SEDAR 28 Gulf of Mexico Cobia Stock Assessment Report

SEDAR 28

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 28

Gulf of Mexico Cobia

Stock Assessment Report

April 2013

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

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Section I: Introduction

Contents

1. Introduction

1.1 SEDAR Process Description

SouthEast Data, Assessment, and Review (SEDAR) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. The improved stock assessments from the SEDAR process provide higher quality information to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commission representatives: Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment process, which is conducted via a workshop and several webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as ‘appropriate for management’ and development of specific management recommendations.

SEDAR workshops are public meetings organized by SEDAR staff and the lead Council. Workshop participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

SEDAR Review Workshop Panels typically consist of a chair, three reviewers appointed by the Center for Independent Experts (CIE), and one or more SSC representatives appointed by each council having jurisdiction over the stocks assessed. The Gulf stocks of Spanish mackerel and cobia in SEDAR 28 were reviewed through the CIE desk review process, wherein three reviewers received all stock assessment materials and generated individual summary reports of their findings with respect to the terms of reference.

2. Gulf of Mexico Cobia Management History

2.1. Fishery Management Plan and Amendments

The following summary describes only those management actions that likely affect cobia fisheries and harvest

Original GMFMC FMP:

The Fishery Management Plan for Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic (FMP) and Environmental Assessment (EA), approved in 1982 and implemented by regulations effective in February of 1983, treated king and Spanish mackerel each as one U.S. stock. Allocations were established for recreational and commercial fisheries, and the commercial allocation was divided between net and hook-and-line fishermen.

GMFMC FMP Amendments affecting cobia:

Description of Action	FMP/Amendment	Effective Date
Established 33" FL minimum size limit in all sectors	-	1985
Cobia included in Gulf CMP FMP, established 2 fish/person/day bag limit	CMP Amendment 5	1990

GMFMC Regulatory Amendments:

May 14, 2003: Establishes definitions of maximum sustainable yield (MSY), optimum yield (OY), the overfishing threshold, and the overfished condition for cobia and Gulf group king and Spanish mackerel.

2.2. Management Program Specifications

Table 2.2.1. General Management Information

Gulf of Mexico

Species	Gulf of Mexico Cobia
Management Unit	Southeastern US
Management Unit Definition	All waters within Gulf of Mexico Fishery Management Council Boundaries

Management Entity	Gulf of Mexico Fishery Management Council
Management Contacts SERO / Council	Ryan Rindone Sue Gerhart
Current stock exploitation status	Not undergoing overfishing/not overfished
Current stock biomass status	1370 mt (2001 Gulf Cobia MSAP Report)

Table 2.2.2. Specific Management Criteria

Criteria	Gulf of Mexico - Current (2001)		Gulf of Mexico - Proposed	
	Definition	Value	Definition	Value
MSST	$(1\text{-}M)*SSB_{MSY}$	2.11 mp	$(1\text{-}M)*SSB_{MSY}$	SEDAR 28
MFMT	F_{MSY}	0.34	F_{MSY}	SEDAR 28
MSY	Yield at F_{MSY}	0.34	Yield at F_{MSY}	SEDAR 28
F_{MSY}	F_{MSY}	0.34	F_{MSY}	SEDAR 28
OY	Equilibrium Yield @ F_{OY}	1.45 mp	Equilibrium Yield @ F_{OY}	SEDAR 28
F_{OY}	75% of F_{MSY}	0.26	F_{OY} = 65%,75%, 85% F_{MSY}	SEDAR 28
M	n/a	0.30	M	SEDAR 28

NOTE: "Proposed" columns are for indicating any definitions that may exist in FMPs or amendments that are currently under development and should therefore be evaluated in the current assessment. "Current" is those definitions in place now. Please clarify whether landings parameters are 'landings' or 'catch' (Landings + Discard). If 'landings', please indicate how discards are addressed.

Table 2.2.3. Stock projection information.

Gulf of Mexico

Requested Information	Value
First Year of Management	2013
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	Fixed Exploitation
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average of previous 3 years

*Fixed Exploitation would be $F=F_{MSY}$ (or $F<F_{MSY}$) that would rebuild overfished stock to B_{MSY} in the allowable timeframe. Modified Exploitation would be allow for adjustment in $F<=F_{MSY}$, which would allow for the largest landings that would rebuild the stock to B_{MSY} in the allowable timeframe. Fixed harvest would be maximum fixed harvest with $F<=F_{MSY}$ that would allow the stock to rebuild to B_{MSY} in the allowable timeframe.

Projections:

Project future stock conditions and develop rebuilding schedules if warranted, including estimated generation time. Develop stock projections in accordance with the following:

A) If stock is overfished:
    $F=0$, $F_{Current}$, F_{MSY}, F_{OY} (F_{OY}=65%, 75%, 85% F_{MSY})
    $F=F_{Rebuild}$ (max that permits rebuild in allowed time)
B) If stock is undergoing overfishing:
    $F= F_{Current}$, F_{MSY}, F_{OY}
C) If stock is neither overfished nor undergoing overfishing:
    $F= F_{Current}$, F_{MSY}, F_{OY}
D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice

Table 2.2.4. Quota Calculation Details
If the stock is managed by quota, please provide the following information

Current Quota Value	None
Next Scheduled Quota Change	n/a
Annual or averaged quota ?	n/a
If averaged, number of years to average	n/a
Does the quota include bycatch/discard ?	n/a

2.3. Management and Regulatory Timeline

The following tables provide a timeline of Federal management actions by fishery.

Table 2.3.1. Annual Commercial Cobia Regulatory Summary

	Fishing Year	Size Limit	Possession Limit	Open date	Close date	Other
1983	Calendar Year	None	None	All year	n/a	
1984	"	"	"	"	"	
1985	"	33" Fork Length	"	"	"	
1986	"	"	"	"	"	
1987	"	"	"	"	"	
1988	"	"	"	"	"	
1989	"	"	"	"	"	
1990	"	"	2 fish/person/day	"	"	
1991	"	"	"	"	"	
1992	"	"	"	"	"	
1993	"	"	"	"	"	
1994	"	"	"	"	"	
1995	"	"	"	"	"	
1996	"	"	"	"	"	
1997	"	"	"	"	"	
1998	"	"	"	"	"	
1999	"	"	"	"	"	
2000	"	"	"	"	"	
2001	"	"	"	"	"	
2002	"	"	"	"	"	
2003	"	"	"	"	"	
2004	"	"	"	"	"	
2005	"	"	"	"	"	
2006	"	"	"	"	"	
2007	"	"	"	"	"	
2008	"	"	"	"	"	
2009	"	"	"	"	"	
2010	"	"	"	"	"	
2011	"	"	"	"	"	

Table 2.3.2. Annual Recreational Cobia Regulatory Summary

	Fishing Year	Size Limit	Bag Limit	Open date	Close date	Other
1983	Calendar Year	None	None	All year	n/a	
1984	"	"	"	"	"	
1985	"	33" Fork Length	"	"	"	
1986	"	"	"	"	"	
1987	"	"	"	"	"	
1988	"	"	"	"	"	
1989	"	"	"	"	"	
1990	"	"	2 fish/person/day	"	"	
1991	"	"	"	"	"	
1992	"	"	"	"	"	
1993	"	"	"	"	"	
1994	"	"	"	"	"	
1995	"	"	"	"	"	
1996	"	"	"	"	"	
1997	"	"	"	"	"	
1998	"	"	"	"	"	
1999	"	"	"	"	"	
2000	"	"	"	"	"	
2001	"	"	"	"	"	
2002	"	"	"	"	"	
2003	"	"	"	"	"	
2004	"	"	"	"	"	
2005	"	"	"	"	"	
2006	"	"	"	"	"	
2007	"	"	"	"	"	
2008	"	"	"	"	"	
2009	"	"	"	"	"	
2010	"	"	"	"	"	
2011	"	"	"	"	"	

3. Assessment History and Review

Gulf of Mexico cobia has not been previously assessed under the SEDAR process. Historically, cobia has been overseen by the Mackerel Stock Assessment Panel (MSAP) under the purview of the Coastal Migratory Pelagics Fishery Management Plan. Gulf of Mexico cobia was previously assessed in both 1996 (Thompson 1996) and 2001 (Williams 2001). The first assessment of Gulf of Mexico cobia used a virtual population analysis (VPA) model with values of natural mortality (M) of 0.2 and 0.4 (Thompson 1996). In that assessment it was estimated that fishing mortality (F) at age at the fully recruited ages was higher than $F_{0.1}$ and F_{max} in 1994 (Thompson 1996). Spawners per recruit (SPR) in the assessment were estimated at about 25% and 50% for M values of 0.2 and 0.4, respectively (Thompson 1996).

