Program (CSSP) allowed Gulf-wide, synoptic sampling of red snapper during the April through October reproductive season, resulting in 1,002 females for histological analysis (992 for age and histology) and 50 samples for fecundity analysis. Reproductive samples from Florida in 2009 (Lowerre-Barbieri et al. 2012 SEDAR31-DW15, n=237 females) and from oil platforms in Louisiana in summer 2009 and 2010 (Cowan et al. 2012 SEDAR31-DW03, n=337 females) provide additional recent reproductive data that complement the CSSP survey.

Results from the CSSP survey are based predominately on frozen ovarian samples, although there was a fresh vs. frozen histological and fecundity comparison for some samples. Although histological quality of frozen samples compromises the histological preparation, oocyte stages and spawning markers could be identified. Some concerns regarding the effects of freezing and desiccation on the accuracy of fecundity estimates from frozen samples remain, as there was a tendency to overestimate batch fecundity from the frozen samples.

2.7.1 Maturity

Additional data confirms the previously reported 1:1 sex ratio in red snapper. For maturity estimates, only data from the peak reproductive season (June-August) were considered. The 2009 update presented information that some age one females can reach sexual maturity, but the youngest female with spawning markers was age 2 (Cook et al. 2009). The recent data confirms that some female red snapper reach sexual maturity at age 2. However, CSSP data suggests that the percentage of females reaching maturity has decreased for ages 2-6 when compared to the 2004 assessment and the 2009 update. (Figure 1).

The CSSP data supported the difference in age-at-maturity between the east and west Gulf suggested in the 2004 SEDAR. Fish from Louisiana (west Gulf) had a lower percentage of maturity for ages 4-6 compared to fish from the eastern Gulf (Florida and Alabama). Similar results were seen in Cowan et al. (2012 SEDAR 31-DW03); female red snapper around natural banks in Louisiana reached 50% maturity at age 5, while those around platforms reached 50% maturity at age 4.

2.7.2 Spawning Frequency

Spawning frequency was evaluated in the CSSP study by the percentage of females containing spawning markers (hydrated oocytes or new POFs, accounting for a 34 h period of potential spawning). At the peak of the spawning season, 60% of the females had spawning markers Gulfwide, indicating a high spawning frequency.

New reproductive data confirms data from the 2004 SEDAR that spawning frequency increases with increasing age. Gulfwide, only 18% of age 2 females had spawning markers, while >50% of fish age 8 and older had spawning makers (Figure 4) (Fitzhugh et al. 2012 SEDAR31-DW07). At

Louisiana offshore structures, fish ages 6-8 spawned every 3 to 7 days, while age 3 fish spawned every 12-17 days (Cowan et al. 2012 SEDAR31-DW03).

2.7.3 Duration and Spatial Differences in Spawning Intensity

The spawning season (determined by the presence of actively spawning females, or females with spawning markers (ovaries containing hydrated oocytes or new postovulatory follicles-POF) extends from May – October Gulf-wide (CSSP data, Figure 2); actively spawning females were found off Florida from June through September, although spawning capable females were found from March through October. CSSP results suggest a 168 day spawning season, a slight increase over the 151 day season determined in the 2004 SEDAR. However, peak spawning throughout the Gulf occurs from June through mid-September (107 days).

There is evidence for spatial differences in spawning. A higher percentage of females captured by long line were found with spawning markers compared to those collected in shallower areas by vertical lines (Fitzhugh et al. 2012 SEDAR31-DW07). Within similar depth zones, there appears to be differences among habitats, as the highest percentage of spawning capable females were found on toppled platforms in Louisiana, while the lowest percentage were found on standing platform structures (Cowan et al. 2012 SEDAR31-DW03). Finally, the percentage of females with spawning markers was lower in the eastern Gulf compared to the western Gulf; in particular, fish from the west Florida shelf exhibited the lowest percentage of spawning markers (25%) based on the CSSP collections (Fitzhugh et al. 2012 SEDAR31-DW07) (Table 10). A greater percentage of actively spawning fish in Florida were captured off the Panhandle as compared to west of Tampa Bay (Lowerre-Barbieri et al. 2012 SEDAR31-DW15, Fitzhugh et al 2012 SEDAR31-DW07). Spawning fraction on the AL-MS shelf (39%) was similar to the Florida Panhandle (35%) during the CSSP survey (Table 10). In the western Gulf, sub-regional patterns are becoming more evident as well. The highest spawning fractions were associated with the outer shelf of central-western Louisiana (48%) and south Texas (46%) in contrast to the Louisiana delta (25%) and north Texas (28%) (Table 10). These regional reproductive results may correlate with spatial patterns of size/age composition (see section on stock composition).

Duration of the spawning season also appears to be positively correlated with age. Red snapper ages 7 and older show evidence of spawning markers one month prior to age 2-3 fish, and the percentage of age 2-3 fish with spawning markers declines a month prior to that of older fish (Fitzhugh et al. 2012 SEDAR31-07), suggesting that young fish have a markedly reduced spawning season compared to older fish (Figure 3). Similar results were seen in Florida, where age 2 fish appear to have a shorter spawning season than older fish (Lowerre-Barbieri et al. 2012 SEDAR 31-DW15).

2.7.4 Batch Fecundity

An additional 88 batch fecundity estimations have been done since the 2004 SEDAR. Relative batch fecundity ranges from 27-142 eggs/g fish weight over the time of collections (Table 11). Relative batch fecundity is preferable for comparisons as it tends to normalize the effect of size. However, variability among annual means are high and the broad range in relative batch fecundity does not show any strong trends. Fecundity values from the recent CSSP survey tend to be lower than earlier

values, but it is unclear if this is due to methodology of using frozen samples, impacts of Deepwater Horizon, seasonal and/or small sample size effects in some years or if this is an actual trend of decreasing fecundity. There may be fecundity differences across the Gulf, as CSSP data showed lowest relative fecundity from Florida (40 eggs/g) and highest fecundity from the western Gulf (Texas; 70 eggs/g) similar to the pattern in spawning fraction.

Previous SEDAR assessments have used batch fecundity at age for entry into the model. Recent CSSP fecundity estimates show the expected increase in fecundity with age, despite lower overall fecundity measurements (Figure 5). It is anticipated that inclusion of new batch fecundity measurements into the model will not alter the currently used batch fecundity at age relationship.

2.7.5 Recommendations

1. Spawning marker fraction and batch fecundity should be included in the models as an estimate of spawning potential, and age and season should be included as variables in the regression. Spawning marker fraction is a better metric than maturity.
2. New fecundity estimates should be added to the existing fecundity at age regression.
3. Future surveys should collect ovarian samples fixed in formalin for histology analysis, spawning marker fraction analysis and age/size at maturity analysis.
4. Additional fecundity collections are necessary from all areas of the Gulf.
5. Additional research is necessary to further clarify regional reproductive and demographic differences.

2.7.6 Summary

1. The sex ratio is 1:1
2. First age at maturity is 2 years. However, there appears to be a recent trend for increasing age at maturity.
3. Red snapper from eastern Gulf have a lower age at maturity than those from the western Gulf.
4. Spawning occurs from May through September, peak spawning June – August.
5. Regional differences may occur in which highest spawning fractions are found off south Texas and central-western Louisiana and lowest fractions found off west Florida.
6. Similarly, spawning season of Florida fish appears shorter than that of fish from the northcentral and northwestern Gulf.
7. A high percentage of red snapper have spawning markers during the peak spawning season, indicating a relatively high spawning frequency.
8. Spawning frequency and the percentage of spawning markers increases with increasing age.
9. Older fish have a longer spawning season than younger fish.
10. Fecundity increases with increasing age.

2.8 Movement and Migration

2.8.1 Transformation

After a short period in the pelagic environment as larvae, red snapper metamorphosis and settlement to benthic habitats (Szedlmayer and Conti 1999; Rooker et al. 2004). Age-0 red snapper begin to use reefs shortly after they settle out of the plankton and move to available low-relief, structured habitat (Workman and Foster, 1994; Szedlmayer and Howe, 1997; Szedlmayer and Conti, 1999; Szedlmayer and Lee, 2004; Patterson et al. 2005; Wells et al. 2008; Gallaway et al. 2009). These new recruits quickly outgrow their initial benthic habitats and search for larger structured habitats by fall after the spawning season (Szedlmayer and Conti, 1999; Szedlmayer and Lee, 2004; Wells et al. 2008; Szedlmayer, 2011).

2.8.2 Post settlement

Recent studies have suggested that even the newest settlers will move to structured habitats if available, i.e., habitat with an absence of potential predators (Szedlmayer and Lee 2004; Piko and Szedlmayer 2007; Mudrak and Szedlmayer 2012). In fact, it may be that individuals that don't find structured shelter shortly after settlement will be subject to excessive predation mortality, shrimp trawl mortality, reduced growth and subsequent poor survival, and make little contribution to subsequent year classes. It then appears that young recruits that have located low relief structure will stay on these structures for their first and second years (Gallaway et al 1999; Gallaway et al 2009; Szedlmayer 2011; Mudrak and Szedlmayer 2012). In turn, the presence of these older age-1 and age-2 red snapper, through predation and competitive exclusion, may limit the immigration of new age-0 recruits to particular locations (Bailey et al., 2001; Piko and Szedlmayer, 2007; Gallaway et al., 2009; Mudrak and Szedlmayer, 2012).

2.8.3 Age-2 and older

After about age-2 red snapper appear to be able to better fend for themselves and move to larger more extensive structured habitats that may in fact have extensive resident predators, but as larger age-2 and 3 fish they are better able to escape predators (Gallaway et al. 2009). At this point and for the next couple of years, red snapper studies have reported different patterns of movements and residency around structured habitats. Several studies suggest a relative lack of residence, with some individuals showing long distance emigrations (Patterson et al. 2001; Patterson and Cowan 2003; Westmeyer et al. 2007; Addis et al. 2012) while other studies suggest relatively high site fidelity and with small home ranges (Szedlmayer, 1997; Szedlmayer and Schroepfer, 2005; Schroepfer and Szedlmayer 2006; Strelcheck et al. 2007; Topping and Szedlmayer, 2011a; Topping and Szedlmayer 2011b; Piraino and Szedlmayer 2012). Diamond et al. (2007) suggested both patterns are consistent with red snapper movement behavior but potentially influenced by many external variables. There are many caveats with tagging studies. Conventional tagging has the most difficulty with estimation of tag loss, non-reporting by fishers, and incorrect locations of recapture reported by private fishers. Telemetry methods have consistent problems with low sample sizes and difficulty with estimation of long distance movement. However, from a combination of these tagging studies it might be suggested that red snapper may show high site fidelity in the short term

(i.e., 1-2 years) while greater movement and lower site fidelity might be predicted on a longer term basis.

It has been suggested that larger older red snapper show less attachment to reef structure and show greater movements over open habitats (see habitat section). This scenario is principally supported by long-line studies over extensive open habitats that showed very few large old red snapper in the eastern Gulf of Mexico, but substantially greater catches from the western Gulf of Mexico (Mitchell et al. 2004). The suggestion being that larger older red snapper move to the western Gulf of Mexico. However, in contrast many larger older red snapper have been observed and continue to be collected from reef areas in the northeastern Gulf of Mexico (Orange Beach Red snapper tournament, Orange Beach, AL), but typical reef habitats from this area are difficult or impossible to sample with long-line gear. Actual mark and recapture data is almost non-existent for these large older red snapper and could potentially greatly help in this relatively unknown later life stage of red snapper.

Despite the different patterns of movement behavior observed by different studies, they are somewhat consistent in suggesting that as a whole, stocks don't show major long distance migrations and are for the most part self-replenishing, i.e., eastern compared to western Gulf stocks.

2.8.4 Recommendations

1. More information is needed to understand movement of young and older adult red snapper across along shore barriers. In particular the LHW recommends a large scale tagging study focused west and east of the Mississippi River.

2. Telemetry versus tagging approaches need to be expanded and evaluated according to shelf characteristics; e.g. cross compared in areas with little natural hard bottom habitat (yet high artificial reefs) versus areas with relatively high areal coverage of hard bottom and with more dispersed artificial reefs.

3. The LHW recommends a workshop or research symposia be convened to synthesize results and assess methodology for estimating red snapper movements and home range.

2.9 Conversion factors

Length and weight conversions in English units for SEDAR 7 (SEDAR 31-RD01) were repeated from Schirripa and Legault (1999). Most of these conversions have been updated using the combined Panama City Laboratory and Gulf States (2009-2011) dataset. The Florida Fish and Wildlife (2007-2011) dataset was used for length conversions to maximum total length and the Panama City Laboratory dataset (1994-1996, 2000 and 2008) used for weight to weight conversions.

2.9.1 Length conversions

During the workshop it was noted that total length was recorded differently depending on sampling program. Usually either a maximum total length (Max TL; pinching the caudal fin to maximum length; Kahn et al. 2004) or natural total length (Nat TL) was recorded. For consistency, Max TL was selected as the standard measure of total length for SEDAR 31. Nat TL, fork length (FL) and standard length (SL) were converted to Max TL using a 2007-2011 dataset from the Florida Fish and Wildlife Research Institute in which Max TL, Nat TL, FL and SL were measured for each red snapper. Nat TL (inches) was converted to Max TL (inches) using the regression equation shown in Equation 1 [R^2 = 0.99 (N= 1,866)], FL (inches) was converted to Max TL (inches) using the regression equation shown in Equation 2 [R^2 = 0.99 (N= 1,883)] and SL (inches) was converted to Max TL (inches) using the regression equation shown in Equation 3 [R^2 = 0.97 (N= 1,797).

Max TL (in) = 0.1325 + Nat TL (in)*1.022 (1)

Max TL (in) = 0.3868 + FL (in)*1.058 (2)

Max TL (in) = 2.0303 + SL (in)*1.162 (3)

Length to weight conversions

Max TL inches to whole weight (WW) pounds were converted using the Panama City dataset 2009-2011 fitted to the model of Equation 4 [R^2 = 0.97 (N = 6,089)]. FL inches to whole weight (WW) pounds were converted using the model of Equation 5 [R^2 = 0.98 (N= 5,063)].

WW (lbs) = 4.47E-04 * Max TL (in) ^ 2.994(4)

WW (lbs) = 6.90E-04 * FL (in) ^ 2.968 (5)

Commercial landings are most often reported in gutted condition. Therefore, Max TL and FL conversions to gutted weight (GW) were needed for analyses. The Panama City Laboratory data set was used to establish the relation between Max TL and GW as shown in Equation 6 [R^2 = 0.97 (N = 6,514)] and FL and GW in Equation 7 [R^2 = 0.98 (N = 3,686)].

GW (lbs) = 4.63E-04 * Max TL (in) ^ 3.009 (6)

GW (lbs) = 5.69E-04 * FL (in) ^ 3.012 (7)

The conversion of Max TL to GW (equation 6) reported was similar to the equation given in Schirripa and Legault (1999), but it was noted that the Max TL to GW conversions (equation 6) were greater than WW conversions (equation 4). Therefore, equation 4 may underestimate WW. This may be due to the size distributions used for the equations, since the GW conversion equation was estimated using larger commercial fish (typically gutted at sea), while WW conversions were estimated using smaller recreational and fishery-independent survey fish.

2.9.2 Weight conversions

The Panama City laboratory had a small sample set (N= 217) of red snapper with both GW and WW recorded. The GW (lbs) was converted to WW (lbs) using the regression in shown Equation 8 [R^2 =0.99] and WW (lbs) was converted to GW (lbs) using regression in Equation 9.

WW (lbs) = 1.11*GW (lbs) – 0.264 (8)

GW (lbs) = 0.89*WW(lbs) +0.2837 (9)

It is noteworthy that the slope of equation 8 was the same as the conversion factor (1.11) for GW to WW given in Schirripa and Legault (1999) from an unknown data source.

2.9.3 Recommendations

1. The LHW recommends that maximum total length be used as the standard measure for SEDAR 31.

2. In order to reduce measurement error in the future, the LHW recommends that port agent, observers and field scientists record maximum total length for red snapper.

3. To increase the sample size for weight conversions the LHW recommends that both WW and GW be taken over a range of red snapper sizes.

2.10 Episodic Events

Gulf of Mexico red snapper populations are often impacted by a variety of episodic environmental perturbations of varying temporal and spatial scales. In the northern Gulf of Mexico, the seasonal occurrence of hypoxia can potentially effect red snapper populations. Although we are not aware of large-scale mortality of red snapper in association with summer hypoxic events, reductions in dissolved oxygen concentrations greatly reduce habitat quality. In Alabama, catch-per-unit-effort of juvenile (age-0 and age-1) red snapper within trawl samples declined significantly from July to August, likely in association with bottom dissolved oxygen concentrations that were 0 ppm (Szedlmayer and Shipp 1994). Further, an examination of essential fish habitat for juvenile red snapper indicated that recent increases in the real extent of hypoxia in the northern Gulf of Mexico may have reduced habitat carrying capacity for juvenile red snapper by an average of 19% (Gallaway et al. 1999). Hypoxia can also impact older red snapper, although the occurrence of offshore oil platforms within areas impacted by hypoxia may provide some vertical refugia (Stanley and Wilson 2004). In addition to direct effects on red snapper, hypoxia may alter the dynamics of shrimp trawl fishery and, subsequently, the quantity of bycatch-related mortality of juvenile red snapper. Macal (2002) found that shrimping effort off of Louisiana shifted offshore during years of extensive hypoxia, potentially increasing the overlap between shrimping effort and juvenile red snapper populations and associated bycatch mortality. It is important to note, however, that these potential impacts may be offset by recent reductions in overall shrimping effort.

Other environmental perturbations in addition to hypoxia have the potential to affect red snapper populations. Hurricanes can also affect red snapper populations, although hurricane-related impacts appear to relate primarily to movement and site fidelity of red snapper. In a study on artificial reefs in the north-central Gulf of Mexico, the occurrence of Hurricane Opal in 1995 greatly increased not only the probability that red snapper would move away from their original tagging location, but also significantly influenced the distance of red snapper movement (Patterson et al. 2001). 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 and Lugo- Fernández 1999; Collard et al. 2000). Temperature reductions also appear to contribute to seasonally-dynamic movement patterns (Topping and Szedlmayer (2011a SEDAR31-RD22). Large- scale pollution events such as the Deep Water Horizon oil spill, can result in impacts that are both direct (e.g., acute –phase mortality) and indirect (e.g., bioaccumulation through the food web) (Sumaila et al. 2012). In order to improve the stock assessment process of incorporating additional non-fishing mortality data, SEDAR is conducting a Gulf of Mexico SEDAR Episodic Events Workshop November 13-15, 2012.

2.11 Oil and Gas Platform Removal

There are estimated to be approximately 4,000 oil and gas platforms in the Gulf of Mexico (Keevin and Hempen 1997 SEDAR31-RD44; Kaiser and Pulsipher 2007). Every year some are taken out of service or removed and new platforms are added to production. Versar (2008 SEDAR31-RD31) indicated the number of platforms removed through 2020 will far exceed the number of new ones. Estimates as of 2009, indicate 140 are removed annually with 60 percent of these removals conducted by the use of explosive charges (Herbst personal communication). These structures have been shown to be used as habitat for many species of fishes. Impacts of removals to marine fishes may be significant, with an estimated 515 red snapper killed per each platform removed via explosives (Gitschlag et al. 2000 SEDAR31-RD04). Numerous methodologies exist to mitigate impacts, such as tactics to displace fish away from structures prior to ignition of crippling charges (Keevin and Hempen 1997) . Keevin and Hempen (1997 SEDAR31-RD44) discuss impacts to fishes due to the pressure wave of the explosion and fishes with large swim bladders tended to be more vulnerable to internal damage. Due to this effect, surface estimates of mortality are not sufficient and estimating those fish that sink must be obtained. However, for red snapper Gitschlag et al. (2000 SEDAR31-04) found that even when mortality was doubled, impacts were estimated to be small, well within the variation of current assessments.

Providing information on fish mortality during platform removals to management agencies is not a priority of the Bureau of Environmental Safety and Enforcement because reliable estimates of red snapper abundances would be limited to surface counts (Herbst personal communication). Future cooperation is encouraged in order to include these data into assessments.

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2.13 Tables

Table 1. Recent mortality studies – early life history.

Study	Z Age 0	Age 1	Age >1	M Age 0	Age 1	Age >1	Comments
Wells et al. 2008 Max likelihood Catch curve	6.2-8.8 2.6-9.1						Age 120-199 d extrapolated to 1 yr. Ala. untrawled sand/shell habitat. Authors caution emigration/gear bias and extrapolation to annual estimate.
Gazey et al. 2008 Model	2.2 peak prob. (0.686-3.151)	1.3 peak prob. (0.397-1.825)					Repeated from 2009 update. Best model VBGF with dens. dep. mortality. West Gulf data. Potential emigration bias.
Gallaway et al. 2009 Catch curve	2.6			2.0	1.2		Ala. Untrawled artificial habitat, Ave. for 3 yr. classes, Potential emigration bias, best-M inferred several studies.
Szedlmayer 2011 Catch curve	3.4			3.4			Age > 60 d. Ala. Diver counts on untrawled artificial reef. (Z=2.7 first 3 months, 0.7 next 9 months). Potential emigration bias but no evidence for spillover: Author suggests best approximation for M.
Topping and Szedlmayer 2011, SEDAR31-DW13 Telemetry			0.43-0.5			0.12-0.22	Ala. artificial and natural reefs, red snapper >500 mm TL (age-3 expected dom. age), (F=0.3-0.38). Potential effect of sample size and length of study.
Books et al. SEDAR31-RD02 RE model est. RE model dens. dep.	3.3-3.7	1.6-2.25		3.3-3.7 2.6-3.5	0.76-1.4 0.6-1.3		Repeated from 2009 update, Table 8. Gulf-wide. Low q for age 0, potential emigration bias. Analysis continues for 2012 results

Table 2. Equations for estimating natural mortality (M).

Method	Parameters	Authors & Parameter Explanations	Equation
Alverson & Carney	k, tmax	Quinn & Deriso (1999):	M = 3k/(exp(0.38*tmax*k)-1)
Beverton & Holt	k, am	Beverton and Holt (1956; a_m = age at 50% maturity)	M = 3k/(exp(a_m*k)-1)
Hoenig$_{(fish)}$	tmax	Hoenig (1983; for fish)	M=exp(1.46 - 1.01*ln(tmax))
Hoenig$_{(\text{all taxa})}$	tmax	Hoenig (1983; fish plus other taxa)	M=exp(1.44-0.982*ln(tmax))
Pauly	Linf, k, T	Quinn & Deriso (1999):	M=exp(-0.0152+0.6543*ln(k)-0.279*ln(Linf, cm)+0.4634*lnT(°C))
		Pauly (1980):	M = 10^(-0.0066-0.279*(log(Linf))+0.6543*log(K)+0.4634*Log(T))
Pauly Method II (snappers and groupers)	Linf, k, T	Pauly and Binohlan (1996)	M=10^(-0.0636-0.279*(log(Linf)+0.6543*log(k)+0.4634*log(T))
			T=Average annual Sea Temperature at depth
Ralston	k	Ralston (1987)	M=0.0189 + 2.06*k
Ralston (geometric mean)	k	Ralston (1987)	M=-0.0666+2.52*k
Ralston Method II	k	Pauly and Binohlan (1996)	M=-0.1778+3.1687*k
Lorenzen Age-Specific	W at age	Lorenzen (1996; ocean)	M=3.69*W^(-0.305)
Jensen	k	Jensen (1996)	M = 1.5*K
Alagaraja	tmax, survivorship to tmax	Alagaraja (1984)	M=-ln[S(tmax)]/tmax; derived from S(tmax)=exp(-M*tmax)
Rule of thumb	tmax	Hewitt and Hoenig (2005)	M = 2.996/tmax

Table 3. Estimates of natural mortality from equations in Table 2, based upon permutations of recent age data and resulting changes in oldest observed age and von Bertalanffy growth functions (VBGF). VBGF fits were corrected for age truncation due to commercial and recreational size limits (Diaz et al. 2004). Water temperature based upon annual mean estimate at bottom from the U.S. Gulf shelf (Johnson et al. 1995, DeVries 2006).

Data Source	Observed Max Age (years)	Number of Fish Aged	VBGF Linf (mm)	VBGF k	Water Temp. (°C)	Age at 50% Mat.	Alverson & Carney	Beverton & Holt	**Hoenig (fish)**	Hoenig (all taxa)	Pauly	Pauly Method II (snappers and groupers)	Ralston	Ralston (geometric mean)	Ralston Method II	Jensen	Hewitt & Hoenig	Alagaraja (1% survival)	Alagaraja (5% survival)
2009-2011 age data	55	23785	848.48	0.22	22	2	0.0068	1.1957	0.0752	0.0825	0.4422	0.3878	0.4696	0.4848	0.5155	0.3282	0.0545	0.0837	0.0545
2009-2011 east male age data	30	2538	961.07	0.17	22	2	0.0871	1.2622	0.1387	0.1496	0.3591	0.3150	0.3648	0.3565	0.3542	0.2519	0.0999	0.1535	0.0999
2009-2011 east female age data	17	2502	1022.15	0.15	22	2	0.2802	1.2927	0.2462	0.2613	0.3210	0.2815	0.3180	0.2993	0.2823	0.2178	0.1762	0.2709	0.1762
2009-2011 west male age data	35	2844	834.31	0.23	22	2	0.0329	1.1773	0.1187	0.1286	0.4632	0.4062	0.4993	0.5211	0.5611	0.3498	0.0856	0.1316	0.0856
2009-2011 west female age data	44	2948	879.16	0.21	22	2	0.0198	1.2091	0.0942	0.1027	0.4241	0.3719	0.4482	0.4586	0.4826	0.3126	0.0681	0.1047	0.0681

Table 4. Values for Z from unweighted catch curve regression and Chapman-Robson method using criteria of peak age and right truncation of numbers-at-age.

Data source	Z, regression	Z, Chapman-Robson	N for age classes with ≥ 5 obs.	Age classes
CM HL east	1.032	0.8081	2610	4-8 yrs
CM LL east	0.808	0.5922	1249	4-9 yrs
Rec HL east	1.064	0.8700	426	4-7 yrs
FI LL east	0.7801	0.7106	103	6-9 yrs
CM HL west	0.901	0.7443	3773	4-11 yrs
CM LL west	0.1461	0.1222	231	5-15 yrs
Rec HL west	1.058	0.8718	948	5-9 yrs
FI LL west	0.1292	0.1981	405	7-24 yrs

Table 5. Otoliths sampled and otoliths assigned an age (in parentheses) by NOAA Fisheries-Panama City Laboratory and Gulf States from the major sectors during years 2009 through 2011. Panama City Laboratory sub-sampling was only conducted for the commercial hand-line sectors for Florida Panhandle and Louisiana. Sub-sampling was based upon yearly, bi-monthly waves (i.e., wave 1 = January/February; wave 2 = March/April; wave 3 = May/June; wave 4 = July/August; wave 5 = September/October; and wave 6 = November/December).

	2009	**2010**	**2011**	**TOTAL**
COMMERCIAL				
Hand-line	3,664 (3,544)	3,327 (3,277)	4,149 (4,121)	**11,140 (10,942)**
Long-line	983 (937)	430 (417)	395 (391)	**1,808 (1,745)**
Spear		1 (1)		**1 (1)**
Unknown	134 (134)	177 (177)	20 (20)	**331 (331)**
Vertical Long- line	1 (1)	124 (124)		**125 (125)**
Sub-Total	**4,782 (4,616)**	**4,059 (3,996)**	**4,564 (4,532)**	**13,405 (13,144)**
RECREATIONAL				
Charter Party	769 (766)	204 (203)	1,291 (1,289)	**2,264 (2,258)**
Headboat	665 (635)	529 (522)	965 (937)	**2,159 (2,094)**
Private	409 (408)	511 (511)	194 (194)	**1,114 (1,113)**
Sub-Total	**1,843 (1,809)**	**1,244 (1,236)**	**2,450 (2,420)**	**5,537 (5,465)**
TOURNAMENT				
Hand-line			40 (40)	**40 (40)**
Spear			16 (16)	**16 (16)**
Sub-Total			**56 (56)**	**56 (56)**
FISHERY INDEPENDENT				
Hand-line	378 (375)	1,155 (1,130)	1,812 (1,801)	**3,345 (3,306)**
Long-line	78 (76)	53 (51)	765 (749)	**896 (876)**
Trap	465 (458)	101 (99)	178 (174)	**744 (731)**
Trawl	157 (153)	307 (305)	11 (11)	**475 (469)**
Vertical Long-line		178 (178)	33 (33)	**211 (211)**
Sub-Total	**1,078 (1,062)**	**1,794 (1,763)**	**2,799 (2,768)**	**5,671 (5,593)**
TOTAL	**7,703 (7,487)**	**7,097 (6,995)**	**9,869 (9,776)**	**24,669 (24,258)**

Table 6. Otoliths sampled and otoliths assigned an age (in parentheses) by NOAA Fisheries-Panama City Laboratory and Gulf States from the major sectors by state during years 2009 through 2011. Panama City Laboratory sub-sampling was only conducted for the commercial hand-line sectors for Florida Panhandle and Louisiana. Sub-sampling was based upon yearly, bi-monthly waves (i.e., wave 1 = January/February; wave 2 = March/April; wave 3 = May/June; wave 4 = July/August; wave 5 = September/October; and wave6=November/December).

	ALABAMA	FLORIDA	LOUISIANA	MISSISSPPI	TEXAS	TOTAL
COMMERCIAL						
Hand-line	253 (248)	4,644 (4,548)	2,295 (2,254)	334 (332)	3,614 (3,560)	**11,140 (10,942)**
Long-line		1,510 (1,456)	32 (32)		266 (257)	**1,808 (1,745)**
Spear		1 (1)				**1 (1)**
Unknown		4 (4)	327 (327)			**331 (331)**
Vertical Long-line		125 (125)				**125 (125)**
Sub-Total	**253 (248)**	**6,284 (6,134)**	**2,654 (2,613)**	**334 (332)**	**3,880 (3,817)**	**13,405 (13,144)**
RECREATIONAL						
Charter Party	813 (813)	507 (504)	666 (666)	33 (32)	245 (243)	**2,264 (2,258)**
Headboat	190 (167)	455 (444)	481 (468)		1,033 (1,015)	**2,159 (2,094)**
Private	129 (128)	39 (39)	583 (583)	32 (32)	331 (331)	**1,114 (1,113)**
Sub-Total	**1,132 (1,108)**	**1,001 (987)**	**1,730 (1,717)**	**65 (64)**	**1,609 (1,589)**	**5,537 (5,465)**
TOURNAMENT						
Hand-line		40 (40)				**40 (40)**
Spear		16 (16)				**16 (16)**
Sub-Total		**56 (56)**				**56 (56)**
FISHERY INDEPENDENT						
Hand-line	66 (66)	2,006 (1,975)	831 (825)		442 (440)	**3,345 (3,306)**
Long-line	73 (72)	127 (127)	369 (357)		327 (320)	**896 (876)**
Trap		571 (558)	102 (102)		71 (71)	**744 (731)**
Trawl	18 (17)	85 (84)	156 (154)		216 (214)	**475 (469)**
Vertical Long-line	6 (6)	159 (159)	20 (20)		26 (26)	**211 (211)**
Sub-Total	**163 (161)**	**2,948 (2,903)**	**1,478 (1,458)**		**1,082 (1,071)**	**5,671 (5,593)**
TOTAL	**1,548 (1,517)**	**10,289 (10,080)**	**5,862 (5,788)**	**399 (396)**	**6,571 (6,477)**	**24,669 (24,258)**

Table 7. Total number of red snapper aged by Panama city Laboratory for years 1991 – 2011 for each NMFS shrimp statistical grid (Kutkuhn 1962), including the total number of red snapper aged for gear type = long-line and total # of red snapper that were aged to be 20+ years old. Dark gray fill = grids for which long-line gear had a relatively high percent frequency of samples aged. Light gray fill = grids for which long-line gear and 20+ year old red snapper had a percent frequency greater than 15 percent but smaller than 30 percent frequency. Blank = shrimp statistical grids for which no grid was assigned due to lack of sufficient information.

Shrimp Statistical Grid	Total # of Aged Fish	Total # of 20+ Years	% Frequency of 20+ Years	Total # of Aged Fish for Long-line Gear	% Frequency of Long-line Gear
1	64				0.000%
2	238	2	0.840%	218	91.597%
3	146	5	3.425%	123	84.247%
4	645	5	0.775%	286	44.341%
5	1,457	10	0.686%	989	67.879%
6	1,880	3	0.160%	899	47.819%
7	321			31	9.657%
8	3,107	1	0.032%	249	8.014%
9	1,809	3	0.166%	33	1.824%
10	4,426	22	0.497%	137	3.095%
11	2,236	9	0.403%	164	7.335%
12	501	2	0.399%		0.000%
13	2,679	14	0.523%	396	14.782%
14	3,435	30	0.873%	643	18.719%
15	2,006	23	1.147%	415	20.688%
16	3,390	50	1.475%	381	11.239%
17	2,224	43	1.933%	225	10.117%
18	2,881	26	0.902%	243	8.435%
19	555	9	1.622%	50	9.009%
20	1,548	73	4.716%	557	35.982%
21	3,544	77	2.173%	1,065	30.051%
Blank	24,410	100		1,099	
Total	**63,502**	**507**		**8,203**	

Table 8. Summary of von Bertalanffy growth parameters (Linf = asymptotic length, k = growth coefficient, t_0 = size at time zero), sigma (global variance parameter), and negative log-likelihood from the size-modified von Bertalanffy growth model for red snapper (2009-2011). Commercial size-limit = 330.2 mm and recreational size-limit = 406.4. All lengths are in maximum total length (mm). CM HL = commercial hand line, CM LL =commercial long-line, REC = recreational. EAST = Florida, Alabama and Mississippi, WEST = Louisiana and Texas.

Region	Mode & Gear	Sex	n	Linf	k	to	sigma	nLL
ALL	ALL	ALL	23,785	848.4797	0.2188	-0.0611	79.0628	135235.00
ALL	CM HL	ALL	10,890	814.0920	0.2214	-0.1402	74.8917	60951.90
ALL	CM LL	ALL	1,744	787.9280	0.2814	-0.1479	65.9517	9739.25
ALL	REC	ALL	5,114	780.8090	0.2886	-0.0010	76.3411	28716.80
ALL	ALL	MALE	5,382	847.4239	0.2256	-0.0465	80.0254	30680.00
ALL	ALL	FEMALE	5,450	889.5321	0.2011	-0.0827	83.5110	31275.20
EAST	ALL	ALL	8,354	887.8340	0.2066	-0.0010	76.1314	46624.00
EAST	CM HL	ALL	5,090	934.2734	0.1843	-0.0010	75.1549	28293.20
EAST	CM LL	ALL	1,455	799.6480	0.2828	-0.0786	64.0740	8080.04
EAST	REC	ALL	1,809	820.7583	0.2323	-0.0010	81.0256	9968.87
EAST	ALL	MALE	2,538	961.0663	0.1679	-0.4532	71.7103	14198.90
EAST	ALL	FEMALE	2,502	1022.1548	0.1452	-0.5759	76.5227	14147.00
WEST	ALL	ALL	9,394	797.8550	0.2431	-0.1487	79.8890	53345.50
WEST	CM HL	ALL	5,800	806.2735	0.1879	-0.9697	72.3472	32534.40
WEST	CM LL	ALL	289	831.4622	0.2032	-0.2090	61.4247	1595.54
WEST	REC	ALL	3,305	778.1142	0.2790	-0.5071	70.6705	18553.90
WEST	ALL	MALE	2,844	834.3052	0.2332	-0.0010	86.8095	16425.50
WEST	ALL	FEMALE	2,948	879.1609	0.2084	-0.0010	89.1393	17092.30

Table 9. Region, fishery and sex, size-modified von Bertalanffy growth curves were compared using a likelihood ration test for coincident curves. CM HL = commercial hand line, CM LL =commercial long-line, REC = recreational. EAST = Florida, Alabama and Mississippi, WEST = Louisiana and Texas.

Comparison	Likelihood Ratio	P value
East vs. West	1125.07	1.18E-246
East vs. All data	8896.16	0.00E+00
West vs. All data	8738.53	0.00E+00
CM Hand-line		
East vs. West	710.95	1.24E-156
East vs. All CM HL	3906.39	0.00E+00
West vs. All CM HL	3641.16	0.00E+00
CM Long-line		
East vs. West	2360.28	0.00E+00
East vs. All CM LL	271.75	4.72E-61
West vs. All CM LL	522.79	1.05E-115
Recreational		
East vs. West	1123.77	2.25E-246
East vs. All REC	1913.95	0.00E+00
West vs. All REC	1443.63	0.00E+00
Male vs. Female	103.41	2.72E-24
Male vs. All data	7983.68	0.00E+00
Female vs. All data	7979.83	0.00E+00
Female		
East vs. West	473.19	6.47E-105
East vs. All Females	1984.89	0.00E+00
West vs. All Females	1781.17	0.00E+00
Male		
East vs. West	369.71	2.16E-82
East vs. All Males	1955.39	0.00E+00
West vs. All Males	1776.86	0.00E+00

Table 10. Fraction of females bearing histological spawning markers by region and statistical grid during 2011 Gulf-wide CSSP survey (re-drawn with further break down by grid from Table 2 in Fitzhugh et al. (2012 SEDAR 31-DW07).

	Statistical grids	N females	Fraction with spawning markers
W FL shelf	3-7	60	0.25
FL panhandle	8-9	125	0.35
AL-MS	10-12	80	0.39
E LA	13-14	100	0.27
W LA	15-17	328	0.48
N TX	18-19	152	0.28
S TX	20-21	157	0.46

Table 11. Relative batch fecundity of red snapper, 1991 – 2012.

Year	Relative Batch Fecundity	S.D	N	Location	Source
1991	84	47	9	FL	PC Lab
1992	64	50	12	FL	PC Lab
1993	63	61	42	FL	PC Lab
1994	73	59	52	FL, AL, LA	PC Lab
1998	56	86	54	Gulf-wide	PC Lab
1999	111	69	52	Gulf-wide	PC Lab
1999	96	71	41	AL, LA	USA
1999	67	40	21	AL	Szedlmayer and Furman
2000	108	116	14	Gulf-wide	PC Lab
2000	108	87	125	AL, LA	USA
2001	94	66	14	Gulf-wide	PC Lab
2001	142	115	53	AL, LA	USA
2002	106	69	12	Gulf-wide	PC Lab
2004	27	27	6	Tortugas, FL	Brown-Peterson et al.
2009	107		8	LA	Cowan et al.
2011	49	40	50	Gulf-wide	CSSP
2012	126	35	4	FL	PC Lab

2.14 Figures

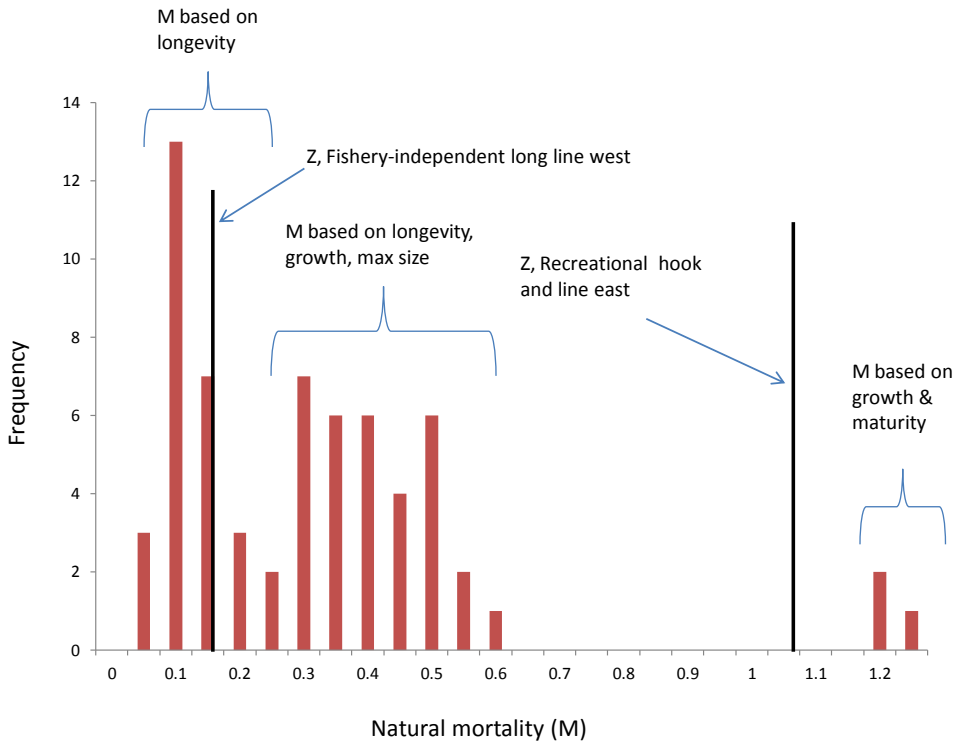

Figure 1. Bar chart of natural mortality estimates shown for graphical purposes; note that estimates from life history equations are not independent, rather they are based upon permutations of age and growth data (see Table 3). For comparison, Z values (black lines) are shown for highest and lowest regression estimates (see Table 4).

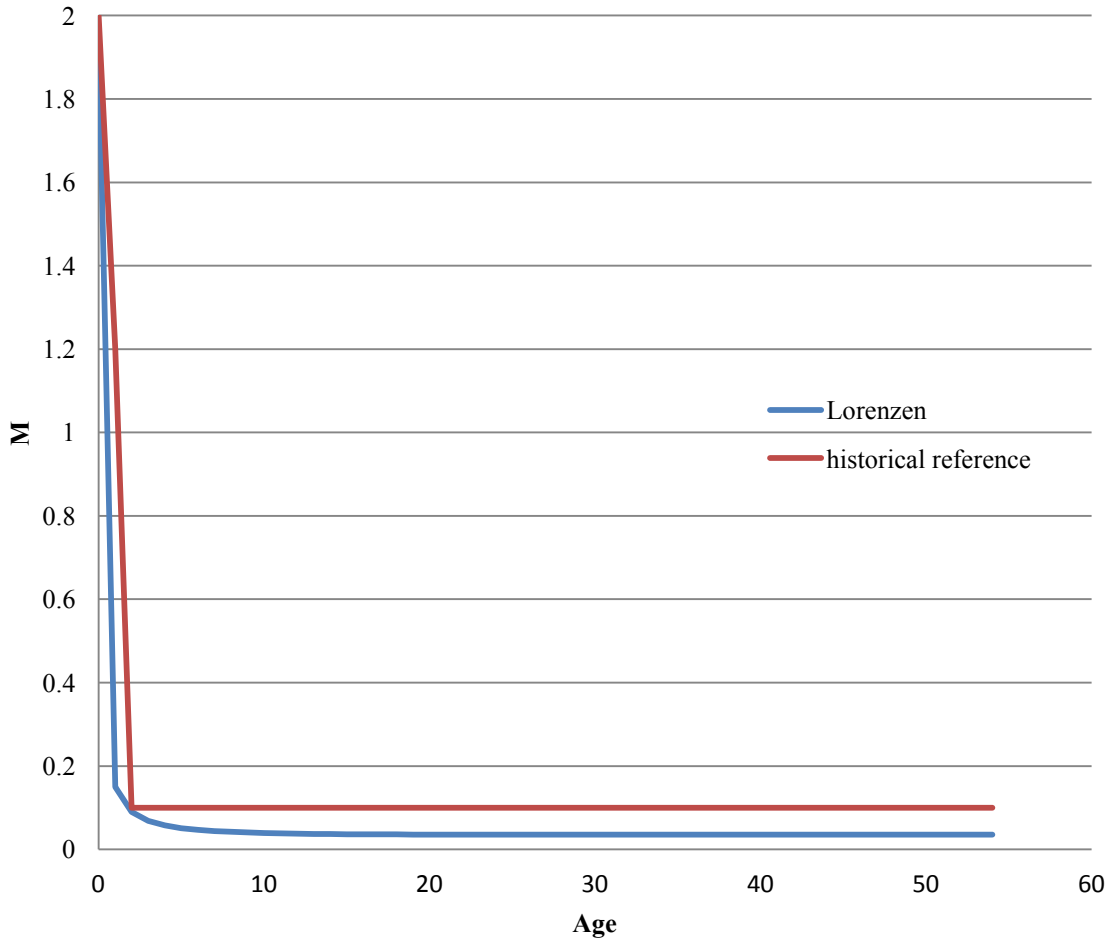

Figure 2. Values for natural mortality used in the 2009 assessment update (in red); age-0 = 2.0, age-1 = 1.2, ages > 1 = 0.1. For purposes of comparison, a Lorenzen fit is shown (in blue) scaled to t_{max} = 50 years.

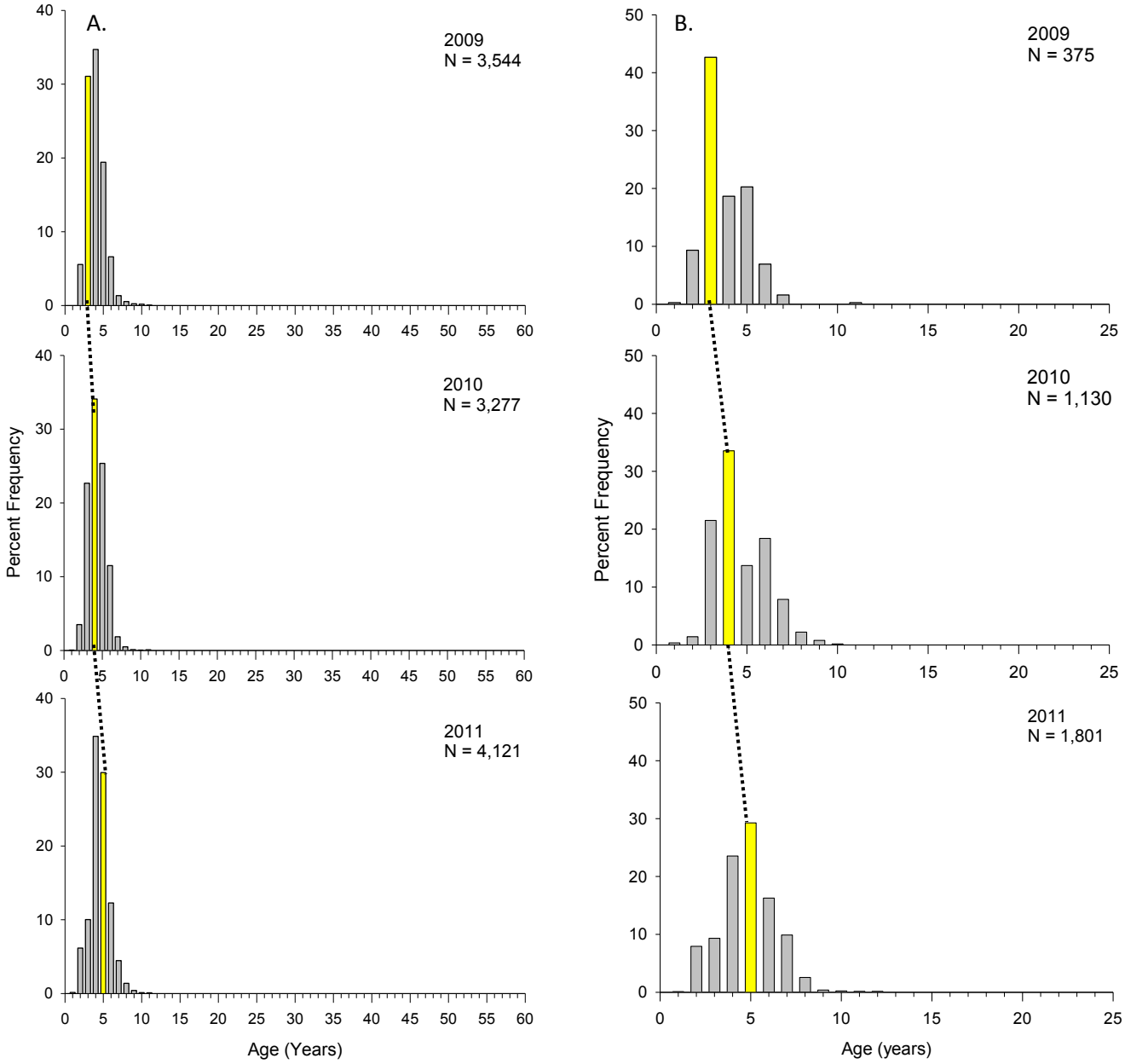

Figure 3. Red snapper age frequency distributions 2009 to 2011 for the commercial hand-line fishery (A) and fishery-independent hand-line survey (B). Yellow bars and dotted lines represent 2006 year class.

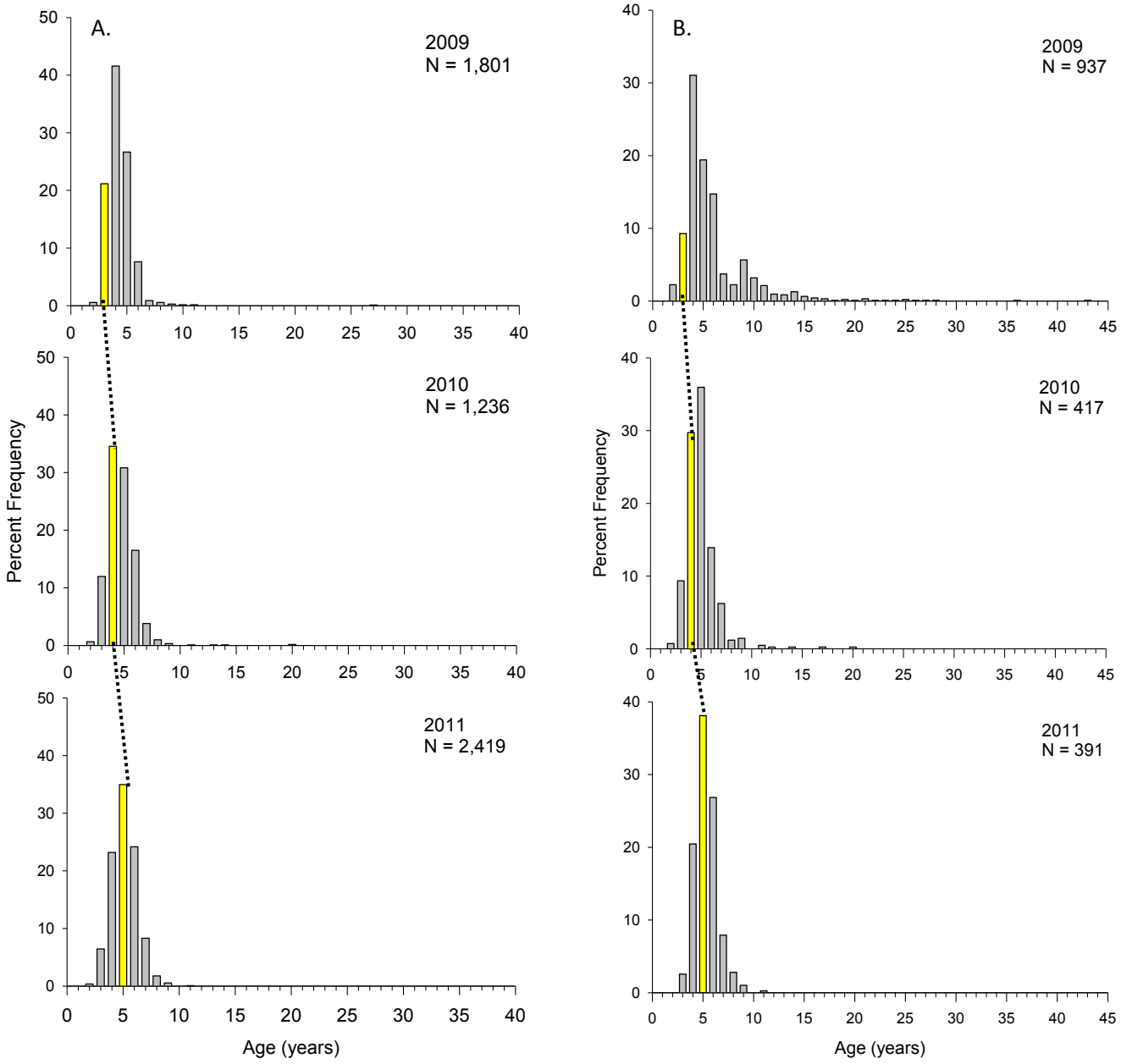

Figure 4. Red snapper age frequency distribution 2009 to 2011 for the recreational hand-line fishery (A) and the commercial long-line fishery (B). Yellow bars and dotted lines represent 2006 year class.

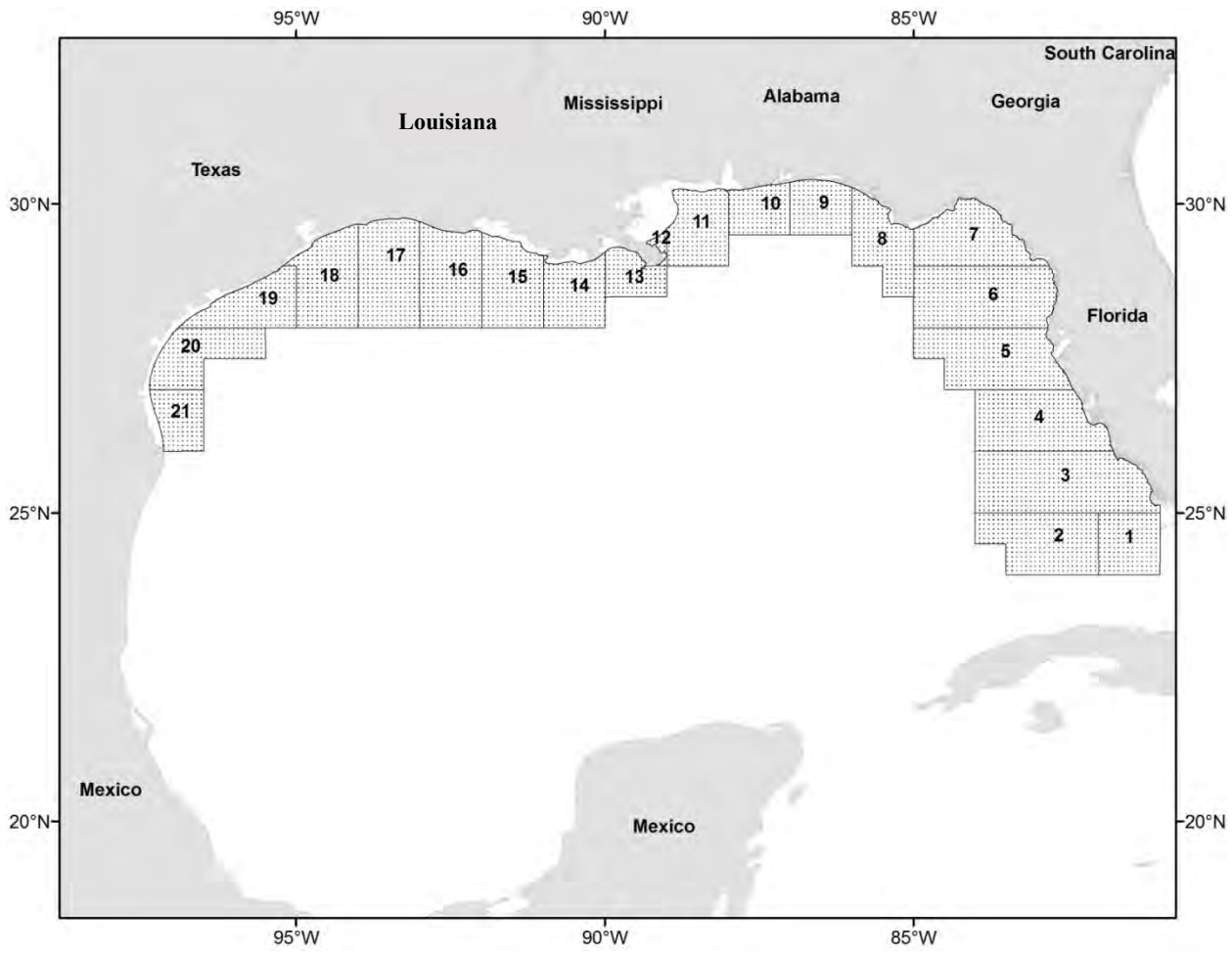

Figure 5. Map of Northern Gulf of Mexico indicating statistical subareas 1 – 21.

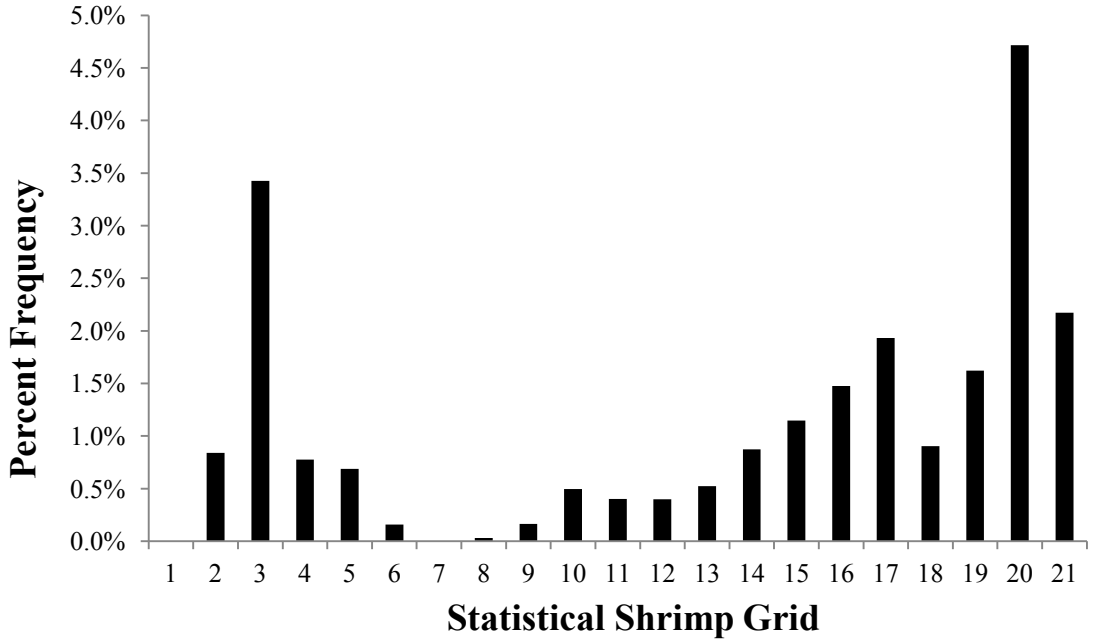

Figure 6. Percent frequency of red snapper age 20 years and older by statistical shrimp grid (1991-2011).

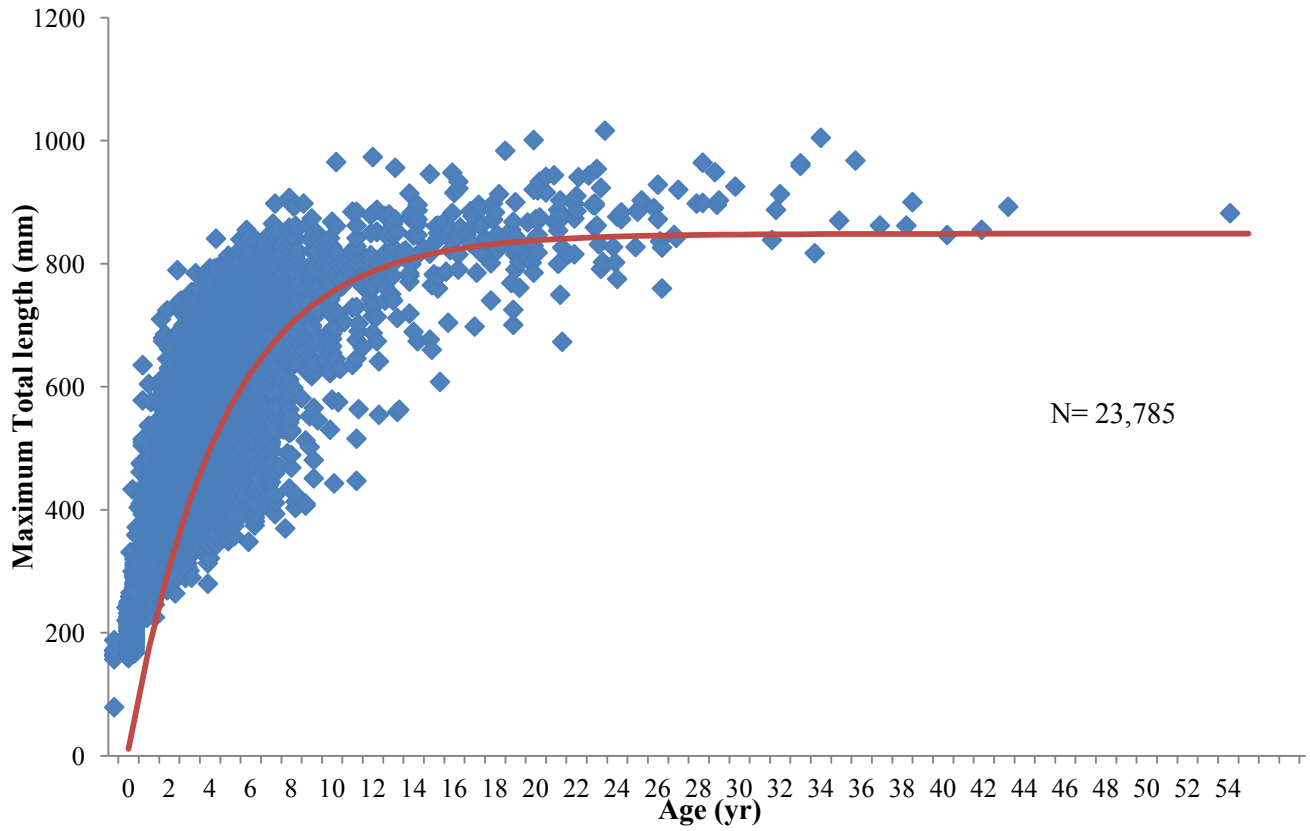

Figure 7. Size-modified von Bertalanffy growth curve developed for Gulf of Mexico red snapper from fishery dependent and independent collections.

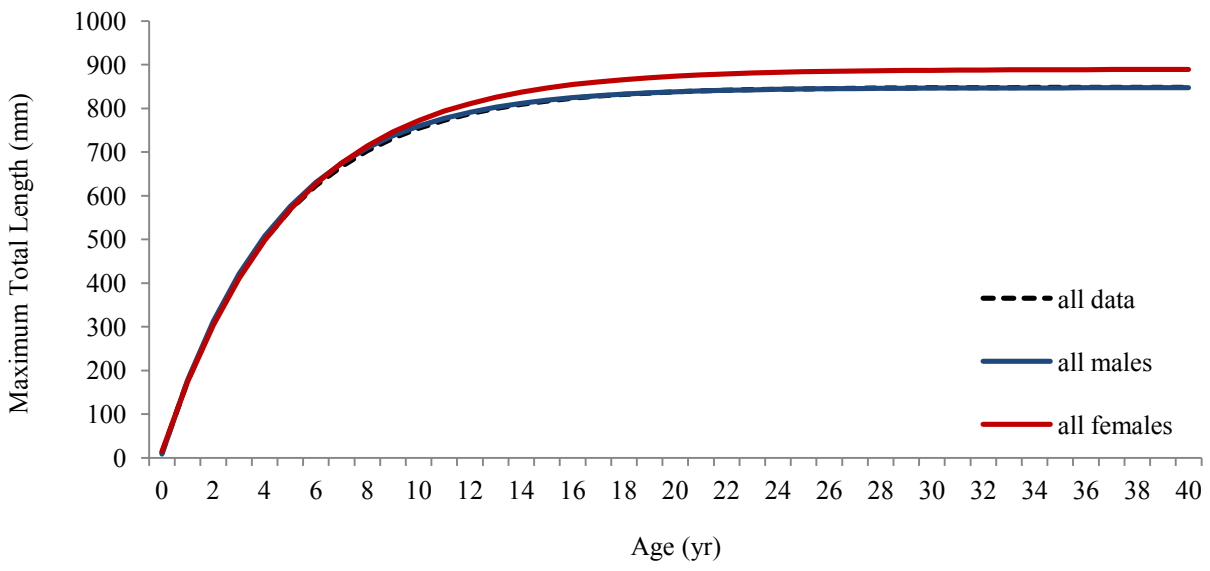

Figure 8. Size-modified, sex specific von Bertalanffy growth curves for Gulf of Mexico red snapper.

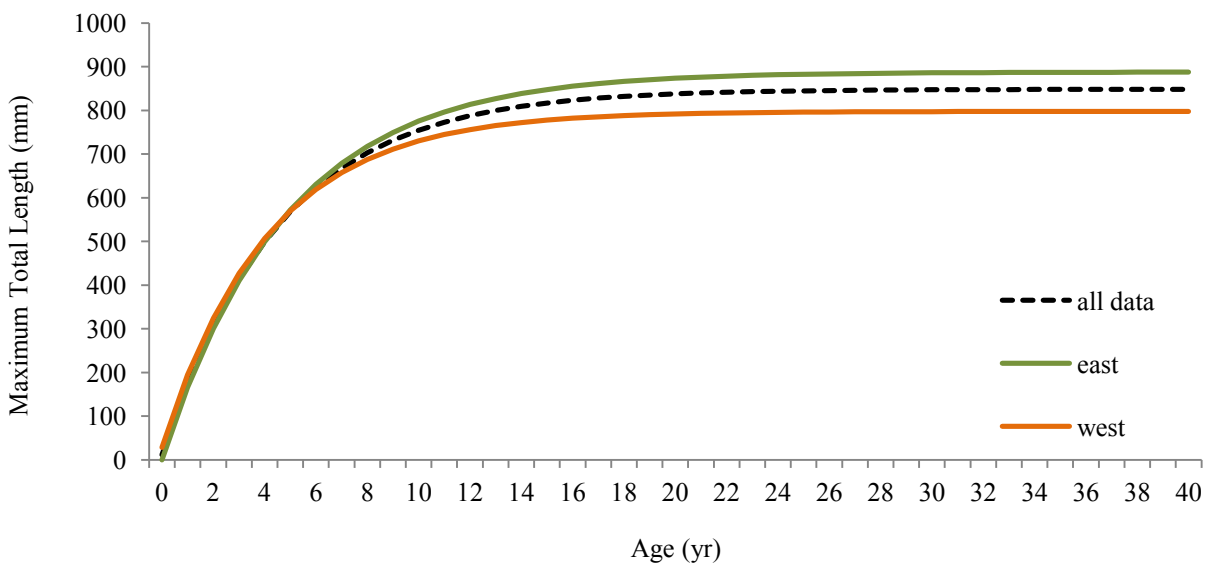

Figure 9. Size-modified, region specific von Bertalanffy growth curves for Gulf of Mexico red snapper corrected.

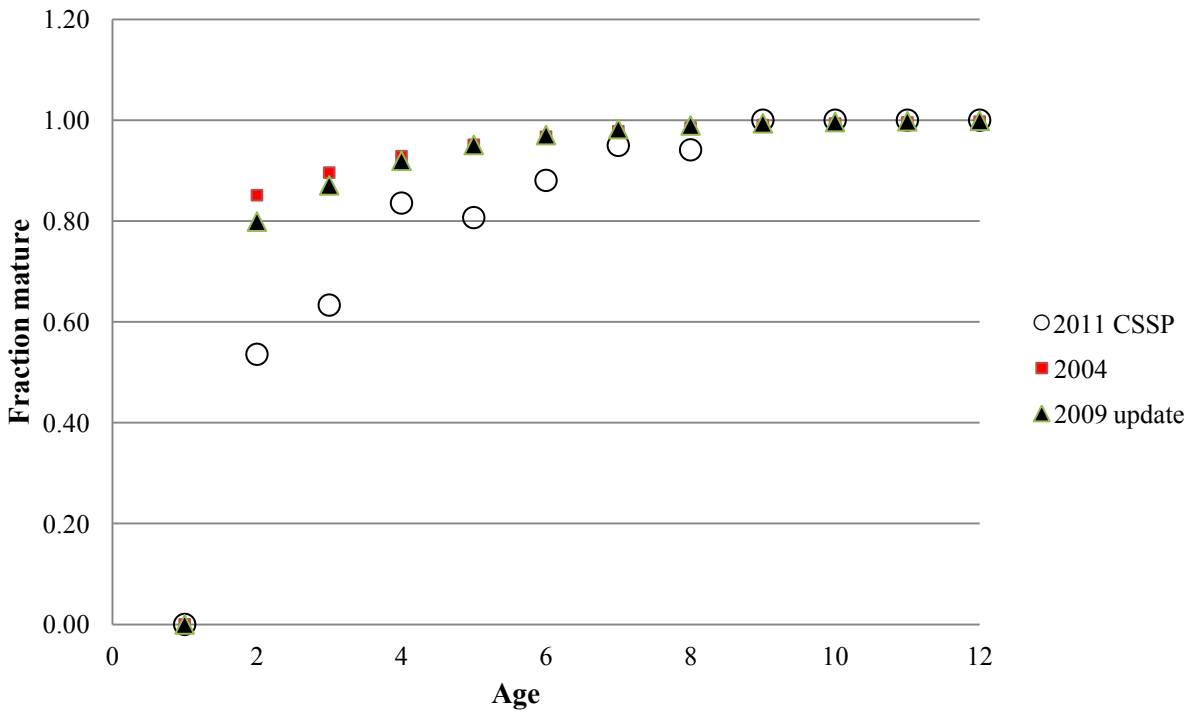

Figure 10. Fitted points (solid symbols) for female age-at-maturity are shown for previous assessments; 2004 and update in 2009 (n=2371 females). Estimated fraction mature aggregated at age are shown (open circles) for the 2011 CSSP project (n=433 females). Age 12 is a plus group for CSSP data.

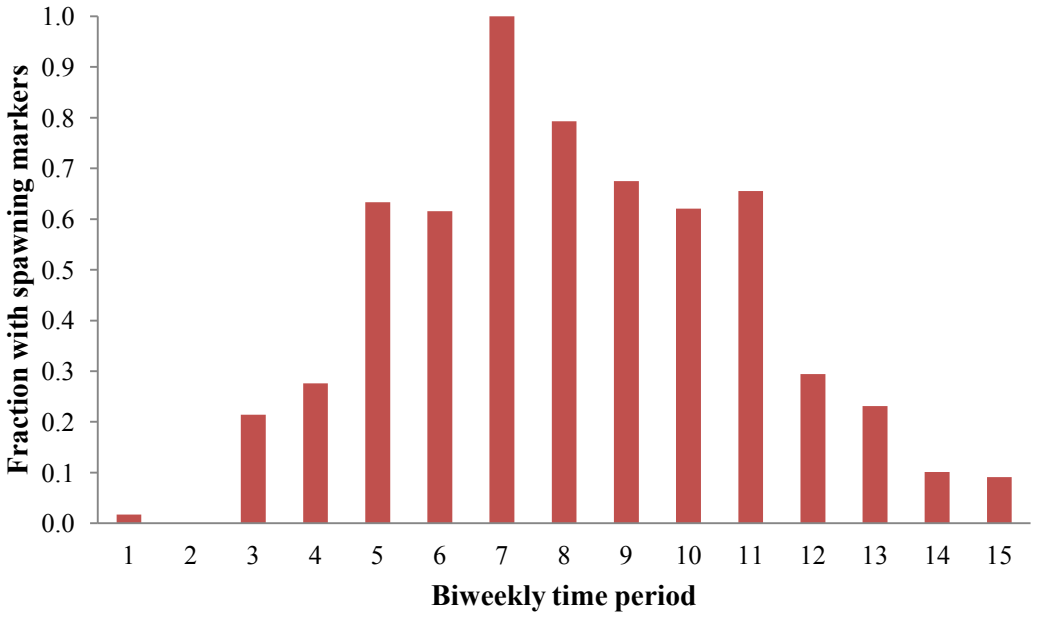

Figure 11. Seasonal reproductive development of female red snapper summarized by biweekly time period during the 2011 CSSP survey (N = 992, biweekly dates range from April-October, see Fitzhugh et al. 2012). Note that time period 7 is represented by small sample size (n= 2).

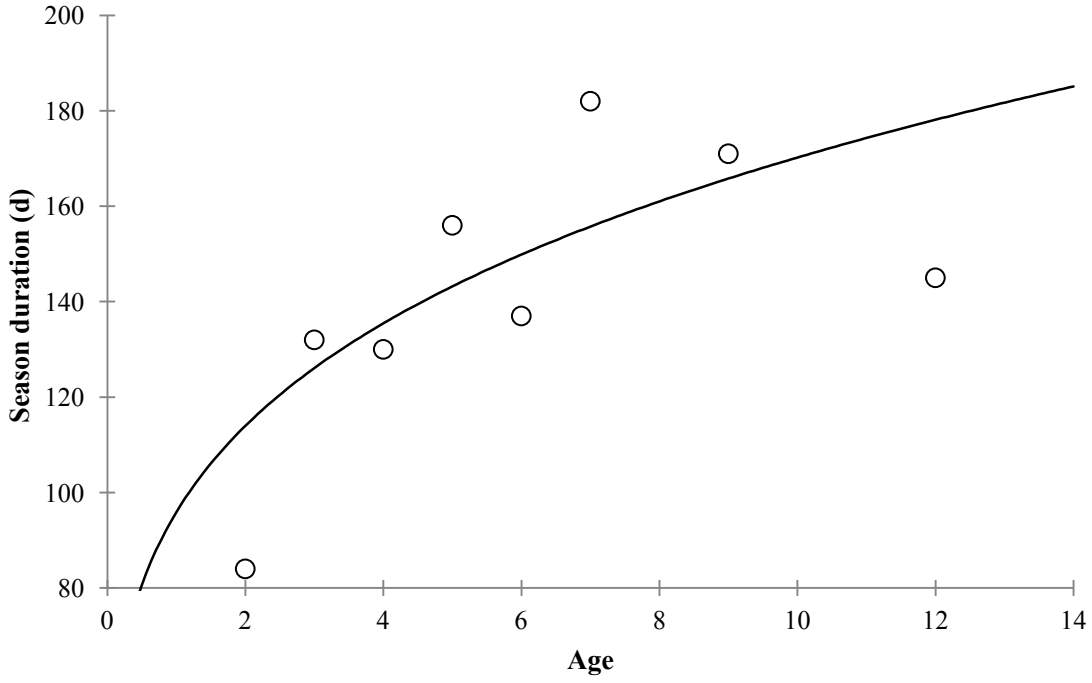

Figure 12. Non-linear weighted regression of the spawning season duration in days by age. Duration determined based upon the earliest and latest appearance of spawning markers by age. Due to sample size, ages 8-10 were aggregated and oldest ages aggregated as plus group, age 11+. Duration = 95.895 $(Age)^{0.249}$. R^2=0.47 (from Fitzhugh et al. 2012 SEDAR31-DW07).

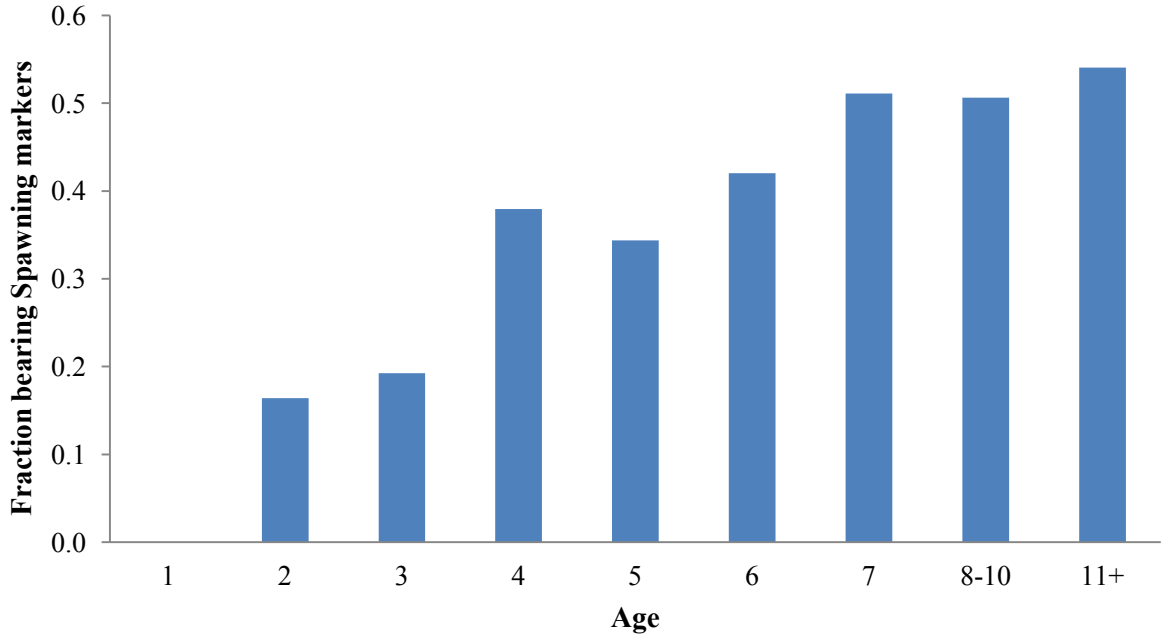

Figure 13. Fraction of females histologically assessed bearing spawning markers (H, POF stage, from Fitzhugh et al. 2012).

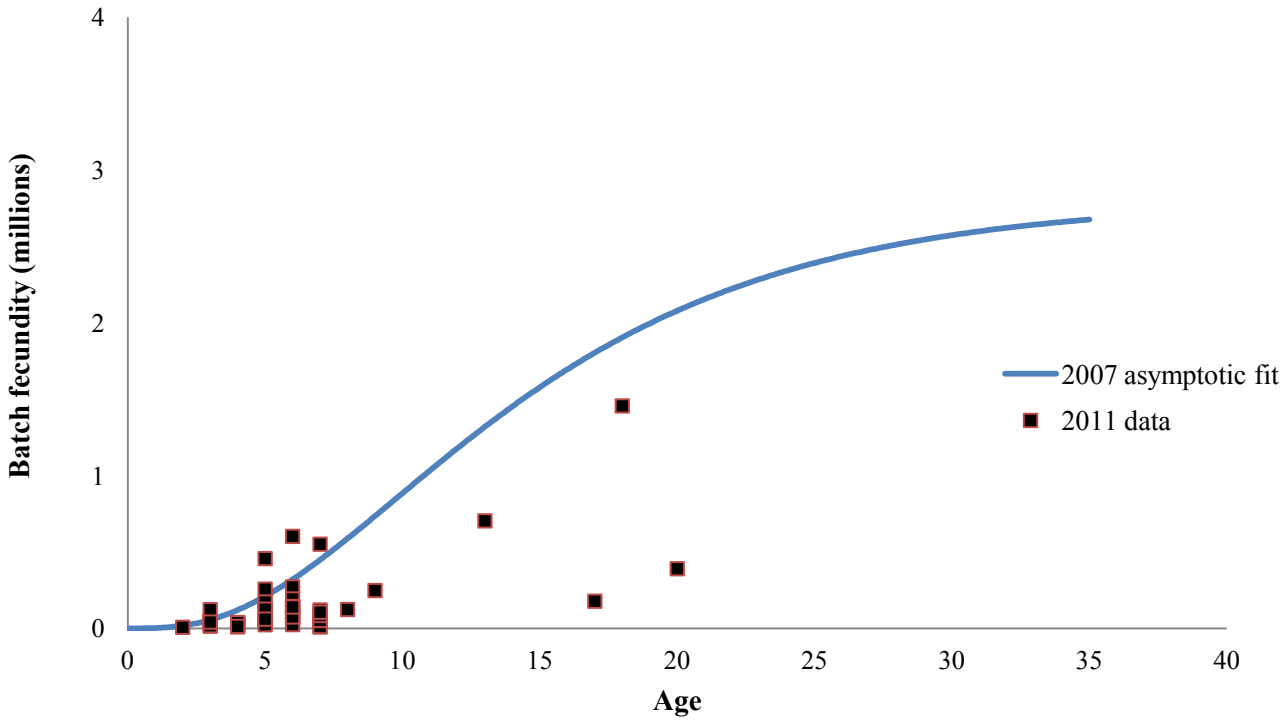

Figure 14. Batch fecundity by age from females in late hydration from the 2011 CSSP survey (from Fitzhugh et al. 2012). For comparison, the asymptotic age-batch fecundity relationship is shown (Porch et al. 2007) based upon a larger batch fecundity data set.

3 Commercial Fishery Statistics

3.1 Overview

Commercial landings of red snapper for the U.S. Gulf of Mexico were constructed using data housed in the NOAA's Southeast Fisheries Science Center's Accumulated Landings System (ALS) from 1964 through 2011. For landings between 1880 and 1963, previously constructed historical landings were used. In constructing the 1964-2011 time series, port of landing was used to assign water body when water body was not present. For missing or unclassified gears, proportions from the Coastal Fisheries Logbook Program (CFLP) were used when available. Florida General Canvass gear proportions were applied to Florida landings. Total annual landings from the IFQ program were used for years 2007-2011. These landings were used to reapportion 2007-2011 ALS landings across strata.

Discards were calculated for the directed fishery using CFLP discard logbook data, as well as from the reef fish observer program. In addition to the directed fishery discards, shrimp bycatch estimates of red snapper were calculated using observer data and estimated shrimping effort.

Length frequency distributions were constructed for red snapper in the years 1984-2011 using available TIP length data. Length frequencies were provided by year, region (East GoM, West GoM), and gear (longline, handline). Length frequency distributions were also constructed from observer data from 2006-2011. This allowed for investigation of discard lengths by year and by IFQ allocation. Age frequency distributions were constructed by year, region, and gear. A comparison of the age lengths with the length data was done to assess bias in otolith sampling.

3.1.1 Participants in SEDAR 31 Data Workshop Commercial Workgroup

Neil Baertlein, NMFS Miami (group leader)
Ching-Ping Chih, NMFS Miami
David Donaldson, GMFMC
David Gloeckner, NMFS Miami
Gary Graham, Gulf Red Snapper AP
Wade Griffin, Texas A&M University
David Krebs, Commercial Fisherman
Brian Linton, NMFS Miami (lead assessment scientist)
Jim Nance, NMFS Galveston
Jessica Stephen, NMFS SERO
Donnie Waters, Commercial Fisherman
Wayne Werner, Commercial Fisherman

Other contributors: Shannon Calay, Kevin McCarthy, Refik Orhun, Benny Gallaway

3.1.2 Issues Discussed at the Data Workshop

Issues the workgroup addressed in terms of commercial landings included historical landings, boundaries, gears, and IFQ reported landings. For red snapper discards and bycatch the

workgroup discussed estimates created from self-reported logbooks, directed fishery observers, and shrimping bycatch. Size composition discussions included the representativeness of lengths sampled from observers and dockside sampling, as well as from otoliths obtained from dockside samples.

3.2 Review of Working Papers

The workgroup considered data and analyses presented from five data workshop working papers.

SEDAR31-DW02: This document provides an overview of the Gulf of Mexico Red Snapper IFQ program as well as a description of the data collected by the IFQ office at NOAA's Southeast Regional Office. The group recommended the total landings be used for the years 2007 through 2011.

SEDAR31-DW10: This document provides length frequency distributions for commercial and recreational red snapper landings in the Gulf of Mexico.

SEDAR31-DW30: This document provides shrimp bycatch estimations for red snapper in the Gulf of Mexico as well as the Bayesian model used to construct estimations. The group recommended using the 3-depth zone model for bycatch estimations.

SEDAR31-DW31: A detailed summary of the methods used to calculate total commercial discards from self-reported logbooks and observed trips.

SEDAR31-DW32: A detailed summary of the methods used to produce red snapper size frequency histograms of discarded and landed (kept) fish using data collected by commercial fisheries observers

3.3 Commercial Landings

Commercial landings were compiled from the ALS from 1964-2011. Red snapper landings are provided in Table 3.1 by year, gear (longline, handline+) and region (Eastern and Western Gulf of Mexico). Landings for 'handline+' in the eastern Gulf of Mexico were also separated by southern and northern sub-regions in Table 3.2. As recognized in the 2004 SEDAR 7 DW report, 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 1962 – 1977
2. In 1962 and 1963, significant proportions of landings, 99.89% and 18.26%, respectively, are only reported as water body code 5000 (Gulf of Mexico), without the distinction to eastern or western Gulf
3. For Florida, gear and fishing area are <u>not</u> available for monthly data for 1977 - 1984
4. For Louisiana, gear and fishing area are <u>not</u> available for 1990 - 1999

5. For Texas, an unusually large of allocations of red snapper landings are assigned to shrimp trawl gear for 1978 - 1983
6. For Texas, gear and fishing area are not available for 1990 - 2011.

There is a lack of resolution for the 1962 - 1977 period, 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 – 1989 to allocate gear and statistical area to the landings.

To supply gears and areas for the Louisiana data, CFLP data were used to apportion landings accordingly.

Landings in Texas from 1978 to 1983 were classified as gear code '0' or '215' (unclassified gear or shrimp trawl). No vertical (hand or electric) or longline gear was present for TX landings. To account for the missing gears, apportioning of Texas landings by gear for 1978 through 1984 was performed by using proportions. See section 3.3.4 for further discussion.

To supply gears and areas for the Texas landings beginning in 1990, CFLP data were used to apportion landings accordingly.

In summary, for landings 1990 and later the gear allocations available in the general canvass (trip ticket) data were retained and the gear allocations from the CFLP were used for Louisiana (1990 - 1999, the Louisiana trip ticket data without gear designations for 2000 - 2003) and for Texas landings.

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

3.3.1 Historical Landings

In SEDAR7, historical landings of red snapper were constructed from 1880-1962 using various data sources. Landings data were by port, but were assigned to region based upon several historical references. Further detail can be found in SEDAR7-AW22 (Porch). A table of the historical landings can be found in Table 3.3.

Decision 1: Use Historical landings (1880-1963) as constructed in 2004 (Porch).

3.3.2 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.

Statistical areas 1-12 are assigned to the eastern Gulf stock, statistical areas 13-21 are assigned to the western Gulf stock. The 'handline+' landings in the eastern Gulf are further distinguished into a southeastern component, statistical areas 1- 7, and a northeastern component, statistical areas 8- 12.

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 is used to assign the nearest statistical area.

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.

> **Decision 2:** The workgroup's decision was to maintain the region boundaries as defined in SEDAR7.
>
> - Eastern Gulf of Mexico: Statistical areas 1-12
> - Western Gulf of Mexico: Statistical areas 13-21

3.3.4 Gears

Gears were assigned in the same fashion as done in SEDAR7 by using two gear types, long line and 'handline+', which is hand line and all other gears. The codes for these gear types are in ALS, Florida General Canvass data, and the CFLP and can be found in Tables 3.4 and 3.5.

Landings in Texas from 1978 to 1983 were classified as gear code '0' or '215' (unclassified gear or shrimp trawl). No vertical (hand or electric) or longline gear was present for TX landings. To account for the missing gears, apportioning of Texas landings by gear for 1979 through 1983 was performed by using proportions presented in Parrack and McClellan, 1986. Proportions used were an annual accumulative of proportions by age and gear for the western Gulf of Mexico (Table 3.6) Proportions for 1978 were not available and as best estimate the proportions from 1979 were also used for 1978.

> **Decision 3:** Use landings provided in 1986 document (Parrack and McClellan, 1986) to apportion TX landings in 1978-1983.

3.3.5 IFQ Landings

The red snapper Individual Fishing Quota program (RS-IFQ) is an online system where all transactions (share, allocation, and landing transfers) are recorded immediately upon entry by RS-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 RS-IFQ program records all weights in gutted pounds, but these

analyses all landings were converted to whole weight by multiplying by 1.11. Individual landings were summed for annual total pounds landed. Please refer to the Data Workshop working document SEDAR31-DW02 for further details about the RS-IFQ program.

In the IFQ years (2007 and later) commercial landings were based on ALS and IFQ reporting, rather than just ALS. IFQ landings reported were more likely to be accurate and, with the exception of 2009, possessed a higher landings total. The range in landings disparities between ALS and IFQ ranged from -0.37% to 3.27%. 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 3.7). The resulting total ALS landings for 2007 through 2011 would then reflect that of IFQ.

> **Decision 4:** Use total IFQ landings from 2007 through 2011. Apply the differences between ALS and IFQ to ALS data across all strata.

3.4 Discards and Bycatch

Red snapper discards in the Gulf of Mexico were calculated from data collected by the CFLP's self-reported discard logbook and NOAA Fisheries Gulf of Mexico reef fish observer program. In addition to these directed fisheries discards, estimates of red snapper bycatch from the commercial shrimping fleet were also generated.

3.4.1 Discards from Finfish Directed Fisheries

Full details of the methods of discard calculation can be found in SEDAR31-DW31.

Yearly red snapper discards calculated using self-reported discard rates, uncorrected for possible under reporting are provided in Tables 3.8 (vertical line) and 3.9 (bottom longline). Discards totals were in close agreement to those calculated for the 2009 red snapper assessment update. Minor differences were likely due to removal of duplicate records and correction of erroneous records in the data base. In addition, where discard rates were calculated as a mean rate across multiple years; those rates changed with additional years of data. Very low calculated discards for "IFQ west" were driven by decreasing reported effort over time and low discard rates reported, especially during 2009-11.

The vertical line fishery accounted for the majority of red snapper discards, by one to two orders of magnitude per year/region/season stratum, compared to the bottom longline fishery. The disparity in discards among gears was also found during the years of management through IFQs. Yearly discards calculated using observer reported discard rates are shown in Table 3.10. Those observer discard rate based calculations resulted in higher total vertical line discards than did the calculations using self-reported discard rates; often four to five times higher. The 2007-2008 eastern Gulf longline self-reported discards were higher than the observer reported discards, perhaps due to low observer coverage. Calculated discards of eastern Gulf longline vessels were similar using observer and self-reported data. Observer coverage was higher during those years.

Western Gulf longline calculated discards were low using discard rates from either data set. No observer data were available from the western Gulf longline fishery during 2006-2007.

Total discards calculated using data filtered to remove records reporting "no discards" are included in Tables 3.11 (vertical line) and 3.12 (bottom longline). Also included are total discards calculated with "no discards" records included. Not surprisingly, with "no discards" records excluded (i.e., removal of some zero discard records) total calculated discards were usually greater than those calculated prior to filtering the data set. In two cases, calculated discards were unchanged following removal of "no discards" records (e.g., west closed season vertical line). For vertical line in the western Gulf of Mexico, differences in total discards within strata following exclusion of "no discards" records were relatively small; less than 10 percent in all but two cases and often less than five percent. In the eastern Gulf of Mexico, vertical line calculated discards were usually more than 10 percent higher with the exclusion of "no discards" records. In four strata, calculated discards were more than 15 percent greater after data filtering.

The bottom longline fishery reported fewer red snapper discards than the vertical line fishery. Exclusion of "no discards" records resulted in proportionally much higher calculated red snapper discards in the bottom longline fishery. In some cases (e.g., IFQ west), discards calculated with "no discards" records excluded were two orders of magnitude greater than discards calculated with "no discards". Total discards calculated for the longline fishery were much lower than vertical line fishery discards, however, even with "no discards" records excluded from the calculations.

> **Decision 5:** Wait for recommendations from the external review of the observer program. Depending on recommendations, recalculation of logbook and observer discard estimates may be necessary. The workgroup will discuss any changes and present recommendations to the panel in a future webinar.

Remaining Tasks:
-Waiting for results from external review of directed fishery discard analyses. Forthcoming review may suggest an improved method of discard calculation. Additional work will be discussed via Webinar.

3.4.2 Bycatch from the Shrimp Fishery

Shrimp bycatch estimates for Gulf of Mexico red snapper were generated using the same approach developed by Scott Nichols in the SEDAR 7 Gulf of Mexico red snapper assessment (Nichols 2004a, 2004b). The primary data on CPUE in the shrimp fishery came from a series of shrimp observer programs, which began in 1972 and extend to the current shrimp observer program. Additional CPUE data were obtained from the SEAMAP groundfish survey. Point estimates and associated standard errors of shrimp effort were generated by the NMFS Galveston Lab using their SN-pooled model (Nance 2004). Most CPUE data were reported in fish per net-hour, while the shrimp effort data were reported in vessel-days. Therefore, data from the Vessel Operating Units File were needed to estimate the average number of nets per vessel for the shrimp fishery to convert total shrimp effort to net-hours. A detailed description of the data and methods used to produce the shrimp bycatch estimates can be found in Linton (2012).

Model 02 from Nichols (2004a) was used to estimate shrimp bycatch. Two model runs were made using different depth zone stratifications: 1) a three depth zone run (0 fm – 10 fm, 10 fm – 30 fm, 30+ fm), and 2) a two depth zone run (0 fm – 10 fm, 10+ fm). The shrimp bycatch estimation model was fit using WinBUGS version 1.4.3. Markov Chain Monte Carlo (MCMC) methods were used to estimate the marginal posterior distributions of key parameters and derived quantities. Convergence of the MCMC chains was determined by visual inspection of trace plots, marginal posterior density plots, and Gelman-Rubin statistic (Brooks and Gelman 1998) plots.

> **Decision 6:** Using age compositions from observer data to define 0 and 1year red snapper in shrimp estimates.
>
> **Decision 7:** The three depth zone run was chosen to provide shrimp bycatch estimates for the assessment, because this run incorporates finer spatial resolution in the data. In particular, the three depth zone run includes the 10 fm to 30 fm zone where the majority of red snapper (i.e., approximately 80% according to observer program data) are thought to be caught by the shrimp fishery.

The MCMC chains demonstrated good convergence properties. Convergence diagnostics for the local terms precision (1/variance) parameter are presented in Figure 3.2 as an example. Region-specific annual estimates of shrimp bycatch from the three depth zone run are presented in Figure 3.3 and Tables 3.13 and 3.14. Marginal posterior densities of the annual shrimp bycatch estimates all showed varying degrees of right-skew. In the eastern Gulf, CVs of the annual estimates ranged from 0.10-2.03 with a mean CV of 1.22. In the western Gulf, CVs of the annual estimates ranged from 0.08-2.29 with a mean CV of 0.91. Trimester-based estimates of shrimp bycatch were also produced, and are available for use in the assessment.

Shrimp effort is used as an index of shrimp fishing mortality in the assessment, in addition to its use in the estimation of shrimp bycatch. Shrimp effort estimates by region and depth zone are presented in Figure 3.4.

> **Decision 8:** Shrimp effort for depths greater than 10 fm was chosen to provide an index of shrimp fishing mortality in the assessment, because effort from these depths is thought to best represent the fishing pressure experienced by red snapper in the shrimp fishery. This decision is in keeping with decisions made for SEDAR 7 and the 2009 Gulf of Mexico red snapper update assessment.

Shrimp effort for depths greater than 10 fm is presented in Table 3.15.

3.5 Commercial Effort

The distribution of directed commercial effort in trips by year was compiled from the Coastal Fisheries Logbook Program for 1992-2011 and supplied here for informational purposes. These data are presented in Figures 3.5-3.7.

Maps of the total estimated shrimping effort are also supplied for informational purposes and can be found in Figures 3.8-3.10.

3.6 Biological Sampling

Length distributions were provided from commercial landings provided in the Trip Interview Program (TIP) database and the Gulf Fisheries Information Network (FIN). The length distributions were presented by year, gear, and region. Length distributions constructed from the reef fish observer program were also provided from 2006-2011. The observer data allowed for comparison of size distributions between discarded and kept fish. The impact of available IFQ allocation on fishing behavior was also discussed by the workgroup. Age distributions were also developed by year, gear, and region. A comparison between lengths from otolith samples and the complete length dataset was performed to determine representativeness of otolith sampling.