The 2001 stock assessment used a surplus-production model (ASPIC) and a forward-projecting, age-structured population model programmed in the AD Model Builder (ADMB) software. The primary data used in the model consisted of commercial and recreational landings data from 1980 to 2000, length composition from the commercial (1983-2000) and recreational (1981-2000) fisheries, and four standardized CPUE time series derived from the Marine Recreational Fisheries Statistics Survey (MRFSS) (1981-1999), Southeast region headboat survey (1986-1999), Texas creel survey (1983-1999), and shrimp bycatch estimates (1980-1999). The ASPIC model applied to the cobia data provided unsatisfactory results. The age-structured model fit described the observed length composition data and fishery landings fairly well. For the age-structured model, the choice of natural mortality had a large influence on the perceived status of the population (a range of values for M from 0.2 - 0.4 was used in the analyses). Population status as measured by spawning stock biomass in the last year relative to the value at maximum sustainable yield (SSB_{2000}/SSB_{MSY}), spawning stock biomass in the last year relative to virgin spawning stock biomass (SSB_{2000}/S_0), and static spawning stock biomass per recruit (SSBR) all indicated the population was either depleted, near MSY, or well above MSY depending on the choice of M. The variance estimates for these benchmarks were very large and in most cases ranged from depleted to very healthy status. The only statement that could be made with any degree of certainty about cobia in the Gulf of Mexico is that the population had increased since the 1980s. The main conclusion from this assessment was that the population status of Gulf of Mexico cobia is virtually unknown, given the degree of uncertainty in the estimates from the assessment model.

References Cited:

Thompson, N.B. 1996. An assessment of cobia in southeast U.S. waters. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami Lab., Contrib. No. MIA-95/96-28. 10 p.

Williams, E.H. 2001. Assessment of cobia, *Rachycentron canadum*, in the waters of the U.S. Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-469, 54 p.

4. Regional Maps

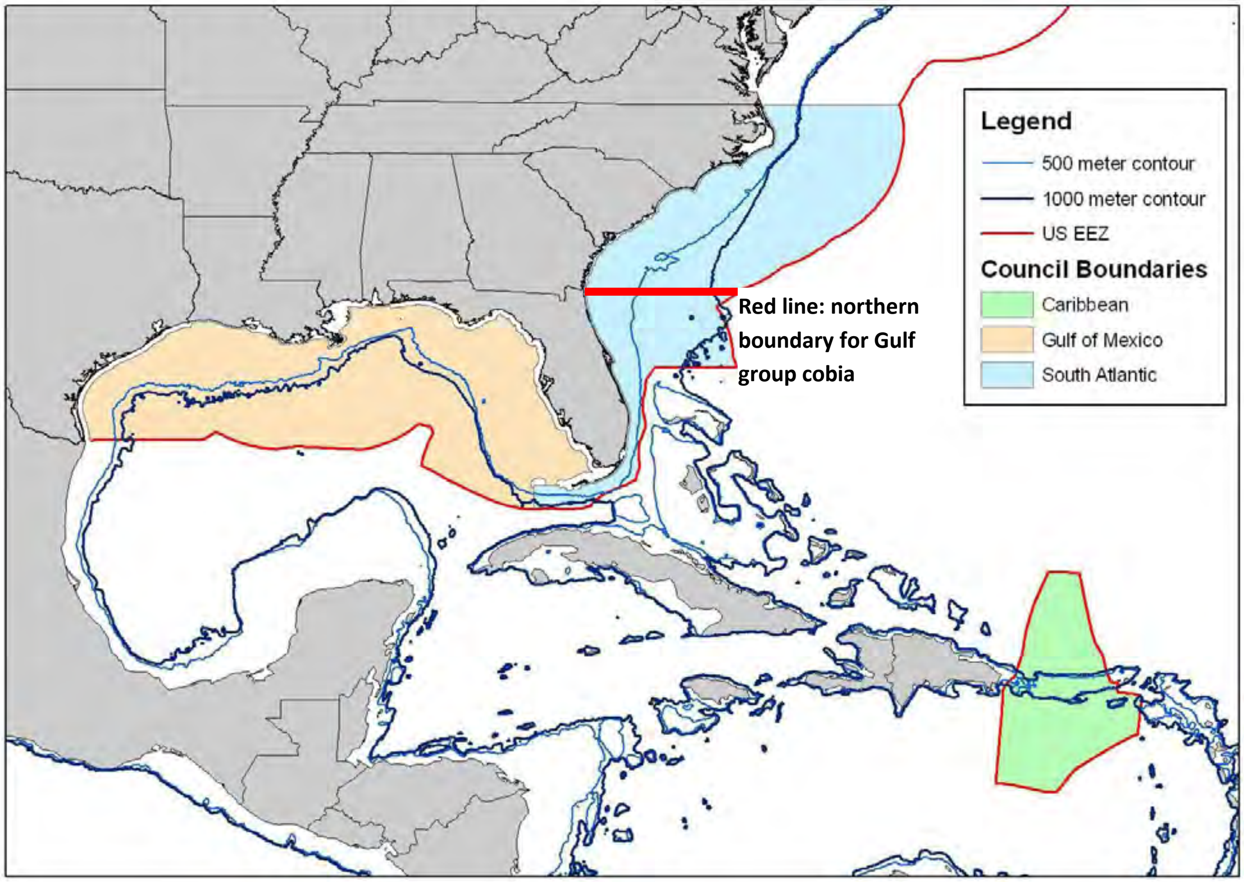

Figure 4.1: South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Council boundaries, and United States EEZ. The red line at the Florida/Georgia state line indicates the northern boundary for the Gulf of Mexico cobia population proposed by the SEDAR 28 Data Workshop Panel.

5. Assessment Summary Report

The Assessment Summary Report provides a broad but concise view of the 2012 Gulf of Mexico cobia (*Rachycentron canadum*) stock assessment (SEDAR 28). It recapitulates: (a) the information available to and prepared by the Data Workshop (DW); (b) the application of those data, development and execution of assessment models, and identification of a preferred model configuration by the Assessment Workshop (AW); and (c) the findings and advice determined during the CIE desk review performed in lieu of an in-person Review Workshop.

Executive Summary

The Gulf of Mexico cobia stock assessment presented by the SEDAR 28 Assessment Workshop (AW) Panel was provided as a desk review to three reviewers from the Center for Independent Experts (CIE) with outputs and results. Each reviewer conducted an evaluation of the material and produced an independent review report. The modeling environment used was Stock Synthesis (SS) (Methot 2011) version 3.4d. No clear status determination can be made from the assessment, as the independent reviewers differed on the appropriateness of the assessment for making such determinations.

Stock Status and Determination Criteria

Due to a lack of consensus amongst the CIE reviewers responsible for evaluating the assessment, point estimates of population benchmarks cannot be provided at this time. Phase plots of the base run put forth by the AW Panel and related sensitivities are provided in Figures 5.7 and 5.8.

Stock Identification and Management Unit

Microsatellite-based analyses demonstrated that tissue samples collected from NC, SC, east coast Florida (near St. Lucie), MS and TX showed disparate allele frequency distributions, and subsequent analysis of molecular variance showed population structuring occurring between states. Results showed that the Gulf of Mexico cobia stock appeared to be genetically homogeneous. The Gulf cobia population continued around the Florida peninsula to St. Lucie Florida, with a genetic break somewhere between St. Lucie Florida and Port Royal Sound in South Carolina. Tag-recapture data suggest two stocks of fish overlapping at Brevard County Florida, corroborating genetic findings.

The South Atlantic and Gulf stocks were separated at the FL/GA line because genetic data suggested that the split is north of the Brevard/Indian River County line. There were no tagging data to dispute this split. The FL/GA line was selected as the stock boundary based on recommendations from the commercial and recreational work groups and comments that, for ease of management, the FL/GA line would be the preferable stock boundary and did not conflict with available life history information. However, there was not enough resolution in the genetic or tagging data to suggest that a biological stock boundary exists specifically at the FL/GA line, only that a mixing zone occurs around Brevard County, FL and potentially to the north.

Assessment Methods

The Stock Synthesis (SS) integrated statistical catch-at-age modeling environment was selected by the AW Panel to be the primary assessment model for cobia. SS has been widely used and tested for assessment evaluations, particularly in the US west coast NMFS centers (Methot

2011). Descriptions of SS algorithms and options are available in the SS user's manual (Methot 2011) and at the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/). Modeling was implemented with AD Model Builder. SS is widely used for stock assessments in the United States and internationally. SS takes relatively unprocessed input data and incorporates many of the important processes (e.g., mortality, selectivity, growth) that operate in conjunction to produce observed catch, size and age composition and CPUE indices. Because many of these inputs are correlated, SS models these inputs together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment. SS can incorporate an early, data-poor time period for which only catch data are available and a more recent, data-rich time period for which indices and length and age observations are available. SS also offers substantial flexibility for constructing models of varying complexity. Data inputs and model parameters can be easily "turned on or off" to create alternative models of varying degrees of complexity. For this assessment SS was first constructed as a simple production model with minimal parameters. The model was then extended to an age-structured production model. Finally, length and age composition data were added to construct a length-structured catch-at-age model. General trends in estimated stock biomass over time remained similar as model complexity was increased. The model presented is a fully parameterized length-based statistical-catch-at-age model. This model was selected by the AW Panel because it incorporates all available data sources and is best suited for providing management advice.

Assessment Data

Life history data used in the assessment included natural mortality, growth, maturity, and fecundity. Some life history data were input in the Stock Synthesis model as fixed values, while others were treated as estimable parameters. For the estimable parameters, the initial parameter values were taken from the DW. Commercial landings (1927-2011) were aggregated across gears. Handline landings represented approximately 67% of total commercial landings since 1981. Commercial landings were reported in 1000s lbs whole weight and converted to metric tons for input into the assessment model. Recreational landings (1950-2011) were aggregated across modes and regions. Private/rental boat landings represented approximately 75% of the total recreational landings by numbers since 1981. Recreational landings were reported in numbers of fish and input into the assessment model as 1000s of fish. Annual recreational and commercial length compositions were combined into 3-cm bins (min: 6 cm; max: 165 cm). Due to small annual sample sizes, the length composition data from the SEAMAP trawl survey was aggregated over years into a single length distribution and assumed to be representative of the shrimp fishery using the super-year approach (Methot 2011). Commercial age composition data was not used in the assessment. Recreational age compositions were made conditional on length.

Five indices of abundance were presented to the DW Indices working group. Three of the five indices were rejected due to inadequacies: the fishery dependent commercial logbook index, the Texas Park and Wildlife Department fishery dependent index, and the fishery-independent SEAMAP Groundfish survey. The DW Panel recommended the use of two indices for the assessment: the Marine Recreational Fishery Statistics Survey (MRFSS) and the Headboat Survey (see SEDAR 28 Section II: Data Workshop Report).

Release Mortality
Commercial discards were reported as numbers of fish and converted to metric tons for the assessment. The mean length of a discarded cobia from the reef fish observer program was estimated at 70 cm; the average weight of a 70 cm cobia was 3.76 kg (8.28 lbs). The DW Panel recommended a discard mortality rate of 5% for all commercial hook and line fisheries and 51% for the gillnet fishery. Estimates of discard mortality came from data collected by observers as part of the commercial logbook programs for commercial vessels operating in the South Atlantic and Gulf of Mexico. Recreational discards were reported as numbers of fish and input into the assessment as 1000s of fish. A discard mortality rate of 5%, as recommended by the DW Panel, was used for the recreational fishery. Due to concerns about the accuracy and precision of the annual estimates of cobia bycatch from the shrimp fishery, the AW Panel agreed to not use annual point estimates of bycatch in the assessment model. The AW Panel recommended that shrimp fishery effort be used as a proxy for cobia bycatch trends since shrimp fishery effort is known with more certainty. The median estimate of shrimp bycatch over the time series, 1972-2011, was used to represent the magnitude of cobia removals from the shrimp fleet and input into SS using the super-year approach of Methot (2011).

Catch Trends
The cobia fishery was dominated by the recreational fleet. Observed recreational landings began in 1981, peaking in 1982 and again in 1997. Recreational discards began in 1981 and were variable with a peak in 1991. Commercial landings peaked in the mid 1990s, followed by a small decline. Commercial landings have remained relatively stable since the early 2000s. Commercial dead discards peaked in 1999, and declined after. See Figure 5.5 for details on landings and discard trends.

Fishing Mortality Trends
The estimated time series of fishing mortality rates (F) from SS increased steadily until 1989, followed by a drop in the 1990s after the implementation of the 2-fish per person bag limit. Fishing mortality rates since 1990 have fluctuated, but have been otherwise fairly stable. In the last decade of data (2002-2011), estimates of F have averaged ~0.284. The recreational fleet has been the largest contributor to total F throughout the time series (Figures 5.1, 5.5).

Stock Abundance and Biomass Trends
Total estimated abundance decreased to its lowest level in the late 1980s, increased through the 1990s, decreased again through the 2000s, and is now again increasing through the last decade. A strong year class was predicted to have occurred in 2010 comparable to those predicted periodically in the late 1980s and throughout the 1990s. However, predicted recruitment in recent years (2007-2009) has been below average. Total biomass and spawning biomass showed similar trends - generally higher biomass in the 1990s and early 2000s compared to the 1980s and a second decline in the early 2000s followed by an increase in the most recent years (Figures 5.2, 5.3).

Scientific Uncertainty
Uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter. Asymptotic standard errors are based upon the model's analytical estimate of the variance near the converged solution. Uncertainty was further investigated using a

parametric bootstrap approach. Bootstrapping is a standard technique used to estimate confidence intervals for model parameters or other quantities of interest. There is a built-in option to create bootstrapped datasets using SS. This feature performs a parametric bootstrap using the error assumptions and sample sizes from the input data to generate new observations about the fitted model expectations. The model was refit to 1000 bootstrapped datasets and the distribution of the parameter estimates was used to represent the uncertainty in the parameters and derived quantities of interest.

Likelihood profiles were completed for two key model parameters: steepness of the stock-recruit relationship (h) and unexploited equilibrium recruitment (R_0). Likelihood profiles are commonly used to elucidate conflicting information among various data sources, to determine how asymmetric the likelihood surfaces surrounding point estimates may be, and to provide an additional evaluation of how precisely parameters are being estimated.

Retrospective analyses did not suggest any patterns in F, SSB, or recruits, and seemed to indicate no retrospective error. The data set ending in 2008 predicted a spike in recruitment in the final year that was not predicted for the 2009-2011 data sets. The final two years of recruitment had high uncertainty in the base model and thus divergence in predicted recruitments was expected, since there are no data to inform the most recent years in any of the models.

Significant Assessment Modifications

The greatest change from the 2003 MSAP assessment for Gulf of Mexico cobia was the transition to Stock Synthesis from the previously used surplus-production model (ASPIC) and forward-projecting, age-structured population model. Additional diagnostics were also performed, including retrospective analyses, likelihood profiling, and jittering exercises.

Sources of Information

The contents of this summary report were taken from the SEDAR 28 Gulf of Mexico Cobia Data, Assessment, and CIE desk review reports.