3.6.1 Length Distribution of Commercial Landings

Length samples for commercial fisheries were obtained from the Trip Interview Program (TIP) database and the Gulf Fisheries Information Network (FIN) database. All commercial data were grouped into four strata (handline east (HE), handline west (HW), longline east (LE) and longline west (LW)). The eastern Gulf and western Gulf were defined based on Gulf shrimp grids (grids 1 to 12 for the eastern Gulf and 13 to 21 for the western Gulf). Length samples were assigned by fishing area to different strata. When a fishing area was not available, landing area was used. Length frequencies were calculated for each year and season (4 month periods) for each stratum. Length samples were first grouped into 1 inch bins (e.g., if $1 \leq \text{length} < 2$ then length=1). Length frequencies for handline samples collected from the eastern Gulf were further weighted by landings from the northeastern and southeastern Gulf. The southeastern Gulf was defined as grids 1 to 7, and the northeastern Gulf was defined as grids 8-12. All length values in the original data sets were converted to total length by using the equations listed in the SEDAR7 final assessment report.

Full details of the analyses can be found in SEDAR-31-DW10. Plots of the length distributions by gear and region can be found in Figures 3.11-3.14.

> **Decision 9:** Accept length compositions by year, gear, and region produced from TIP and FIN.

Remaining Tasks:
- In the process of comparing these length distributions with the age-length distributions it was discovered that several updated data files had recently become available. Length distributions will be reconstructed with the updated files.

3.6.2 Size Frequency Data from Commercial Fisheries Observers

A detailed summary of the methods used to produce red snapper size frequency histograms of discarded and landed (kept) fish using data collected by commercial fisheries observers is available in working paper SEDAR31 DW32.

The available observer reported red snapper size and disposition data were used to construct size frequency histograms of discarded and kept fish for each region and gear. Regions were defined as Gulf of Mexico statistical areas 1-12 (east) and 13-21 (west). Gears included vertical lines (handline and electric/hydraulic reels) and bottom longlines. No attempt was made to account for the fraction of fish that was not measured (e.g., if 70% of discarded fish within a stratum were measured while 95% of kept fish were measured in the same stratum, no adjustment was made for that difference in sampling fraction).

Prior to 2007, observer data were available for the period July-December, 2006. During those months, the commercial fishery was subject to seasonal closures. Data collected during 2006 were stratified by season (open and closed), region, and gear and size frequency histograms constructed for each stratum.

In addition to region/gear stratification, observer data from the period 2007-2011 were further stratified by the amount of red snapper Individual Fishing Quota allocation available to the observed vessel. Allocation categories were defined by dividing the data (number of measured fish) into roughly equal groups. In each region/gear stratum, a "no allocation" stratum was defined. All region/gear/allocation strata are defined in Table 3.16.

Finally, yearly changes in the size frequency of discarded and kept red snapper were examined. Histograms were produced following stratification of the data by year, region, and gear. Data were not stratified by the amount of red snapper allocation available to each vessel.

Sample sizes of observed fish are provided within each figure. The number of trips with red snapper observed are included in Table 3.17 (sample sizes in 2006), Tables 3.18A-3.18B (trips by gear, region, and red snapper allocation), and Tables 3.19A-3.19B (trips by gear, year, and region).

Size frequency histograms of observed red snapper discards and kept fish are provided in the figures listed below. In some strata data could not be presented due to confidentiality restrictions and have been identified in the figure captions.

It is likely that data entry errors and mismatching of data sets while merging observer data with red snapper allocation data resulted in the incorrect assignment to allocation category of a very few trips (e.g., kept fish observed on trips with no red snapper allocation). SEFSC and SERO staff will work to resolve those data issues and new size frequency histograms will be constructed.

A higher fraction of observed kept red snapper were measured (usually >90%) than were observed discarded red snapper (typically 70-90%). The working group recognized that the

histograms should be adjusted to account for that fraction of the observed red snapper that were not measured.

Decision 10: Accept discard length compositions from reef fish observer data.

Remaining Tasks:
-Redefine allocation bins based upon fisher and assessment scientist input.
-Correct data entry errors and data set merge problems to properly assign the few trips that were likely misassigned to an incorrect allocation category.
-Account for the proportion of fish not measured when constructing frequency histograms.
-Construct new size frequency histograms from the observer data once the above issues have been resolved.

3.6.3 Age Distribution

To explore the possibility of non-representative sampling of fish chosen for otolith analysis, the working group requested the length distribution of all available samples be compared to the length distribution of the samples selected for otolith analysis. It was expected the two length distributions would be very similar if the otolith samples were a representative subsample of the total observed fish. In both cases, the length distributions were weighted by the landings as previously described. The resulting length compositions can be found in Appendix B.

The working group concluded there was evidence of non-representative sampling prior to 2000 in all fisheries. The Panama City lab reported that some of these early samples were taken to construct an age length key, rather than to construct a growth curve. After 2000, scientific samplers were directed to obtain a representative sample by length for otolith analysis.

The length frequency comparisons (see Appendix B) indicate that this objective was met in most cases.

Decision 11: Otolith samples from 2000 forward mostly appear to be representative, correspond with changes in sampling protocols.

Remaining Tasks:
-Address non-representative age samples.

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 1880-2011. There was some uncertainty in the landings provided for 1880-1963 as reported landings were inconsistent and derived from port of landing. The regional boundaries set and the landings by gear group were agreed upon by the workgroup. Total IFQ landings used for 2007 through 2011 were also agreed upon as adequate.

Discard and bycatch estimations were also adequate, but possessed a lesser level certainty than the landings. The total discards calculated from logbook and observer data may be recalculated based upon results from an external review of the observer program and discard calculation methods. There is also a higher level of uncertainty in the discards for 1990 through 2001 as these estimates are based upon an average discard rate from 2002 through 2006. If the external review of the observer sampling is found adequate, calculated discards for 2007-2011 from the observer data would likely be preferable. Bycatch estimates from the shrimp fishery were considered adequate. A three depth zone model run was performed, which was recommended over previous 2-depth zone runs as it provided finer spatial resolution. These estimations were performed using a well established methodology.

Most length distributions appeared to be adequate however some strata were not adequate as sample sizes were small. This was especially the case for longline samples in the western Gulf. Length distributions of discarded fish from samples obtained from the observer program appeared to be adequate. However, these will be revisited pending an external review of the program. Upon a comparison with the length compositions age distributions appeared to be adequate from 2000-2011. This trend is in agreement with a shift in the dockside sampling protocol.

3.8 Research Recommendations for Red Snapper

Landings
1. Revisit how the historical landings were constructed.
2. Explore ways to ensure that IFQ and trip ticket landings match.
3. Apportion landings accordingly in ALS for TX landings with missing gear.

Discard
1. Add species to discard logbook form.
2. Provide better instructions on how to complete the discard logbook.
3. Consider and use relevant input from external review of observer program.
4. Social and economic impacts on fisher behavior in terms of fish discards.
5. Better determine available allocation to vessels on a given trip.

Length/Age
1. Standardize length and age data formats from various data sources.
2. Build age databases with Trip ID number for FL and FIN data.
3. Evaluate how to handle catch at age of non-representative age samples.

3.9 Literature Cited

Linton, B. 2012. Shrimp fishery bycatch estimates for Gulf of Mexico red snapper, 1972-2011. SEDAR31-DW30.

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3.10 Tables

Table 3.1 Red snapper landings in the Gulf of Mexico for 1964-2011.

	Eastern		Western			
Year	Handline+	Longline	Handline+	Longline	Total	Source
1964	3,606,670		3,590,301		7,196,971	ALS
1965	3,712,564		3,646,081		7,358,645	ALS
1966	3,098,765		3,041,229		6,139,994	ALS
1967	2,906,944		4,230,951		7,137,895	ALS
1968	2,617,546		5,160,886		7,778,432	ALS
1969	2,441,942		4,187,460		6,629,402	ALS
1970	2,309,454		4,652,728		6,962,182	ALS
1971	2,223,569		5,366,029		7,589,598	ALS
1972	2,374,322		4,841,776		7,216,098	ALS
1973	2,713,032		4,867,197		7,580,229	ALS
1974	3,767,565		4,433,800		8,201,365	ALS
1975	3,576,624		3,932,964		7,509,588	ALS
1976	3,288,126		3,325,599	1,074	6,614,799	ALS
1977	2,263,749		2,873,097		5,136,847	ALS
1978	1,996,352		2,694,000		4,690,352	ALS
1979	2,037,895		2,472,483		4,510,378	ALS
1980	1,895,748	94,005	2,516,508	44,054	4,550,316	ALS
1981	2,127,655	179,859	3,143,304	49,261	5,500,079	ALS
1982	2,291,907	226,574	3,661,535	71,617	6,251,633	ALS
1983	2,387,540	445,023	3,820,146	98,736	6,751,444	ALS
1984	1,631,916	368,449	2,906,413	762,672	5,669,450	ALS
1985	1,623,772	114,339	1,846,043	604,890	4,189,043	ALS
1986	859,831	75,897	1,933,384	831,375	3,700,486	ALS
1987	796,819	63,474	1,474,284	734,038	3,068,614	ALS
1988	857,959	76,666	2,355,109	670,131	3,959,865	ALS
1989	673,086	78,572	1,891,961	454,743	3,098,362	ALS
1990	697,614	74,787	1,757,789	120,421	2,650,611	ALS
1991	395,176	20,704	1,724,713	72,592	2,213,185	ALS
1992	406,493	5,689	2,674,497	19,820	3,106,498	ALS
1993	436,981	15,235	2,901,388	20,291	3,373,894	ALS
1994	527,124	7,958	2,671,460	15,809	3,222,351	ALS
1995	172,740	8,459	2,735,403	17,506	2,934,108	ALS
1996	233,980	7,587	4,044,133	27,362	4,313,063	ALS
1997	184,411	4,627	4,589,501	31,418	4,809,958	ALS
1998	379,399	5,514	4,267,523	27,224	4,679,660	ALS
1999	548,422	6,474	4,230,449	90,572	4,875,917	ALS
2000	665,284	8,619	3,979,683	183,538	4,837,125	ALS
2001	797,925	10,130	3,692,770	124,453	4,625,279	ALS

2002	1,048,705	18,125	3,565,962	146,195	4,778,986	ALS
2003	1,019,257	13,853	3,204,247	171,270	4,408,627	ALS
2004	950,935	19,353	3,225,236	455,829	4,651,354	ALS
2005	792,010	21,121	3,000,323	282,789	4,096,244	ALS
2006	760,327	16,335	3,611,689	260,652	4,649,003	ALS
2007	875,240	15,727	2,103,261	188,503	3,182,731	IFQ Corr 2007
2008	834,499	34,124	1,559,132	55,848	2,483,603	IFQ Corr 2008
2009	918,874	14,627	1,498,298	51,766	2,483,565	IFQ Corr 2009
2010	1,397,647	75,510	1,880,858	38,193	3,392,209	IFQ Corr 2010
2011	1,613,106	84,286	1,878,310	18,850	3,594,552	IFQ Corr 2011

Table 3.2 Red snapper landings for 1964-2011 in the Eastern Gulf of Mexico for Handline and other non-longline gears.

Year	Northeastern handline+	Southeastern handline+	Total	Source
1964	1,758,520	1,848,150	3,606,670	ALS
1965	1,915,030	1,797,534	3,712,564	ALS
1966	1,531,449	1,567,316	3,098,765	ALS
1967	1,748,659	1,158,285	2,906,944	ALS
1968	1,440,724	1,176,822	2,617,546	ALS
1969	1,408,310	1,033,632	2,441,942	ALS
1970	1,303,461	1,005,993	2,309,454	ALS
1971	1,366,094	857,475	2,223,569	ALS
1972	1,472,114	902,208	2,374,322	ALS
1973	1,904,386	808,646	2,713,032	ALS
1974	1,861,812	1,905,753	3,767,565	ALS
1975	1,905,105	1,671,519	3,576,624	ALS
1976	1,695,350	1,592,776	3,288,126	ALS
1977	1,322,907	940,843	2,263,749	ALS
1978	1,222,205	774,147	1,996,352	ALS
1979	1,261,112	776,784	2,037,895	ALS
1980	1,275,269	620,479	1,895,748	ALS
1981	1,535,436	592,220	2,127,655	ALS
1982	1,730,710	561,197	2,291,907	ALS
1983	1,924,502	463,038	2,387,540	ALS
1984	1,181,640	450,276	1,631,916	ALS
1985	1,160,061	463,711	1,623,772	ALS
1986	712,324	147,506	859,831	ALS
1987	682,028	114,790	796,819	ALS
1988	746,347	111,612	857,959	ALS
1989	590,936	82,149	673,086	ALS
1990	550,348	147,266	697,614	ALS

1991	362,700	32,475	395,176	ALS
1992	389,891	16,601	406,493	ALS
1993	381,940	55,041	436,981	ALS
1994	487,422	39,702	527,124	ALS
1995	153,815	18,925	172,740	ALS
1996	222,101	11,879	233,980	ALS
1997	171,928	12,483	184,411	ALS
1998	353,122	26,277	379,399	ALS
1999	477,638	70,784	548,422	ALS
2000	600,899	64,385	665,284	ALS
2001	716,515	81,410	797,925	ALS
2002	954,913	93,792	1,048,705	ALS
2003	918,807	100,450	1,019,257	ALS
2004	814,322	136,614	950,935	ALS
2005	624,364	167,646	792,010	ALS
2006	574,995	185,332	760,327	ALS
2007	754,895	120,346	875,240	IFQ Corr 2007
2008	703,784	130,715	834,499	IFQ Corr 2008
2009	681,668	237,206	918,874	IFQ Corr 2009
2010	1,014,881	382,766	1,397,647	IFQ Corr 2010
2011	1,178,568	434,538	1,613,106	IFQ Corr 2011

Table 3.3 Reconstructed historical landings as described in SEDAR7-AW-22

Red Snapper landings from U.S. waters		
Year	**East**	**West**
1880	1,824,641	891,034
1881	2,052,381	801,943
1882	2,282,108	711,859
1883	2,509,861	634,313
1884	2,737,622	556,765
1885	2,965,390	478,225
1886	3,195,145	400,672
1887	3,422,926	203,970
1888	3,277,425	212,884
1889	3,483,431	269,327
1890	4,192,327	242,531
1891	3,822,273	269,541
1892	4,010,384	293,175
1893	4,132,232	311,969
1894	4,227,631	324,863
1895	4,125,291	333,838
1896	4,167,613	340,888
1897	4,138,252	340,642
1898	4,612,379	544,671
1899	5,146,576	722,625
1900	5,674,141	889,976
1901	6,027,029	1,020,372
1902	6,283,575	1,126,034
1903	5,722,123	1,059,802
1904	5,286,731	1,011,726
1905	4,756,040	940,928
1906	4,240,944	867,673
1907	3,743,104	791,605
1908	3,363,251	735,773
1909	2,890,857	632,940
1910	2,436,701	538,109
1911	2,455,472	527,520
1912	2,473,439	517,874
1913	2,491,078	508,475
1914	2,507,351	498,829
1915	2,522,773	489,183
1916	2,537,294	478,596
1917	2,479,260	468,950
1918	2,492,553	459,305
1919	2,718,931	471,382
1920	2,954,424	483,458
1921	3,198,932	496,724
1922	3,452,171	508,800
1923	3,707,316	520,876
1924	3,621,389	503,176
1925	3,627,316	485,474
1926	3,532,334	467,525

1927	3,857,579	585,907
1928	3,444,187	426,871
1929	3,658,800	417,093
1930	2,233,495	553,559
1931	2,249,781	342,794
1932	2,416,037	411,305
1933	2,184,361	447,623
1934	1,964,863	464,740
1935	2,411,025	675,130
1936	2,773,983	871,388
1937	2,458,439	946,575
1938	3,180,371	935,330
1939	3,732,701	854,469
1940	2,496,953	815,871
1941	2,271,791	737,892
1942	1,818,353	544,639
1943	1,446,274	371,388
1944	1,670,030	279,690
1945	1,455,205	153,741
1946	2,319,802	323,401
1947	2,432,194	478,181
1948	2,598,682	595,421
1949	3,108,401	869,794
1950	1,693,118	1,476,048
1951	2,016,917	1,477,540
1952	2,245,040	1,654,176
1953	2,026,470	1,358,592
1954	1,883,191	1,365,982
1955	2,106,652	1,492,039
1956	2,520,865	2,017,420
1957	2,261,891	2,013,517
1958	3,724,587	3,357,390
1959	3,407,851	3,431,602
1960	3,816,825	3,601,182
1961	3,504,256	4,248,967
1962	3,612,712	4,131,601
1963	3,174,817	3,509,846

Table 3.4 ALS gear code grouping.

NMFS Code	Description	Group
614	Long Line, Vertical	Longline
675	Lines Long Set With Hooks	Longline
676	Lines Long, Reef Fish	Longline
677	Lines Long, Shark	Longline
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+
616	Rod and Reel, Electric (Hand)	Handline+
215	Otter Trawl Bottom, Shrimp	Handline+
*	All other codes	Handline+

Table 3.5 CFLP gear code grouping.

Logbook Gear	Description	Group
L	Longline	Longline
H	Hand line	Handline+
E	Electric	Handline+
T	Trap	Handline+
*	All other codes	Handline+

Table 3.6 Proportions by gear presented in 1986 paper (Parrack and McClellan) used for apportioning 1978-1983 landings by gear.

Appendix.

Table 3. Proportion (cumulative) of annual red snapper (Lutjanus campechanus) catches by gear and age group for the western Gulf of Mexico stock.

Commercial Rod & Reel

AGE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
79	0.0012	0.1199	0.2392	0.2723	0.2828	0.2864	0.2865	0.2895	0.2952	0.2952	0.2952	0.2952	0.2952	0.2952	0.2953	0.2953
80	0.0001	0.0397	0.1083	0.1809	0.1998	0.1994	0.2009	0.2026	0.2036	0.2046	0.2046	0.2046	0.2046	0.2046	0.2047	0.2049
81	0.0001	0.0042	0.0438	0.1142	0.1492	0.1538	0.1573	0.1573	0.1573	0.1574	0.1580	0.1581	0.1585	0.1585	0.1586	0.1586
82	0.0003	0.0522	0.1102	0.1913	0.2254	0.2349	0.2414	0.2418	0.2418	0.2429	0.2431	0.2431	0.2431	0.2432	0.2432	0.2433
83	0.0362	0.2177	0.2338	0.2339	0.2340	0.2356	0.2372	0.2554	0.2555	0.2555	0.2934	0.2935	0.2935	0.2936	0.2936	0.2936
84	0.0025	0.1487	0.2925	0.3581	0.3554	0.3611	0.3941	0.3941	0.3985	0.4268	0.4280	0.4288	0.4289	0.4289	0.4290	0.4290
85	0.0001	0.0776	0.2079	0.2554	0.2822	0.3010	0.3186	0.3211	0.3252	0.3455	0.3570	0.3570	0.3572	0.3572	0.3573	0.3573

Commercial Trawl

AGE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
79	0.0002	0.0098	0.0159	0.0171	0.0176	0.0178	0.0179	0.0181	0.0183	0.0184	0.0184	0.0184	0.0184	0.0184	0.0184	0.0184
80	0.0000	0.0031	0.0058	0.0075	0.0087	0.0098	0.0098	0.0100	0.0100	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102
81	0.0000	0.0004	0.0034	0.0077	0.0099	0.0101	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
82	0.0000	0.0013	0.0032	0.0055	0.0064	0.0068	0.0071	0.0071	0.0072	0.0077	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078
83	0.0021	0.0127	0.0136	0.0136	0.0136	0.0137	0.0138	0.0149	0.0149	0.0149	0.0171	0.0171	0.0171	0.0171	0.0171	0.0171
84	0.0003	0.0090	0.0161	0.0193	0.0197	0.0217	0.0220	0.0220	0.0225	0.0243	0.0244	0.0244	0.0245	0.0245	0.0245	0.0245
85	0.0000	0.0044	0.0096	0.0114	0.0125	0.0135	0.0141	0.0142	0.0146	0.0156	0.0161	0.0161	0.0161	0.0161	0.0161	0.0161

Commercial Bottom Longline

AGE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
80	0.0000	0.0053	0.0094	0.0121	0.0122	0.0124	0.0124	0.0124	0.0126	0.0130	0.0130	0.0131	0.0131	0.0131	0.0131	0.0131
81	0.0000	0.0007	0.0090	0.0206	0.0263	0.0271	0.0278	0.0279	0.0280	0.0284	0.0280	0.0280	0.0280	0.0280	0.0280	0.0280
82	0.0003	0.0028	0.0045	0.0079	0.0091	0.0099	0.0105	0.0110	0.0119	0.0134	0.0138	0.0138	0.0138	0.0141	0.0143	0.0145
83	0.0061	0.0367	0.0395	0.0396	0.0396	0.0399	0.0400	0.0427	0.0500	0.0500	0.0507	0.0507	0.0507	0.0507	0.0507	0.0507
84	0.0006	0.0135	0.0257	0.0385	0.0386	0.0454	0.0455	0.0455	0.0459	0.0579	0.0584	0.0585	0.0585	0.0585	0.0585	0.0585
85	0.0001	0.0210	0.0435	0.0617	0.0668	0.0696	0.0702	0.0706	0.0795	0.0930	0.0930	0.0930	0.0930	0.0931	0.0931	0.0932

Commercial Other

AGE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
85	0.0000	0.0002	0.0004	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007

Table 3.7 Comparison of landings in ALS and IFQ databases. Final totals from IFQ landings were used. Percentage difference was applied to ALS landings across strata.

Year	ALS	IFQ	Diff. (lbs)	Diff. (%)
2007	3,081,955	3,182,731	100,776	3.27%
2008	2,464,662	2,483,603	18,941	0.77%
2009	2,501,837	2,483,565	(18,272)	-0.73%
2010	3,328,451	3,392,209	63,758	1.92%
2011	3,565,259	3,594,552	29,292	0.82%

Table 3.8 Calculated red snapper discards for vertical line gear from self reported logbooks.

Year	East open season	East closed season	West open season	West closed season
1990	133,336		513,291	
1991	222,762	97,969	783,451	94,438
1992	56,712	272,327	261,768	162,617
1993	46,291	194,610	298,582	74,272
1994	45,560	300,107	303,044	48,373
1995	35,084	292,159	300,971	46,224
1996	70,458	406,998	759,844	49,649
1997	63,919	309,097	642,199	75,036
1998	82,149	323,831	753,786	75,451
1999	92,221	396,469	713,691	59,700
2000	127,549	213,319	627,137	74,537
2001	115,499	204,549	725,673	58,987
2002	171,371	139,016	729,981	163,220
2003	152,134	336,173	644,390	37,335
2004	70,463	165,902	607,907	42,021
2005	126,063	116,561	831,849	30,515
2006	100,183	82,239	424,546	17,504
	IFQ East		IFQ West	
2007	222,957		98,321	
2008	280,914		86,129	
2009	434,561		10,825	
2010	204,267		6,145	
2011	220,596		13,269	

Table 3.9 Calculated red snapper discards for longline gear from self reported logbooks.

Year	East open season	East closed season	West open season	West closed season
1990	6,317		711	
1991	7,651	8,712	2,140	90
1992	1,848	15,607	336	160
1993	1,268	19,452	709	307
1994	1,497	22,876	1,042	415
1995	971	19,225	1,387	773
1996	1,454	20,012	1,136	564
1997	1,398	25,284	671	349
1998	1,097	23,012	691	424
1999	1,453	22,324	2,325	794
2000	1,289	17,523	1,760	590
2001	1,180	16,929	1,036	405
2002	1,408	8,643	1,577	540
2003	1,307	4,798	3,401	656
2004	1,690	27,990	5,174	569
2005	1,424	9,676	4,518	476
2006	1,851	5,889	4,058	334
	IFQ East		IFQ West	
2007	72,116		355	
2008	70,187		302	
2009	37,792		390	
2010	20,689		217	
2011	29,525		202	

Table 3.10 Calculated red snapper discards from observer program.

Year	East vertical line	East longline	East longline*	West vertical line	West longline
2006	440,784	9,222		463,912	
2007	613,590	34,048		384,168	
2008	353,038	4,268	12,644	424,410	527
2009	856,207	32,298		32,501**	754
2010	497,910	14,187		469,714	483
2011	265,467	20,817		201,740	450

*includes nonrandomly selected eastern Gulf longline trips during 2008.
**low west vertical line total discards in 2009 due to very low observed discard rate (0.01 vs. 0.1-0.2 fish/hook hour observed during other years). Few sets were observed during 2009. The highest discard rate, 0.22 red snapper/hook hour, also occurred in a year (2010) with few sets observed.

Table 3.11 Total vertical line gear discards compared with "no discard" reports removed from the analyses.

Year	East open season		East closed season		West open season		West closed season	
	continuity	"no discards" excluded	continuity	"no discards" excluded	continuity	"no discards" excluded	continuity	"no discards" excluded
1990	133,336	160,529			513,291	514,832		
1991	222,762	283,019	97,969	110,132	783,451	789,015	94,438	94,552
1992	56,712	70,130	272,327	306,349	261,768	268,014	162,617	163,905
1993	46,291	51,412	194,610	222,746	298,582	316,531	74,272	77,583
1994	45,560	51,153	300,107	341,137	303,044	314,558	48,373	51,525
1995	35,084	38,470	292,159	338,125	300,971	313,774	46,224	50,618
1996	70,458	75,826	406,998	468,420	759,844	780,752	49,649	53,995
1997	63,919	70,864	309,097	357,005	642,199	665,234	75,036	80,294
1998	82,149	95,073	323,831	369,511	753,786	780,944	75,451	80,691
1999	92,221	104,236	396,469	451,302	713,691	735,395	59,700	65,489
2000	127,549	142,410	213,319	245,565	627,137	650,846	74,537	81,421
2001	115,499	131,998	204,549	234,182	725,673	749,238	58,987	64,550
2002	171,371	178,383	139,016	144,089	729,981	729,981	163,220	163,848
2003	152,134	168,982	336,173	461,119	644,390	678,232	37,335	42,437
2004	70,463	77,097	165,902	195,082	607,907	615,041	42,021	44,474
2005	126,063	135,848	116,561	126,734	831,849	848,414	30,515	31,865
2006	100,183	106,061	82,239	94,408	424,546	434,172	17,504	17,504
	IFQ East				IFQ West			
	continuity	"no discards" excluded			continuity	"no discards" excluded		
2007	222,957	249,901			98,321	105,229		
2008	280,914	321,773			86,129	94,040		
2009	434,561	491,041			10,825	11,047		
2010	204,267	249,282			6,145	7,228		
2011	220,596	251,164			13,269	13,713		

Table 3.12 Total longline gear discards compared with "no discard" reports removed from the analyses.

Year	East open season		East closed season		West open season		West closed season	
	continuity	"no discards" excluded	continuity	"no discards" excluded	continuity	"no discards" excluded	continuity	"no discards" excluded
1990	6,317	9,785			711	830		
1991	7,651	11,759	8,712	8,996	2,140	2,521	90	133
1992	1,848	2,891	15,607	16,170	336	400	160	235
1993	1,268	1,955	19,452	44,553	709	851	307	452
1994	1,497	2,330	22,876	54,211	1,042	1,248	415	611
1995	971	1,522	19,225	35,527	1,387	1,635	773	1,139
1996	1,454	2,206	20,012	34,621	1,136	1,398	564	832
1997	1,398	2,177	25,284	48,846	671	818	349	515
1998	1,097	1,701	23,012	49,086	691	834	424	625
1999	1,453	2,283	22,324	48,548	2,325	2,979	794	1,170
2000	1,289	2,019	17,523	29,246	1,760	2,137	590	869
2001	1,180	1,833	16,929	27,449	1,036	1,261	405	596
2002	1,408	2,214	8,643	9,026	1,577	1,889	540	795
2003	1,307	2,054	4,798	5,638	3,401	4,289	656	966
2004	1,690	2,658	27,990	28,535	5,174	6,574	569	839
2005	1,424	2,239	9,676	17,841	4,518	5,853	476	701
2006	1,851	2,911	5,889	6,427	4,058	5,174	334	492

	IFQ East		IFQ West	
	continuity	"no discards" excluded	continuity	"no discards" excluded
2007	72,116	100,630	355	10,196
2008	70,187	97,939	302	9,924
2009	37,792	52,734	390	5,343
2010	20,689	28,869	217	2,925
2011	29,525	41,200	202	4,175

Table 3.13 Summary statistics of marginal posterior densities of annual estimates of shrimp bycatch in the eastern Gulf of Mexico.

year	mean	sd	MC error	2.50%	25.00%	median	75.00%	97.50%	sample
1972	19.25	23.85	0.311	3.775	8.197	12.85	21.69	75.13	20000
1973	2.027	2.75	0.03642	0.3012	0.7503	1.27	2.261	8.628	20000
1974	1.223	1.878	0.02554	0.1684	0.4234	0.7311	1.339	5.395	20000
1975	1.294	0.5437	0.00723	0.6701	0.9588	1.188	1.495	2.538	20000
1976	1.969	3.886	0.03859	0.2672	0.6363	1.108	2.066	8.885	20000
1977	1.831	1.469	0.01598	0.797	1.182	1.517	2.046	4.716	20000
1978	0.4079	0.6179	0.00861	0.07556	0.16	0.2574	0.4486	1.625	20000
1979	1.714	2.411	0.04985	0.2767	0.6791	1.133	1.967	6.658	20000
1980	0.669	0.9862	0.009861	0.1659	0.3039	0.45	0.7305	2.478	20000
1981	2.125	3.732	0.04465	0.3924	0.8016	1.283	2.233	8.891	20000
1982	2.221	2.584	0.03751	0.5385	1.057	1.59	2.52	7.752	20000
1983	1.974	3.901	0.04389	0.277	0.6971	1.203	2.147	8.241	20000
1984	1.444	2.307	0.03193	0.2084	0.5124	0.8648	1.554	6.309	20000
1985	1.169	1.815	0.02057	0.1655	0.4207	0.7153	1.282	4.908	20000
1986	0.3596	0.4643	0.006637	0.05219	0.1381	0.2345	0.4136	1.418	20000
1987	0.5431	0.938	0.009909	0.07644	0.2014	0.3388	0.6014	2.174	20000
1988	0.6322	0.8407	0.01131	0.09348	0.2402	0.4092	0.7226	2.548	20000
1989	1.202	2.177	0.02376	0.1386	0.3841	0.6785	1.317	5.575	20000
1990	3.734	6.136	0.06735	0.4921	1.258	2.225	4.129	16.25	20000
1991	3.146	5.046	0.0621	0.4105	1.091	1.897	3.466	13.29	20000
1992	1.628	1.269	0.01369	0.4944	0.8949	1.286	1.932	4.785	20000
1993	1.397	2.831	0.02449	0.1878	0.4313	0.7529	1.434	6.636	20000
1994	2.21	4.194	0.03874	0.3977	0.7246	1.155	2.142	10.75	20000
1995	2.868	4.762	0.04986	0.3269	0.8751	1.566	3.01	13.83	20000
1996	2.284	4.239	0.04132	0.2485	0.6648	1.2	2.342	11	20000
1997	3.259	6.09	0.05837	0.3679	0.9947	1.793	3.392	15.03	20000
1998	1.769	0.8451	0.01031	0.9693	1.329	1.611	2.004	3.418	20000
1999	2.912	4.771	0.05609	0.429	1.07	1.799	3.201	12.03	20000
2000	3.249	5.109	0.04627	1.027	1.598	2.183	3.309	11.78	20000
2001	2.417	0.6724	0.006984	1.665	2.049	2.308	2.635	3.759	20000
2002	2.2	0.2276	0.001853	1.819	2.041	2.178	2.333	2.706	20000
2003	1.317	0.3537	0.003055	1.008	1.165	1.265	1.39	1.902	20000
2004	1.498	0.5234	0.004625	1.114	1.283	1.402	1.559	2.519	20000
2005	0.975	1.351	0.01374	0.248	0.4157	0.6152	1.02	4.037	20000
2006	2.186	1.371	0.01726	0.805	1.362	1.855	2.602	5.458	20000
2007	1.427	1.016	0.01094	0.6364	0.9604	1.229	1.629	3.377	20000
2008	0.1911	0.1089	0.00149	0.109	0.1406	0.1653	0.2065	0.4346	20000
2009	0.3791	0.1443	0.00145	0.2067	0.2913	0.3514	0.43	0.7124	20000
2010	0.2245	0.1612	0.001311	0.1376	0.1684	0.1917	0.2294	0.5283	20000
2011	0.3637	0.1669	0.002056	0.2177	0.2811	0.3299	0.4008	0.6982	20000

Table 3.14 Summary statistics of marginal posterior densities of annual estimates of shrimp bycatch in the western Gulf of Mexico.

year	mean	sd	MC error	2.50%	25.00%	median	75.00%	97.50%	sample
1972	208.7	404	5.459	24.21	63.02	112.9	213.1	1007	20000
1973	18.62	14.61	0.184	5.838	10.47	14.82	21.9	54.44	20000
1974	20.4	10.23	0.1438	9.72	14.36	18.12	23.47	44.65	20000
1975	14.09	22.25	0.2987	1.783	4.612	8.205	15.18	63.03	20000
1976	31.12	6.725	0.07137	21.18	26.52	30.05	34.54	46.98	20000
1977	12.33	5.305	0.05381	7.729	9.912	11.44	13.55	21.6	20000
1978	7.612	4.151	0.05795	3.688	5.376	6.706	8.698	16.68	20000
1979	38.59	58.3	1.292	4.846	13.23	23.55	43.37	162.6	20000
1980	27.69	9.538	0.1038	16.28	21.55	25.66	31.25	51.13	20000
1981	84.86	126.9	1.39	26.76	40.16	54.87	84.94	327	20000
1982	46.25	106.1	1.014	6.581	14.69	24.64	46.61	211.5	20000
1983	31.5	51.49	0.6613	4.46	10.8	18.46	33.72	138.2	20000
1984	23.13	42.21	0.5253	3.022	7.666	13.4	24.97	101.3	20000
1985	17.87	28.15	0.3362	2.551	6.333	10.86	19.4	75.14	20000
1986	10.11	21.36	0.2358	1.34	3.432	5.984	10.9	43.29	20000
1987	21.24	35.53	0.4085	2.857	7.282	12.44	22.71	92.75	20000
1988	17.12	28.18	0.3177	2.218	5.813	10.11	18.53	73.62	20000
1989	18.24	30.51	0.3897	2.39	6.269	10.79	19.61	79.98	20000
1990	70.75	127.9	1.41	9.02	23.38	40.82	75.64	313.6	20000
1991	71.59	156.1	1.601	9.324	23.92	41.61	77.99	308.2	20000
1992	33.55	12.48	0.1078	21.93	27.71	31.72	36.82	55.59	20000
1993	35.51	4.969	0.04401	27.51	32.03	34.92	38.3	46.98	20000
1994	35.99	8.982	0.08234	26.69	31.57	34.75	38.73	52.27	20000
1995	49.98	11.16	0.1103	33.61	42.37	48.22	55.53	76.27	20000
1996	54.1	68.45	0.6661	17.88	27.89	37.76	56.23	194.8	20000
1997	31.48	17.72	0.2344	13.85	20.99	27.08	36.36	75.43	20000
1998	61.38	24.65	0.2293	32.4	45.42	56.13	71.02	122.4	20000
1999	26.87	13.12	0.1796	15.95	20.43	23.98	29.16	55.74	20000
2000	13.7	6.137	0.07398	8.906	10.85	12.32	14.59	27.01	20000
2001	26.98	13.42	0.1489	17.94	21.5	24.16	28.21	53.54	20000
2002	22.48	2.771	0.02428	17.86	20.51	22.21	24.12	28.73	20000
2003	31.51	6.308	0.04975	21.95	27.08	30.61	34.88	46.4	20000
2004	30.63	12.72	0.1235	20.56	24.73	27.99	32.73	56.22	20000
2005	20.52	38.35	0.3439	5.255	8.376	12.22	20.65	84.94	20000
2006	13.22	6.846	0.09009	6.484	9.327	11.63	15.03	29.28	20000
2007	7.043	1.34	0.01857	5.413	6.292	6.837	7.496	9.911	20000
2008	2.727	0.2139	0.001907	2.366	2.586	2.714	2.852	3.154	20000
2009	3.795	0.7306	0.005286	2.508	3.288	3.736	4.246	5.372	20000
2010	2.978	1.136	0.009457	2.154	2.521	2.785	3.149	5.009	20000
2011	6.314	0.6983	0.005826	5.057	5.831	6.273	6.751	7.794	20000

Table 3.15 Gulf of Mexico shrimp effort (days fished) for depths greater than 10 fm.

Year	East	West	Gulfwide
1972	24,338	72,350	96,688
1973	26,828	57,689	84,518
1974	25,950	56,919	82,869
1975	25,878	53,859	79,737
1976	24,005	62,661	86,667
1977	28,444	53,672	82,116
1978	21,984	62,809	84,793
1979	22,626	65,484	88,110
1980	13,852	39,688	53,539
1981	21,746	61,312	83,058
1982	21,669	62,621	84,290
1983	23,736	50,568	74,303
1984	27,849	64,404	92,253
1985	26,876	62,592	89,468
1986	27,859	86,109	113,968
1987	22,574	88,206	110,780
1988	21,283	85,452	106,734
1989	25,798	76,977	102,774
1990	22,599	74,000	96,599
1991	23,260	89,911	113,171
1992	28,202	92,730	120,932
1993	23,293	91,600	114,893
1994	24,093	73,573	97,667
1995	28,500	63,856	92,356
1996	32,200	67,133	99,333
1997	33,958	81,666	115,624
1998	42,667	74,103	116,771
1999	26,291	69,751	96,042
2000	22,593	76,096	98,689
2001	25,378	81,591	106,969
2002	30,191	96,078	126,269
2003	25,164	77,521	102,684
2004	24,957	71,209	96,166
2005	21,018	51,477	72,495
2006	13,626	38,425	52,051
2007	10,233	31,001	41,234
2008	6,690	22,238	28,928
2009	10,304	26,469	36,773
2010	6,463	25,891	32,354
2011	8,049	31,822	39,870

Table 3.16 Red snapper allocation categories by region and gear.

Region	Vertical line	Longline
East	No allocation 1-2,582 pounds 2,583-7,048 pounds 7,049-16,762 pounds >16,762 pounds	No allocation 1-688 pounds 689-3,436 pounds >3,436 pounds
West	No allocation 1-3,909 pounds 3,910-19,807 pounds 19,808-61,124 pounds >61,124 pounds	No allocation 1-17,908 pounds 17,909-28,810 pounds >28,810 pounds

Table 3.17 Number of trips with observed red snapper by gear, region, and red snapper season during 2006. There was no observer coverage of bottom longline trips in the western Gulf of Mexico during 2006.

Gear	Red snapper season	East	West
Bottom longline	Closed	6	N/A
	Open	6	
Vertical line	Closed	8	Confidential data
	Open	12	10

Table 3.18 Number of trips with observed red snapper by gear, region, and red snapper allocation in pounds.

A. Bottom longline.

Red snapper allocation	East	West
0	51	N/A
1-688	49	
689-3,436	39	
>3,436	44	
0	N/A	Confidential data
1-17,908		5
17,909-28,810		Confidential data
>28,810		4

B. Vertical line.

Red snapper allocation	East	West
0	87	N/A
1-2,582	104	
2,582-7,048	43	
7,048-16,762	22	
>16,762	40	
0	N/A	14
1-3,909		19
3,910-19,807		15
19,808-61,124		14
>61,124		10

Table 3.19 Number of trips with observed red snapper by gear, year, and region.

A. Bottom longline.

Year	East	West
2006	10	
2007	8	
2008	Confidential data	Confidential data
2009	22	4
2010	42	4
2011	71	4

B. Vertical line.

Year	East	West
2006	21	11
2007	73	17
2008	31	15
2009	33	5
2010	40	6
2011	75	12

3.11 Figures

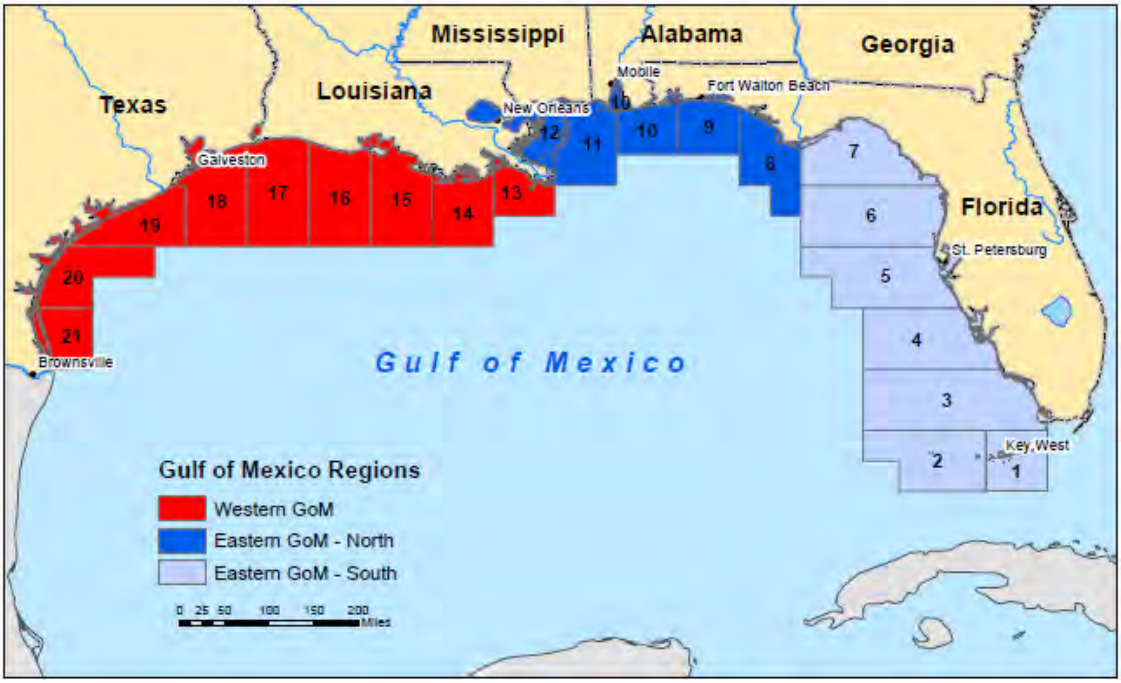


Figure 3.1 Regions defined for commercial landings. North and South Eastern subregions are used only for 'handline+' landings.

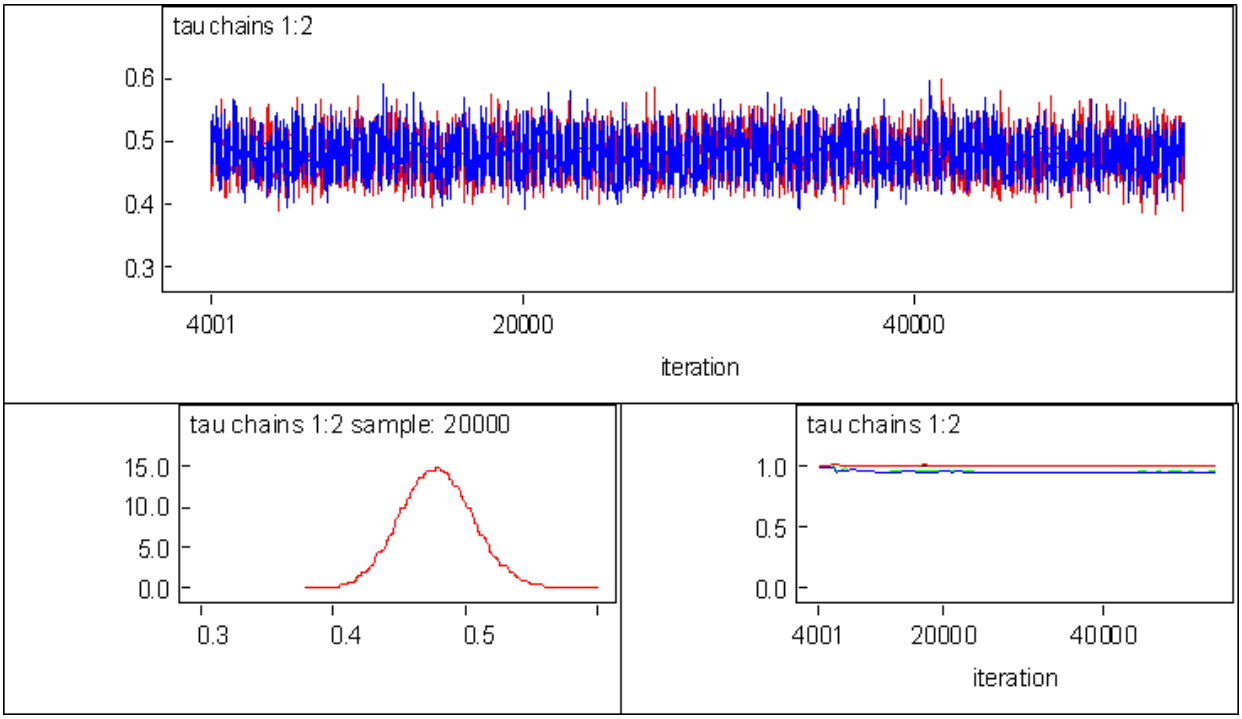


Figure 3.2 MCMC diagnostics for the local terms precision (1/variance) parameter. Diagnostics include trace plot (top panel), marginal posterior density plot (bottom left panel), and Gelman-Rubin convergence statistic plot (bottom right) as produced by WinBUGS.

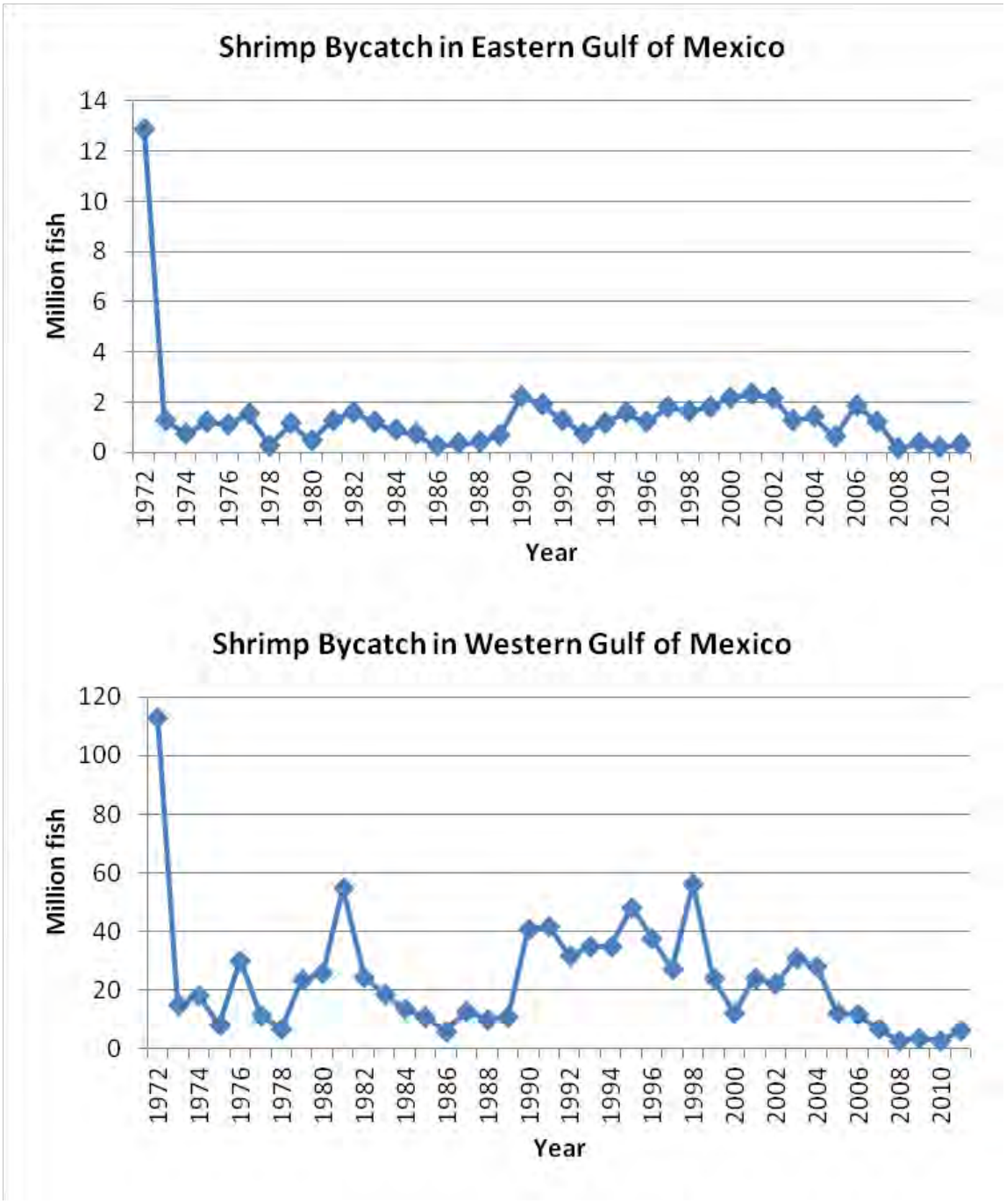


Figure 3.3 Annual estimates of shrimp bycatch (million fish) in the eastern (top panel) and western (bottom panel) Gulf of Mexico.

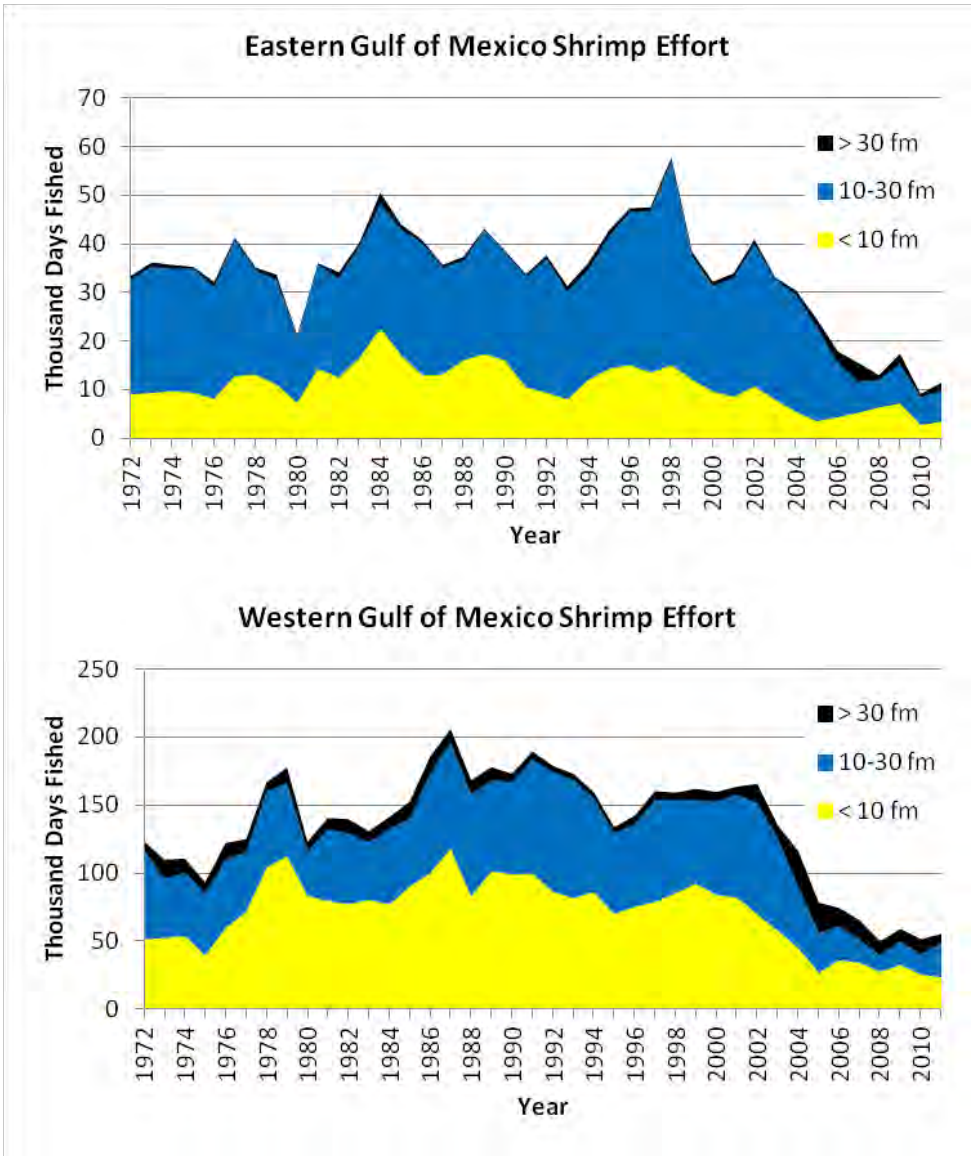


Figure 3.4 Gulf of Mexico shrimp effort (thousand days fished) by region and depth zone. Regions include eastern (top panel) and western Gulf (bottom panel). Depth zones include inside 10 fm, 10 fm to 30 fm, and outside 30 fm.

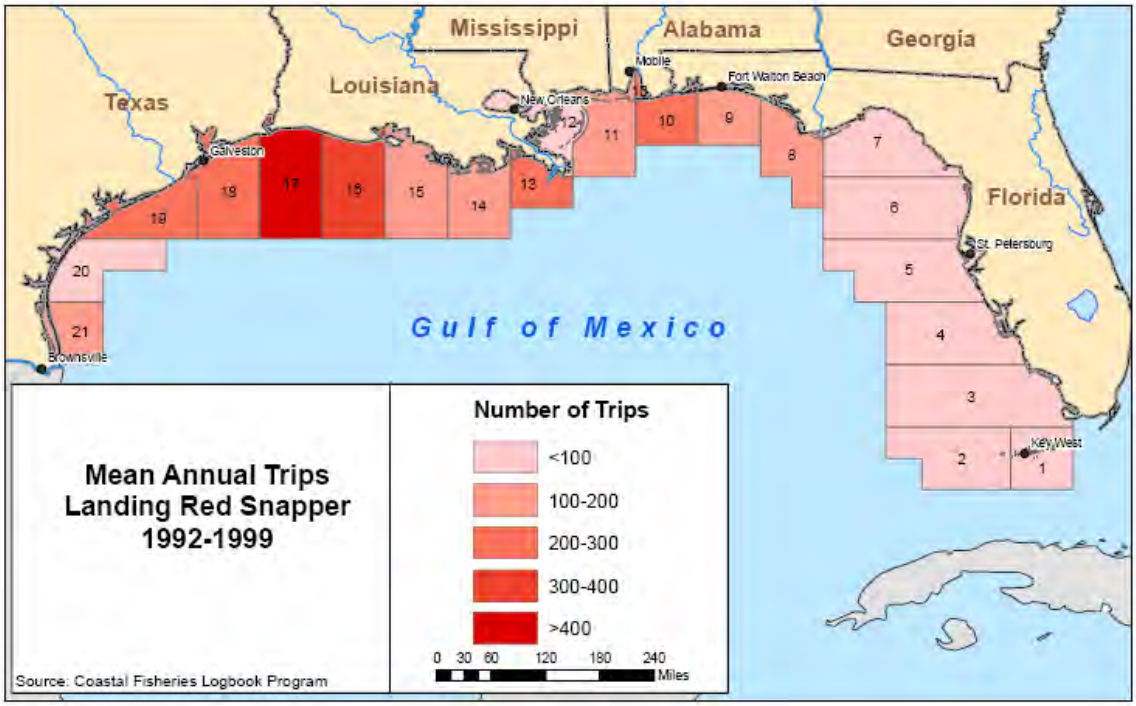


Figure 3.5 Map of red snapper effort as reported to the Coastal Fisheries Logbook Program 1992-1999

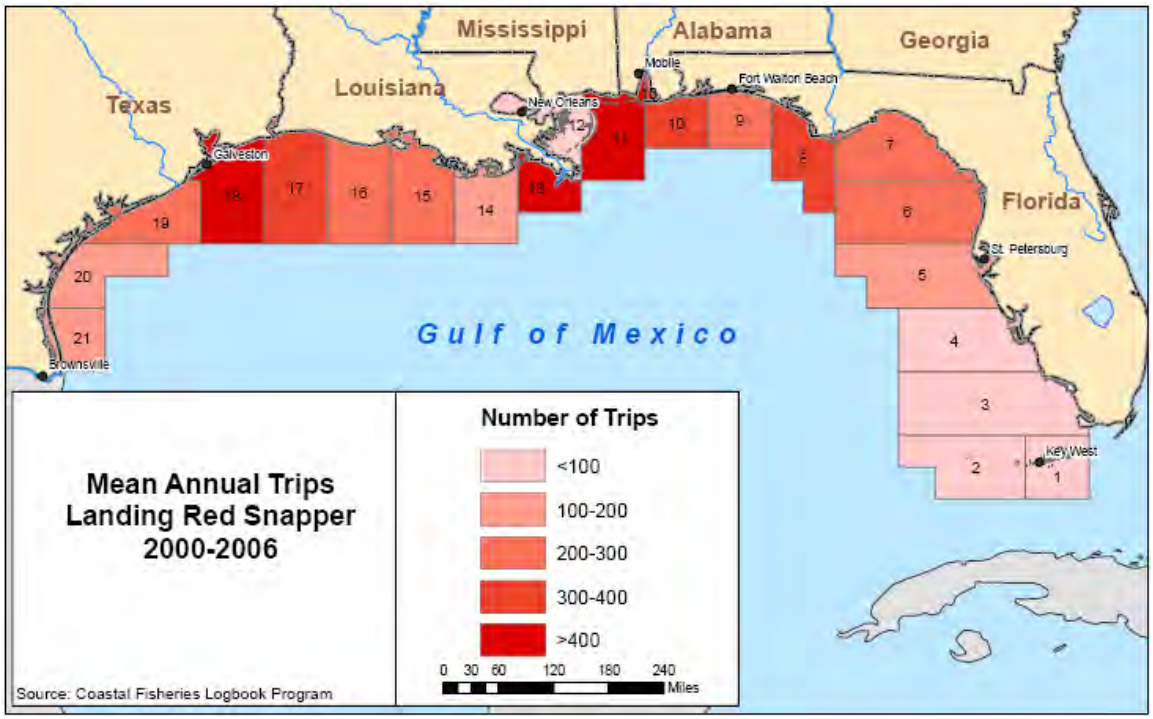


Figure 3.6 Map of red snapper effort as reported to the Coastal Fisheries Logbook Program 2000-2006

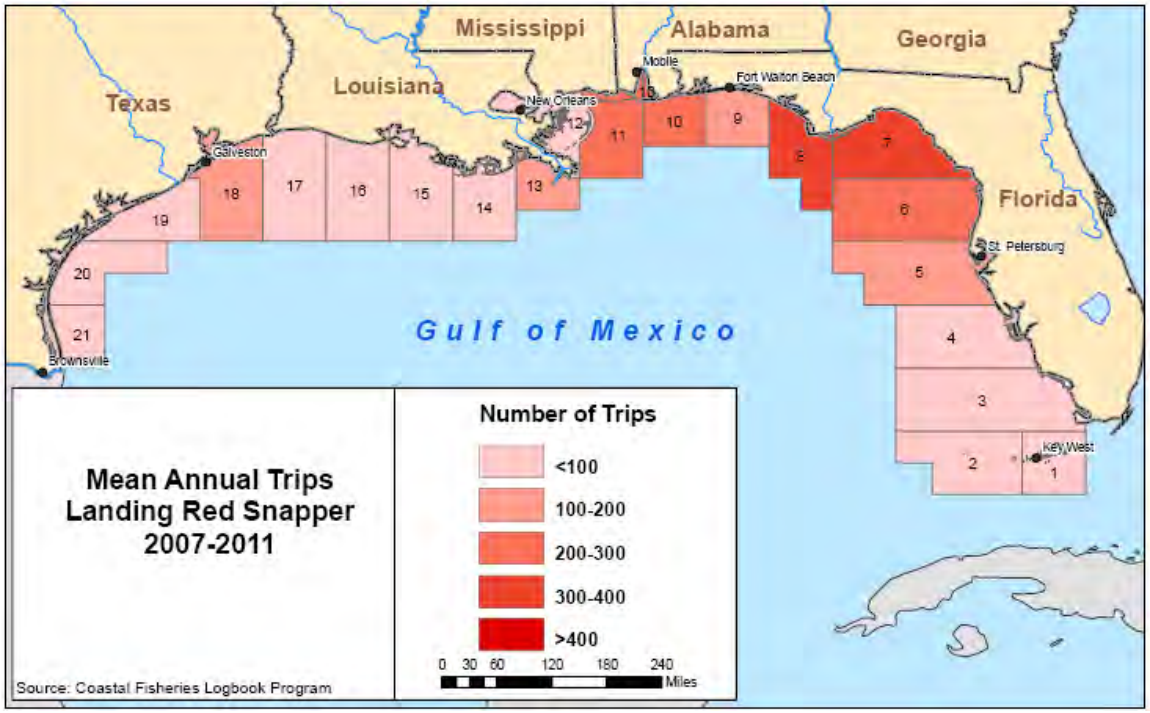


Figure 3.7 Map of red snapper effort as reported to the Coastal Fisheries Logbook Program 2007-2011

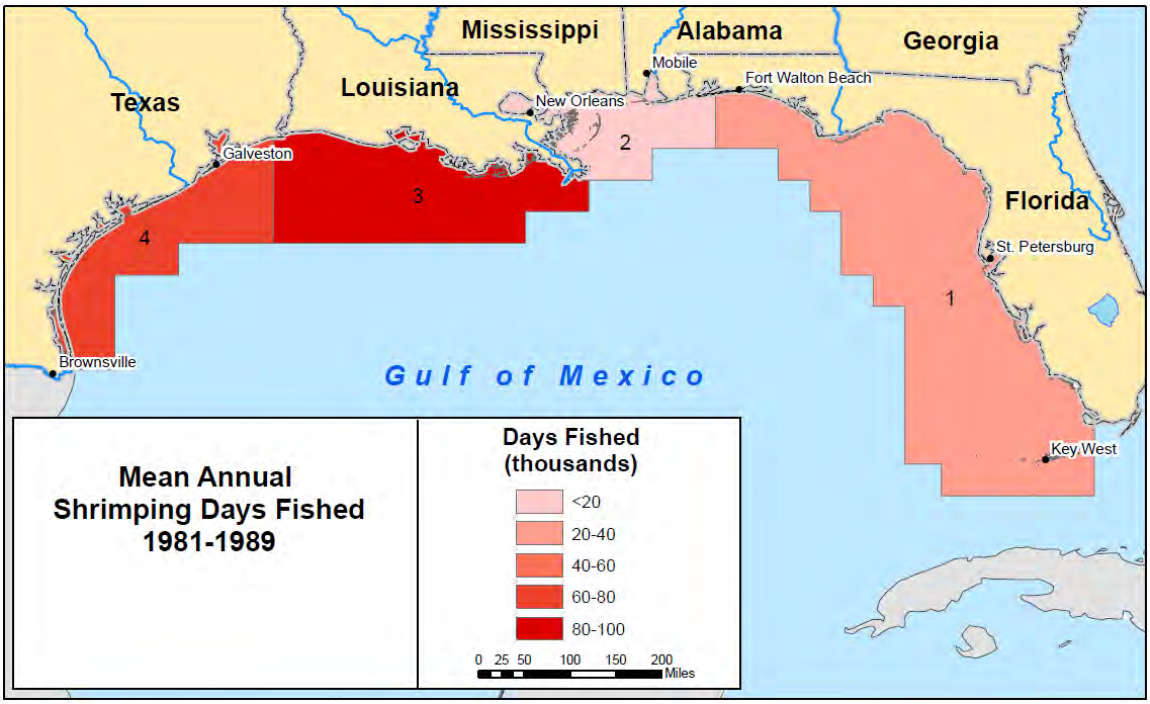


Figure 3.8 Map of estimated shrimping effort 1981-1989.

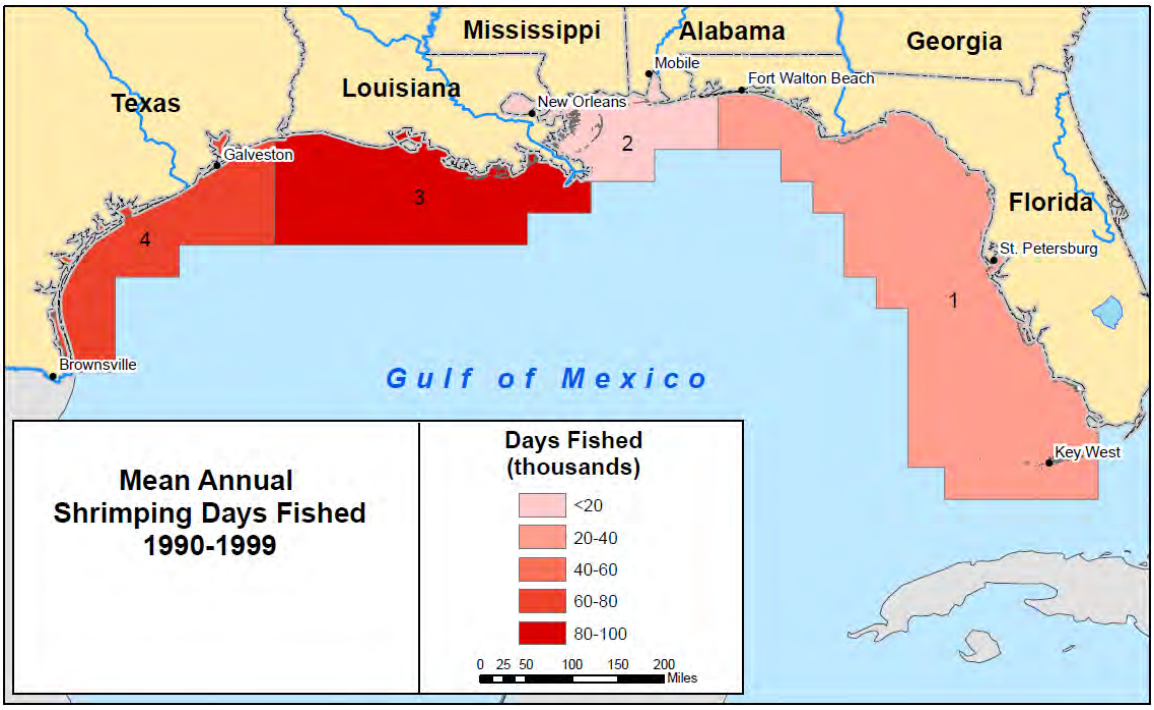


Figure 3.9 Map of estimated shrimping effort 1990-1999.

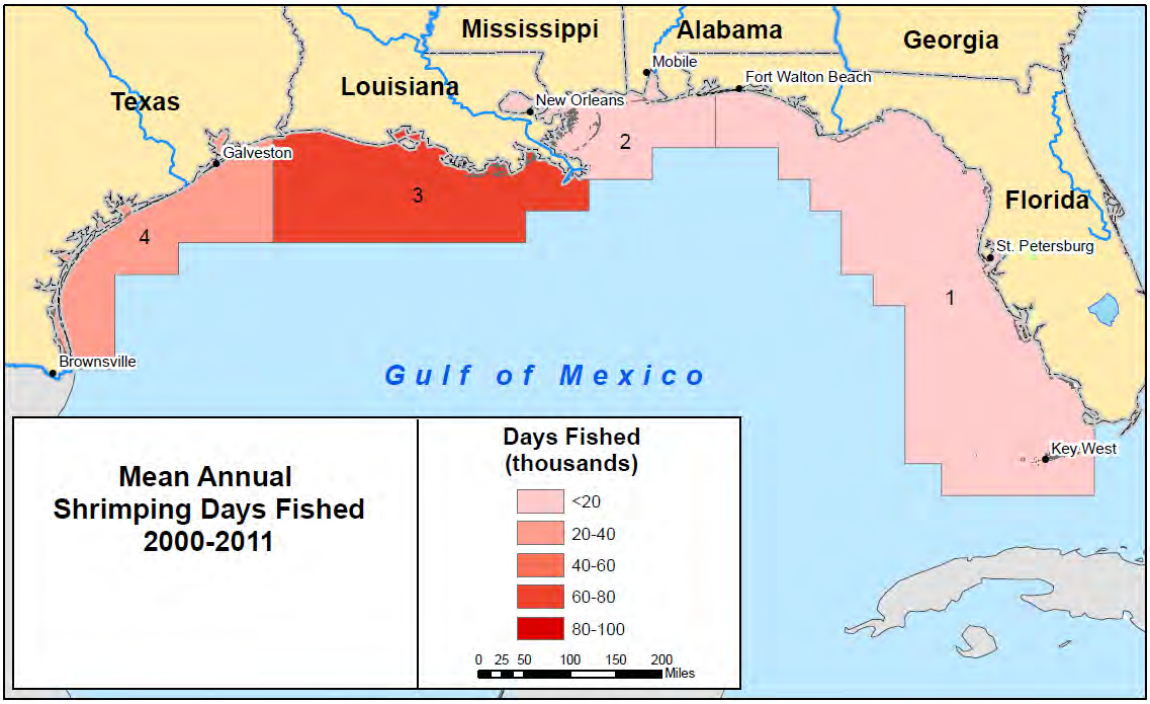


Figure 3.10 Map of estimated shrimping effort 2000-2011.

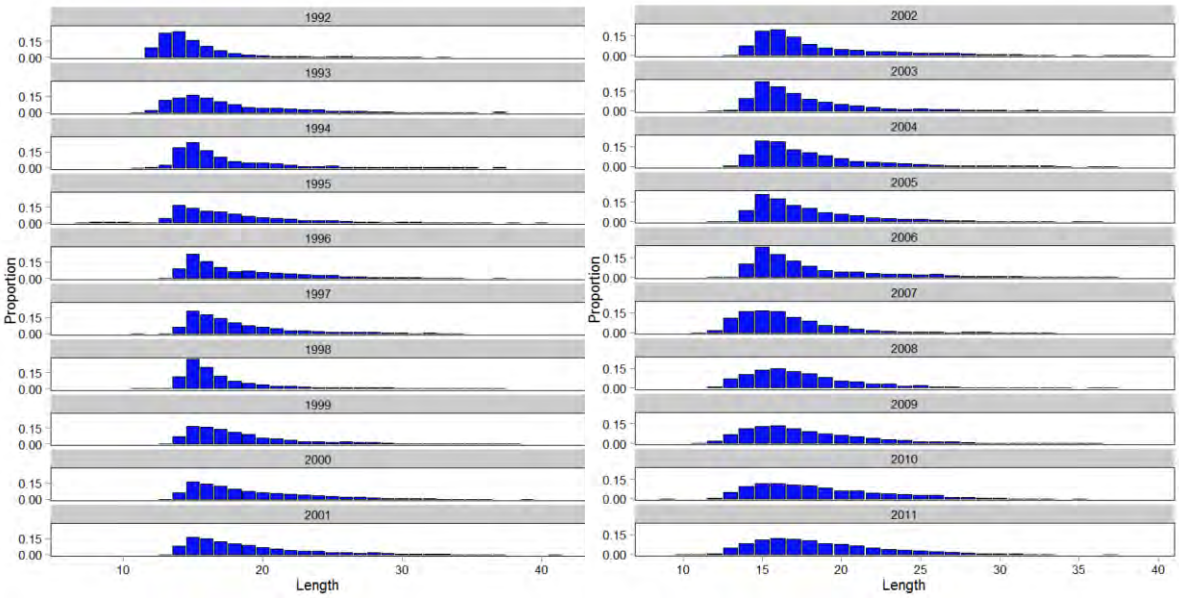


Figure 3.11 Length frequency distributions of length samples collected from commercial handline fisheries located in the eastern Gulf of Mexico (HE) from 1992 to 2011.

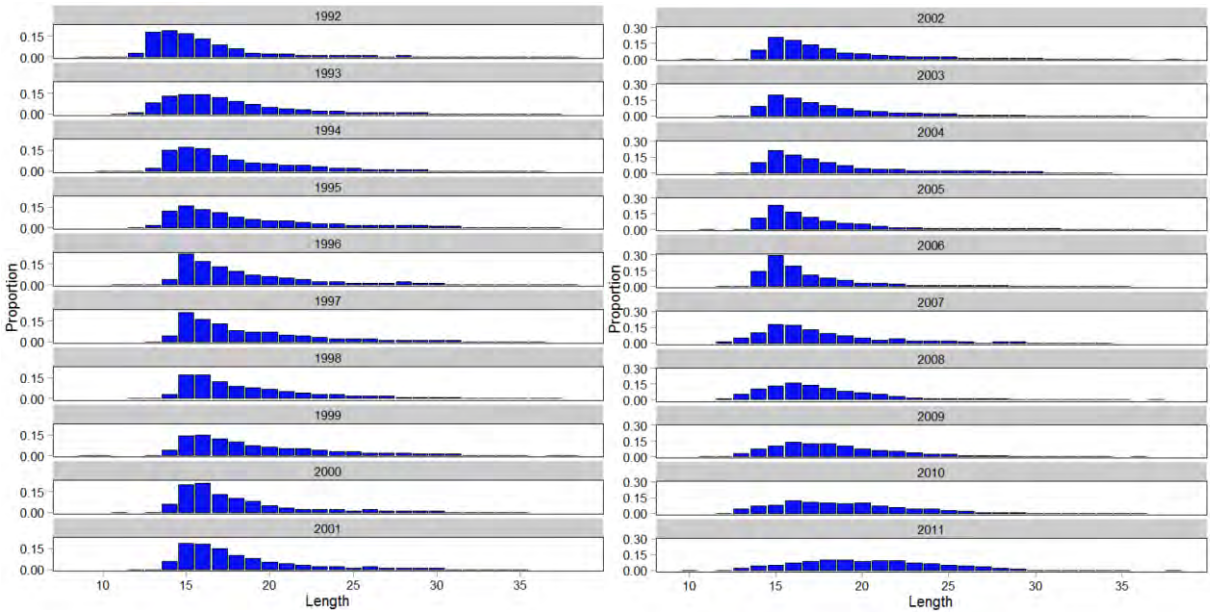


Figure 3.12 Length frequency distributions of length samples collected from commercial handline fisheries located in the western Gulf of Mexico (HW) from 1992 to 2011.

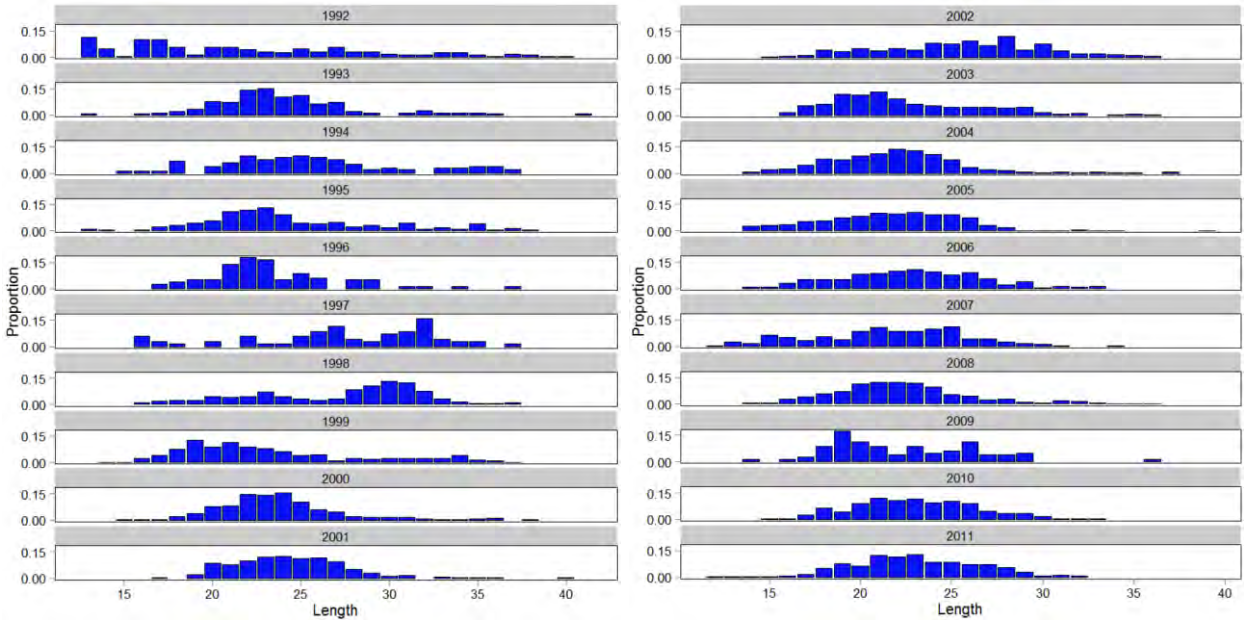


Figure 3.13 Length frequency distributions of length samples collected from commercial longline fisheries located in the eastern Gulf of Mexico (LE) from 1992 to 2011.

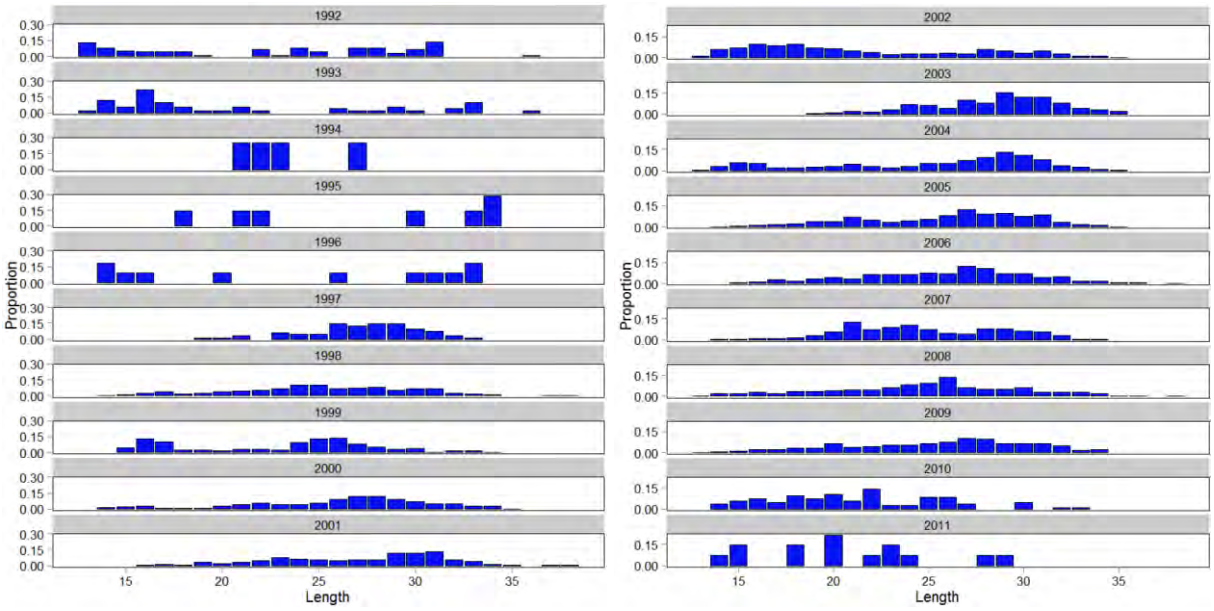


Figure 3.14 Length frequency distributions of length samples collected from commercial longline fisheries located in the western Gulf of Mexico (LW) from 1992 to 2011.

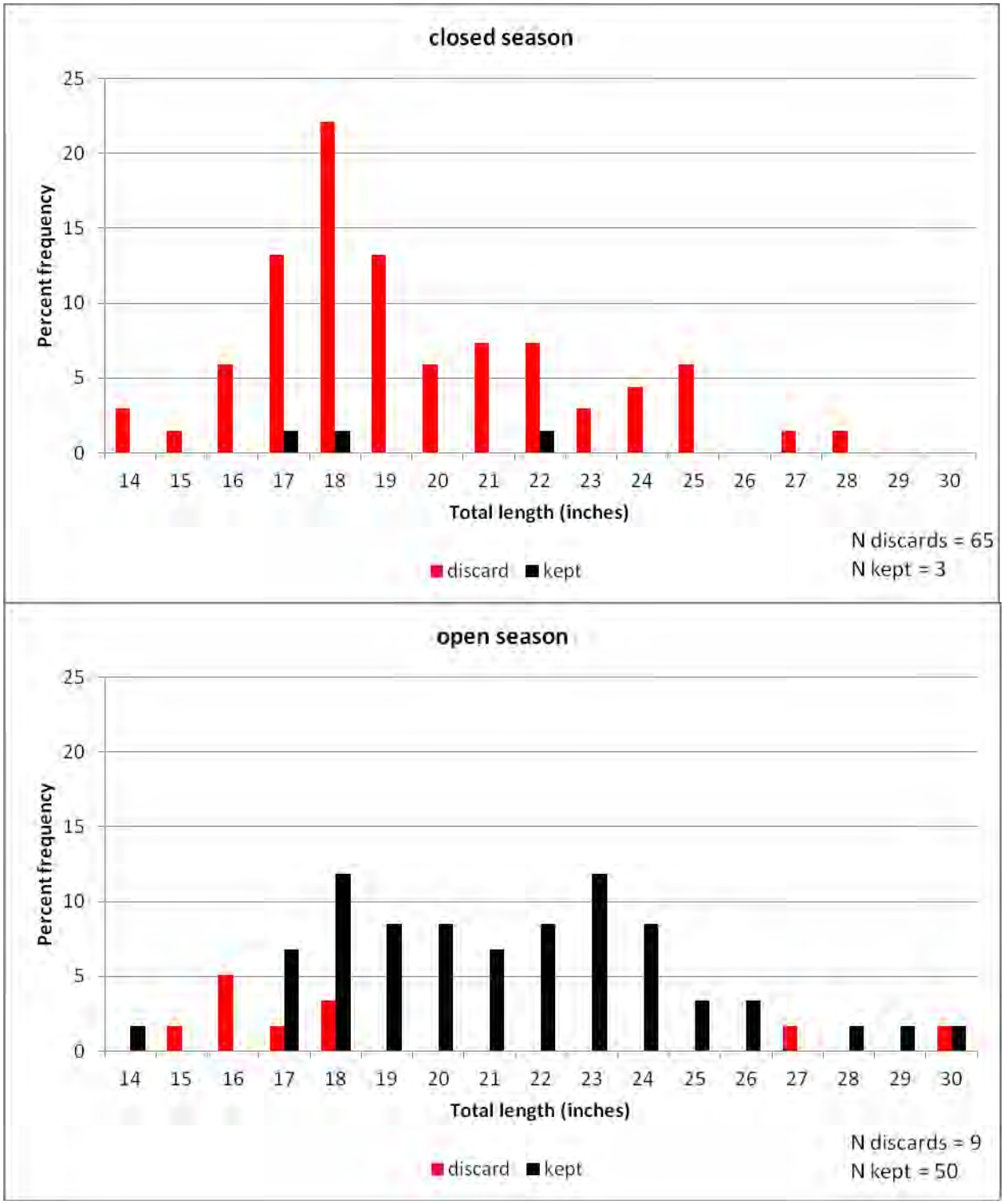


Figure 3.15 Commercial bottom longline eastern Gulf of Mexico 2006 observed red snapper size composition. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

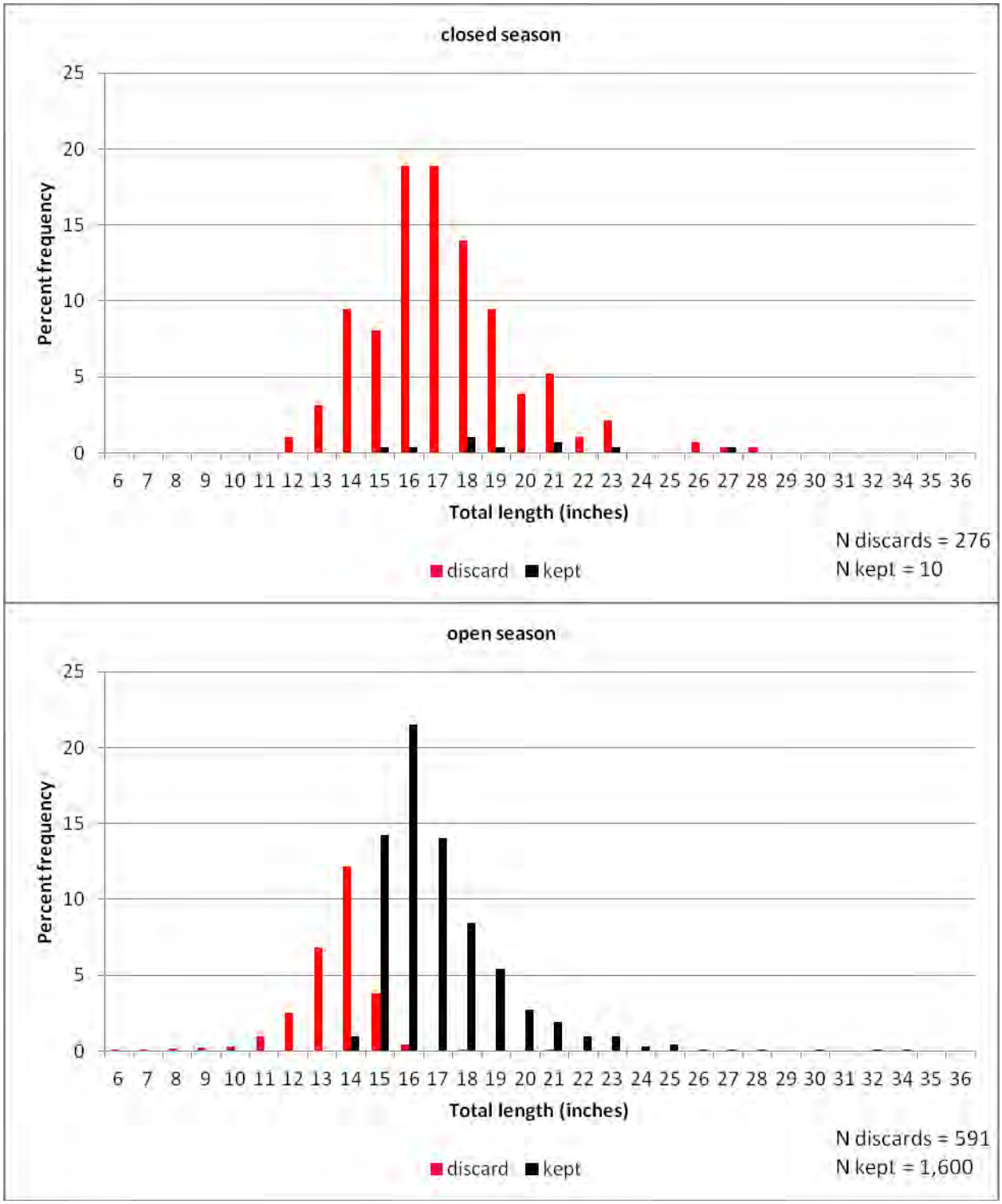


Figure 3.16 Commercial vertical line eastern Gulf of Mexico 2006 observed red snapper size composition. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

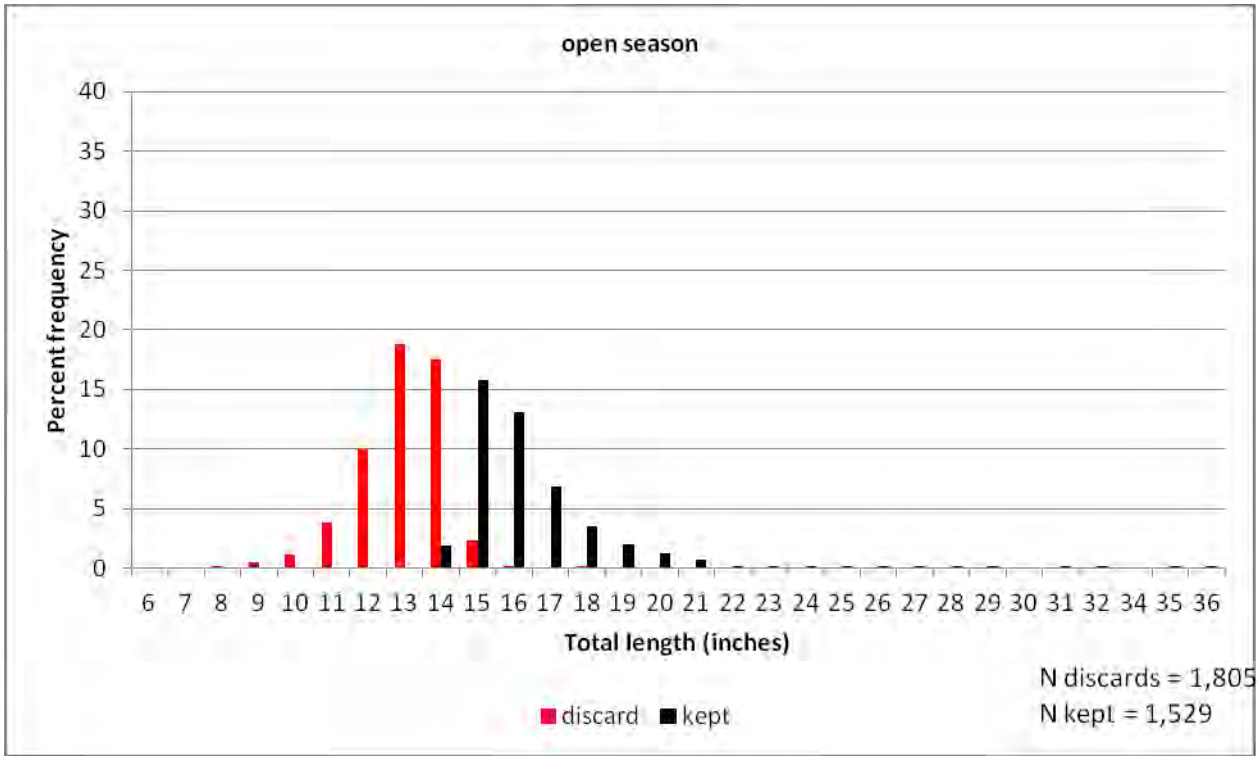


Figure 3.17 Commercial vertical line western Gulf of Mexico 2006 observed red snapper size composition. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches. Data collected during the closed season cannot be shown due to confidentiality restrictions.

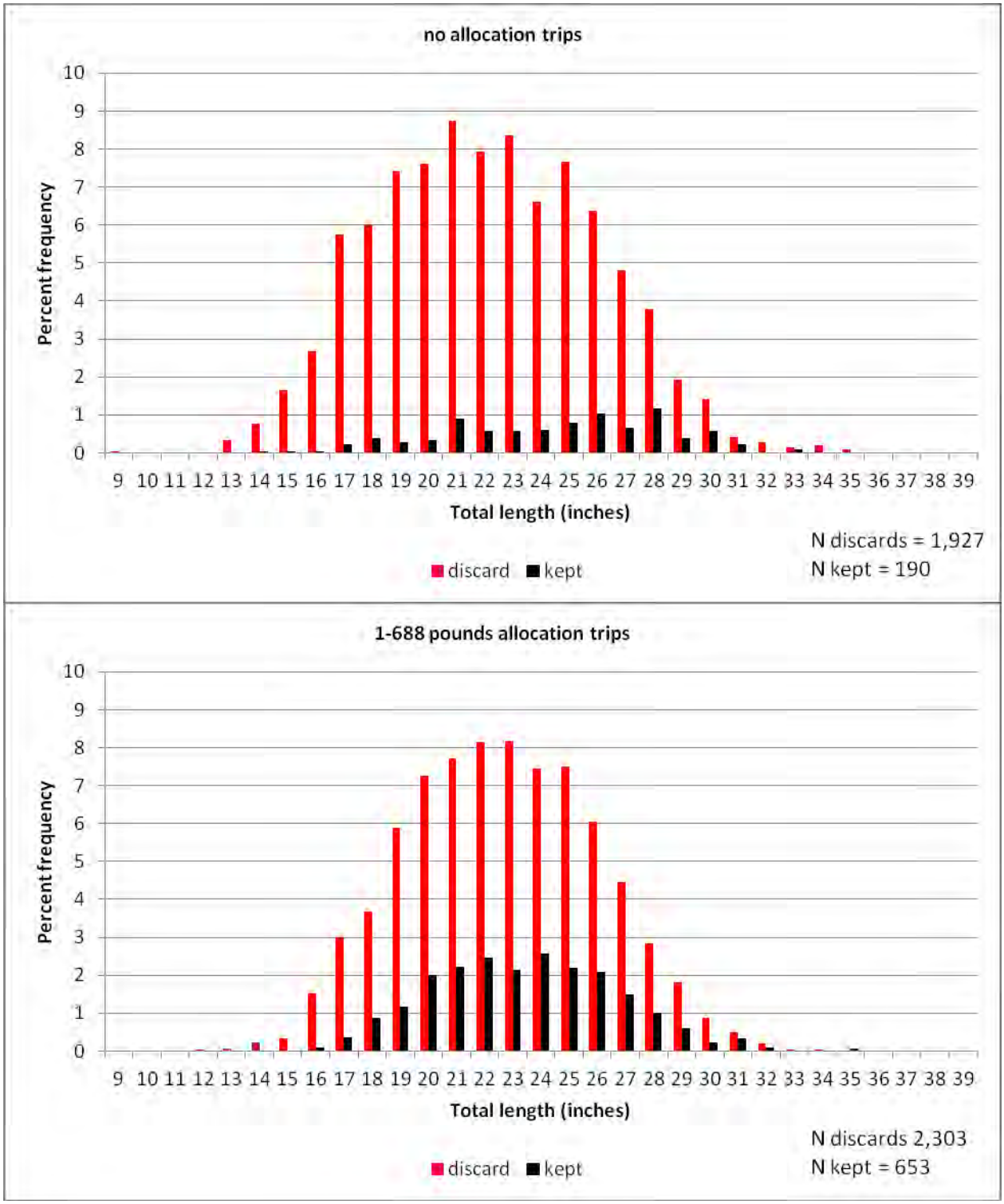


Figure 3.18 Commercial bottom longline eastern Gulf of Mexico observed red snapper size composition by red snapper allocation. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

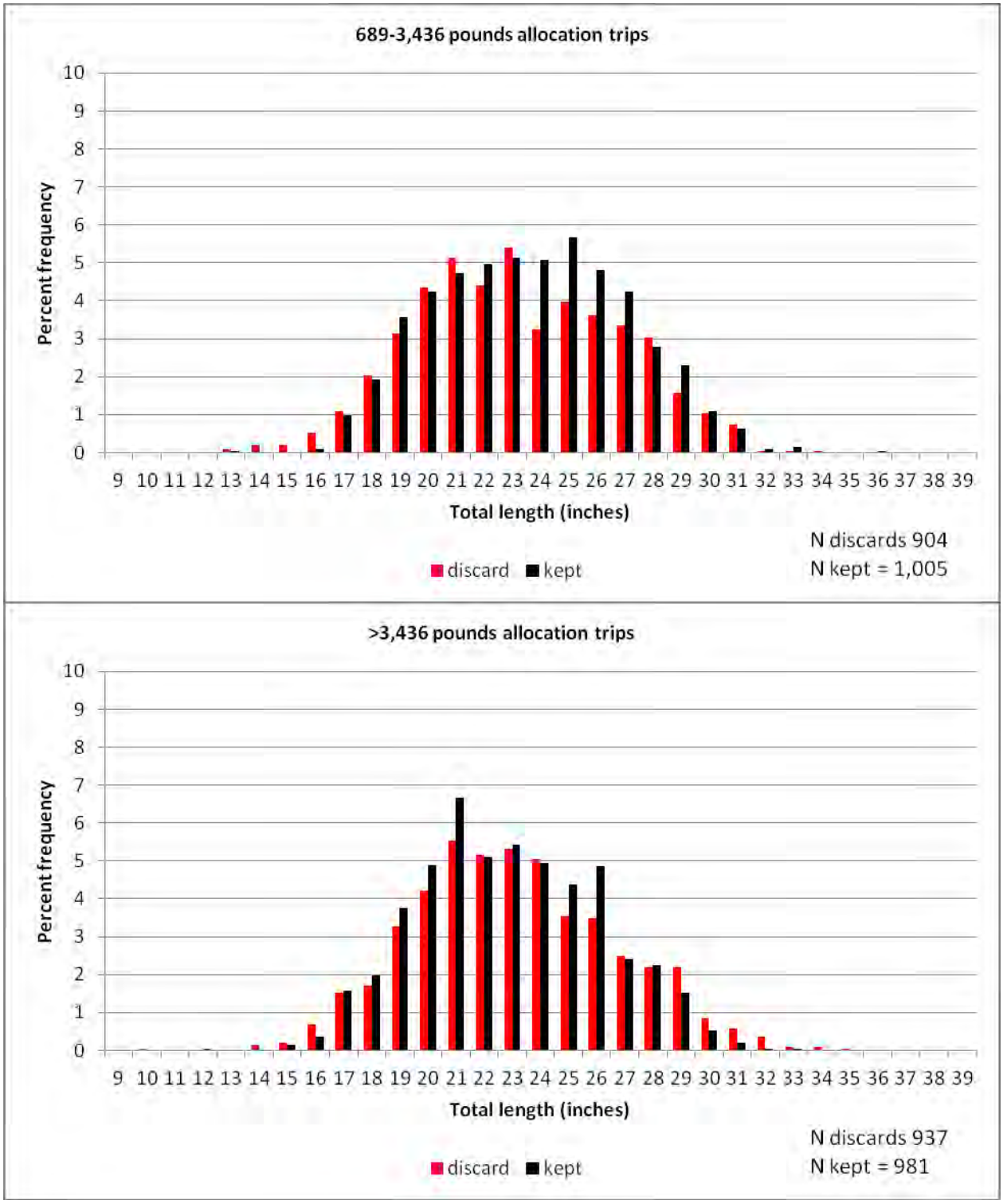


Figure 3.18 Commercial bottom longline eastern Gulf of Mexico observed red snapper size composition by red snapper allocation, continued.