Figures

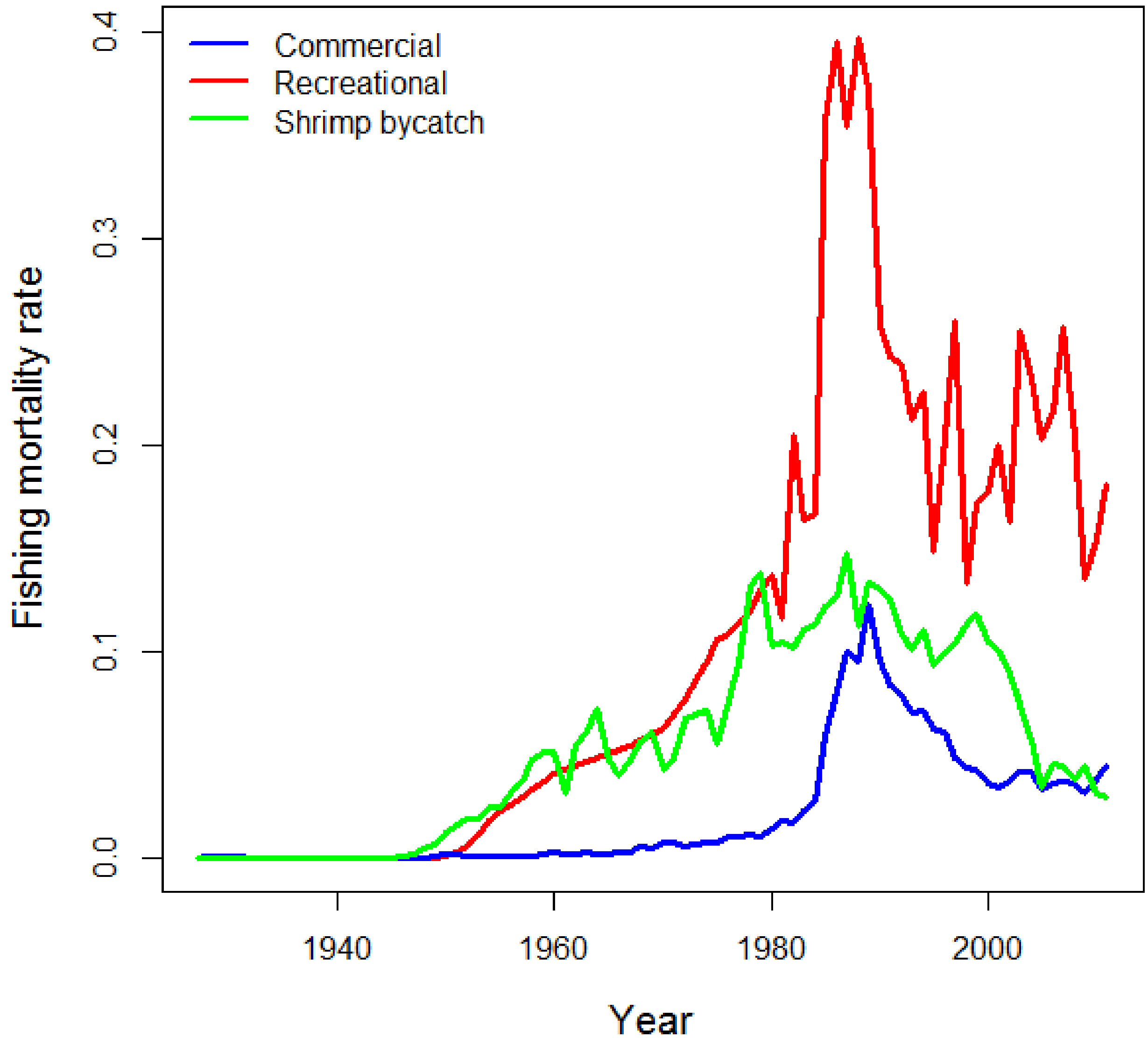

Figure 5.1. Fleet-specific estimates of instantaneous fishing mortality rate in terms of exploitable biomass.

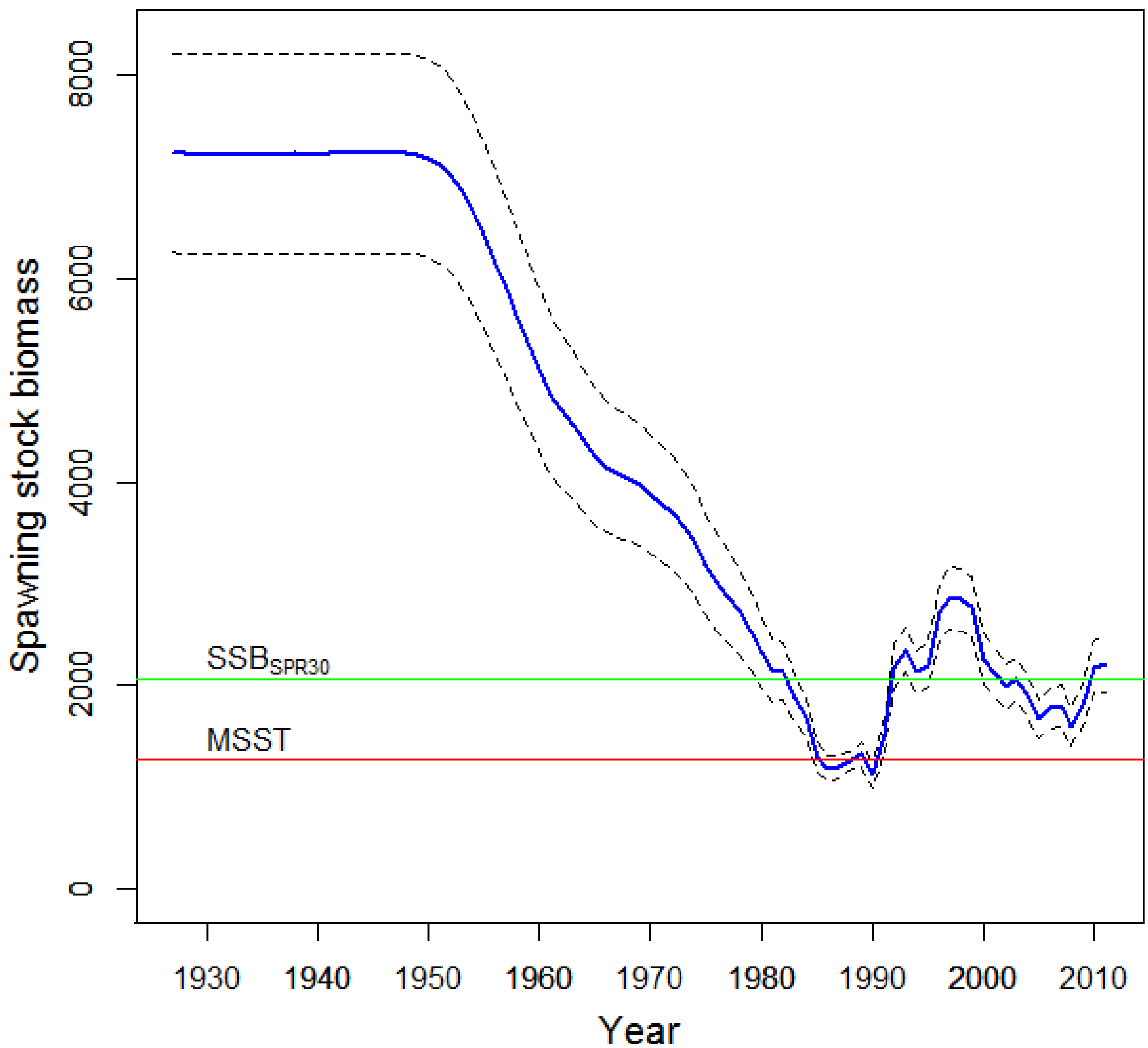

Figure 5.2. Predicted spawning biomass (mt) of Gulf of Mexico cobia (blue line) with associated 80% asymptotic intervals (dashed lines). The green line represents spawning stock biomass at $F_{SPR30\%}$ and the red line represents the minimum stock size threshold (MSST).