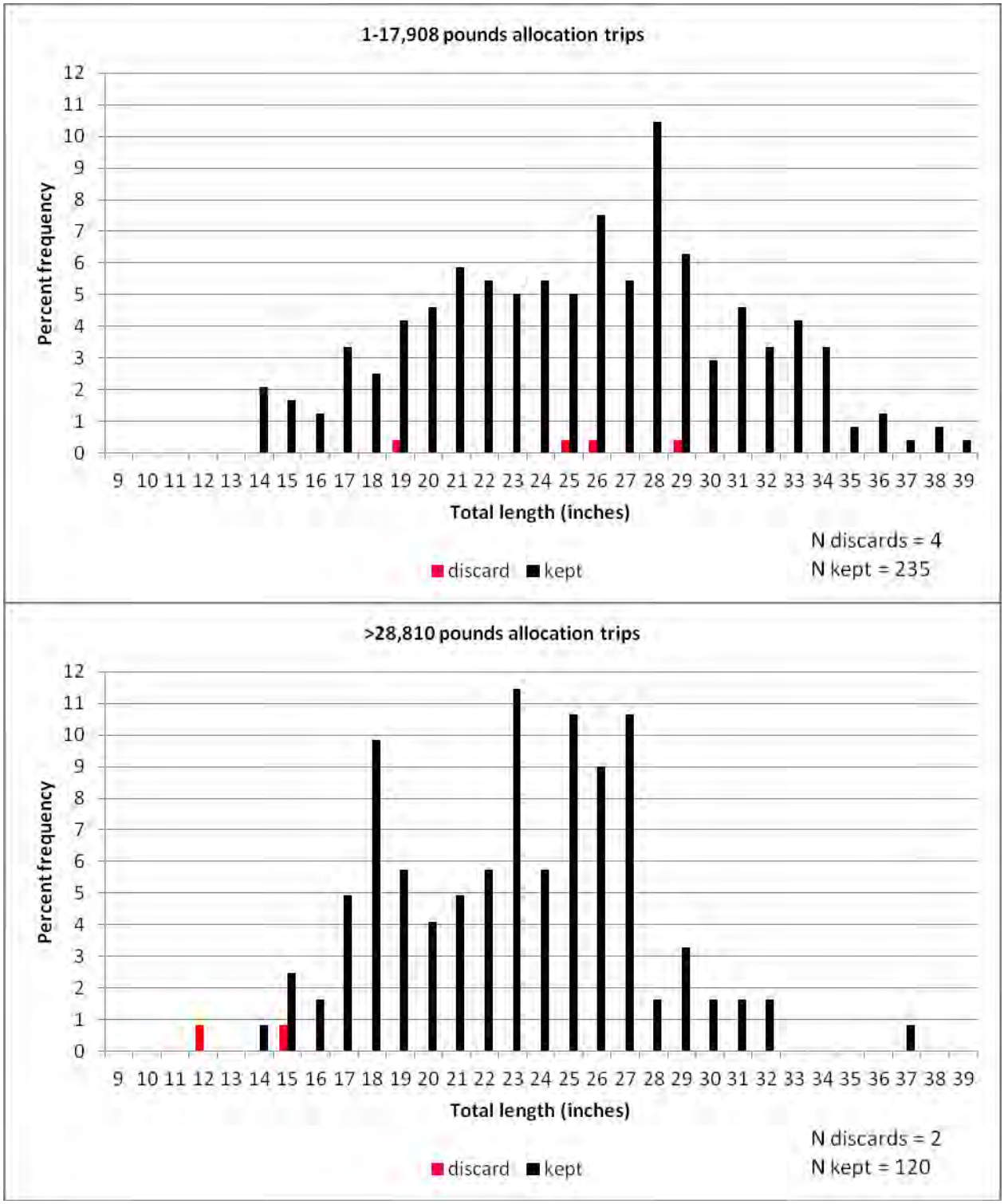


Figure 3.19 Commercial bottom longline western Gulf of Mexico observed red snapper size composition by red snapper allocation. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches. Data from trips with no allocation and from trips with 17,909-28,810 pounds of allocation cannot be shown due to confidentiality restrictions.

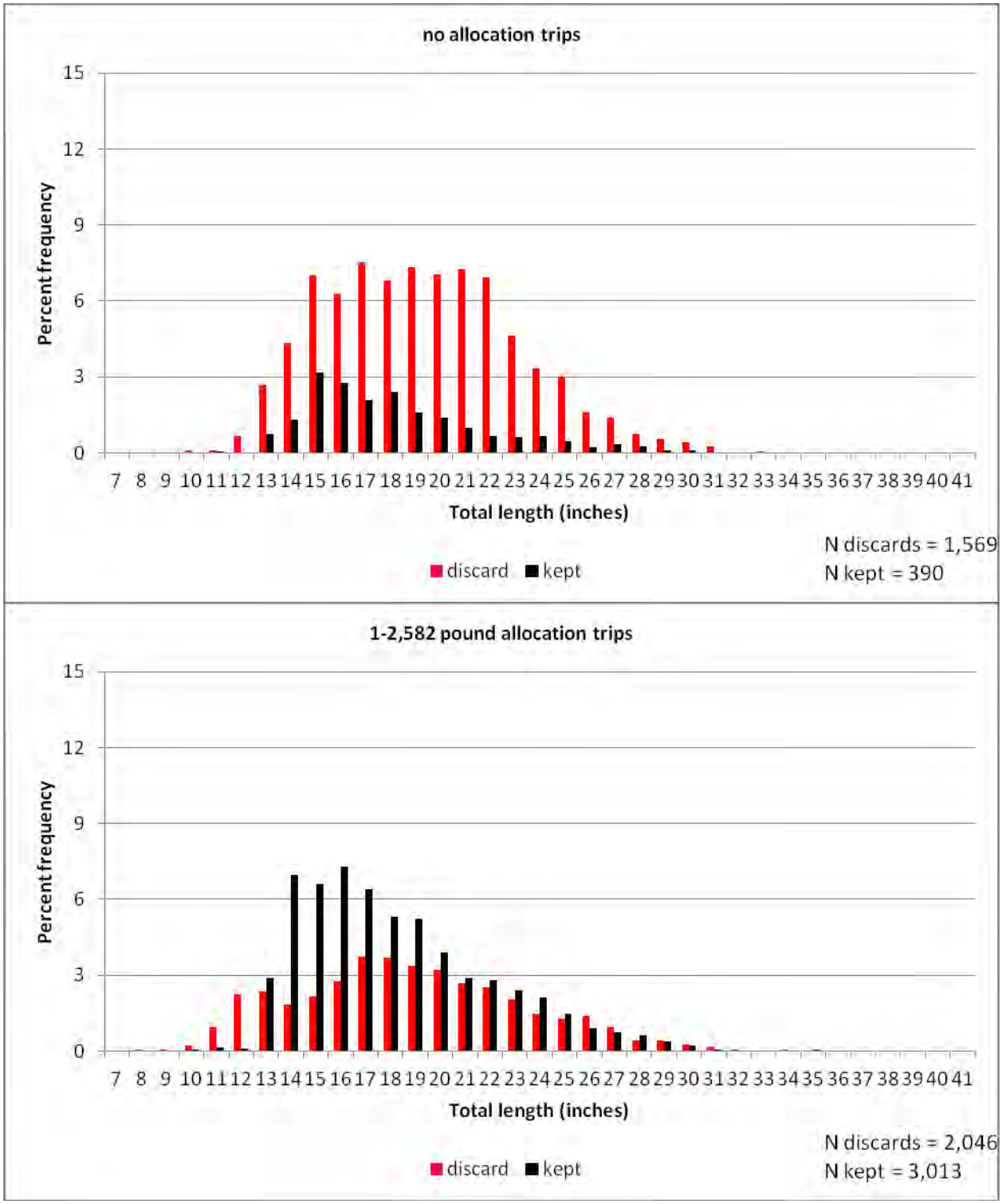


Figure 3.20 Commercial vertical line eastern Gulf of Mexico observed red snapper size composition by red snapper allocation. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

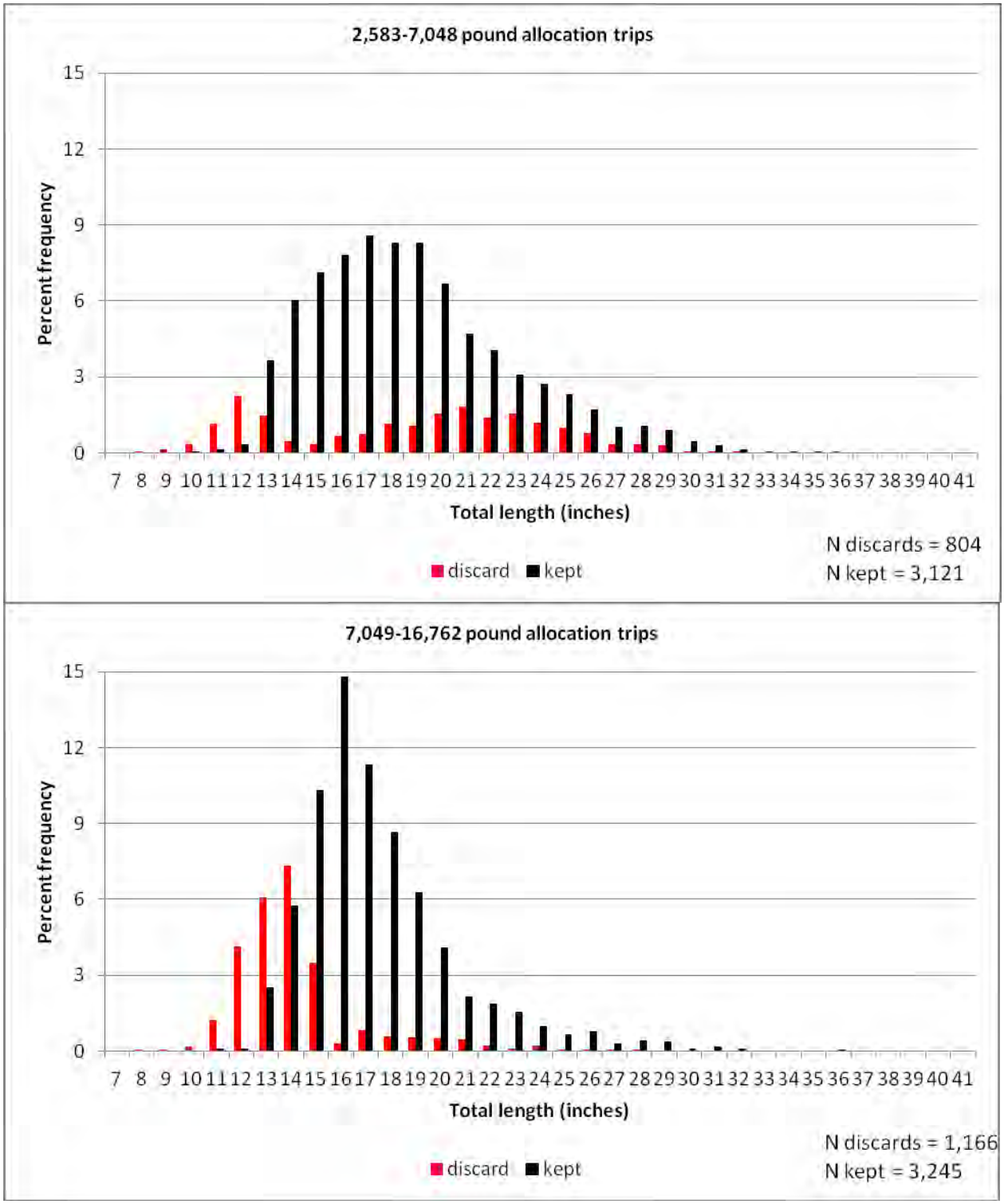


Figure 3.20 Commercial vertical line eastern Gulf of Mexico observed red snapper size composition by red snapper allocation, continued.

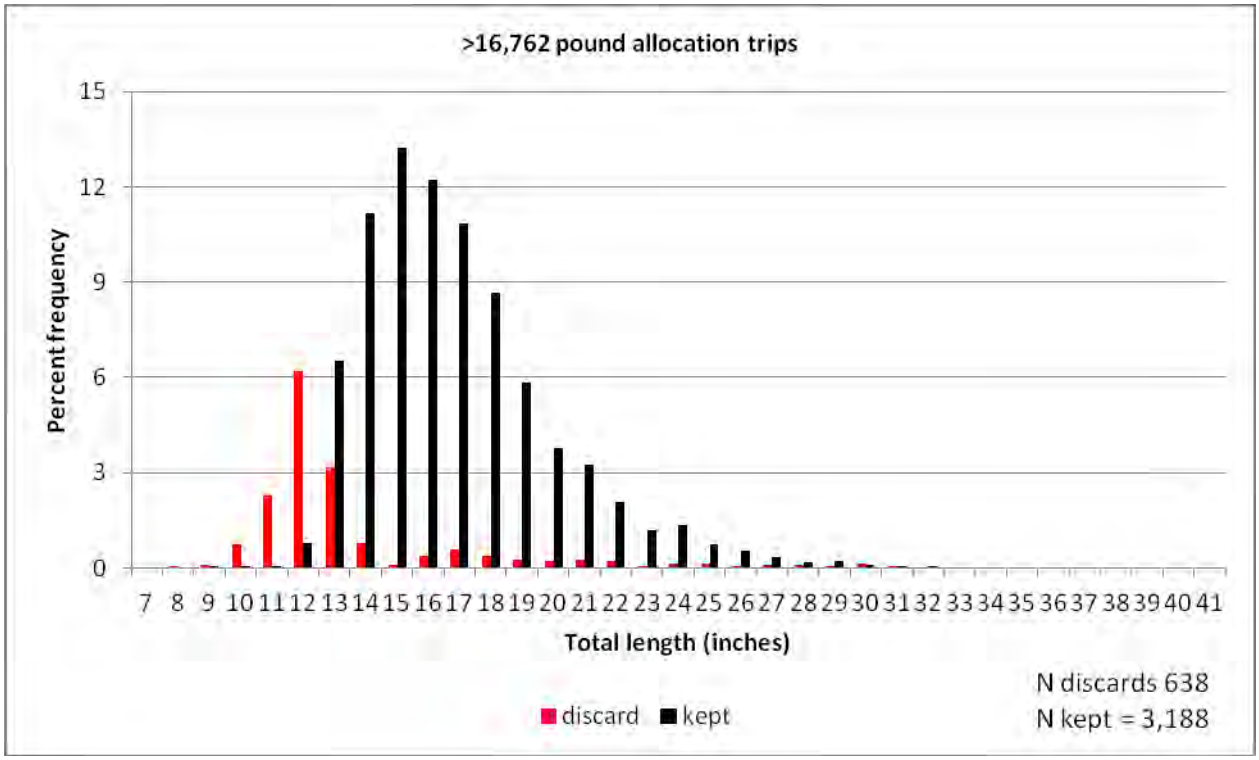


Figure 3.20 Commercial vertical line eastern Gulf of Mexico observed red snapper size composition by red snapper allocation, continued.

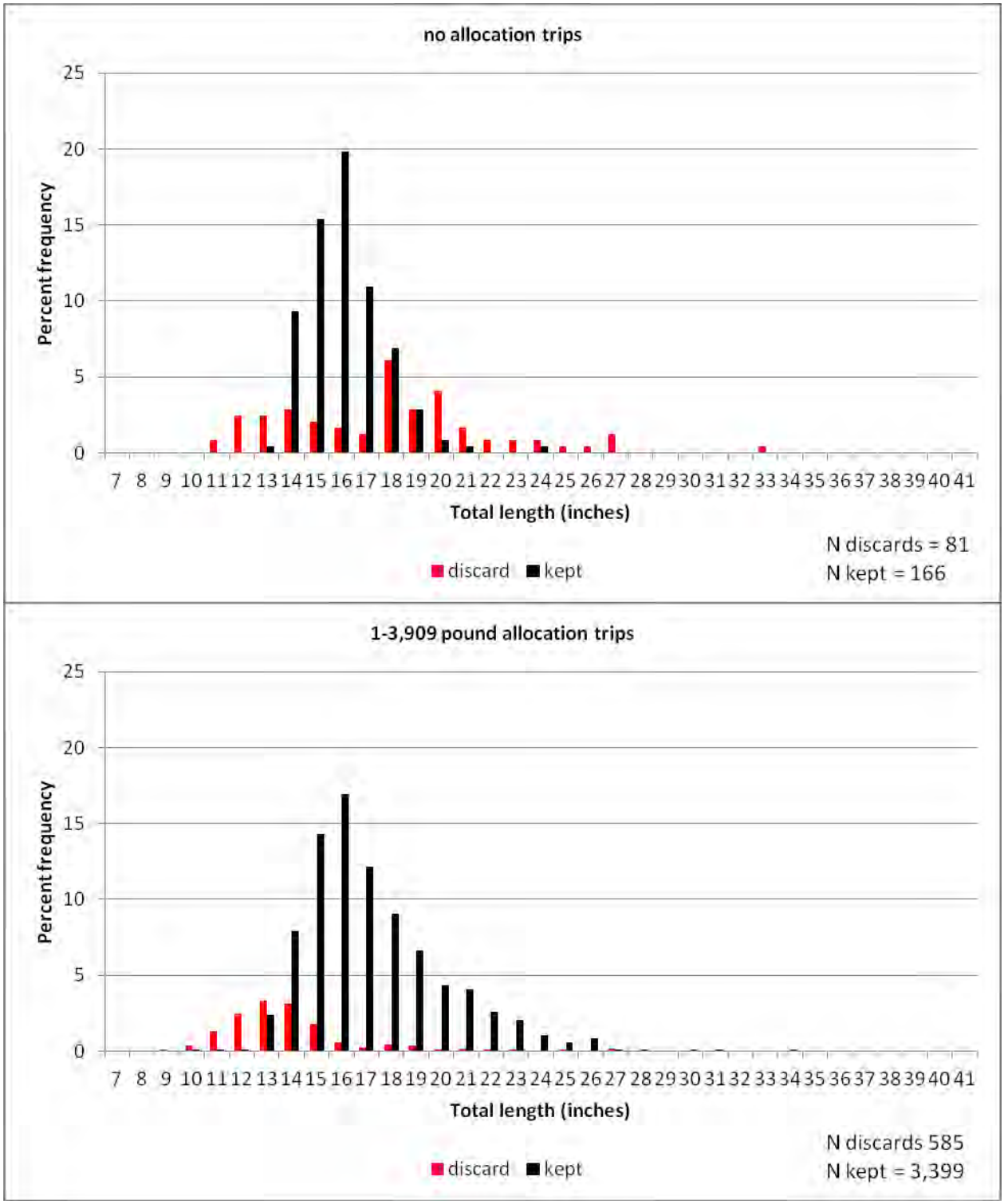


Figure 3.21 Commercial vertical line western Gulf of Mexico observed red snapper size composition by red snapper allocation. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

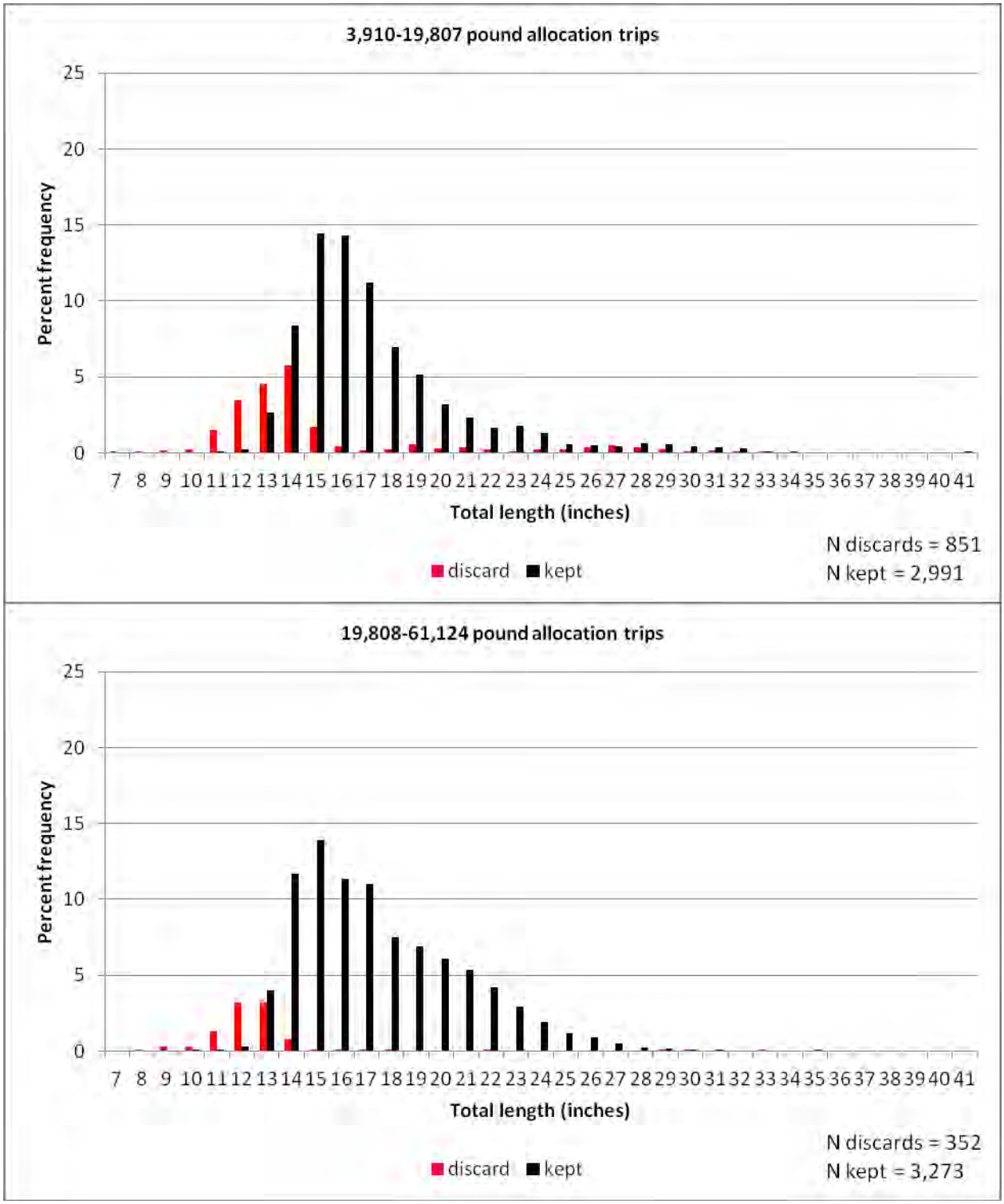


Figure 3.21 Commercial vertical line western Gulf of Mexico observed red snapper size composition by red snapper allocation, continued.

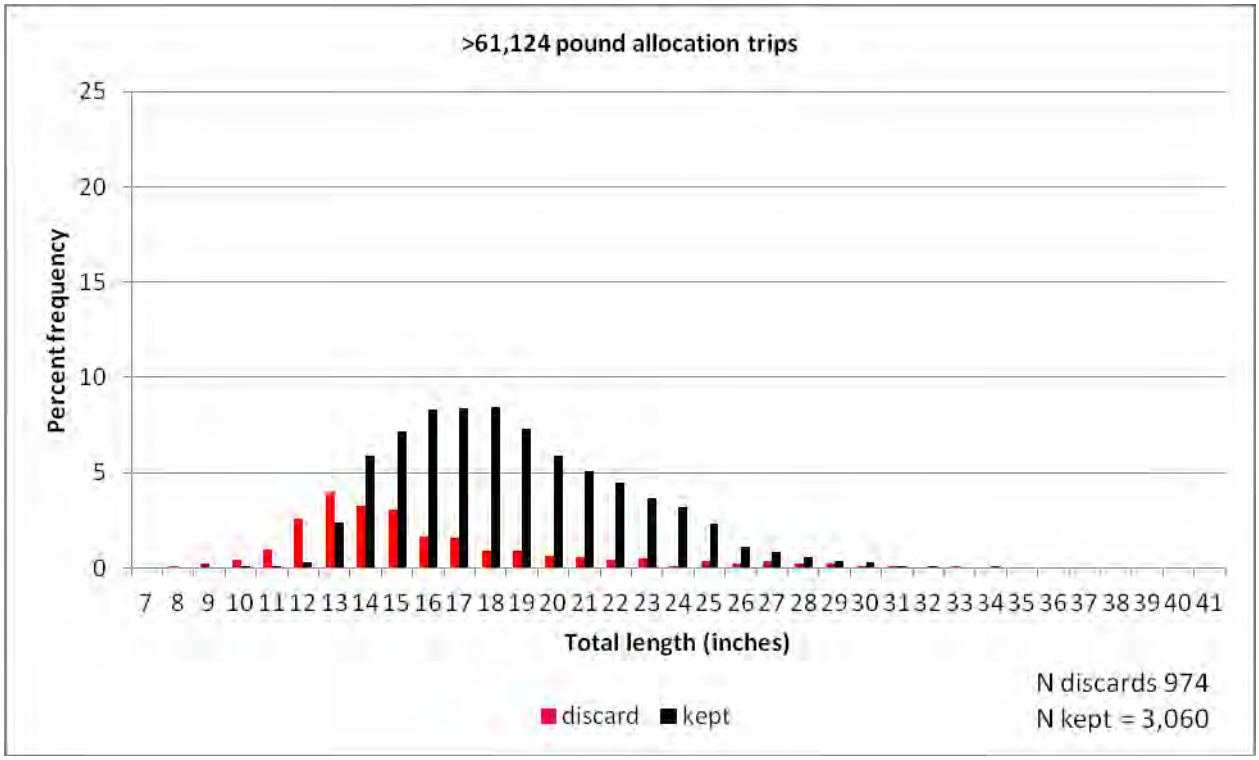


Figure 3.21 Commercial vertical line western Gulf of Mexico observed red snapper size composition by red snapper allocation, continued.

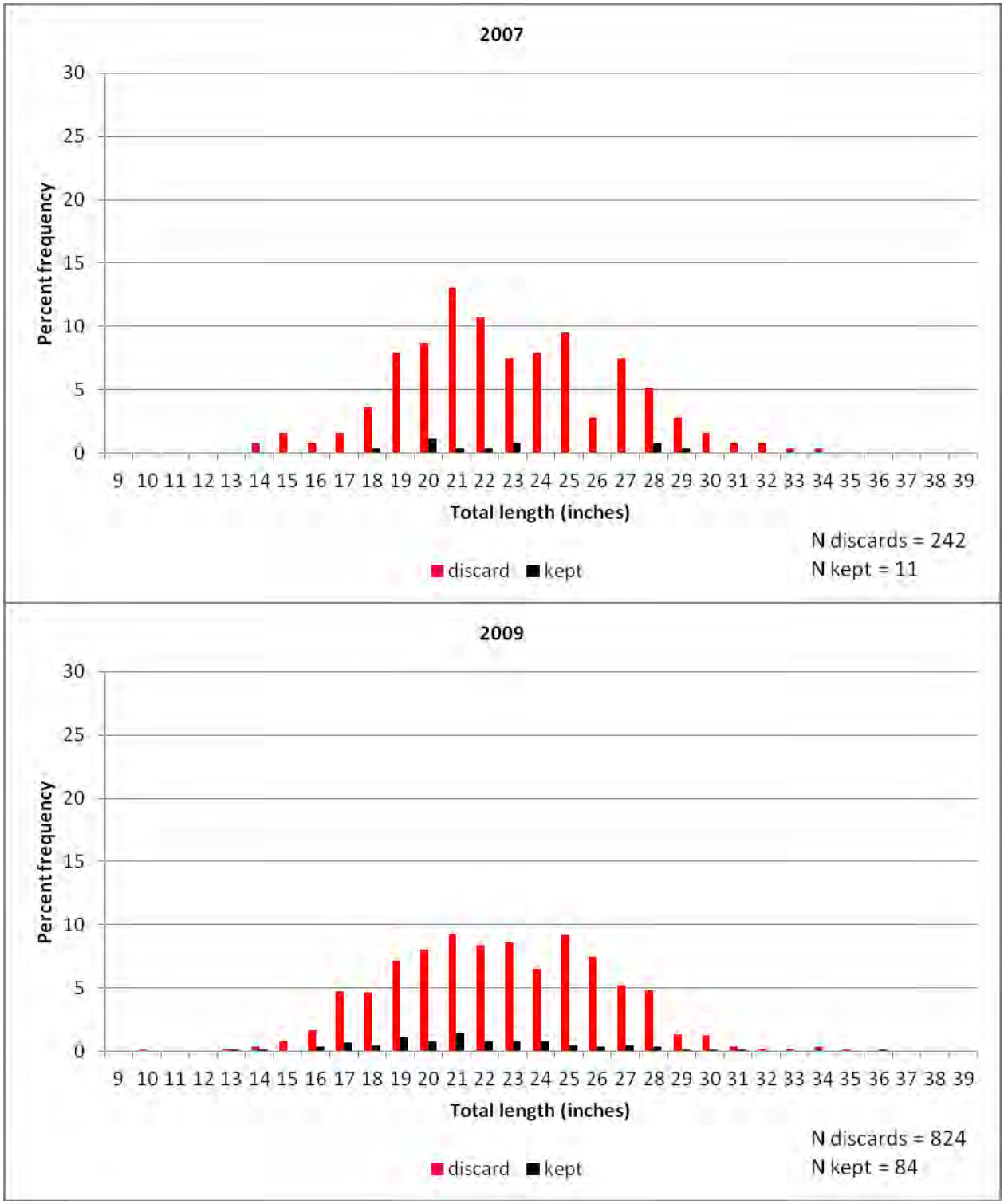


Figure 3.22 Commercial bottom longline eastern Gulf of Mexico observed red snapper size composition by year. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches. Data from 2008 cannot be shown due to confidentiality restrictions.

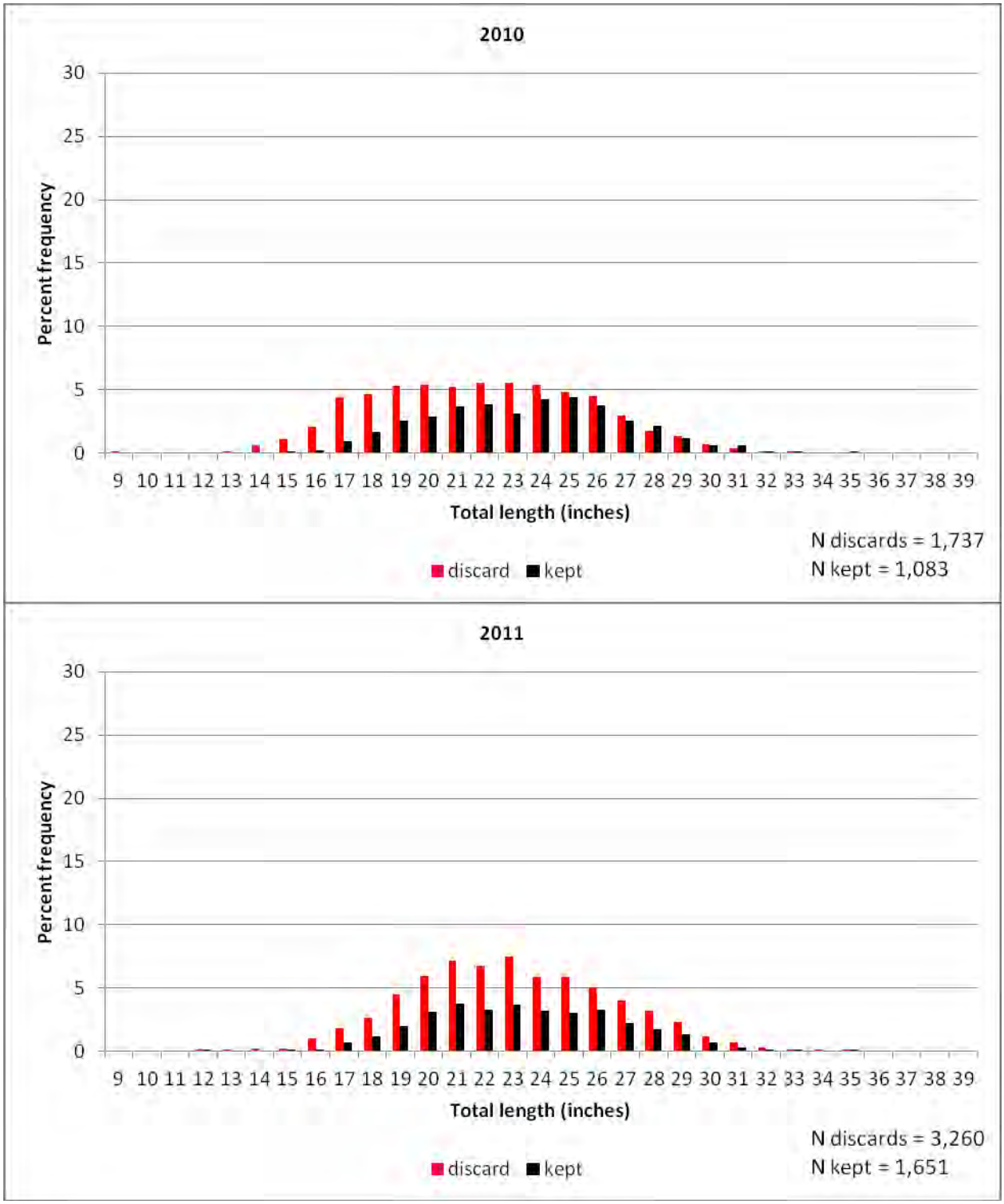


Figure 3.22 Commercial bottom longline eastern Gulf of Mexico observed red snapper size composition by year, continued.

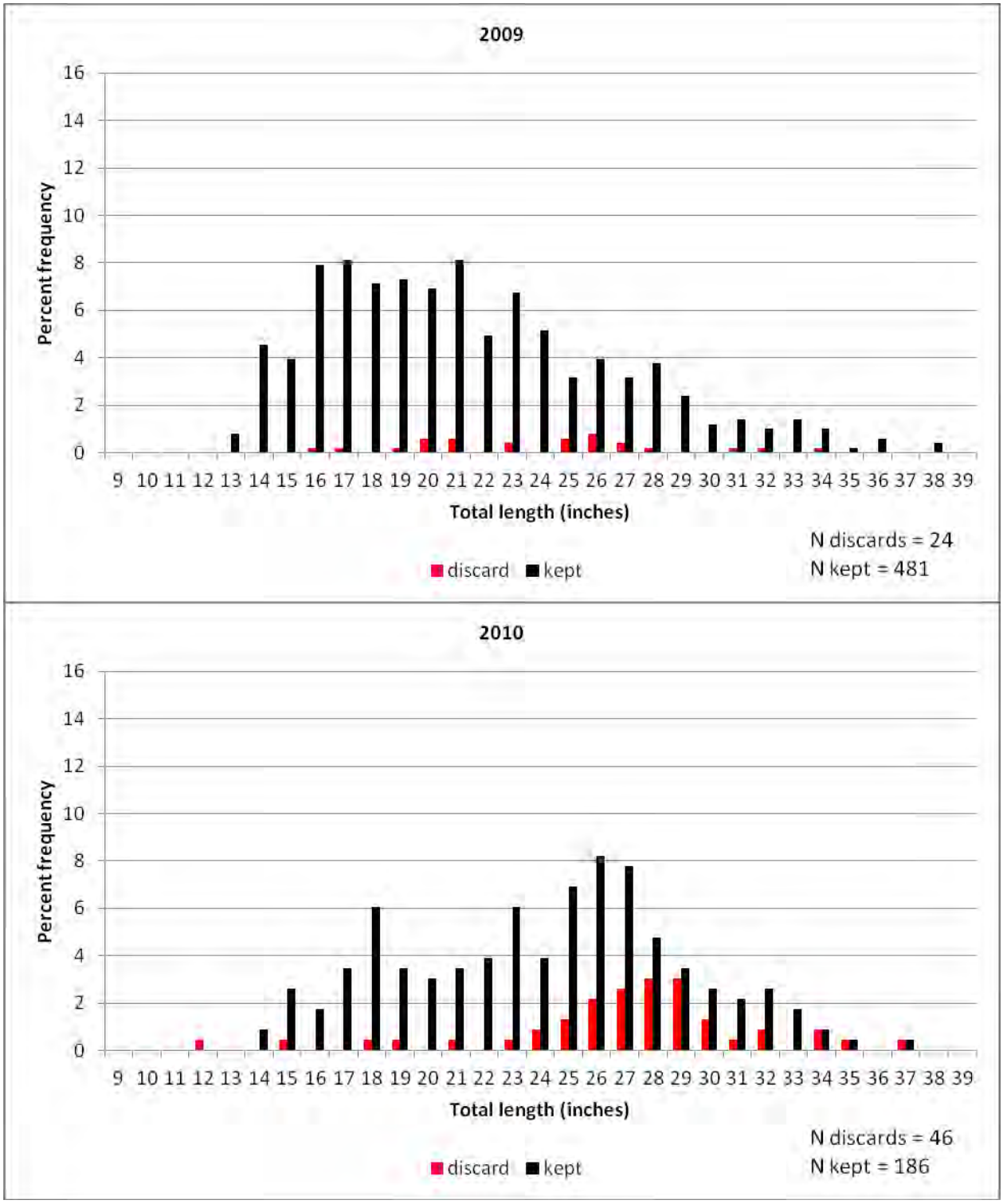


Figure 3.23 Commercial bottom longline western Gulf of Mexico observed red snapper size composition by year. No western Gulf of Mexico bottom longline trips had observers onboard during 2007. Data from 2008 cannot be shown due to confidentiality restrictions. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

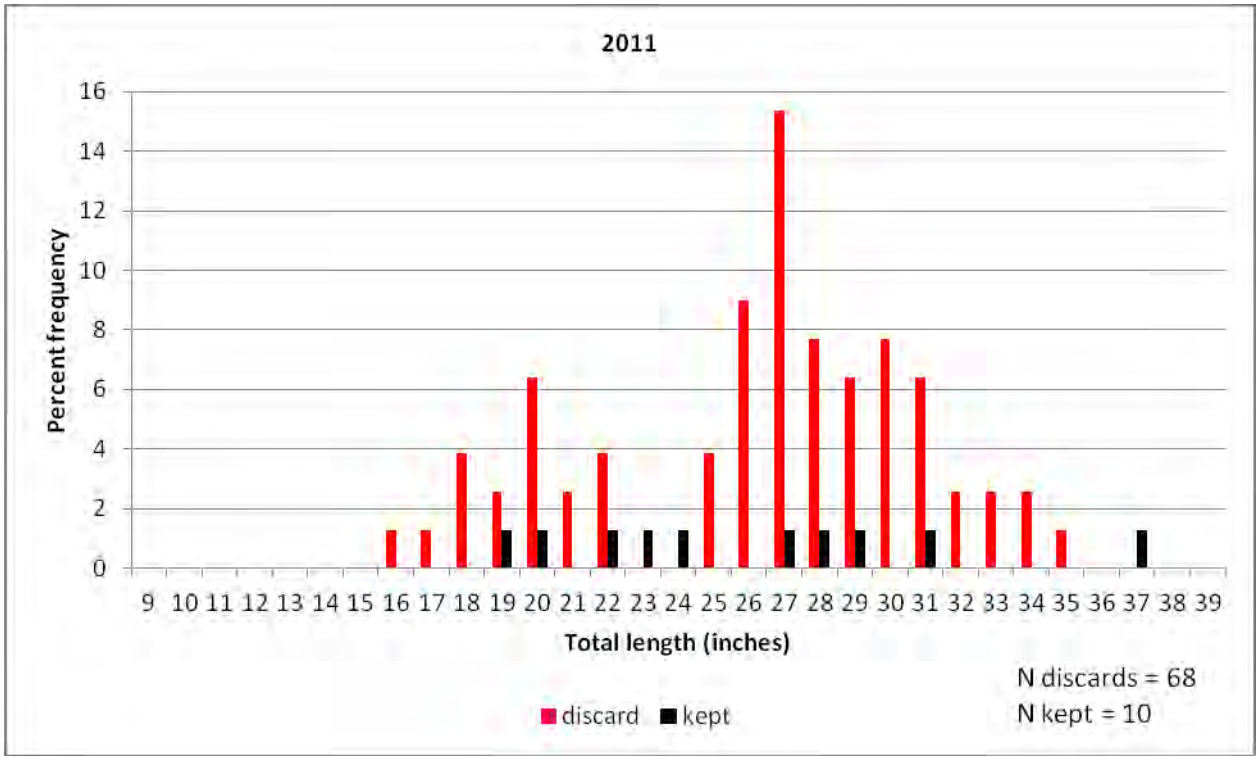


Figure 3.23 Commercial bottom longline western Gulf of Mexico observed red snapper size composition by year, continued.

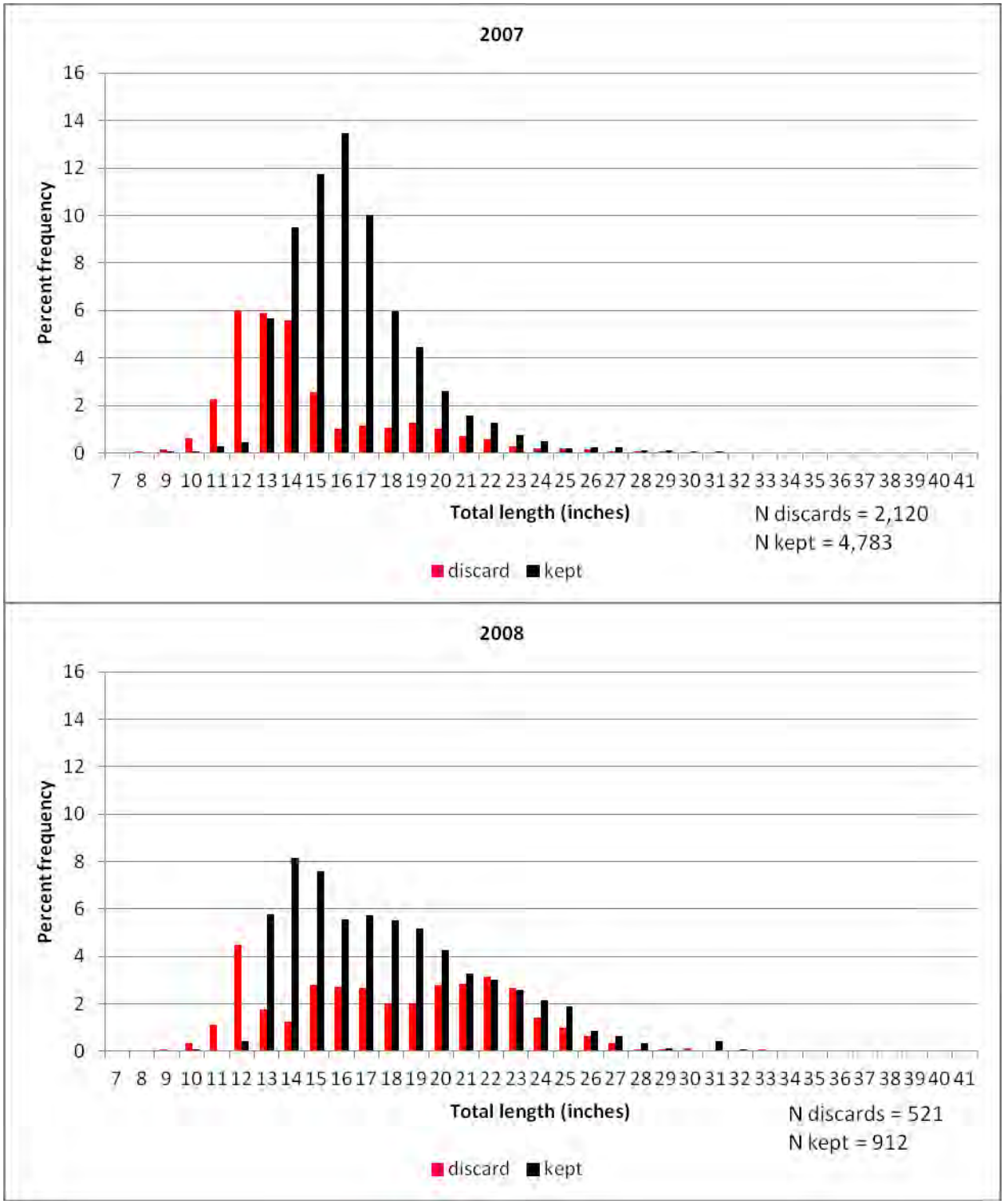


Figure 3.24 Commercial vertical line eastern Gulf of Mexico observed red snapper size composition by year. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

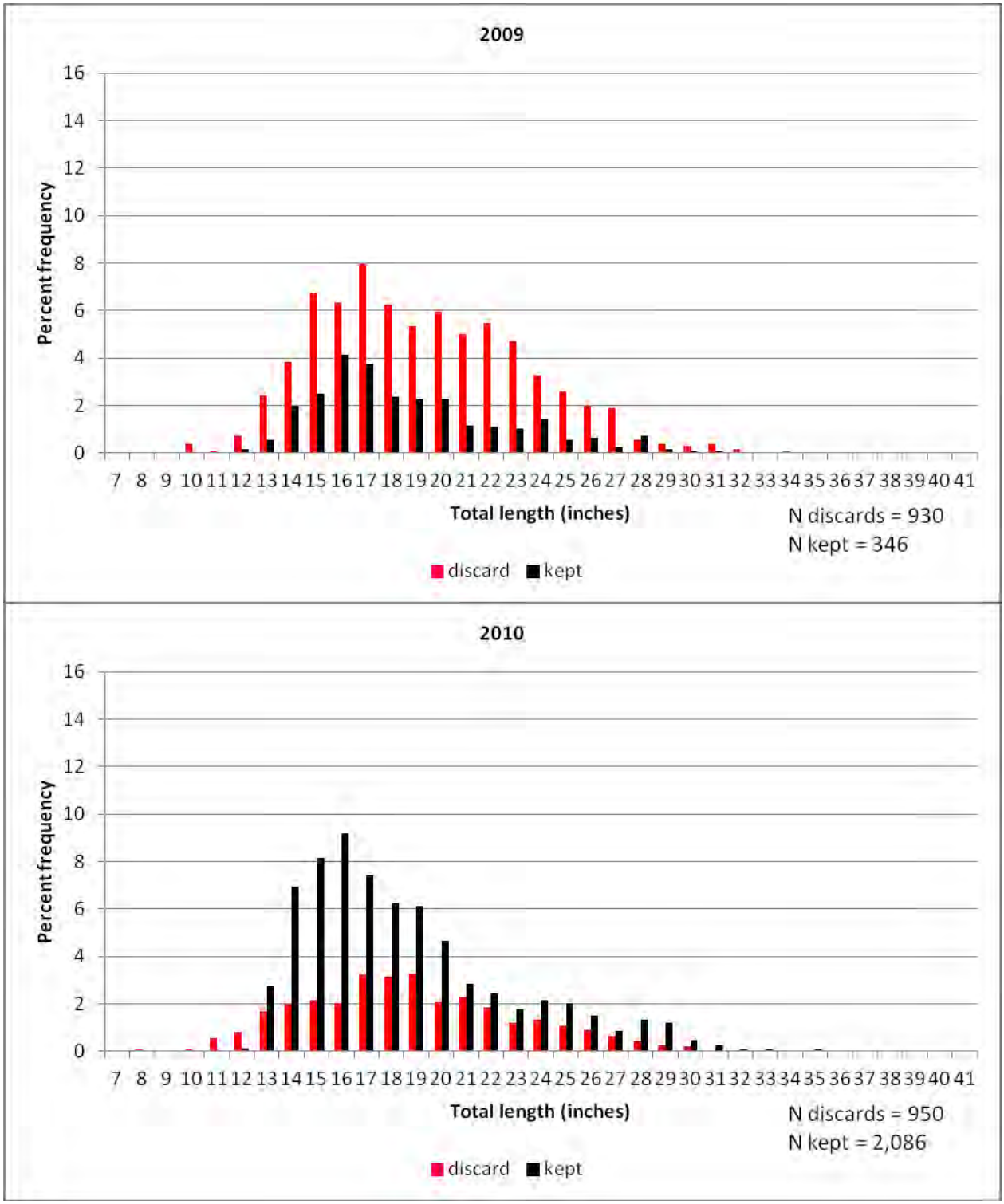


Figure 3.24 Commercial vertical line eastern Gulf of Mexico observed red snapper size composition by year, continued.

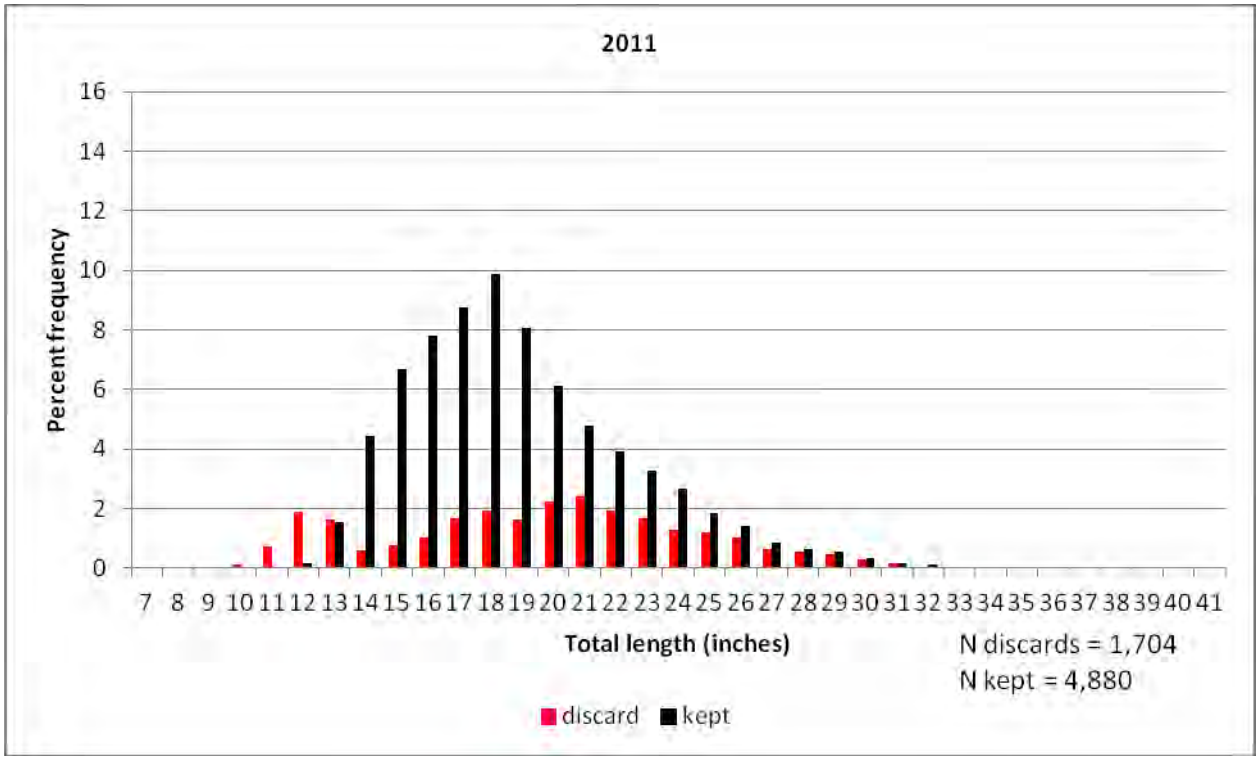


Figure 3.24 Commercial vertical line eastern Gulf of Mexico observed red snapper size composition by year, continued.

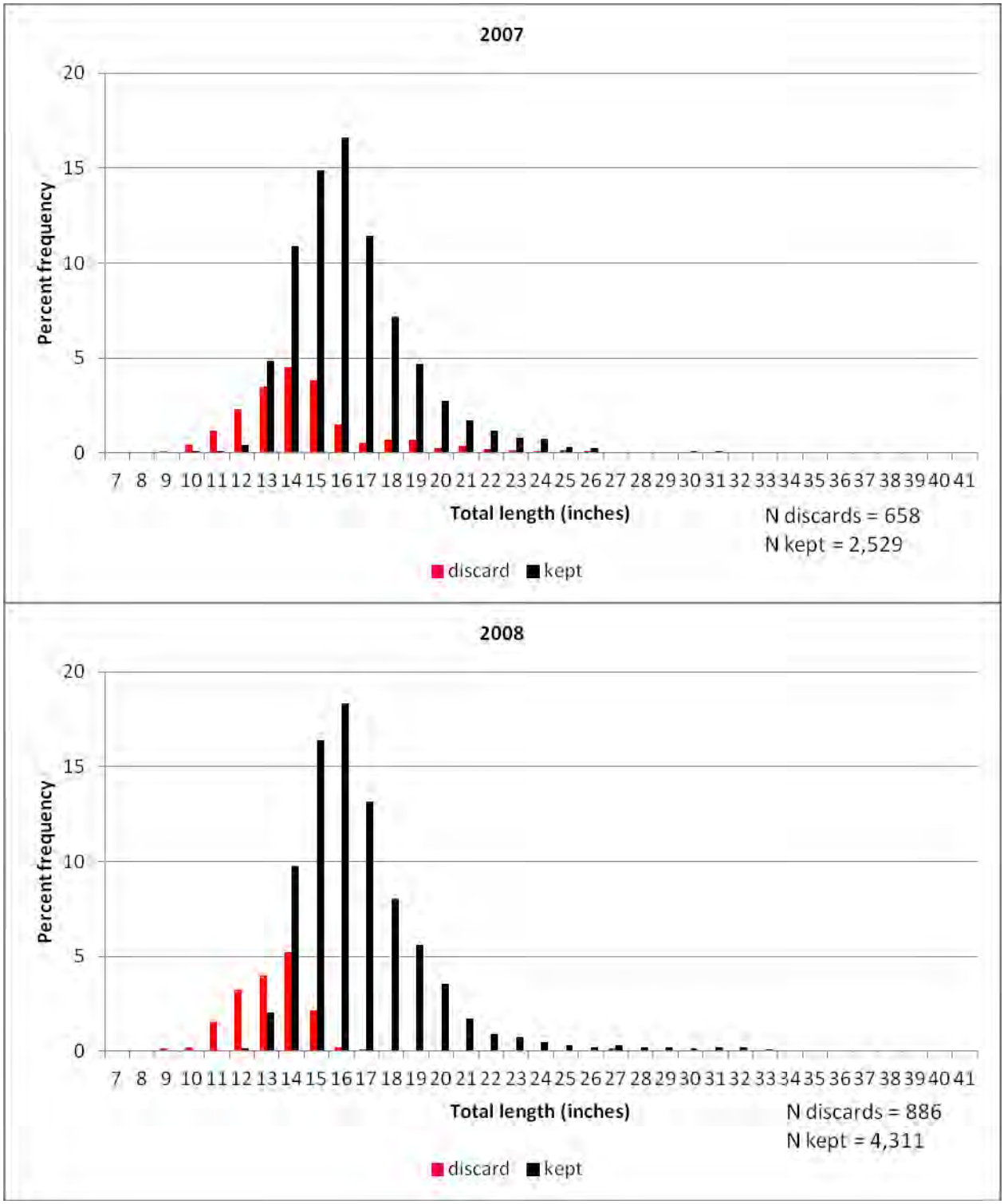


Figure 3.25 Commercial vertical line western Gulf of Mexico observed red snapper size composition by year. Sizes are in inches total length, where bins are one inch; e.g., 15 = 15-15.99 inches.

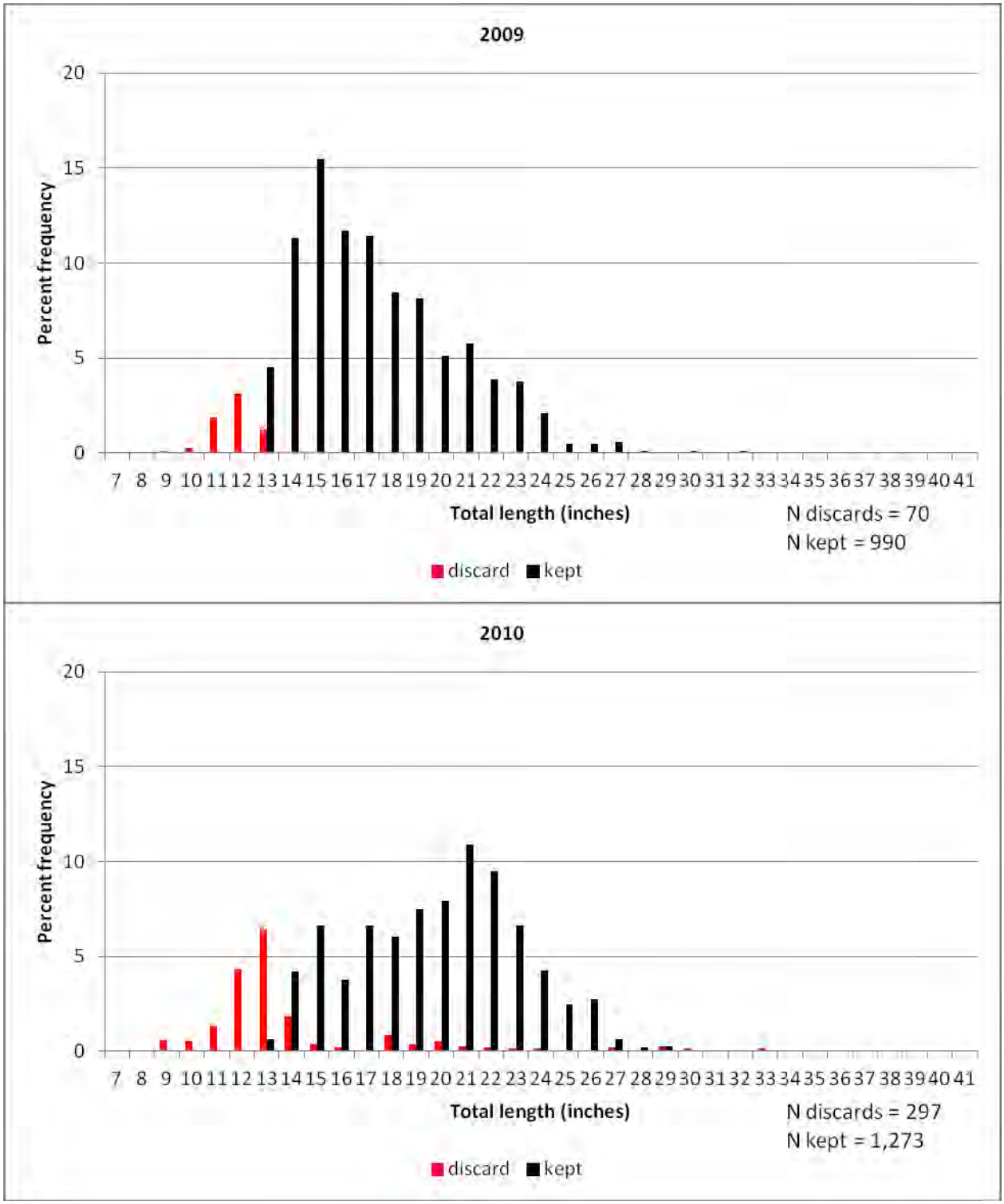


Figure 3.25 Commercial vertical line western Gulf of Mexico observed red snapper size composition by year, continued.

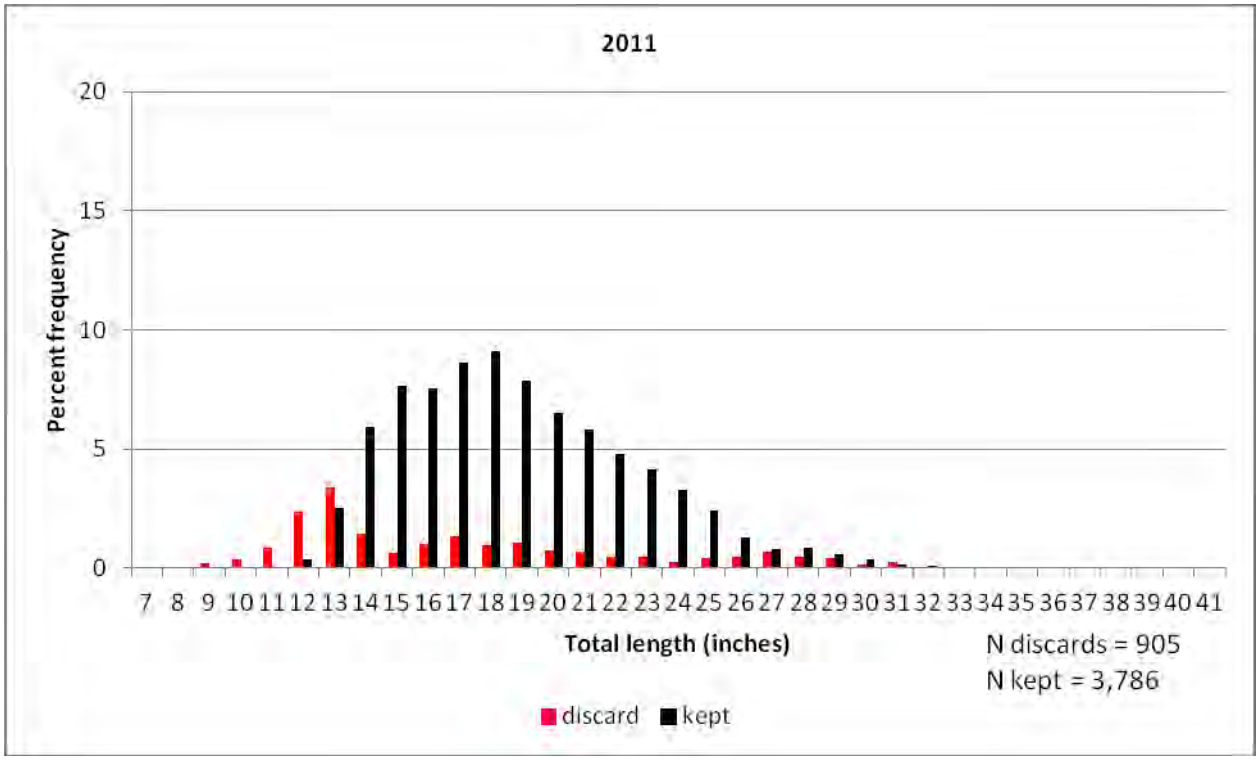


Figure 3.25 Commercial vertical line western Gulf of Mexico observed red snapper size composition by year, continued.

3.12 Appendix A: Description of databases used for Commercial Landings (Section 3.3):

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 late1800s (first year varies by species). Fairly serious collection activity began in the 1920s. The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SECPR Oracle database server is a continuous data set 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, these 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 databases cover. 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. 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 were 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 databases.

1960 - Late 1980s
==========
Although the data processing and database management responsibility 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 were 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
==========

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 SEFIN 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
=======
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.

Alabama
=======
Data collection in Alabama is voluntary and is conducted by state and federal port agents that visit dealers and docks monthly. Summaries of the total landings (pounds) and value for species or market category are recorded. Port agents provide information on gear and fishing area from their knowledge of the fisheries and interaction with fishermen and dealers. As of mid- 2000, the State of Alabama required fishermen and dealers to report all commercial landings data through a trip ticket system. As of 2001 the ALS system relies solely on the Alabama trip ticket data to create the ALS landings data for Alabama.

Mississippi
==========
Data collection in Mississippi is voluntary and is conducted by state and federal port agents that visit dealers and docks monthly. Summaries of the total landings (pounds) and value for species or market category are recorded. Port agents provide information on gear and fishing area from their knowledge of the fisheries and interaction with fishermen and dealers.

Louisiana
==========
Prior to 1993, commercial landings statistics were collected in Louisiana by Federal port agents following the traditional procedures established by the NMFS. Monthly summaries of the quantity and value were collected from each dealer in the state. The information on gear, area and distance from shore were added by the individual port agents.

Beginning in January 1993, the Department of Wildlife and Fisheries, State of Louisiana began to enforce the states' mandatory reporting requirement. Dealers have to be licensed by the State and are required to submit monthly summaries of the purchases that were made for individual

species or market categories. With the implementation of the State statute, Federal port agents did not participate in the collection of commercial fishery statistics.

Since the implementation of the State program, information on the gear used, the area of catch and the distance from shore has not been added to the landings statistics (1992-1999). In 1998 the State of Louisiana required fishermen and dealers to report all commercial landings data through a trip ticket system. These data contain detailed landings information by trip including gear, area of capture and vessel information. As of 2000, the ALS system relies solely on the Louisiana trip ticket data to create the ALS landings data for Louisiana.

Texas
=====
The State has a mandatory reporting requirement for dealers licensed by the State. Dealers are required to submit monthly summaries of the quantities (pounds) and value of the purchases that were made for individual species or market categories.

Information on gear, area and distance from shore are added to the state data by SEFSC personnel. Furthermore, landings of species that are unloaded in Texas, but transported to locations in other states are added to the commercial landings statistics by SEFSC personnel.

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 commercial landings data base which reports where the marine resource was landed. With the advent of some State trip ticket programs as the data source 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: Description of methods and results for age distributions (Section 3.6.3)

Otolith observations were obtained from several sources:

Data Sources

1) Panama City Laboratory:
    a. File 1: rs_ps_tip_9102.sas7bdat
    b. File 2: rs_ps_tip_0308.sas7bdat
    c. File 3: rs_pc_tip_0910.sas7bdat
    d. File 4: 2009-2010 red snapper age data PCLAB.xls
    e. File 5: 2009 & 2010 red snapper age additions PCLAB.xls
2) GulfFIN/Panama City:
    a. File 6: GOM_RS0308FINAL.xls (from Gregg Bray)
    b. File 7: RSnapper2011 with PC fields.xls
    c. File 8: GulfStates_RSnapperDataSet_2012 SEDAR 31.xls
3) FWRI/Panama City:
    a. File 9: 2009-2010 red snapper age data PCLAB.xls
    b. File 10: 2009 & 2010 red snapper age additions PCLAB.xls
    c. File 11: FWRI_Lcamp_2009_2010_2011.xls

The recreational landings by region and mode (**Table 1**) and the northeast and southeast GOM commercial HL landings (**Table 2**) were obtained from the SEFSC FSD group. The landings were used when combining modes or regions (i.e. REC: HB + "PR+CB" and COMHL: NE + SE) to weight the raw catch-at-age matrices.

Construction of the Dataset:

The Trip Interview Program (TIP) location and gear variables were merged with the Panama City Laboratory data to fill missing gear, area fished, latitude, longitude and county landed information.

The dataset was restricted in the following manner:

1) Included years 1991-2011
2) Included modes: Commercial, Private Boat, Headboat, Charter Boat
3) Included gears: Handline and Longline.
4) Observations determined to be "non-random" (e.g. obtained from quota-sampling) were deleted.
5) Observations determined to be "Biased" (e.g. stratified) were deleted.
6) Data were deleted if the variables biological age, gear or mode were missing.
7) Data were deleted if no location was provided.

The final dataset contained ~98,000 age observations from Age-0 to Age-57.

Assignment of Region:

For the PC LAB/TIP dataset, the variable "REGION" was assigned using the following hierarchy:

1) REGION = Area Fished (Panama City, **Fig. 1**)
    a. Statistical Grids 1-7 = "Southeast"
    b. Statistical Grids 8-12 = "Northeast"
    c. Statistical Grids 13-21 = "West"
2) if REGION unassigned then Area Fished (TIP, **Fig. 1**)
    a. Statistical Grids 1-7 = "Southeast"
    b. Statistical Grids 8-12 = "Northeast"
    c. Statistical Grids 13-21 = "West"
3) if REGION unassigned then Latitude/Longitude (PC LAB or TIP **Fig. 2**)
    a. if Longitude < 85ºW then region = "Southeast"
    b. if Longitude ≥ 85ºW and < 89ºW then region = "Northeast"
    c. if Longitude ≥ 89ºW and < 90ºW then:
        i. if Latitude > 29ºN then region = "Northeast"
        ii. if Latitude ≤ 29ºN then region = "West"
    d. if Longitude ≥ 90ºW then region = "West"
4) if REGION unassigned then Location Landed (Panama City, **Fig. 3**)
    a. All TX counties, region = "West"
    b. LA counties from "Plaquemines" westward, region = "West"
    c. LA counties east of (and not including) "Plaquemines", region = "Northeast"
    d. All MS and AL counties, region = "Northeast"
    e. FL counties from "Gulf" westward, region = "Northeast"
    f. FL counties from "Franklin" eastward and southward, region = "Southeast"
5) if REGION unassigned then County Landed (TIP, **Fig. 3**)
    a. All TX counties, region = "West"
    b. LA counties from "Plaquemines" westward, region = "West"
    c. LA counties east of (and not including) "Plaquemines", region = "Northeast"
    d. All MS and AL counties, region = "Northeast"
    e. FL counties from "Gulf" westward, region = "Northeast"
    f. FL counties from "Franklin" eastward and southward, region = "Southeast"
6) if REGION unassigned then State Landed (Panama City)
    a. States TX and LA, region = "West"
    b. States MS, AL, FL = "Northeast"
    c. ***Note:*** The only gear/mode requiring the NE/SE split is the Commercial Handline. It was not necessary to use "State Landed" to assign the location of any CM HL samples. Therefore, the only compromise associated with this method is the all samples from LA are assigned to the west. This seems an appropriate compromise if no other location variables are available.
7) if REGION unassigned then delete: Deletes 90 samples with no location info.

Weighting Observed Catch-at-Age by Landings:

The current structure for CATCHEM requires the following input matrices:
1) COM HL East (NE + SE)
2) COM HL West
3) COM LL East
4) COM LL West

5) REC East (HB + "PR&CB)
6) REC West (HB + "PR&CB)

Of these, items 1, 5 and 6 require calculating combined matrices weighted by the landings (by region or mode). To do so, the following equation was used:

if $L_{r1,y} + L_{r2,y} > 0$ then: $$Weighted\ PAA_{a,y} = \frac{(PAA_{r1,a,y} * L_{r1,y}) + (PAA_{r2,a,y} * L_{r2,y})}{L_{r1,y} + L_{r2,y}}$$

else Weighted PAA = 0

where *PAA* is the proportion at age, *L* is the landings, *r1* and *r2* are the regions (or modes) to be combined, *a* is the age and *y* is the year.

The effective sample sizes for items 1, 5 and 6 were also adjusted using the landings weights (consistent with SEDAR 7 and the 2009 update). The equation is as follows:

if N_{r1} and $N_{r2} \neq 0$ then: $$Eff\ N = \left(L_{r1,y} + L_{r2,y}\right)^2 \Big/ \left(\frac{L_{r1,y}^2}{N_{r1,y}} + \frac{L_{r2,y}^2}{N_{r2,y}}\right)$$

else if N_{r1} or $N_{r2} = 0$ then replace 0 with 1.0 then use equation above
else if N_{r1} and $N_{r2} = 0$ then Eff N = 0

where *L* is the landings, *r1* and *r2* are the regions or modes to be combined and *y* is the year.

The direct observed catch-at-age matrices are summarized in **Tables 3-5**. The results were compared to a 2011 update of the direct observed age composition in **Figs. 4-9**. The working group noted that the results were nearly identical to those previously reported. The recent proportion catch-at-age (from direct observed age composition), by gear and mode, is summarized in **Fig. 10**. In most cases, the fisheries landed older fish in 2010 and 2011 than in 2009. The exception is the commercial longline fishery in the western gulf, however very few samples are available in 2011 for this fishery (n = 84).

To explore the possibility of non-representative sampling of fish chosen for otolith analysis, the working group requested that the length distribution of all available samples be compared to the length distribution of the samples selected for otolith analysis. It was expected that the two length distributions would be very similar if the otolith samples were a representative subsample of the total observed fish. In both cases, the length distributions were weighted by the landings as previously described. The resulting length compositions are illustrated in **Figs 11-16**.

The working group concluded that there was evidence of non-representative sampling prior to 2000 in all fisheries. The Panama City lab reported that that some of these early samples were taken to construct an age length key, rather than to construct a growth curve. After 2000, scientific samplers were directed to obtain a representative sample by length for otolith analysis. The length frequency comparisons indicate that this objective was met in most cases.

Some disparity in the length distributions was noted in the recreational fisheries during 2009-2011 and in the western gulf commercial longline fishery in 2002. After further explorations of the data it was noted that the length composition dataset was lacking revised and additional observations made available during the 2009 update assessment, and for a 2011 SERO request. These additional samples will be included in a revised analysis which will be completed prior to the assessment workshop.

Table 1. Recreational Landings used to weight the otolith observations by modes (HB, PR+CB). For the mode PR+CB, all modes besides HB were combined. These data were prepared by V. Matter (SEFSC).

Sum of ab1	Gulf	new_moden							
	East			East Total	West			West Total	Grand Total
YEAR	Cbt	Hbt	Priv		Cbt	Hbt	Priv		
1981	77,922	47,780	722,891	848,594	109,814	344,252	1,336,640	1,790,705	2,639,299
1982	313,304	153,823	401,094	868,222	623,249	388,247	447,698	1,459,195	2,327,417
1983	492,178	301,790	289,223	1,083,191	420,687	370,500	1,450,635	2,241,822	3,325,014
1984	66,608	40,842	79,096	186,546	442,359	373,218	207,057	1,022,634	1,209,180
1985	147,160	90,234	252,973	490,367	394,950	368,605	194,638	958,193	1,448,560
1986	451,143	16,364	107,323	574,830	114,717	316,090	282,516	713,322	1,288,153
1987	331,869	9,685	206,133	547,687	91,514	319,348	73,198	484,060	1,031,747
1988	364,052	13,832	145,441	523,325	22,496	423,024	279,185	724,705	1,248,030
1989	227,433	10,797	235,086	473,316	31,366	372,473	187,926	591,765	1,065,081
1990	130,541	15,539	174,590	320,670	59,069	187,006	69,907	315,982	636,651
1991	245,168	15,580	287,919	548,667	207,619	264,686	46,881	519,186	1,067,853
1992	250,388	33,873	580,573	864,834	148,516	413,056	169,971	731,543	1,596,377
1993	689,379	37,275	545,697	1,272,351	162,487	458,772	253,524	874,784	2,147,135
1994	380,993	28,998	391,839	801,830	90,920	497,738	220,979	809,637	1,611,467
1995	373,953	23,078	243,530	640,562	120,536	354,550	265,585	740,671	1,381,233
1996	370,778	28,388	199,791	598,957	59,699	349,266	182,185	591,151	1,190,108
1997	614,151	48,439	347,630	1,010,220	68,573	347,424	180,314	596,311	1,606,530
1998	585,798	76,759	168,530	831,088	31,710	244,738	149,113	425,562	1,256,649
1999	347,340	67,432	374,542	789,315	22,574	98,699	123,445	244,718	1,034,032
2000	418,248	57,640	279,733	755,621	25,605	111,410	131,986	269,001	1,024,622
2001	396,680	51,289	436,450	884,418	20,666	116,358	86,900	223,924	1,108,342
2002	572,951	75,121	535,340	1,183,411	49,923	138,475	52,169	240,567	1,423,979
2003	476,542	71,021	491,036	1,038,598	44,255	157,905	68,339	270,498	1,309,097
2004	513,146	63,482	677,476	1,254,104	82,732	110,329	46,443	239,504	1,493,608
2005	371,453	46,791	353,210	771,454	79,730	99,988	86,457	266,175	1,037,629
2006	394,258	47,882	399,388	841,528	96,436	121,177	139,781	357,395	1,198,923
2007	471,983	63,603	592,196	1,127,783	63,965	110,314	142,470	316,749	1,444,532
2008	266,355	61,986	325,283	653,623	30,592	57,569	90,161	178,322	831,946
2009	204,625	81,590	493,710	779,925	32,693	75,998	98,944	207,635	987,560
2010	71,264	35,943	255,749	362,956	7,674	51,514	29,199	88,387	451,343
2011	144,158	69,187	344,762	558,106	11,516	50,656	55,964	118,136	676,243
Grand Total	10,761,821	1,786,044	10,938,234	23,486,099	3,768,643	7,693,385	7,150,212	18,612,240	42,098,339

Table 2. GOM commercial handline landings used to weight the otolith observations by region. These data were prepared by R. Orhun (SEFSC).

2011 Norestriction file			geargroup2					
YEAR	East Gulf handline+	East Gulf longline	East Gulf Total	West Gulf handline+	West Gulf longline	West Gulf Total	Grand Total	Source
1991	395,176	20,704	415,880	1,724,713	72,592	1,797,305	2,213,185	ALS
1992	406,493	5,689	412,181	2,674,497	19,820	2,694,317	3,106,498	ALS
1993	436,981	15,235	452,215	2,901,388	20,291	2,921,679	3,373,894	ALS
1994	527,124	7,958	535,082	2,671,460	15,809	2,687,269	3,222,351	ALS
1995	172,740	8,459	181,199	2,735,403	17,506	2,752,909	2,934,108	ALS
1996	233,980	7,587	241,568	4,044,133	27,362	4,071,495	4,313,063	ALS
1997	184,411	4,627	189,038	4,589,501	31,418	4,620,920	4,809,958	ALS
1998	379,399	5,514	384,914	4,267,523	27,224	4,294,747	4,679,660	ALS
1999	548,422	6,474	554,896	4,230,449	90,572	4,321,021	4,875,917	ALS
2000	665,284	8,619	673,904	3,979,683	183,538	4,163,221	4,837,125	ALS
2001	797,925	10,130	808,055	3,692,770	124,453	3,817,223	4,625,279	ALS
2002	1,048,705	18,125	1,066,830	3,565,962	146,195	3,712,156	4,778,986	ALS
2003	1,019,257	13,853	1,033,110	3,204,247	171,270	3,375,517	4,408,627	ALS
2004	950,935	19,353	970,288	3,225,236	455,829	3,681,066	4,651,354	ALS
2005	792,010	21,121	813,131	3,000,323	282,789	3,283,113	4,096,244	ALS
2006	760,327	16,335	776,662	3,611,689	260,652	3,872,341	4,649,003	ALS
2007	875,240	15,727	890,967	2,103,261	188,503	2,291,764	3,182,731	IFQ Corr 2007
2008	834,499	34,124	868,623	1,559,132	55,848	1,614,980	2,483,603	IFQ Corr 2008
2009	918,874	14,627	933,502	1,498,298	51,766	1,550,063	2,483,565	IFQ Corr 2009
2010	1,397,647	75,510	1,473,157	1,880,858	38,193	1,919,052	3,392,209	IFQ Corr 2010
2011	1,613,106	84,286	1,697,392	1,878,310	18,850	1,897,160	3,594,552	IFQ Corr 2011

YEAR	handline+ NE handline+	handline+ SE handline+	Grand Total	Source
1991	362,700	32,475	395,176	ALS
1992	389,891	16,601	406,493	ALS
1993	381,940	55,041	436,981	ALS
1994	487,422	39,702	527,124	ALS
1995	153,815	18,925	172,740	ALS
1996	222,101	11,879	233,980	ALS
1997	171,928	12,483	184,411	ALS
1998	353,122	26,277	379,399	ALS
1999	477,638	70,784	548,422	ALS
2000	600,899	64,385	665,284	ALS
2001	716,515	81,410	797,925	ALS
2002	954,913	93,792	1,048,705	ALS
2003	918,807	100,450	1,019,257	ALS
2004	814,322	136,614	950,935	ALS
2005	624,364	167,646	792,010	ALS
2006	574,995	185,332	760,327	ALS
2007	754,895	120,346	875,240	IFQ Corr 2007
2008	703,784	130,715	834,499	IFQ Corr 2008
2009	681,668	237,206	918,874	IFQ Corr 2009
2010	1,014,881	382,766	1,397,647	IFQ Corr 2010
2011	1,178,568	434,538	1,613,106	IFQ Corr 2011

Table 3. Landings (in numbers), proportion-at-age, number of observations (N) and effective sample size (EFF N) for the recreational fishery (HB + "PR&CB").

A) REC EAST

Fishery	year	Landings	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	age 15+	N	EFF N
REC_HL_E	1991	548,667	0.000	0.012	0.647	0.294	0.035	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	85	84
REC_HL_E	1992	864,834	0.000	0.181	0.295	0.396	0.094	0.023	0.007	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	410	362
REC_HL_E	1993	1,272,351	0.000	0.081	0.475	0.274	0.112	0.043	0.005	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	642	409
REC_HL_E	1994	801,830	0.000	0.070	0.346	0.333	0.145	0.071	0.030	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	667	426
REC_HL_E	1995	640,562	0.003	0.196	0.232	0.249	0.160	0.085	0.043	0.008	0.005	0.013	0.000	0.000	0.000	0.000	0.000	0.005	374	374
REC_HL_E	1996	598,957	0.019	0.141	0.569	0.173	0.031	0.010	0.009	0.019	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	218	111
REC_HL_E	1997	1,010,220	0.000	0.000	0.733	0.110	0.088	0.018	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	153	62
REC_HL_E	1998	831,088	0.001	0.016	0.351	0.498	0.114	0.014	0.004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1615	1322
REC_HL_E	1999	789,315	0.000	0.003	0.218	0.436	0.307	0.026	0.008	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	1429	1407
REC_HL_E	2000	755,621	0.000	0.040	0.492	0.337	0.112	0.014	0.000	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.002	647	583
REC_HL_E	2001	884,418	0.000	0.077	0.565	0.252	0.085	0.014	0.003	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	603	431
REC_HL_E	2002	1,183,411	0.003	0.044	0.258	0.410	0.176	0.062	0.027	0.016	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	2248	2196
REC_HL_E	2003	1,038,598	0.000	0.014	0.268	0.439	0.202	0.038	0.020	0.010	0.004	0.001	0.000	0.000	0.001	0.000	0.000	0.001	6585	5068
REC_HL_E	2004	1,254,104	0.000	0.040	0.324	0.358	0.173	0.057	0.023	0.011	0.006	0.002	0.000	0.002	0.000	0.000	0.000	0.002	4087	3810
REC_HL_E	2005	771,454	0.000	0.012	0.324	0.432	0.135	0.064	0.022	0.005	0.002	0.001	0.001	0.000	0.000	0.001	0.000	0.000	5380	4904
REC_HL_E	2006	841,528	0.000	0.015	0.396	0.394	0.112	0.041	0.027	0.009	0.002	0.001	0.000	0.001	0.001	0.000	0.001	0.001	3921	3914
REC_HL_E	2007	1,127,783	0.000	0.013	0.305	0.492	0.139	0.026	0.011	0.004	0.005	0.001	0.002	0.002	0.002	0.000	0.000	0.000	806	666
REC_HL_E	2008	653,623	0.000	0.009	0.413	0.377	0.165	0.026	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	490	421
REC_HL_E	2009	779,925	0.002	0.001	0.086	0.329	0.362	0.167	0.038	0.009	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	1292	697
REC_HL_E	2010	362,956	0.000	0.000	0.058	0.286	0.385	0.174	0.063	0.024	0.008	0.002	0.001	0.000	0.000	0.000	0.000	0.000	1906	1699
REC_HL_E	2011	558,106	0.000	0.000	0.028	0.161	0.323	0.304	0.129	0.034	0.015	0.004	0.002	0.000	0.000	0.000	0.000	0.000	1181	1106

B) REC WEST

Fishery	year	Landings	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	age 15+	N	EFF N
REC_HL_W	1991	519,186	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
REC_HL_W	1992	731,543	0.000	0.021	0.349	0.464	0.086	0.029	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	513	79
REC_HL_W	1993	874,784	0.000	0.074	0.587	0.251	0.067	0.015	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1128	739
REC_HL_W	1994	809,637	0.000	0.028	0.436	0.278	0.178	0.064	0.013	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	388	7
REC_HL_W	1995	740,671	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10	3
REC_HL_W	1996	591,151	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
REC_HL_W	1997	596,311	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
REC_HL_W	1998	425,562	0.000	0.039	0.238	0.323	0.228	0.105	0.038	0.020	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.003	924	914
REC_HL_W	1999	244,718	0.000	0.000	0.119	0.402	0.336	0.098	0.030	0.010	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	193	193
REC_HL_W	2000	269,001	0.000	0.019	0.694	0.139	0.044	0.037	0.039	0.017	0.002	0.003	0.000	0.002	0.000	0.000	0.000	0.005	247	6
REC_HL_W	2001	223,924	0.000	0.014	0.219	0.178	0.151	0.110	0.137	0.096	0.014	0.014	0.014	0.027	0.000	0.000	0.000	0.027	73	4
REC_HL_W	2002	240,567	0.000	0.065	0.372	0.340	0.119	0.040	0.027	0.020	0.005	0.003	0.000	0.000	0.000	0.003	0.004	0.003	774	521
REC_HL_W	2003	270,498	0.000	0.010	0.329	0.308	0.177	0.098	0.028	0.017	0.024	0.003	0.001	0.001	0.001	0.002	0.002	0.001	944	377
REC_HL_W	2004	239,504	0.000	0.077	0.466	0.220	0.141	0.032	0.027	0.014	0.012	0.003	0.000	0.003	0.000	0.001	0.003	0.002	1187	637
REC_HL_W	2005	266,175	0.000	0.034	0.423	0.247	0.126	0.093	0.037	0.016	0.008	0.002	0.004	0.006	0.001	0.001	0.001	0.002	1433	1003
REC_HL_W	2006	357,395	0.000	0.015	0.399	0.407	0.101	0.034	0.022	0.010	0.003	0.005	0.001	0.001	0.000	0.000	0.000	0.003	1465	1102
REC_HL_W	2007	316,749	0.000	0.030	0.293	0.422	0.189	0.036	0.017	0.005	0.002	0.003	0.001	0.002	0.000	0.000	0.000	0.001	1075	459
REC_HL_W	2008	178,322	0.000	0.008	0.178	0.491	0.263	0.049	0.006	0.001	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	726	599
REC_HL_W	2009	207,635	0.000	0.004	0.079	0.252	0.370	0.220	0.044	0.011	0.002	0.006	0.005	0.001	0.000	0.000	0.001	0.005	856	798
REC_HL_W	2010	88,387	0.000	0.000	0.004	0.172	0.364	0.349	0.077	0.024	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.001	443	227
REC_HL_W	2011	118,136	0.000	0.001	0.026	0.103	0.254	0.348	0.182	0.069	0.013	0.001	0.001	0.000	0.000	0.000	0.000	0.003	1083	952

Table 4. Landings (in lbs), proportion-at-age, number of observations (N) and effective sample size (EFF N) for the commercial handline fishery.

A) COM HL EAST (NE+SE)

Fishery	year	Landings	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	age 15+	N	EFF N
CM_HL _E	1991	395,175	0.000	0.138	0.678	0.092	0.057	0.023	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	87	61
CM_HL _E	1992	406,492	0.000	0.024	0.704	0.156	0.105	0.000	0.002	0.002	0.002	0.005	0.000	0.000	0.000	0.000	0.000	0.000	137	128
CM_HL _E	1993	436,981	0.000	0.031	0.402	0.422	0.084	0.028	0.019	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.006	153	151
CM_HL _E	1994	527,124	0.000	0.000	0.410	0.271	0.195	0.069	0.049	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.003	148	136
CM_HL _E	1995	172,740	0.000	0.080	0.469	0.332	0.083	0.024	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	92	89
CM_HL _E	1996	233,980	0.000	0.000	0.667	0.222	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9	10
CM_HL _E	1997	184,411	0.000	0.000	0.022	0.035	0.004	0.004	0.002	0.000	0.932	0.000	0.000	0.000	0.000	0.000	0.000	0.000	32	1
CM_HL _E	1998	379,399	0.000	0.000	0.084	0.472	0.225	0.128	0.016	0.021	0.005	0.000	0.000	0.000	0.005	0.000	0.000	0.043	177	152
CM_HL _E	1999	548,422	0.000	0.002	0.196	0.372	0.237	0.093	0.057	0.026	0.012	0.002	0.004	0.000	0.000	0.000	0.000	0.000	509	509
CM_HL _E	2000	665,284	0.000	0.005	0.256	0.363	0.278	0.070	0.016	0.006	0.005	0.000	0.002	0.000	0.000	0.000	0.000	0.000	985	850
CM_HL _E	2001	797,925	0.000	0.023	0.173	0.340	0.247	0.130	0.048	0.015	0.008	0.008	0.004	0.002	0.000	0.000	0.000	0.005	1215	1163
CM_HL _E	2002	1,048,705	0.000	0.012	0.471	0.290	0.137	0.042	0.039	0.005	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.002	1077	601
CM_HL _E	2003	1,019,257	0.000	0.016	0.344	0.360	0.183	0.048	0.022	0.009	0.002	0.002	0.001	0.003	0.001	0.000	0.000	0.009	1160	629
CM_HL _E	2004	950,936	0.001	0.029	0.306	0.359	0.201	0.062	0.017	0.010	0.008	0.000	0.001	0.002	0.004	0.000	0.000	0.001	1002	1001
CM_HL _E	2005	792,010	0.000	0.004	0.287	0.338	0.175	0.140	0.032	0.012	0.003	0.004	0.001	0.001	0.000	0.002	0.001	0.001	1170	818
CM_HL _E	2006	760,327	0.001	0.013	0.304	0.359	0.134	0.100	0.048	0.018	0.006	0.003	0.001	0.001	0.001	0.002	0.000	0.009	1299	1127
CM_HL _E	2007	875,241	0.000	0.074	0.423	0.386	0.090	0.018	0.006	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	1266	1094
CM_HL _E	2008	834,499	0.000	0.070	0.301	0.408	0.160	0.060	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	906	233
CM_HL _E	2009	918,874	0.000	0.020	0.334	0.373	0.189	0.060	0.017	0.003	0.000	0.002	0.001	0.000	0.001	0.000	0.000	0.000	1345	1282
CM_HL _E	2010	1,397,647	0.000	0.004	0.141	0.377	0.314	0.124	0.030	0.006	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	1876	1709
CM_HL _E	2011	1,613,106	0.000	0.010	0.149	0.235	0.336	0.188	0.061	0.015	0.005	0.001	0.000	0.001	0.000	0.000	0.000	0.000	2435	1701

****** Note: The unexpectedly large value at Age 8 in 1997 is caused by having only one otolith observation in 1997 in the NE Com HL. The small EFF N (1) indicates that the model will strongly downweight the proportion-at-age in 1997 due to the small sample size.***

B) COM HL WEST

Fishery	year	Landings	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	age 15+	N	EFF N
CM_HL_W	1991	1,724,713	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_HL_W	1992	2,674,497	0.000	0.005	0.575	0.173	0.107	0.051	0.051	0.019	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.009	214	214
CM_HL_W	1993	2,901,388	0.000	0.023	0.340	0.442	0.137	0.029	0.017	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	344	344
CM_HL_W	1994	2,671,460	0.000	0.037	0.314	0.304	0.237	0.057	0.022	0.014	0.006	0.002	0.002	0.000	0.000	0.000	0.000	0.006	507	507
CM_HL_W	1995	2,735,403	0.000	0.000	0.227	0.412	0.155	0.155	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	97	97
CM_HL_W	1996	4,044,133	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_HL_W	1997	4,589,501	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_HL_W	1998	4,267,523	0.000	0.009	0.056	0.449	0.255	0.135	0.035	0.027	0.018	0.005	0.004	0.001	0.001	0.000	0.000	0.005	1085	1085
CM_HL_W	1999	4,230,449	0.000	0.001	0.159	0.411	0.254	0.105	0.048	0.012	0.005	0.003	0.001	0.000	0.000	0.000	0.000	0.002	1818	1818
CM_HL_W	2000	3,979,683	0.000	0.006	0.293	0.358	0.181	0.091	0.045	0.017	0.003	0.003	0.001	0.001	0.000	0.000	0.000	0.001	1055	1055
CM_HL_W	2001	3,692,770	0.000	0.007	0.159	0.317	0.243	0.145	0.076	0.027	0.015	0.006	0.002	0.001	0.000	0.001	0.000	0.002	1003	1003
CM_HL_W	2002	3,565,962	0.006	0.050	0.358	0.272	0.159	0.075	0.046	0.018	0.006	0.002	0.003	0.001	0.000	0.001	0.000	0.004	2533	2533
CM_HL_W	2003	3,204,247	0.000	0.008	0.188	0.405	0.209	0.092	0.042	0.030	0.011	0.004	0.001	0.004	0.002	0.002	0.000	0.004	1319	1319
CM_HL_W	2004	3,225,236	0.000	0.002	0.156	0.379	0.256	0.100	0.047	0.031	0.011	0.007	0.003	0.001	0.001	0.001	0.001	0.003	1757	1757
CM_HL_W	2005	3,000,323	0.000	0.020	0.211	0.282	0.223	0.113	0.057	0.030	0.016	0.011	0.005	0.005	0.005	0.006	0.005	0.010	2267	2267
CM_HL_W	2006	3,611,689	0.000	0.002	0.343	0.364	0.135	0.085	0.041	0.012	0.008	0.006	0.003	0.001	0.001	0.000	0.000	0.000	2659	2659
CM_HL_W	2007	2,103,261	0.000	0.004	0.232	0.445	0.161	0.058	0.052	0.023	0.010	0.003	0.004	0.002	0.001	0.001	0.001	0.003	1438	1438
CM_HL_W	2008	1,559,132	0.000	0.006	0.237	0.374	0.251	0.076	0.025	0.012	0.009	0.003	0.002	0.002	0.000	0.000	0.000	0.002	1201	1201
CM_HL_W	2009	1,498,298	0.000	0.004	0.174	0.379	0.276	0.125	0.026	0.007	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.002	2094	2094
CM_HL_W	2010	1,880,858	0.000	0.001	0.071	0.284	0.372	0.207	0.050	0.009	0.002	0.002	0.001	0.002	0.000	0.001	0.001	0.002	1997	1997
CM_HL_W	2011	1,878,310	0.000	0.005	0.106	0.255	0.324	0.200	0.073	0.022	0.010	0.002	0.001	0.001	0.000	0.000	0.000	0.001	1665	1665

Table 5. Landings (in lbs), proportion-at-age, number of observations (N) and effective sample size (EFF N) for the commercial longline fishery.

A) COM LL EAST

Fishery	year	Landings	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	age 15+	N	EFF N
CM_LL_E	1991	20,704	0.000	0.083	0.667	0.083	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.083	0.000	12	12
CM_LL_E	1992	5,689	0.000	0.000	0.000	0.267	0.067	0.333	0.067	0.133	0.000	0.000	0.067	0.000	0.000	0.000	0.000	0.067	15	15
CM_LL_E	1993	15,235	0.000	0.000	0.133	0.200	0.367	0.100	0.033	0.067	0.000	0.000	0.033	0.000	0.000	0.033	0.000	0.033	30	30
CM_LL_E	1994	7,958	0.000	0.000	0.125	0.375	0.250	0.125	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8	8
CM_LL_E	1995	8,459	0.000	0.000	0.053	0.421	0.421	0.053	0.000	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19	19
CM_LL_E	1996	7,587	0.000	0.000	0.000	0.000	0.333	0.500	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6	6
CM_LL_E	1997	4,627	0.000	0.100	0.200	0.400	0.200	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10	10
CM_LL_E	1998	5,514	0.000	0.000	0.000	0.040	0.240	0.400	0.240	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	25	25
CM_LL_E	1999	6,474	0.000	0.000	0.020	0.363	0.304	0.196	0.088	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.010	102	102
CM_LL_E	2000	8,619	0.000	0.000	0.012	0.107	0.238	0.238	0.179	0.083	0.036	0.024	0.024	0.000	0.012	0.000	0.012	0.036	84	84
CM_LL_E	2001	10,130	0.000	0.000	0.022	0.099	0.308	0.352	0.165	0.022	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.011	91	91
CM_LL_E	2002	18,125	0.000	0.027	0.077	0.191	0.197	0.219	0.137	0.044	0.027	0.016	0.011	0.000	0.000	0.000	0.005	0.049	183	183
CM_LL_E	2003	13,853	0.000	0.005	0.076	0.239	0.168	0.223	0.102	0.066	0.046	0.015	0.010	0.005	0.000	0.010	0.010	0.025	197	197
CM_LL_E	2004	19,353	0.000	0.004	0.123	0.261	0.340	0.170	0.040	0.020	0.008	0.000	0.012	0.000	0.000	0.000	0.004	0.020	253	253
CM_LL_E	2005	21,121	0.000	0.000	0.032	0.173	0.338	0.341	0.092	0.017	0.000	0.003	0.000	0.000	0.003	0.000	0.000	0.000	346	346
CM_LL_E	2006	16,335	0.000	0.000	0.025	0.223	0.332	0.223	0.124	0.045	0.010	0.000	0.000	0.000	0.005	0.010	0.000	0.005	202	202
CM_LL_E	2007	15,727	0.000	0.036	0.099	0.260	0.265	0.197	0.085	0.040	0.013	0.004	0.000	0.000	0.000	0.000	0.000	0.000	223	223
CM_LL_E	2008	34,124	0.000	0.002	0.086	0.251	0.357	0.158	0.051	0.025	0.018	0.012	0.006	0.006	0.002	0.006	0.004	0.014	487	487
CM_LL_E	2009	14,627	0.000	0.004	0.088	0.392	0.268	0.196	0.020	0.008	0.016	0.000	0.000	0.000	0.004	0.000	0.000	0.004	250	250
CM_LL_E	2010	75,510	0.000	0.000	0.008	0.090	0.361	0.378	0.113	0.035	0.013	0.003	0.000	0.000	0.000	0.000	0.000	0.000	635	635
CM_LL_E	2011	84,286	0.000	0.000	0.013	0.111	0.353	0.332	0.141	0.032	0.016	0.000	0.003	0.000	0.000	0.000	0.000	0.000	377	377

B) COM LL WEST

Fishery	year	Landings	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	age 15+	N	EFF N
CM_LL_W	1991	72,592	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_LL_W	1992	19,820	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_LL_W	1993	20,291	0.000	0.034	0.931	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29	29
CM_LL_W	1994	15,809	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_LL_W	1995	17,506	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_LL_W	1996	27,362	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_LL_W	1997	31,418	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
CM_LL_W	1998	27,224	0.000	0.000	0.009	0.087	0.127	0.193	0.063	0.054	0.063	0.054	0.069	0.051	0.045	0.045	0.027	0.111	332	332
CM_LL_W	1999	90,572	0.000	0.000	0.263	0.539	0.118	0.066	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	76	76
CM_LL_W	2000	183,538	0.000	0.000	0.003	0.023	0.055	0.168	0.194	0.159	0.110	0.041	0.038	0.041	0.023	0.017	0.006	0.122	345	345
CM_LL_W	2001	124,453	0.000	0.000	0.000	0.017	0.061	0.240	0.179	0.117	0.078	0.073	0.039	0.039	0.028	0.022	0.017	0.089	179	179
CM_LL_W	2002	146,195	0.000	0.012	0.095	0.068	0.125	0.068	0.104	0.083	0.053	0.059	0.047	0.045	0.030	0.036	0.033	0.142	337	337
CM_LL_W	2003	171,270	0.000	0.000	0.000	0.004	0.004	0.039	0.039	0.135	0.116	0.073	0.073	0.081	0.066	0.046	0.050	0.274	259	259
CM_LL_W	2004	455,829	0.000	0.000	0.024	0.150	0.064	0.068	0.092	0.088	0.079	0.074	0.052	0.061	0.049	0.040	0.034	0.126	674	674
CM_LL_W	2005	282,789	0.000	0.000	0.003	0.046	0.118	0.155	0.118	0.128	0.082	0.079	0.043	0.043	0.072	0.036	0.020	0.056	304	304
CM_LL_W	2006	260,652	0.000	0.000	0.002	0.022	0.054	0.103	0.153	0.137	0.085	0.107	0.067	0.071	0.040	0.038	0.026	0.095	496	496
CM_LL_W	2007	188,503	0.000	0.000	0.006	0.043	0.085	0.211	0.179	0.100	0.088	0.060	0.068	0.017	0.031	0.011	0.028	0.071	351	351
CM_LL_W	2008	55,848	0.000	0.003	0.029	0.087	0.102	0.148	0.163	0.119	0.105	0.081	0.026	0.035	0.012	0.009	0.017	0.064	344	344
CM_LL_W	2009	51,766	0.000	0.000	0.007	0.048	0.111	0.103	0.081	0.074	0.181	0.111	0.074	0.033	0.026	0.044	0.022	0.085	271	271
CM_LL_W	2010	38,193	0.000	0.000	0.095	0.214	0.190	0.226	0.107	0.036	0.024	0.036	0.012	0.012	0.012	0.012	0.000	0.024	84	84
CM_LL_W	2011	18,850	0.000	0.000	0.000	0.214	0.286	0.214	0.143	0.071	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14	14

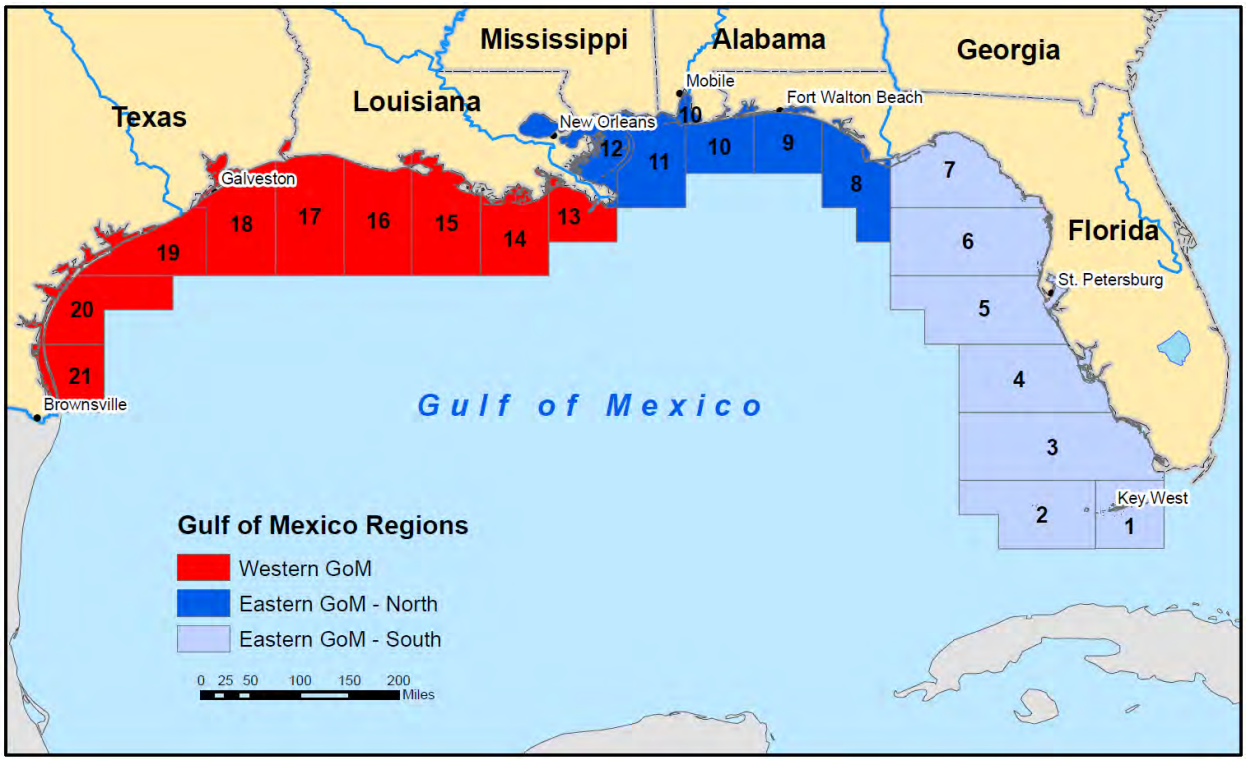


Figure 1. Statistical grids (fishing areas) used to define "REGION".

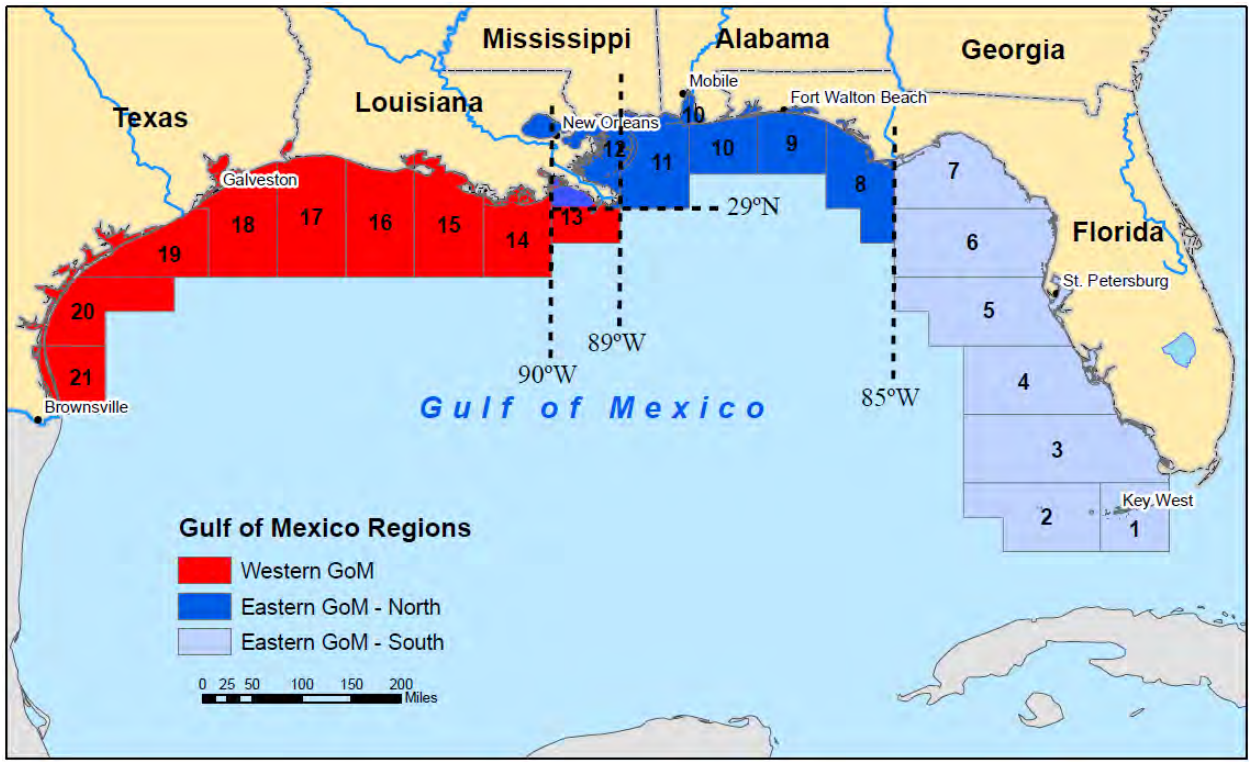


Figure 2. The use of longitude and latitude to define "REGION".

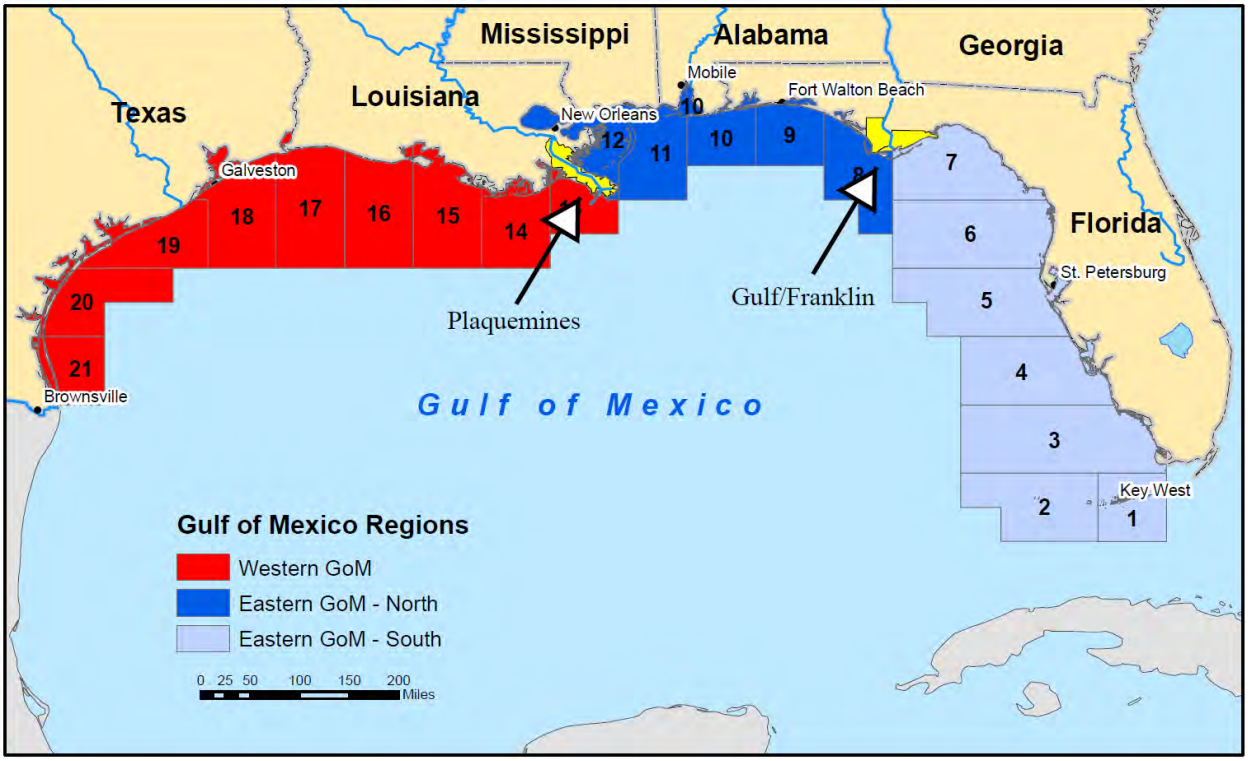


Figure 3. The use of "Location" and "County Landed" to define "REGION".

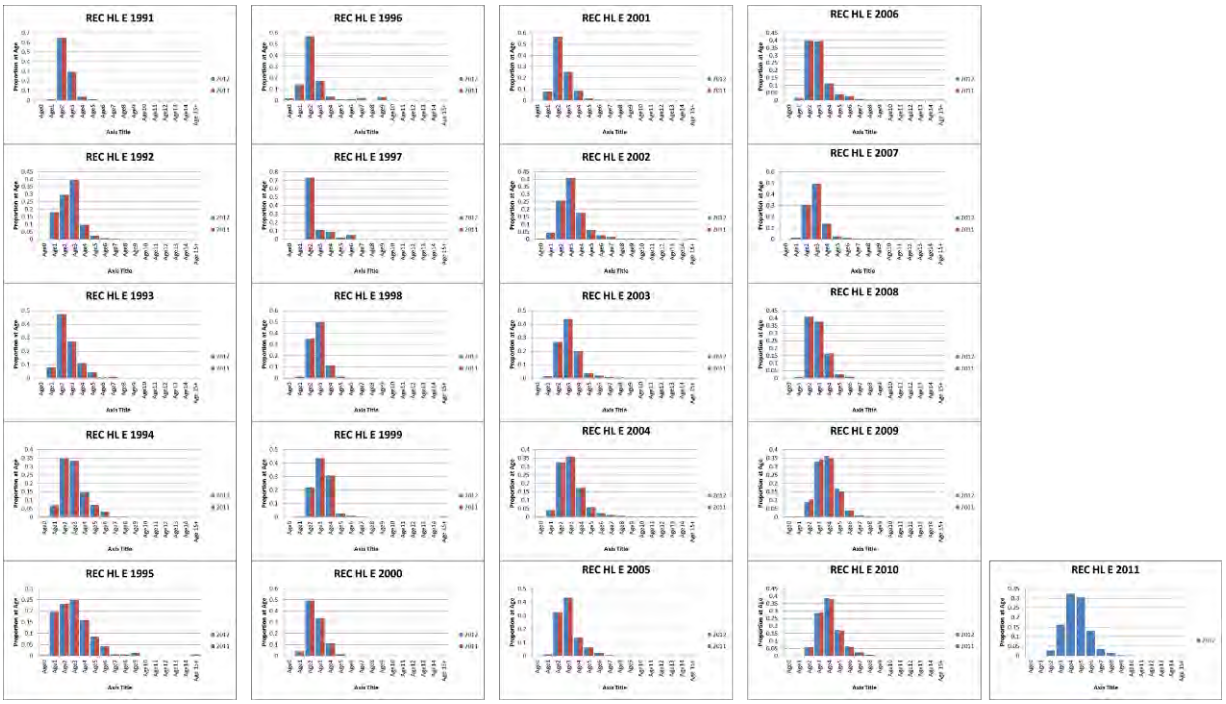


Figure 4. ***REC EAST***: Comparison of 2011 direct age composition (red) and the age composition developed for the 2012 red snapper data workshop (blue).

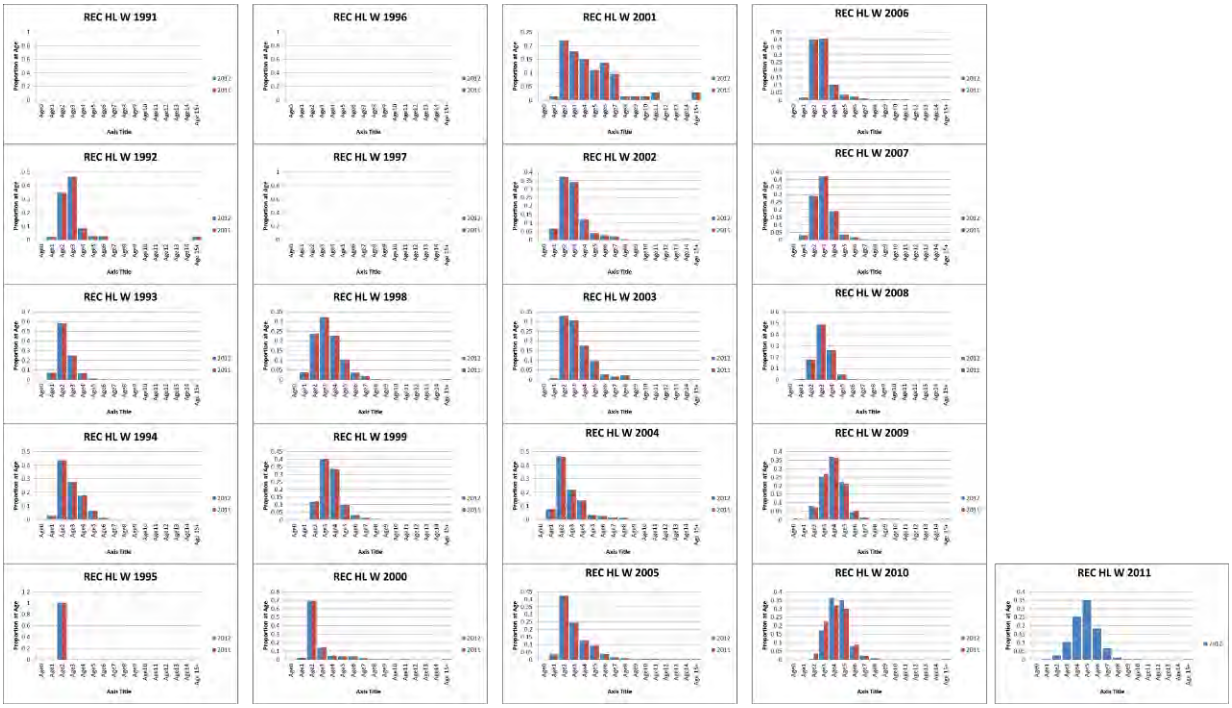


Figure 5. ***REC WEST***: Comparison of 2011 direct age composition (red) and the age composition developed for the 2012 red snapper data workshop (blue).

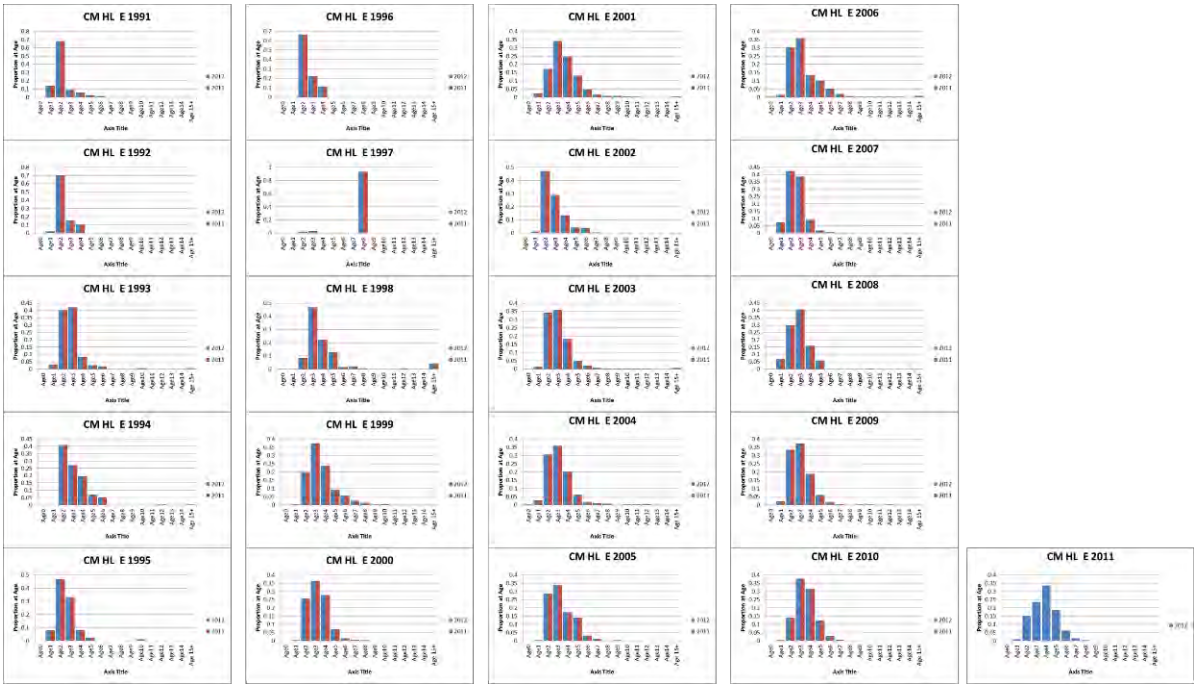


Figure 6. ***COM HL EAST***: Comparison of 2011 direct age composition (red) and the age composition developed for the 2012 red snapper data workshop (blue).

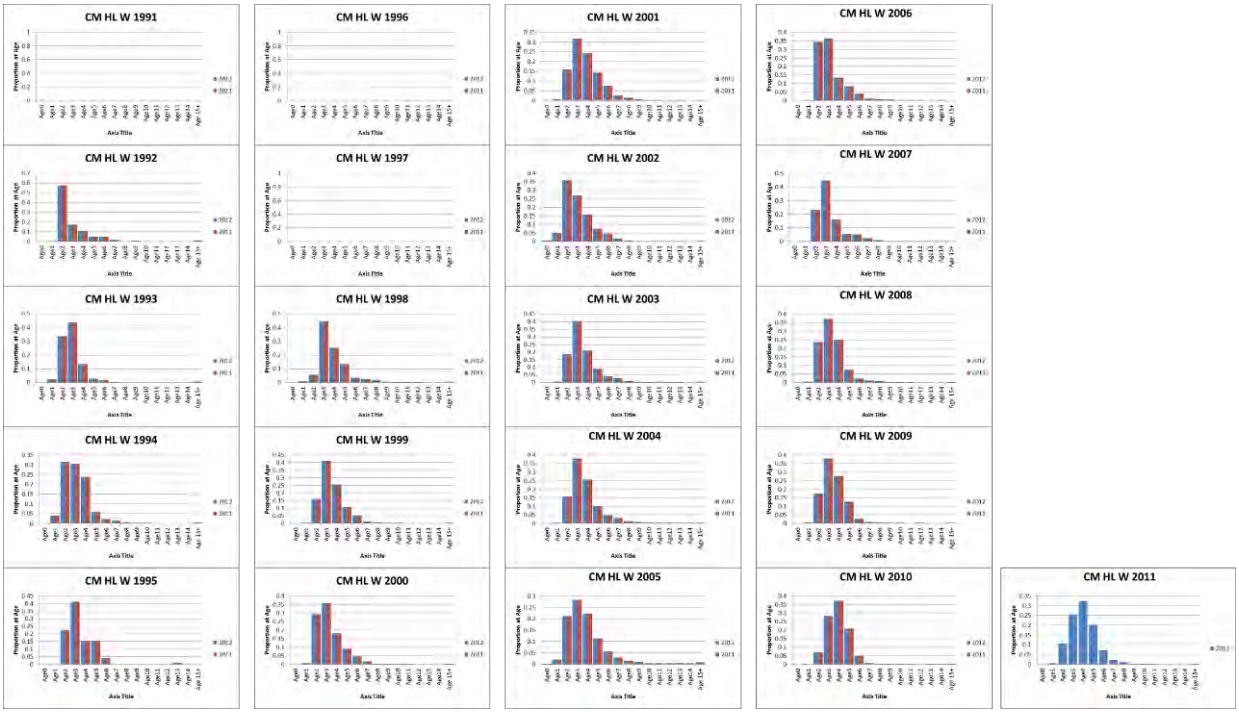


Figure 7. ***COM HL WEST***: Comparison of 2011 direct age composition (red) and the age composition developed for the 2012 red snapper data workshop (blue).

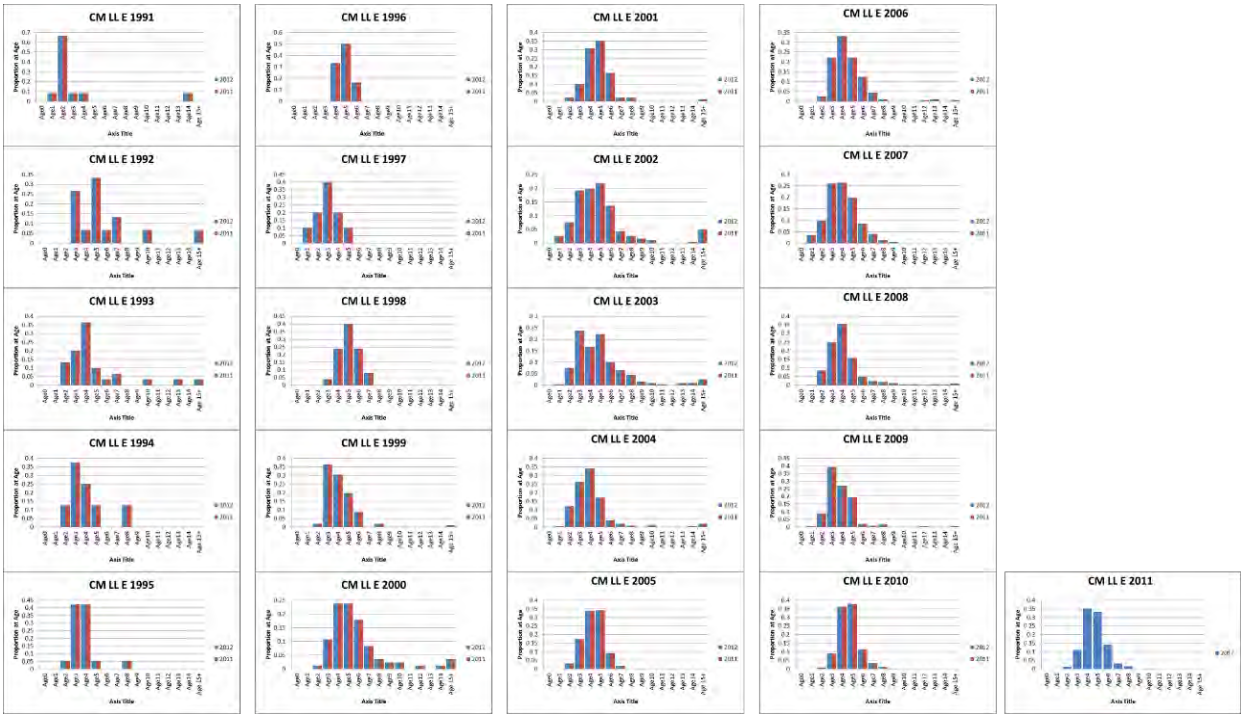


Figure 8. ***COM LL EAST***: Comparison of 2011 direct age composition (red) and the age composition developed for the 2012 red snapper data workshop (blue).

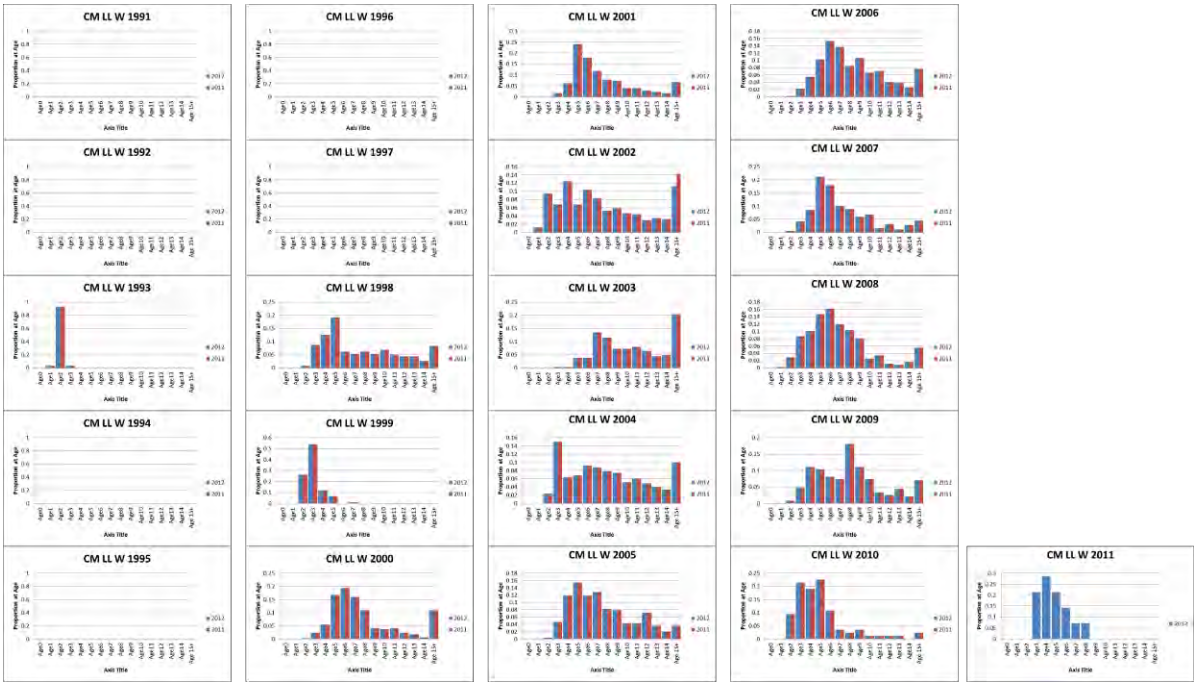


Figure 9. ***COM LL WEST***: Comparison of 2011 direct age composition (red) and the age composition developed for the 2012 red snapper data workshop (blue).

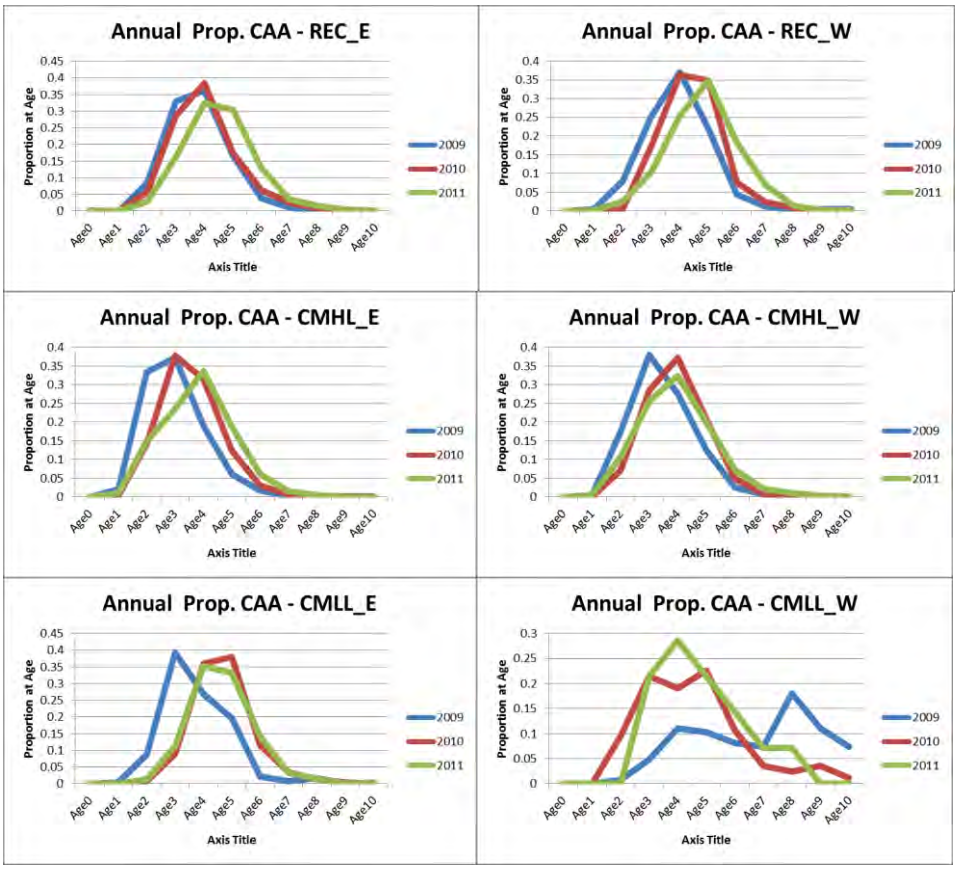


Figure 10. Recent direct observed age composition developed for the 2012 red snapper data workshop.

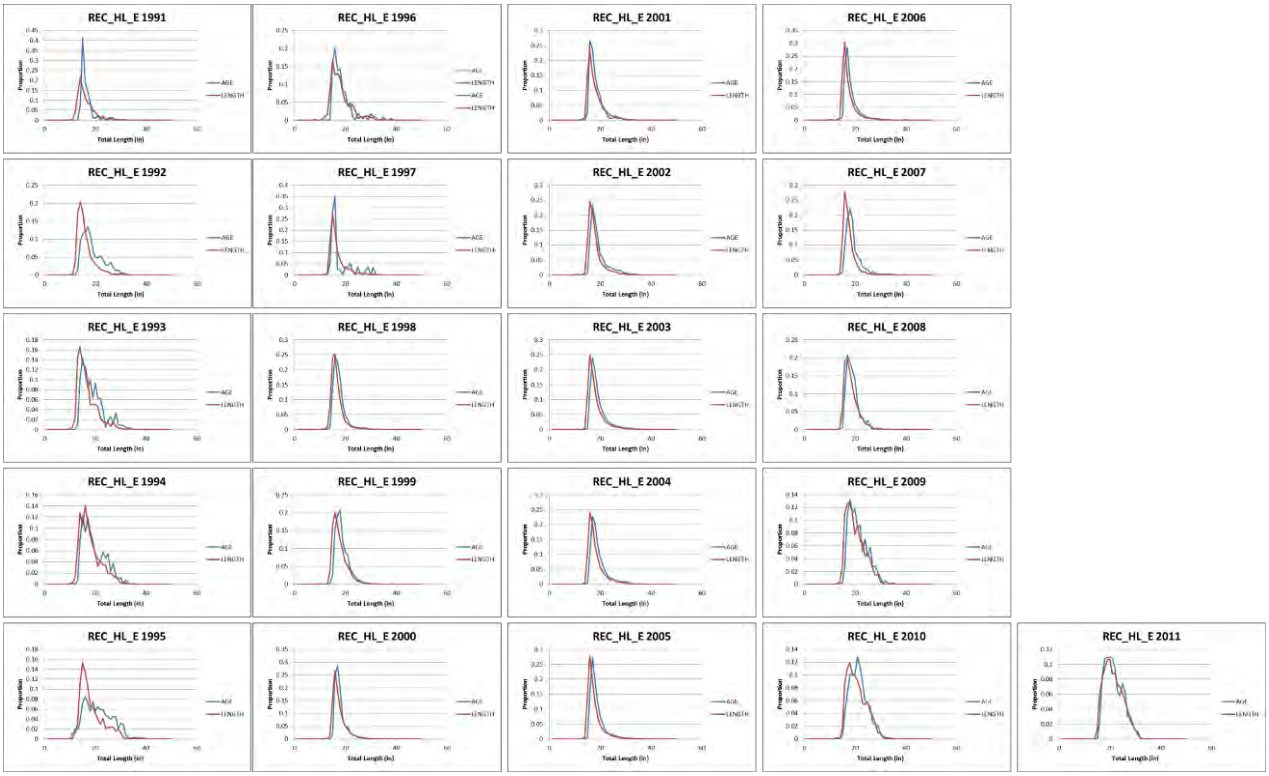


Figure 11. ***REC East:*** Comparison of the length distribution of all available samples versus those selected for otolith analysis.

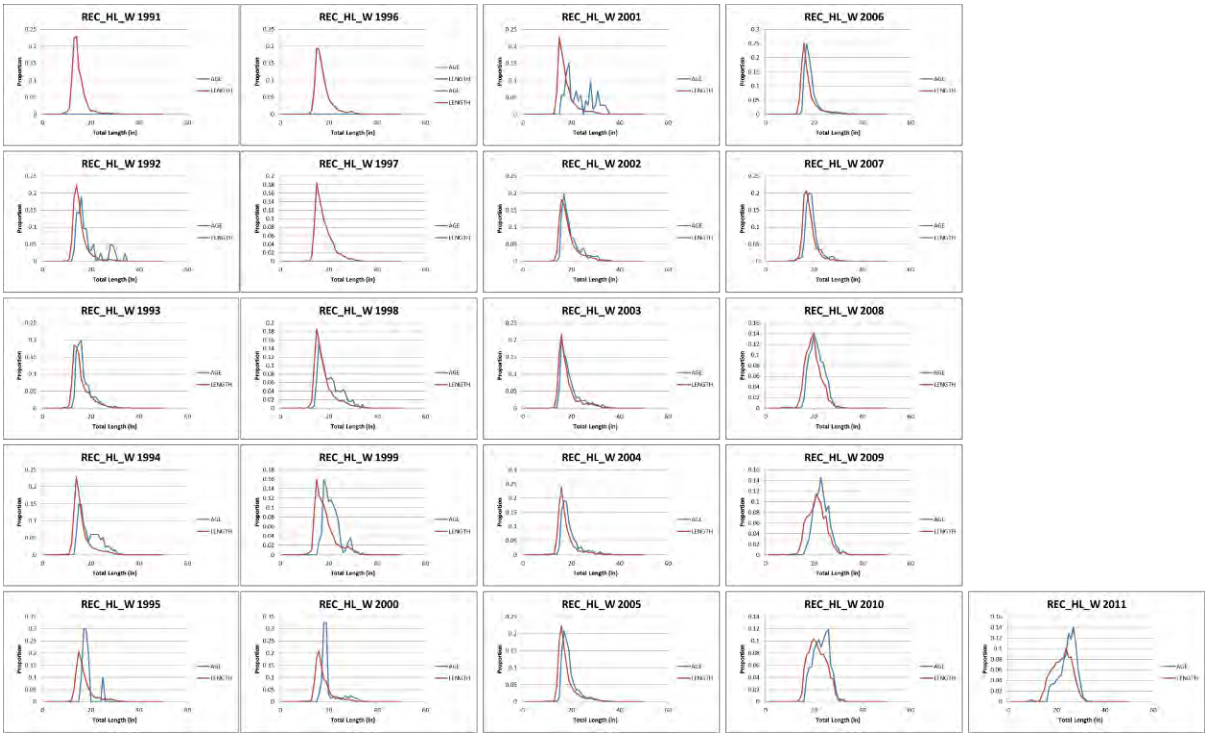


Figure 12. ***REC West:*** Comparison of the length distribution of all available samples versus those selected for otolith analysis.

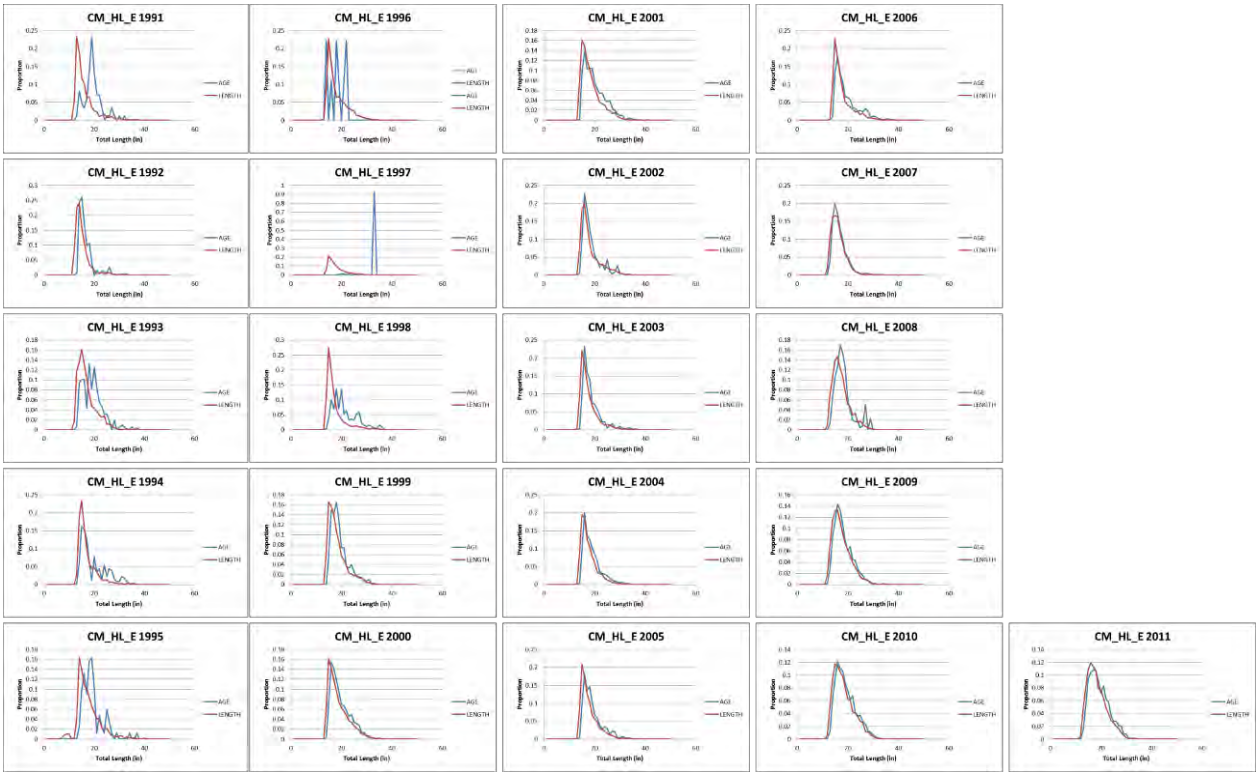


Figure 13. ***COM HL East:*** Comparison of the length distribution of all available samples versus those selected for otolith analysis.

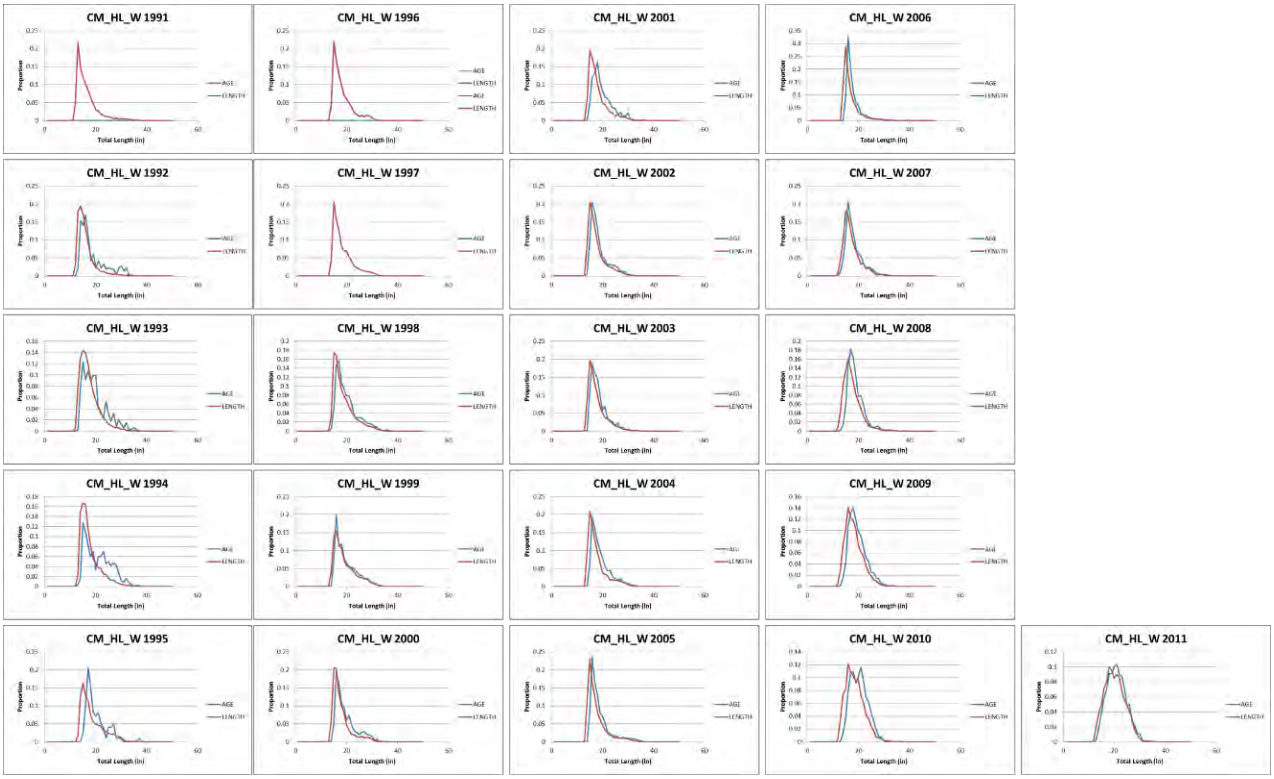


Figure 14. ***COM HL West:*** Comparison of the length distribution of all available samples versus those selected for otolith analysis.

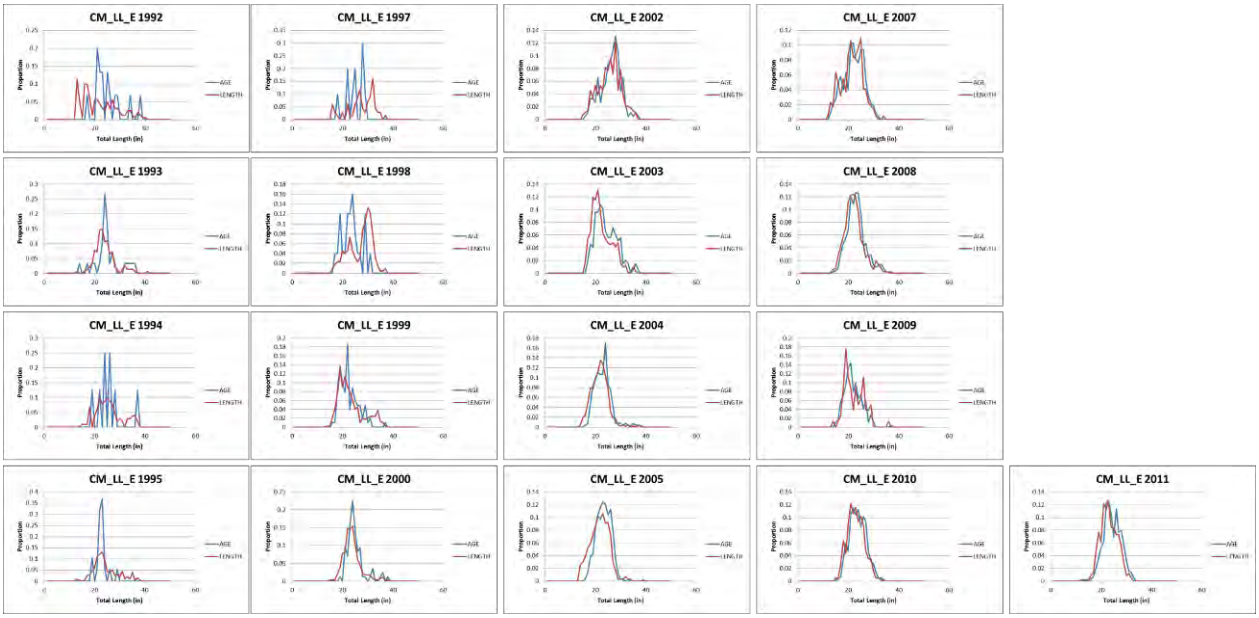


Figure 15. ***COM LL East:*** Comparison of the length distribution of all available samples versus those selected for otolith analysis.

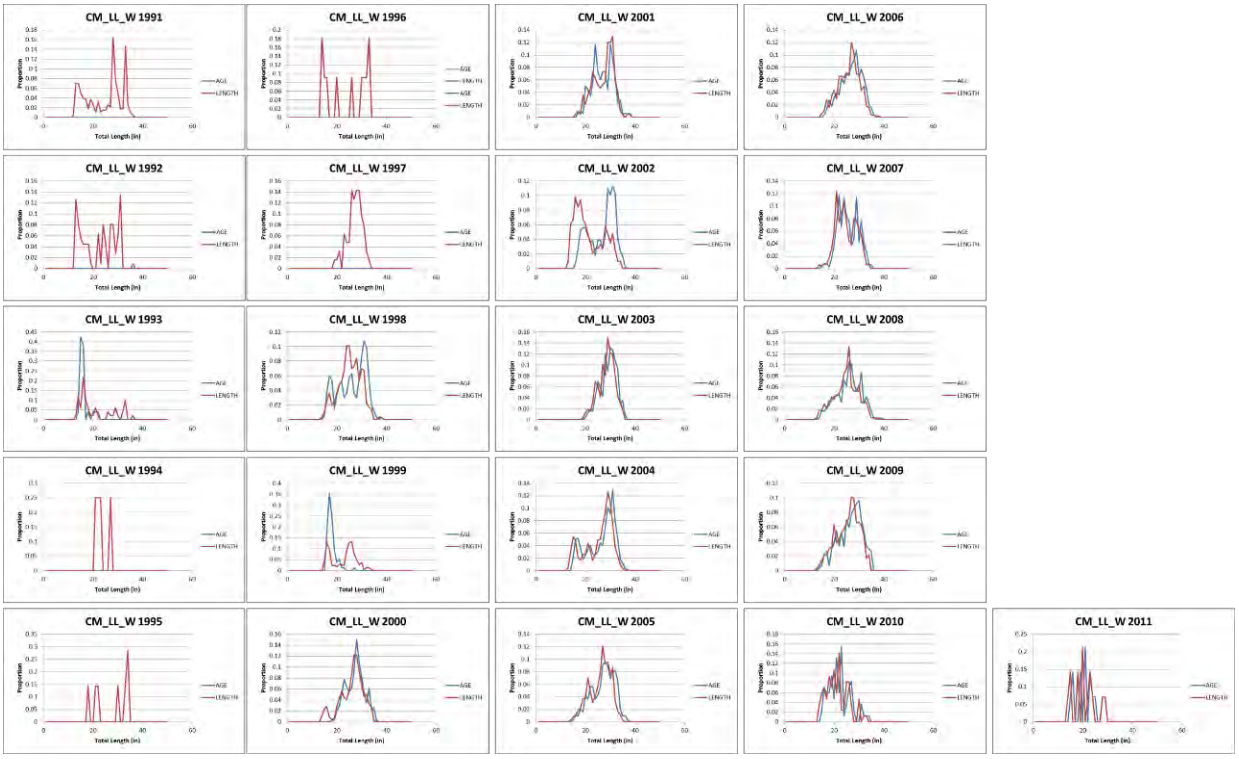


Figure 16. ***COM LL West:*** Comparison of the length distribution of all available samples versus those selected for otolith analysis.

4 Recreational Fishery Statistics

4.1 Overview

Recreational landings and discards of red snapper in the eastern and western Gulf of Mexico were compiled for the period 1981-2011 from federal and state databases. Sampling intensities of fish lengths by recreational fishing mode, Gulf region, and year were considered, and length frequency distributions were developed by year for east and west Gulf of Mexico red snapper. A summary of the issues discussed and data presented at the data workshop is included here.

4.1.1 Recreational Workgroup Members

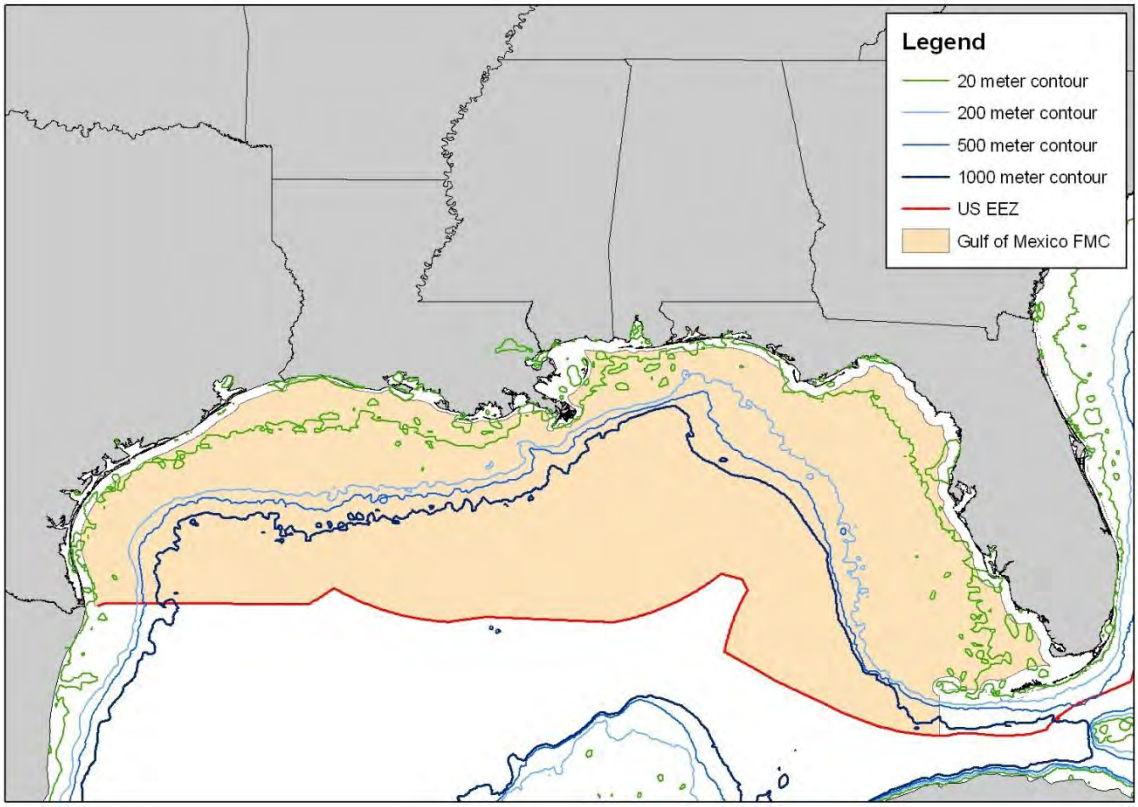
Barbara Dorf, Gulf SSC
Vivian Matter, NOAA Fisheries, Miami, FL
Adyan Rios, NOAA Fisheries, Miami, FL (leader)
Beverly Sauls, FL FWC, St. Petersburg, FL
Mike Thierry, Gulf Red Snapper AP
John Ward, Gulf SSC

4.1.2 Issues Discussed at the Data Workshop

The Workgroup discussed several issues that needed to be resolved before data could be compiled. The issues are listed below and are described in more detail in the following sections.

1) Calibration of Marine Recreational Fisheries Statistics Survey charterboat estimates (1981-1997).
2) Calibration of Marine Recreational Fisheries Statistics Survey estimates to Marine Recreational Information Program estimates (1981-2003).
3) Incorporating estimates of variance from the Texas Parks and Wildlife Department.
4) Use of shore mode estimates.
5) Adjustments and substitutions (1981-1985).
6) Estimating recreational landings in weight.
7) Estimating historical recreational landings (pre-1981).
8) Estimating discards for the Southeast Region Headboat Survey.
9) Estimating discards for the Texas Parks and Wildlife Department.

4.1.3 Gulf of Mexico Fishery Management Council Jurisdictional Boundaries



4.2 Review of Working Papers

The workgroup reviewed four working papers.

SEDAR31-DW4, *Recreational Survey Data for Red snapper in the Gulf of Mexico. Vivian M. Matter.*

This working paper presents recreational survey data for red snapper in the Gulf of Mexico from the Marine Recreational Fisheries Statistics Survey (MRFSS), the Marine Recreational Information Program (MRIP), the NMFS Southeast Region Headboat Survey (SRHS), and the Texas Parks and Wildlife Department (TPWD) survey. Issues addressed include the use of shore mode estimates, the calibration of MRFSS charterboat estimates back in time, 1981-1985 adjustments and substitutions, calibration of MRFSS estimates for 1981-2003 to MRIP estimates, estimating discards from the SRHS and TPWD, variance estimates from TPWD, and estimating recreational landings in weight from the surveys.

SEDAR31-DW11, *A Summary of Data on the Size Distribution and Release Condition of Red Snapper Discards from Recreational Fishery Surveys in the Gulf of Mexico. Beverly Sauls.*

This working paper presents a summary of available information on the size, release condition, and disposition of red snapper collected by trained observers since 2005 during at-sea surveys on for-hire vessels in the Gulf of Mexico. Additionally, a summary of information collected from a self-recruited volunteer angler catch card program is provided and compared to information collected from at-sea observer surveys.

SEDAR31-DW25, *Estimated Conversion Factors for Adjusting MRFSS Gulf of Mexico Red Snapper Catch Estimates and Variances in 1981-2003 to MRIP Estimates and Variances. Adyan Rios, Vivian M. Matter John F. Walter, Nicholas Farmer, and Stephen C. Turner.*

Ratio estimators were developed to appropriately adjust estimates from the Marine Recreational Fisheries Statistics Survey (MRFSS) to estimates from the Marine Recreational Information Program (MRIP). This working paper presents the adjusted catch and variances of red snapper in the Gulf of Mexico between 1981 and 2003.

SEDAR31-DW10, *Length frequency distributions for red snappers in the Gulf of Mexico from 1984-2011. Ching-Ping Chih.*

This working paper presents changes in length frequency distributions of samples collected from recreational fisheries in each the east and west Gulf of Mexico from 1992 to 2011.

4.3 Recreational Landings

A map and figures summarizing all recreational landings of red snapper in the Gulf of Mexico are provided in Figure 4.11.1.

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 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 charterboat 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 size in the dockside intercept portion have been increased over time to improve precision of catch estimates. 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. Catch rate data have improved through increased sample quotas and additional sampling (requested and funded by the states) to the intercept portion of the survey. 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 pilot tested in the Gulf of Mexico in 1998 and officially adopted in 2000. 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, etc). As a result of the Deepwater Horizon oil spill in April 2010, the MRFSS/MRIP For-Hire Survey increased sampling rates of charterboat vessel operators from 10% to 40% from May, 2010 through June 2011.

Calibration of traditional MRFSS charterboat estimates

Conversion factors have been estimated to calibrate the traditional MRFSS charterboat estimates with the FHS for 1986-1997 in the Gulf of Mexico (SEDAR7-AW-03). The relationship between the old charterboat 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, the period of 1981-1985 could not be calibrated with the same ratios developed for 1986+ because in the earlier 1981-1985 time period, MRFSS considered charterboat and headboat as a single combined mode. 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 charterboat and headboat mode effort estimates in 1981-1985, conversion factors were estimated

using 1986-1990 effort estimates from both modes, in equivalent effort units, an angler trip (SEDAR28-DW-12). These calibration factors were applied to the charterboat estimates and are tabulated in SEDAR31-DW-04.

MRIP weighted estimates and the calibration of MRFSS estimates
The Marine Recreational Information Program (MRIP) was implemented in 2004. The 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 this improved estimation method, were released on January 25, 2012. These estimates are available for the Atlantic and Gulf Coasts for 2004 through 2011.

Since new MRIP estimates are available for a portion of the recreational time series that the MRFSS covers, conversion factors between the MRFSS estimates and the MRIP 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 snapper to hind-cast catch and variance estimates by fishing mode. In order to apply the charterboat ratio estimator back in time to 1981, charterboat landings were isolated from the combined cbt/hbt mode for 1981-1985. The MRFSS to MRIP calibration process is detailed in SEDAR31-DW25.

Calculating landings estimates in weight
The MRFSS and the MRIP surveys use different methodologies for estimating landings in weight. In order to maintain consistency over the entire time frame, the Southeast Fisheries Science Center (SEFSC) has developed a standardized approach for calculating average weight that can be applied to the MRIP (or MRIP adjusted) landings in number for all years. This method has been used in the past for filling in MRFSS weight estimates when they were missing (I.e. when there was an estimate of landings in number but not in weight due to missing weight samples in a given strata). The SEFSC method uses the MRFSS/MRIP sample data to obtain an average weight using the following hierarchy: species, region, year, state, mode, wave, and area (SEDAR22-DW16). The minimum number of weights used at each level of substitution is 30 fish, except for the final species level, where the minimum is 1 fish. In cases where the sample data include a length but not a weight, the length-weight equation from SEDAR 7 was used to convert those lengths to weights (W=0.000662*(L^2.9970) where W is whole weight in pounds and L is fork length in inches). Average weights were then multiplied by the landings estimates in numbers to obtain estimates of landings in weight. These estimates are provided in pounds whole weight.

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 10 gag grouper and SEDAR 12 Gulf red grouper).

Texas
Texas data from the MRFSS is only available from 1981-1985 and is sporadic, not covering all modes and waves. For these reasons, Texas boat mode estimates from the MRFSS were not included. Instead, TPWD data, which covers charter and private modes, were used to fill in theses modes prior to the start of the TPWD survey in May 1983. This methodology is consistent with past SEDARs (e.g. SEDAR 16 king mackerel, SEDAR 28 Spanish mackerel).

Shore mode
The workgroup discussed the validity of the shore mode estimates generated by MRFSS/MRIP. The intercept data that led to these estimates mainly came from Monroe County, FL and places where one would not expect to intercept red snapper. These red snapper intercepts were most likely the result of misclassification. The workgroup recommended that all shore mode estimates be excluded.

MRIP landings in numbers of fish and in whole weight in pounds by Gulf region are presented in Table 4.10.1. CVs associated with estimated landings in numbers are also shown.

4.3.2 Southeast Region Headboat Survey

Introduction
The Southeast Region Headboat Survey (SRHS) estimates landings and effort for headboats in the Gulf of Mexico. The SRHS began in the Gulf of Mexico in 1986 and extends from Naples, FL to South Padre Island, TX. The South Atlantic and Gulf of Mexico Headboat Surveys generally include 70-80 vessels participating in each region annually. The Headboat Survey incorporates two components for estimating catch and effort. (1) Information about the size of fishes 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 mean weights for all species by area and month. Port samplers also collect otoliths for ageing studies during dockside sampling events. (2) Information about total catch and effort are collected via the logbook, a form filled out by vessel personnel and containing total catch and effort data for individual trips. The logbooks are summarized by vessel to generate estimated landings by species, area, and time strata. The SRHS does not generate variances of the landings estimates.

The Headboat Survey was inconsistent in LA in 2002-2006. 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 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 2006 there were no trip reports or fish sampled, and no substitutes were used, so there are no estimates or samples from 2004 to 2006 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.

The SRHS began operating in Mississippi (area 28) in 2010. Headboat data for red snapper from the Dry Tortugas, FL and west (areas 18-28) were included as part of Gulf of Mexico.
Texas headboat estimates 1981-1985

Headboat landings estimates by mode from 1981-1985 come from the MRFSS/MRIP survey for all states except Texas. The standard method used in past SEDARs (e.g. SEDAR 28 Spanish mackerel and cobia) is to use the average Texas headboat mode estimates from SRHS from 1986-1988 to fill in the missing years.

SRHS landings in numbers of fish and in whole weight in pounds by Gulf region are presented in Table 4.10.2.

4.3.3 Texas Parks and Wildlife Department

Introduction

The TPWD Sport-boat Angling Survey was implemented in May 1983 and samples fishing trips made by sport-boat anglers fishing in Texas marine waters. All sampling takes place at recreational boat access sites. The raw data include information on catch, effort and length composition of the catch for sampled boat-trips. These data are used by TPWD to generate recreational catch and effort estimates. The survey is designed to estimate landings and effort by high-use (May 15-November 20) and low-use seasons (November 21-May 14). SEFSC personnel disaggregated the TPWD seasonal estimates into waves (2 month periods) using the TPWD intercept data. This was done to make the TPWD time series compatible with the MRFSS/MRIP time series. TPWD surveys private and charterboat fishing trips. While TPWD samples all trips (private, charterboat, ocean, bay/pass), most of the sampled trips are associated with private boats fishing in bay/pass, as these trips represent most of the fishing effort. Charterboat trips in ocean waters are the least encountered in the survey.

Producing landings estimates in weight

In the TPWD survey, landings estimates are produced only in number of fish. In addition, the TPWD sample data does not provide weights, only lengths of the intercepted fish. Because TPWD length samples are measured as maximum possible total lengths, a TPWD length-weight equation for red snapper (W=10^(-5.242 +(3.145*log10(L))) where W is gutted weight in grams and L is maximum total length in mm) was used to convert lengths to weights (Green and Campbell 2005). The SEFSC method (described above) was applied to the TPWD landings to obtain estimated landings in weight.

1981-1983 Texas estimates

The TPWD survey began with the high-use season in 1983 (May15, 1983). Texas charter and private mode estimates do not exist from the start of 1981 to May of 1983. Averages from TPWD 1983-1985 by mode and wave were used to fill in the missing estimates.

2011 incomplete year

Data from 2011 is only through the 2011 TPWD high-use season (November 20th). Comparing seasonal estimates to wave estimates for 2000-2010, revealed that relatively few landings came from Nov 21-Dec 31. As such, the workgroup recommended that 2011 be accepted as a complete year.

Variances
Recently, TPWD has provided NMFS with standard errors associated with their seasonal estimates. Although the variances derived from these standard errors apply only to the seasonal TPWD seasonal and do not match up exactly to the TPWD wave estimates, this information provides a measure of the uncertainty of the TPWD estimates. The workgroup recommended using these TPWD variances.

TPWD landings in numbers of fish and in whole weight in pounds for Texas are presented in Table 4.10.3. CVs associated with estimated landings in numbers are also shown.

4.3.4 Estimating Historical Recreational Landings

The historic time period for red snapper landings in the Gulf of Mexico is defined as pre-1981, and prior to the start of the Marine Recreational Fisheries Statistics Survey (MRFSS). The recreational workgroup was tasked with evaluating potential sources and methods to compile landings of red snapper prior to the available time series of MRFSS/MRIP estimated landings. The workgroup reviewed the following two methods for estimating historical landings:

1) Coastal Census Method outlined in SEDAR31-RD46.
2) The U.S. Fish and Wildlife Service, National Survey of Fishing, Hunting and Wildlife-Associated Recreation (FHWAR) Survey Method outlined in SEDAR31-RD25.

Coastal Census Method
The coastal census method by Scott (SEDAR31-RD46) was used to estimate historical catch of red snapper in SEDAR 7. This method uses general linear models (GLMs) by Gulf region using data from 1981-2003 (Figure 4.11.2). The variables in each GLM include state, human population from coastal counties, fishing mode, and year class strength from SEAMAP surveys.

The workgroup rejected this method for three reasons. (1) The workgroup was not comfortable carrying back an average value of year class strength for all years prior to 1987. (2) The workgroup considered coastal counties as an arbitrary selection of counties. (3) The workgroup was uneasy with the choice of human population as a proxy for recreational red snapper landings.

FHWAR Survey Method
The FHWAR Survey Method by Brennan and Fitzpatrick (SEDAR31-RD25) was used to estimate historical catch of Spanish mackerel and cobia in SEDAR 28. The FHWAR method uses the FHWAR survey data of total US anglers, total US anglers by region, and total saltwater days to estimate regional saltwater effort. Total saltwater effort is then multiplied by an average CPUE calculated from the early years of MRFSS/MRIP data for each region. Due to an incomplete spatial overlap of available landings and effort data for red snapper during 1981-1985, the FHWAR method was modified to estimate landings by Gulf region and to use average estimates of CPUE calculated from 1986-1990 (Figure 4.11.3).

The workgroup had two main concerns associated with the FHWAR Survey Method. (1) The workgroup concluded that the effort estimates, based on national ratios to determine total

saltwater historical effort, did not accurately capture the emergence of the offshore headboat fishery in the Gulf of Mexico. (2) The workgroup found it inappropriate to use an average CPUE over the entire historical time series, as CPUE is known to have changed due to factors such as technological advances and changes in fleet behavior. Participants at the data workshop agreed that the FHWAR Method was preferable to the Coastal Census Method, but also that further improvements to this method should be explored.

Additional Methods to Be Explored
The workgroup recommended that its members continue to explore existing and new methods for estimating historical landings of red snapper in the Gulf of Mexico. In order to accurately get at historical effort for the headboat fishery, suggestions included tracking consumables (gas, ice, bait) to develop price indices along the coast. Another suggestion was to compile trip frequency, and average trip information for the Gulf of Mexico headboat fishery from available literature, similar to what was done for red grouper in 2006 by Walter (SEDAR12-DW15).

4.4 Recreational Discards

A map and figures summarizing all recreational discards of red snapper in the Gulf of Mexico are provided in Figure 4.11.4.

4.4.1 MRFSS/MRIP discards

Discarded live fish are reported by the anglers interviewed by the MRIP/MRFSS, so both the identity and quantities reported are unverified. Furthermore, discarded fish sizes are unknown for all fishing modes sampled by the MRFSS/MRIP. As such, lengths and weights of discarded fish are not estimated by the survey.

To characterize the size distribution of live discarded fishes, at-sea sampling of headboat discards was initiated was initiated in Alabama in 2004 and expanded to FLW in 2005 as part of the improved for-hire survey.

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

MRIP discards in numbers of fish and associated CVs by Gulf region are presented in Table 4.10.4.

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”. These self-reported data are currently not validated within the Headboat Survey.

The SRHS discard ratios were compared with the At-Sea Observer Data discard ratios in order to assess the validity of these discard estimates. In Alabama and West Florida, the observer data discard ratios were far greater than those reported by the SRHS for 2004-2007.

A recommendation for estimating SHRS discard ratios was presented and approved at the post-data workshop webinar. The recommendation was to use discard rates from SRHS headboats with consistent patterns of reporting for 2004-2011, and to scale the resulting rates using observer data. To hind-cast headboat rates for 1981-2003, the recommendation was to use data from MRIP as a proxy. The MRIP proxy will be developed from the mode or modes (charterboat, private, or both) whose discard rates have the strongest positive correlation to the 2004-2011 headboat discard rates. After obtaining a full time series of headboat discard rates for each region (east and west) and by open/closed seasons, the rates will be applied to landings to obtain total discards. These discard rates and resulting discards will be tabulated in an assessment working paper.

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. Observer surveys were conducted in Alabama from 2004 to 2007, and in West Florida from 2005-2007 and 2009-2011. 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 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. In the Florida Keys (sub-region 3) some vessels that ran trips longer than 24 hours were also sampled to collect information on trips that fish farther from shore and for longer periods of time, primarily in the vicinity of the Dry Tortugas.

4.4.4 Texas Parks and Wildlife Department Discards

The TPWD recreational survey does not estimate discards. The recreational workgroup evaluated available data and recommended that the MRFSS/MRIP discard ratios from Louisiana by year and mode (charter and private) be applied to the TPWD landings to estimate discards from Texas.

Discards in numbers of fish for Texas are presented in Table 4.10.5.

4.5 Biological Sampling

Length samples from recreational landings were obtained from the Marine Recreational Fisheries Statistics Survey, the Southeast Region Headboat Survey, the Texas Parks and Wildlife Department, the Fisheries Information Network, and the Trip Interview Program. Additionally, length data were available from observer programs operating in Florida, Alabama, and Louisiana. The years of observer coverage and the number of trips observed are described in Sauls (SEDAR-DW11).

4.5.1 Sampling Intensity

Sampling proportions of recreational landings by all modes combined are presented in Ping (SEDAR31-DW10).

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 preferred when time is constrained. Ageing 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 red snapper measured or weighed in the Gulf of Mexico (FLW-TX) from MRFSS/MRIP by year, mode, and state are summarized in Table 4.10.6. The number of angler trips with measured or weighed red snapper in the Gulf of Mexico (FLW-TX) in the MRFSS/MRIP charter fleet and private-rental mode are summarized in Matter (SEDAR31-DW04).

Headboat Survey Biological Sampling
Lengths were collected from 1986 to 2011 by headboat dockside samplers in the Gulf of Mexico, in all of the coastal Gulf states except Mississippi, where sampling started 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. Number of red snapper measured for length in the headboat fleet by year is presented in Table 4.10.7. Numbers of trips from which red snapper were measured are summarized in Matter (SEDAR31-DW04).

Texas Parks and Wildlife Department Biological Sampling
The TPWD Sport-boat Angling Survey samples fishing trips made by sport-boat anglers fishing in Texas marine waters. All sampling takes place at recreational boat access sites. Length composition of the catch for sampled boat-trips has been collected since the high-season of 1983 (mid-May). Total length is measured by compressing the caudal fin lobes dorsoventrally to obtain the maximum possible total length. Weights of sampled fish are not recorded.

The number of red snapper measured in the TPWD charter and private-rental modes are summarized by year in Table 4.10.8. The number of trips with measured red snapper in the TPWD charter and private-rental modes are summarized in Matter (SEDAR31-DW04).

Observer Programs
Numbers of sampled red snapper on observed headboat trips in Florida and Alabama, and on observed charterboat trips in Florida are presented in Sauls (SEDAR31-DW11). Biological samples such as scales, otoliths, spines, stomachs and gonads, are not typically collected as part of this protocol.

4.5.2 Length Distributions

Length freq histograms from SEDAR31-DW10 are reproduced in Figures 4.11.5 and 4.11.6.

Recreational Landings
Length frequencies from recreational landings were calculated by year (1992 to 2011), by season (4 month period), and by Gulf region. These recreational length data were grouped by Gulf region (east and west). The eastern Gulf included Florida, Alabama and Mississippi, and the western Gulf included Louisiana and Texas. Detailed methods and proportions of each length by year and region are available in Ping (SEDAR31-DW10).

Changes in length frequency distributions were analyzed to examine the possible changes in selectivity-on-size. Changes in length frequency distributions appear to coincide with changes in fishing regulations and fishing behavior. Noticeable differences were found in the length frequency distributions of recreational length samples collected after 2007, when the bag limits per person per boat was cut from 4 to 2. These differences may indicate a change in selectivity-on-size due to the changes in fishing regulations (SEDAR31-DW10).

Observer Programs
Length frequency histograms for harvested and discarded red snapper by year for Florida headboats, Florida charterboats, Alabama headboats, and Texas charterboats are presented in Sauls (SEDAR31-DW11).

Length frequency distributions from observed headboat data in Florida also showed an increase in the proportion of larger fish caught in 2009-2011 compared to 2005-2007 (SEDAR31-DW11).

4.5.3 Recreational Catch-at-Age

Catch-at-age matrices were developed from direct observed age composition. The methods and resulting matrices are reported in Appendix B. A summary of the findings associated with the age composition of recreational red snapper sampled in the Gulf of Mexico follows.

Catch at age matrices developed in 2012 were nearly identical to those previously reported. However, a comparison of length composition of fish chosen for otolith analysis to that of the lengths of all samples revealed evidence of non-representative sampling prior to 2000, and missing length composition data during 2009-2011. A revised analysis will be completed prior to the assessment workshop to include additional length composition data (Appendix B).

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 and TPWD effort in angler trips are included in Figure 4.11.7. A map and figures summarizing SRHS effort in angler days are included in Figure 4.11.8.

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 (charterboat 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). Angler trip estimates are tabulated in Table 4.10.9 by year and Gulf region. An angler-trip is a single day of fishing in the specified mode, not to exceed 24 hours. Both Texas and shore mode effort estimates have been excluded from the MRFSS/MRIP estimates since these strata were excluded from the landings estimates of red snapper.

4.6.2 Headboat Effort

Headboats report catch and effort data for each trip via the SHRS logbooks. A vessel's captain or designated crew member completes a logbook form for each trip. The form details the total number and weight of all the species kept, along with the total number of fish discarded for each species. Numbers of anglers on a given trip represents the measure of effort reported in the SRHS logbooks. 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). This standardization assumes that all anglers fished the entire time. 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 by month and area, along with estimates of effort.

Estimated headboat angler days are tabulated in Table 4.10.10. Estimated headboat angler days have decreased in the Gulf of Mexico in recent years. The most obvious factor which impacted the headboat fishery in both the Atlantic and Gulf of Mexico was the high price of fuel. This coupled with the economic down, turn starting in 2008, has resulted in a marked decline in angler days in the 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 Gulf of Mexico in 2010, the year of the Deepwater Horizon oil spill.

4.6.3 Texas Parks and Wildlife Effort

The TPWD survey is designed to estimate landings and effort by high-use (May 15-November 20) and low-use seasons (November 21-May 14). Only private and charterboat fishing modes are surveyed. Most of the sampled trips are from private boats fishing in bay/pass because these represent most of the fishing effort, but all trips (private, charterboat, ocean, bay/pass) are sampled. Charterboat trips in ocean waters are the least encountered in the survey. Estimates of TPWD angler trips are shown in Table 4.10.11 by year, season, and mode.

4.7 Tasks to Be Completed

1) Task: Estimate headboat discards using methods described in Section 4.4.2.
   Responsibility: Vivian Matter, NOAA Fisheries
   Expected Completion Date: To be tabulated in an Assessment Workshop working paper.
2) Task: Explore existing and new methods for estimating historical recreational landings.
   Responsibility: Adyan Rios, NOAA Fisheries
   Expected Completion Date: To be developed into an Assessment Workshop working paper.

4.8 Research Recommendations

1) Evaluate the technique used to apply sample weights to landings. Investigate the SEFSC Method by analyzing the order of variables in the hierarchy and the minimum number of fish used. Furthermore, evaluate alternative methods, including a meta-analysis of the existing information from difference sources, areas, states, surveys, etc. that could be performed.
2) Develop methods to identify angler preference and targeted effort. Require a reef fish stamp for anglers targeting reef fish, pelagic stamp for migratory species, and deep-water complex stamp for deep-water species. The program would be similar to the federal duck stamp required of hunters and could help managers identify what anglers were fishing for.
3) Continue and expand fishery dependent at sea observer surveys to collect discard information. This would help to validate self-reported headboat discard rates.
4) Track Texas commercial and recreational discards.
5) Estimate variances associated with the headboat program.
6) Evaluate existing and new methods to estimate historical landings. Hind-casting of red snapper landings is complicated by a lack of reliable historical effort data. To get at estimating historical effort, analysts could track consumables (gas, ice, bait) to develop price indices.
7) Investigate how CPUE changes over time due to technological advances and changes in fishing practices.

4.9 Literature Cited

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4.10 Tables

Table 4.10.1. Gulf of Mexico (FLW-LA) red snapper landings (numbers of fish and whole weight in pounds) from MRIP by year and Gulf region. Estimates from 1981-2003 have been adjusted to MRIP numbers. *CVs for 1981-1985 only reflect the private mode CVs, since charter and headboat mode CVs are unavailable.

	East			West			Total Gulf		
YEAR	Number	CV_num	Weight (lbs)	Number	CV_num	Weight (lbs)	Number	CV_num	Weight (lbs)
1981	848,594	0.46*	1,456,721	1,384,112	0.55*	2,778,388	2,232,706	0.38*	4,235,109
1982	868,222	0.50*	1,716,769	1,052,602	0.23*	1,672,942	1,920,824	0.26*	3,389,710
1983	1,083,191	0.17*	1,947,352	1,834,671	0.35*	2,630,776	2,917,863	0.23*	4,578,128
1984	186,546	0.28*	405,824	651,177	0.18*	2,352,335	837,723	0.15*	2,758,159
1985	490,367	0.21*	942,058	517,021	0.14*	1,367,201	1,007,388	0.13*	2,309,259
1986	558,466	0.24	1,881,787	269,493	0.32	496,234	827,960	0.19	2,378,021
1987	538,002	0.30	1,089,945	117,316	0.49	217,516	655,318	0.26	1,307,461
1988	509,493	0.27	1,185,811	248,104	0.32	817,542	757,597	0.21	2,003,354
1989	462,519	0.44	1,008,082	194,983	0.48	566,098	657,502	0.34	1,574,180
1990	305,131	0.29	783,510	103,483	0.68	204,773	408,613	0.28	988,283
1991	533,087	0.23	1,200,588	214,000	0.69	735,422	747,087	0.26	1,936,010
1992	830,961	0.18	2,115,316	283,851	0.31	832,673	1,114,812	0.15	2,947,989
1993	1,235,076	0.18	3,423,992	369,889	0.34	1,219,021	1,604,965	0.16	4,643,013
1994	772,832	0.16	2,632,008	224,480	0.34	902,448	997,312	0.15	3,534,456
1995	617,484	0.23	1,962,004	288,724	0.38	1,149,264	906,208	0.20	3,111,268
1996	570,569	0.23	2,362,141	156,415	0.51	606,334	726,984	0.21	2,968,474
1997	961,781	0.21	3,458,577	168,344	0.34	820,190	1,130,124	0.18	4,278,766
1998	754,329	0.08	2,331,406	114,799	0.38	509,110	869,127	0.09	2,840,516
1999	721,883	0.11	2,797,578	91,976	0.33	557,182	813,858	0.11	3,354,760
2000	697,981	0.11	2,449,054	104,877	0.39	682,569	802,858	0.11	3,131,624
2001	833,129	0.12	3,499,414	58,959	0.59	217,017	892,088	0.12	3,716,430
2002	1,108,290	0.09	4,247,380	49,195	0.32	289,474	1,157,486	0.09	4,536,854
2003	967,577	0.12	3,839,526	74,244	0.33	416,761	1,041,822	0.12	4,256,287
2004	1,190,622	0.13	4,396,367	88,405	0.15	316,965	1,279,027	0.12	4,713,332
2005	724,663	0.10	2,753,276	110,503	0.19	471,898	835,166	0.09	3,225,174
2006	793,646	0.10	2,640,826	172,934	0.17	598,502	966,580	0.08	3,239,328
2007	1,064,180	0.09	3,524,483	159,638	0.20	587,047	1,223,818	0.08	4,111,530
2008	591,637	0.09	2,520,422	84,311	0.27	516,408	675,949	0.09	3,036,829
2009	698,335	0.13	3,132,241	97,250	0.24	639,081	795,585	0.12	3,771,321
2010	327,013	0.16	1,614,967	6,676	0.68	55,687	333,689	0.16	1,670,654
2011	488,919	0.13	3,176,492	31,349	0.36	303,813	520,269	0.12	3,480,305

Table 4.10.2 Gulf of Mexico red snapper landings (number of fish) from the SRHS by year and Gulf region.

	East		West		Total Gulf	
YEAR	Number	Weight (lbs)	Number	Weight (lbs)	Number	Weight (lbs)
1981			335,366	416,165	335,366	416,165
1982			335,366	416,165	335,366	416,165
1983			335,366	416,165	335,366	416,165
1984			335,366	416,165	335,366	416,165
1985			335,366	416,165	335,366	416,165
1986	16,364	37,848	316,090	372,639	332,454	410,487
1987	9,685	26,297	319,348	384,743	329,033	411,040
1988	13,832	32,800	423,024	581,356	436,856	614,156
1989	10,797	23,828	372,473	962,612	383,270	986,440
1990	15,539	35,760	187,006	342,552	202,545	378,312
1991	15,580	35,161	264,686	448,511	280,266	483,672
1992	33,873	77,211	413,056	872,851	446,929	950,062
1993	37,275	84,344	458,772	1,300,045	496,047	1,384,389
1994	28,998	83,818	497,738	1,441,631	526,736	1,525,449
1995	23,078	74,911	354,550	1,282,712	377,628	1,357,623
1996	28,388	84,397	349,266	1,324,382	377,654	1,408,779
1997	48,439	120,636	347,424	1,183,775	395,863	1,304,411
1998	76,759	184,095	244,738	940,650	321,497	1,124,745
1999	67,432	195,966	98,699	503,001	166,131	698,967
2000	57,640	177,839	111,410	585,448	169,050	763,287
2001	51,289	167,617	116,358	405,868	167,647	573,486
2002	75,121	217,585	138,475	607,217	213,596	824,802
2003	71,021	222,142	157,905	569,754	228,926	791,897
2004	63,482	190,118	110,329	503,158	173,811	693,276
2005	46,791	146,482	99,988	379,855	146,779	526,337
2006	47,882	125,533	121,177	450,704	169,059	576,238
2007	63,603	173,753	110,314	313,252	173,917	487,004
2008	61,986	185,243	57,569	222,709	119,555	407,952
2009	81,590	314,558	75,998	491,335	157,588	805,893
2010	35,943	145,448	51,514	284,079	87,457	429,527
2011	69,187	320,646	50,656	309,916	119,843	630,563

Table 4.10.3 Texas red snapper landings (number of fish and whole weight in pounds) from TPWD by year. CVs are taken from the TPWD seasonal estimates.

	West		
YEAR	Number	CV_num	Weight (lbs)
1981	71,227		151,411
1982	71,227		151,411
1983	71,785	0.31	89,287
1984	36,091	0.37	66,690
1985	105,806	0.48	298,260
1986	127,739	0.83	180,456
1987	47,396	0.54	85,627
1988	53,577	0.57	87,243
1989	24,309	0.42	38,807
1990	25,493	0.41	42,996
1991	40,500	0.36	73,611
1992	34,636	0.24	83,061
1993	46,123	0.37	124,665
1994	87,419	0.31	247,943
1995	97,397	0.28	318,581
1996	85,470	0.26	313,608
1997	80,543	0.28	290,105
1998	66,025	0.36	267,721
1999	54,043	0.35	192,878
2000	52,714	0.34	174,773
2001	48,607	0.31	157,517
2002	52,897	0.28	187,823
2003	38,349	0.28	133,651
2004	40,770	0.32	133,493
2005	55,684	0.26	202,327
2006	63,284	0.37	209,284
2007	46,797	0.28	169,573
2008	36,442	0.41	174,935
2009	34,387	0.27	197,680
2010	30,197	0.39	177,228
2011	36,131	0.41	195,121

Table 4.10.4 Gulf of Mexico (FLW-LA) red snapper discards (numbers of fish) from MRIP by year and Gulf region. Estimates from 1981-2003 have been adjusted to MRIP numbers. *CVs for 1981-1985 only reflect the private mode CVs, since charter and headboat mode CVs are unavailable.

	East		West		Total Gulf	
YEAR	Discards	CV	Discards	CV	Discards	CV
1981	51,548	0.88*	10,037	1.01*	61,586	0.75*
1982	16,659	0.76*	14,344	0.26*	31,003	0.42*
1983	479	1.98*	3,585	0.00*	4,064	0.23*
1984	25,159	1.52*	0	0.00*	25,159	1.52*
1985	15,349	0.99*	45,856	1.35*	61,204	1.04*
1986	39,599	0.54	5,036	0.78	44,635	0.49
1987	62,666	0.48	7,844	1.25	70,509	0.45
1988	64,040	0.51	147,211	0.81	211,251	0.59
1989	168,435	0.65	114,579	0.72	283,014	0.48
1990	424,721	0.57	172,929	0.83	597,650	0.47
1991	769,651	0.32	256,574	0.64	1,026,225	0.29
1992	847,379	0.20	214,942	0.38	1,062,321	0.18
1993	900,495	0.25	259,803	0.43	1,160,298	0.22
1994	709,312	0.25	282,222	0.49	991,534	0.23
1995	393,610	0.38	408,644	0.48	802,254	0.31
1996	878,667	0.28	100,060	0.84	978,727	0.27
1997	1,796,061	0.24	103,049	0.46	1,899,110	0.23
1998	933,276	0.10	105,271	0.44	1,038,546	0.10
1999	1,268,605	0.12	228,956	0.34	1,497,561	0.12
2000	1,433,219	0.15	127,605	0.52	1,560,824	0.14
2001	1,934,396	0.13	54,550	0.50	1,988,947	0.13
2002	2,280,040	0.14	43,270	0.38	2,323,310	0.13
2003	1,973,629	0.14	184,735	0.43	2,158,364	0.13
2004	2,413,011	0.12	274,135	0.23	2,687,146	0.11
2005	1,849,815	0.12	339,593	0.20	2,189,408	0.11
2006	2,393,573	0.10	429,127	0.17	2,822,700	0.09
2007	2,959,674	0.10	284,832	0.23	3,244,506	0.09
2008	1,845,033	0.12	262,197	0.28	2,107,231	0.11
2009	1,947,812	0.12	195,482	0.20	2,143,294	0.11
2010	1,426,636	0.16	6,779	0.73	1,433,415	0.16
2011	1,412,941	0.14	108,302	0.42	1,521,243	0.13

Table 4.10.5 Texas red snapper discards (numbers of fish) from TPWD by year.

	West
YEAR	Discards
1981	514
1982	619
1983	86
1984	0
1985	47,238
1986	236
1987	7,619
1988	34,329
1989	15,429
1990	26,652
1991	86,464
1992	24,753
1993	30,631
1994	95,673
1995	149,909
1996	39,742
1997	50,180
1998	60,634
1999	131,464
2000	64,560
2001	42,833
2002	62,256
2003	133,373
2004	229,890
2005	185,774
2006	169,427
2007	82,617
2008	118,428
2009	73,095
2010	19,754
2011	120,537

Table 4.10.6 Number of red snapper measured or weighed in the Gulf of Mexico in the MRFSS/MRIP by year, mode, and state.

	Cbt					Hbt					Priv						Grand
YEAR	LA	MS	AL	FLW	All	TX	LA	AL	FLW	All	TX	LA	MS	AL	FLW	All	Total
1981	22		62	20	104		10	22	13	45		35		53	68	156	305
1982	5	10	40	29	84		134	33	25	192		153	7	14	63	237	513
1983	424		118	86	628		416	28	127	571		129	5	3	7	144	1,343
1984	214		3	38	255		26	2	19	47		52	1	14	6	73	375
1985	40		36	3	79	79	62	2	15	158	25	30	1	2	9	67	304
1986	354	16	105	61	536							52	1	7	10	70	606
1987	230	10	242	219	701							22	3	59	117	201	902
1988	6	42	246	65	359							68	17	1	24	110	469
1989	20	27	125	17	189							64		5	11	80	269
1990	83	14	136	17	250							23	7	42	9	81	331
1991	281	42	646	51	1,020							5	46	146	2	199	1,219
1992	312	250	1,290	220	2,072							68	216	331	14	629	2,701
1993	125	98	314	257	794							62	53	155	29	299	1,093
1994	118	33	328	116	595							68	46	136	17	267	862
1995	145	5	197	58	405							58	22	83	15	178	583
1996	108	36	133	61	338							48	33	61	14	156	494
1997	89	11	530	670	1,300							25	97	88	7	217	1,517
1998	186	13	1,288	1,632	3,119							18	53	74	14	159	3,278
1999	37	65	3,626	3,686	7,414							117	56	579	123	875	8,289
2000	86	66	2,908	4,762	7,822							14	5	354	85	458	8,280
2001	10	80	2,786	3,585	6,461							8	5	387	105	505	6,966
2002	237	154	2,729	4,404	7,524								22	545	78	645	8,169
2003	308	57	2,229	4,139	6,733							1	30	300	83	414	7,147
2004	356	15	1,719	3,757	5,847							7		326	89	422	6,269
2005	185		1,471	3,674	5,330							18	1	138	62	219	5,549
2006	588	15	1,062	2,880	4,545							31	5	74	128	238	4,783
2007	552		983	3,402	4,937							51	4	81	254	390	5,327
2008	70	4	284	1,563	1,921							29	8	79	152	268	2,189
2009	88		305	534	927							57	37	112	53	259	1,186
2010		4	197	822	1,023							30		72	122	224	1,247
2011	41	11	235	736	1,023							17	1	154	111	283	1,306
Grand Total	5,320	1,078	26,373	41,564	74,335	79	648	87	199	1,013	25	1,360	782	4,475	1,881	8,523	83,871

Table 4.10.7 Number of red snapper measured or weighed in the Gulf of Mexico in the SRHS by year and state.

YEAR	TX	LA	AL/FLW	All states
1986	6,015	237	163	6,415
1987	5,565	413	192	6,170
1988	4,048	553	196	4,797
1989	5,033	1,278	286	6,597
1990	3,547	716	333	4,596
1991	2,478	944	497	3,919
1992	5,877	2,001	683	8,561
1993	5,399	1,658	385	7,442
1994	5,790	855	1,316	7,961
1995	7,024	1,303	441	8,768
1996	4,201	1,060	496	5,757
1997	2,185	1,814	1,142	5,141
1998	4,359	2,198	2,158	8,715
1999	1,340	1,945	884	4,169
2000	473	2,723	1,136	4,332
2001	1,022	1,513	654	3,189
2002	1,440	945	1,250	3,635
2003	992	1,016	1,089	3,097
2004	808		544	1,352
2005	822	194	303	1,319
2006	658	109	481	1,248
2007	535	233	1,280	2,048
2008	259	142	1,223	1,624
2009	611	255	947	1,813
2010	797		708	1,505
2011	689	279	737	1,705
Grand Total	71,967	24,384	19,524	115,875

Table 4.10.8 Number of red snapper measured or weighed in the state of Texas in the TPWD by year and mode.

YEAR	Cbt	Priv	All modes
1983	19	369	388
1984	6	393	399
1985	84	613	697
1986	6	363	369
1987	35	450	485
1988	25	448	473
1989	9	326	335
1990	7	371	378
1991	15	504	519
1992	66	642	708
1993	28	826	854
1994	48	1,120	1,168
1995	47	1,898	1,945
1996	89	1,501	1,590
1997	79	1,424	1,503
1998	111	1,204	1,315
1999	95	704	799
2000	101	1,011	1,112
2001	126	856	982
2002	144	934	1,078
2003	145	935	1,080
2004	133	879	1,012
2005	147	1,073	1,220
2006	203	1,342	1,545
2007	257	935	1,192
2008	157	733	890
2009	155	903	1,058
2010	86	611	697
2011	69	887	956
Grand Total	2,492	24,255	26,747

Table 4.10.9 Gulf of Mexico (FLW-TX) estimated number of **angler trips** for MRFSS (1981-2003) and MRIP (2004-2011) by year and Gulf region. TX angler trip estimates have been excluded. Shore mode angler trip estimates have been excluded.