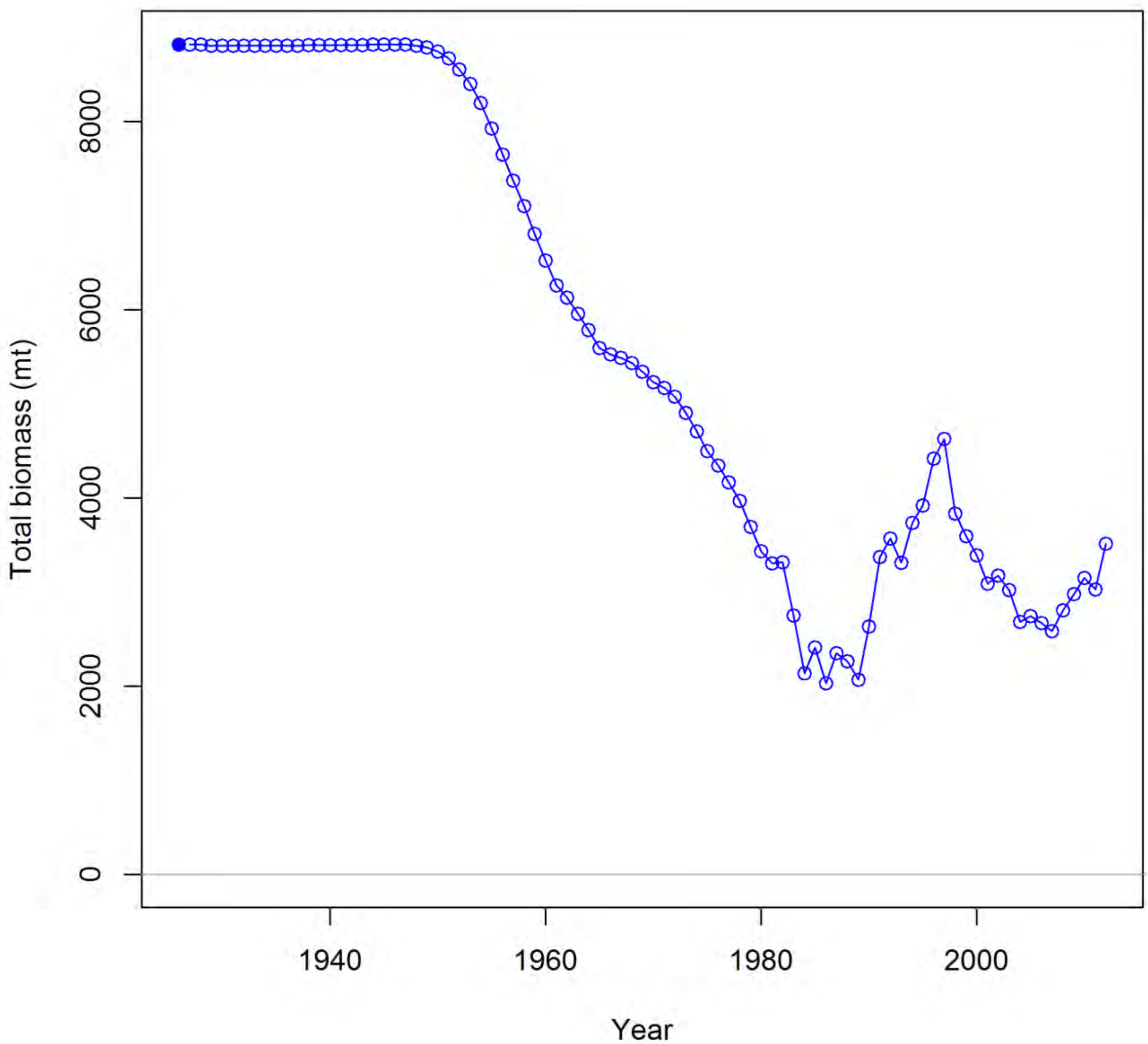

Figure 5.3. Predicted total biomass (mt) of Gulf of Mexico cobia from 1927-2011.

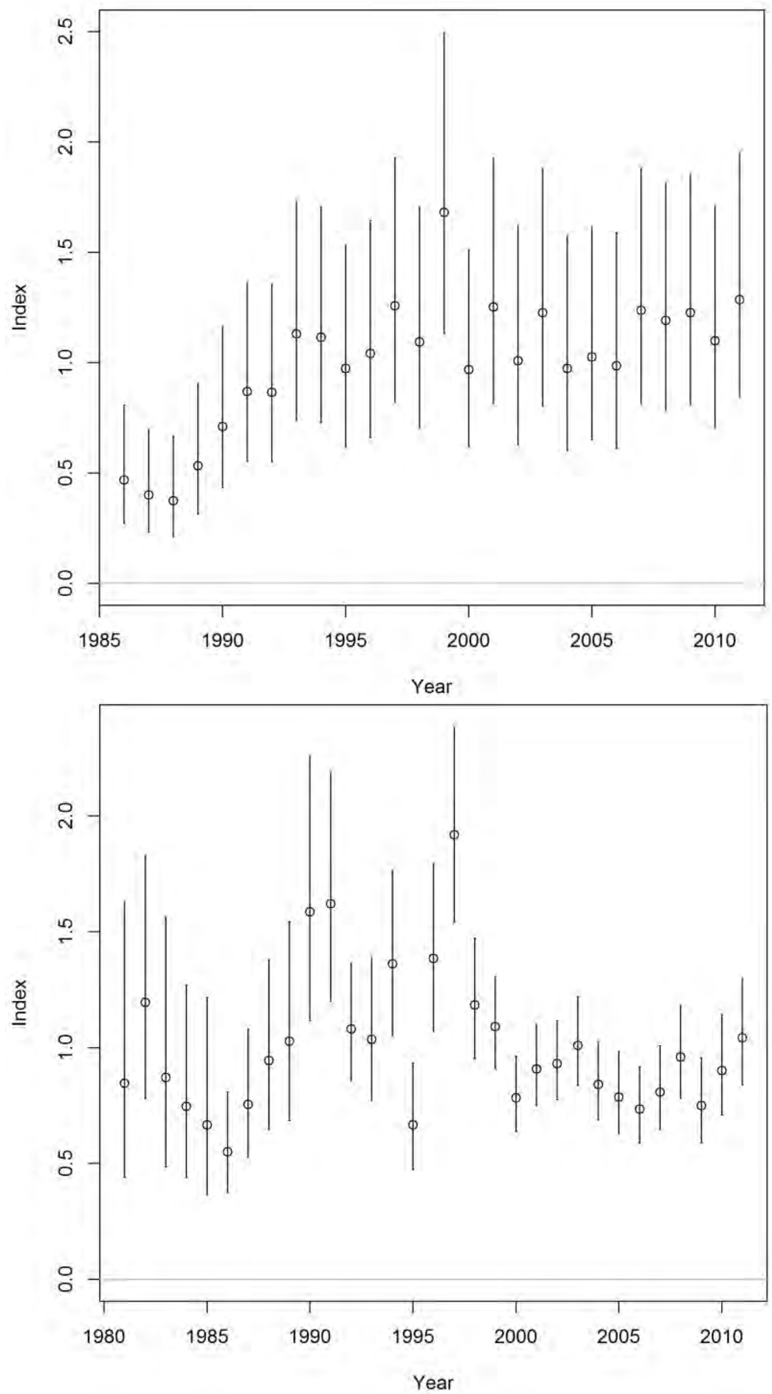

Figure 5.4. (Top) Standardized index of relative abundance and associated standard errors from the Gulf of Mexico recreational headboat fishery, 1985-2011. (Bottom) Standardized index of relative abundance and associated standard errors from the Gulf of Mexico recreational fishery (MRFSS), 1981-2011.

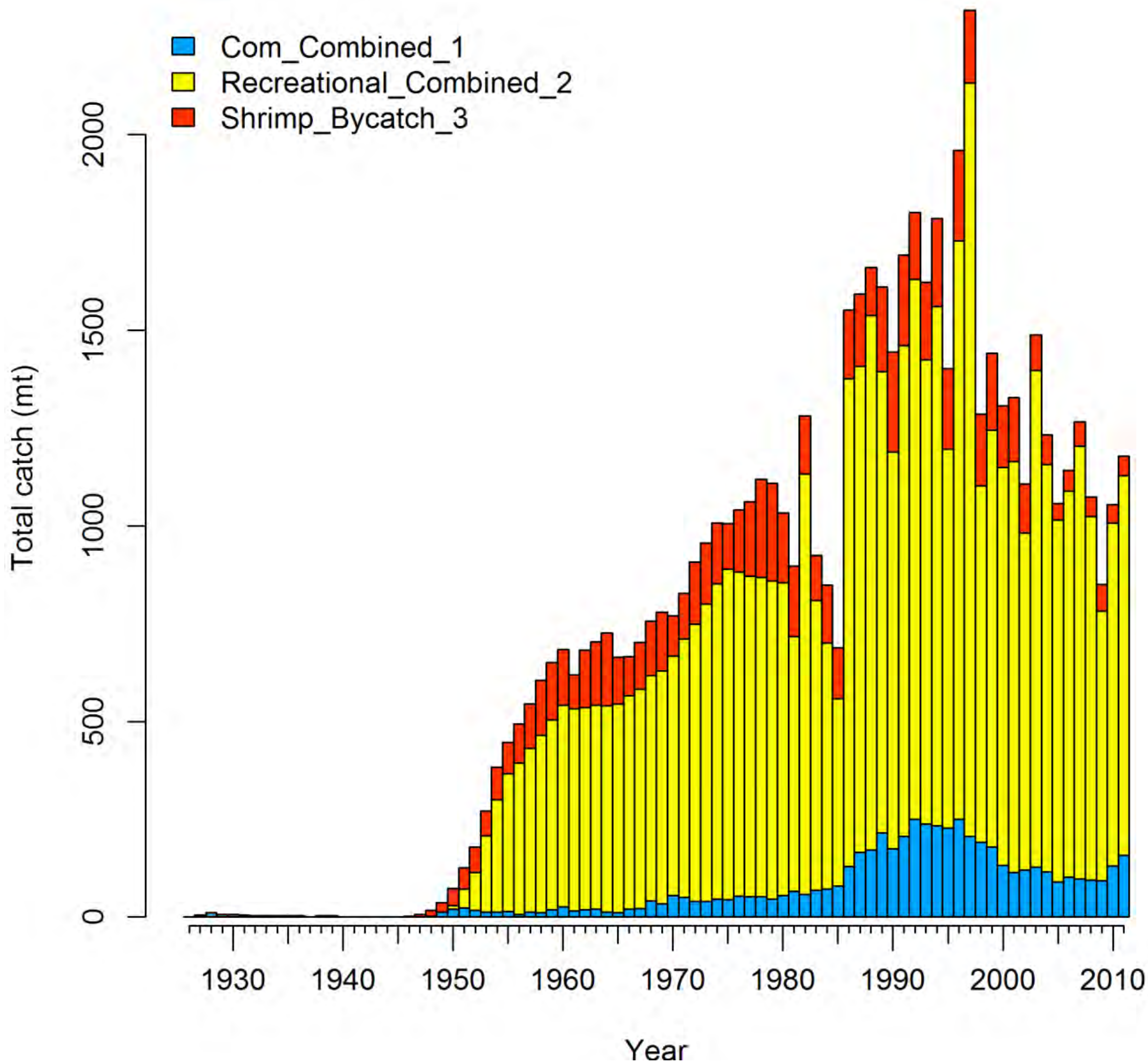

Figure 5.5. Gulf of Mexico Cobia estimated catch history, 1926-2011. Estimated catch includes both landings and discards.

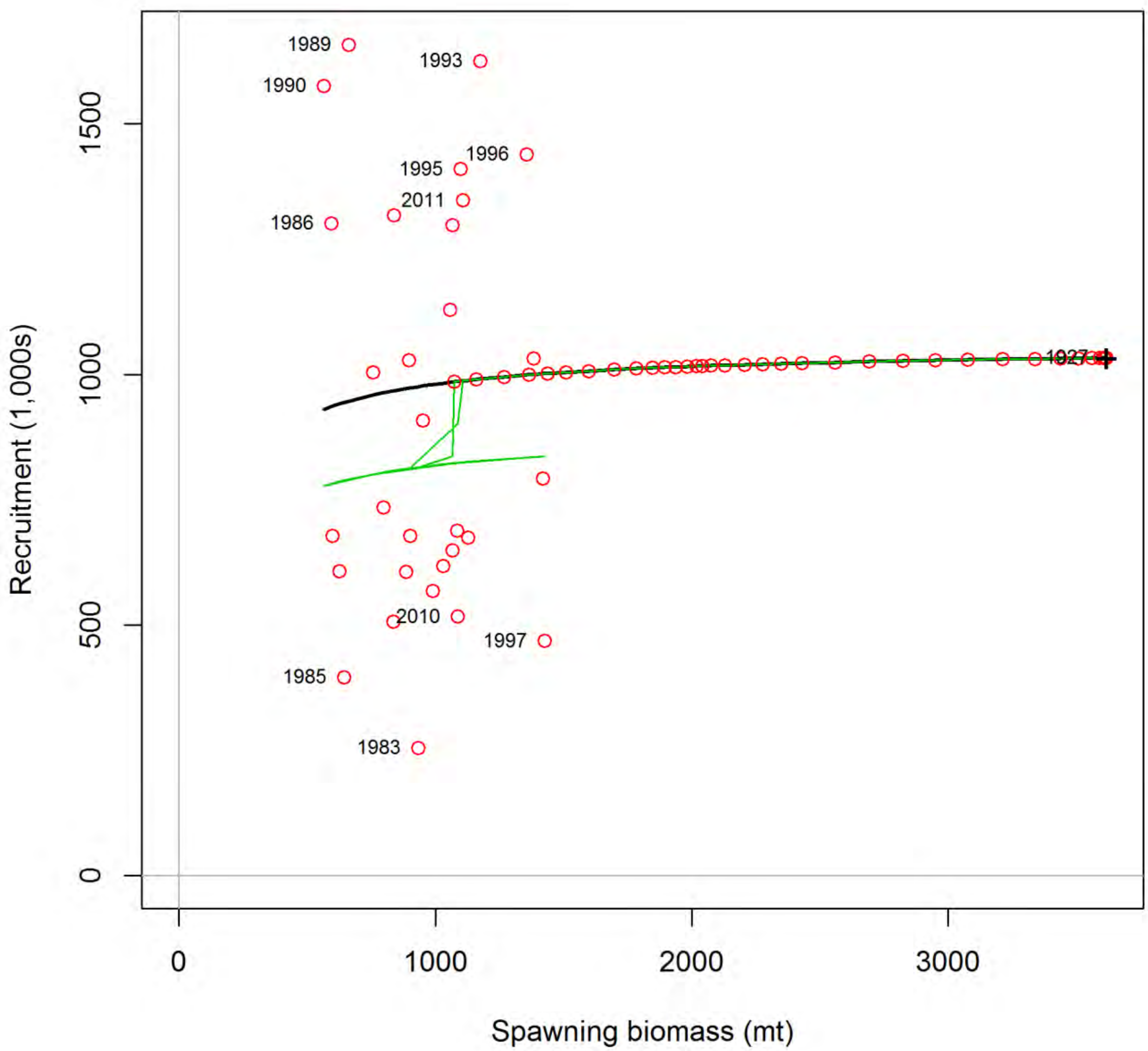

Figure 5.6. Predicted stock-recruitment relationship for Gulf of Mexico cobia for the base model. Plotted are predicted annual recruitments from SS (circles), expected recruitment from the stock-recruit relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (green line).