YEAR	East	West	Total Gulf
1981	6,085,559	992,986	7,078,545
1982	4,676,602	1,606,279	6,282,881
1983	5,493,444	1,786,898	7,280,342
1984	6,714,199	1,339,849	8,054,048
1985	6,280,179	1,338,503	7,618,682
1986	6,674,808	1,974,776	8,649,584
1987	7,204,841	1,859,711	9,064,552
1988	8,977,342	2,280,703	11,258,045
1989	7,482,360	1,754,103	9,236,464
1990	6,268,723	1,373,917	7,642,640
1991	7,787,797	1,748,850	9,536,647
1992	7,858,050	1,984,866	9,842,916
1993	7,710,287	2,119,075	9,829,362
1994	8,316,214	1,928,957	10,245,170
1995	8,190,613	2,400,669	10,591,282
1996	8,069,748	2,271,727	10,341,474
1997	8,923,703	2,363,251	11,286,954
1998	7,777,364	1,922,209	9,699,572
1999	7,732,807	2,048,764	9,781,571
2000	9,723,508	2,816,590	12,540,098
2001	10,349,484	2,764,039	13,113,524
2002	10,054,340	2,344,977	12,399,317
2003	11,402,447	3,398,922	14,801,369
2004	12,510,631	3,964,532	16,475,162
2005	11,369,702	2,906,178	14,275,879
2006	11,468,139	2,988,229	14,456,369
2007	12,532,422	3,299,482	15,831,904
2008	12,326,691	3,687,302	16,013,994
2009	10,906,116	3,359,031	14,265,147
2010	10,131,111	3,133,817	13,264,928
2011	10,191,640	3,454,320	13,645,959
Grand Total	271,190,868	73,213,512	344,404,380

Table 4.10.10 Gulf of Mexico estimated number of **angler days** from SRHS by year and Gulf region.

YEAR	East	West	Total Gulf
1986	240,077	62,459	302,536
1987	217,049	69,725	286,774
1988	195,948	78,087	274,035
1989	208,325	66,256	274,581
1990	213,906	65,042	278,948
1991	174,312	66,342	240,654
1992	184,802	86,129	270,931
1993	207,898	92,160	300,058
1994	204,562	113,429	317,991
1995	182,410	100,962	283,372
1996	154,913	102,840	257,753
1997	149,442	91,215	240,657
1998	185,331	85,504	270,835
1999	176,117	66,261	242,378
2000	159,331	63,347	222,678
2001	157,243	61,583	218,826
2002	141,831	73,173	215,004
2003	144,211	81,068	225,279
2004	158,430	64,990	223,420
2005	130,233	59,857	190,090
2006	124,049	75,794	199,843
2007	136,880	66,286	203,166
2008	130,176	44,133	174,309
2009	142,438	54,005	196,443
2010	111,516	47,371	158,887
2011	158,796	49,170	207,966
Grand Total	4,390,226	1,887,188	6,277,414

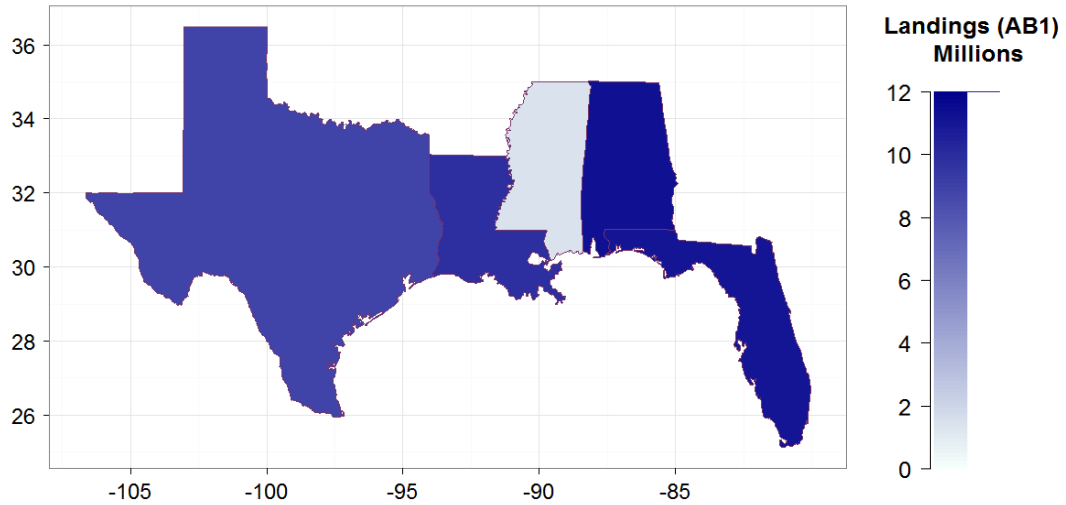
Table 4.10.11 Texas estimated number of **angler trips** from TPWD by year and season (High- May 15th -Nov 20th; Low- Nov 21st-May 14th).

YEAR	High	Low	Total
1983	669,126		669,126
1984	559,713	175,608	735,321
1985	611,251	261,821	873,072
1986	576,966	353,576	930,542
1987	775,656	361,874	1,137,530
1988	729,324	340,276	1,069,600
1989	714,053	243,593	957,645
1990	650,895	220,197	871,092
1991	675,614	225,488	901,102
1992	765,954	264,420	1,030,374
1993	721,964	328,451	1,050,415
1994	792,955	392,843	1,185,798
1995	727,097	426,173	1,153,270
1996	800,241	377,200	1,177,440
1997	775,724	324,887	1,100,611
1998	759,292	326,636	1,085,927
1999	887,954	432,612	1,320,566
2000	828,750	494,748	1,323,498
2001	791,628	359,044	1,150,672
2002	748,641	358,148	1,106,789
2003	762,020	369,633	1,131,654
2004	750,642	375,916	1,126,558
2005	702,874	358,604	1,061,479
2006	724,252	432,478	1,156,730
2007	720,176	337,594	1,057,770
2008	679,629	377,775	1,057,404
2009	708,020	327,473	1,035,493
2010	701,791	285,532	987,323
2011	743,213	382,188	1,125,401
Grand Total	21,055,415	9,514,789	30,570,204

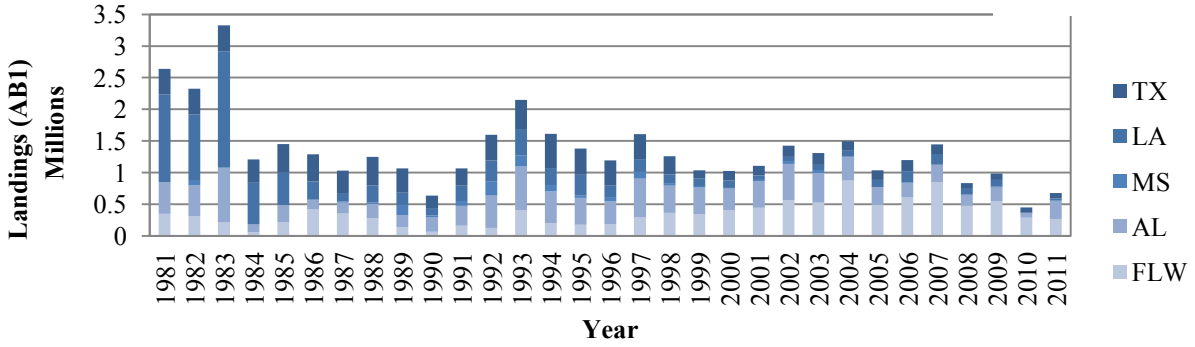
4.11 Figures

Figure 4.11.1: Gulf of Mexico estimated number of red snapper landings from MRFSS/MRIP, TPWD, and SRHS (1981-2011) by state (a), by state and year (b), and by state and mode (c).

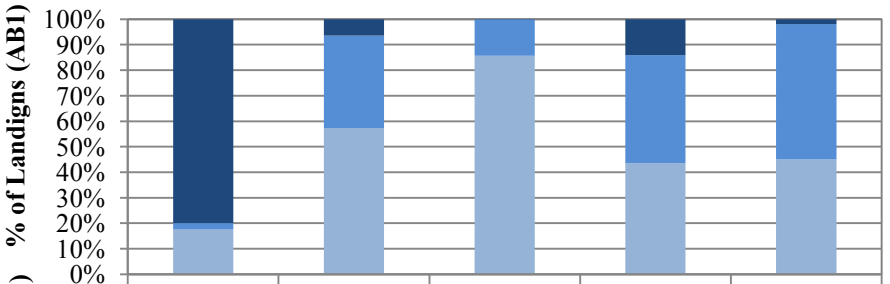
a) **AB1 Red Snapper by State 1981-2011**



b) **AB1 Red Snapper by State and Year 1981-2011**



c) **AB1 Red Snapper by State and Mode 1981-2011**



Landings (AB1)	TX	LA	MS	AL	FLW
Hbt	7,057,522	635,863	1,263	1,578,822	205,959
Cbt	219,008	3,549,635	186,216	4,729,989	5,845,617
Priv	1,544,057	5,606,155	1,122,831	4,860,447	4,954,956

Figure 4.11.2 Estimates of historical recreational catch of red snapper in the Gulf of Mexico by region using the coastal census method. Solid lines represent reported catch while dashed lines represent estimated catch. Catch for the east Gulf are shown in light blue, while landings for the west Gulf are shown in dark blue.

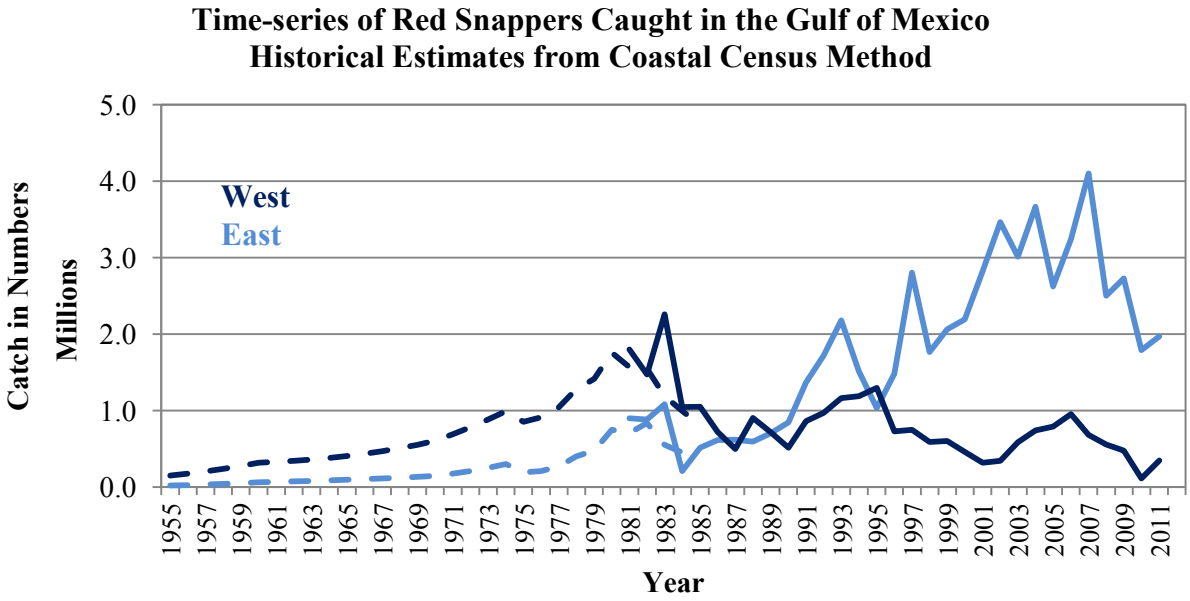


Figure 4.11.3 Estimates of historical recreational landings of red snapper in the Gulf of Mexico by region using the modified FHWAR method. Solid lines represent reported landings while dashed lines represent estimated landings. Landings for the east Gulf are shown in dark blue, while landings for the west Gulf are shown in light blue.

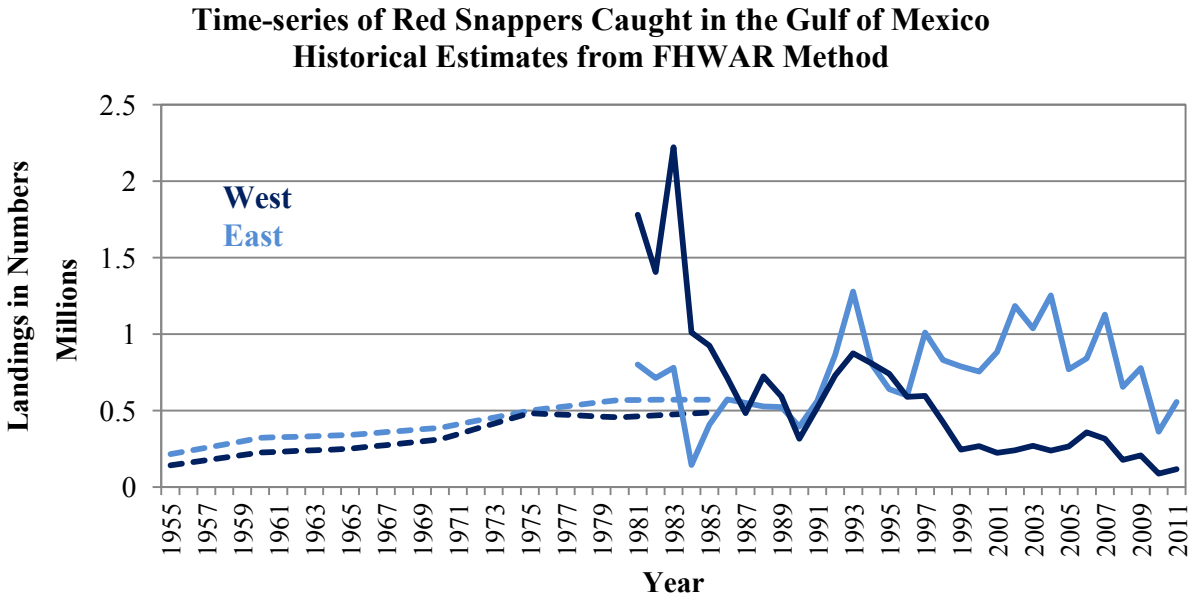
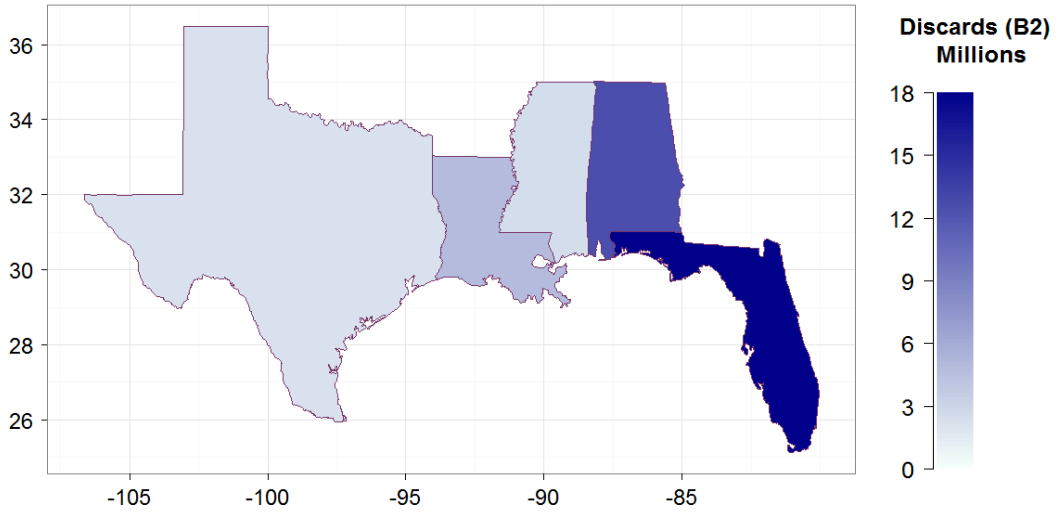
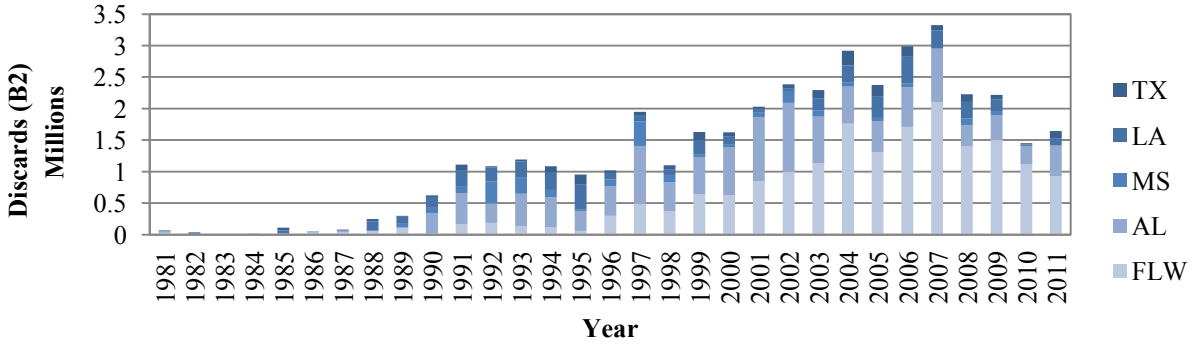


Figure 4.11.4: Gulf of Mexico estimated number of red snapper discards from MRFSS/MRIP and TPWD (1981-2011) by state (a), by state and year (b), and by state and mode (c). SRHS discard not yet included.

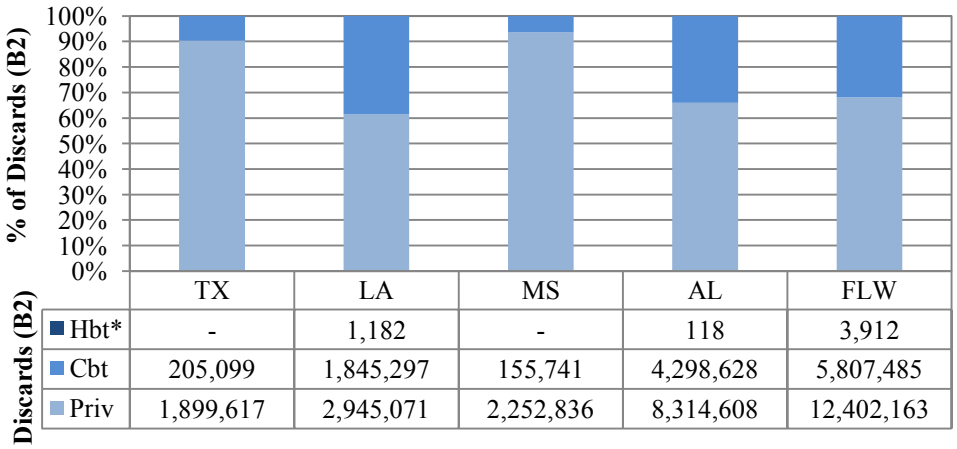
a)



b)



c)



Discards (B2)	TX	LA	MS	AL	FLW
Hbt*	-	1,182	-	118	3,912
Cbt	205,099	1,845,297	155,741	4,298,628	5,807,485
Priv	1,899,617	2,945,071	2,252,836	8,314,608	12,402,163

*Hbt (1981-1985 only)

Figure 4.11.5a: Length frequency distributions of length samples collected from recreational fisheries located in the eastern Gulf of Mexico (RE) from 1992 to 2001.

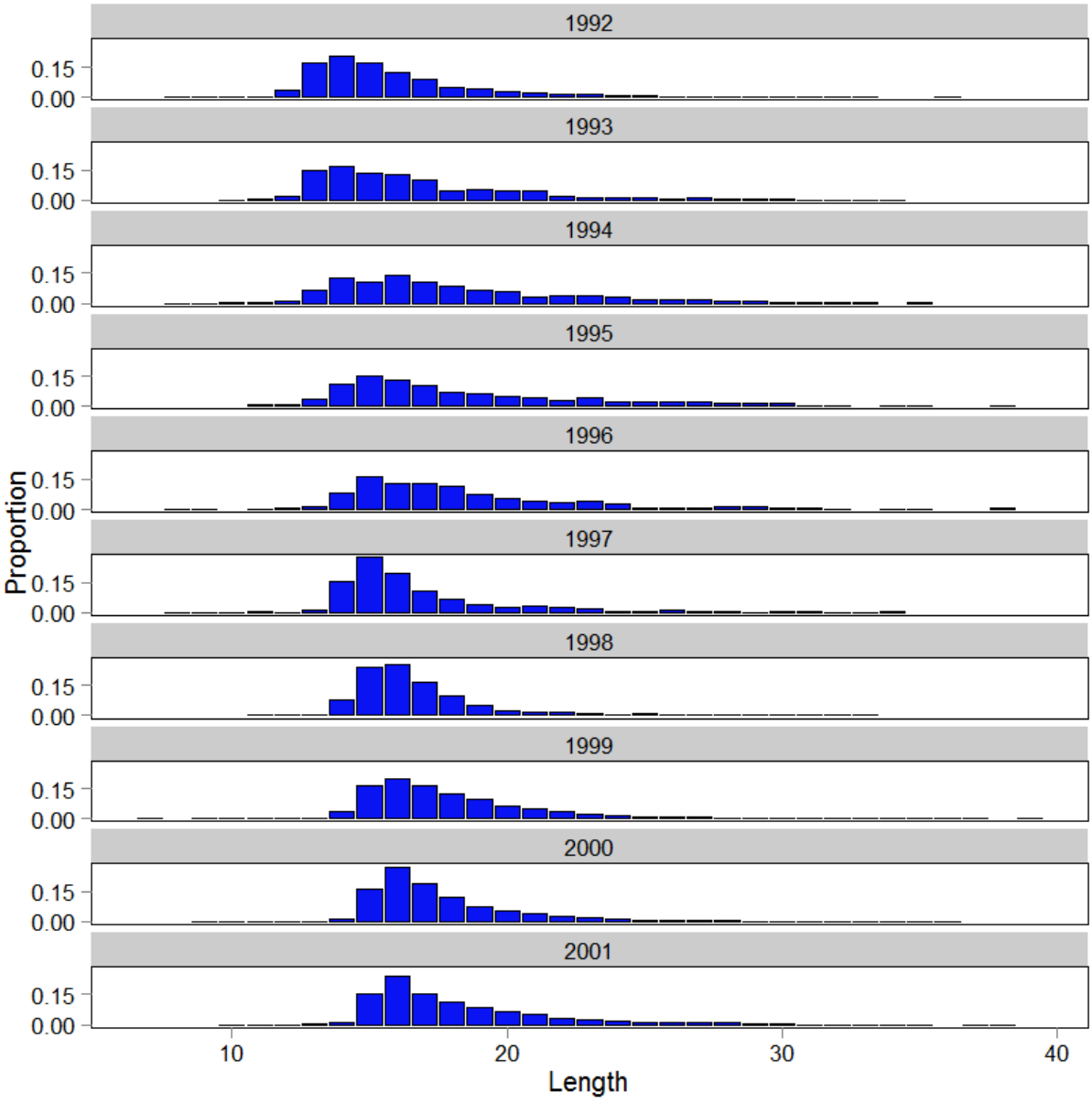


Figure 4.11.5b: Length frequency distributions of length samples collected from recreational fisheries located in the eastern Gulf of Mexico (RE) from 2002 to 2011.

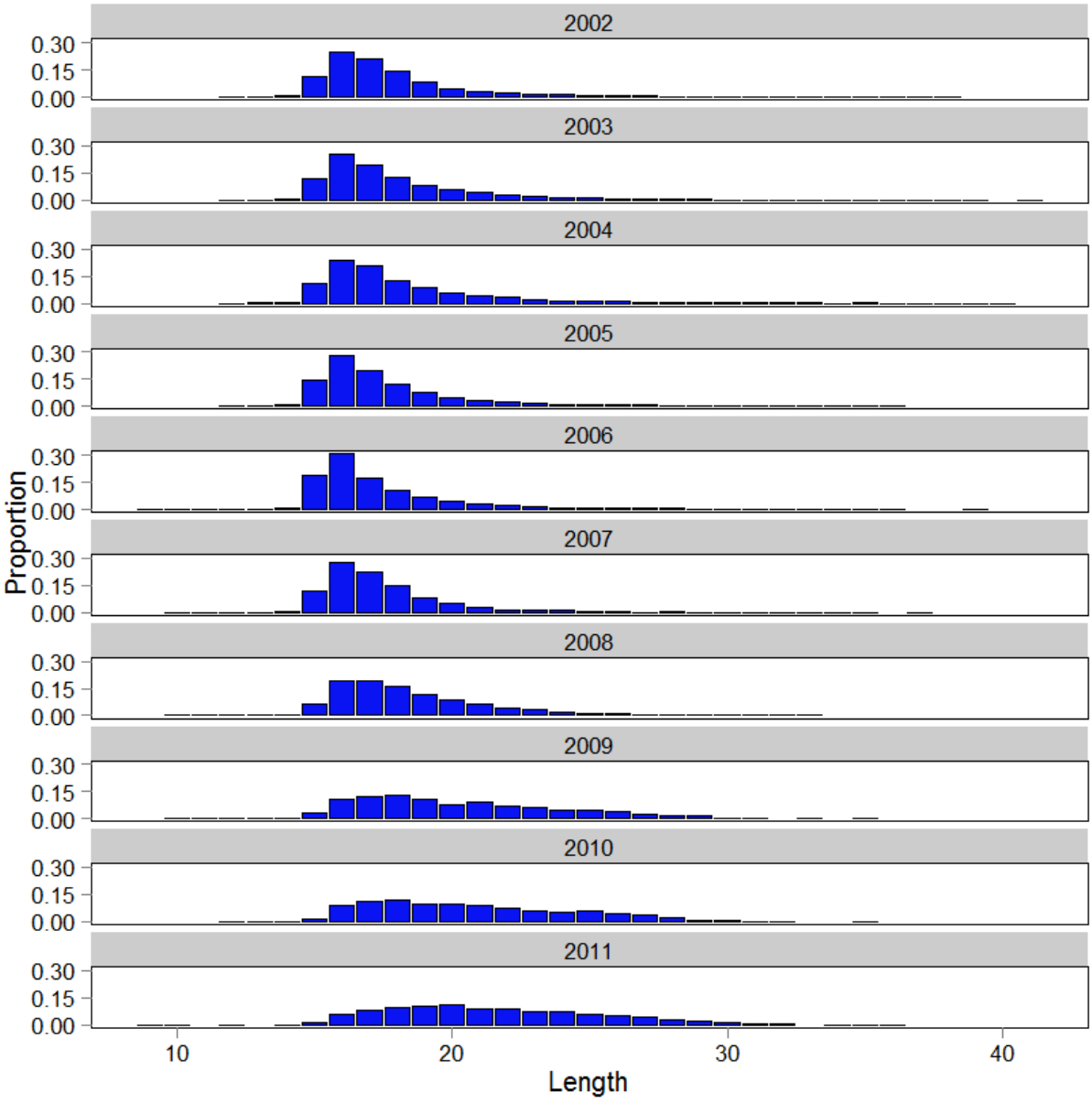


Figure 4.11.6a: Length frequency distributions of length samples collected from recreational fisheries located in the western Gulf of Mexico (RW) from 1992 to 2001.

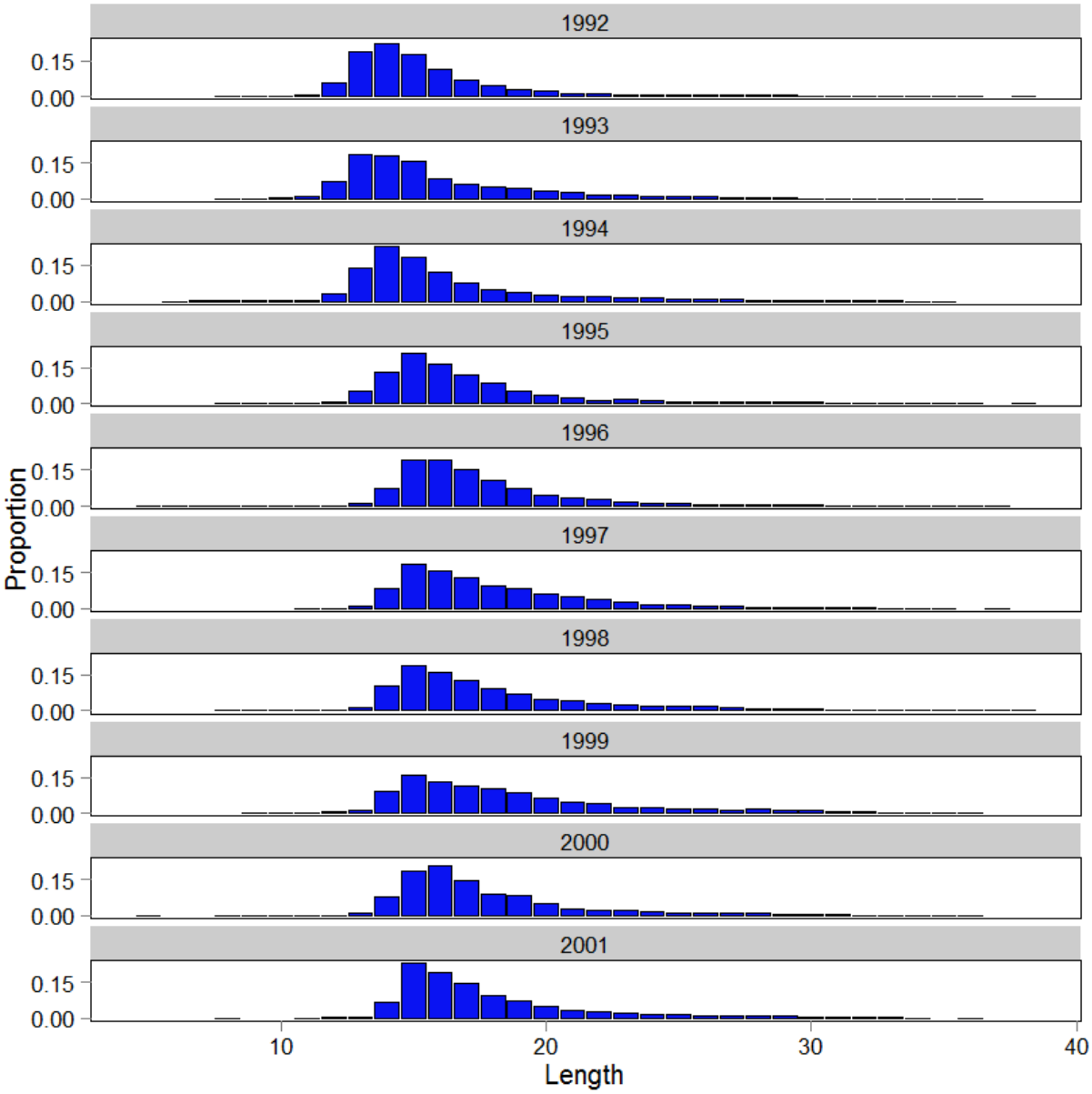


Figure 4.11.6b: Length frequency distributions of length samples collected from recreational fisheries located in the western Gulf of Mexico (RW) from 2002 to 2011.

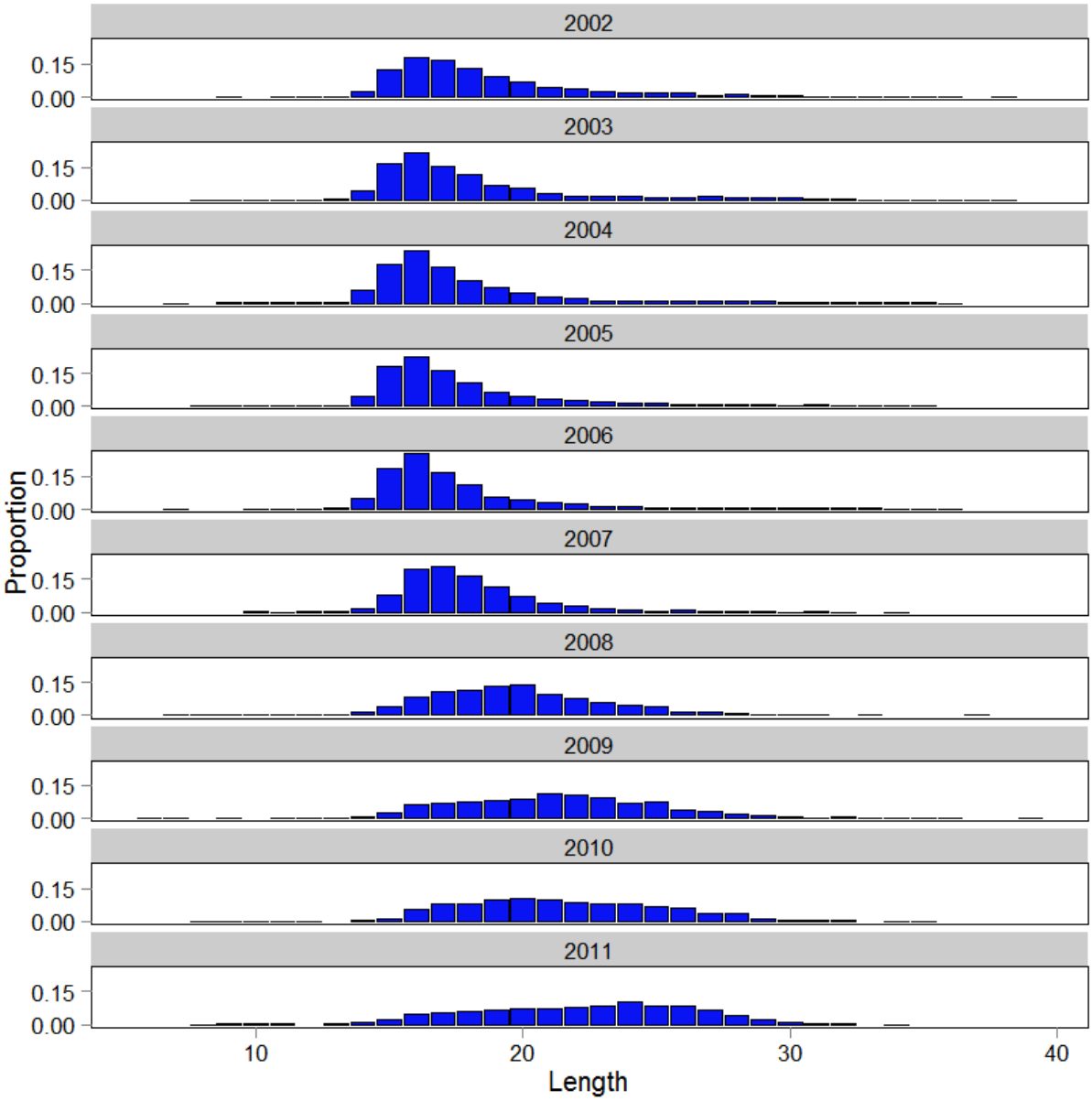
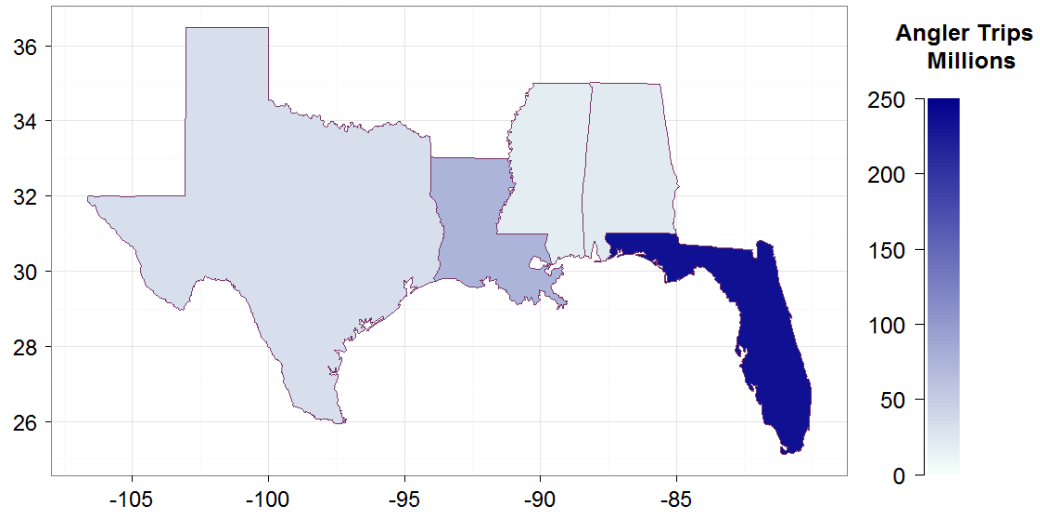
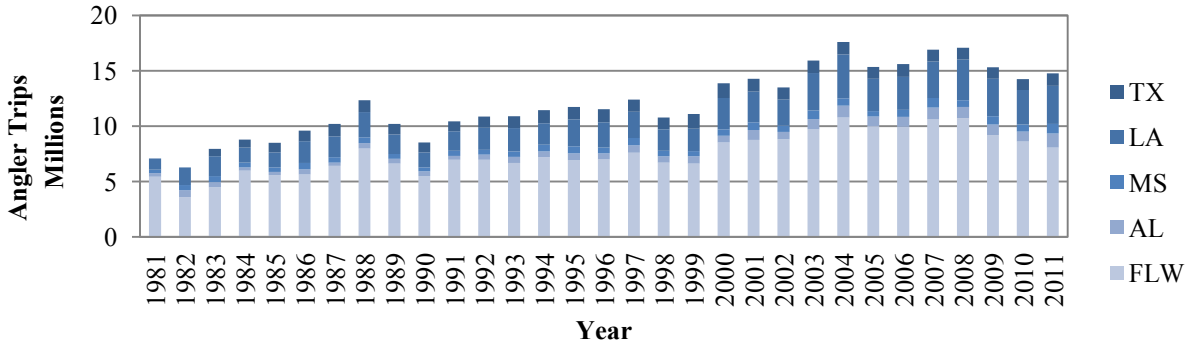


Figure 4.11.7: Gulf of Mexico estimated number of angler trips from MRFSS/MRIP (1981-2011) and TPWD (1983-2011) by state (a), by state and year (b), and by state and mode (c).

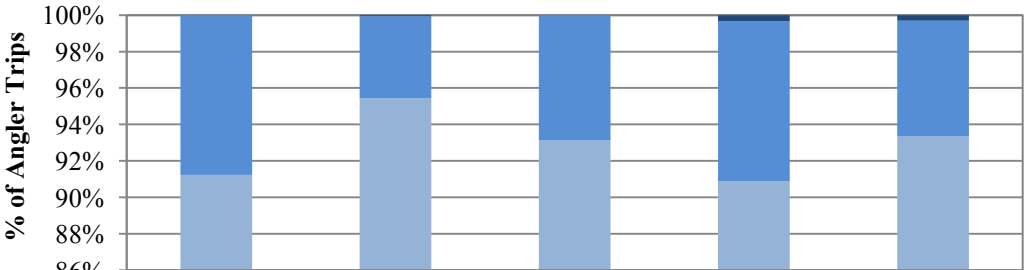
a) **Angler Trips by State 1981-2011**



b) **Angler Trips by State and Year 1981-2011**



c) **Angler Trips by State and Mode 1981-2011**

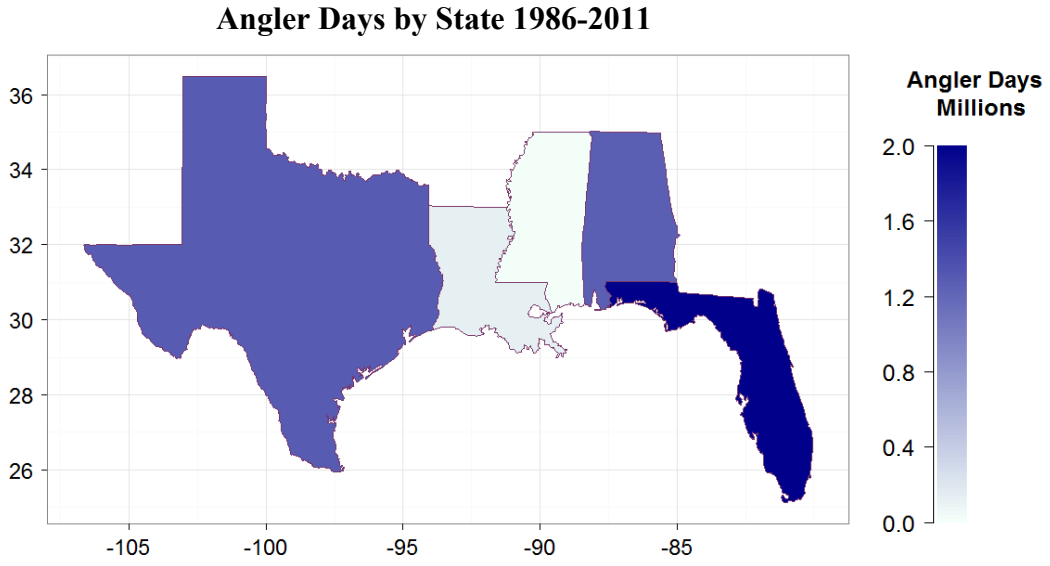


Angler Trips	TX*	LA	MS	AL	FLW
Hbt*	-	43,262	-	69,072	714,752
Cbt	2,680,830	3,284,955	1,191,846	1,764,970	14,822,758
Priv	27,889,374	69,885,295	16,211,174	18,274,733	218,141,562

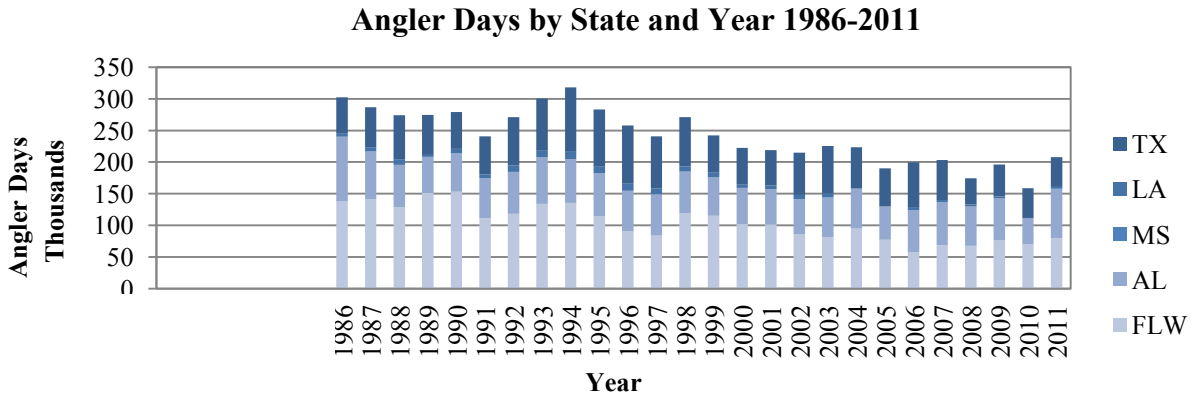
*Hbt (1981-1985); TX (1983-2011)

Figure 4.11.8: Gulf of Mexico estimated number of angler days from SRHS (1986-2011) by state (a), by state and year (b), and by state and mode (c).

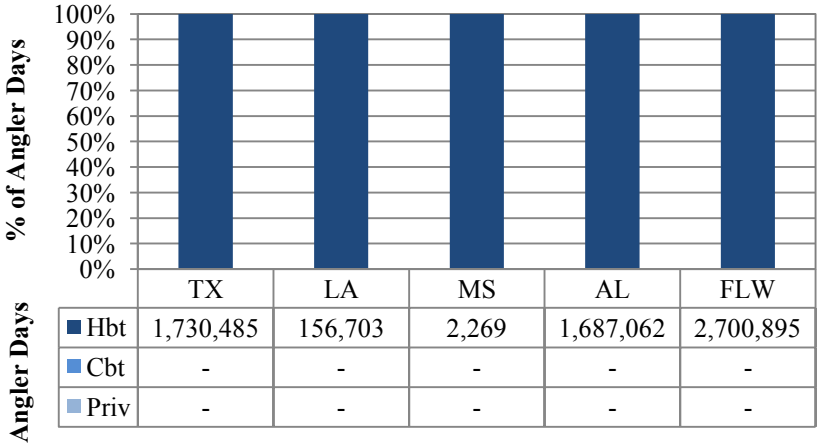
a)



b)



c)



Angler Days	TX	LA	MS	AL	FLW
Hbt	1,730,485	156,703	2,269	1,687,062	2,700,895
Cbt	-	-	-	-	-
Priv	-	-	-	-	-

5. Measures of Population Abundance

5.1 Overview

Analytical results of numerous data sets were presented to the Index Working Group (IWG) of both fishery-dependent and fishery-independent origin. These data sets are listed in Table 5.1.1 along with brief descriptions. Also, a simplified chart, depicting spatial coverage of each data set is included in Figure 5.1.1. Five fishery-independent and three fishery-dependent indices of abundance are recommended for use in the assessment by the IWG. They are:

Fishery-independent
NMFS bottom longline survey
NMFS SEAMAP trawl survey
SEAMAP reef fish survey
FWC Reef fish survey
NMFS Panama City trap and camera survey

Fishery-dependent
MRFSS/TPW private recreational and charter survey
NMFS headboat survey
Commercial handline survey

Other indices were considered and not recommended for use in the assessment by the IWG.

Group Membership

IWG members included, Walter Ingram, Adam Pollack Clay Porch, Neil Baertlein, Kevin McCarthy, Steve Saul, Claudia Friess, Beverly Sauls, Meaghan Bryan, Theodore Switzer, and Robert McMichael. and included other DW participants as needed for discussions throughout the week.

5.2 Review of Working Papers

The following working papers were reviewed:

5.3 Fishery Independent Indices

5.3.1 SEAMAP Groundfish Survey (SEDAR 31-DW-20)

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized groundfish surveys under the Southeast Area Monitoring and Assessment Program (SEAMAP) in the Gulf of Mexico (GOM) since 1987. 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 Gulf of Mexico (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. The purpose of this section to provide a review of the red snapper indices presented during the Data Workshop.

A full review of the survey design and methodologies are described in SEDAR31-DW20. Due to the large number of indices presented (40+), this section will only present the ones that were recommended for use in the assessment, but will discuss all indices in section 5.3.1.6. All other indices and related information can be found in the document prepared for the Data Workshop (SEDAR31-20).

5.3.1.1 Methods of Estimation

Data Filtering Techniques

Based upon the limited sampling that has taken place in shrimp statistical zones 3-9 (Table 5.3.1.1 and Table 5.3.1.2), it was decided to limit the data for this analysis to only zones 10-21 (note that zone 12 is completely outside of the depth range of this survey (5 to 60 fathoms), therefore it is not sampled). For this assessment, the decision was made to split the stock into east and west sub-stocks. Therefore, the western sub-stock was composed of statistical zones 13-21 and the eastern sub-stock was composed of statistical zones 10 and 11.

Standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for red snapper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992).

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 (Eastern Gulf)

Year: 1987-2011
Depth Zone: <10 fathoms, 10-30 fathoms, >30 fathoms
Time of Day: Day, Night

Submodel Variables (Western Gulf – Extended Time Series)

Year: 1987-2011
Area: Primary (statistical zones 13-16), Secondary (statistical zones 17-21),
Depth Zone: <10 fathoms, 10-30 fathoms, >30 fathoms
Time of Day: Day, Night

Annual Abundance Indices

For a full review of the backward selection procedure for each submodel and diagnostic plots, refer to SEDAR31-DW20.

For the WGOM abundance index for red snapper (summer survey), year, area and depth zone were retained in the binomial submodel, while year, time of day, area and depth were retained in the lognormal submodel. The AIC for the binomial and lognormal submodels were 22,239.1 and 5,574.8, respectively. The diagnostic plots for the binomial and lognormal submodels indicated the distribution of the residuals is approximately normal.

For the WGOM abundance index for red snapper (fall survey), year, time of day, area and depth zone were retained in both the binomial and the lognormal submodels. The AIC for the binomial and lognormal submodels were 32,539.5 and 12,410.8, respectively. The diagnostic plots for the binomial and lognormal submodels indicated the distribution of the residuals is approximately normal.

For the EGOM abundance index for red snapper (summer survey), year, time of day and depth zone were retained in both the binomial and lognormal submodels. The AIC for the binomial and lognormal submodels were 6,477.5 and 1,018.4, respectively. The diagnostic plots for the binomial and lognormal submodels indicated the distribution of the residuals is approximately normal.

For the EGOM abundance index for red snapper (fall survey), year, time of day and depth zone were retained in both the binomial and lognormal submodels. The AIC for the binomial and lognormal submodels were 11,674.6 and 4,108.1, respectively. The diagnostic plots for the binomial and lognormal submodels indicated the distribution of the residuals is approximately normal.

5.3.1.2 Sampling Intensity

A total of 6,335 were sampled from 1982- 2011 during the Summer SEAMAP Groundfish survey (Table 5.3.1.1 and Figure 5.3.1.1). While, 9,596 stations were sampled from 1972- 2011 during the Fall SEAMAP Groundfish survey (Table 5.3.1.2 and Figure 5.3.1.2).

5.3.1.3 Size/Age Data

The sizes of red snapper represented in this index are presented in Table 5.3.1.3 and Figures 5.3.1.3 – 5.3.1.4. For surveys prior to 1987, there was no length data available.

5.3.1.4 Catch Rates

Standardized catch rates are presented in Tables 5.3.1.4 - 5.3.1.7 and Figures 5.3.1.5 – 5.3.1.8.

5.3.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Tables 5.3.1.4 - 5.3.1.7.

5.3.1.6 Comments on Adequacy for Assessment

The SEAMAP Groundfish Survey was recommended for inclusion in the stock assessment model for red snapper. These indices characterized long running, start dates of 1982 and 1972 for the summer and fall respectively, fishery independent surveys. The surveys have undergone some changes in methodology over time, along with an expansion of the area sampled; however, the model was able to account for these differences with the addition of variables. The final interactions of the model recommended for use were the long time series with separate indices for the summer and fall surveys, along with a split into east and west gulf. However, if the combination index with Dauphin Island is accepted, we would recommend using that in place of the eastern gulf indices. The decision to split the indices into summer and fall centered on the age structure of each survey, with the summer representative of age 1 fish and the fall representative of age 0 fish.
For the rest of the indices presented in SEDAR31-DW20, the following is a brief discussion on why the indices were not selected for use based upon discussion at the Data Workshop. Based on the work of the life history group and the decision to split the stock into eastern and western components, no full gulf indices were considered for use. In addition, it was decided that the stock assessment model was more capable of estimating changes in the indices with regard to selectivity; therefore the indices that had incorporated the selectivity factor in calculating catch were not recommended. The age specific indices were initially recommended for use; however, with the inclusion of the early part of the time series (pre-1987), it was no longer possible to separate the catch by age. Given the two options, using the longer time series was more desirable than using the age specific indices, especially since the stock assessment model would be able to utilize the catch structure of the groundfish data.

5.3.2 SEAMAP Fall Plankton Survey (SEDAR 31-DW-27)

The Southeast Area Monitoring and Assessment Program (SEAMAP) is a collaborative effort between federal, state and university programs, designed to collect, manage and distribute fishery independent data throughout the region. This program has supported collection and analysis of ichthyoplankton samples from resource surveys in the Gulf of Mexico (GOM) since 1982 with the goal of producing a long-term database on the early life stages of fishes. These surveys are the only Gulf-wide survey of U.S. continental shelf and coastal waters during the red snapper (*Lutjanus campechanus*) spawning season. The occurrence and abundance of red snapper larvae captured during SEAMAP surveys in the Gulf of Mexico have been used to reflect trends in relative spawning stock size of red snapper since 2004.

A full review of the survey design and methodologies are described in SEDAR31-DW27.

5.3.2.1 Methods of Estimation

Data Filtering Techniques

The intended sample design for SEAMAP surveys calls for bongo sample to be taken at each site (SEAMAP station) in the systematic grid. However, over the years additional samples have been taken using SEAMAP gear and collection methods at locations other than designated SEAMAP stations. Some locations were also sampled more than once during a survey year. This year to year variability in spatial coverage during SEAMAP resource surveys was addressed by limiting observations to samples taken at SEAMAP stations that were sampled during at least 14 years of the survey time series (Figure 5.3.2.1). In instances where more than one sample was taken at a SEAMAP station, the sample closest to the central position of the systematic grid location was selected for inclusion in the data set. When SEAMAP stations were sampled by more than one vessel during the survey, priority was given to samples taken by the National Marine Fisheries Service (and not the state) vessel. Only samples from the 1986-1997, 1999-2004, 2006-2007 and 2009-2010 SEAMAP Fall Plankton surveys taken in accordance with the sample design from stations sampled during at least 14 years (60%) of the time series were used to calculate the red snapper larval indices and summaries presented in this report. The three 'missing' fall plankton survey years were 1998, 2005 and 2008 when the surveys were cancelled or severely curtailed due to tropical storms.

Standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for 10.5 day old larval red snapper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992). Due to low catches in the eastern GOM, the final model was based only on the binominal model.

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 (Eastern Gulf)

Year: 1986-2010
Area: Mississippi/Alabama (statistical zones 10-11), Florida (statistical zones 1-9)
Start Depth: Depth at the start of the tow
Time of Day: Day, Night

Submodel Variables (Western Gulf)

Year: 1986-2010
Area: Texas (statistical zones 18-21), West Delta (statistical zones 13-17),
Start Depth: Depth at the start of the tow
Time of Day: Day, Night

Annual Abundance Indices

For a full review of the backward selection procedure for each submodel and diagnostic plots, refer to SEDAR31-DW27.

For the EGOM abundance index of larval red snapper year, time of day and subregion were retained in the model. Akaike's Information Criteria (AIC) for the model was 6337.5. The diagnostic plots for the model indicated the distribution of the residuals is approximately normal. For the WGOM abundance index of larval red snapper adjusted to 10.5 days old, year and time of day were retained in the binomial submodel, while year, time of day and subregion were retained in the lognormal submodel. The AIC for the binomial and lognormal submodels were 5277.0 and 542.8, respectively. The diagnostic plots for the binomial and lognormal submodels indicated the distribution of the residuals is approximately normal.

5.3.2.2 Sampling Intensity

A total of 1,153 and 1,085 stations were sampled in the eastern and western GOM, respectively (Figure 5.3.2.1).

5.3.2.3 Size/Age Data

The sizes of larval red snapper captured during the SEAMAP Fall Plankton Survey are presented in Figures 5.3.2.2, while the ages of the larval red snapper used in the indices (3.75 – 9.25 mm) are presented in Figure 5.3.2.3.

5.3.2.4 Catch Rates

Standardized catch rates are presented in Tables 5.3.2.1 and 5.3.2.2 and Figures 5.3.2.4 and 5.3.2.5.

5.3.2.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Tables 5.3.2.1 and 5.3.2.2.

5.3.2.6 Comments on Adequacy for Assessment

The SEAMAP Fall Plankton Survey was recommended for use in the assessment model. This survey represented a long, fishery independent time series, with no change in methodology. Additionally, it was the only survey that characterizes larval red snapper. The final versions of

the abundance indices recommended for use were the age adjusted index for the western GOM that included all larvae between 3.75 and 9.25 mm, and the frequency of occurrence model for the eastern GOM. The frequency of occurrence model was chosen over the delta-lognormal index due to extremely low catches and occurrence of red snapper in the eastern GOM. The group agreed that back-calculating of ages was appropriate, especially since high mortality rates existed in the larval data and by back-calculating it brought the index closer to the number of larvae hatched.

5.3.3 NMFS Bottom Longline (SEDAR 31-DW-19)

Based on the recommendations from the IWG, two standardized indices (Eastern GOM and Western GOM) were developed using NMFS bottom longline survey data.

5.3.3.1 Methods, Gears, and Coverage

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico, Caribbean, and Western North Atlantic since 1995. The objective of these surveys is to provide fisheries independent data for stock assessment purposes for as many species as possible. These surveys are conducted annually in U.S. waters of the Gulf of Mexico (GOM) and/or the Atlantic Ocean, and they provide an important source of fisheries independent information on large coastal sharks, snappers and groupers from the GOM and Atlantic. In 2011, an Expanded Stock Assessment Survey was conducted where high levels of survey effort were maintained from April through October. For this analysis, only data collected during the same time period as the annual survey were used to increase sample size. Results from analyses of data collected on red snapper during this survey are presented below in order to aid in the current assessment of this stock in the GOM.

Data Filtering

Survey data collected between 9 and 366m in the US GOM were used for index development.

Standardization

CPUE indices for both the Eastern GOM and the Western GOM were modeled using a delta-lognormal approach with a backward selection procedure in both submodels.

Model Input

The GLIMMIX and MIXED procedures in SAS (v. 9.1, 2004) were used to develop the binomial and lognormal submodels, respectively. Similar covariates were tested for inclusion for both submodels: water depth [three depth categories: shallow (9 – 55 m), medium (55 – 183 m), and deep (183 – 366 m)], survey region [two regions in the GOM: Eastern Gulf (east of 89.15^{o} west longitude) and Western Gulf (west of 89.15^{o} west longitude)] and year. A backward selection procedure was used to determine which variables were to be included into each submodel based on type 3 analyses with a level of significance for inclusion of $\alpha = 0.05$. If year was not

significant then it was forced into each submodel in order to estimate least-squares means for each year, which are *predicted annual population margins (i.e.,* they estimate the marginal annual means as if over a balanced population). Catch per unit effort (CPUE) was defined as number of fish per 100 hook-hours.

Diagnostics

The distribution of residuals for both submodels was approximately normal.

5.3.3.2 Sampling Intensity and Time Series

The time series of data between 1996 and 2011 were used to develop abundance indices for red snapper for the GOM. Number of stations per year ranged between 50 and 597.

5.3.3.3 Size/Age data

A total of 723 red snapper from the NMFS BLL survey were aged. Ages ranged from 1 to 44 years with a mode around 5-6 years.

5.3.3.4 Catch Rates

Index results are shown in Table 5.3.3.1 and Figure 5.3.3.1 for the Western GOM and in Table 5.3.3.2 and Figure 5.3.3.2 for the Eastern GOM.

5.3.3.5 Uncertainty and Measures of Precision

Coefficients of variation (CV) were in the range of 0.22-1.16 over the entire time series for the Eastern GOM index. Coefficients of variation (CV) were in the range of 0.15-1.24 over the entire time series for the Western GOM index.

5.3.3.6 Comments on Adequacy for Assessment

The index work group recommends that the assessment panel consider the use of indices from both the Eastern GOM and the Western GOM.

5.3.4 SEAMAP Reef Fish Video Survey (SEDAR 31-DW-08)

The primary objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) reef fish video survey is to provide an index of the relative abundances of fish species associated with topographic features (e.g. 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 the survey is conducted on topographic features 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 2004-2011 and historically takes place from May – August. The 2001 survey was abbreviated due to ship scheduling, during which, the only sites that were completed were 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 snapper sampled over the history of the survey had fork lengths ranging from 146 – 917 mm, and mean annual fork lengths ranging from 370.6 – 593.1 mm. Age and reproductive data cannot be collected with the camera gear but beginning with the 2012 survey, a vertical line component will be coupled with the video drops to collect hard parts, fin clips, and gonads.

5.3.4.1 Methods of Estimation

Data Filtering Techniques

Various limitations either in design, implementation, or performance of gear causes limitations in calculating minimum counts and are therefore dropped from the design-based indices development and analysis as follows. In 1992, each fish was counted every time it came into view over the entire record time and the total of all these counts was the maximum count. Maximum count methodologies are not preferred and the 1992 video tapes were destroyed during Hurricane Katrina and cannot be re-viewed, so 1992 data is excluded from analyses (unknown number of stations). The 2001 survey was abbreviated due to ship scheduling, during which, the only sites that were completed were located in the western GOM. Because of the spatial imbalance associated with data gathered in 2001, that entire year has been dropped (80 total sites). Stratum 1 (South Florida) and stratum 7 (S. Texas) are blocks that contain very little reef and were not consistently chosen for sampling and were also dropped (184 total sites). Occasionally tapes are unable to be read (i.e. organisms cannot be identified to species) for the following reasons including: 1) camera views are more than 50% obstructed, 2) sub-optimal lighting conditions, 3) increased backlighting, 4) increased turbidity, 5) cameras out of focus, 6) cameras failed to film. In all of these cases the station is flagged as 'XX' in the data set and dropped (190 total sites). Sites that did not receive a stratum assignment are also dropped (62). By these criteria the data set is reduced in design based estimates from 4707 down to 4228 sites analyzed. Model based runs all available data.

An ad hoc group evaluating the efficacy of combining a set of less extensive reef fish video surveys (NMFS-PC, DISL, and FWRI) identified an issue associated with estimating length using lasers, versus the stereo video from NMFS-PC data. Laser data appears to potentially be underestimating size significantly. It is unclear at this point if this is a measurement issue associated with parallelism of the laser mounting, or if this is associated with fish behavior relative to the camera gear (e.g. smaller fish swarming closer to the gear). At this point the NMFS-MS lab survey has no comparison data available to reassure the working group that this survey does not suffer from the same issue. The group is therefore recommending that the length composition data that was estimated using lasers is excluded from analysis until it can be determined if length is also underestimated in this survey as well.

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 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 mounted in an aluminum housing. All of the camcorder housings we have used were rated to a maximum depth of 150 meters while the stereo camera housings are rated to 600 meters. 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 minutes total, however the cameras and CPU delay filming for 5 minutes to allow for descent to the bottom, and settling of suspended sediment following impact. Once turned on, the cameras film for approximately 30 minutes before shutting off and retrieval of the array. During camera deployment the vessel drifts away from the site and a CTD cast 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 selected for viewing out of four possible. If all four video cameras face reef fish habitat and are in focus, tape selection is random. Videos are viewed for twenty minutes 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 minute 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 20 minute video is evaluated to determine the highest minimum count observed during a 20 minute recording. The 2008-2011 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 does not use the TITO method. Both the TITO and current viewing procedure result in the minimum count estimator of relative abundance. Minimum count methodology is preferred because it prevents counting the same fish more than once.

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 in 2008-2010 allow size estimation from fish images. The Vision Measurement System (Geometrics Inc.) was used to estimate size of red snapper. We

estimated a length frequency distribution by weighting station length frequencies by station Minimum Counts.

Standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for red snapper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992).

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: The survey has been executed from 1992-1997, 2001-2002, and 2004-2011
Region: East and west of the Mississippi River delta, 89.15 west longitude.
Depth: 10 – 200 meters.

5.3.4.2 Sampling Intensity, Catch Rates and Measures of Precision

A total of 4,407 stations were sampled from over the history of the survey (Table 5.3.4.1). Standardized catch rates by region are presented in Tables and Figures 5.3.4.1 (west) and 5.3.4.2 (east).

Annual CVs of catch rates are presented in Tables 5.3.4.1 (west) and 5.3.4.2 (east).

5.3.4.3 Size/Age Data

Length frequency data gathered in this survey are constructed from survey data are presented by year for the years 2008-2011 in Figures 5.3.4.3 – 5.3.4.10, and descriptive stats shown in Table 5.3.4.3.

5.3.4.4 Comments on Adequacy for Assessment

Assessment scientists evaluated the abundance indices and coefficient of variation output and advised the working group that the model based runs were most appropriate for use in the assessment models, therefore those runs are presented in this report, however, all of the runs are available in the working document that was provided prior to the workshop (Campbell et al. DW-08).

An ad hoc group evaluating the efficacy of combining a set of less extensive reef fish video surveys (NMFS-PC, DISL, and FWRI) identified an issue associated with estimating length using lasers, versus the stereo video from NMFS-PC data. Laser data appears to potentially be underestimating size. It is unclear at this point if this is a measurement issue associated with parallelism of the laser mounting, or if this is associated with fish behavior relative to the camera gear (e.g. smaller fish swarming closer to the gear). At this point the NMFS-MS lab survey has no comparison data available to reassure the working group that this survey does not suffer from the same issue. The group is therefore recommending that the length composition data that was estimated using lasers is excluded from analysis until it can be determined if length is also underestimated in this survey as well.

5.3.5 Reef-fish Surveys on the West Florida Shelf (SEDAR 31-DW-24)

5.3.5.1. Overview

Reef fishes, including red snapper, support extensive commercial and recreational fisheries along the West Florida Shelf (WFS). Historically, the assessment and management of reef fishes in the Gulf of Mexico has relied heavily on data from fisheries-dependent sources, although limitations and biases inherent to these data are admittedly a major source of uncertainty in current stock assessments. The accuracy of harvest estimates, particularly on the recreational side, has been challenged in recent years. Additionally, commercial, headboat, and recreational landings data are restricted to harvestable-sized fish, and thus are highly influenced by regulatory changes (i.e., size limits, recreational bag limits, and seasonal closures). These limitations render it difficult to forecast potential stock recovery associated with strong year classes entering the fishery. There has been a renewed emphasis in recent years to increase the availability of fisheries-independent data on reef fish populations in the Gulf of Mexico that reflect the status of fish populations as a whole, rather than just the portion of the population taken in the fishery. To meet the emerging needs of fisheries-independent data for reef fishes, the Florida Fish and Wildlife Conservation Commission (FWC) has been working collaboratively with scientists from the National Marine Fisheries Service (NMFS) to expand regional monitoring capabilities and provide timely fisheries-independent data for a variety of state- and federally-managed reef fishes. Results are summarized from a fisheries-independent reef fish survey initiated by FWC in 2008 to complement ongoing NMFS surveys of reef habitats along the shelf break (NMFS – Pascagoula) and in the northeastern Gulf of Mexico (NMFS – Panama City).

5.3.5.2. Survey Design, Sampling Methods, and Analyses:

The FWC reef fish survey includes a portion of the WFS bounded by 26° and 28° N latitude and depths from 10 – 110 m (Figure 5.3.5.1). The boundaries of the WFS sampling universe were chosen to compliment ongoing NMFS reef-fish surveys. To assure adequate spatial coverage of sampling effort, the WFS survey area is 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 1km x 1km sampling units. Results from 2008 indicated that 1km x 1km 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 0.1nm x 0.3 nm sampling units. Overall sampling effort (annual goal of n = 200 sampling units) was proportionally allocated among the four sampling zones based on habitat availability (TBN: Tampa Bay Nearshore; TBO: Tampa Bay Offshore; CHN: Charlotte Harbor Nearshore; CHO: Charlotte Harbor Offshore), and specific sampling units were selected randomly within each sampling zone.

Very little is known regarding the fine-scale distribution of reef habitat throughout much of the WFS, and due to anticipated cost and time requirements, mapping the entire WFS survey area was not feasible prior to initiating the WFS reef fish survey. 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 100m-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 1nm 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, while for part of 2010 and all of 2011 the acoustic survey was conducted using an L3-Klein 3900 side scan sonar. Based on results from these acoustic surveys, sampling effort was relocated to a nearby sampling unit should evidence of reef habitat be identified.

At each sampling station, two types of sampling gears were utilized: stationary underwater camera arrays (SUCA) and chevron traps. Gear deployments and collection and processing of field data followed established NMFS protocols. At each station, 1-2 SUCAs were deployed that consisted of a pair of stereo imaging system (SIS) units positioned at an angle of 180º 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 snapper observed (MaxN, or the maximum number of red snapper observed on a single video frame). In addition, 1-4 chevron traps were baited (generally Atlantic mackerel) and deployed for ninety minutes prior to retrieval; all red snapper collected were identified, enumerated, and measured. All individual gear deployments (SUCA and chevron traps) were spaced a minimum of 100 m apart. In addition to data on red snapper, geographic coordinates, depth, physiochemical conditions (e.g., temperature, salinity, dissolved oxygen, pH), and time of day were recorded at each specific sampling site.

Preliminary examination of semivariograms for red snapper indicated that the 100m spacing resulted in observations that were generally independent. Nevertheless, all data from a given sampling site were first averaged to avoid potential pseudoreplication. For each year and sampling zone, frequency of occurrence as well as mean (± SE) relative abundance of red snapper was calculated across stations for both SUCA and chevron trap data. For SUCA videos, relative abundance was calculated as the average MaxN, whereas for chevron traps, relative

abundance was calculated as the average number of red snapper per trap set. For chevron trap data only, annual size-frequency distributions were also calculated.

5.3.5.3. Results / Discussion

From 2008 – 2011, a total of 484 stations were sampled; all stations were sampled with chevron traps, whereas only 457 stations were sampled using SUCA (Tables 5.3.5.1 and 5.3.5.2). The reduced number of stations sampled using SUCA was attributable to instances where the cameras malfunctioned or weather conditions prevented sampling. Due to weather and mechanical issues, planned effort of n = 200 sampling stations was only achieved in 2011; from 2008 – 2010 total sampling effort varied from 73 – 117 stations. Although all four spatial zones were sampled each year, allocation of completed sampling effort varied significantly; accordingly, data were summarized independently for each zone.

Analyses of SUCA (Figures 5.3.5.2 and 5.3.5.3) and chevron trap data (Figures 5.3.5.4 and 5.3.5.5) indicated that red snapper were never observed within the Charlotte Harbor – Nearshore zone, and only rarely observed in the Tampa Bay – Nearshore zone. In the offshore zones, red snapper were generally more frequently observed off Tampa Bay in both SUCA and chevron traps. Overall there has been a marked increase in both the frequency of occurrence and relative abundance of red snapper in both the Tampa Bay – Offshore and Charlotte Harbor – Offshore zones (Figures 5.3.5.2 – 5.3.5.5). The one notable exception to this trend is the frequency of occurrence and relative abundance of red snapper from chevron traps in the Charlotte Harbor – Offshore zone (Figures 5.3.5.4 and 5.3.5.5). In 2009, red snapper were collected at exceptionally high abundances (n > 25 red snapper per station) at two stations. Insufficient length data were available from the SUCA to make any meaningful comparisons, but red snapper collected in chevron traps ranged from 150 – 500 mm SL, although most individuals ranged from 300 – 450 mm SL (Figure 5.3.5.6). No marked changed in size frequency were evident through time.
It is apparent that red snapper are becoming common in the offshore waters (20 – 60 fa) off the WFS, as they were observed at nearly 30% of all stations off of Tampa Bay and 20% of all stations off of Charlotte Harbor in 2011. At present, it is impossible to reconcile whether the increasing trends through time result from increased abundance of red snapper, increased survey efficiency, or a combination of the two. Survey efficiency has undoubtedly increased through time, and the proportion of stations sampled that actually contained reef habitat has increased significantly. A more appropriate examination of trends through time would require detailed post-stratification where sites that did not contain reef habitat were excluded from these analyses.

At present we do not have sufficient habitat data for prior survey years (especially 2008 and 2009) to satisfactorily post-stratify these data, although ongoing mapping efforts targeting previously-sampled stations will improve our ability to post-stratify data in the future.

5.3.5.4. Comments on Adequacy for Assessment

There was discussion within the IWG of combining all video indices into one index. However, the NMFS Video Survey is conducted on offshore banks throughout the Gulf, while the other video surveys, including this one, were conducted closer to shore. Therefore, a combined video

index utilizing both the Panama City NMFS and the FWRI Video Survey Data was suggested, and will be presented at the Assessment Workshop.

5.3.6. NMFS Panama City Laboratory Trap & Camera Survey (SEDAR 31-DW-28)

5.3.6.1. Survey History and Overview

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 in 2003 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 (Figure 5.3.6.1), an area separated from the shelf off Panama City by Cape San Blas - an established hydrographic and likely zoogeographic boundary (Zieman and Zieman 1989).

Beginning in 2005, the collection of visual (stationary video) data was added to the survey to provide insight on trap selectivity, more complete information on community structure, relative abundance estimates on species rarely or never caught in the trap, and additional, independent estimates of abundance on species typically caught in the traps. Video sampling was only done in Apalachee Bay that first year, but was expanded to the entire survey in 2006. Also in 2005 the target species list was expanded to include the 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 with the camera array followed immediately by a single trap. Beginning in 2009 trap effort was reduced ~50%, with one deployed at about every other video site, starting with the first site of the day. This was done so the number of video samples, and thereby the accuracy and precision of the video abundance estimates, could be increased. Camera arrays are much less selective and provide abundance estimates for many more species than traps, and those estimates are usually much less biased. All sampling has occurred between May and early October, but primarily during June through September. At each site, a CTD cast was made to collect temperature, salinity, oxygen, and turbidity profiles.

The survey sampling design was systematic through 2009 because of a very limited sample site universe, but was changed to stratified random in 2010 after side scan sonar surveys that year yielded an order of magnitude increase in that universe. To ensure uniform geographic and bathymetric coverage, 2-stage sampling is used. Five by five minute blocks, stratified by depth

zone (< and >30 m) and geographical location, and known to contain reef sites, are randomly chosen first, then 2 sites a minimum of 300 m apart within each selected block (Figure 5.3.6.2). Depth coverage was ~8-30 m during 2004-07, and since then was steadily expanded to ~8 – 47 m (Figure 5.3.6.3). Sampling effort has also increased since 2004. Sample sizes were 59 in 2004 (33 W: 26 E), 101 in '05 (24 W: 77 E), 113 in '06 (25 W: 89 E), 86 in '07 (29 W: 57 E), , 98 in '08 (31 W: 66 E), , 143 in '09 (48 W: 97 E), , 162 in '10 (53 W: 109 E), , and 170 in '11 (65 W: 115 E). In 2004 and 2005 some sites were sampled twice: 9 in 04 and 23 in 05; thereafter each site was only sampled once in a given year.

5.3.6.2. Methods

Sampling is conducted only during daytime from 1 hr after sunrise until 1 hr before sunset. Chevron traps, identical to that used in the MARMAP program (McGovern et al. 1998) except for 50% smaller throat opening, 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 that day. 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).

During 2005 – 2008, visual data were collected using a stationary camera array composed of 4 high definition (HDEF), digital video cameras 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 180º from the other SIS was added, reducing the number of HDEFs to two; both SIS's were also upgraded with HDEF, color mpeg cameras.

When only HDEF cameras were used (through 2008), soak time for the array was 30 min to allow sediment stirred up during camera deployment to dissipate and ensure tapes with an unoccluded 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 hard drive in the SIS to shut down before retrieval. 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. 65º) – were scanned, and again, the one with the best view of the habitat was analyzed. Twenty min of the tape were viewed, beginning when the cloud of sediment disturbed by the landing of the array has dissipated. All fish captured on videotape were identified to the lowest discernible 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), 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. In contrast, when using the scaling lasers on the array to obtain length data, there was no way to eliminate the possibility of double measuring a given fish, although this was probably not a serious problem, as usable laser hits were typically rare for any one sample.

Because of the significant differences in both species composition and abundance for many reef fishes east and west of Cape San Blas, especially in the inner and mid-shelf depths sampled by the Panama City survey, many of the results presented herein are shown separately for the two areas.

Censored data sets were used in deriving the indices of relative abundance from video data. Prior to 2010, the year we began using side scan sonar to locate reefs, lack of knowledge of reef habitat locations east of the Cape necessitated making a much higher proportion of "exploratory" camera and trap drops there versus west of the Cape. To compensate, more overall effort was expended in the east. Some of these "exploratory" sample sites turned out to be sand, mostly sand, or very marginal reef habitat at best, yielding little or no reef fish data. In addition, the gear occasionally missed the intended reef site. Inclusion of data from those sites would have reduced the precision of the abundance estimates and confounded any analyses. For that reason, video data – both habitat classification and fish counts – from all sites were screened, and those with no evidence that hard or live bottom was in close proximity, as well as sites where the view was obscured for some reason (poor visibility, bad camera angle), were censored (excluded) from calculations of relative abundance. As a result of this screening, of video samples east of the Cape, only 31 of 41 in 2005, 47 of 89 in 2006, 23 of 57 in 2007, 56 of 66 in 2008, 62 of 97 in 2009, 95 of 109 in 2010, and 99 of 115 in 2011 met the reef and visibility criteria and were retained. In contrast, west of the Cape, 24 of 25 sites in 2006, 29 of 29 in 2007, 29 of 31 in 2008, 42 of 47 in 2009, 52 of 53 in 2010, and 57 of 64 in 2011 were retained for analyses.

Standardization

The delta-lognormal index of relative abundance as described by Lo *et al*. (1992) was estimated. For a full review of the backward selection procedure for each submodel and diagnostic plots, refer to SEDAR31-DW28.

The month effect was dropped from the binomial submodel based on type 3 analyses. However, with the variable removal there was a corresponding increase in AIC, but due to the high insignificance of the month variable, it was left out of the model. For the lognormal submodel for nonzero observation of red snapper, the water depth variable was dropped from the model, and there was a corresponding decrease in the AIC value.

5.3.6.4. Results

Red snapper distribution and abundance on the inner and mid shelf have consistently and noticeably differed east and west of Cape San Blas since the Panama City survey began in 2004/5 (Tables 5.3.6.1 and 5.3.6.2, Figures 5.3.6.4 and 5.3.6.5)(DeVries et al. 2008, 2009). Red snapper has been, by far, the most commonly encountered exploited reef fish west of Cape San Blas (the Cape) every year, occurring in 47 – 88 % of trap catches and 91 – 100 % of video samples (Table 5.3.6.1, Figure 5.3.6.6). In contrast, east of the Cape, red snapper have been much less common, especially during 2004-08, when they occurred in 0-8 % of trap sets and 9-26 % of video samples. Since 2009, up through 2011, those numbers have been considerably higher: 20-36 % for traps and 26-46 % for video (Table 5.3.6.1, Figure 5.3.6.4). Some of the increase reflects 1) the difference in the distribution of depths sampled in each area, e.g., only a small proportion of sites <20 m have been sampled west of the Cape, while in the east through 2009, very few sites >20 m were sampled; as well as 2) the expansion of sampling to deeper depths over time (Figure 5.3.6.3). Figure 5.3.6.4 clearly shows that red snapper east of Cape San Blas were rarely observed in depths <20 m. Although the sampling depth differences and changes likely explain some of the increases in occurrence, it also appears to reflect an expansion of the population into Apalachee Bay, as occurrence increased noticeably even in shallow (<20 m) areas, especially an area in northwest Apalachee Bay in 2009 (Figure 5.3.6.5).

Overall modal size of red snapper taken in traps was fairly stable 2005-2007, ranging from 300 to 350 mm TL, then steadily increased through 2011, when it was 375 to 425 mm TL (Figure 5.3.6.7). Along with this increase in modal size, the lower (left hand) tail of the distribution also shifted, increasing from around 200-225 mm in 2005 to about 325 mm in 2011. Part of this shift may reflect the expansion of the sampling depth range west of the Cape during those years, as a comparison of size structure in depths < and > 30 m (Figure 5.3.6.8) clearly showed smaller average sizes in shallower depths. However, the shift in size structure co-occurred with increasingly restrictive management measures and mirrored the steady increases in average sizes (and catch rates) of recreationally harvested fish in the area, which suggests it shows a real trend in the population and is not just an artifact of changes in sampling depths.

Not surprisingly, a comparison of size data from trap catches with that from stereo images indicated that the traps do select against most red snapper >650 mm TL, although fish that large appear to be uncommon in the survey area based on the few stereo measurements obtained (Figure 5.3.6.9). For the most part, in 2011, west of the Cape, the size distributions were surprisingly similar between the two gears, except for the rare large fish detected only with the video gear. Earlier (2007-09) size data from scaling lasers suggested traps were selecting against the smallest individuals, perhaps an inhibiting effect of larger, more aggressive fish entering the trap first. In 2009, unexpectedly, the distribution of the laser measurements was shifted to the left (smaller) of that from the stereo data, with an obviously smaller mode; while the distributions of the trap fish and that from the stereo images, like in 2011, were very similar. Given the problem of potentially measuring the same fish more than once with lasers, length data from stereo images taken from a frame with no more than the min count of that site is likely to be more unbiased.

Age structure in trap catches during 2005-2007 was dominated by 2 and 3 yr olds, with an obvious mode at age 2 ; one and four yr olds were uncommon, except for age ones in 2005 (Figure 5.3.6.10). In 2008 and 2009, two and three yr olds still dominated the age structure; and in 2008, for the first time, four yr olds were quite common and a few fish to age 8 were caught. The 2006 and 2007 year classes, equating to the 2 and 3 yr old modal group in 2009, continued to dominate the age structure as 3 and 4 yr olds in 2010 and 4 and 5 yr olds in 2011, suggesting these two year classes were fairly strong. In 2010, age ones were no longer present, and by 2011, as the distribution continued to shift to older ages, age 2 fish were also virtually nonexistent.

5.3.6.5. Video indices of abundance

Figure 5.3.6.11 and Table 5.3.6.3 summarize indices of red snapper developed from the Panama City video data, 2005-2011, using a delta-lognormal model. The index, scaled to a mean of one over the time series, peaked in 2009; and based on the age frequency data from trap catches (Figure 5.3.6.9), the fish were primarily from the 2006 and 2007 year classes. The index declined in 2010 and 2011, perhaps as the influence of the apparently strong 06 and 07 cohorts waned. Diagnostics for each of the submodels in the index development and QQ plots can be found in reference document SEDAR31-DW-28.

5.3.6.6. Comments on Adequacy for Assessment

There was discussion within the IWG of combining all video indices into one index. However, the NMFS Video Survey is conducted on offshore banks throughout the Gulf, while the other video surveys, including this one, were conducted closer to shore. Therefore, a combined video index utilizing both the Panama City NMFS and the FWRI Video Survey Data was suggested, and will be presented at the Assessment Workshop.

5.3.7. Other Fishery-Independent Datasets

Data was presented by the Dauphin Island Sea Lab concerning bottom longline and trawling off the Alabama coast. It was discussed that these data should be analyzed and possibly combined with NMFS survey data to produce joint indices. These analyses will be conducted and presented during the Assessment Workshop.

5.4 Fishery Dependent Indices

5.4.1. Fishery Dependent Recreational Surveys (SEDAR 31-DW-33)

The recreational fisheries in the Gulf of Mexico are surveyed by three programs:

- Marine Recreational Fishery Statistics Survey (MRFSS) conducted by the NOAA Fisheries (NMFS).
- Texas Marine Sport-Harvest Monitoring Program by the Texas Parks and Wildlife Department (TPWD).

- Headboat Survey (HBS) conducted by NMFS, Southeast Fisheries Science Center, Beaufort, NC.

These three surveys together provide information on catch in numbers, fishing effort, and length and weight samples. The MRFSS and the TPWD survey are both sampling-based, while the Headboat Survey is a census of headboats using logbooks provided to all headboats to report total landings per trip and fishing effort. MRFSS was conducted in TX through 1985, after which the Texas Parks and Wildlife Department covered surveying efforts. In addition, starting in 1986, MRFSS no longer covered headboats in the Gulf of Mexico and instead this sector of the recreational fishery was covered by the Headboat Survey. MRFSS provides information on participation, effort, and species-specific catch. Data are collected to provide catch and effort estimates in two-month periods ("waves") for each recreational fishing mode (shore fishing, private/rental boat, charterboat, or headboat/charterboat combined) and area of fishing (inshore, state Territorial Seas, U.S. Exclusive Economic Zone) in each Gulf of Mexico state (except Texas). Total catch information is collected by MRFSS on fish landed whole and observed by the interviewers ("Type A"), fish reported as killed by the fishers ("Type B1") and fish reported as released alive by the fishers ("Type B2"). Similar to MRFSS, the Texas Parks and Wildlife survey also, provides information on participation, effort and species-specific landings however no discards are reported in this dataset.

5.4.1.1 Methods of Estimation

Data Filtering Techniques

The Stephens and MacCall approach (2004) was used to select trips that fished in the same habitat and could have caught red snapper. Data was split east and west of the Mississippi River in order to generate indices for the eastern and western Gulf of Mexico. In addition, indices were estimated separately for the private boat/for hire and headboat sectors of the recreational fishery. For the headboat survey, based on the working group's recommendation, the data was subset such that only data collected during red snapper open seasons was used in the analysis. The reason for this was because fishing effort that took place outside of the red snapper fishing season would not have targeted red snapper, and any red snapper caught incidentally would have been discarded and not recorded in the headboat survey.

Standardization

Two different ways of standardizing CPUE for the recreational red snapper fishery were explored. One used a Delta lognormal approach, which models the presence or absence of encountering the species on that trip as zero or one using a binomial model, separately from the positive observations of actual CPUE using a lognormal model. The second approach also used a Delta model however a censored lognormal regression model was used to model the positive observations of CPUE. The reason for using this model was to capture the effect of the bag limit on CPUE, which had become increasingly strict over the time series. The working group recommended the use of the censored approach to standardizing CPUE because of its ability to account for the bag limit effect which, if not accounted for, would otherwise give the artificial perception that abundance had decreased unnecessarily over the time series.

The main advantage of using the Delta method is to allow for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a censored lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992). The sub-models of the delta-lognormal model were built using a forward selection procedure based on type 3 analyses based on reduction of AIC and a reduction in deviance of greater than one percent.

Submodel Variables

Headboat

Year: 1986-2011
Month: 1-12
Headboat Areas: 16(west coast of Florida), 18(Dry Tortugas Gulf waters), 20(South West Florida), 21(Naples-Crystal River), 22(Florida Middle Grounds), 23(NW Florida and Alabama), 24(Louisiana), 25(NE Texas Sabne-Freeport), 26(Central Texas Port Aransas), 27(South Texas Port Isabel)
Number of Anglers (Binomial Component only): 10, 20, 30, 40, 50, 60, 70, 80 or 90 where 90 is a plus group

MRFSS/Texas Parks and Wildlife Survey

Year: 1981-2011 for private/for hire, and 1986-2011 for headboat
Wave (groupings of every two months): 1-6
Area: Inshore waters, state waters, federal waters
State: Florida, Alabama, Mississippi, Louisiana, Texas
Number of Anglers (Binomial Component only): 1- 10, where 10 is a plus group

Annual Abundance Indices

Tables with the final annual indices and coefficient of variations can be found in Tables 5.4.1.1 and 5.4.1.2. Please see the working paper SEDAR 31-DW-33 for fit diagnostics and additional synthesis of the model results including final model selection tables for the binomial component and censored lognormal regression component with the factors that were included in the models.

5.4.1.2 Sampling Intensity

Tables of sample sizes across strata can be found in working document SEDAR 31-DW-33.

5.4.1.3 Size/Age Data

Please see SEDAR 31-DW-10.

5.4.1.4 Catch Rates

Standardized catch rates are presented in Tables 5.4.1.1 and 5.4.1.2 and Figure 5.4.1.1.

5.4.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Tables 5.4.1.1 and 5.4.1.2.

5.4.1.6 Comments on Adequacy for Assessment

The working group recommended the use of the censored approach to standardizing CPUE using red snapper data from the recreational fishery. The group felt that the censored approach was able to account for the bag limit effect which would otherwise give the artificial perception that abundance had decreased over the time series. After reviewing the resulting recreational indices, the working group recommended that the both the for/hire and headboat indices be used in the assessment for both the eastern and western Gulf of Mexico. These indices were decided to be included in the assessment because they cover a long time series, the entire spatial domain of the stock, and provide the stock assessment model with a source of information about the recreational sector of the red snapper fishery.

5.4.2. Commercial Fishery Catch Rates (SEDAR7-DW-47 and SEDAR7-AW-9)

Indices constructed for the 2009 Gulf of Mexico red snapper assessment included data for the period 1990 (beginning of self-reported logbook program) through 2006 (final year in which red snapper management measures did not include Individual Fishing Quotas, IFQs). Fisher behavior has reportedly changed from that characteristic of a derby fishery to one in which red snapper are not specifically targeted. No accepted method has been demonstrated by which catch and effort data from the pre-IFQ and IFQ years can be integrated into a single index of abundance. Research funds have been obtained by SEFSC to address this issue, but that project is ongoing. For the period 1990-2006, the indices constructed for the 2009 update assessment have been provided for use in the current assessment. Methods and results of those analyses are provided below.

5.4.2.1. Commercial Handline

Data from the National Marine Fisheries Service reef fish logbook program were used to construct separate abundance indices of red snapper for the eastern and western Gulf of Mexico (divided at the Mississippi River). Indices included the years 1990-2006. Unlike the 2004 assessment, the current assessment model was able to accommodate changes in minimum size limits, therefore, the CPUE time series was not truncated to include only those years of consistent minimum size limits. After 2006 an Individual Fishing Quota (IFQ) system was established for red snapper. Catch and effort data for those years were not included in the analyses because under the IFQ system, fishing behavior and catchability may have changed from earlier years. Such a change prevents the direct comparison of CPUEs in 2007-2011 with CPUEs of earlier years.

The index constructed from eastern Gulf of Mexico (GOM) data used the Stephens and MacCall (2004) method for identifying trips with fishing effort in red snapper habitat. Construction of the western GOM index of abundance initially used the Stephens and MacCall (2004) approach for trip selection, however, this resulted in greater than 90% positive trips. A lognormal model was used because a delta-lognormal model is not appropriate with such a high proportion of positive trips.

The utility of the commercial catch rates as indices of population abundance was of some concern because of the potential effect of trip limits on the results. Over much of the time series, vessels were limited by permit to either 2,000 or 200 pounds of landed red snapper per trip. In the western GOM, a large percentage of trips met or exceeded the trip limit (48.5% of 2,000 pound permitted trips; 39.1% of 200 pound permitted trips; 5.4% of trips with no permit). Of those trips that met or exceeded the trip limit, red snapper accounted for more than 50% of the landings in 99% of the 2,000 pound permitted trips, 90% of the 200 pound permitted trips, and 100% of the non permitted trips. If a trip limit was reached in the western GOM, in nearly all cases the trip ended once the limit was reached and the effort may reasonably be assumed to have been directed at red snapper; i.e., effort was not shifted to other species. If effort were shifted to other species, the available logbook data could not be apportioned among multiple targeted species for a single trip. In addition, effort was calculated as hook hours fished on each trip, therefore, CPUE could be properly calculated for red snapper even though the trip limit was reached. Changes in abundance would be reflected by changes in catch per hour. If effort had been defined as landings per trip, trip limits would have affected CPUE calculations because CPUE would have had an insufficiently defined time component. Longer (or shorter) trips would not be accounted for in CPUE calculations if "trip" were the measure of effort.

In the eastern GOM, a smaller percentage of trips met or exceeded the trip limits than was reported in the western GOM. Approximately 22.5% of 2,000 pound permitted trips, 32.2% of 200 pound permitted trips, and 0.07% of non permitted trips met or exceeded the trip limit. Of the trips that met or exceeded the trip limit, 96% of 2,000 pound permitted trips, 63% of 200 pound permitted trips, and 100% of non permitted trips reported landings of more than 50% red snapper. Although 37% of the 200 pound permitted trips reported landings of less than 50% red snapper, those trips accounted for only 5.6% of the total trips included in the analysis. Trip limits likely had little effect on index construction in the eastern GOM. Indices were also constructed with only those trips reporting red snapper landings below the trip limit and are compared with indices constructed using the full data set in Figures 5.4.2.1 (eastern GOM) and 5.4.2.2 (western GOM). Only minor differences between the indices were apparent.

Catch rate was calculated in weight of fish per hook-hour. Seven factors were tested for their possible affects on the proportion of positive trips (east only) and catch rate. Factors were: year, red snapper season (open or closed; only open season data used in the west), area fished, permit type (2,000 pound, 200 pound, or none), days at sea, season of the year (Jan-Apr, May-Aug, Sep-Dec), and number of crew.

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 ≥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).

Final models in the eastern Gulf of Mexico:

Binomial model on proportion positive trips

PPT = RS Season + Subregion + Year + Permit + Days at Sea + RS Season*Year + RS Season*Permit + Subregion*Days at Sea + Year*Days at Sea

Lognormal on CPUE of successful trips

Log(CPUE) = Days at Sea + Red Snapper Season + Year + Permit + Crew + Red Snapper Season*Year + Days at Sea*Year + Days at Sea*Permit+ Year*Permit

Final model in the western Gulf of Mexico:

Lognormal on CPUE of successful trips

Log(CPUE) = Days at Sea + Area Fished + Year + Permit + Crew + Area*Permit + Area*Year + Area*Crew + Year*Crew+ Days at Sea*Area

Standardization methods followed those used in the 2004 red snapper assessment where indices of abundance were constructed using the delta-lognormal approach of Lo et al. (1992) in the eastern GOM. The western index was constructed using a lognormal analysis. Indices are provided in Table 5.4.2.1 and Figures 5.4.2.1 – 5.4.2.2.

5.4.3 Index of Abundance for Pre-Fishery Recruit Red Snapper from Florida Headboat Observer Data (SEDAR 31-DW-09)

Fishery

Recreational hook-and-line fishing on head boats

Geographic Region

Sampled vessels operated from northwest Florida to the central west coast of Florida (Figure 5.4.3.1).

Time Period Covered

2005 through 2007 and June 2009 to present.

Data Collection Methods

Head boats in each of two regions (Figure 5.4.3.1) were randomly selected each week throughout the year for observer coverage. All head boats operating in the two regions voluntarily permitted observers on scheduled trips. Single day trips took place in nearshore and offshore fishing areas (Figure 5.4.3.1) and ranged from 4 to 15 hours in duration. Multi-day trips were sampled as a separate strata in the central west coast region, and these trips were greater than 24 hours in duration and took place farther offshore (Figure 5.4.3.1). One to two observers were scheduled per sampled trip and each observer selected a set of 5 to 10 anglers that they could visually observe. For more detailed methods, see Sauls and Cermak (2012). .

Variables Recorded

For each trip sampled, the following variables were collected consistently throughout the time-series:

- Day, month and year
- Region (northwest Florida, central west Florida)
- Trip type (single-day, multi-day)
- Trip duration
- Minimum and maximum depths fished
- Area fished the majority of time (state territorial seas, federal EEZ)
- Number of anglers on board
- Number of anglers observed

For each fish caught by an observed angler, the following variables were collected consistently throughout the time series:

- Species
- Disposition (harvested, released alive, released dead)
- Length (in mm) at the midline was recorded before fish were released or harvested, as time permitted, for all managed species. Red snapper were given high priority, and almost all red snapper were measured before they were released.

Size Composition of Red Snapper

Figure 5.4.3.2 shows length frequencies for all red snapper observed during June and July by year for 1 cm length bins. Total length in mm was calculated as: 1.89 + 1.06* fork length in mm, and converted to cm. Length frequencies for sublegal sizes (pre-fishery recruits) are included in bins for 40cm (39.5-40.4 cm) and lower. The months of June and July were consistently open to harvest each year during the time series. Other months were excluded since the duration of the harvest season varied each year (Table 5.4.3.1), which could influence length frequencies for observed fish if vessels target legal sized fish during the harvest season and/or avoid red snapper by-catch during the non-harvest season.

Data Exclusions

Head boat vessel operators throughout the Gulf of Mexico have been required by NMFS to report harvested red snapper on logbook trip reports since the 1980's. The logbook time-series covers a larger geographic region that overlaps temporally and spatially with this data source. Therefore, harvested fish are excluded from this analysis, but could be included if the NMFS logbook is not used as an index for SEDAR 31. In 2005, space was provided on the logbook data sheet to record red snapper discards. Comparisons between individual logbook trip reports and at-sea observer data indicate that self-reported logbook data for numbers of red snapper harvested are reliable, but that discards may be under reported and are frequently omitted on logbook trip reports (Sauls and Brennan, unpublished data). Therefore, self-reported logbook data may not be a reliable data source for constructing a pre-fishery recruit index. This analysis explores the utility of head boat at-sea observer data from Florida for constructing an index of abundance for pre-fishery recruits in the eastern Gulf of Mexico.

There was a reduction in the length of the red snapper harvest season over the course of this time series, and an interruption in funding prevented trips from being sampled every month or every year (Table 5.4.3.1). Temporal changes in the recreational harvest season could affect CPUE if vessels change their fishing areas and methods to target legal-size red snapper when the season is open. Since small red snapper may be more abundant in state waters than in federal waters, the spatial coverage of the harvest season was also important. We identified two months where the red snapper season was consistently open in both federal and state jurisdictions during all years 2005 to 2012. Size limits and bag limits also remained unchanged from 2005 to 2012. Head boat trips were consistently sampled during June and July each year from 2005 to 2012, except 2008. Therefore, we chose the months of June and July to construct an index of abundance. During years when harvest closed mid-way during the month of July, only trips sampled during the portion of the month open to harvest were included in the index (excluded trips after July 24, 2010; July 18, 2011; and July 16, 2012). The year 2010 should be viewed with caution due to spatial shifts in effort following the Deepwater Horizon disaster, when portions of the study area were closed to all fishing during a large portion of June and July.