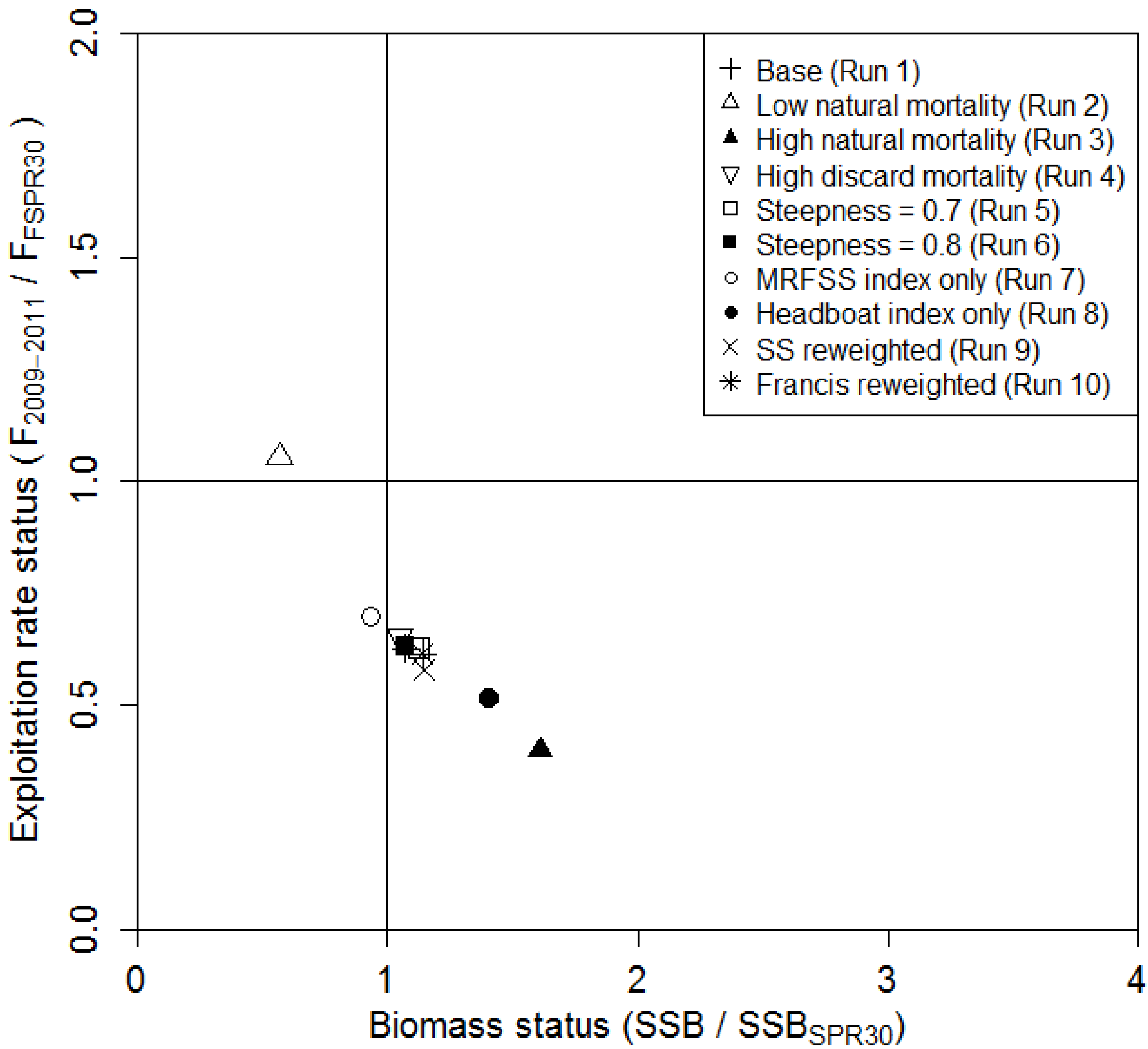

Figure 5.7. Phase plot of terminal status estimates relative to SPR 30% levels for all sensitivity runs.

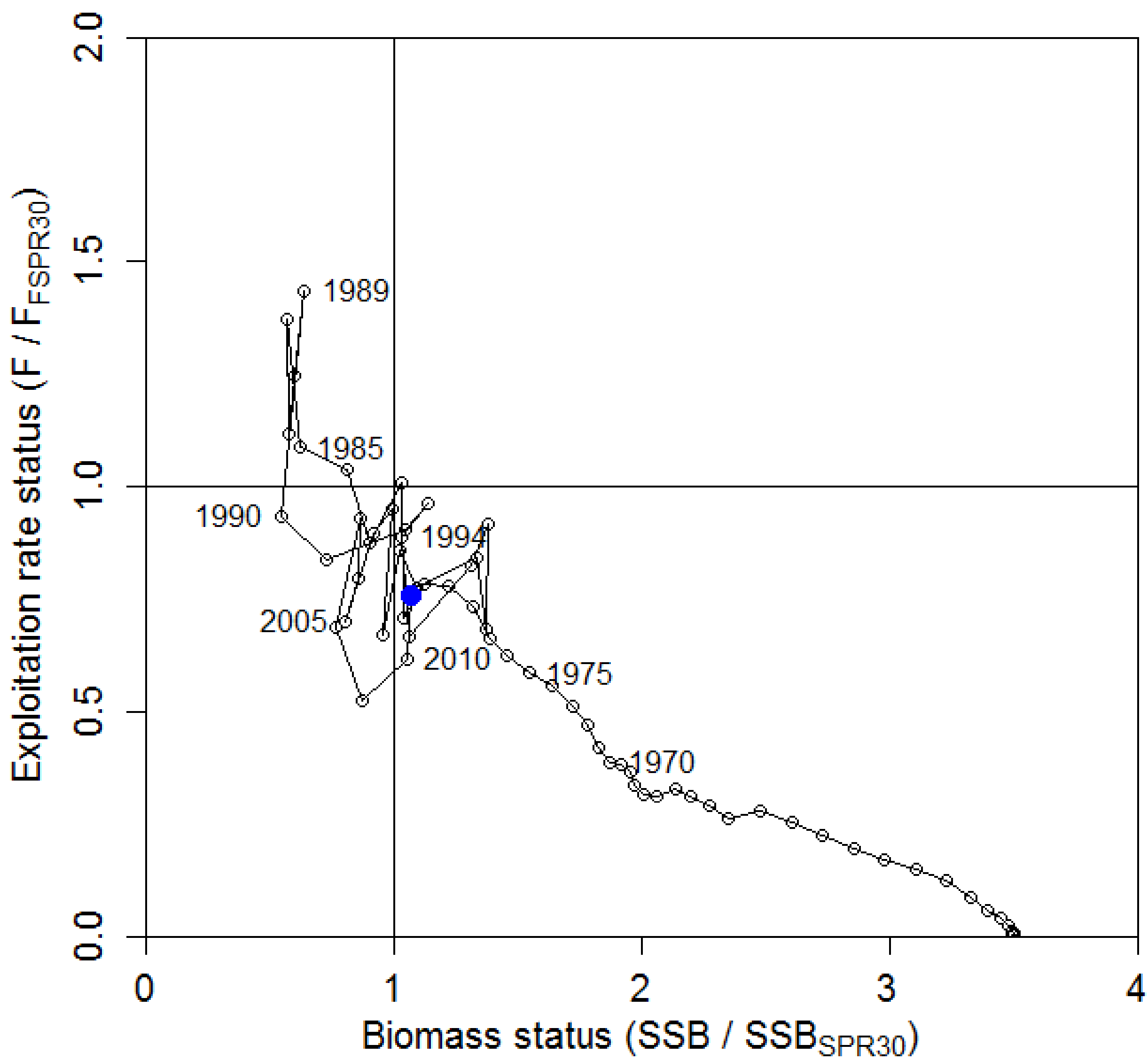

Figure 5.8. Stock status relative to reference targets for fishing mortality rate (FSPR30%) and spawning stock biomass (SSBSPR30%) over time for the base model. The large blue dot represents predicted stock status in 2011.