Data Reduction Techniques

The proportions of head boat trips with releases of undersized red snapper ranged from roughly 40% and 60% in June and July overall (Figure 5.4.3.3), but the proportions of trips with releases were much greater in the NW FL region (60-100%) than in the TB region (7-31%). Undersized releases of red snapper were observed by at-sea samplers only in head boat catches (Figures 5.4.3.4-5.4.3.5) from average water depths of 50' or deeper (average of minimum and maximum depths for 2005-2007 and 2009-2011). Releases of undersized red snapper tended to be in deeper waters in the TB region compared to the NW FL region. Trips where water depths fished were greater than or equal to 50' in both regions were chosen for analyses from the NW FL and TB regions. The proportion of trips with undersized releases of red snapper appears related to water depth fished (Figure 5.4.3.4), and suggests that the average depth fished may be a useful covariate in the binomial sub-model. However, the rates of releases of undersized red snapper by anglers appear more complex, and changes over time in the NW FL region (Figure 5.4.3.5).

While it may be a useful covariate in the model for trips with undersized releases, interaction terms may be necessary to handle this covariate when examining release rates.

A suitable method for selecting a universe of trips to evaluate (i.e., all trips which could have caught undersized red snapper – zeros as well as positives) has not been developed yet, but possibly could be done using clustering techniques (e.g., Shertzer and Williams 2008) or other selection procedures (e.g., Stephens and MacCall 2004). Species caught on trips with undersized red snapper were tabulated by frequency of occurrence, and those occurring on 10% or more of the trips with releases of undersized red snapper were analyzed. The Stephens and MacCall (2004) logistic selection method was attempted using data from NW FL and TB regions, but produced unsatisfactory results and in fact failed to converge successfully using more than one species (in this case, vermilion snapper) and more than a single region. There was little difference between using the occurrence of vermilion snapper to select NW FL trips for the analyses and using the samples from water depths greater than or equal to 50' as described in the preceding section. For the combined NW FL and TB regions, the species assemblages in the two regions caught with undersized red snapper were sufficiently different to cause the logistic selection analyses to be unhelpful. Therefore, all of the trips (with and without releases of undersized red snapper) from the NW FL and TB region from water depths fished of 50' or greater were used without the logistic selection criteria for identifying potential "zero" trips based upon species assemblages.

Model Standardization

There was one index produced for released undersized red snapper for the combined NW FL and TB regions. Trips with the average number of released undersized red snapper (zero and positive trips) were selected by region, year, month, and average water depth fished. Region, year, and month were used as classification variables, and average water depth fished was used as a potential covariate in the analyses. No interaction terms were included in the model formulations (for a discussion of the use of interaction terms in CPUE standardizations, see SEDAR 2008, S15A Mutton Snapper Review Workshop Consensus Report Section 2.1).

A general linear model [GENMOD procedure (SAS Institute Inc. 2008)] using a forward stepwise selection technique was used to estimate trends in the average number of released undersized red snapper per angler-trip. Two types of model probability distributions were used: binomial (with a logit link function) and gamma (with a log link function) (McCullagh and Nelder 1989). The binomial sub-model analyzed the presence or absence of released undersized red snapper by anglers on a trip, and the gamma sub-model analyzed the average releases of undersized red snapper per angler-trip on positive trips. The forward selection process analyzed the null model (no class variables chosen), and then each class variable or covariate added singly in the sub-model. If the GLM successfully converged, the reduction in deviance from the null model was assessed for each of these runs, and the class variable with the largest percentage reduction in deviance, a significant χ^2 (Chi-square) value, and a lower corrected Akaike Information Criterion (AICc) than other class variables or covariate was selected for the sub-models. The next series of sub-model runs included the variable selected in the previous series along with each of the remaining variables or covariate (one at a time), and each of the resulting two-variable sub-models were assessed for sub-model convergence, the largest percentage

reduction in deviance from the null model and significance criteria (χ^2, AICc) as before. This process continued until the percentage reduction in deviance became less than some desired level or until neither variable nor covariate added was significant. For these model runs, a 1% reduction in deviance from the null model was the selected level of acceptance for a suite of class variables. If there were cases when the variable of interest (in this case, year was important) failed to be selected, it would have been included in the sub-model statement so that a year effect could be estimated. However, both of the sub-models included year using the criteria described. Annual values (and associated coefficients of variation) were estimated using the least squares mean method (SAS Institute Inc. 2008) for the year effect.

Model Diagnostics

The results of the analyses from the forward stepwise selection of variables for the linear models, the diagnostic plots (standardized residuals by year, q-q plot, and standardized residuals versus the fitted distribution) and scaled index values (index values scaled to their means) over time can be found in reference document SEDAR31-DW-09.

Model Results

The adjusted average undersized red snapper release rates (numbers per angler-trip), coefficient of variation (as a percentage of the mean), and the scaled index values are in Tables 5.4.3.2-5.4.3.3. A comparison of the adjusted means (rescaled by the n-weighted mean of the series) is in Figure 5.4.3.6. Nominal average undersized red snapper release rates (simple arithmetic and log-transformed means) and adjusted means (Figure 5.4.3.7).

5.4.3.2. Comments on Adequacy for Assessment

This index was not recommended for use by the Indices Workgroup because the survey area is limited to the eastern Gulf and overlaps with the headboat index discussed in section 5.4.1 of this report. However, it should be noted that this index was developed using sub-legal sized discards to avoid overlap with the headboat survey, since the headboat index in 5.4.1 only includes red snapper that were legal harvest size. It is possible to update this pre-fishery recruit index to include the 2012 sample year in time for the Assessment Workshop if this index was to be considered for use. During the Data Workshop, the Indices Workgroup was asked to re-work this index to include red snapper of all size classes and evaluate the potential for using this index in place of the NMFS headboat index for the Eastern Gulf. The index was re-constructed, but was not reviewed by the Index Workgroup in time for inclusion in this report. A working paper for this re-worked index can be submitted for consideration during the Assessment Workshop if requested.

5.5. Research Recommendations made by Members of the IWG

The following are research recommendations that could improve the utility (precision) of the SEAMAP larval index for red snapper.

1. Expand the use of molecular genetics to identify the smallest and most abundant snapper larvae in SEAMAP samples that cannot be positively identified as red snapper because diagnostic morphological characters are not yet developed.
2. Begin directed sampling for fish eggs on SEAMAP summer trawl and fall plankton surveys using vertical nets hauls. The protocols for fish egg sampling have been established by NMFS/SWFSC scientists and are in use on the west coast. Fish egg collections are easy to make and take little additional sampling time. The eggs in these samples would have to be identified genetically but the protocols for genetic identification of red snapper eggs have been worked out by Frank Hernandez and Keith Bayha at DISL. The results of their MARFIN funded project using CUFES samples from our SEAMAP Fall Plankton surveys are impressive and significant. They produced maps of red snapper egg (i.e. spawning) distribution over the entire Gulfwide survey area. Estimates of egg abundance data coupled with the updated reproduction parameters (spawning frequency and fecundity) generated by NMFS scientists at the Panama City Lab could eventually be used to produce an actual spawning biomass estimate for red snapper.
3. Continue aging red snapper larvae from SEAMAP samples to improve the age-length relationship (key). This should improve the precision of the SEAMAP larval abundance index that is now based on a single age class of larvae across years.
4. Produce a SEAMAP larval index based on the abundance of red snapper larvae captured during SEAMAP summer shrimp/groundfish surveys (past and present). This survey has for a number of years now been expanded to include the entire northern Gulf of Mexico shelf. I don't need to remind you that the data from summer months (i.e. during peak red snapper spawning months) could be a far better indication of spawning production than data from the end of season from which the current SEAMAP larval index is derived.
5. Explore the utility of a larval red snapper index based on a comprehensive modeling approach that includes all SEAMAP stations (regardless of how many times they have been sampled over the time series) and both sampling gears, i.e. neuston and bongo samples. There are other likely explanatory variables (one for sure is salinity) that could ultimately improve the index.

5.6 Literature Cited

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5.7 Tables

Table 5.1.1. Datasets Reviewed for Indices Development.

Series	*Author*	*Reference*	*Data Source*	*Area*	*Years*	*Season*	*Biomass/Number*	*Fishery Type*	*Standardization*	*Selectivity Info*	*Age Range*
NMFS BLL	Ingram and Pollack	SEDAR31-DW-19	NMFS BLL Survey Data	FL-TX	1996-2011	Aug-Sept	Number per 100 hook-hours	Independent	Delta-lognormal	Age frequency	1-43
NMFS SEAMAP Trawl Survey	Pollack et al.	SEDAR31-DW-20	NMFS SEAMAP Trawl Survey Data	AL-TX	1987-2011	Summer and Fall	Number per trawl-hour	Independent	Delta-lognormal	Length and Age	Primarily Age-0 and Age-1
SEAMAP Reef Fish Video	Campbell et al.	SEDAR31-DW-08	SEAMAP Reef Fish Video Survey Data	FL-TX	1993-1997, 2001-2002, 2004-2011	May-Aug	Video min count	Independent	Delta-lognormal	Length frequency (consistently 2005 onwards)	Primarily 2-7
FWC Reef Fish	Switzer et al.	SEDAR31-DW-24	FWC Reef Fish Survey Data	FL	2008-2011	June-Sept	Video min count; number per trap	Independent	none	Length and Age	Primarily 1-6
NMFS Panama City	DeVries et al.	SEDAR31-DW-28	NMFS Panama City Trap and Camera Data	FL	2004-2011 (trap); 2005-2011 (video)	May-Oct	Video min count	Independent	Delta-lognormal	Length and Age frequency (2005-2011)	Primarily 1-6
Larval	Pollack et al.	SEDAR31-DW-27	SEAMAP Fall Plankton Survey Data	FL-TX	1986-2010	Late Summer, early Fall	number under 10 m2 sea surface	Independent	Delta-lognormal	Length and Age	Age-0
MRFSS and TPWD	Saul and Walter	SEDAR31-DW-33	MRFSS and TPWD data	FL-LA	1981-2011	Year-round	Number per angler-hour	Dependent	Censored lognormal	None	2-43
FWC Recreational Hook-and-Line on Head Boats	O'Hop and Sauls	SEDAR31-DW-09	Recreational hook-and-line fishing on head boats	FL	2005-2007 and June 2009-present	June-July	Number of undersized red snapper released by head boat anglers per trip	Dependent	GLM	Length Frequency	Pre-fishery recruits
Headboat	Saul and Walter	SEDAR31-DW-33	MRFSS and TPWD Survey data	FL-TX	1986-2011	Year-round	Number per angler-hour	Dependent	Censored lognormal	None	2-43
Commercial Handline	McCarthy and Cass-Calay	SEDAR7-DW-47 and SEDAR7-AW-9	NMFS Reef Fish logbook program	FL-TX	1990-2006	Year-round	Weight of fish per hook-hour	Dependent	Delta-lognormal and lognormal	None	2-43
Headboat Observer	O'Hop and Sauls	SEDAR31-DW-9	NMFS Headboat Observer data	FL	2005-2007 and June 2009-2011	June-July	Number of released fish per angler-trip	Dependent	Delta-Gamma	None	2-43

Table 5.3.1.1. Number of stations sampled by shrimp statistical zone during the Summer SEAMAP groundfish survey from 1982-2011.

	Shrimp Statistical Zone																			
Year	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	21	Total
1982									14	22	24	26	8	1	11	30	10	3	23	*172*
1983							5	19	8	13		6	16	19	25	24	21	5	17	*178*
1984									13	16	10	16	16	22	17	15	23	28	14	*190*
1985									10	26	5	7	8	10	7	7	12	11	10	*113*
1986									14	21	2	5	14	8	11	8	11	14	6	*114*
1987									30	66	6	20	19	25	20	16	25	28	19	*274*
1988									19	49	5	4	3	19	24	14	25	28	23	*213*
1989									23	30		3	18	25	7	15	20	29	24	*194*
1990										68	11	20	15	23	16	20	23	24	20	*240*
1991										46	12	24	13	23	22	24	18	23	26	*231*
1992									1	45	2	20	24	20	25	12	31	26	20	*226*
1993										45	10	19	17	24	19	14	29	24	22	*223*
1994										61	6	17	22	25	17	20	22	26	22	*238*
1995										44	10	16	18	22	23	13	27	26	21	*220*
1996										46	14	12	19	22	18	17	21	26	25	*220*
1997										44		12	16	22	23	10	28	26	26	*207*
1998										35	2	14	21	25	18	14	22	36	17	*204*
1999										44	7	20	19	20	23	13	25	32	20	*223*
2000										45	2	19	15	19	27	8	29	31	21	*216*
2001										36	7	18	18	13	3	10	9	17	21	*152*
2002										44	11	14	21	27	19	15	25	29	22	*227*
2003										44	9	10	8	2	17	20	22	26	23	*181*
2004										39	11	18	17	20	25	21	19	25	21	*216*
2005										32	10	9	11	16	21	5	28	22	27	*181*
2006										45	11	21	12	20	23	17	23	31	18	*221*
2007										41		6	15	22	23	7	29	32	21	*196*
2008			1	8	11	6	11	8	11	43	24	19	27	23	22	17	24	21	29	*305*
2009			35	21	29	15	16	18	24	67	25	20	36	39	46	53	33	29	23	*529*
2010		31	26	21	24	10	12	14	14	22	5	20	16	21	33	34	27	27	19	*376*
2011	11	24	22	20	29	2	14	11	8	16	7	14	17	24	29	29	18	21	13	*329*
Total	*11*	*55*	*84*	*70*	*93*	*33*	*58*	*70*	*189*	*1195*	*248*	*449*	*499*	*601*	*614*	*522*	*679*	*726*	*613*	*6809*

Table 5.3.1.2. Number of stations sampled by shrimp statistical zone during the Fall SEAMAP groundfish survey from 1972-2011.

	Shrimp Statistical Zone																		
Year	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	21	Total
1972									10	55	27	41	34	17						*184*
1973								11	17	98	34	71	39	2						*272*
1974									12	92	35	73	31							*243*
1975										93	33	80	35	32	7					*280*
1976										108	42	79	56	22						*307*
1977										97	31	76	38							*242*
1978									36	101	32	67	58	25						*319*
1979										109	35	72	55	2						*273*
1980									24	85	22	70	32							*233*
1981									21	85	33	66	49	25						*279*
1982									21	102	41	72	37							*273*
1983									17	82	35	63	25							*222*
1984										82	32	64	47	1						*226*
1985									30	59	17	27	51	32	10	20	20	19	19	*304*
1986							20	10	21	19	7	15	14	27	35	26	23	22	21	260
1987									16	28	15	14	16	17	15	15	15	18	3	*172*
1988									8	28	7	22	17	18	26	19	21	31	20	*217*
1989										43	12	19	17	22	20	17	22	25	26	*223*
1990										52	14	12	23	22	19	18	22	19	27	*228*
1991										46	6	24	14	20	25	24	19	25	22	*225*
1992										33	7	23	14	25	18	17	27	30	18	*212*
1993										72	10	19	17	26	18	16	25	28	18	*249*
1994										50	9	16	21	25	20	21	23	24	20	*229*
1995										40	10	17	18	24	19	14	26	30	19	*217*
1996										45	9	18	19	17	28	13	25	29	24	*227*
1997										44	10	17	20	26	19	18	23	22	24	*223*
1998										44	10	22	14	34	11	15	24	29	22	*225*
1999										42	10	17	18	29	18	12	28	29	22	*225*
2000										43	10	14	22	20	26	12	30	25	21	*223*
2001										21	10	17	19	26	20	14	27	28	23	*205*
2002									1	51	10	13	22	22	23	14	26	30	21	*233*
2003									1	76	9	16	21	24	22	20	23	25	23	*260*
2004										43		11	18	17	27	14	24	30	21	*205*
2005										44	11	20	16	33	18	14	23	24	27	*230*
2006									1	47	7	22	14	18	28	13	23	32	19	*224*
2007										31	9	20	17	18	28	17	20	18	26	*204*
2008				15	14	4	4	3	4	35	18	28	34	42	46	44	19	36	20	*366*
2009			20	21	25	10	21	13	12	48	12	23	23	30	49	47	31	36	22	*443*
2010			9	27	27	18	16	11	14	16	7	15	18	26	31	29	18	19	14	*315*
2011							9	11	6	14	6	15	16	27	31	28	21	19	15	*218*
Total			*29*	*63*	*66*	*32*	*70*	*59*	*272*	*2303*	*694*	*1390*	*1069*	*793*	*657*	*531*	*628*	*702*	*557*	*9915*

Table 5.3.1.3. Summary of the red snapper length data collected during Summer (top) and Fall (bottom) SEAMAP groundfish surveys conducted between 1987 and 2011.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
1987	274	464	222	100	304	170	46
1988	213	215	185	87	365	177	51
1989	194	240	184	31	423	145	56
1990	240	1312	775	42	760	159	38
1991	231	528	463	22	357	177	52
1992	226	465	334	31	774	158	54
1993	223	542	372	32	279	147	35
1994	238	904	555	39	378	153	38
1995	220	733	575	14	739	160	67
1996	220	1397	658	30	860	154	65
1997	207	768	502	29	636	163	44
1998	204	408	386	51	785	156	58
1999	223	375	352	25	776	169	89
2000	216	742	674	18	778	143	72
2001	152	174	172	31	339	147	63
2002	227	641	496	11	675	171	69
2003	181	312	286	13	830	162	70
2004	216	1248	568	30	752	157	45
2005	181	787	616	18	796	165	62
2006	221	598	576	20	324	151	57
2007	196	777	777	32	651	169	47
2008	305	954	952	24	648	175	71
2009	529	496	490	18	710	156	80
2010	376	707	659	29	811	191	92
2011	329	885	881	46	719	166	66
Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Fork Length (mm)	
25	6042	16,672	12,710			163	

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
1987	172	327	164	50	606	154	83
1988	217	818	507	42	777	131	61
1989	223	2118	1077	40	852	109	45
1990	228	2090	1332	25	670	125	54
1991	225	2782	1782	36	407	118	41
1992	212	784	633	50	374	137	57
1993	249	1893	1288	20	680	128	63
1994	229	4807	1670	33	625	120	62
1995	217	4080	1886	32	630	114	48
1996	227	1935	1471	30	605	128	55
1997	223	3222	1616	40	549	117	46
1998	225	1614	1027	30	806	109	45
1999	225	2532	1869	37	453	112	39
2000	223	2047	1562	29	742	127	50
2001	205	2063	1239	40	780	126	61
2002	233	1609	1254	16	767	103	49
2003	260	3240	1867	31	750	103	38
2004	205	4964	2088	32	740	120	44
2005	230	3742	2239	33	754	128	53
2006	224	2900	1831	31	403	116	46
2007	204	2881	2825	31	365	101	37
2008	366	1239	1213	28	760	145	79
2009	443	5737	5346	26	692	115	38
2010	315	1645	1591	33	700	123	58
2011	218	1807	1813	31	805	125	69
Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Fork Length (mm)	
25	5998	62,876	41,190			118	

Table 5.3.1.4. Indices of abundance for red snapper collected during SEAMAP groundfish surveys (WGOM / Summer) developed using the delta-lognormal model for 1982-2011. 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	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1982	0.34559	136	9.68293	2.76042	0.22061	1.78495	4.26899
1983	0.21805	133	2.61778	0.74628	0.28670	0.42538	1.30926
1984	0.18012	161	2.60053	0.74136	0.28423	0.42455	1.29457
1985	0.31169	77	3.52033	1.00358	0.30842	0.54919	1.83391
1986	0.15190	79	0.96477	0.27504	0.44280	0.11800	0.64109
1987	0.26404	178	2.26203	0.64486	0.22291	0.41514	1.00171
1988	0.26207	145	1.07137	0.30543	0.25298	0.18560	0.50263
1989	0.17730	141	0.92607	0.26401	0.31031	0.14396	0.48414
1990	0.46512	172	7.95389	2.26750	0.16406	1.63679	3.14125
1991	0.33514	185	3.12870	0.89193	0.19231	0.60927	1.30574
1992	0.31667	180	1.94602	0.55477	0.20208	0.37183	0.82772
1993	0.33146	178	2.22018	0.63293	0.19775	0.42780	0.93642
1994	0.37853	177	4.47239	1.27499	0.18215	0.88836	1.82990
1995	0.41477	176	3.72633	1.06230	0.17465	0.75109	1.50247
1996	0.41379	174	4.01042	1.14329	0.17530	0.80733	1.61907
1997	0.43558	163	3.11888	0.88913	0.17733	0.62536	1.26416
1998	0.34911	169	2.72386	0.77652	0.19625	0.52638	1.14552
1999	0.32961	179	2.12056	0.60453	0.19842	0.40807	0.89559
2000	0.49123	171	4.46720	1.27351	0.16076	0.92526	1.75285
2001	0.27586	116	2.50799	0.71498	0.26630	0.42358	1.20684
2002	0.39891	183	3.44222	0.98131	0.17436	0.69421	1.38714
2003	0.36496	137	1.75783	0.50112	0.21809	0.32562	0.77122
2004	0.44068	177	4.30779	1.22807	0.16742	0.88066	1.71253
2005	0.49324	148	4.80496	1.36980	0.17343	0.97081	1.93278
2006	0.51136	176	4.51050	1.28586	0.15285	0.94885	1.74256
2007	0.41935	155	3.51267	1.00140	0.18718	0.69091	1.45141
2008	0.41262	206	3.45699	0.98552	0.16042	0.71650	1.35556
2009	0.29605	304	1.94707	0.55507	0.16259	0.40183	0.76675
2010	0.44279	201	4.92609	1.40433	0.16030	1.02122	1.93117
2011	0.49419	172	6.52496	1.86014	0.15891	1.35636	2.55103

Table 5.3.1.5. Indices of abundance for red snapper collected during SEAMAP groundfish surveys (WGOM / Fall) developed using the delta-lognormal model for 1972-2011. 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	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1972	0.61345	119	47.4707	3.51592	0.15792	2.56869	4.81245
1973	0.52740	146	25.0846	1.85789	0.16533	1.33776	2.58024
1974	0.38129	139	7.9569	0.58932	0.20911	0.38964	0.89135
1975	0.33690	187	11.4657	0.84921	0.19477	0.57731	1.24916
1976	0.37186	199	10.8937	0.80684	0.18064	0.56383	1.15460
1977	0.42069	145	11.6182	0.86050	0.18419	0.59718	1.23994
1978	0.25275	182	8.8133	0.65276	0.24733	0.40096	1.06268
1979	0.39024	164	13.3094	0.98576	0.18418	0.68412	1.42041
1980	0.70161	124	50.6640	3.75243	0.14446	2.81506	5.00193
1981	0.50289	173	18.2883	1.35452	0.16175	0.98220	1.86799
1982	0.50000	150	12.1770	0.90189	0.17042	0.64296	1.26508
1983	0.36585	123	10.3043	0.76319	0.23672	0.47842	1.21744
1984	0.34028	144	4.0200	0.29774	0.22518	0.19083	0.46453
1985	0.33023	215	6.0595	0.44880	0.19678	0.30391	0.66275
1986	0.45789	190	5.6679	0.41980	0.17552	0.29630	0.59476
1987	0.45313	128	2.0813	0.15415	0.21132	0.10148	0.23415
1988	0.53039	181	4.7575	0.35236	0.16542	0.25367	0.48945
1989	0.56667	180	10.0273	0.74267	0.15299	0.54788	1.00672
1990	0.65714	175	11.1991	0.82946	0.13710	0.63135	1.08975
1991	0.68156	179	12.5597	0.93024	0.12582	0.72399	1.19523
1992	0.53073	179	3.6303	0.26888	0.16068	0.19538	0.37003
1993	0.57062	177	6.7122	0.49714	0.14943	0.36932	0.66920
1994	0.65363	179	19.4755	1.44245	0.13080	1.11166	1.87168
1995	0.73446	177	23.2818	1.72437	0.11811	1.36269	2.18204
1996	0.61878	181	9.7908	0.72515	0.14138	0.54732	0.96078
1997	0.64045	178	16.3524	1.21114	0.13438	0.92683	1.58267
1998	0.55249	181	7.6931	0.56979	0.15470	0.41892	0.77499
1999	0.68132	182	16.6575	1.23374	0.12875	0.95468	1.59438
2000	0.68156	179	10.4400	0.77324	0.12927	0.59772	1.00029
2001	0.58696	184	8.0699	0.59770	0.14481	0.44808	0.79728
2002	0.59669	181	7.6371	0.56564	0.13997	0.42810	0.74736
2003	0.65574	183	13.7058	1.01512	0.13468	0.77636	1.32731
2004	0.78395	162	22.0336	1.63192	0.11631	1.29423	2.05772
2005	0.77957	186	16.5295	1.22426	0.10863	0.98582	1.52037
2006	0.66477	176	12.9572	0.95967	0.13277	0.73672	1.25010
2007	0.56647	173	9.3984	0.69610	0.15516	0.51132	0.94764
2008	0.61672	287	5.9126	0.43792	0.12049	0.34444	0.55676
2009	0.73260	273	25.5069	1.88917	0.10018	1.54693	2.30713
2010	0.59322	177	9.1741	0.67948	0.14864	0.50556	0.91322
2011	0.65169	178	10.6889	0.79168	0.14083	0.59817	1.04778

Table 5.3.1.6. Indices of abundance for red snapper collected during SEAMAP groundfish surveys (EGOM / Summer) developed using the delta-lognormal model for 1982-2011. 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	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1982	0.19444	36	2.8888	1.09250	0.54008	0.39718	3.00503
1983	0.28571	21	2.1433	0.81056	0.58033	0.27594	2.38097
1984	0.06897	29	0.2171	0.08210	1.16402	0.01290	0.52262
1985	0.27778	36	1.4967	0.56601	0.46155	0.23503	1.36310
1986	0.05714	35	0.1757	0.06645	1.20597	0.00999	0.44213
1987	0.21875	96	2.0033	0.75761	0.31616	0.40865	1.40459
1988	0.16176	68	1.5787	0.59705	0.44054	0.25716	1.38619
1989	0.26415	53	4.1722	1.57783	0.37850	0.75899	3.28007
1990	0.38235	68	3.2224	1.21863	0.27355	0.71210	2.08546
1991	0.34783	46	3.3646	1.27244	0.34726	0.64797	2.49872
1992	0.28261	46	7.0297	2.65851	0.38679	1.25984	5.60995
1993	0.20000	45	1.1508	0.43519	0.48819	0.17262	1.09715
1994	0.32787	61	2.6490	1.00182	0.31533	0.54120	1.85445
1995	0.18182	44	1.0238	0.38718	0.51995	0.14555	1.02992
1996	0.26087	46	1.9485	0.73688	0.41160	0.33403	1.62560
1997	0.34091	44	2.0989	0.79375	0.36108	0.39411	1.59867
1998	0.08571	35	0.6920	0.26170	0.85004	0.05988	1.14377
1999	0.11364	44	0.5000	0.18907	0.68469	0.05471	0.65341
2000	0.31111	45	2.0417	0.77212	0.37570	0.37331	1.59700
2001	0.13889	36	0.8554	0.32350	0.65950	0.09725	1.07606
2002	0.11364	44	0.8130	0.30746	0.66342	0.09188	1.02885
2003	0.20455	44	1.8220	0.68906	0.47948	0.27742	1.71150
2004	0.23077	39	1.9260	0.72836	0.47421	0.29591	1.79280
2005	0.30303	33	4.5320	1.71392	0.43577	0.74441	3.94612
2006	0.22222	45	1.2538	0.47415	0.45943	0.19761	1.13769
2007	0.56098	41	7.5152	2.84208	0.26799	1.67837	4.81268
2008	0.42593	54	11.7878	4.45790	0.28388	2.55457	7.77933
2009	0.27473	91	1.8817	0.71162	0.28979	0.40327	1.25575
2010	0.37838	37	4.6645	1.76404	0.36729	0.86601	3.59328
2011	0.29167	24	1.8788	0.71051	0.52792	0.26357	1.91531

Table 5.3.1.7. Indices of abundance for red snapper collected during SEAMAP groundfish surveys (EGOM / Fall) developed using the delta-lognormal model for 1972-2011. 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	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1972	0.67692	65	43.6574	3.27439	0.22927	2.08227	5.14903
1973	0.51304	115	7.1767	0.53826	0.18783	0.37090	0.78114
1974	0.40385	104	8.4347	0.63262	0.24490	0.39040	1.02512
1975	0.44086	93	6.9768	0.52328	0.22225	0.33729	0.81181
1976	0.45370	108	8.4324	0.63245	0.20645	0.42032	0.95164
1977	0.43299	97	11.6354	0.87268	0.24406	0.53942	1.41182
1978	0.45985	137	5.2682	0.39512	0.18587	0.27331	0.57123
1979	0.39450	109	4.1681	0.31261	0.21558	0.20412	0.47878
1980	0.49541	109	7.7914	0.58437	0.19938	0.39373	0.86733
1981	0.59434	106	26.9305	2.01984	0.19221	1.38000	2.95634
1982	0.71545	123	29.9358	2.24525	0.15134	1.66170	3.03372
1983	0.50505	99	4.3068	0.32302	0.19694	0.21867	0.47716
1984	0.34146	82	3.5334	0.26501	0.29985	0.14737	0.47657
1985	0.21348	89	1.6241	0.12181	0.30546	0.06703	0.22137
1986	0.12500	40	1.5295	0.11472	0.66374	0.03427	0.38407
1987	0.25000	44	2.5507	0.19130	0.43068	0.08384	0.43653
1988	0.36111	36	3.3413	0.25060	0.37730	0.12081	0.51983
1989	0.67442	43	49.8205	3.73664	0.28304	2.14463	6.51041
1990	0.71698	53	27.7674	2.08261	0.26237	1.24307	3.48916
1991	0.76087	46	31.7855	2.38397	0.22842	1.51852	3.74269
1992	0.42424	33	2.5964	0.19473	0.33867	0.10074	0.37641
1993	0.50000	72	18.8373	1.41283	0.29898	0.78693	2.53656
1994	0.52000	50	4.6211	0.34659	0.24565	0.21358	0.56242
1995	0.62500	40	9.6240	0.72182	0.24339	0.44675	1.16627
1996	0.52174	46	7.3109	0.54834	0.28379	0.31427	0.95672
1997	0.48889	45	12.2807	0.92108	0.30546	0.50684	1.67387
1998	0.45455	44	2.9987	0.22491	0.30515	0.12383	0.40848
1999	0.53488	43	7.9702	0.59778	0.28922	0.33912	1.05372
2000	0.65909	44	21.8594	1.63950	0.23221	1.03672	2.59275
2001	0.61905	21	6.8914	0.51687	0.38283	0.24669	1.08292
2002	0.44231	52	5.6057	0.42044	0.30216	0.23279	0.75935
2003	0.64935	77	16.4241	1.23184	0.22272	0.79331	1.91280
2004	0.41860	43	4.4729	0.33548	0.31992	0.17969	0.62634
2005	0.68182	44	9.7321	0.72993	0.24780	0.44796	1.18938
2006	0.89583	48	37.8969	2.84234	0.18441	1.97167	4.09750
2007	0.77419	31	24.5363	1.84027	0.24935	1.12604	3.00753
2008	0.51282	39	4.9821	0.37367	0.27418	0.21809	0.64023
2009	0.80000	60	40.5835	3.04384	0.23536	1.91311	4.84287
2010	0.53333	30	4.7111	0.35335	0.36541	0.17406	0.71730
2011	0.40000	20	2.7178	0.20384	0.44724	0.08677	0.47884

Table 5.3.2.1. Indices of abundance for larval red snapper collected during the Fall SEAMAP Plankton Survey (Eastern Gulf of Mexico) developed using a frequency of occurrence model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the Index, the 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*	Index	Scaled Index	CV	LCL	UCL
1986	0.00000	53	0	0			
1987	0.03509	57	0.06373	0.88099	1.56081	0.09549	8.12799
1988	0.03125	32	0.0312	0.43127	1.96039	0.03498	5.31755
1989	0.00000	34	0	0			
1990	0.00000	39	0	0			
1991	0.04651	43	0.06353	0.87824	0.87899	0.19339	3.9884
1992	0.00000	46	0	0			
1993	0.00000	50	0	0			
1994	0.01639	61	0.01426	0.19707	0.43662	0.08547	0.45441
1995	0.03448	58	0.03547	0.49037	1.01435	0.09119	2.63703
1996	0.00000	61	0	0			
1997	0.03390	59	0.04109	0.56798	0.90692	0.12062	2.67463
1998							
1999	0.05085	59	0.05716	0.79011	0.3223	0.42134	1.48165
2000	0.06780	59	0.07255	1.00289	1.1405	0.16158	6.22461
2001	0.05085	59	0.07069	0.97717	0.61022	0.31717	3.0106
2002	0.05128	39	0.06033	0.83394	1.69951	0.08109	8.5768
2003	0.06667	60	0.07549	1.04349	0.75188	0.27356	3.98035
2004	0.02439	41	0.0153	0.21148	2.46211	0.01291	3.46467
2005							
2006	0.05085	59	0.05459	0.75466	1.02735	0.13819	4.12123
2007	0.09677	62	0.13728	1.89767	0.32556	1.00584	3.58022
2008							
2009	0.06452	62	0.08567	1.18421	0.8961	0.25501	5.4991
2010	0.15000	60	0.27912	3.85845	0.31648	2.07995	7.15771

Table 5.3.2.2. Indices of abundance for larval red snapper collected during the Fall SEAMAP Plankton Survey (Western Gulf of Mexico) adjusted to 10.5 days old developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 m^2 sea surface), 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
1986	0.08163	49	1.72024	0.51313	0.81893	0.12245	2.15016
1987	0.07273	55	2.16447	0.64563	0.67184	0.19048	2.18833
1988	0.00000	28					
1989	0.14286	28	3.19923	0.95429	0.75494	0.24908	3.65609
1990	0.19355	31	2.13106	0.63567	0.53839	0.23175	1.74360
1991	0.09677	31	0.54755	0.16333	0.76633	0.04194	0.63598
1992	0.12727	55	0.94156	0.28085	0.42395	0.12455	0.63331
1993	0.12727	55	1.23128	0.36727	0.47201	0.14978	0.90062
1994	0.07273	55	0.95695	0.28544	0.65262	0.08672	0.93952
1995	0.23636	55	3.84496	1.14690	0.34376	0.58781	2.23774
1996	0.16364	55	2.19804	0.65564	0.40881	0.29868	1.43922
1997	0.25926	54	4.13821	1.23437	0.32949	0.64952	2.34583
1998							
1999	0.14545	55	1.89683	0.56580	0.43937	0.24420	1.31093
2000	0.27273	55	6.06269	1.80842	0.33602	0.94017	3.47848
2001	0.14894	47	4.83119	1.44108	0.48318	0.57652	3.60214
2002	0.22222	54	3.48667	1.04003	0.38893	0.49097	2.20311
2003	0.29630	54	7.83030	2.33567	0.37476	1.13118	4.82272
2004	0.22222	54	3.57389	1.06604	0.36625	0.52433	2.16741
2005							
2006	0.23077	52	6.86608	2.04806	0.43882	0.88480	4.74069
2007	0.29630	54	5.32629	1.58876	0.31580	0.85753	2.94353
2008							
2009	0.30909	55	5.39710	1.60988	0.26593	0.95443	2.71545
2010	0.14815	54	2.05759	0.61375	0.43108	0.26878	1.40148

Table 5.3.3.1. Indices of abundance for red snapper collected during NMFS Bottom Longline Surveys (West GOM). *Frequency* listed is nominal frequency, *N* is the number of bottom longline stations, *Index* is the abundance index in CPUE units, *Scaled Index* is the index scaled to a mean of one over the time series, *CV* is the coefficient of variation on the index value, and *LCL* and *UCL* are 95% confidence limits.

Survey Year	*Frequency*	*N*	*Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
1996	0.03125	32	0.04902	0.08784	1.23704	0.01279	0.60334
1997	0.08247	97	0.57197	1.02482	0.51420	0.38899	2.69992
1999	0.02500	80	0.10384	0.18605	0.86676	0.04163	0.83144
2000	0.25926	108	0.73217	1.31184	0.24629	0.80741	2.13141
2001	0.18519	135	0.54078	0.96893	0.25505	0.58646	1.60084
2002	0.22152	158	0.48713	0.87281	0.21362	0.57205	1.33169
2003	0.19048	105	0.52859	0.94709	0.28012	0.54659	1.64105
2004	0.19608	102	0.61010	1.09313	0.27837	0.63297	1.88783
2006	0.15584	77	0.44889	0.80429	0.36356	0.39753	1.62723
2007	0.14754	61	0.46597	0.83488	0.41770	0.37437	1.86188
2008	0.22222	27	0.52562	0.94176	0.49310	0.37045	2.39418
2009	0.27059	85	0.98404	1.76314	0.25283	1.07171	2.90065
2010	0.15094	53	0.40471	0.72512	0.45197	0.30615	1.71749
2011	0.24823	282	1.36087	2.43831	0.14600	1.82365	3.26014

Table 5.3.3.2. Indices of abundance for red snapper collected during NMFS Bottom Longline Surveys (East GOM). *Frequency* listed is nominal frequency, *N* is the number of bottom longline stations, *Index* is the abundance index in CPUE units, *Scaled Index* is the index scaled to a mean of one over the time series, *CV* is the coefficient of variation on the index value, and *LCL* and *UCL* are 95% confidence limits.

Survey Year	*Frequency*	*N*	*Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
1996	0.01923	52	0.01989	0.31973	1.15337	0.05080	2.01230
1997	0.01389	72	0.01282	0.20605	1.15578	0.03265	1.30017
1999	0.03546	141	0.07450	1.19741	0.52048	0.44974	3.18801
2000	0.00775	129	0.00738	0.11866	1.15853	0.01875	0.75093
2001	0.02128	141	0.02927	0.47048	0.67350	0.13846	1.59867
2002	0.03175	63	0.03259	0.52371	0.81883	0.12500	2.19419
2003	0.02857	175	0.04855	0.78021	0.52186	0.29237	2.08204
2004	0.02740	145	0.05216	0.83827	0.58298	0.28416	2.47288
2005	0.02000	50	0.04068	0.65377	1.15303	0.10392	4.11311
2006	0.03448	58	0.03715	0.59708	0.81796	0.14268	2.49862
2007	0.02778	72	0.07019	1.12808	0.82008	0.26879	4.73448
2009	0.07368	95	0.10785	1.73327	0.43416	0.75495	3.97940
2010	0.12632	95	0.15987	2.56944	0.32563	1.36175	4.84820
2011	0.08571	315	0.17819	2.86383	0.22206	1.84665	4.44132

Table 5.3.4.1. West GOM red snapper Lo and standardized index of abundance by year for model based runs for the SEAMAP Reef Fish Video Survey.

Survey Year	*Frequency*	*N*	*Lo Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
1993	0.17021	47	0.32502	0.55434	0.46715	0.22797	1.34800
1994	0.22222	45	0.40985	0.69902	0.41710	0.31378	1.55724
1995	0.22892	83	0.31509	0.53741	0.29894	0.29936	0.96476
1996	0.23392	171	0.32834	0.55999	0.24919	0.34276	0.91490
1997	0.54135	133	0.88256	1.50526	0.15520	1.10561	2.04936
2001	0.28889	45	0.41267	0.70384	0.35269	0.35486	1.39599
2002	0.38144	97	0.54674	0.93250	0.22054	0.60306	1.44191
2004	0.30000	50	0.55731	0.95052	0.29913	0.52927	1.70702
2005	0.38235	136	0.66606	1.13601	0.17575	0.80148	1.61017
2006	0.20588	136	0.27406	0.46743	0.29992	0.25990	0.84069
2007	0.39241	158	0.76710	1.30833	0.16188	0.94846	1.80474
2008	0.28467	137	0.40156	0.68489	0.23416	0.43146	1.08718
2009	0.35028	177	0.64564	1.10117	0.17019	0.78538	1.54394
2010	0.53333	105	1.30970	2.23376	0.18087	1.56025	3.19800
2011	0.40367	109	0.95308	1.62553	0.16231	1.17741	2.24421

Table 5.3.4.2. East GOM red snapper Lo and standardized index of abundance by year for model based runs for the SEAMAP Reef Fish Video Survey.

Survey Year	*Frequency*	*N*	*Lo Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
1993	0.05785	121	0.01032	0.14507	2.28759	0.00970	2.17045
1994	0.02062	97	0.00288	0.04046	6.26370	0.00087	1.89067
1995	0.04444	180	0.00302	0.04240	4.16360	0.00140	1.28472
1996	0.06623	151	0.00720	0.10113	2.56188	0.00588	1.73942
1997	0.03049	164	0.00861	0.12102	2.71622	0.00655	2.23463
2002	0.15294	170	0.07411	1.04138	0.80026	0.25499	4.25291
2004	0.20000	150	0.07826	1.09977	0.77984	0.27708	4.36508
2005	0.19636	275	0.10491	1.47423	0.67608	0.43216	5.02901
2006	0.08865	282	0.04482	0.62979	0.92859	0.13010	3.04874
2007	0.15710	331	0.07977	1.12090	0.72005	0.30775	4.08259
2008	0.10753	279	0.07523	1.05708	0.80929	0.25563	4.37123
2009	0.13356	292	0.10527	1.47920	0.69914	0.41887	5.22366
2010	0.25000	240	0.17141	2.40863	0.61045	0.78150	7.42349
2011	0.27746	346	0.23050	3.23892	0.56357	1.13300	9.25916

Table 5.3.4.3. Red snapper lengths (fork lengths in mm) measured by laser from video tapes (1995-2007) and by stereo still cameras (2008-2010) for the SEAMAP Reef Fish Video Survey.

	East Gulf					West Gulf				
Year	N	Minimum	Maximum	Mean	SE	N	Minimum	Maximum	Mean	SE
1995	0	-	-	-	-	9	430.0	766.0	582.33	38.09
1996	0	-	-	-	-	110	214.0	860.0	449.62	10.64
1997	134	236.0	758.0	406.52	9.56	0	-	-	-	-
2001	0	-	-	-	-	13	400.0	725.0	593.15	27.19
2002	0	-	-	-	-	195	245.0	917.0	506.83	8.16
2004	1044	207.0	915.0	417.97	3.25	0	-	-	-	-
2005	259	146.0	790.0	476.37	6.69	191	200.0	733.0	446.62	7.59
2006	103	183.0	752.0	412.33	14.90	63	276.0	668.0	442.63	13.16
2007	389	190.0	874.0	386.77	5.06	273	213.0	868.0	443.60	8.13
2008	24	284.2	834.0	459.93	27.59	23	287.7	721.9	470.06	26.34
2009	27	275.0	583.0	370.63	13.48	120	253.0	545.0	375.46	6.34
2010	72	290.6	798.6	514.81	13.03	71	271.4	742.5	415.60	11.91
2011	122	294.69	865.55	512.07	9.64	45	205.69	735.59	468.08	31.34

Table 5.3.5.1. Summary of annual stationary underwater camera array (SUCA) sampling effort by spatial zone from 2008 – 2011 for the FWC reef fish survey. Values represent total number of sampling stations, while values in parentheses represent the total number of individual gear deployments (1 – 2 arrays deployed per station).

Region	2008	2009	2010	2011	Total
TBN	5 (10)	25 (34)	16 (24)	56 (122)	102 (190)
TBO	18 (33)	33 (66)	25 (50)	49 (72)	125 (221)
CHN	20 (38)	28 (43)	23 (46)	35 (60)	106 (187)
CHO	24 (48)	30 (60)	29 (56)	41 (55)	124 (219)
Total	67 (129)	116 (203)	93 (176)	181 (309)	457 (817)

Table 5.3.5.2. Summary of chevron trap sampling effort by spatial zone from 2008 – 2011 for the FWC reef fish survey. Values represent total number of sampling stations, while values in parentheses represent the total number of individual gear deployments (1 – 4 chevron traps deployed per station).

Region	2008	2009	2010	2011	Total
TBN	8 (32)	25 (84)	18 (60)	63 (141)	114 (317)
TBO	18 (72)	33 (132)	26 (78)	49 (70)	126 (352)
CHN	21 (84)	29 (102)	23 (69)	35 (40)	108 (295)
CHO	26 (104)	30 (120)	31 (93)	49 (65)	136 (382)
Total	73 (292)	117 (438)	98 (300)	196 (316)	484 (1346)

Table 5.3.6.1. Annual % frequencies of occurrence of red snapper in trap and video samples east and west of Cape San Blas, and total number of sites sampled for the PC NMFS video survey. Data from all sites were included for trap estimates; censored data sets were used to calculate video frequencies.

	Chevron trap				Video			
	Total sites sampled		% Freq. Occur.		Total sites sampled		% Freq. Occur.	
Year	East	West	East	West	East	West	East	West
2004	53	33	3.8	63.6				
2005	77	24	6.5	87.5	31		9.7	
2006	89	25	7.9	88.0	47	24	25.5	95.8
2007	57	26	7.0	69.2	29	23	13.8	100.0
2008	51	29	0	86.2	56	29	8.9	96.6
2009	53	30	35.8	86.7	62	42	45.2	100.0
2010	53	17	18.9	47.1	95	52	46.3	92.3
2011	50	32	20.0	84.4	99	57	26.3	91.2

Table 5.3.6.2. Mean annual video min counts, standard errors, and sample sizes of red snapper east and west of Cape San Blas, 2005-2011 for the PC NMFS video survey. Estimates calculated using censored data sets (see Methods).

	Total sites sampled		Mean nominal min count		Standard error	
Year	East	West	East	West	East	West
2005	31		0.129		0.077	
2006	47	24	0.830	7.583	0.581	1.103
2007	29	23	0.345	10.348	0.974	1.537
2008	56	29	0.089	6.345	0.428	0.826
2009	62	42	1.452	10.452	0.723	1.375
2010	95	52	1.305	6.942	0.409	0.915
2011	99	57	0.515	5.491	0.318	0.672

Table 5.3.6.3. PC Video abundance indices for red snapper. *Frequency* listed is nominal frequency, *N* is the number of video stations, *Index* is the abundance index in CPUE units, *Scaled Index* is the index scaled to a mean of one over the time series, *CV* is the coefficient of variation on the index value, and *LCL* and *UCL* are 95% confidence limits.

Survey Year	*Frequency*	*N*	*Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
2005	0.09677	31	2.60619	0.68621	0.60876	0.22324	2.10931
2006	0.49296	71	5.12543	1.34953	0.18824	0.92917	1.96005
2007	0.51923	52	4.50183	1.18533	0.26125	0.70902	1.98164
2008	0.38824	85	2.54182	0.66926	0.26481	0.39762	1.12648
2009	0.67308	104	5.70097	1.50107	0.12231	1.17641	1.91532
2010	0.62585	147	3.90904	1.02925	0.15843	0.75121	1.41020
2011	0.50633	158	2.20034	0.57935	0.18720	0.39970	0.83974

Table 5.4.1.1. Index values, upper confidence limits, lower confidence limits, and coefficient of variation for the recommended censored regression fit private/for hire mode index for red snapper for Fishery Dependent Recreational Surveys.

	EASTERN GULF				WESTERN GULF			
Year	**Index**	**UCI**	**LCI**	**CV**	**Index**	**UCI**	**LCI**	**CV**
1981	0.498	1.562	0.159	0.621	0.253	1.136	0.056	0.870
1982	0.328	1.101	0.098	0.665	0.546	1.383	0.216	0.491
1983	1.101	3.453	0.351	0.622	1.206	2.147	0.677	0.295
1984	0.645	2.801	0.149	0.845	0.574	1.090	0.302	0.329
1985	0.793	2.537	0.248	0.635	0.250	0.484	0.129	0.340
1986	0.308	0.950	0.100	0.611	0.526	0.991	0.279	0.325
1987	0.545	0.996	0.298	0.308	0.621	1.228	0.314	0.351
1988	0.172	0.358	0.082	0.381	0.599	1.156	0.310	0.338
1989	0.103	0.223	0.047	0.403	0.560	1.131	0.277	0.363
1990	0.106	0.248	0.045	0.445	0.381	0.719	0.202	0.326
1991	0.267	0.544	0.131	0.368	0.918	1.748	0.482	0.330
1992	0.560	0.971	0.323	0.280	0.977	1.678	0.569	0.275
1993	0.465	0.866	0.250	0.319	1.032	1.810	0.589	0.286
1994	0.299	0.589	0.152	0.349	1.155	1.995	0.669	0.278
1995	0.305	0.637	0.146	0.381	1.312	2.164	0.795	0.254
1996	0.381	0.790	0.184	0.376	1.010	1.674	0.609	0.257
1997	1.033	1.882	0.567	0.307	0.886	1.471	0.533	0.258
1998	1.559	2.338	1.040	0.205	0.921	1.529	0.555	0.258
1999	1.207	1.707	0.854	0.174	0.552	0.922	0.331	0.261
2000	1.158	1.704	0.787	0.195	0.680	1.141	0.406	0.263
2001	0.972	1.464	0.645	0.207	0.643	1.098	0.377	0.272
2002	1.517	2.265	1.015	0.203	0.804	1.343	0.482	0.261
2003	1.277	1.892	0.861	0.199	0.667	1.111	0.401	0.259
2004	1.083	1.539	0.763	0.177	0.616	1.018	0.373	0.255
2005	0.845	1.242	0.575	0.194	0.884	1.466	0.533	0.257
2006	0.988	1.497	0.652	0.210	0.711	1.126	0.449	0.233
2007	2.866	4.410	1.863	0.218	1.866	3.049	1.142	0.249
2008	2.690	3.849	1.880	0.181	1.775	2.892	1.089	0.248
2009	1.708	2.745	1.063	0.240	2.256	3.722	1.368	0.254
2010	3.439	5.433	2.177	0.232	3.308	6.082	1.799	0.312
2011	1.781	2.840	1.117	0.236	2.512	4.226	1.493	0.265

Table 5.4.1.2. Index values, upper confidence limits, lower confidence limits, and coefficient of variation for the recommended censored regression fit headboat mode index for red snapper for Fishery Dependent Recreational Surveys.

	EASTERN GULF				WESTERN GULF			
Year	**Index**	**UCI**	**LCI**	**CV**	**Index**	**UCI**	**LCI**	**CV**
1986	0.114	0.468	0.028	0.802	0.642	1.012	0.407	0.230
1987	0.125	0.512	0.030	0.803	0.768	1.150	0.514	0.203
1988	0.166	0.660	0.042	0.780	0.929	1.382	0.624	0.201
1989	0.188	0.749	0.047	0.782	0.812	1.198	0.551	0.196
1990	0.204	0.817	0.051	0.787	0.587	0.864	0.399	0.195
1991	0.243	0.980	0.060	0.791	0.949	1.451	0.621	0.215
1992	0.359	1.426	0.090	0.781	1.667	2.566	1.083	0.218
1993	0.468	1.822	0.120	0.766	1.691	2.557	1.119	0.209
1994	0.372	1.474	0.094	0.780	1.331	1.962	0.903	0.196
1995	0.313	1.245	0.079	0.782	1.400	2.146	0.913	0.216
1996	0.468	1.810	0.121	0.761	1.457	2.363	0.898	0.245
1997	0.783	3.005	0.204	0.756	1.577	2.418	1.029	0.216
1998	1.200	4.653	0.309	0.763	1.343	2.082	0.867	0.222
1999	1.149	4.411	0.299	0.757	0.421	0.643	0.275	0.214
2000	1.145	4.406	0.297	0.758	0.567	0.892	0.361	0.229
2001	1.100	4.237	0.285	0.759	0.821	1.464	0.460	0.296
2002	1.602	6.194	0.414	0.761	0.711	1.212	0.417	0.272
2003	1.443	5.569	0.374	0.760	0.609	0.999	0.371	0.251
2004	1.147	4.433	0.297	0.761	0.459	0.748	0.282	0.248
2005	1.165	4.556	0.298	0.769	0.507	0.823	0.312	0.246
2006	0.680	2.647	0.174	0.767	0.598	1.029	0.348	0.276
2007	1.440	5.857	0.354	0.797	1.098	2.035	0.593	0.316
2008	1.819	7.386	0.448	0.796	1.185	3.333	0.421	0.554
2009	3.357	13.831	0.815	0.807	1.240	2.217	0.693	0.297
2010	3.152	12.583	0.789	0.784	1.253	2.599	0.604	0.377
2011	1.798	9.101	0.355	0.964	1.376	3.939	0.481	0.564

Table 5.4.2.1. Vertical line standardized index of abundance and CVs for red snapper (1990-2006) in the Gulf of Mexico.

YEAR	Eastern GOM Standardized Index	CV (Index)	Western GOM Standardized Index	CV (Index)
1990	0.265945	0.8731	0.66143	0.2429
1991	0.420385	0.69	1.08012	0.2171
1992	1.268586	0.631	1.76699	0.2252
1993	0.698897	0.6026	1.15677	0.1623
1994	0.626484	0.6033	1.15504	0.1625
1995	0.745558	0.6196	1.3402	0.1624
1996	0.4489	0.6860	1.3387	0.1622
1997	0.3675	0.7141	1.1762	0.1621
1998	1.2883	0.6803	0.9335	0.1621
1999	0.7796	0.6920	0.8658	0.1623
2000	1.4717	0.6859	0.9879	0.1624
2001	1.3417	0.6899	0.8514	0.1623
2002	1.6504	0.6720	0.8156	0.1624
2003	1.4638	0.6646	0.7899	0.1624
2004	1.6566	0.6993	0.6571	0.1624
2005	1.3668	0.6758	0.5891	0.1625
2006	1.1386	0.6858	0.8341	0.1628

Table 5.4.3.1. Months when head boat trips were sampled and recreational red snapper harvest was either closed the entire month (X), open during any portion of the month in both state and federal waters adjacent to Florida (O), or open only in state waters (S). No trips were sampled during 2008 or the first half of 2009 due to funding. (Recreational hook-and-line fishing on head boats)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	X	X	X	O	O	O	O	O	O	O	X	X
2006	X	X	X	O	O	O	O	O	O	O	X	X
2007	X	X	X	S	S	O	O	O	S	S	X	X
2008												
2009						O	O	O	X	X	X	X
2010*	X	X	X	X	X	O	O	X	X	O	O	X
2011	X	X	X	X	X	O	O	X	X	X	X	X
2012	X	X	X	X	X	O	O	ONGOING				

*Portions of federal EEZ and state territorial seas in northwest Florida closed to fishing during June through August due to Deepwater Horizon.

Table 5.4.3.2. Index from delta-gamma model of rates of undersized red snapper released by head boat anglers per trip from trips where average depth fished was 50 feet or deeper. The proportion positives were obtained by the binomial sub-model, and the positives from the product of the binomial and gamma sub-model estimates. Monte Carlo simulations were used to estimate the means, standard errors, and cv values for the delta-gamma model. (Recreational hook-and-line fishing on head boats)

Year	proportion positives	n (all)	n (positives)	Mean	Std Error	Lower	Upper	CV (%)
2005	0.866	19	13	0.674	0.234	0.423	1.179	34.71
2006	0.758	15	7	0.799	0.388	0.219	1.168	48.53
2007	0.603	8	6	0.768	0.449	0.289	1.623	58.41
2008								
2009	0.579	27	16	0.461	0.191	0.180	0.885	41.53
2010	0.461	24	12	0.296	0.141	0.120	0.675	47.70
2011	0.227	24	9	0.042	0.026	0.015	0.095	61.01
total		117	63					

Table 5.4.3.3. Index re-scaled to grand mean from the n-weighted annual means. (Recreational hook-and-line fishing on head boats)

Year	n (positives)	Mean	Std Error	Lower	Upper	CV (%)
2005	13	1.402	0.487	0.881	2.454	34.71
2006	7	1.664	0.807	0.456	2.432	48.53
2007	6	1.598	0.934	0.602	3.377	58.41
2008						
2009	16	0.960	0.399	0.374	1.841	41.53
2010	12	0.616	0.294	0.249	1.405	47.70
2011	9	0.088	0.054	0.030	0.198	61.01

5.8 Figures

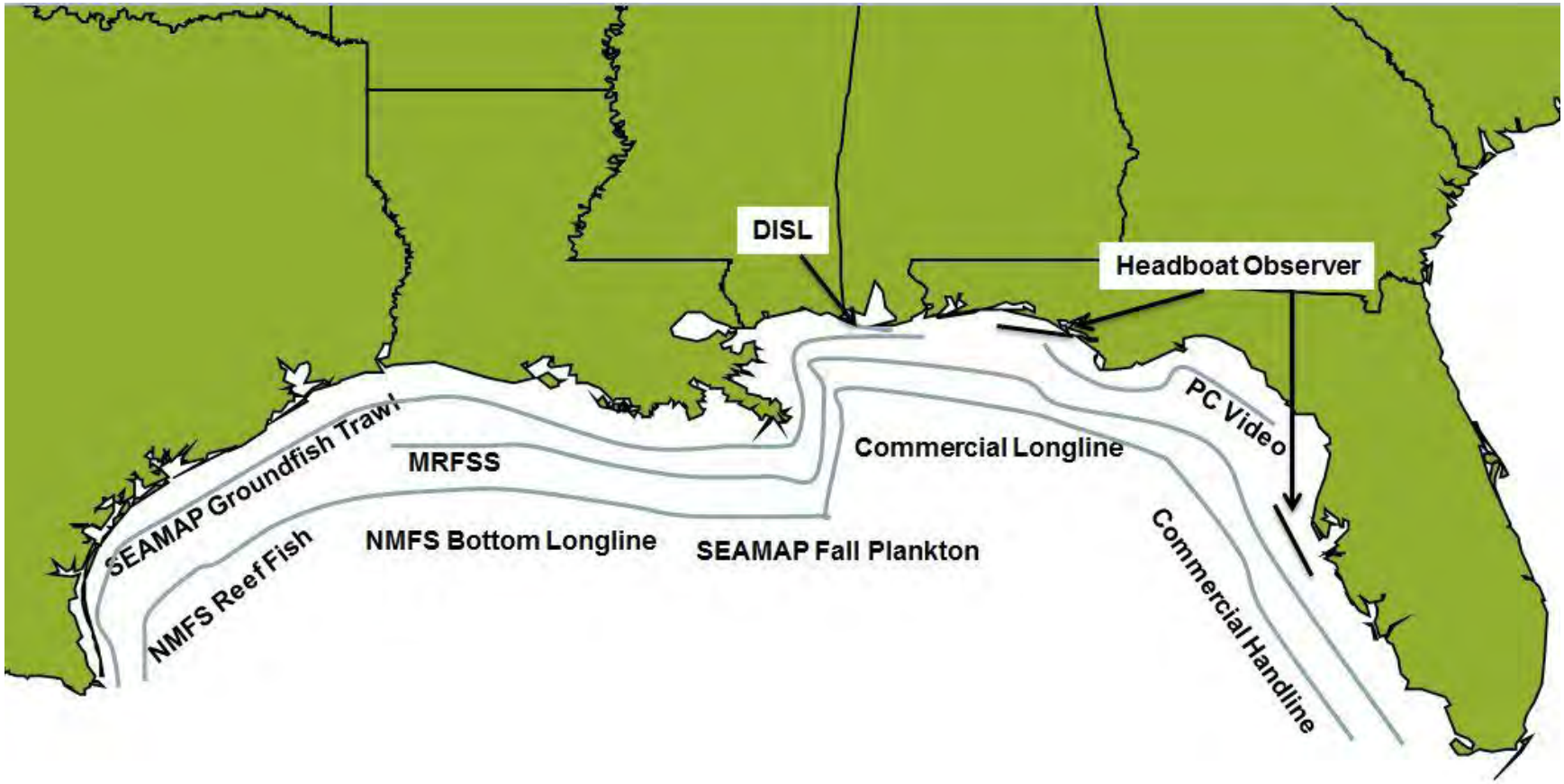


Figure 5.1.1. Spatial coverage of datasets used to develop indices.

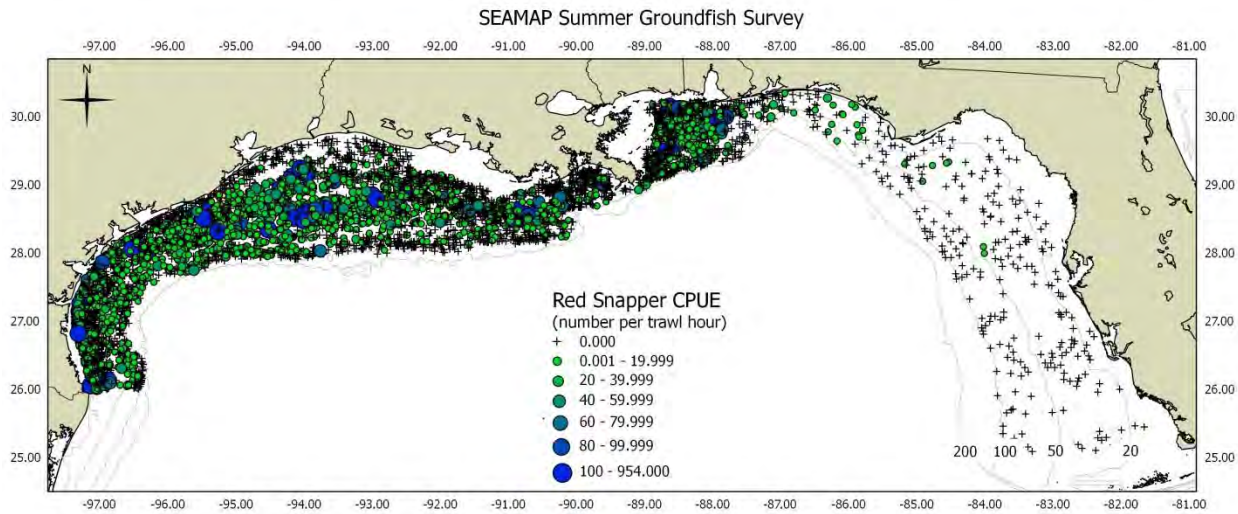


Figure 5.3.1.1. Stations sampled from 1982 to 2011 during the Summer SEAMAP Groundfish Survey with the CPUE for red snapper.

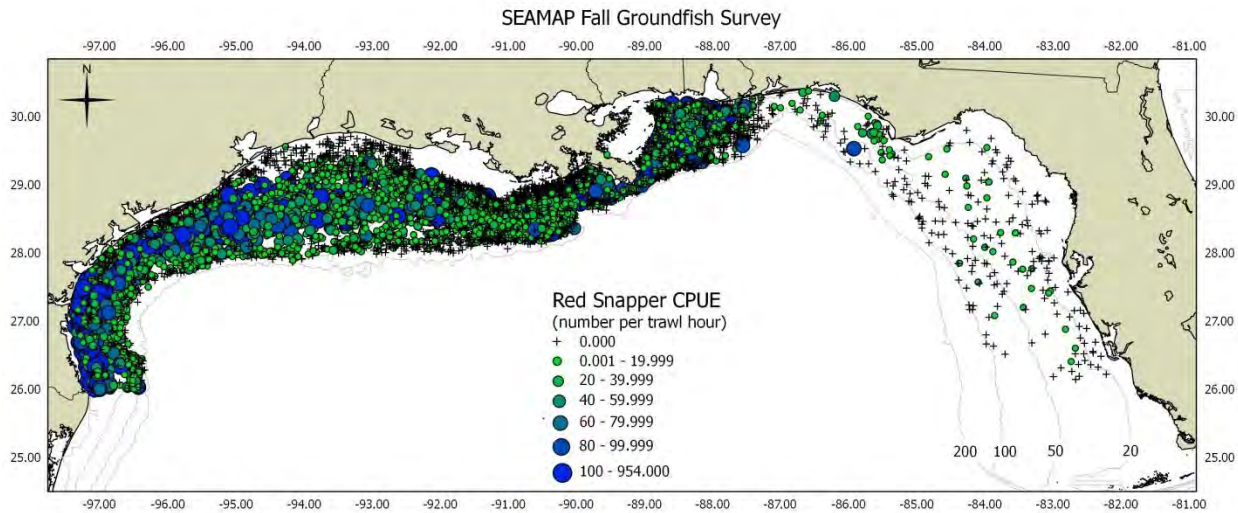


Figure 5.3.1.2. Stations sampled from 1972 to 2011 during the Fall SEAMAP Groundfish Survey with the CPUE for red snapper.

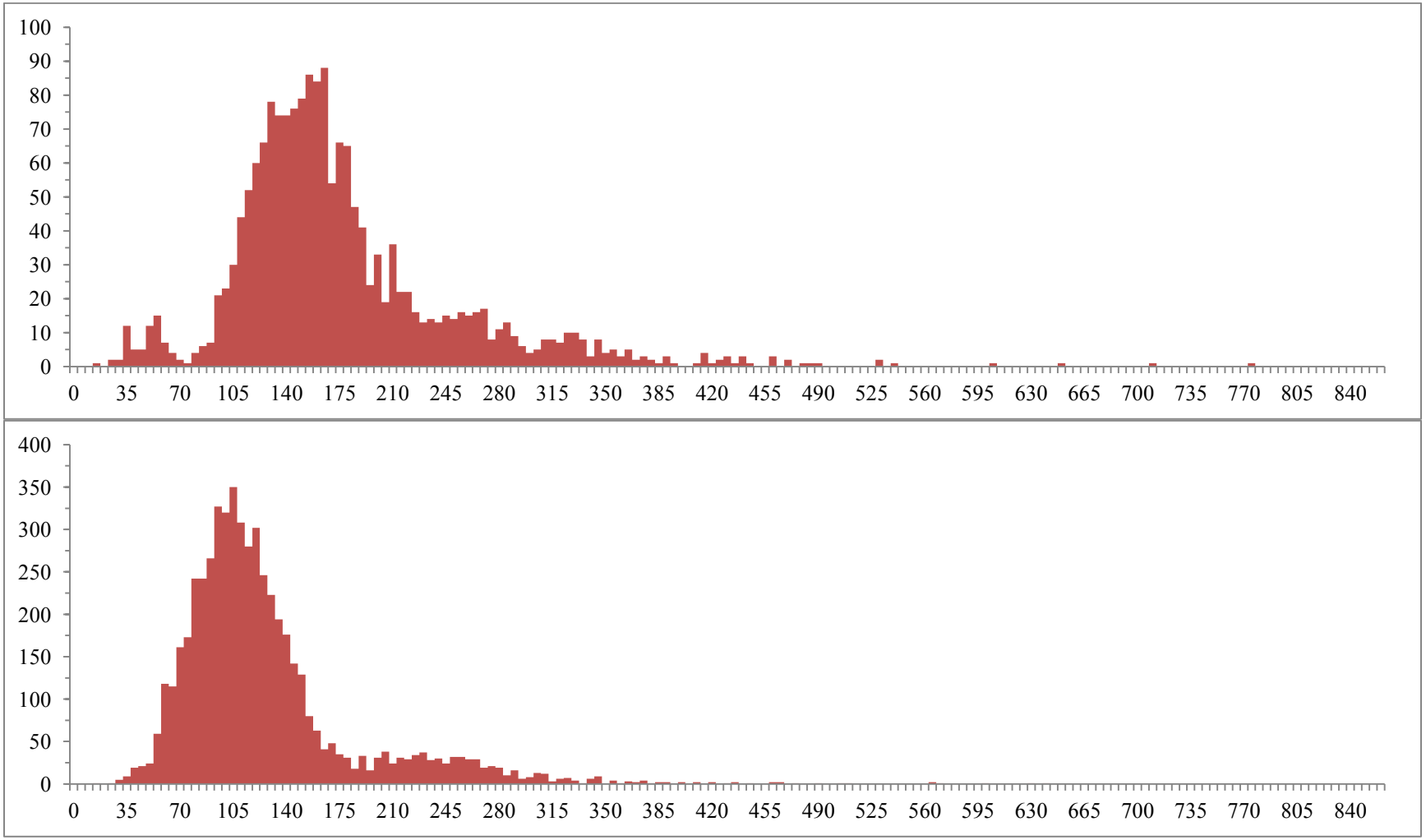


Figure 5.3.1.3. Length frequency histograms for red snapper captured in the eastern Gulf of Mexico during the Summer (top) and Fall (bottom) SEAMAP Groundfish surveys from 1987-2010.

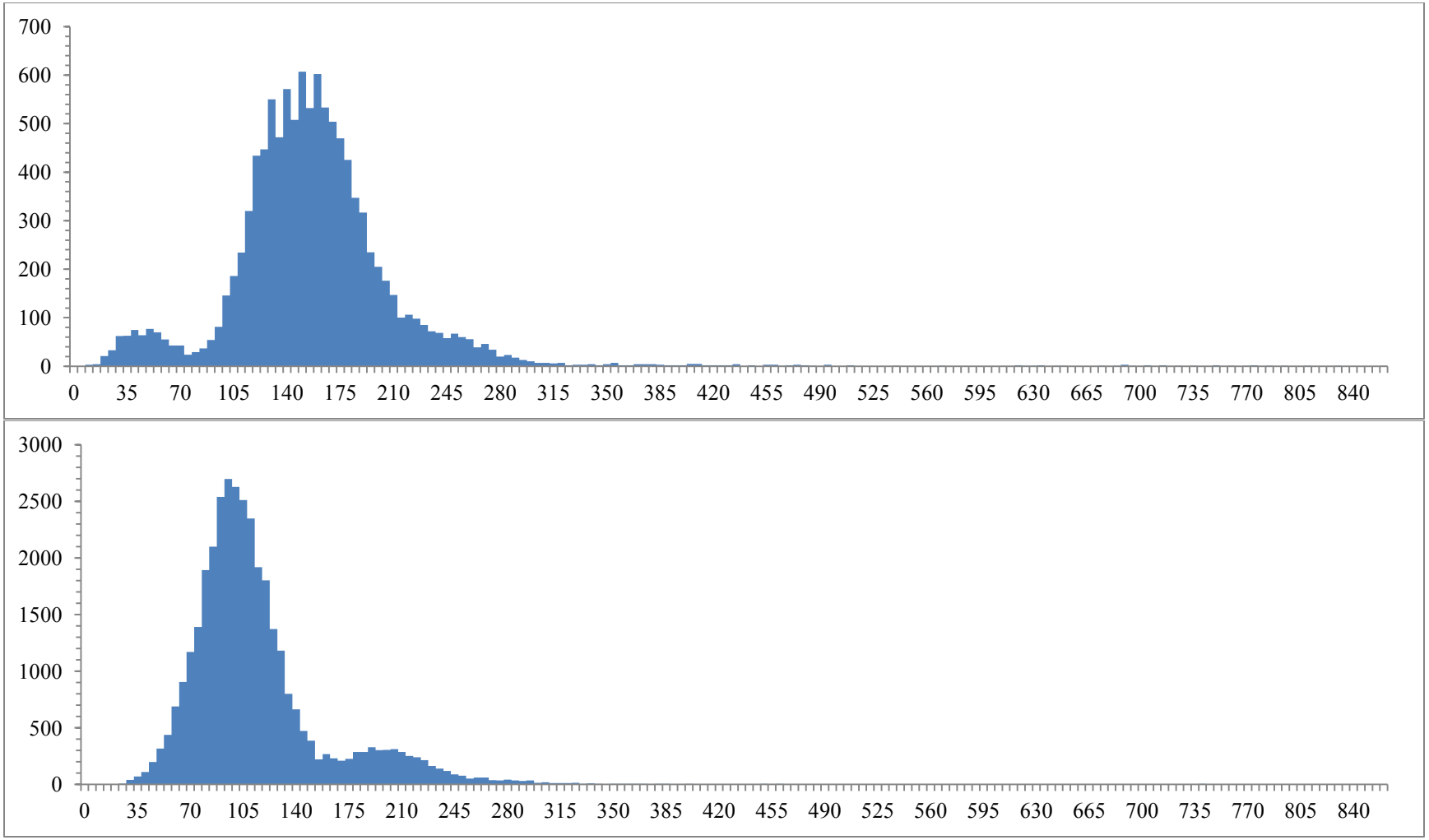


Figure 5.3.1.4. Length frequency histograms for red snapper captured in the western Gulf of Mexico during the Summer (top) and Fall (bottom) SEAMAP Groundfish surveys from 1987-2010.

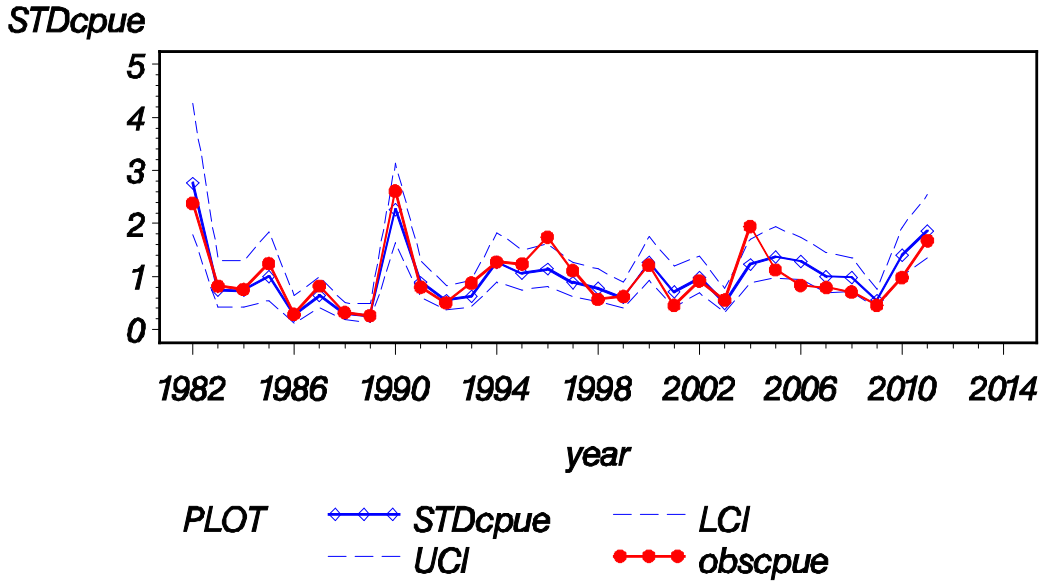


Figure 5.3.1.5. Annual index of abundance for red snapper (WGOM / Summer) from the SEAMAP Groundfish Survey from 1982 – 2011.

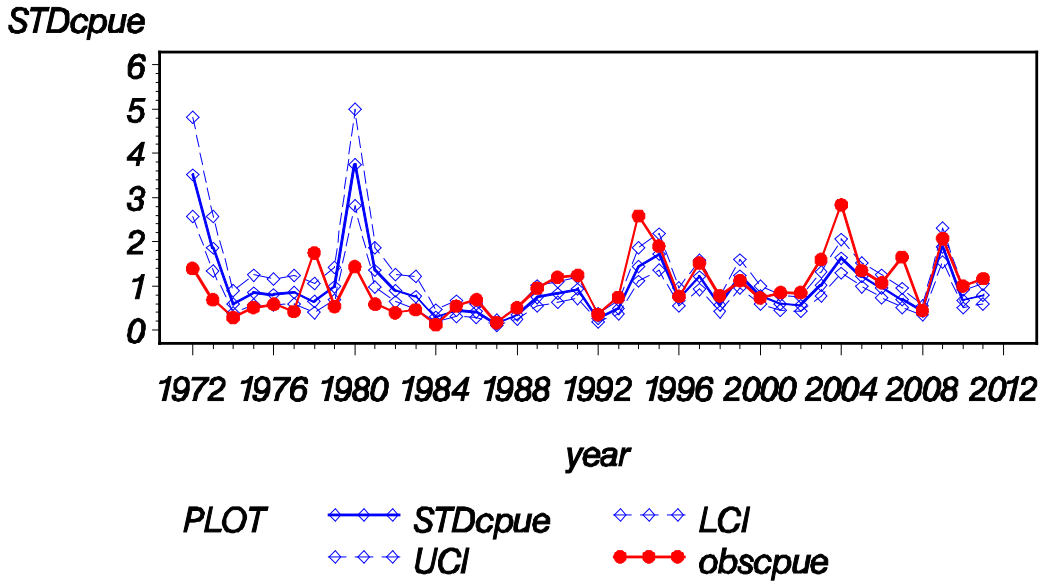


Figure 5.3.1.6. Annual index of abundance for red snapper (WGOM / Fall) from the SEAMAP Groundfish Survey from 1972 – 2011.

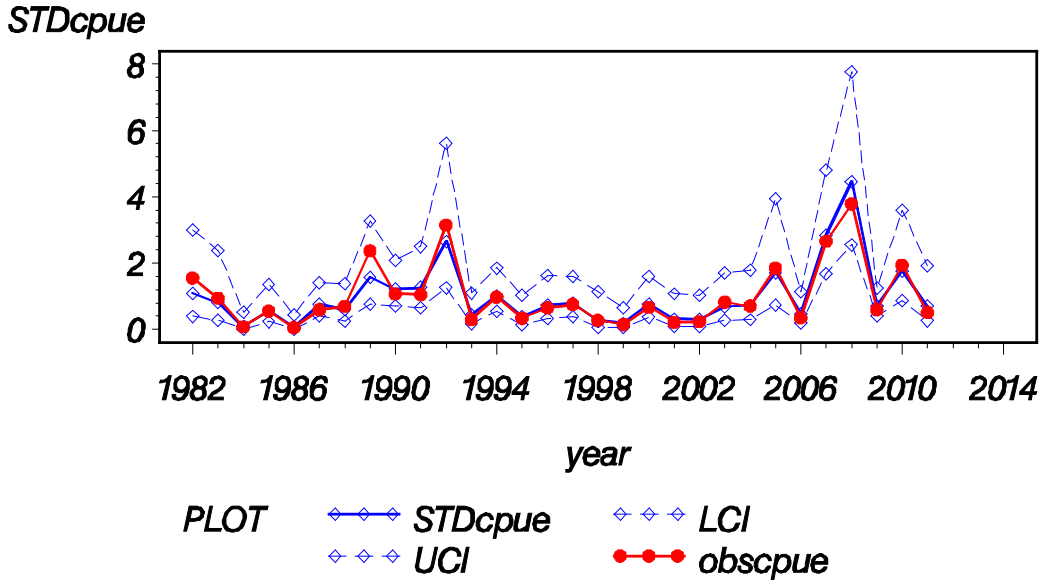


Figure 5.3.1.7. Annual index of abundance for red snapper (EGOM / Summer) from the SEAMAP Groundfish Survey from 1982 – 2011.

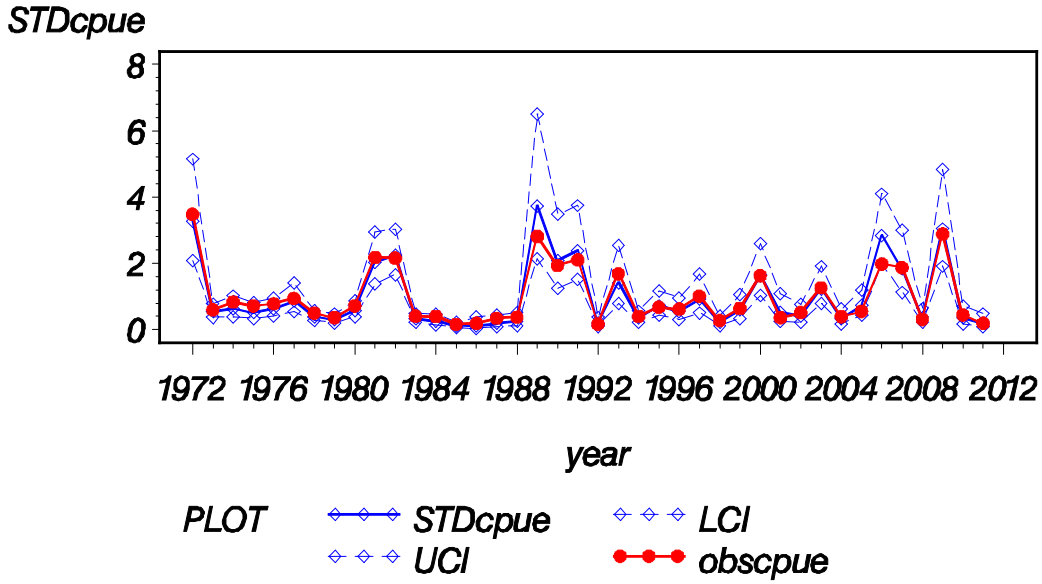


Figure 5.3.1.8. Annual index of abundance for red snapper (EGOM / Fall) from the SEAMAP Groundfish Survey from 1972 – 2011.

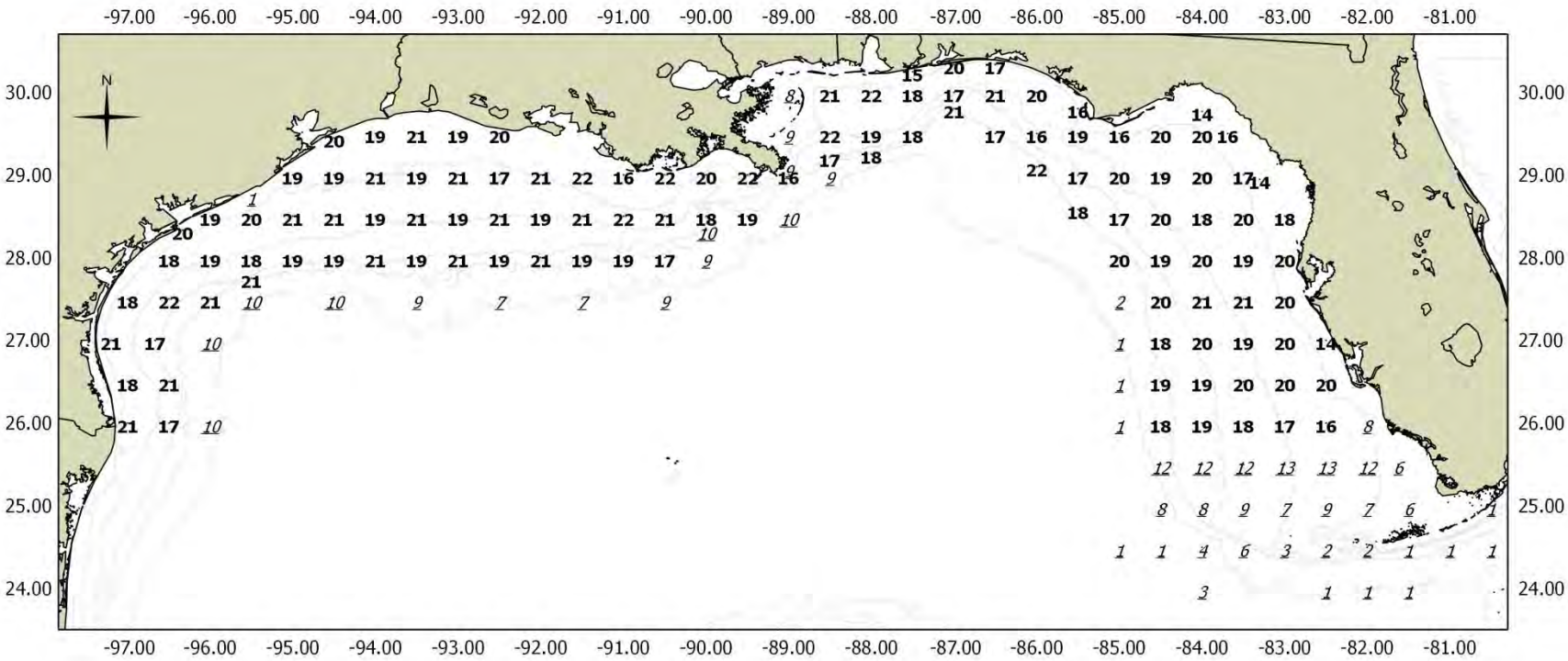


Figure 5.3.2.1. Number of samples taken at each SEAMAP B-number location from 1986-2010 during the SEAMAP Fall Plankton Survey. Bold numbers represent locations that were sampled at least 14 times (60%) during the survey and were included in analysis while those underlined and in italics were not included in the analysis.

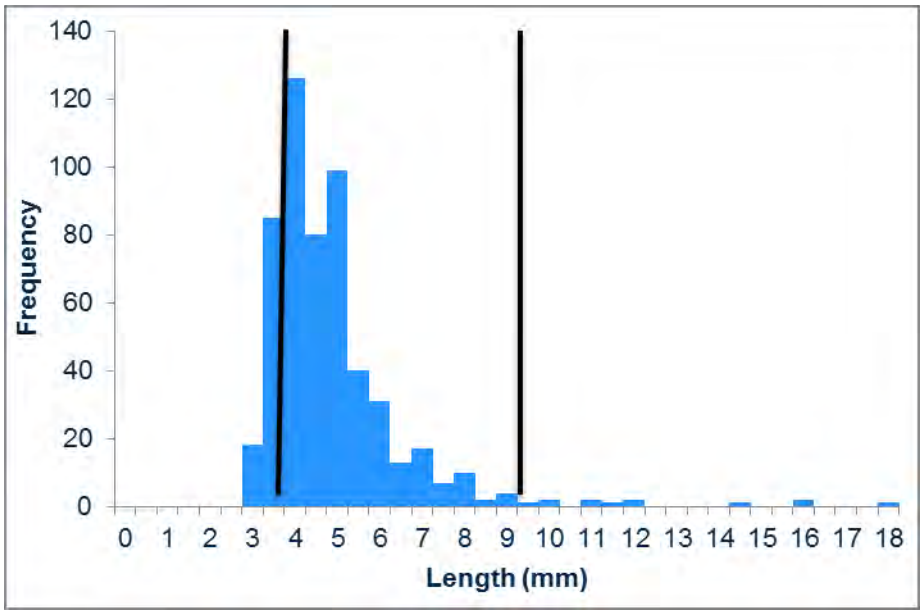


Figure 5.3.2.2. Length frequency histogram displaying catch sizes of larval red snapper caught during SEAMAP Fall Plankton surveys. Area between the black bars represent the larval red snapper used in the indices (3.75 – 9.25 mm).

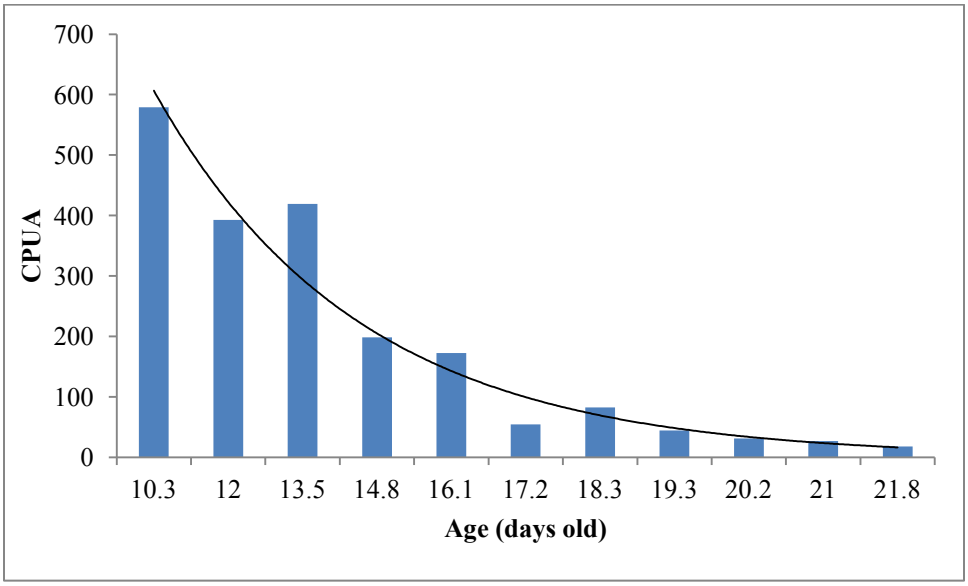


Figure 5.3.2.3. Age distribution (age of the size class midpoint) of the larval red snapper catch and the resulting daily loss rate curve (Z = 0.1503).

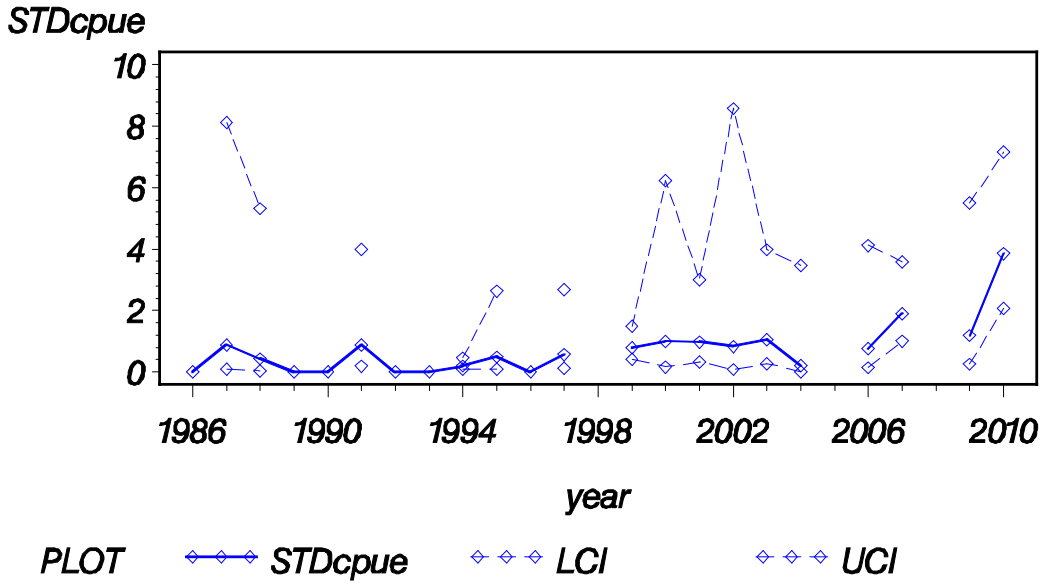


Figure 5.3.2.4. Annual index of abundance for larval red snapper (Eastern Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

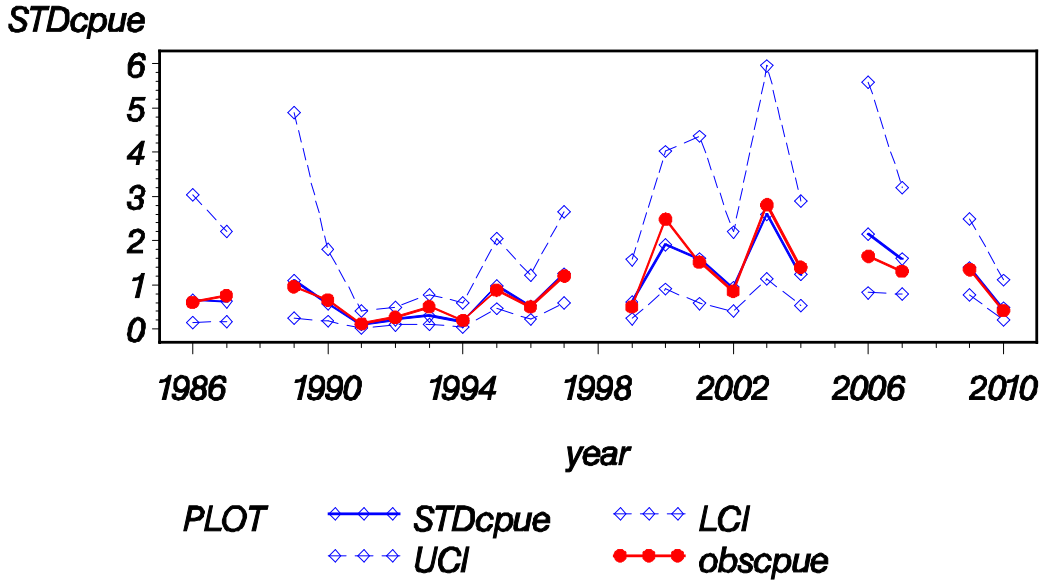


Figure 5.3.2.5. Annual index of abundance for larval red snapper adjusted to 10.5 days old (Western Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

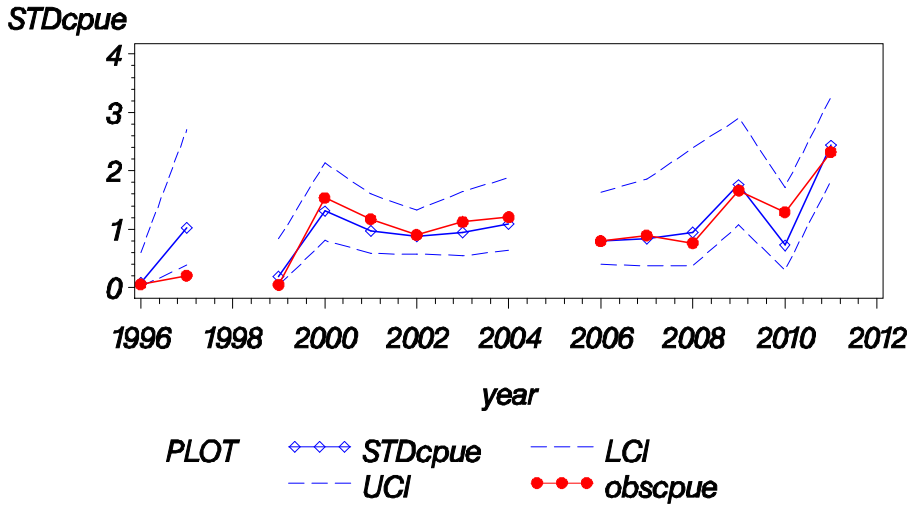


Figure 5.3.3.1. West Gulf abundance indices for red snapper collected during Bottom Longline Surveys. STDcpue is the index scaled to a mean of one over the time series. Obscpue is the average nominal CPUE, and LCI and UCI are 95% confidence limits.

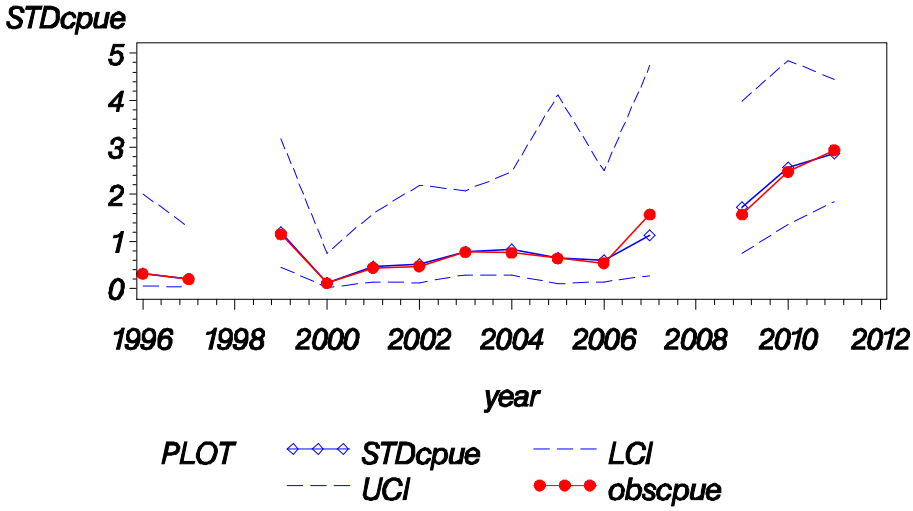


Figure 5.3.3.2. East Gulf abundance indices for red snapper collected during Bottom Longline Surveys. STDcpue is the index scaled to a mean of one over the time series. Obscpue is the average nominal CPUE, and LCI and UCI are 95% confidence limits.

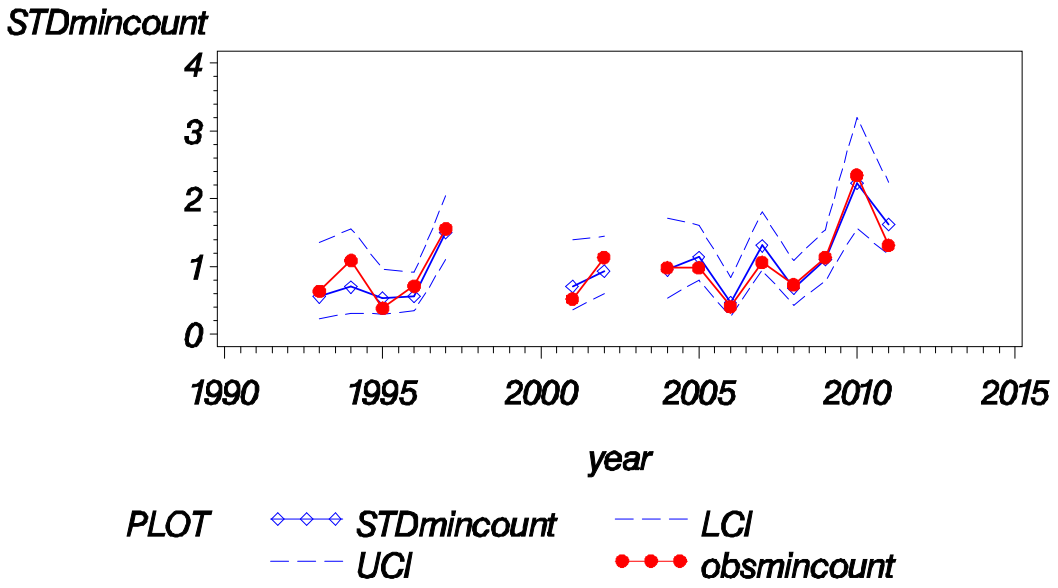


Figure 5.3.4.1. Model based west GOM standardized versus observed mincounts for SEAMAP Reef Fish Video Surveys.

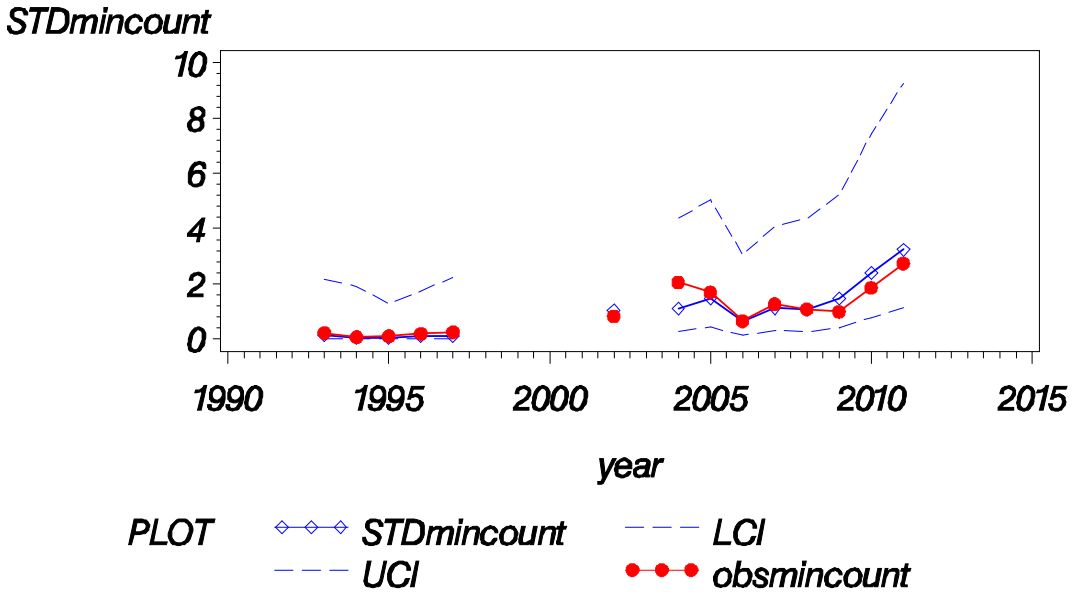


Figure 5.3.4.2. Model based east GOM standardized versus observed mincounts for SEAMAP Reef Fish Video Surveys.

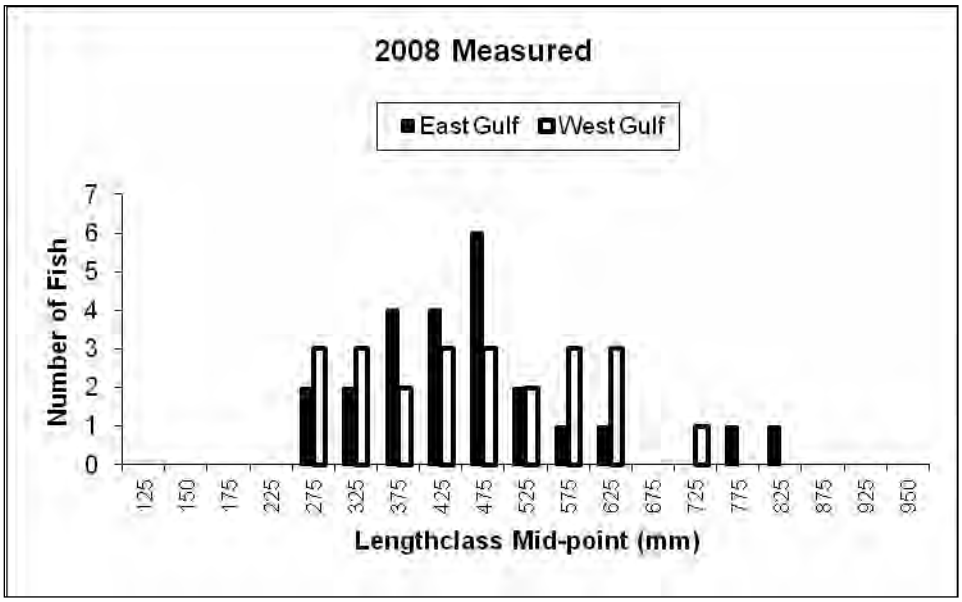


Figure 5.3.4.3. Red snapper length frequency of fish measured with stereo cameras in 2008 for SEAMAP Reef Fish Video Surveys.

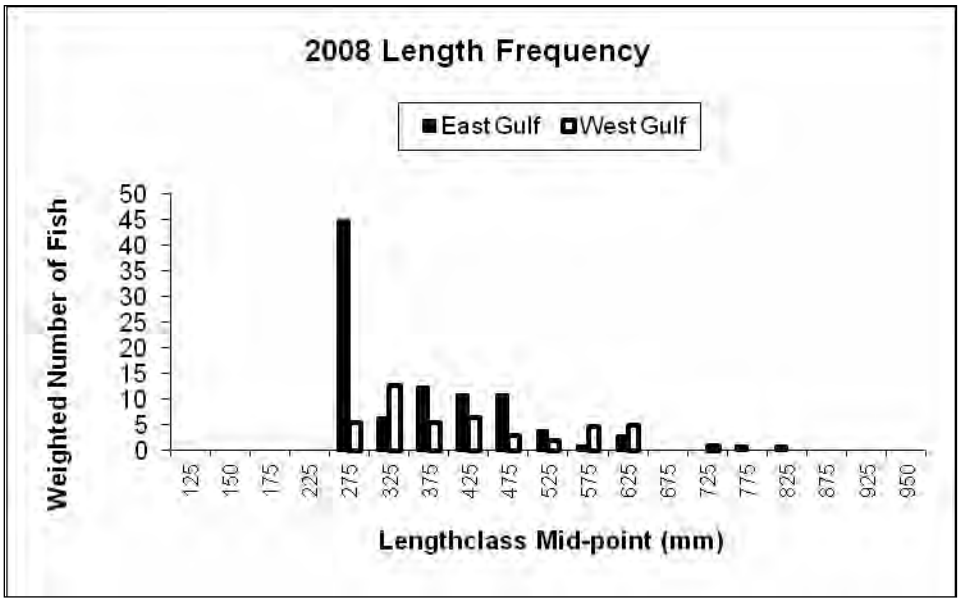


Figure 5.3.4.4. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2008 for SEAMAP Reef Fish Video Surveys.

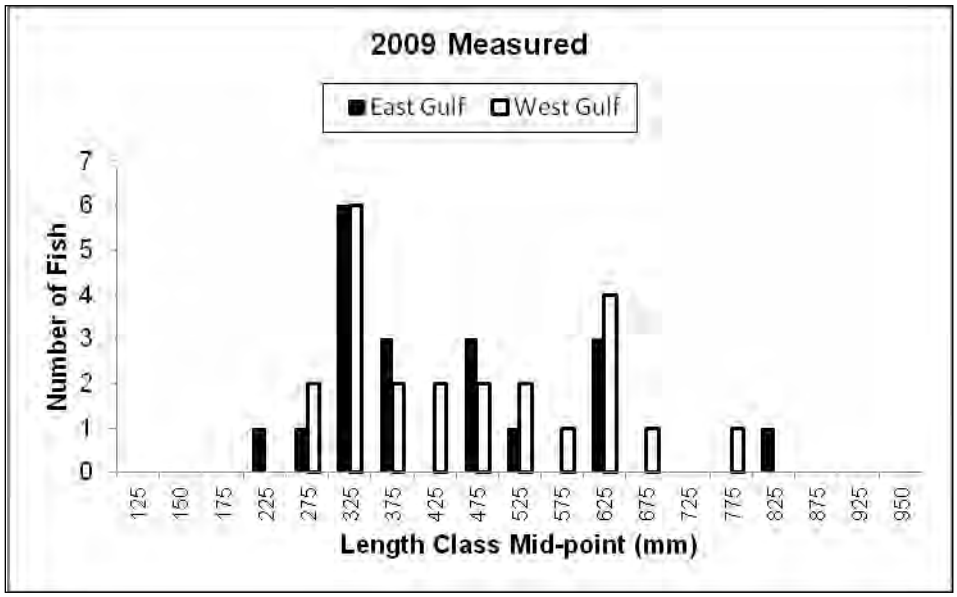


Figure 5.3.4.5. Red snapper length frequency of fish measured with stereo cameras in 2009 for SEAMAP Reef Fish Video Surveys.

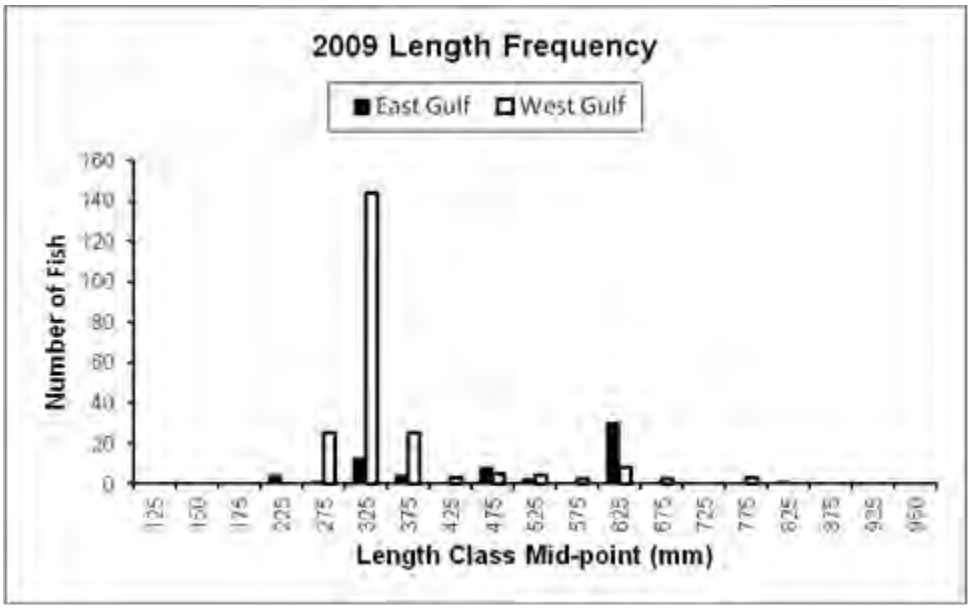


Figure 5.3.4.6. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2009 for SEAMAP Reef Fish Video Surveys.

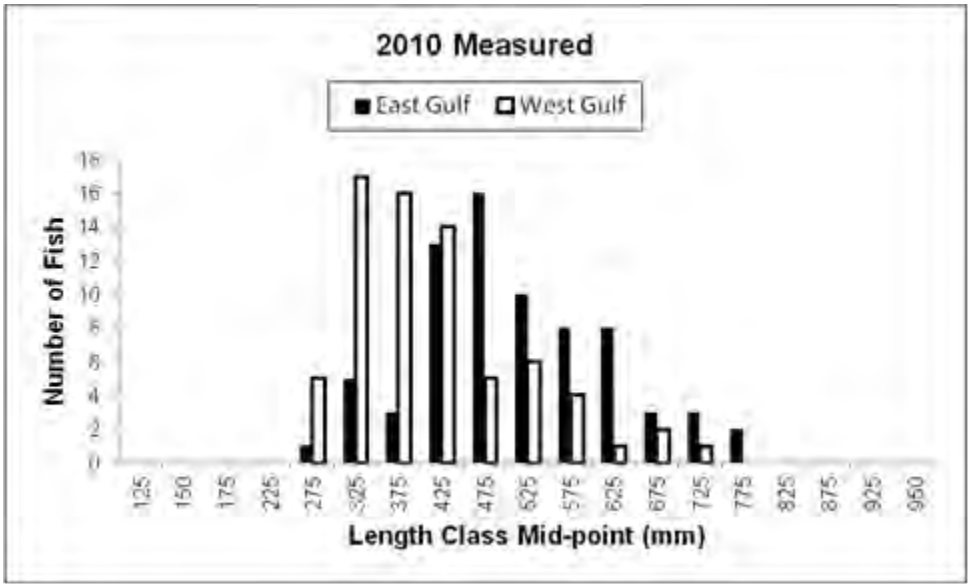


Figure 5.3.4.7. Red snapper length frequency of fish measured with stereo cameras in 2010 for SEAMAP Reef Fish Video Surveys.

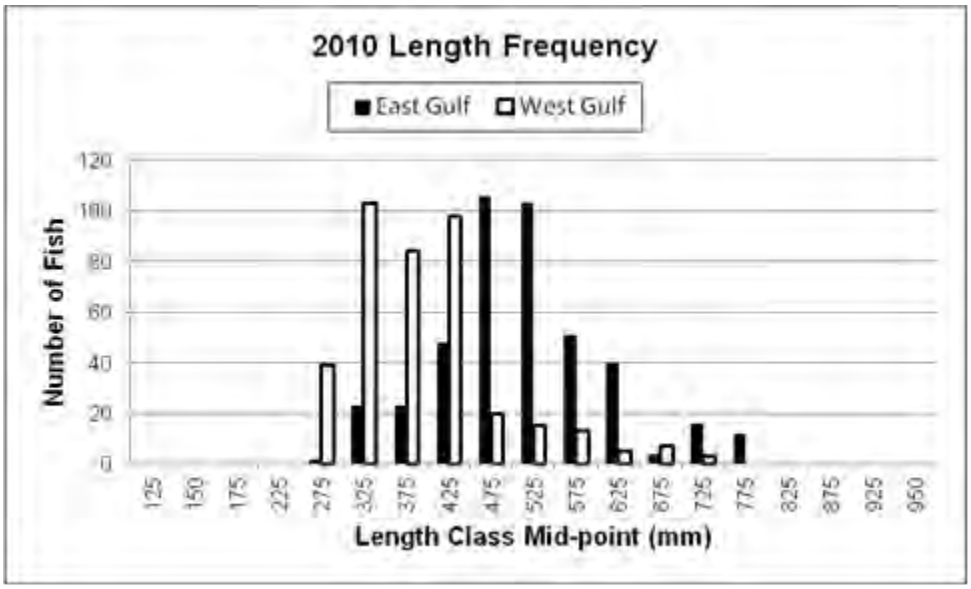


Figure 5.3.4.8. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2010 for SEAMAP Reef Fish Video Surveys.

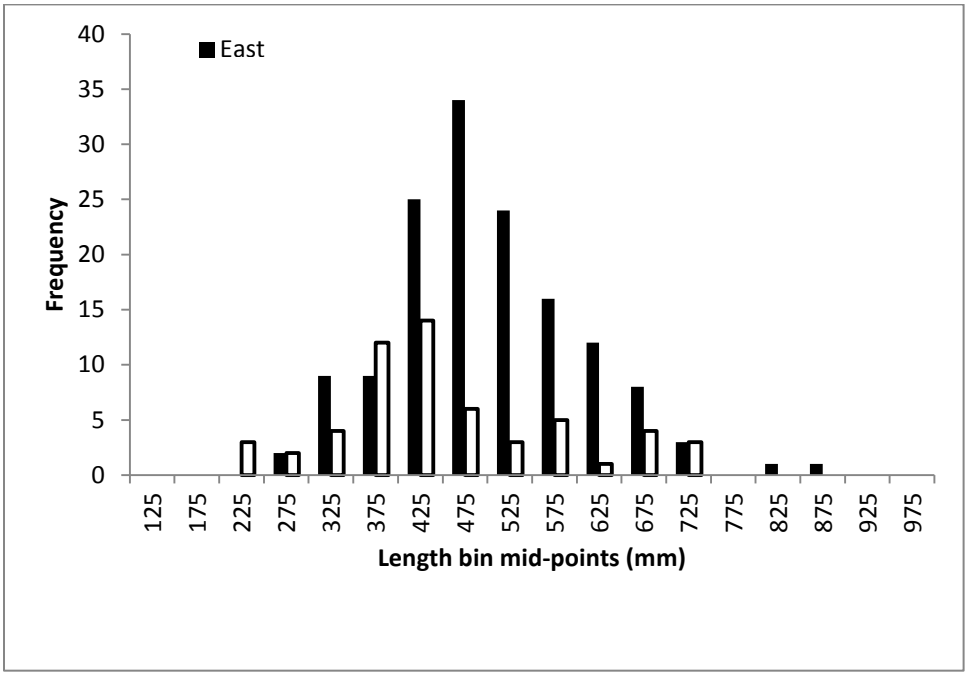


Figure 5.3.4.9. Red snapper length frequency of fish measured with stereo cameras in 2011 for SEAMAP Reef Fish Video Surveys.

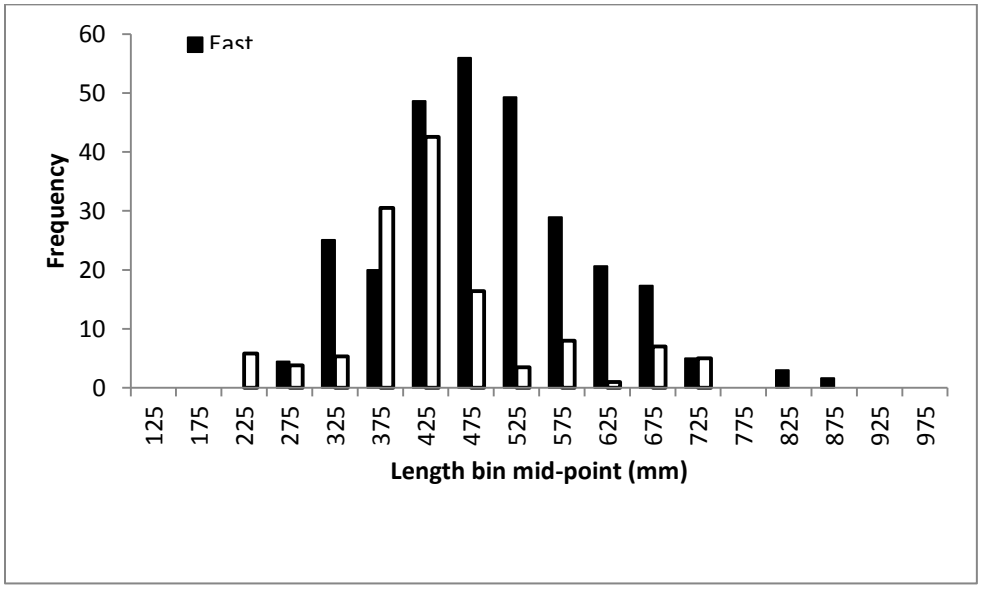


Figure 5.3.4.10. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2011 for SEAMAP Reef Fish Video Surveys.

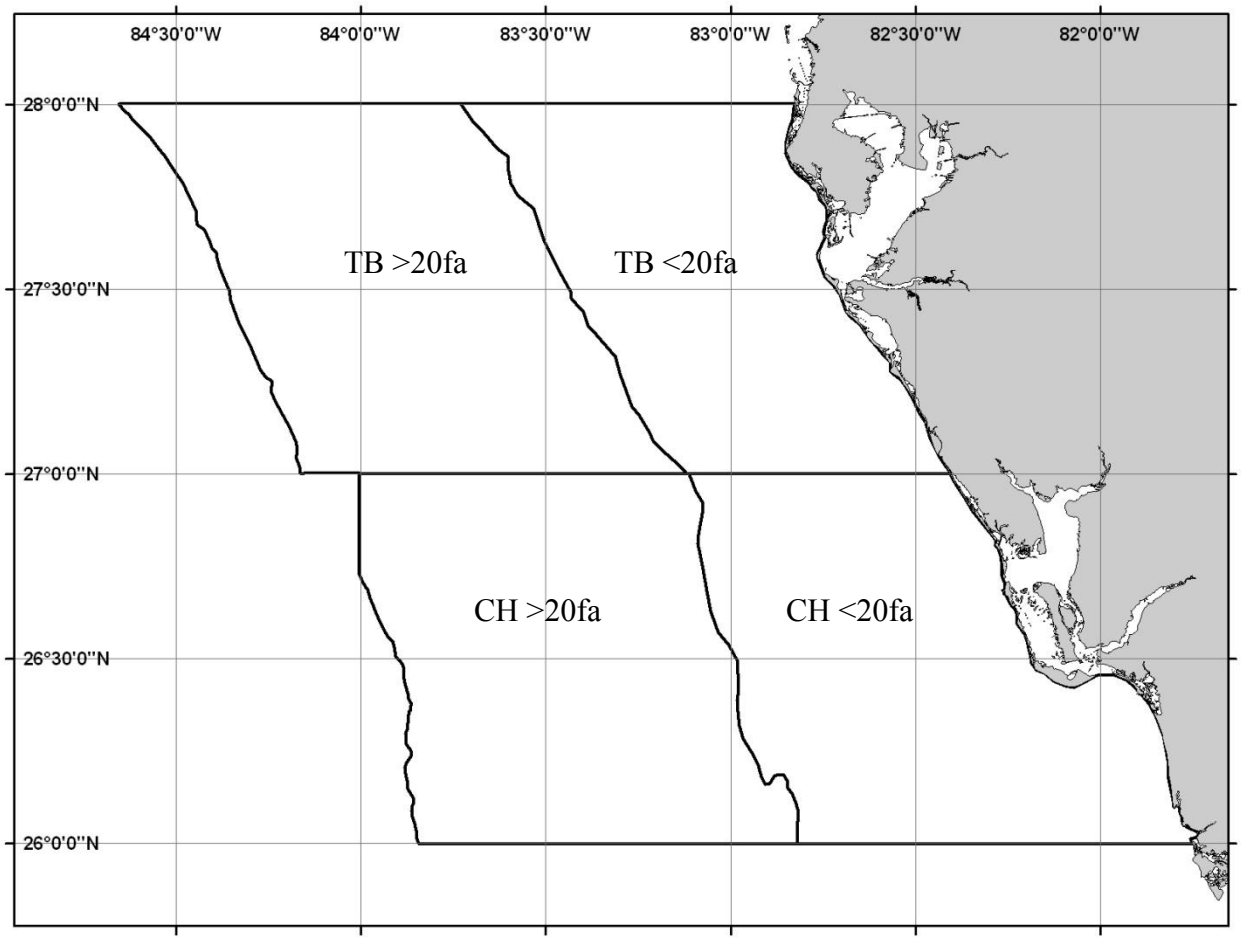


Figure 5.3.5.1. The West Florida Shelf survey area. The 20fa (37m) contour separates nearshore (i.e., TBN and CHN) and offshore (TBO and CHO) sampling zones. The sampling area includes waters 10m – 110m. (FWC Video Survey)

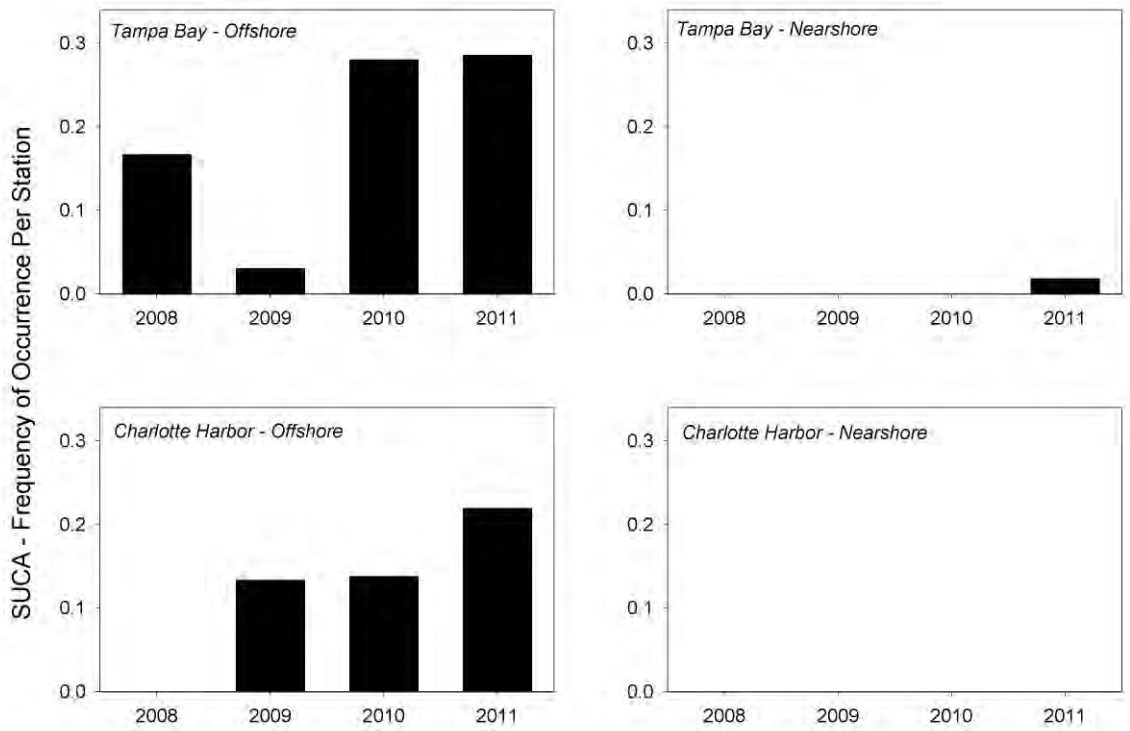


Figure 5.3.5.2. Annual frequency of occurrence of red snapper observed during stationary underwater camera array (SUCA) surveys by spatial zone from 2008 – 2011. (FWC Video Survey)

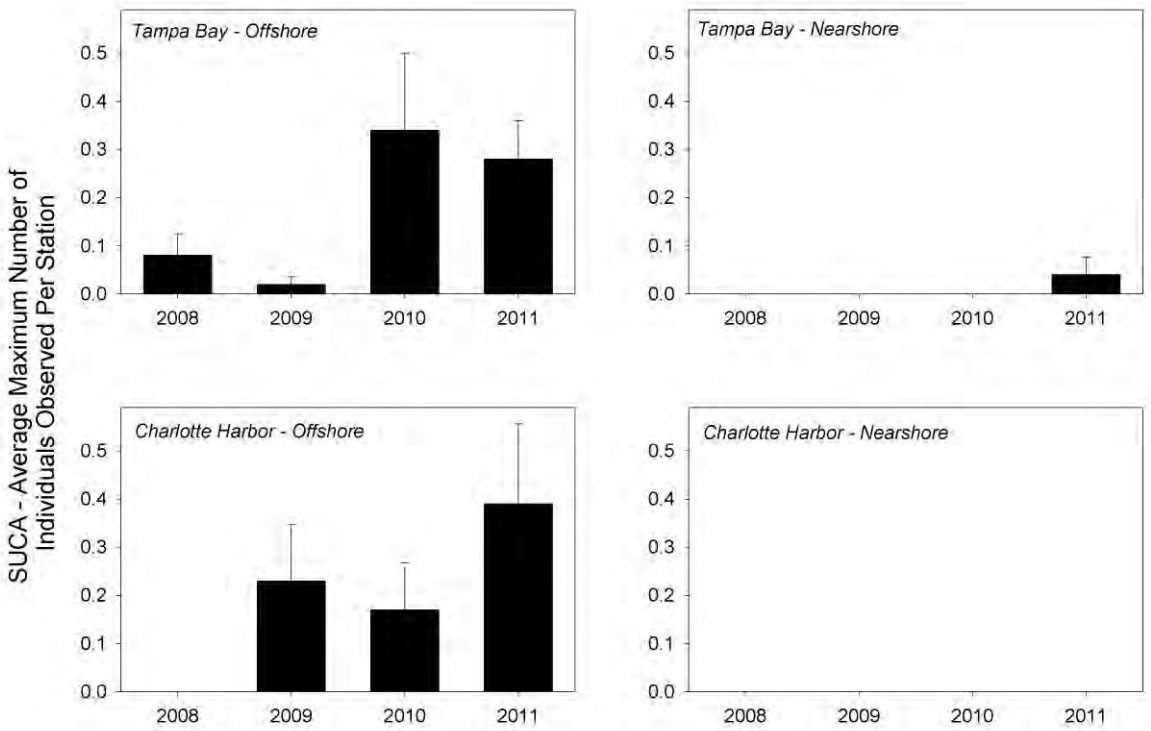


Figure 5.3.5.3. Mean (± SE) annual relative abundance of red snapper observed during stationary underwater camera array (SUCA) surveys by spatial zone from 2008 – 2011. (FWC Video Survey)

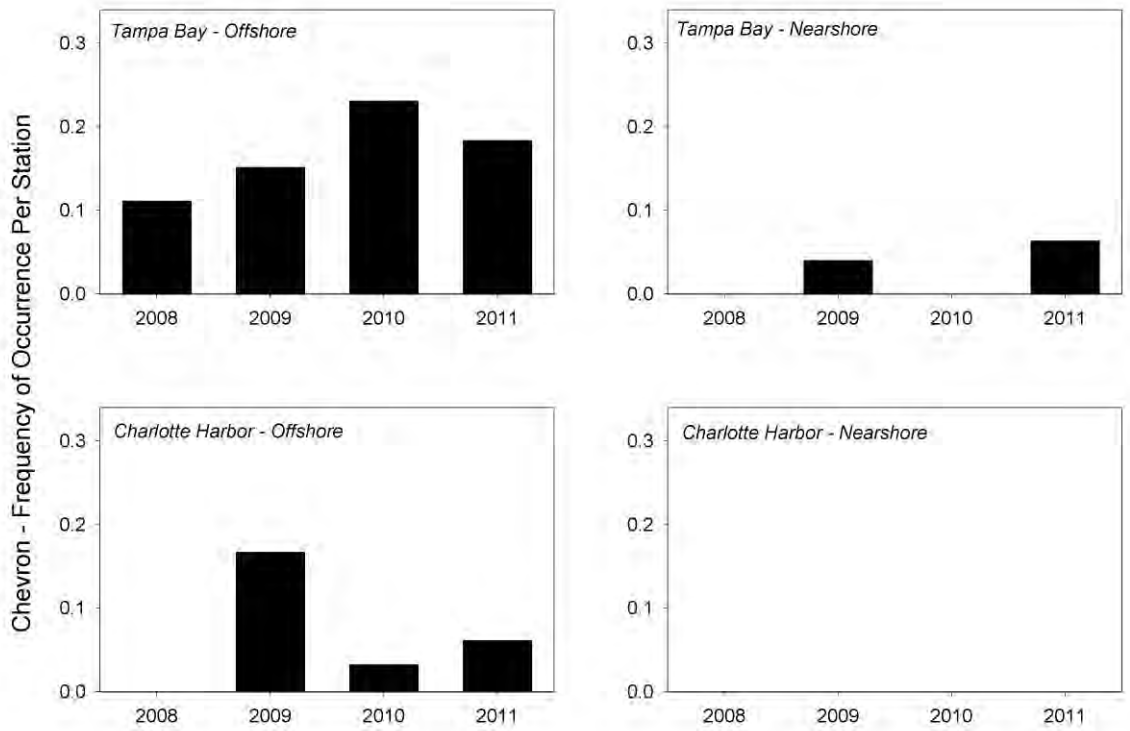


Figure 5.3.5.4. Annual frequency of occurrence of red snapper collected during chevron trap surveys by spatial zone from 2008 – 2011. (FWC Video Survey)

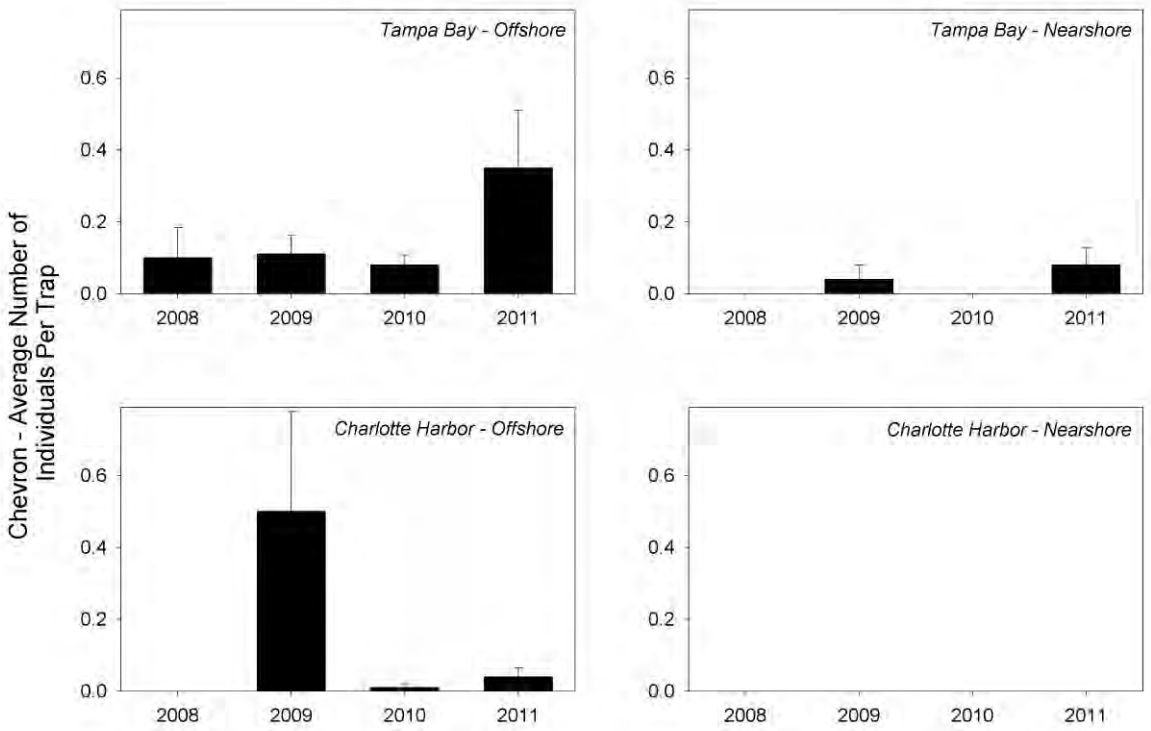


Figure 5.3.5.5. Mean (± SE) annual relative abundance of red snapper collected during chevron trap surveys by spatial zone from 2008 – 2011. (FWC Video Survey)

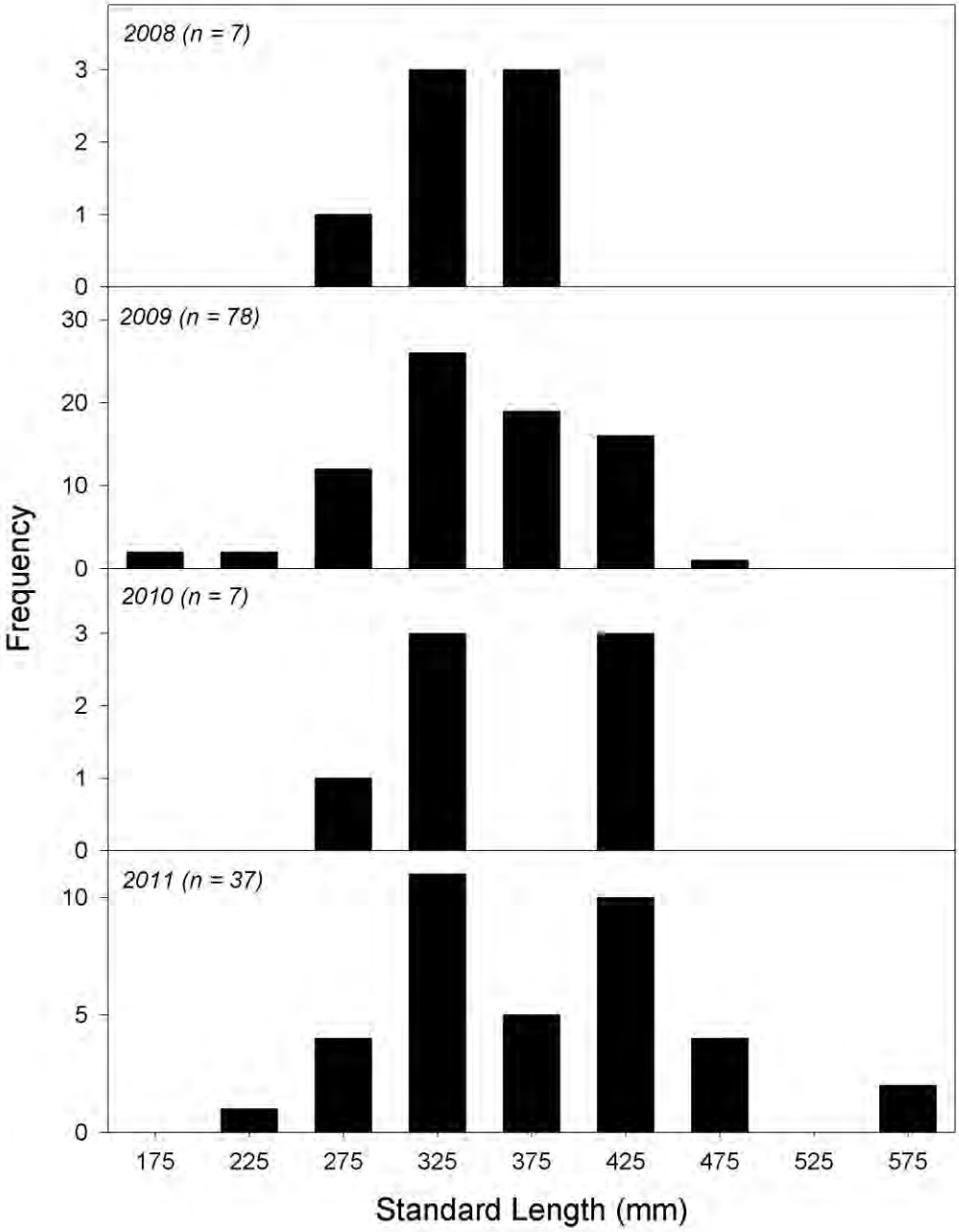


Figure 5.3.5.6. Annual size-frequency distribution of red snapper collected during chevron trap surveys by spatial zone from 2008 – 2011. (FWC Video Survey)

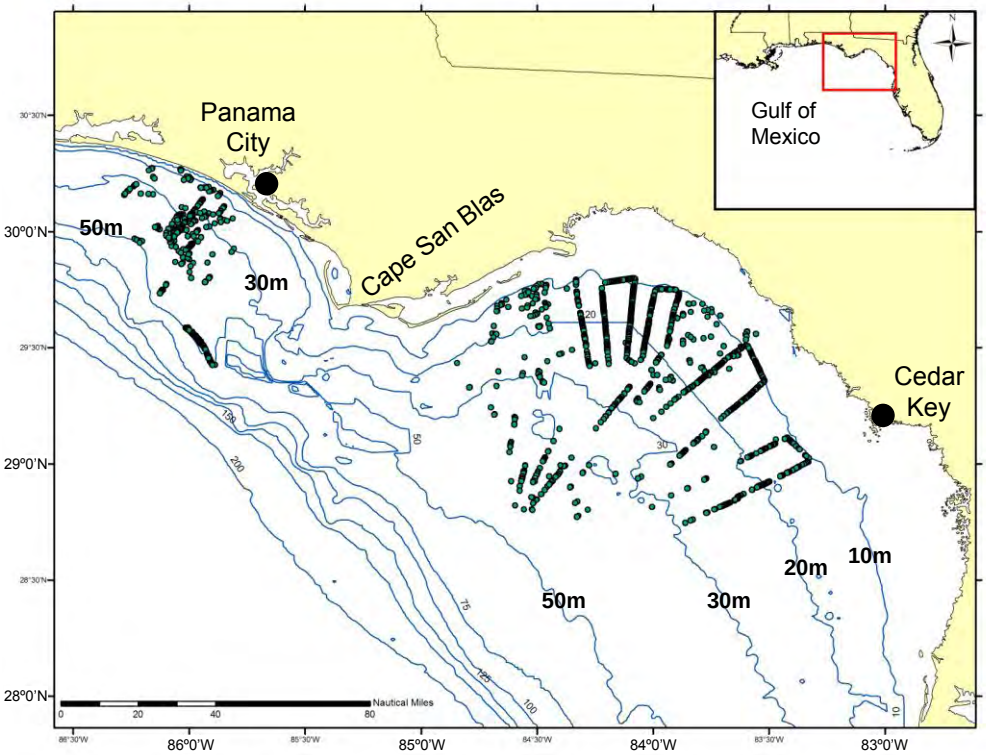


Figure 5.3.6.1. Locations of all natural reefs in the sampling universe of the Panama City NMFS reef fish video survey as of March 2012. Total sites: 2359, 722 west of and 1637 east of Cape San Blas.

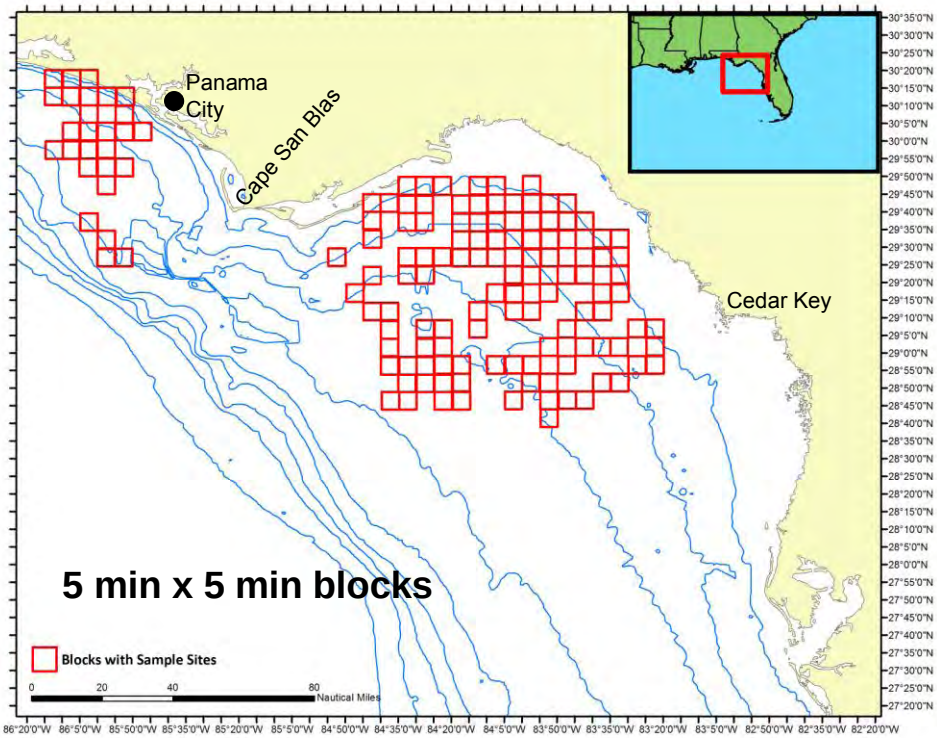


Figure 5.3.6.2. Sampling blocks, as of 2012, of the Panama City reef fish survey.

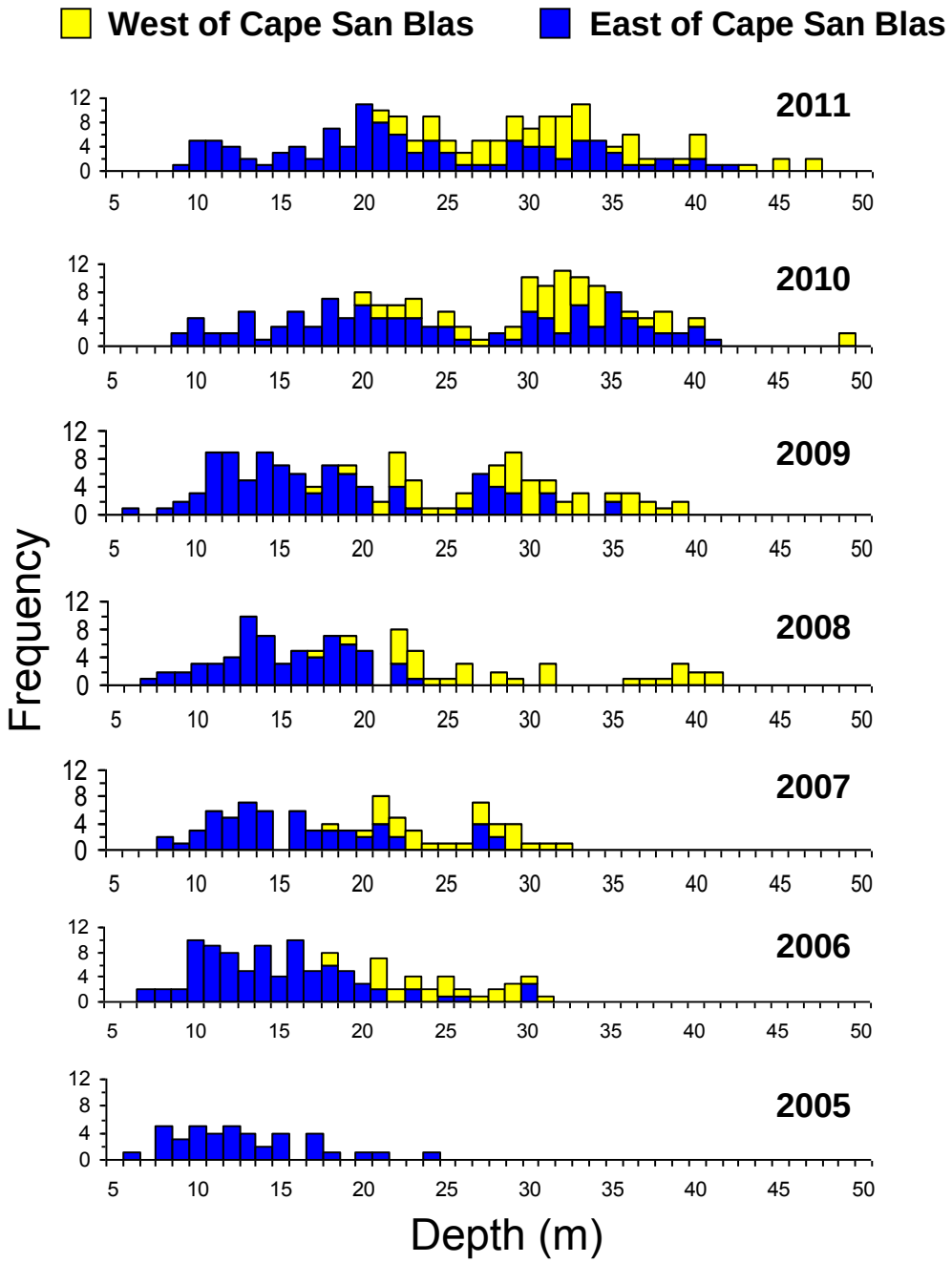


Figure 5.3.6.3. Annual depth distribution of Panama City reef fish survey video sample sites east and west of Cape San Blas, 2005-2011.

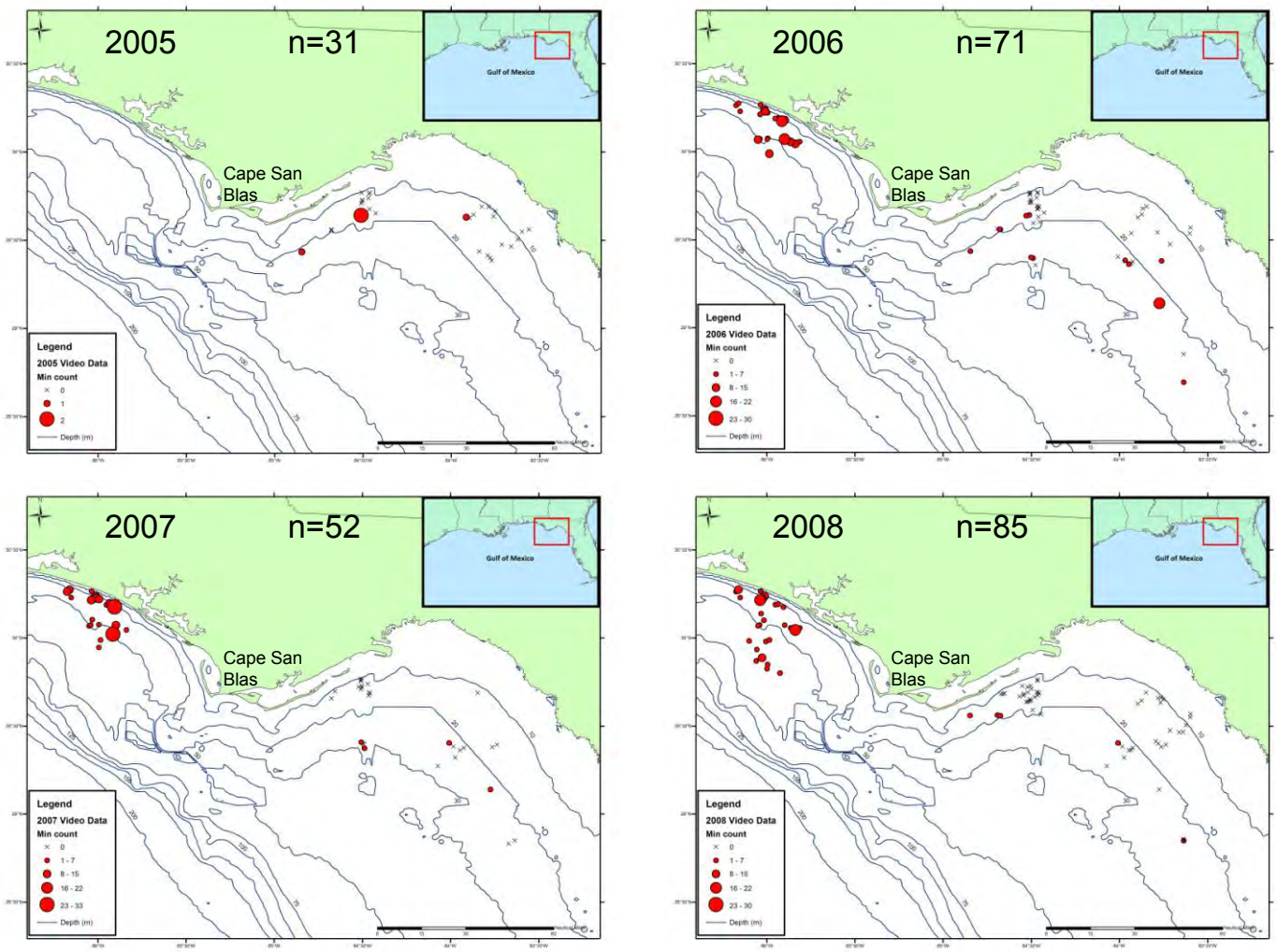


Figure 5.3.6.4. Annual distribution and relative abundance (min counts) of red snapper observed in the Panama City NMFS reef fish survey, 2005-2008, with stationary, high definition video cameras. Sites sampled with video gear, but where no red snapper were observed, are indicated with an X. Sample sizes refer to the total number of sites surveyed.

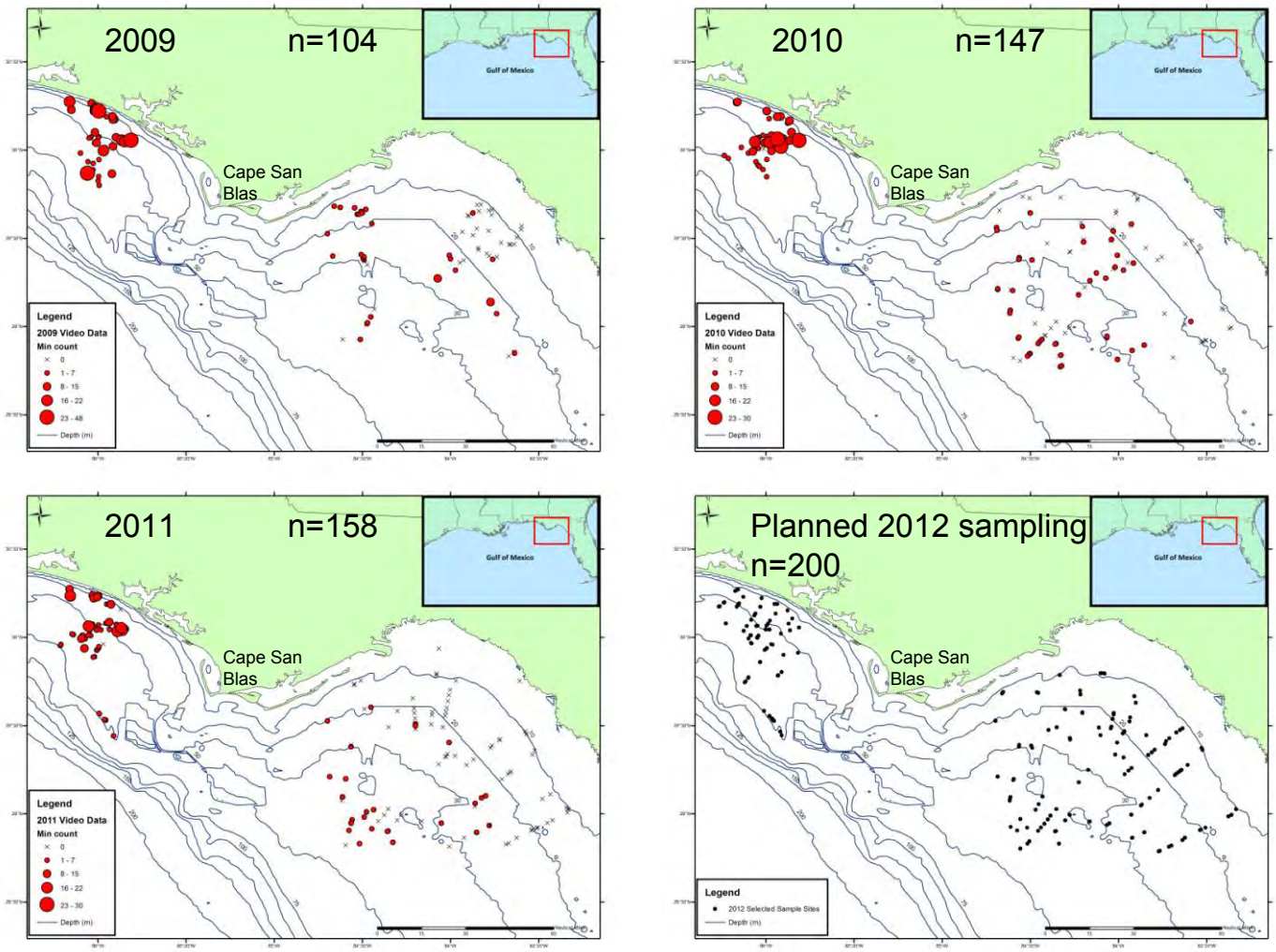


Figure 5.3.6.5. Annual distribution and relative abundance (min counts) of red snapper observed in the Panama City NMFS reef fish survey, 2009-2011, with stationary, high definition video or mpeg cameras. Sites sampled with video gear, but where no red snapper were observed, are indicated with an X. Sample sizes refer to the total number of sites surveyed.

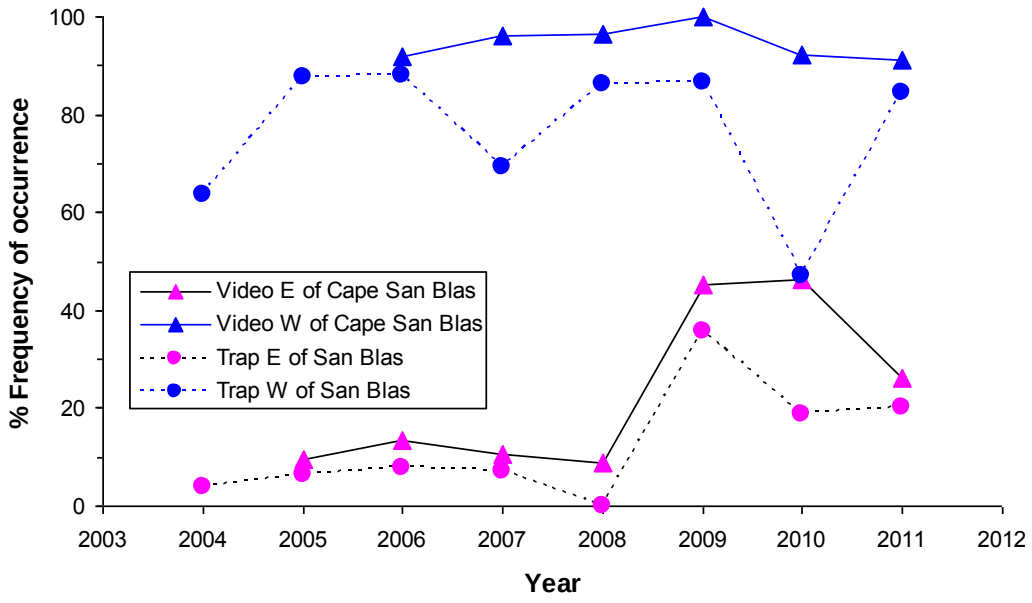


Figure 5.3.6.6. Annual percent frequency of occurrence of red snapper in video and trap samples east and west of Cape San Blas, 2005-2011. All data was included for trap estimates; censored data sets were used to calculate video frequencies.

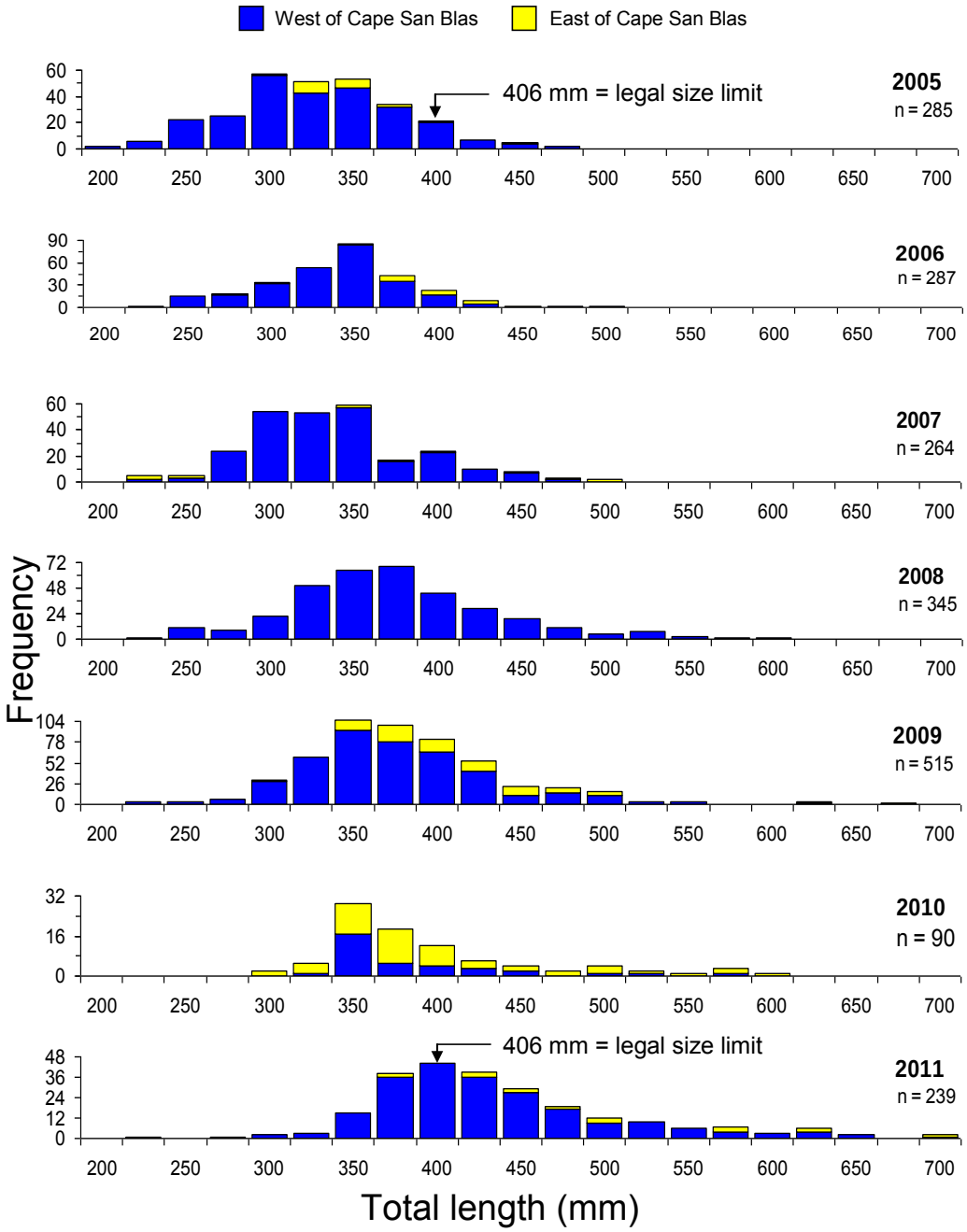


Figure 5.3.6.7. Annual size structure of trap-caught red snapper east and west of Cape San Blas, 2005-2011, in the NMFS Panama City reef fish survey.

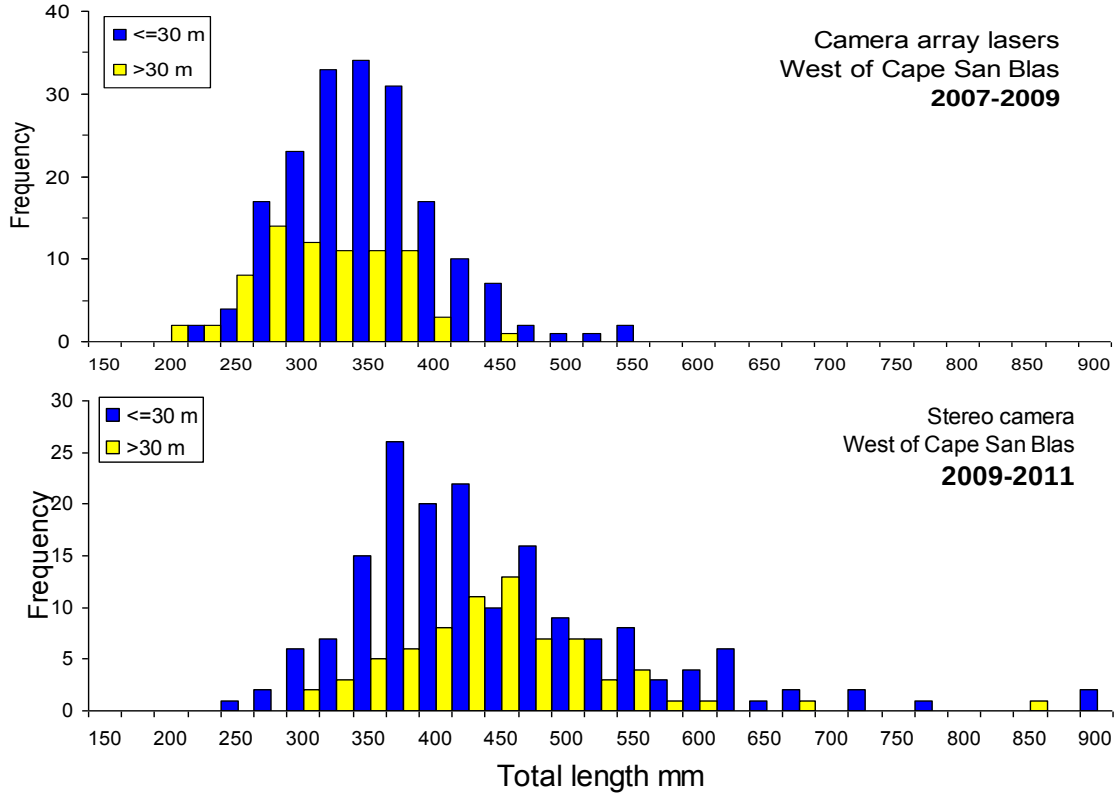


Figure 5.3.6.8. Size structure of red snapper by depth zone (<=30m and >30m) observed west of Cape San Blas based on scaling lasers, 2007-2009, and from stereo camera images, 2009-2011. NMFS Panama City reef fish survey.

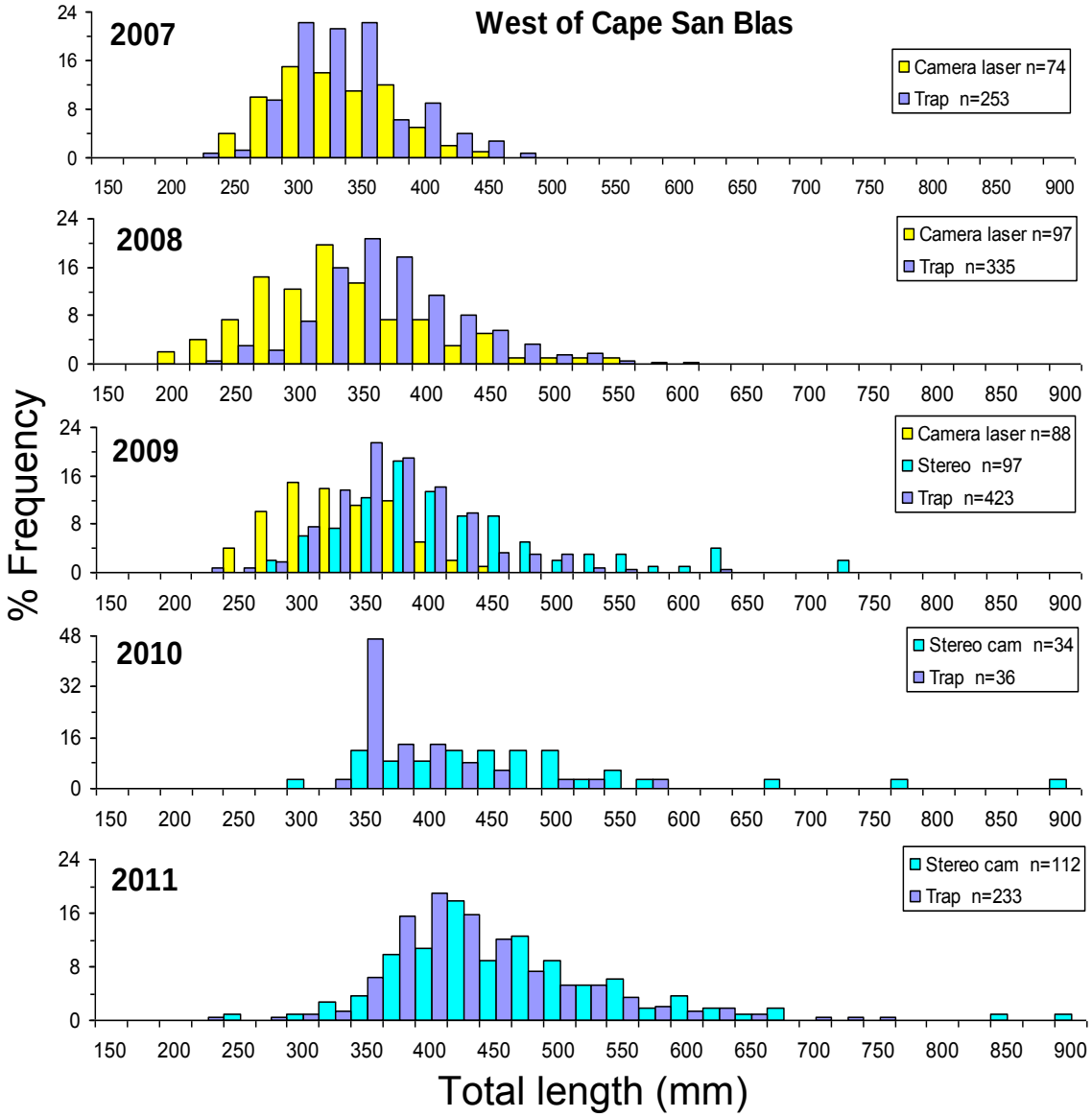


Figure 5.3.6.9. Annual size distributions of red snapper west of Cape San Blas, 2007-2011 collected in chevron traps or measured in high definition video or stereo still images. NMFS Panama City reef fish survey.

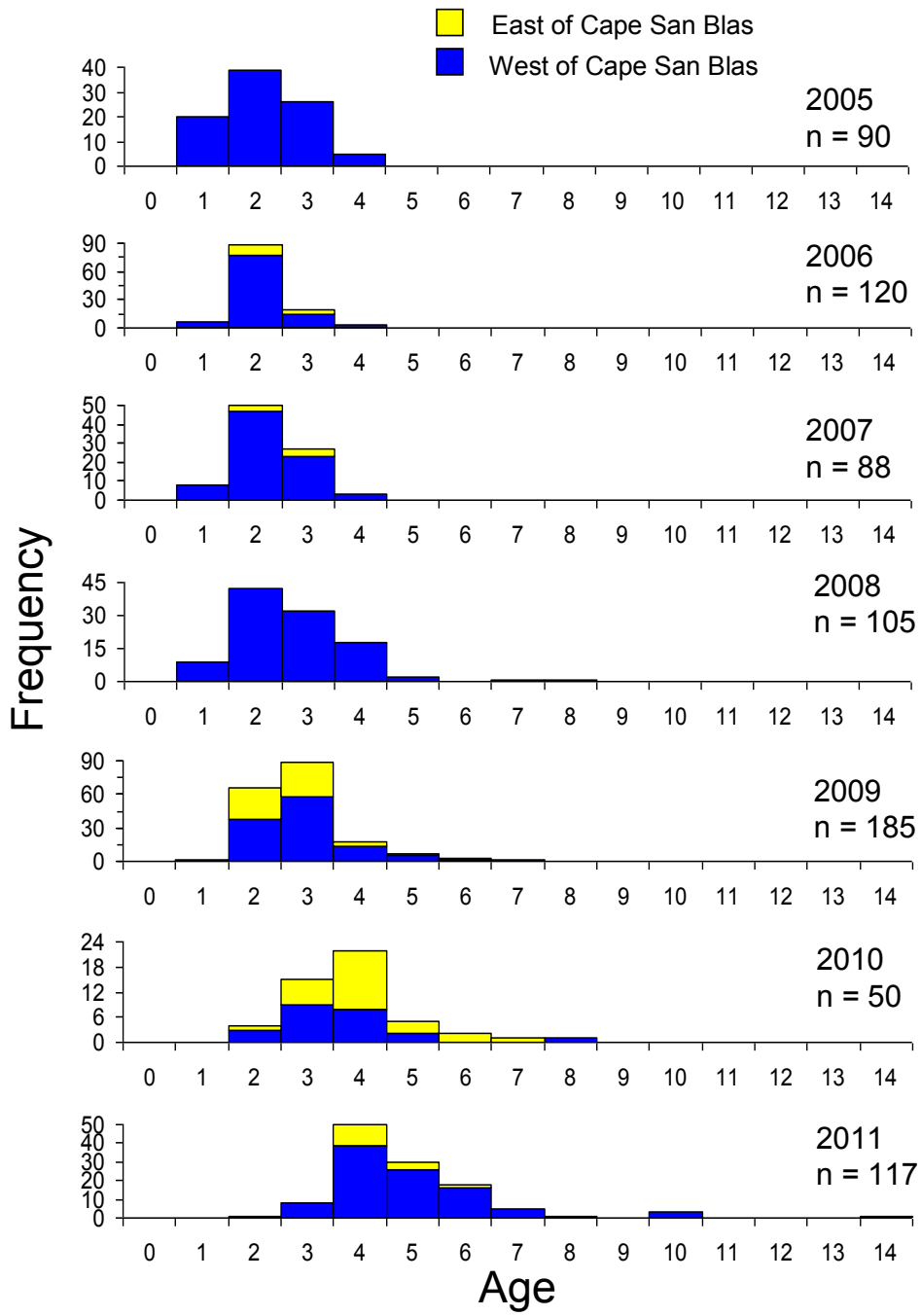


Figure 5.3.6.10. Annual age structure of trap-caught red snapper, 2005-2011, east and west of Cape San Blas. NMFS Panama City reef fish survey.

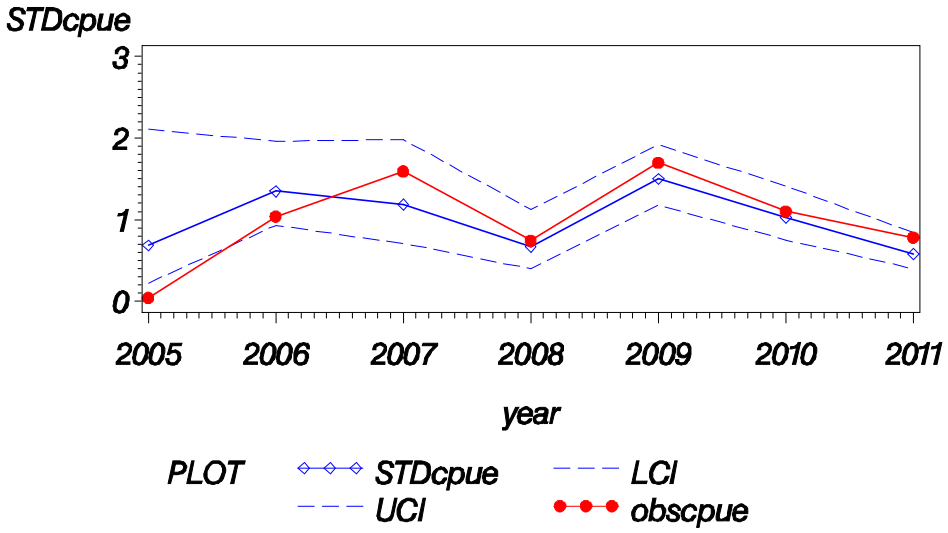


Figure 5.3.6.11. NMFS Panama City Video abundance indices for red snapper. STDcpue is the index scaled to a mean of one over the time series. Obscpue is the average nominal CPUE, and LCI and UCI are 95% confidence limits.

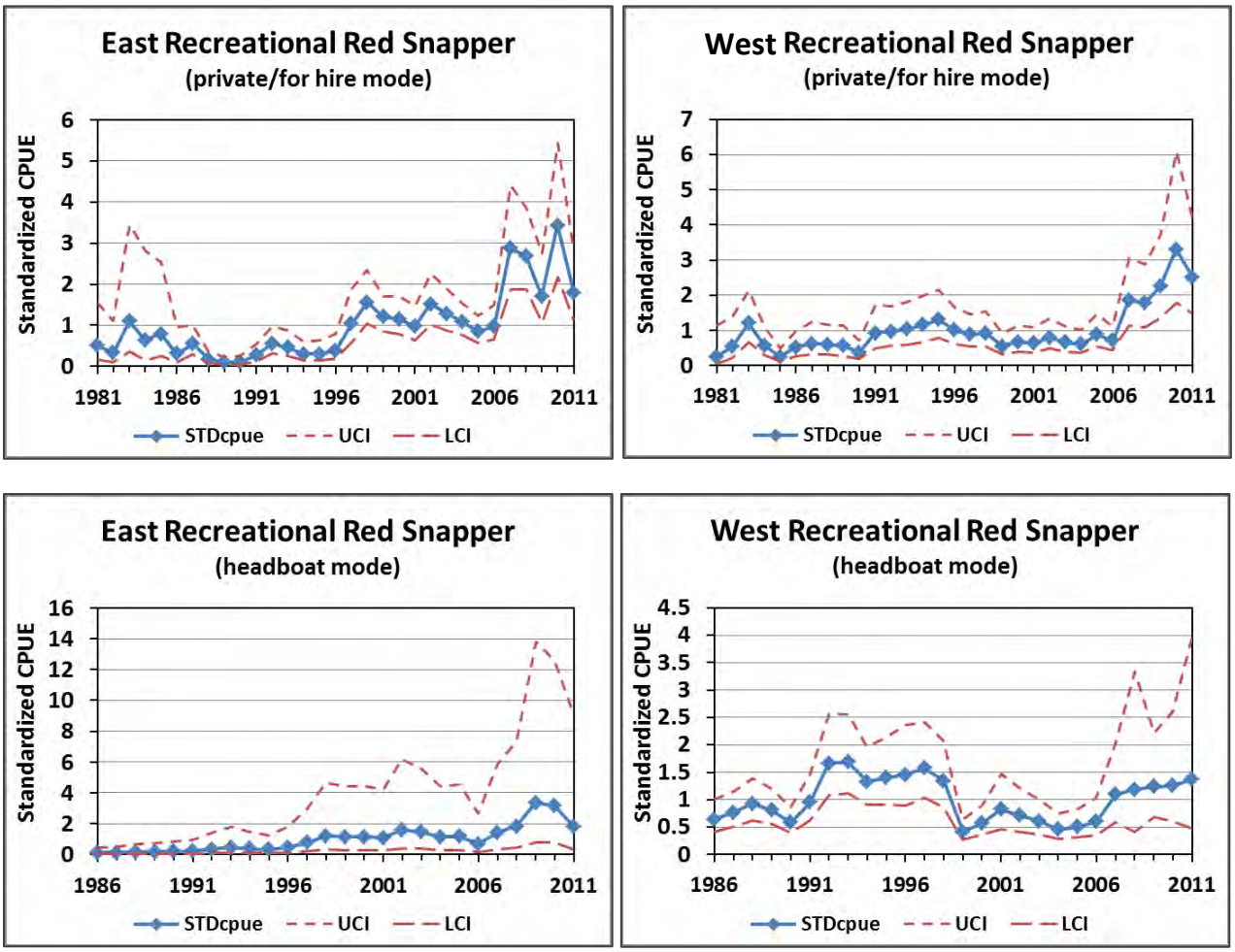


Figure 5.4.1.1. Censored standardized recreational indices of abundance for red snapper from the private/for hire and headboat mode for the east and west GOM.

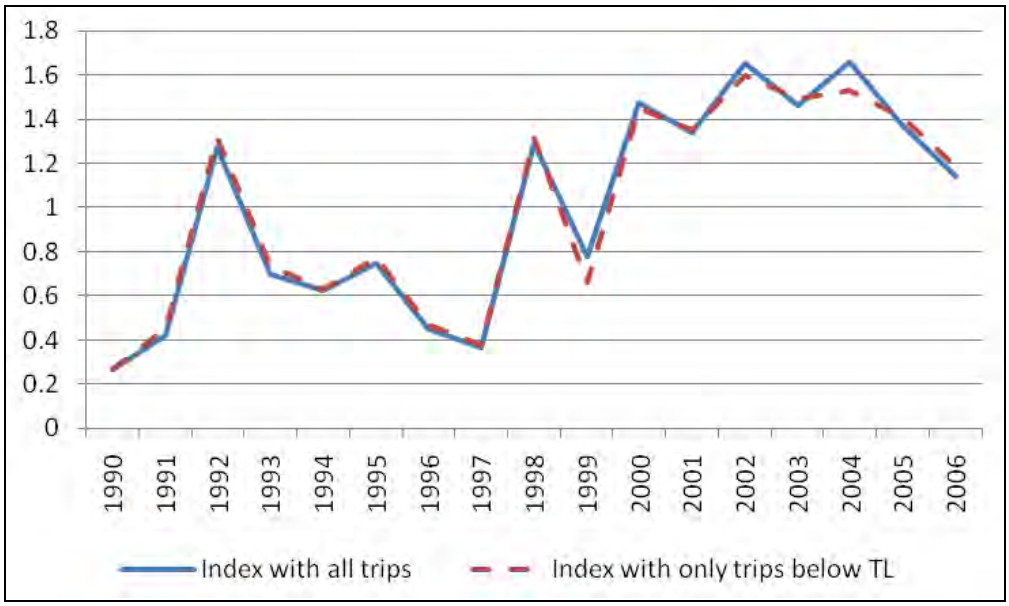


Figure 5.4.2.1. Eastern Gulf of Mexico vertical line index constructed with and without trips meeting or exceeding trip limits.

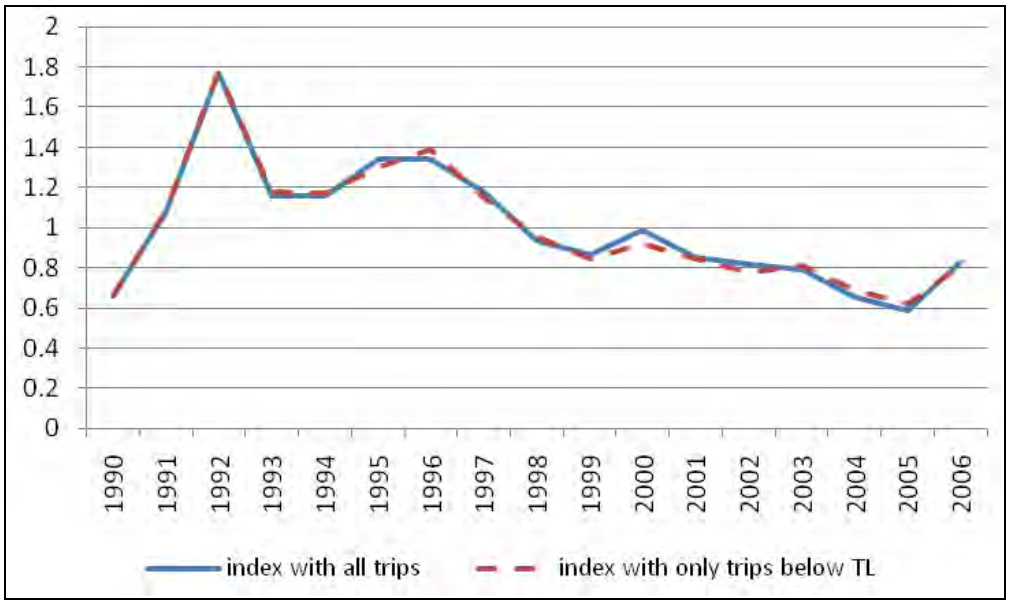


Figure 5.4.2.2. Western Gulf of Mexico vertical line index constructed with and without trips meeting or exceeding trip limits.

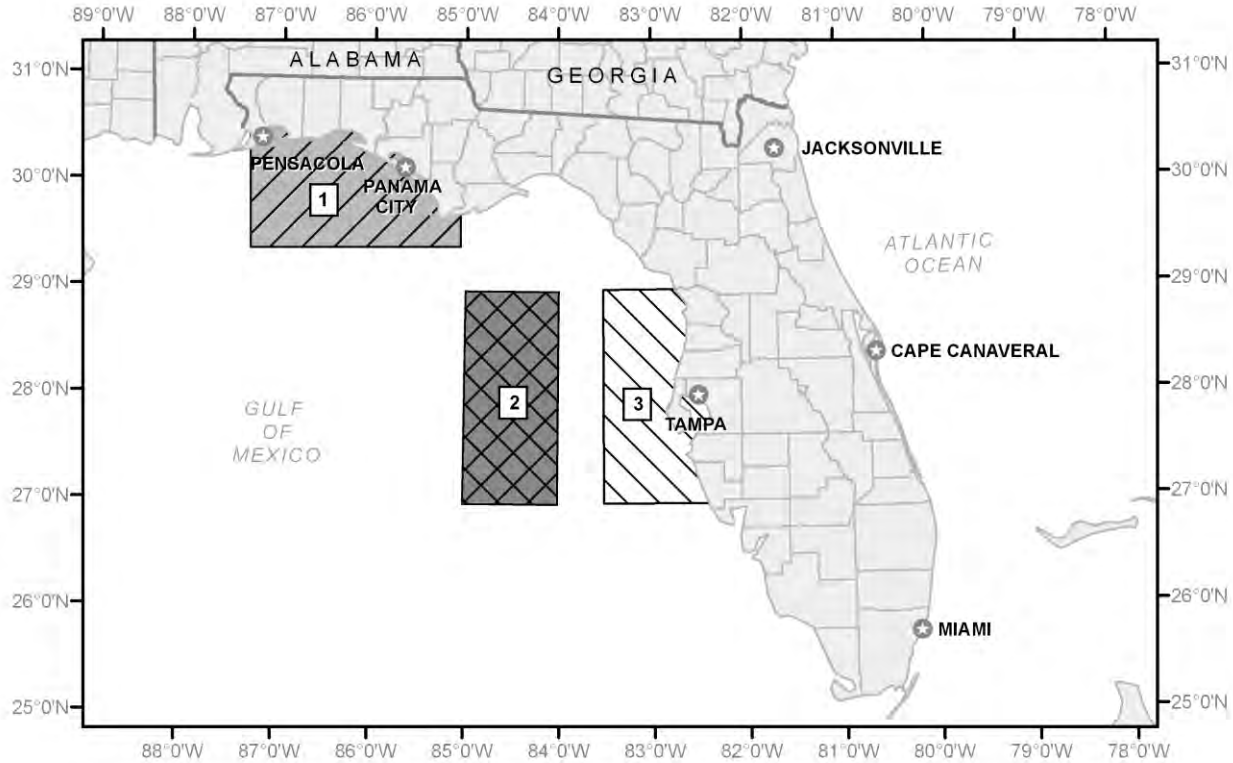


Figure 5.4.3.1. Study areas for Florida headboat observer program in the Gulf of Mexico. Box 1 represents the area where half-day and full-day trips originating from the northwestern panhandle region (NW FL) took place, Box 2 represents the area where multi-day trips originating from the central west region adjacent to Tampa Bay (TB) took place, and Box 3 represents the area where half-day and full-day trips originating from the TB region took place.

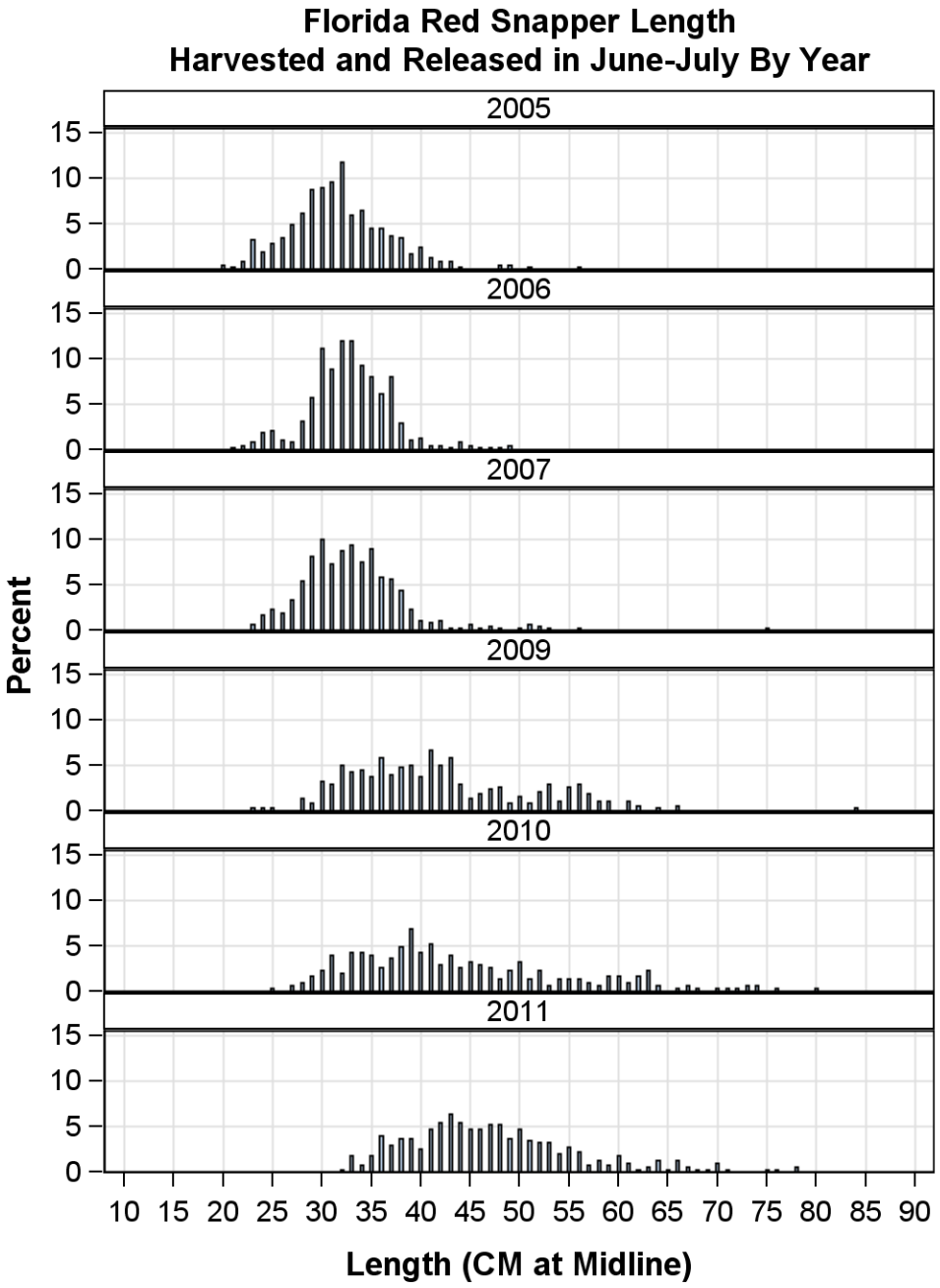
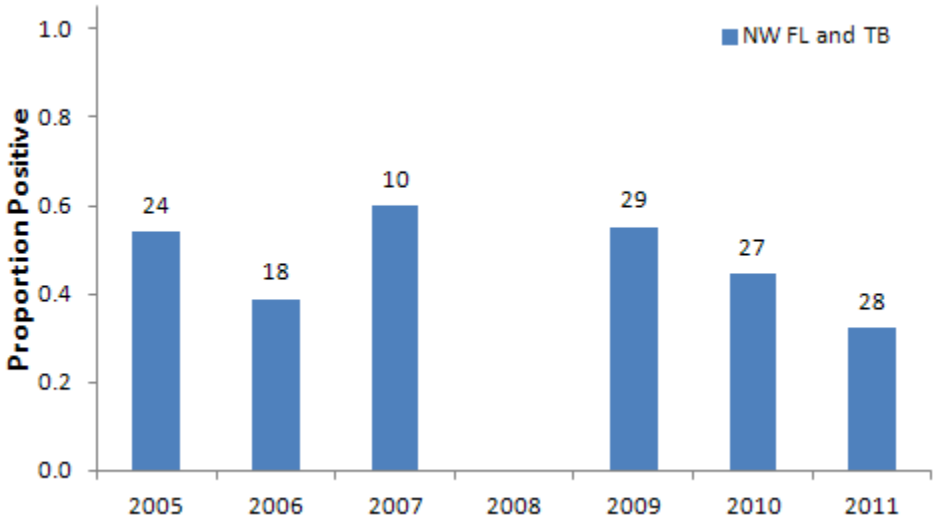


Figure 5.4.3.2. Length frequencies (cm total length) of all red snapper (harvested and released) observed on Florida head boats during the months of June and July. Length bins for 40cm and less are sublegal size classes.

a.) Regions combined.



b.) By region.

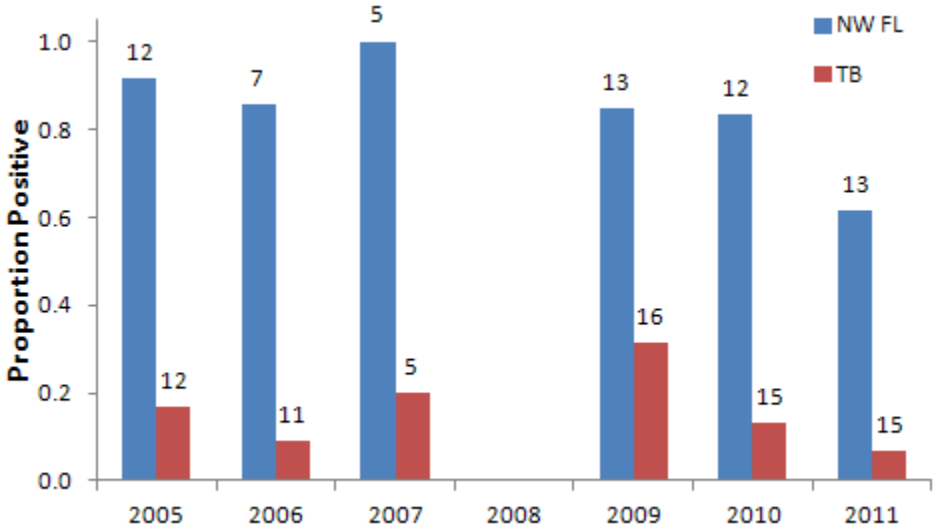
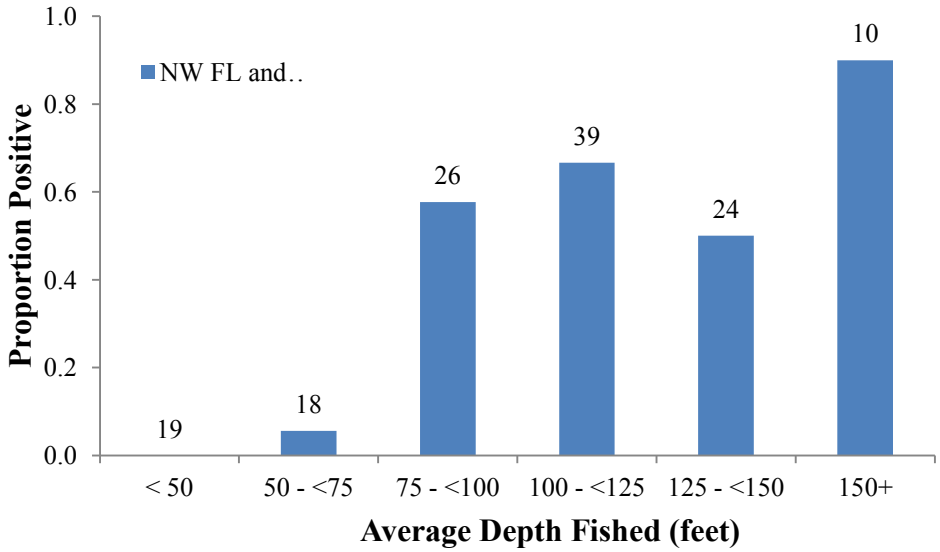


Figure 5.4.3.3. Proportion of trips with releases of undersized red snapper. a.) For the combined regions; and b.) For each region. Sample sizes are shown above the columns.

a.) Regions combined.



b.) By region.

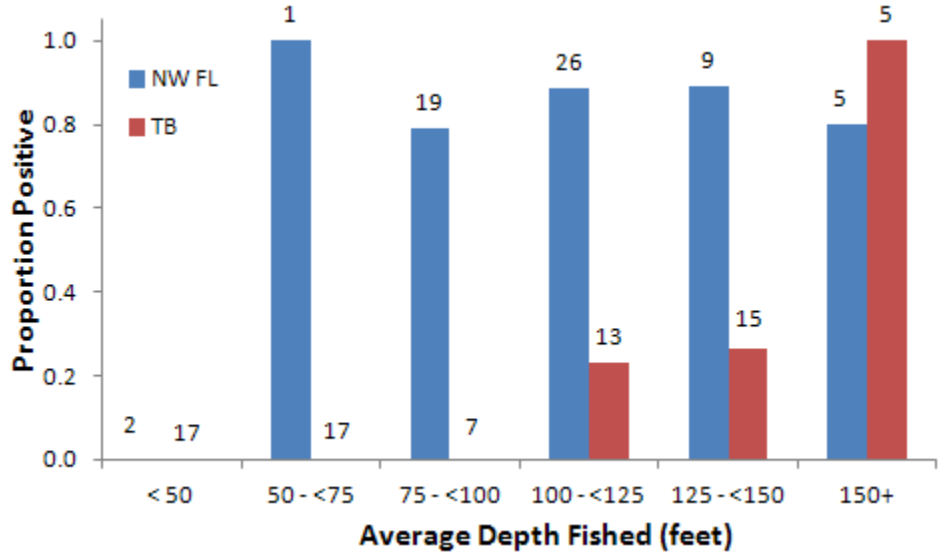
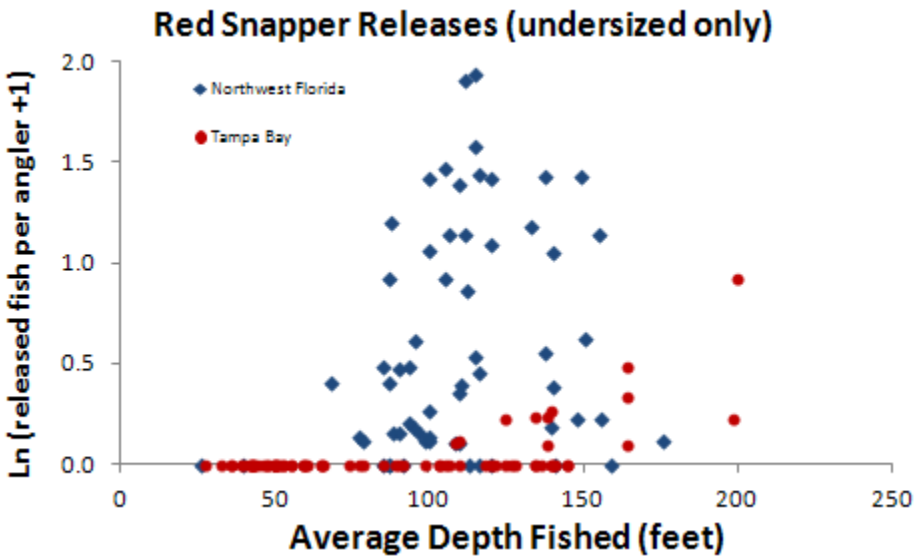


Figure 5.4.3.4. Proportion of trips with releases of undersized red snapper a.) for the combined regions by average water depth; and b.) in each region by average water depth. Sample sizes are shown above the columns.

a.) Released fish rates by region



b.) NW Florida release rates by year, with trend lines

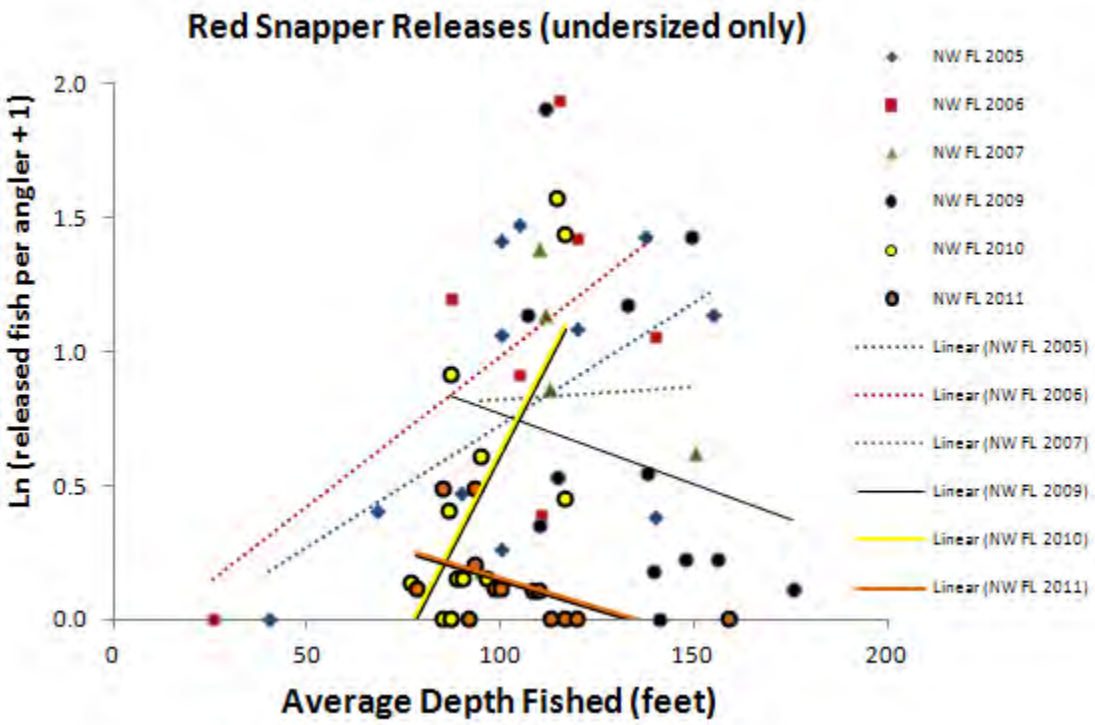


Figure 5.4.3.5. Release rates per angler-trip by average depth fished (in feet) . a.) By region; b.) for the northwest Florida region only, with linear trend lines by year.

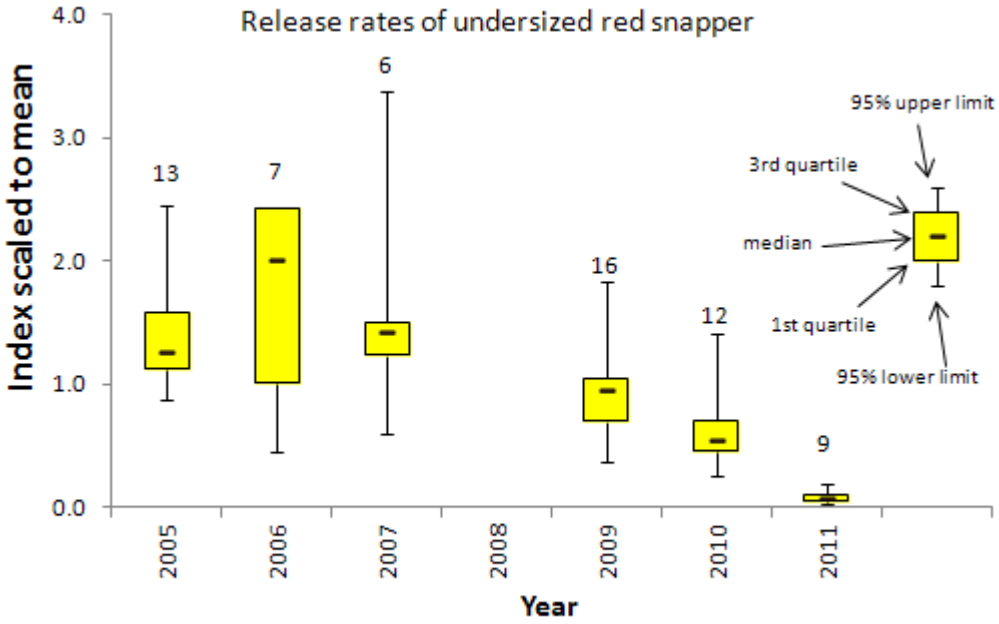


Figure 5.4.3.6. Scaled index for the combined binomial and gamma sub-models for Florida at-sea sampled undersized red snapper releases from head boats in NW FL and TB, 2005-2011. Sample sizes for the positives (gamma sub-model) are shown above the index values. The median values are indicated by the horizontal bars in the shaded boxes representing the 1st and 3rd quartiles. The whiskers extending above and below the boxes are the 95% upper and lower confidence limits, respectively.

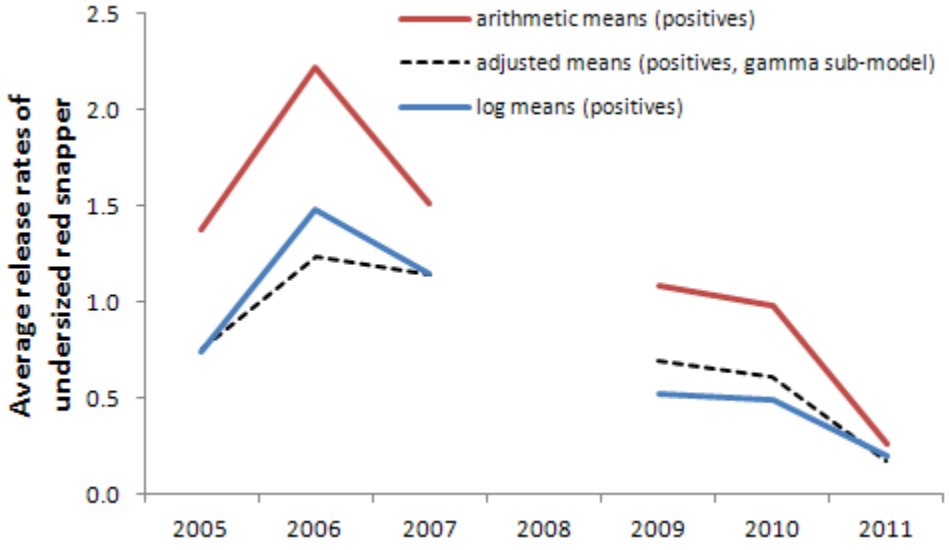


Figure 5.4.3.7. Unscaled arithmetic (positives), log-transformed (positives), and adjusted (gamma sub-model only) means for the combined regions.

6 Ad-Hoc Discard Mortality Rate Working Group

6.1 Group Membership

Matthew Campbell (Leader)	NMFS
Beverly Sauls	FL FWC
William Driggers	NMFS
Barbara Dorf	TPWD

6.2 Background

Red snapper have been utilized as a fishery resource in the Gulf of Mexico (GOM) for over a century and are considered to be one of the most economically important fisheries in the region (Strelcheck and Hood 2007). The first regulations managing the fishery were put in place in 1984 in response to the overfished status of the stock (see Hood et al. 2007 and GMFMC 2012 for a comprehensive management history). In general, both commercial and recreational regulations have focused on reducing total catch by implementing annual time closures, which in turn generates regulatory discards in the off season. Additionally, resource managers implemented minimum size regulations that increased the number regulatory discards. In both cases the fact that regulatory discards are a byproduct necessitates tracking the rate at which fish are discarded, as well as eventual fate following release.

The intent behind catch-and-release (CAR) regulations is to reduce fishing mortality for immature age groups of fish, allow those age groups to grow and mature to reproductive ages, and help preserve age structure in a population. Despite the intent of CAR fishing regulations, for many species stress of capture leads to increased frequency of barotraumas and reduced reflex responses, the synergistic effects of which often results in increased release mortality and renders those regulations ineffective (Davis 2007, Campbell et al. 2010a). Stressors experienced by fishes during CAR fishing can include hook trauma, physical overexertion, barotrauma, rapid thermal change, air exposure, and physical handling (Davis et al. 2001, Rummer and Bennett 2005, Nieland 2007, Jarvis and Lowe 2008). These CAR fishing stressors can also translate into long-term, sub-lethal, negative consequences for individuals and potentially for populations, such as reduced growth and fecundity (Woodley and Peterson 2003, Ryer et al. 2004, Davis 2007). The effects of CAR fishing can be particularly problematic for marine species such as red snapper (*Lutjanus campechanus*) that inhabit relatively deep water and possess a physoclistous gas bladder.

Reported percent discard mortality in the red snapper fishery ranges from 0 to 100% (SEDAR7 2005, Campbell et al. 2012) depending on fishery sector (e.g. recreational and commercial), gear types deployed, capture depth, water temperature, exposure to thermoclines, handling time, and air exposure (Table 6.1, Figure 6.1). Due to the wide range in reported mortality rates and the convoluted nature of interacting factors, a comprehensive evaluation of pertinent research is needed. The focus of the report is to review the status of our knowledge regarding discard mortality in the red snapper fishery with the intent of identifying critical unresolved issues.

The bulk of the currently available research has been focused on the recreational sector which most of this report will reference. Recently, discard observers have been placed on board commercial vessels in part to estimate release mortality for that sector, and to which a section of this report is dedicated.

6.3 Methods of Estimation

6.3.1 Surface Observations

The most common mortality estimation method is surface observation of release activity. Estimates derived using this method are among the most conservative, show high variation among surveys, and report considerable regional differences (Table 6.1, Figures 6.1, 6.2 and 6.3). Surface observation experiments have used two categorization systems. Type-1 surface observation methods classify release activity into four categories: (1) swam down, (2) erratic swimming at the surface with eventual submersion, (3) erratic swimming at the surface without submersion, and (4) floating (Patterson 2001). Type-2 surface release observation methods use slightly different categories: (1) swam down, (2) erratic swimming, (3) floating, and (4) dead (Dorf 2003, Campbell 2010a). While these two systems track erratic swimmers slightly differently, both of these methods consider erratic swimming fish to be mortalities regardless if the erratic swimming fish submerged. The main difference between these two particular studies is that the Patterson (2001) study vented 100% of the fish, while Dorf (2003) the deckhands handling the fish vented only 40% of the fish.

High variation reported among surface observation surveys could be attributable to season, depth, region, or venting practices (Table 6.1, Figures 6.1, 6.2 and 6.3). Dorf (2003) reported the highest release mortality estimates among surface observation studies however data was collected exclusively during the summer on fishery dependent surveys, station depth ranged from 10-95 m, and only 37.2% of the fish were vented. Patterson et al. (2001) reported lower estimates from data collected quarterly on scientific research cruises, station depth ranged from 21 – 30 m, and 100% of the fish were vented. The pattern of higher estimates reported from western GOM data appear to be related to venting methodology or rate rather than true regional differences in red snapper stocks (Figures 6.1 and 6.2). The Dorf (2003) study might better reflect the reality at that time in the fishery as it measures compliance to venting as a practice, conversely a scientific study that carefully vents 100% of the fish might not reflect what is actually happening day to day in the fishery. Currently there is no information regarding the frequency of venting either in the recreational or commercial red snapper fishery, and secondarily we have no idea of how that may have changed over time and across regions.

Surface observations are useful due to low operational costs, minimal equipment requirements, and the ease with which large sample sizes can be generated. Limitations of the method center on its observational nature. For instance, unsuccessful submergence is only a proxy of mortality, release behavior is subjective, observations are immediate (<1 minute), and subsurface observations are rare. Surface observations also ignore issues associated with CAR fishing such as hooking injuries, thermal stress, and barotrauma that could result in mortality over hours to days (Campbell et al. 2010a). In spite of the stated limitations, surface release activity data

should always be collected during surveys. If the method is used to formulate release mortality estimates then clarification is needed in regards to classifying erratically swimming fish, and tag-and-recapture methods should be utilized to evaluate misclassification rates from each unique release activity group.

6.3.2 Cage studies

Cage studies were the first to address delayed mortality, and where comparisons are possible, generally result in higher release mortality estimates within a given depth group (Table 6.1). Like surface observations, this group of studies tends to show a lot of variability about the associated mortality estimates, most of which appears to be related to study specific issues. It should be noted that all of the aforementioned cage studies were performed in Texas and/or Louisiana with cages suspended from oil production platforms, therefore regional differences (east versus west) cannot be discerned and effects of day to day activities on oil platforms may be of concern (e.g. release of drilling muds or petro-chemicals near captive fish).

The first cage study was performed by Parker (1985), unfortunately this frequently cited paper was an internal report that the authors have been unable to obtain, and the two estimates were derived from samples of 14 and 44 fish (Table 6.1). Render and Wilson (1994) reported 20% release mortality from their cage, which is the second highest mortality reported from the < 20 m depth group, and from which the only higher estimate was Dorf (2003) who used the least conservative surface release methodology (type-2). Diamond and Campbell (2009) generated mortality estimates from a cage study that in their associated depth groups, and among all studies combined, are among the highest reported (Table 6.1, Figure 6.1). The Diamond and Campbell (2009) study was confounded by three important factors including high surface water temperatures during summer sampling (~ 32.2 - 33.3 C), fish were placed in cages at the surface for extended periods before descent (waiting for scuba diving intervals to expire), and fish included in the experiment had blood drawn from them which could have influenced mortality rates. While cage studies show high mortality estimates, sample size and methodology appear to cloud the overall picture coming from these sources.

The primary advantage of a cage study is the ability to track survival over extended periods, which gives insight into the long term effects of CAR trauma that the immediate observational estimates cannot produce. Cage studies are biased because they exclude predatory interactions, prevent foraging, can cause additional injury (e.g. abrasions), and disrupt normal behaviors, all of which interact in unknown ways relative to the fate of the released fish. Cage studies are useful in shedding light on the delayed mortality question, but they do not replicate post-release conditions occurring in the fishery about which mortality estimates need to be most reflective.

6.3.3 Hyperbaric Chamber Simulations

Hyperbaric chambers have been used to simulate the effect of depth and temperature to evaluate CAR fishing stress and estimate mortality associated with those stressors (Rummer and Bennett 2005, Burns et al. 2004, Campbell et al. 2010b). Rummer and Bennett (2005) euthanized all fish following barotrauma simulation so that necropsies could be performed and therefore report no mortality estimate. Campbell et al. (2010b) reported no mortality but had two issues that likely

influenced this result, including short acclimation periods in chambers and simulation water temperatures reflected winter/spring conditions. Burns et al. (2004) report mortality estimates, but do not report sample sizes, nor do they report simulation water temperatures. Both Burns et al. (2004) and Campbell et al. (2010b) treated fish for ectoparasites, culled sick fish from the experiments, frequently report no mortalities, and during summer months fish experienced high mortalities during collection and therefore summer collecting was discontinued. Unnatural conditions experienced by fish during chamber experiments, culling of unhealthy fish, and extremely low reported mortalities likely preclude the use of resultant estimates in evaluating release mortality rates of red snapper.

6.3.4 Passive and acoustic tagging

The primary advantage of both acoustic and passive tag-and-recapture studies is that they can produce both immediate and delayed mortality estimates. Recaptured fish can also be used to evaluate the accuracy of surface activity proxies of mortality used in surface observation studies. Tag and recapture studies are also beneficial because they collect additional data on movement, growth, behavior and habitat preferences.

Diamond et al. (2011) utilized acoustic tagging methodology and estimated some of the highest release mortality estimates reported (winter - 40%, and summer - 79%). Furthermore, Diamond reported a strong seasonal component, in which there was low survival in summer and higher survival in winter. However, this study derived mortality estimates from a low sample size (~ 40 total fish), and required surgery to implant tags which could have biased the results. Acoustic tagging requires that the researcher tracks fish using a hydrophone, or that hydrophones are set up in a pre-defined area to evaluate fish activity. Similar to issues with surface observation methods, eventual fate of a subject cannot be assumed once a fish has moved beyond detection, and this particular nuance is especially problematic at low sample sizes.

Passive tagging studies that are dependent upon participants in commercial and recreational fisheries for recapture reports are sensitive to the spatial and temporal distributions of effort in a fishery, and such effects must be accounted for in models that estimate mortality. Passive tagging surveys also have larger initial sample sizes than acoustic tag studies, but frequently suffer from low recapture rates. Three passive tagging studies were available for examination, and all were conducted in the eastern Gulf of Mexico. Patterson et al. (2001) and Patterson and Addis (unpublished data) derived mortality estimates from surface release observations which were covered in an earlier section. The third study estimated the proportion of tagged fish that suffered mortality after initial capture and release through the use of a composite score to compare recapture rates between groups of red snapper released under optimum conditions, versus red snapper exposed to one or more impairments. Methods for this study are detailed in a working paper submitted for this data workshop (Sauls 2012). Estimates of release mortality from these three studies ranged from 10% to 30%, and increased with increasing depth and temperature. In the future, it might be useful to combine data from multiple studies and reassess older tagging information when an acceptable model is developed.

6.4 Depth Effect

Regardless of study methodology or region, a consistent trend among mortality data is a positive correlation between depth and mortality (Table 6.1, Figure 6.1). The eastern GOM estimates showed a linear response from 20 to 40 m (Figure 6.2), and the western GOM estimates showed a steeper linear increase and estimate higher mortality through 40 m after which the response asymptotes (Figure 6.3). The linear relationship that is evident in both the eastern and western GOM from 20 to 40 m indicates the effect of capture depth on released fish appears to function similarly regardless of region. Furthermore the deep water (> 40 m) estimates from the western GOM data are strongly influenced by the less conservative type-2 surface observation methodology in which only 40% of fish were vented, as well as several studies that used methods that might artificially inflate mortality rates.
Extreme estimates in the western GOM come from a cage study and an acoustic tagging study (Diamond and Campbell 2009, Diamond et al. 2011). Diamond and Campbell (2009) report a significant depth effect but had compounding issues associated with the effects of high surface water temperatures and extreme handling situations as discussed earlier. The Diamond et al. (2011) acoustic tagging study showed high mortality rates from deep water, but reported difficulty in having enough fish survive in the summer to conduct the experiment and derived mortality estimates from a small sample size (n ~ 40). If these two experiments are treated as outliers, the functional form appears to strengthen because there is variation about estimates from those particular depths (i.e. the relationship tightens). High surface release estimates from deep water arise from the Dorf study of headboat discards, and as has been pointed out, only 40% of those fish were vented. Extreme estimates in the eastern GOM at 45 and 65 m are associated with the Burns et al. (2004) hyperbaric study, of which there is no published information about the simulated water temperatures during the experiment or sample sizes used to calculate the estimates. It should be noted that these are the only two mortality estimates for fish captured in relatively deep water (>40 m) from the eastern GOM.

The relationship between depth and mortality is most likely associated with injuries sustained during decompression, including gas bladder overexpansion/rupture, esophageal eversion, cloacal prolapse, exophthalmia, and gas infusion into vital organs (Rummer and Bennett 2005, Hannah 2008). Barotrauma injuries do not necessarily result in death, particularly as measured by surface release observation (immediate); however, data from studies estimating delayed mortality would suggest the opposite (Diamond and Campbell 2009, Diamond et al. 2011). In lieu of finding ways to reduce release frequency in the fishery several techniques have been explored to potentially reduce the negative impacts of capture so that release survival improves, including venting and bottom release devices.

6.5 Thermal stress

Mortality shows a strong relationship to season with lowest estimates from winter, intermediate in fall and spring, and highest in summer (Table 6.1, Figure 6.4 and 6.5). There appears to be a strong regional effect with western GOM estimates approximately double the estimates from the east in an equivalent season; however, these regional components are in part due to the differences between type-1 and type-2 surface release observation methods. If season is a proxy

for water temperature, the data then suggest a positive linear relationship between water temperature and mortality, particularly from eastern GOM estimates. Western GOM estimates show a similar decrease in mortality from summer to fall, but unfortunately there is a paucity of data collected during the spring and winter. As such, there may be a linear relationship, but currently there is not enough data collected on a quarterly basis (i.e. encompassing all seasons).

Sub-lethal types of responses show similar relationships with water temperature. Impairment in red snapper, as measured by an index score of barotrauma and reflex responses, increased with increasing water temperature (Diamond and Campbell 2009, Campbell et al. 2010a, Campbell et al. 2010b). Furthermore, impairment in at least two of those studies was linked to increased immediate release mortality as measured by release activity proxies of mortality (type-1 surface observation methods). Additionally, tagging data has shown lowest returns from fish tagged during summer and highest from fish tagged during the winter (Sauls 2012, Diamond et al. 2011). Finally, two separate hyperbaric chamber experiments reported inability to keep fish alive that were collected during the summer and had to postpone trips later in the year for cooler weather (Burns 2004, Campbell 2010a). Most investigations have well-defined depth treatments but have vaguely defined seasonal classifications, while some report months, and only one reported specific water temperatures and thermocline strength. The amount of attention paid to thermal stress is disappointing given that season appears to be a strong indicator of eventual fate, temperature is easily measured in the field, and temperature is easily controlled in a laboratory.

6.6 Hook Type Effects

As catch-and-release studies have become available, new management focus has been placed on gear requirements intended to minimize release mortality. The realized benefits of such gear requirements are also dependent on the methods of execution and the degree of compliance within the fishery (Sauls and Ayala 2012). In 2008, the GMFMC adopted the preferred management alternative in Amendment 27 to the Reef Fish Fishery Management Plan, which required recreational anglers fishing in federal waters to use non–stainless steel circle hooks when catching reef fishes with natural bait (50 CFR 622.41). A circle hook was defined by regulation as "a fishing hook designed and manufactured so that the point is turned perpendicularly back to the shank to form a generally circular, or oval, shape." A minimum hook size to potentially reduce by-catch of undersized red snapper was also considered as an alternative management option but was not adopted. Florida matched federal regulations for state territorial seas in the Gulf of Mexico, with the added specification that a circle hook must have 0° of offset (Florida Administrative Code §68B-14.005). Louisiana matched federal regulations in state waters, Texas requires circle hooks when fishing for red snapper with recreational gear, and Alabama and Mississippi do not require circle hooks in state waters (Wilson and Diaz, 2012).

At the time when regulations were being considered in the Gulf of Mexico, studies to evaluate the potential benefits of circle hook use for reef fishes were limited, but was supported by a comprehensive meta-analysis, which reviewed 43 studies for 25 species (including freshwater and non-reef fish marine species) and concluded that mortality rates were reduced by approximately 50% overall when circle hooks are used compared with J hooks (Cooke and Suski

2004). Circle hooks had a greater tendency to set in the lip or jaw, resulting in fewer internal injuries for the majority of species studied. Two studies have been published since 2008 on the effectiveness of circle hooks specifically for reducing red snapper release mortalities. Sauls and Ayala (2012) observed red snapper caught with circle hooks and J hooks within the recreational fishery and reported a significant 63.5% reduction in potentially lethal hooking injuries for red snapper caught with circle hooks (6.3% potentially lethal injuries, versus 17.1% with J hooks). In contrast, Burns and Froeschke (2012) implied that survival of red snapper was reduced by circle hooks, citing significantly lower tag return rates for red snapper caught with circle hooks (8.1%) compared to J hooks (12.5%). However, the authors did not account for potential differences in tag reporting rates between study areas in the eastern Gulf of Mexico where the majority of fish tagged were originally captured with circle hooks, and the South Atlantic, where more fish were captured with J hooks. Tag reporting rates could potentially vary significantly between these two regions due to varied degrees of fishing effort and different regulations for harvest seasons, size limits and bag limits. Therefore, it is unclear whether the difference in tag return rates was due to varied probabilities for recapture among regions.

6.7 Venting and Bottom Release Devices

As of 2008, venting is required in the Gulf of Mexico red snapper fishery. Venting has been advocated as a conservation approach that may alleviate some of the negative consequences associated with barotrauma; however, a metadata analysis on the efficacy of venting in promoting survival suggests the effect is negligible (Wilde 2009). For red snapper studies specifically analyzed in Wilde (2009), there are mixed results one having shown positive effects of venting on survival (Gitschlag and Renaud 1994), two are neutral (Render and Wilson 1994, Render and Wilson 1994, and one negative (Burns 2004). Results of surface release observation studies show that venting clearly enhances submergence capability (Patterson 2001, Dorf 2003); however, those studies estimate immediate release mortality as a proxy about which the error in classification is largely unknown (i.e. many fish who submerge succumb to trauma after submergence). Given mixed results across a variety of experiment types, the committee recommends no changes in regards to venting regulations particularly in light of the fact that venting at least enhances the released fishes ability to submerge and return to protective habitat. More research on the topic is needed, with emphasis on the effects of capture depth, water temperature during the survey, and the interaction between those variables.

Recent efforts have focused less on venting and more on bottom-release devices, two of which have been experimentally tested. The concept of using bottom release devices is similar to venting in that the intent is to reverse the effects of swim bladder expansion, but instead of deflating the bladder by puncture it is deflated by recompression at depth. Diamond et al. (2011) tested a Shelton Fish Descender™ (SFD) which operates off of a standard reel, and is composed of a reverse barbless hook attached in line with a weight below the hook (details of the device can be found online). Tag returns in the experiment showed nearly identical frequency of recapture between surface-released fish (vented) and those released at depth using the SFD, suggesting that bottom release does not improve survival over conventional venting methods. Stunz and Curtis (2012) have been testing a Boga-Grip™ device that releases fish at a preset depth via a pressure sensitive clamp (details of the device can be found online). Results are

showing that fish released using the Boga-Grip device are more likely to survive than those which were vented and released at the surface. At this point it is difficult to discern why these two experiments showed opposing trends, thus more experimentation is needed and no recommendation is given at this time in regards to bottom release devices.

6.8 Commercial Sector Release Mortality

A previous report on commercial vertical line (bandit gear) release mortality showed that mortality increased with increasing capture depth and reported 64% of those released fish died (Nieland et al. 2007). Commercial fishermen participating in the group discussion during SEDAR 31 expressed concern that these old rates were reflective of the derby style fishing that took place in the past and not necessarily reflective of the current fishery, which appears to be supported by recently gathered fishery observer data.

Gulf of Mexico commercial reef fish fishery observers reported discard survival data were used to model instantaneous (at the vessel) discard mortality on vertical line and bottom longline trips. Vertical line gear included handline and electric/hydraulic reel (bandit rig) gear. Mortality associated with commercial vertical line gear was modeled separately from discard mortality associated with bottom longline gear.

Fishery observer data have been collected from the Gulf of Mexico reef fish fishery since July, 2006. Data include fishing location, gear fished, depth of water, species caught, and the disposition (kept, discarded dead, discarded alive, kept for bait, unknown) of each fish. Only records with discarded fish of the 15 most frequently observed species, by gear and including red snapper, were retained in the analyses. The proportion of live discards was modeled using generalized linear models (GLM; GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA). For each GLM analysis, a type-3 model was fit, a binomial error distribution was assumed, and the logit-link was selected. The response variable was proportion of live discards. Factors in the model included species, region (Gulf of Mexico west of the Mississippi River; southeast Gulf = statistical areas 1-7; and northeast Gulf = statistical areas 8-12); and depth (modeled as a continuous variable).

Proportions of live discards from bottom longline vessels are provided in Figure 6.6. Approximately 71% of red snapper were reported as discarded alive. In the vertical line fishery, 77% of red snapper were reported as discarded alive (Figure 6.7). For both gears, survival of red snapper was intermediate across the range of instantaneous (at release) survival calculated for the 15 most frequently observed species.

During working group discussions there was some confusion about what is actually being measured: immediate mortality as the fish are pulled on to the vessel versus mortality once a fish is released. Commercial fishers from both the eastern and western Gulf of Mexico and from the vertical line and bottom longline fisheries were unanimous in their opinion that immediate survival estimates of red snapper as they come on to the vessel were too low. Discussion with reef fish observer program personnel revealed that discard survival had often not been determined until the fish had been measured, and in some cases the fish were kept in baskets for

significant periods of time until they were measured. The working group was concerned that such delays in discarding fish may have resulted in additional mortality that might not otherwise have occurred during normal commercial fishing operations. In other words, the estimate developed from observer data should be made directly from observations about which fishing crew exclusively handled released fish and under normal commercial fishing operations. Furthermore the estimate needs to be reflective of survival upon release not on how many fish come aboard the vessel alive.

6.9 Developing a Functional Response

At the request of the assessment group, the release mortality group investigated methods to develop a functional response that would use a meta-data approach that incorporates all of these data sets. Regardless of study methodology or region, a consistent trend among mortality data is a positive correlation between depth and mortality (Table 6.1, Figure 6.1). To test this we performed a linear regression testing the effect of depth on mortality. When including all of the data points, there is a significant relationship ($p<0.001$); however, the fit was poor ($r^2 = 0.276$). Taking the log of depth then testing for a linear relationship showed significant slope and the fit was improved ($r^2 = 0.309$). Further analysis of the SAS fit diagnostics, such as leverage tests and Cook's D, identified outliers in the data. The outliers identified were associated with estimates associated with the Diamond and Campbell cage study (highest in depth group), the summer estimate from the Diamond acoustic study (highest in depth group), Burns hyperbaric chamber studies (0 mortality in 3 of 4 groups), and from estimates derived from winter sampling (lowest estimates in respective depth groups). These same studies were also identified in group discussion as having unusual responses relative to other studies, the issues of which are discussed in those sections. Removal of those outliers, followed by testing for a linear relationship between log transformed depth and mortality, resulted in a significant relationship ($F=36.21$, $p<0.001$), improved fit ($r^2 = 0.475$), and resulted in the following relationship $y = 28.789 * \ln(depth) - 79.654$ (Figures 6.8 and 6.9). Another approach to this process would be to weight each respective estimate from each study by sample size or by variance; unfortunately many of the studies don't report depth specific sample sizes for each estimate reported, so at the time of this report that approach could not be performed. Other suggested models include: 1) meta-analysis general linear mixed effects model, 2) generalized least squares model, and 3) full information maximum likelihood model. Those particular models are in the process of being implemented but were not ready in time for inclusion in the data workshop report.

6.10 Comments and Recommendations

Recreational

Regional differences identified in previous reports and in this report were shown to be more truly related to methodology rather than region (e.g. type-2 surface release methodology, Diamond and Campbell cage study). Low estimates from surface release mortality studies are often associated with studies that vented 100% of the fish, whereas the highest estimates are from studies that evaluated discards aboard headboats that inconsistently vented fish. Low estimates of release mortality from surface observation studies may or may not be representative of what

actually took place in the fishery, and high estimates directly measured from the fishery in which venting was an inconsistent practice are likely more representative of reality. However, at this point there is no way to distinguish the rate at which vessels were venting, how that practice has changed through time, nor how best to apply that in the assessment model. In lieu of using separate point estimates for the east and west regions (as has been done in the past), it is recommended that the assessment uses the depth-mortality relationship developed in section 6.8 regardless of region and that produces confidence intervals about those depth specific estimates.

Commercial

The working group recommends that discard mortality should not be calculated using the commercial reef fish observer data. Due to the small number of studies pertaining to commercial fishing release mortality rates, it is advised that either historical rates are applied in the model or that the depth related release mortality model, developed from recreational data, is applied to the commercial fishery. Furthermore, changes in how the fishery has been prosecuted need to be accounted for.

Circle hooks

There is sufficient evidence in the literature, and in red snapper specific literature, that leads us to the conclusion that circle hooks significantly reduce the frequency of gut hooking and lead to improved survival at release.

Venting and bottom release devices

Literature gathered on the topic show mixed results relative to survival. More research is needed on the efficacy of venting, with emphasis on the effects of capture depth, water temperature during the survey, and the interaction between those variables. Secondarily, information about how often venting is used in the recreational fishery would be very beneficial. At this point there have been only two experiments involving bottom release devices, and they showed opposite trends. More experimentation is needed and no recommendation is given at this time in regards to bottom release devices.

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6.12 Tables

Table 6.1. List of studies conducted in the Gulf of Mexico reporting release mortality estimates by 5 meter depth groups.

Depth range (m)	Season	Release Mortality	*N*	Method	Study	Region
< 20	None*	0.00	-	Hyperbaric	Burns et al. (2004) MARFIN	Panama City, FL
21-25	None	21.00	14	Cage+SCUBA	Parker (1985, unpublished)	Daytona, FL
	Quarterly †	20.00	282	Cage	Render and Wilson (1994)	Louisiana
	Fall	1.00	140	Surf obs	Gitschlag and Renaud (1994)	Galveston, TX
	Quarterly †	9.00	2932	Surf obs	Patterson et al. (2001)	AL coast
	None*	0.00	-	Hyperbaric	Burns et al. (2004) MARFIN	Panama City, FL
	Summer	41.00	3851	Surf obs	Dorf (2003)	Texas ports
26-30	none	11.00	44	Cage+SCUBA	Parker (1985, unpublished)	Galveston, TX
	Fall	10.00	31	Surf obs	Gitschlag and Renaud (1994)	Galveston, TX
	Quarterly †	14.00	2932	Surf obs	Patterson et al. (2001)	AL coast
	None*	0.00	-	Hyperbaric	Burns et al. (2004) MARFIN	Panama City, FL
	Summer and fall †	53.00	115	Cage	Diamond and Campbell (2009)	Port Aransas, TX
	Summer	47.00	3851	Surf obs	Dorf (2003)	Texas ports
	Summer and fall †	27.00	137	Surf obs	Campbell et al. (2010a)	Corpus Christi, TX
	Winter	3.00	138	Surf obs	Patterson (personal comm.)[φ]	Pensacola, FL
	Spring	6.40	31	Surf obs	Patterson (personal comm.)[φ]	Pensacola, FL
	Summer	7.00	52	Surf obs	Patterson (personal comm.) [φ]	Pensacola, FL
	Fall	12.00	221	Surf obs	Patterson (personal comm.)[φ]	Pensacola, FL
31-35	Quarterly †	18.00	2932	Surf obs	Patterson et al. (2001)	AL Coast
	Summer	15.00	3851	Surf obs	Dorf (2003)	Texas ports
	Winter	4.00	375	Surf obs	Patterson (personal comm.) [φ]	Pensacola, FL
	Spring	10.00	196	Surf obs	Patterson (personal comm.) [φ]	Pensacola, FL
	Summer	13.00	264	Surf obs	Patterson (personal comm.) [φ]	Pensacola, FL
	Fall	17.00	563	Surf obs	Patterson (personal comm.) [φ]	Pensacola, FL
						Page 1 of 2

36-40	Fall	44.00	61	Surf obs	Gitschlag and Renaud (1994)	Galveston, TX
	Summer	40.00	3851	Surf obs	Dorf (2003)	Texas ports
	Winter	5.00	65	Surf obs	Patterson (personal comm.)[φ]	Pensacola, FL
	Spring	16.00	107	Surf obs	Patterson (personal comm.)[φ]	Pensacola, FL
	Summer	16.00	44	Surf obs	Patterson (personal comm.)[φ]	Pensacola, FL
	Fall	20.00	60	Surf obs	Patterson (personal comm.)[φ]	Pensacola, FL
41-45	None*	40.00	-	Hyperbaric	Burns et al. (2004) MARFIN	Panama City, FL
	Summer and fall †	71.00	97	Cage	Diamond and Campbell (2009)	Port Aransas, TX
	Summer	63.00	3851	Surf obs	Dorf (2003)	Texas ports
46-50	Fall	36.00	55	Cage	Gitschlag and Renaud (1994)	Galveston, TX
	Summer and fall †	69.00	110	Cage	Diamond and Campbell (2009)	Port Aransas, TX
	Summer	61.00	3851	Surf obs	Dorf (2003)	Texas ports
	Summer	79.00	24	Acoustic tags	Diamond et al. (2011) MARFIN	Corpus Christi, TX
	Winter	40.00	20	Acoustic tags	Diamond et al. (2011) MARFIN	Corpus Christi, TX
51-55	Summer	58.00	3851	Surf obs	Dorf (2003)	Texas ports
56-60	None*	45.00	-	Hyperbaric	Burns et al. (2004) MARFIN	Panama City, FL
	Summer	38.00	3851	Surf obs	Dorf (2003)	Texas ports
	Summer and fall †	27.00	282	Surf obs	Campbell et al. (2010a)	Corpus Christi, TX
61-65	Summer	37.00	3851	Surf obs	Dorf (2003)	Texas ports
66-70	Summer	33.00	3851	Surf obs	Dorf (2003)	Texas ports
71-75	Summer	23.00	3851	Surf obs	Dorf (2003)	Texas ports
76-80	Summer	47.00	3851	Surf obs	Dorf (2003)	Texas ports
>81	Summer	56.00	3851	Surf obs	Dorf (2003)	Texas ports

* No temperatures reported for experiment, however fish could only be collected during cold months

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† indicates an experiment that sampled in more than one season but only produces a single estimate

[φ] Estimate calculated from data published in Addis and Patterson (2007).

6.13 Figures

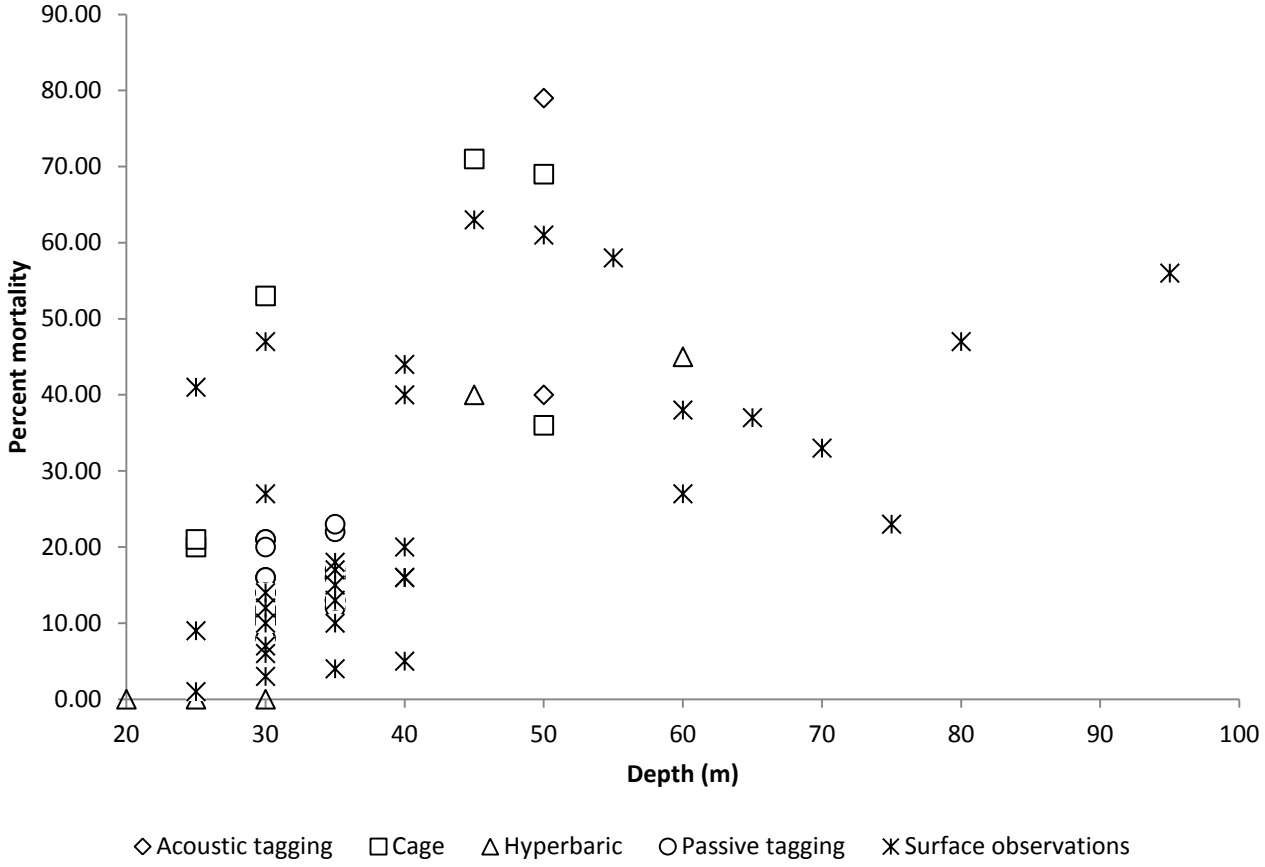


Fig 6.1. Plot of the relationship between study depth and estimated percent release mortality with individual study types identified (acoustic tagging = diamond, cage studies = square, hyperbaric chamber simulation = triangle, passive tag-recapture = circle, and surface observation = asterisk).

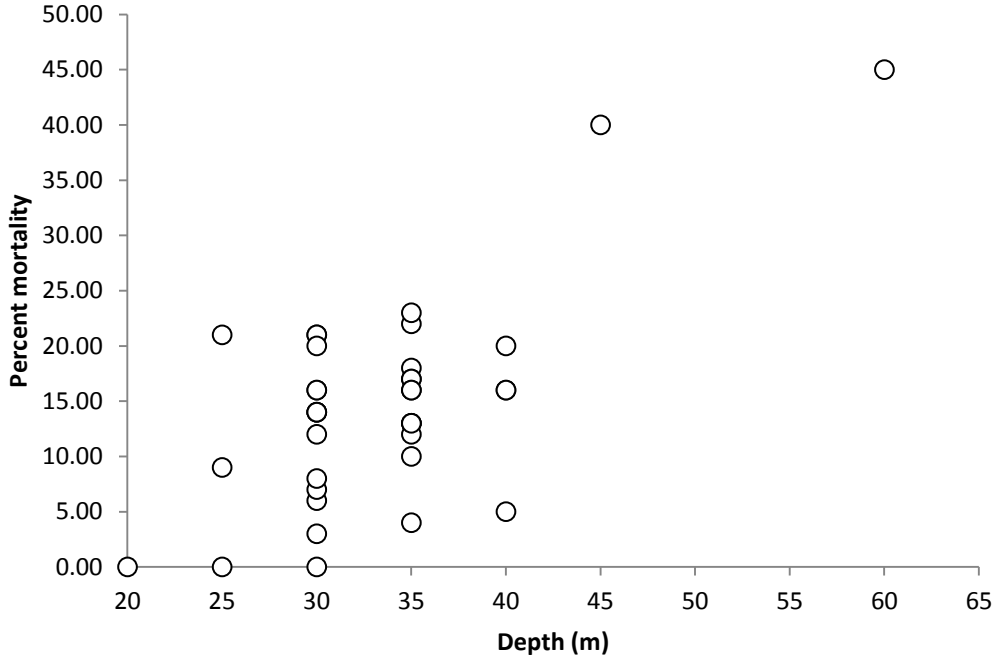


Fig 6.2. Eastern GOM release mortality estimates all methods, all seasons.

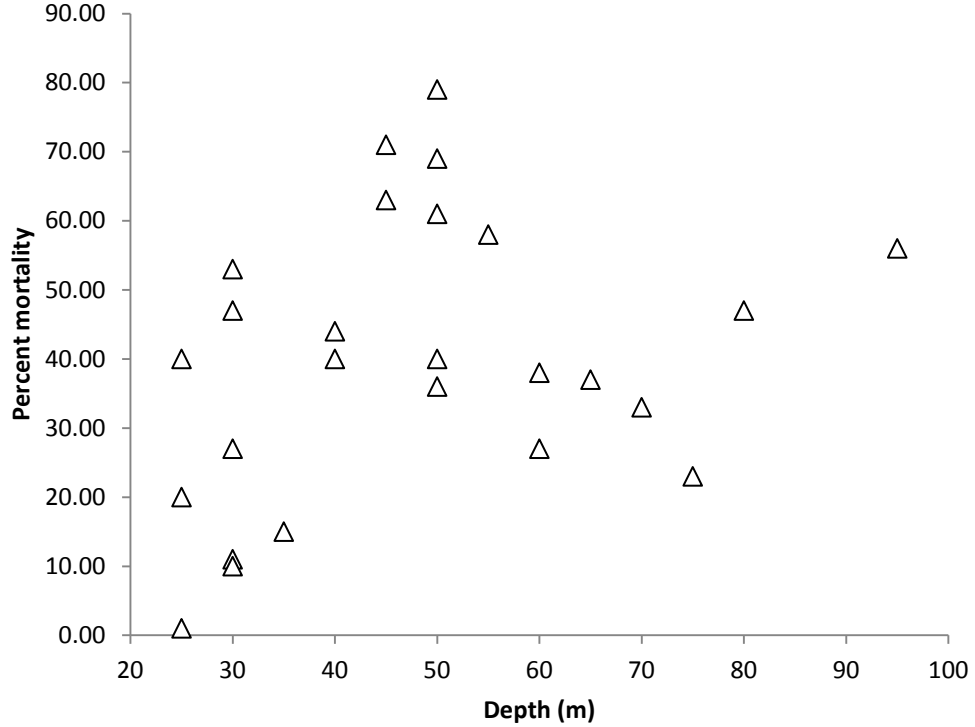


Fig 6.3. Western GOM release mortality estimates all methods, all seasons.

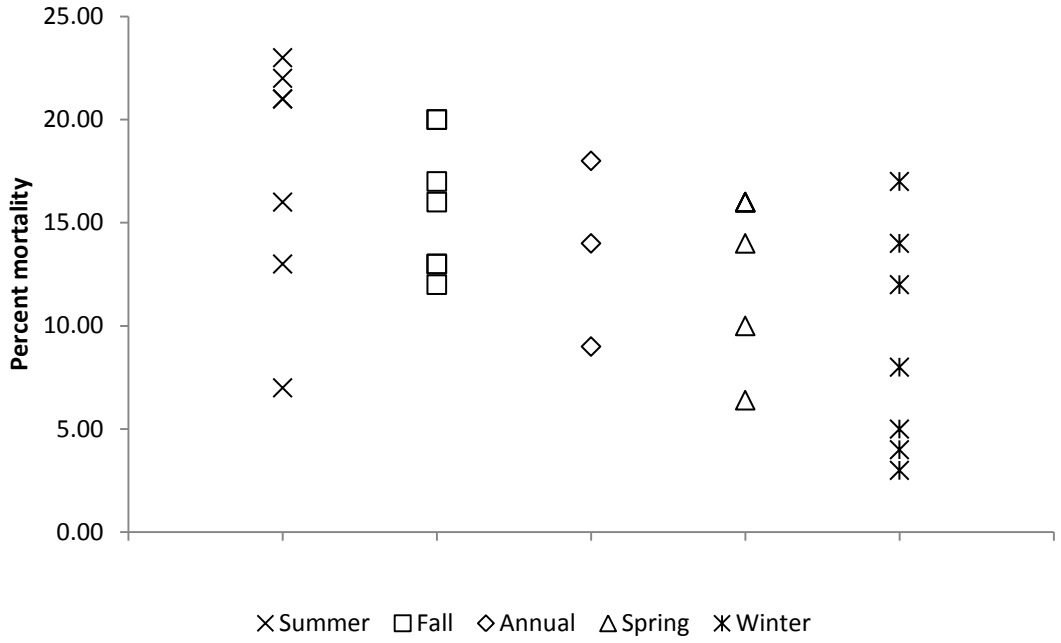


Figure 6.4. Eastern GOM percent release mortality by sampling season.

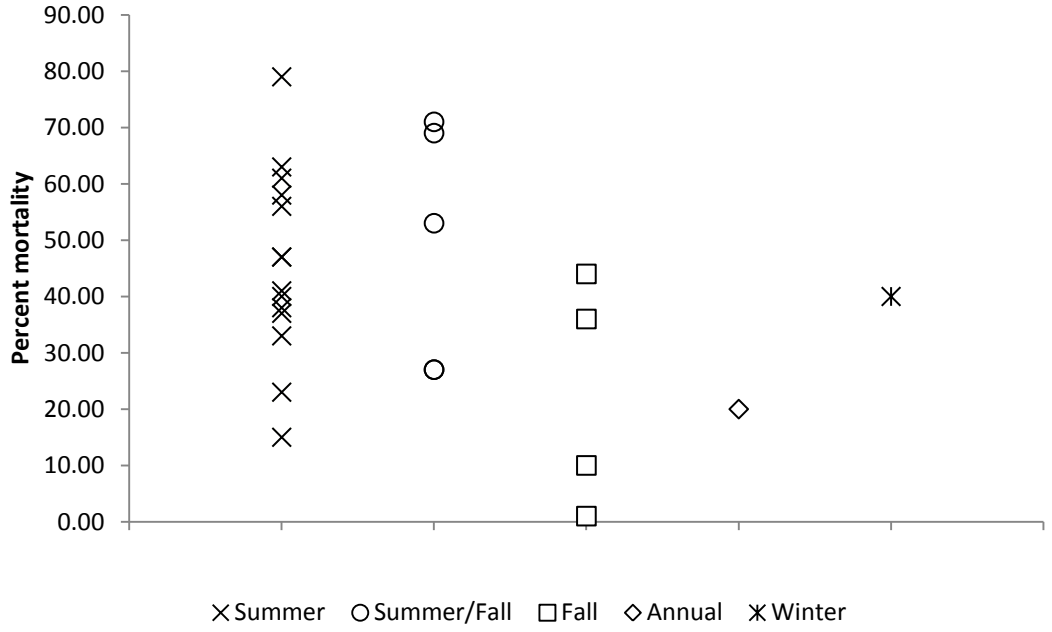


Figure 6.5. Western GOM percent release mortality by sampling season.

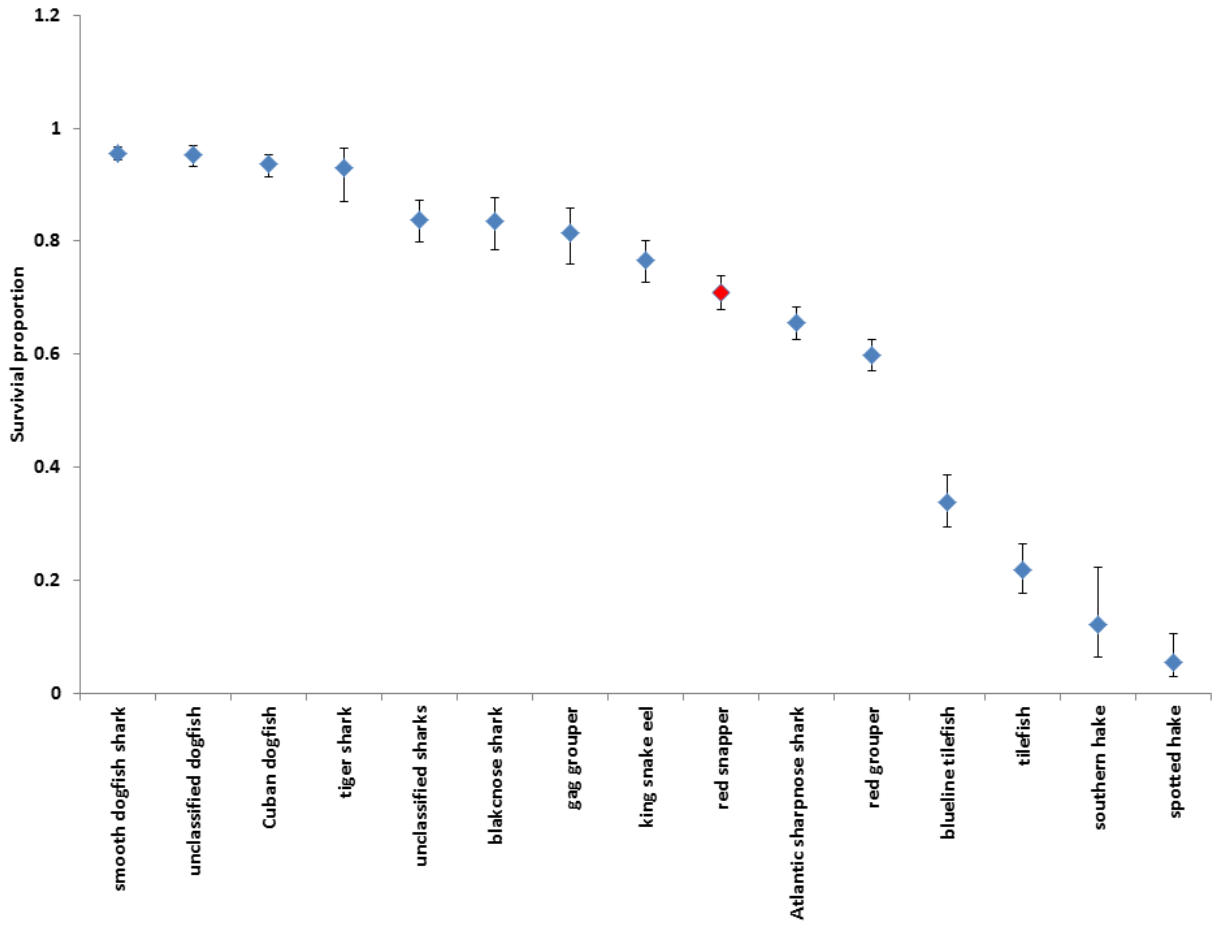


Figure 6.6. Discard mortality of the 15 most frequently observed species or species groups in the Gulf of Mexico commercial longline fishery. Error bars are 95% confidence intervals.

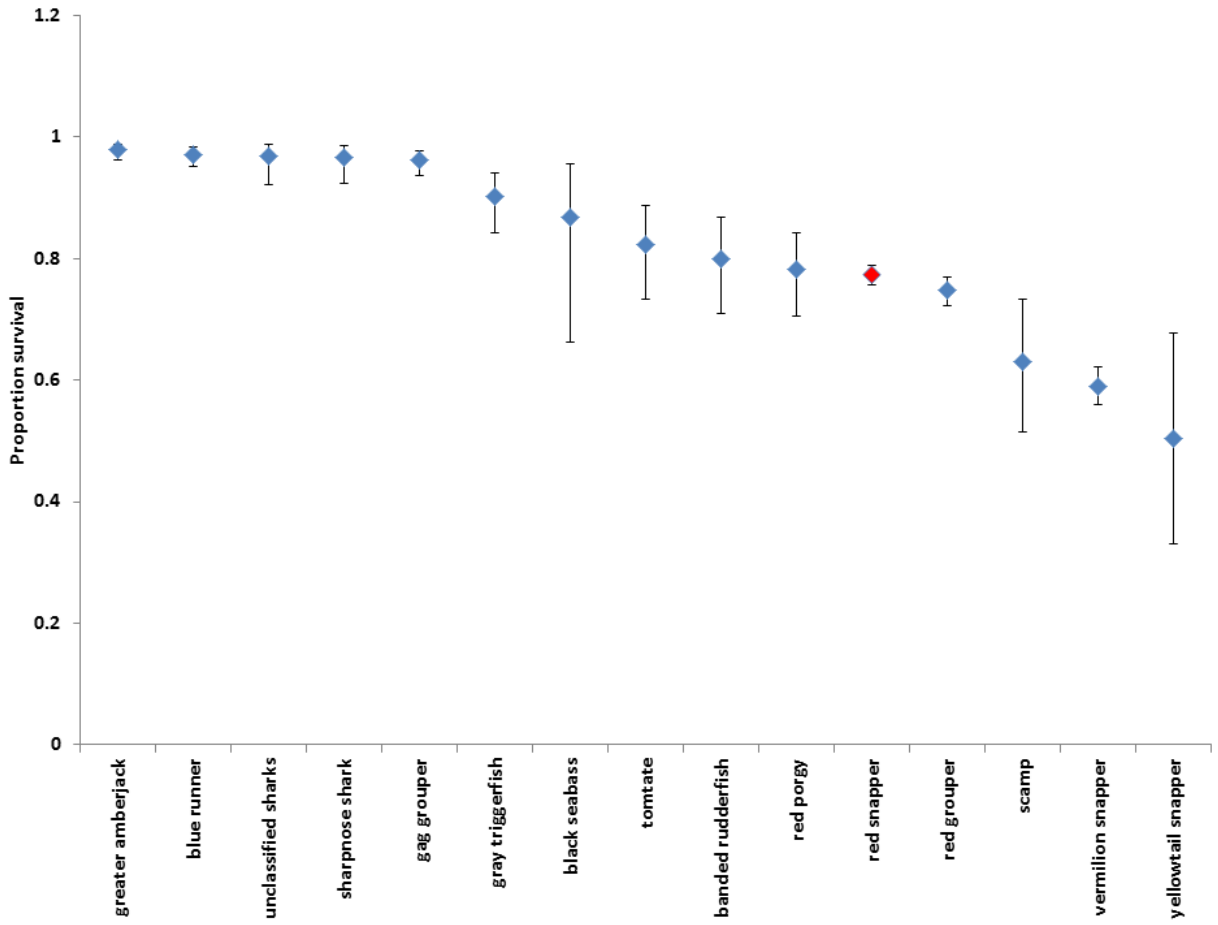


Figure 6.7. Discard mortality of the 15 most frequently observed species or species groups in the Gulf of Mexico commercial vertical line fishery. Error bars are 95% confidence intervals.

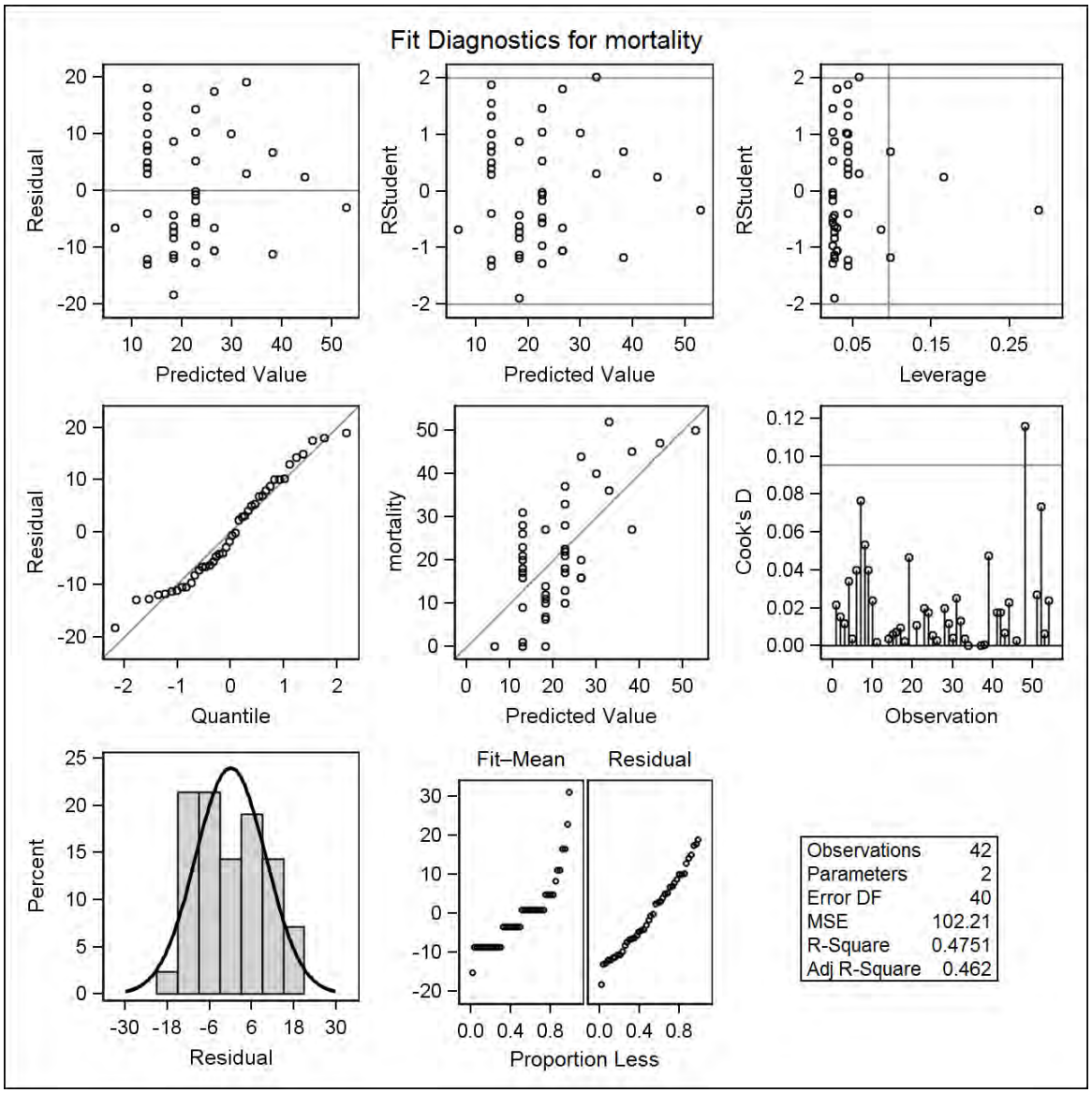


Figure 6.8. Fit diagnostics for the linear regression of log-depth and mortality using after removing studies identified as outliers.

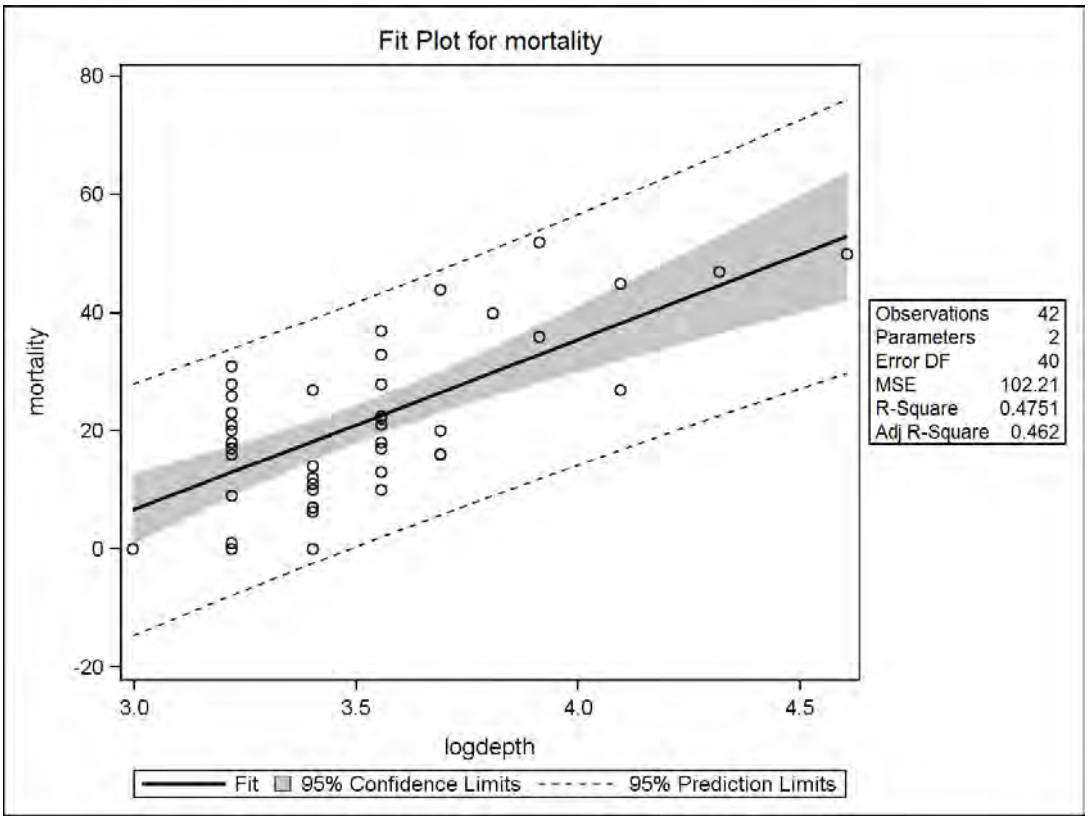


Figure 6.9. Linear regression of log-depth and mortality after removing studies identified as outliers.

7 Analytic Approach

7.1 Overview

The lead analytical agency for Gulf of Mexico Red Snapper is the Southeast Fishery Science Center in Miami, Florida.

7.2 Suggested analytic approach given available data

The assessment models to be used for SEDAR 31- Gulf of Mexico Red Snapper are specified in the Assessment Workshop Terms of Reference. Stock Synthesis and CATCHEM_AD models will be developed.

8 Research Recommendations

8.1 Life History

1. Review the evidence for density dependence in older ages (e.g. ages 2-3). Incorporate full age model of recruitment to examine density-dependent effect.

2. Site and habitat specific comparisons from more regions of the Gulf are needed for estimation of age-0 and age-1 mortality, accounting for shelf characteristics (e.g., width, slope, depth) in tests of density-dependent variation in M and emigration.

3. Broader understanding of habitat value and areal estimates of habitat (distribution—areas of trawlable vs. untrawlable bottom; more refined maps Gulf-wide etc) are needed to further inform the habitat limitation hypothesis for density dependence.

4. Assess the impact of potential predation/competition for taxa of particular interest (lionfish, marine catfish, sciaenids, and red grouper). As well, investigate alternative population regulatory mechanisms including potential sources of density-independent increases in mortality and distant sources of recruitment (but see stock delineation section).

5. Evaluate the potential for sea-bottom restoration or other means to expand habitat and increase survival for post-settlement red snapper.

6. The LHW recommended that existing otolith archives (e.g., NOAA) be used to further investigate interpretation of increment formation based on section orientation, sample source (location), season and year. This could be conducted as a graduate student project in collaboration with agency personnel.

7. Interested Academic representatives (e.g. Auburn University, University of S. Florida) should be included at Gulf States Marine Fisheries Commission sponsored otolith workshops (e.g., May 2013) to review age determinations and promote standardization.

8. Based upon the results of Szedlmayer and Beyer (2011 SEDAR31-RD20), further investigation of longevity is warranted. More recent catches of older fish should allow a direct comparison to ^{14}C coral chronologies established during the nuclear testing period and extend the age that can be directly validated (beyond 38 years in the earlier study by Baker and Wilson 2001).

9. A general recommendation of the LHW is to expand design-based fishery-independent sampling to elucidate regional (i.e., eastern and western GOM) and sub-regional differences in the demographics of red snapper.

10. A further recommendation is to increase random, representative sampling of the catch in order to avoid clustering effects and non-representative sampling which could lead to spurious differences in growth rates. Alternatively, and for localized- or small-scale studies, corrections for length limits and appropriate weighting may need to be utilized to treat data gaps, missing ages and adjust for selectivity (see Chih 2012 SEDAR31-DW18).

11. Future surveys should collect ovarian samples fixed in formalin for histology analysis, spawning marker fraction analysis and age/size at maturity analysis.

12. Additional fecundity collections are necessary from all areas of the Gulf.

13. Additional research is necessary to further clarify regional reproductive and demographic differences.

14. More information is needed to understand movement of young and older adult red snapper across along shore barriers. In particular the LHW recommends a large scale tagging study focused west and east of the Mississippi River.

15. Telemetry versus tagging approaches need to be expanded and evaluated according to shelf characteristics; e.g. cross compared in areas with little natural hard bottom habitat (yet high artificial reefs) versus areas with relatively high areal coverage of hard bottom and with more dispersed artificial reefs.

16. The LHW recommends a workshop or research symposia be convened to synthesize results and assess methodology for estimating red snapper movements and home range.

17. In order to reduce measurement error in the future, the LHW recommends that port agent, observers and field scientists record maximum total length for red snapper.

8.2 Commercial Fishery Statistics

Landings
1. Revisit how the historical landings were constructed.
2. Explore ways to ensure that IFQ and trip ticket landings match.
3. Apportion landings accordingly in ALS for TX landings with missing gear.

Discard
1. Add species to discard logbook form.
2. Provide better instructions on how to complete the discard logbook.
3. Consider and use relevant input from external review of observer program.
4. Social and economic impacts on fisher behavior in terms of fish discards.
5. Better determine available allocation to vessels on a given trip.

Length/Age
1. Standardize length and age data formats from various data sources.
2. Build age databases with Trip ID number for FL and FIN data.
3. Evaluate how to handle catch at age of non-representative age samples.

8.3 Recreational Fishery Statistics

1) Evaluate the technique used to apply sample weights to landings. Investigate the SEFSC Method by analyzing the order of variables in the hierarchy and the minimum number of fish used. Furthermore, evaluate alternative methods, including a meta-analysis of the existing information from difference sources, areas, states, surveys, etc. that could be performed.

2) Develop methods to identify angler preference and targeted effort. Require a reef fish stamp for anglers targeting reef fish, pelagic stamp for migratory species, and deep-water complex stamp for deep-water species. The program would be similar to the federal duck stamp required of hunters and could help managers identify what anglers were fishing for.

3) Continue and expand fishery dependent at sea observer surveys to collect discard information. This would help to validate self-reported headboat discard rates.

4) Track Texas commercial and recreational discards.

5) Estimate variances associated with the headboat program.

6) Evaluate existing and new methods to estimate historical landings. Hind-casting of red snapper landings is complicated by a lack of reliable historical effort data. To get at estimating historical effort, analysts could track consumables (gas, ice, bait) to develop price indices.

7) Investigate how CPUE changes over time due to technological advances and changes in fishing practices.

8.4 Measures of Population Abundance

The following are research recommendations that may improve the utility (precision) of the SEAMAP larval index for red snapper.

1. Expand the use of molecular genetics to identify the smallest and most abundant snapper larvae in SEAMAP samples that cannot be positively identified as red snapper because diagnostic morphological characters are not yet developed.

2. Begin directed sampling for fish eggs on SEAMAP summer trawl and fall plankton surveys using vertical nets hauls. The protocols for fish egg sampling have been established by NMFS/SWFSC scientists and are in use on the west coast. Fish egg collections are easy to make and take little additional sampling time. The eggs in these samples would have to be identified genetically but the protocols for genetic identification of red snapper eggs have been worked out by Frank Hernandez and Keith Bayha at DISL. The results of their MARFIN funded project using CUFES samples from our SEAMAP Fall Plankton surveys are impressive and significant. They produced maps of red snapper egg (i.e. spawning) distribution over the entire Gulfwide survey area. Estimates of egg abundance data coupled with the updated reproduction parameters (spawning frequency and fecundity) generated by NMFS scientists at the Panama City Lab could eventually be used to produce an actual spawning biomass estimate for red snapper.

3. Continue aging red snapper larvae from SEAMAP samples to improve the age-length relationship (key). This should improve the precision of the SEAMAP larval abundance index that is now based on a single age class of larvae across years.

4. Produce a SEAMAP larval index based on the abundance of red snapper larvae captured during SEAMAP summer shrimp/groundfish surveys (past and present). This survey has for a number of years now been expanded to include the entire northern Gulf of Mexico shelf. I don't need to remind you that the data from summer months (i.e. during peak red snapper spawning months) could be a far better indication of spawning production than data from the end of season from which the current SEAMAP larval index is derived.

5. Explore the utility of a larval red snapper index based on a comprehensive modeling approach that includes all SEAMAP stations (regardless of how many times they have been sampled over the time series) and both sampling gears, i.e. neuston and bongo samples. There are other likely explanatory variables (one for sure is salinity) that could ultimately improve the index.

8.5 Discard Mortality Rate

Future surveys, at minimum, should be structured around quarterly sampling, collect water temperature profile data, reflect the range of depths associated with the fishery, and strive to calculate season and depth specific estimates. Due to the limited number of experiments evaluating the relationship between thermal stress and release mortality, it is strongly encouraged that investigators measure and report water temperatures and thermocline profiles associated with capture. More studies evaluating the use of bottom release devices are also needed. Future discard observation surveys should collect frequency data regarding specific barotraumas incurred and loss of reflex response, because similar relationships could be developed as better techniques are developed to measure the delayed mortality component. Experiments estimating impairment scaling, and both immediate and delayed mortality, would be particularly useful so that a relationship among components could be developed and historical immediate release mortality estimates could potentially be adjusted.

Appendix A

SEDAR 31 Data Workshop- Commercial Selectivity/Catchability/Discard Mortality/IFQ Share Ad-Hoc working group notes

Commercial fishers from both the eastern and western Gulf of Mexico vertical line and bottom longline fisheries met with NOAA scientists in a working group on Thursday afternoon, August 23, 2012 during the red snapper SEDAR 31 data workshop. Topics discussed included changes in fishing behavior based upon amount of red snapper Individual Fishing Quota (IFQ) shares available to the fisher, red snapper discard mortality in the commercial fishery, and changes in selectivity and catchability in the red snapper fishery over time.

IFQ Share Bins (pounds of allocation per trip)

Fishers were asked to define amounts of red snapper IFQ share in pounds available to a vessel per trip that would cause a change in fisher behavior when fishing for red snapper. For example, fishers with a low or moderate amount of allocation may actively avoid areas with known red snapper populations, avoid areas known to have high abundance of red snapper (thereby limiting, but not eliminating, catch of red snapper). Fishers with higher allocation and may target other species and retain some or all red snapper caught, selectively discard some or all red snapper due to price, or actively target red snapper.

The following are fisher suggested categories by fishery and region that may prove meaningful to further examine catch and discard trends:

Bottom longline eastern Gulf of Mexico

1. no allocation (discard all red snapper)
2. 1+ pounds allocation (some red snapper catch retained)

Reasoning: Red snapper have not necessarily been targeted by bottom longline fishers in the east to date, but have been more of a 'bycatch' species for those fishers with allocation. Tendencies have been that fish that appeared to be alive were often preferentially released, discards have been less likely to be based on size (catches commonly at or above legal size in the bottom longline fishery), and self-imposed 'trip' limits have been based upon amount of available IFQ share.

Bottom longline western Gulf of Mexico

1. no allocation (discard all red snapper)
2. 1+ pounds allocation (some red snapper retained)

Reasoning: In the west, bottom longliners comprised a smaller fleet making fewer trips than in the eastern Gulf of Mexico where groupers have been more frequently landed. Discarding has been more influenced by time of year and specific lengths with smaller fish (13-16 inch total

length) kept preferentially due to market value and the possibility of encountering larger red snapper with the fishery restricted to depths 50 fathoms or deeper.

Vertical line eastern Gulf of Mexico

1. no allocation
2. 1-500 pounds allocation
3. 500-1,500 pounds allocation
4. >1,500 pounds allocation

Reasoning: limited by vessel hold space in many vessels (3000 lb); many small vessel lease between 300-500 lb/trip; discard viable fish not based on length, but due to IFQ share limitations; stretching IFQ allocation to last all year; amount of red snapper caught may depend on other fish caught. Additional caveats: increase in vermilion snapper vessels in recent years; turtle closures shifted effort from bottom longline to vertical line.

Vertical line western Gulf of Mexico

1. no allocation
2. 1-500 pounds allocation
3. 500-1,500 pounds allocation
4. >1,500 pounds allocation

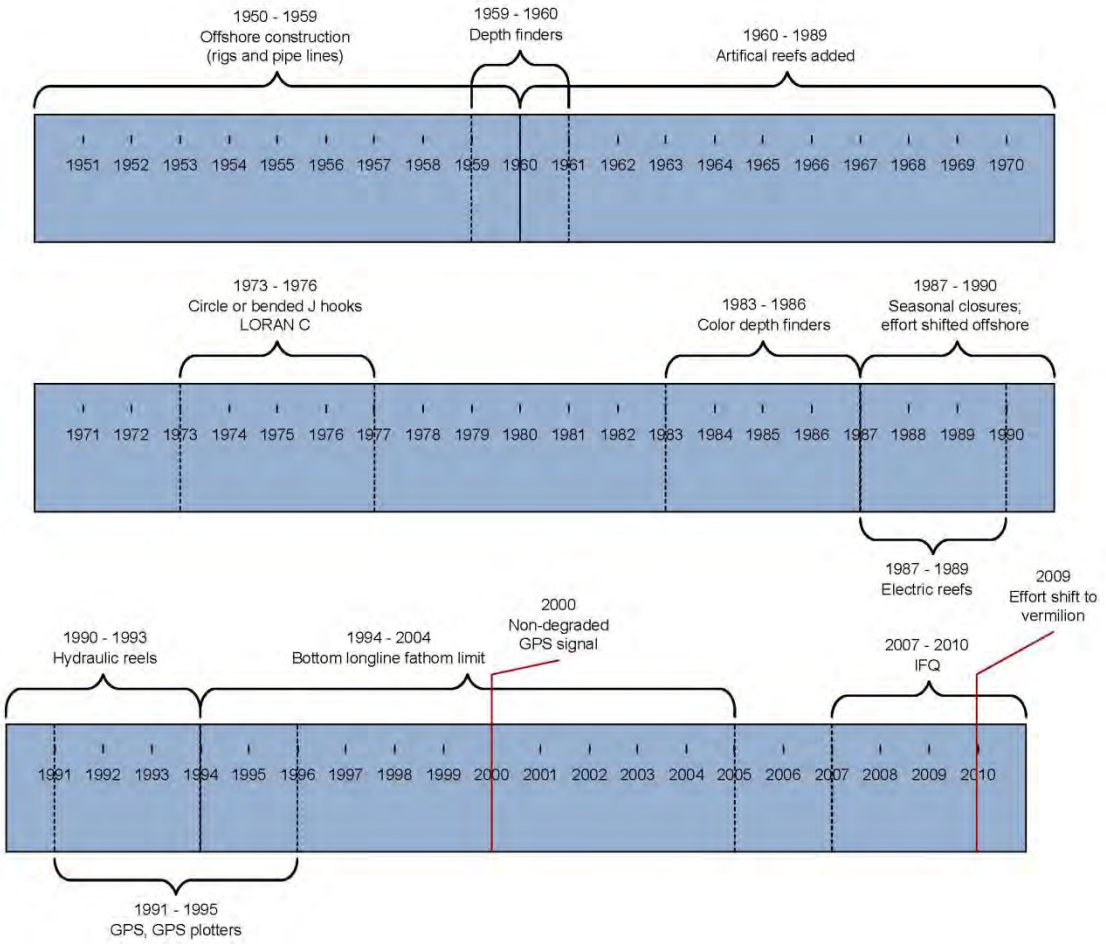
Reasoning: see VL eastern Gulf; additionally, marketability of fish may influence discards (e.g., keep plate size fish)

Discard Mortality

Observer reported discard mortality of 20-30% was likely too high according to commercial fishers. Some unknown level of mortality likely resulted from extended handling time of fish onboard the vessels while observers measured both kept fish and the fish to be discarded (i.e., discard mortality of 20-30% was likely an artifact of delay in release).

Selectivity/Catchability Timeline

Changes in habitat, technology, regulations, and other factors that resulted in changes in fishing behavior that affected selectivity and/or catchability in the commercial red snapper fishery, as identified by the commercial fishers, are provided in the timeline below. Further explanation of the notations appearing on the timeline is provided in the chronology that follows the timeline.



1950s-1990s Offshore oil rig and pipeline construction resulting in additional structure (habitat) in areas exploited by the fishery. Note: approximately 500 structures are in place by 1960, increasing 101 per year on average, to ca. 3800 offshore structures by 1990 and rough stabilization thereafter (Pulsipher et al., 2001).

1959-60 Depth finders introduced into the fishery (paper machines). Note: Camber (1955) reports earliest fathometers available after 1945-46 and mechanical reels with wire line also available at approximately this time (Siebenaler and Brady 1952).

1960s – 1980s Increasing number of artificial reefs constructed in areas exploited by the fishery

Mid-1970s Circle hook use began, not mandated, but some fishers made circle hooks by bending J-hooks

Late 1970s LORAN C introduced into the fishery. Note: LORAN A available in the early 1960's; however, only one fisher at the data workshop reported using LORAN A and the consensus was that LORAN A was used by few commercial fishers.

Mid-1980s Depth finder (color machines) advance = could tell bottom type and could see fish

Late 1980s	Electric reels introduced into the fishery
Late 1980s to early 1990s	Seasonal closures began, moved effort offshore (600-800 feet depths)
1980s - 2006	20% of fishery was longline reported as vertical line, changed to proper reporting with advent of VMS; where 50%+ of large fish (12 lbs+) were from bottom longline
1990	Bottom longline move to 50 fathoms in western (west of Cape San Blas) Gulf of Mexico
Early 1990s	Hydraulic reels introduced into the fishery
1991-92	GPS introduced into the fishery
Mid-1990s	GPS plotters, particularly important for bottom longline
1994-2004	Bottom longline in western GOM fishing within 50 fathom limit in some areas
1994, 1995	Size limit increase lead to increase in discards and more mortality due to hooking/barotraumas/etc. stress
2000	Removed GPS “selective availability” allowed for improved accuracy in vessel positioning due to reception of non-degraded GPS signal
2007	Red snapper fishery became a bycatch/non-targeted fishery due to IFQs; some directed effort in the western GOM
2007	Vessels moved to new areas to avoid concentrations of red snapper, but at the end of year may target the spots with high concentrations of red snapper to use up all their allocation
2007	In western GOM – tendency to select for 13-16 inch (TL) fish due to better price, larger fish may be more frequently discarded; this tendency not reported from the eastern GOM where price is not higher for fish of that size
2010	Effort shift in eastern GOM to vermilion snapper ("beeliners")

Literature Cited

Camber, C. I. 1955. A survey of the red snapper fishery of the Gulf of Mexico, with special reference to the Campeche Banks. Florida Board of Conservation Technical Series12. Marine Laboratory St. Petersburg, Florida.

Pulsipher, A.G, O.O. Iledare, D.V. Mesyanzhinov, A. Dupont, and Q. L. Zhu. 2001. Forecasting the number of offshore platforms on the Gulf of Mexico OCS to the year 2023. Prepared by the Center for Energy Studies, Louisiana State University, Baton Rouge, La. OCS Study MMS 2001-013. Gulf of Mexico OCS Region, New Orleans, La. 52 pp.

Siebenaler, J.B., and W. Brady. 1952. A high speed manual commercial fishing reel. Florida Board of Conservation, Marine Laboratory University of Miami Technical Series No. 4, Coral Gables, Florida.

Appendix B

The following are the Index Report Cards generated by the Indices Working Group. The report cards begin on the following page. Report cards are sorted by index, with the eastern Gulf portion of the index preceding the western Gulf portion, where applicable. The report cards are presented in the following order:

- SEAMAP Groundfish Trawl Survey
- SEAMAP Fall Ichthyoplankton Survey
- NMFS Reef Fish Video Survey
- NMFS Bottom Longline Survey
- Private-for-hire East
- Private-for-hire West
- Headboat East
- Headboat West
- Commercial Vertical Line East
- Commercial Vertical Line West

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).	✓			
B. Describe any changes to reporting requirements, variables reported, etc.	✓			
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			

METHODS

1. Data Reduction and Exclusions

A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

SEDAR31-DW20

SEAMAP Groundfish Survey

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.		✓		
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3A-D. Available On Demand

4A. Lo et al. method

4G. Available On Demand.

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	✓			
2. Table of model statistics (e.g. AIC criteria)	✓			

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	09/20/2012	accept as prepared	N/A	
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

The SEAMAP Groundfish Survey was recommended for inclusion in the stock assessment model for red snapper. These indices characterized long running, start dates of 1982 and 1972 for the summer and fall respectively, fishery independent surveys. The surveys have undergone some changes in methodology over time, along with an expansion of the area sampled; however, the model was able to account for these differences with the addition of variables. The final interactions of the model recommended for use were the long time series with separate indices for the summer and fall surveys, along with a split into east and west gulf. However, if the combination index with Dauphin Island is accepted, we would recommend using that in place of the eastern gulf indices. The decision to split the indices into summer and fall centered on the age structure of each survey, with the summer representative of age 1 fish and the fall representative of age 0 fish.

For the rest of the indices presented in SEDAR31-DW20, the following is a brief discussion on why the indices were not selected for use based upon discussion at the Data Workshop. Based on the work of the life history group and the decision to split the stock into eastern and western components, no full gulf indices were considered for use. In addition, it was decided that the stock assessment model was more capable of estimating changes in the indices with regard to selectivity; therefore the indices that had incorporated the selectivity factor in calculating catch were not recommended. The age specific indices were initially recommended for use; however, with the inclusion of the early part of the time series (pre-1987), it was no longer possible to separate the catch by age. Given the two options, using the longer time series was more desirable than using the age specific indices, especially since the stock assessment model would be able to utilize the catch structure of the groundfish data.

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).	✓			
B. Describe any changes to reporting requirements, variables reported, etc.	✓			
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			

METHODS

1. Data Reduction and Exclusions

A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

SEDAR31-DW27

SEAMAP Fall Plankton Survey

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.		✓		
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3A-D. Available On Demand

4A. Lo et al. method

4G. Available On Demand.

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	✓			
2. Table of model statistics (e.g. AIC criteria)	✓			

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	09/20/2012	accept as prepared		
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

The SEAMAP Fall Plankton Survey was recommended for use in the assessment model. This survey represented a long, fishery independent time series, with no change in methodology. Additionally, it was the only survey that characterizes larval red snapper. The final versions of the abundance indices recommended for use were the age adjusted index for the western GOM that included all larvae between 3.75 and 9.25 mm, and the frequency of occurrence model for the eastern GOM. The frequency of occurrence model was chosen over the delta-lognormal index due to extremely low catches and occurrence of red snapper in the eastern GOM. The group agreed that back-calculating of ages was appropriate, especially since high mortality rates existed in the larval data and by back-calculating it brought the index closer to the number of larvae hatched.

Evaluation of Abundance Indices of list species: List data set (SEDAR28-DW-08)

	Not Applicable	Absent	Incomplete	Complete
DESCRIPTION OF THE DATA SOURCE				
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).	✓			
B. Describe any changes to reporting requirements, variables reported, etc.	✓			
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			
METHODS				
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	✓			
2. Table of model statistics (e.g. AIC criteria)	✓			

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	20 August 2012	Use as presented		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Assessment scientists evaluated the abundance indices and coefficient of variation output and advised the working group that the model based runs were most appropriate for use in the assessment models, therefore those runs are presented in this report, however, all of the runs are available in the working document that was provided prior to the workshop (Campbell et al. DW-08).

An ad hoc group evaluating the efficacy of combining a set of less extensive reef fish video surveys (NMFS-PC, DISL, and FWRI) identified an issue associated with estimating length using lasers, versus the stereo video from NMFS-PC data. Laser data appears to potentially be underestimating size. It is unclear at this point if this is a measurement issue associated with parallelism of the laser mounting, or if this is associated with fish behavior relative to the camera gear (e.g. smaller fish swarming closer to the gear). At this point the NMFS-MS lab survey has no comparison data available to reassure the working group that this survey does not suffer from the same issue. The group is therefore recommending that the length composition data that was estimated using lasers is excluded from analysis until it can be determined if length is also underestimated in this survey as well.

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).	✓			
B. Describe any changes to reporting requirements, variables reported, etc.	✓			
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			

METHODS

1. Data Reduction and Exclusions

A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

SEDAR31-DW-19

NMFS Bottom Longline Survey

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3A-D. Available On Demand

4A. Lo et al. method

4G. Available On Demand.

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	✓			
2. Table of model statistics (e.g. AIC criteria)	✓			

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	09/20/2012	accept as prepared	N/A	
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

The index work group recommends that the assessment panel consider the use of indices from both the Eastern GOM and the Western GOM.

Evaluation of Abundance Indices of Red Snapper for SEDAR 31 Recreational Private/For Hire East (SEDAR31-DW-33 updated 10/12/2012) Data Used in Analysis: MRFSS

DESCRIPTION OF THE DATA SOURCE	Not Applicable	Absent	Incomplete	Complete
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	✓			
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	✓			
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	✓			
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	✓			
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		
METHODS				
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

see sedar31-dw-10

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	✓			
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

covered eastern Gulf of Mexico (Florida, Alabama, and Mississippi)

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.		✓		
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor		✓		
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				✓
2. Table of model statistics (e.g. AIC criteria)		✓		

cannot compare using AIC

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	8/20/2012	recommend for use		
Revision	10/12/2012	recommend for use		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

This paper explored two different ways of standardizing CPUE for this component of the red snapper fishery. One was using a Delta lognormal approach, which models the presence or absence of encountering the species on that trip as zero or one using a binomial model, separately from the positive observations of actual CPUE using a lognormal model. The second approach was to also use a Delta model, however a censored lognormal model was used to model the positive observations of CPUE. The reason for using this model was to capture the effect of the bag limit on CPUE, which had become increasingly strict over the time series.

The working group recommended the use of the censored approach to standardizing CPUE and recommended this index be used in the assessment. The group felt that the censored approach was able to account for the bag limit effect which would otherwise give the artificial perception that abundance had decreased over the time series. In addition, the group decided to recommend this index because it covers a long time series.

Evaluation of Abundance Indices of Red Snapper for SEDAR 31 Recreational Private/For Hire West (SEDAR31-DW-33 updated 10/12/2012) Data Used in Analysis: MRFSS and Texas Parks and Wildlife Survey

DESCRIPTION OF THE DATA SOURCE	Not Applicable	Absent	Incomplete	Complete
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	✓			
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	✓			
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	✓			
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	✓			
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		
METHODS				
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

see sedar31-dw-10

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	✓			
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

covered western Gulf of Mexico (Louisiana and Texas)

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.		✓		
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor		✓		
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				✓
2. Table of model statistics (e.g. AIC criteria)		✓		

cannot compare using AIC

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	8/20/2012	recommend for use		
Revision	10/12/2012	recommend for use		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

This paper explored two different ways of standardizing CPUE for this component of the red snapper fishery. One was using a Delta lognormal approach, which models the presence or absence of encountering the species on that trip as zero or one using a binomial model, separately from the positive observations of actual CPUE using a lognormal model. The second approach was to also use a Delta model, however a censored lognormal model was used to model the positive observations of CPUE. The reason for using this model was to capture the effect of the bag limit on CPUE, which had become increasingly strict over the time series.

The working group recommended the use of the censored approach to standardizing CPUE and recommended this index be used in the assessment. The group felt that the censored approach was able to account for the bag limit effect which would otherwise give the artificial perception that abundance had decreased over the time series. In addition, the group decided to recommend this index because it covers a long time series.

Evaluation of Abundance Indices of Red Snapper for SEDAR 31 Recreational Headboat East (SEDAR31-DW-33 updated 10/12/2012) Data Used in Analysis: NMFS Headboat Survey

DESCRIPTION OF THE DATA SOURCE	Not Applicable	Absent	Incomplete	Complete
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	✓			
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	✓			
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	✓			
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	✓			
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		
METHODS				
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

see sedar31-dw-10

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	✓			
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

covered eastern Gulf of Mexico (Florida, Alabama, and Mississippi)

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.		✓		
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor		✓		
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				✓
2. Table of model statistics (e.g. AIC criteria)		✓		

cannot compare using AIC

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	8/20/2012	recommend for use		
Revision	10/12/2012	recommend for use		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

This paper explored two different ways of standardizing CPUE for this component of the red snapper fishery. One was using a Delta lognormal approach, which models the presence or absence of encountering the species on that trip as zero or one using a binomial model, separately from the positive observations of actual CPUE using a lognormal model. The second approach was to also use a Delta model, however a censored lognormal model was used to model the positive observations of CPUE. The reason for using this model was to capture the effect of the bag limit on CPUE, which had become increasingly strict over the time series.

The working group recommended the use of the censored approach to standardizing CPUE and recommended this index be used in the assessment. The group felt that the censored approach was able to account for the bag limit effect which would otherwise give the artificial perception that abundance had decreased over the time series. In addition, the group decided to recommend this index because it covers a long time series.

Evaluation of Abundance Indices of Red Snapper for SEDAR 31 Recreational Headboat West (SEDAR31-DW-33 updated 10/12/2012) Data Used in Analysis: NMFS Headboat Survey

DESCRIPTION OF THE DATA SOURCE	Not Applicable	Absent	Incomplete	Complete
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	✓			
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	✓			
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	✓			
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	✓			
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		
METHODS				
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

see sedar31-dw-10

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	✓			
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

covered western Gulf of Mexico (Louisiana and Texas)

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.		✓		
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor		✓		
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				✓
2. Table of model statistics (e.g. AIC criteria)		✓		

cannot compare using AIC

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	8/20/2012	recommend for use		
Revision	10/12/2012	recommend for use		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

This paper explored two different ways of standardizing CPUE for this component of the red snapper fishery. One was using a Delta lognormal approach, which models the presence or absence of encountering the species on that trip as zero or one using a binomial model, separately from the positive observations of actual CPUE using a lognormal model. The second approach was to also use a Delta model, however a censored lognormal model was used to model the positive observations of CPUE. The reason for using this model was to capture the effect of the bag limit on CPUE, which had become increasingly strict over the time series.

The working group recommended the use of the censored approach to standardizing CPUE and recommended this index be used in the assessment. The group felt that the censored approach was able to account for the bag limit effect which would otherwise give the artificial perception that abundance had decreased over the time series. In addition, the group decided to recommend this index because it covers a long time series.

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

see SEDAR7-DW-47 and SEDAR7-AW-9 for details

2D unknown, data are pounds landed no size data reported

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			✓	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)			✓	
G. Report convergence statistics.			✓	

Working Group Comments:

see SEDAR7-DW-47 and SEDAR7-AW-9 for details

4F,G. Available on demand

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)			✓	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).			✓	
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

see SEDAR7-DW-47 and SEDAR7-AW-9 for details

1C. Available on demand

2B,D,E. Available on demand

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	9/7/12	accept as submitted		
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

The index was presented as prepared for the 2009 red snapper update, no additional analyses were completed for this data workshop. The working group recommended that the index be accepted as presented.

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

see SEDAR7-DW-47 and SEDAR7-AW-9 for details

2D unknown, data are pounds landed no size data reported

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			✓	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)			✓	
G. Report convergence statistics.			✓	

Working Group Comments:

see SEDAR7-DW-47 and SEDAR7-AW-9 for details

4F,G. Available on demand

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.	✓			
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)	✓			
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

see SEDAR7-DW-47 and SEDAR7-AW-9 for details

1. Index was lognormal on positives only

2B,D,E. Available on demand

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	9/7/12	accept as submitted		
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

The index was presented as prepared for the 2009 red snapper update, no additional analyses were completed for this data workshop. The working group recommended that the index be accepted as presented.