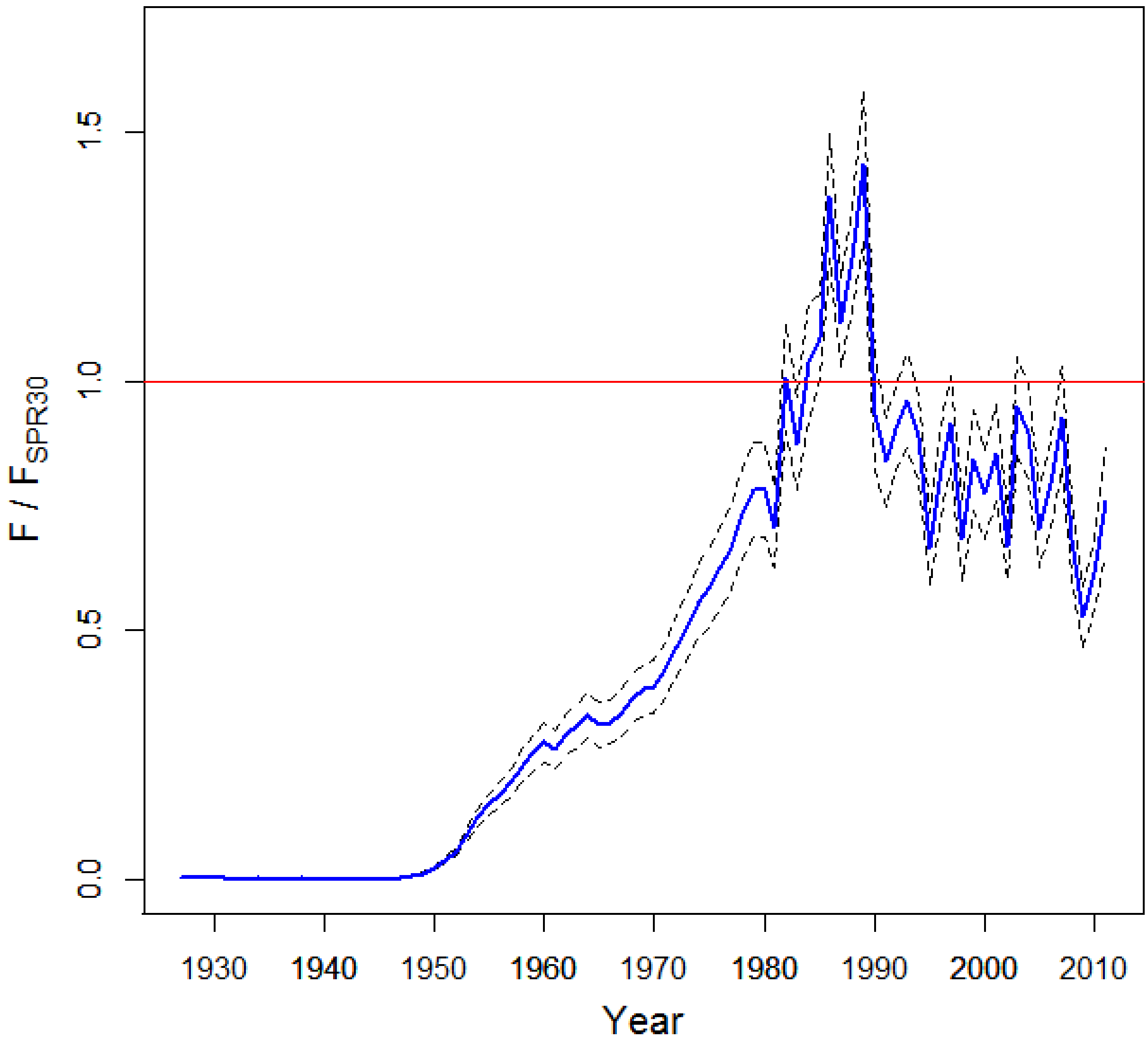

Figure 5.9. Total fishing mortality rate relative to $F_{SPR30\%}$ for Gulf of Mexico cobia with associated 80% asymptotic confidence limits.

6. SEDAR Abbreviations

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
EEZ	exclusive economic zone
F	Fishing mortality (instantaneous)
FMSY	Fishing mortality to produce MSY under equilibrium conditions
FOY	Fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	Fishing mortality rate resulting in retaining XX% of the maximum spawning production under equilibrium conditions
FMAX	Fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F_0	Fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fisheries and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	General Linear Model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MFMT	Maximum Fishing Mortality Threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSST	Minimum Stock Size Threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	Optimum Yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment and Review

SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Southeast Regional Office, National Marine Fisheries Service
SPR	Spawning Potential Ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 28

Gulf of Mexico Cobia

SECTION II: Data Workshop Report

May 2012

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

Contents

1 Introduction

1.1 Workshop Time and Place

The SEDAR 28 Data Workshop was held February 6-10, 2012 in Charleston, South Carolina. Webinars were held January 11, 2012 and March 14, 2012.

1.2 Terms of Reference

I. Data Workshop

1. Characterize stock structure and develop an appropriate stock definition. Provide maps of species and stock distribution.
2. Review, discuss and tabulate available life history information.
   - 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
3. Provide measures of population abundance that are appropriate for stock assessment.
   - Consider and discuss all available and relevant fishery dependent and independent data sources
   - Document all programs evaluated, addressing program objectives, methods, coverage (provide maps), sampling intensity, and other relevant characteristics
   - Develop CPUE and index values by appropriate strata (e.g., age, size, area, and fishery) and provide measures of precision and accuracy
   - Evaluate the degree to which available indices adequately represent fishery and population conditions
   - Recommend which data sources are considered adequate for use in assessment modeling
4. Characterize commercial and recreational catch.
   - Include both landings and discards, in pounds and number of fish
   - Provide estimates of discard mortality rates by fishery and other strata as feasible
   - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector
   - Provide length and age distributions if feasible, and maps of fishery effort and harvest
5. Determine appropriate stock assessment models and/or other methods of evaluating stock status, determining yields, estimating appropriate population benchmarks, and making future projections that are suitable for making management decisions.
6. Describe any environmental covariates or episodic events that would be reasonably expected to affect population abundance.
7. Provide any information available about demographics and socioeconomics of fishermen, especially as they may relate to fishing effort.
8. Provide recommendations for future research, including guidance on sampling design, intensity, and appropriate strata and coverage.

9. Develop a spreadsheet of assessment model input data that reflects the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet.
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

II. Assessment Process

1. Review and provide justifications for any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model.
2. Recommend a model configuration which is deemed most reliable for providing management advice using available compatible data. Document all input data, assumptions, and equations.
3. Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.
4. Provide estimates of stock population parameters.

- Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as appropriate given data availability and modeling approaches
- Include appropriate and representative measures of precision for parameter estimates

5. Characterize uncertainty in the assessment and estimated values.

- Consider components such as input data, modeling approach, and model configuration
- Provide appropriate measures of model performance, reliability, and 'goodness of fit'

6. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.
7. Provide estimates of stock status relative to management criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards for each model run presented for review.
8. Project future stock conditions and develop rebuilding schedules if warranted, including estimated generation time. Develop stock projections in accordance with the following:
   A) If stock is overfished:
      $F=0$, $F_{Current}$, F_{MSY}, F_{OY}
      $F=F_{Rebuild}$ (max that permits rebuild in allowed time)
   B) If stock is undergoing overfishing:
      $F= F_{Current}$, F_{MSY}, F_{OY}
   C) If stock is neither overfished nor undergoing overfishing:
      $F= F_{Current}$, F_{MSY}, F_{OY}
   D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice
9. Provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.

- Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments for use with the Tier 1 ABC control rule
- Provide justification for the weightings used in producing combinations of models

10. Provide recommendations for future research and data collection. Be as specific as possible in describing sampling design and intensity, and emphasize items which will improve assessment capabilities and reliability. Recommend the interval and type for the next assessment.
11. Prepare a spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.
12. Complete the Assessment Workshop Report (Section III: SEDAR Stock Assessment Report).

III. Review Workshop

1. Evaluate the quality and applicability of data used in the assessment.
2. Evaluate the quality and applicability of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.
5. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.
6. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.

- Provide measures of uncertainty for estimated parameters
- Ensure that the implications of uncertainty in technical conclusions are clearly stated
- If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.
- Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments
- Provide justification for the weightings used in producing the combinations of models

7. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.
8. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.
9. Make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring needs that could improve the reliability of future assessments

10. Prepare a Review Summary Report summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Review Summary Report no later than the date set by the Review Panel Chair at the conclusion of the workshop.

The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the SEDAR Guidelines and the SEDAR Review Panel Overview and Instructions.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made, alternate model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.**

1.3 List of Participants

Amy Dukes
Amy Schueller
Beverly Sauls
Bill Parker
Bob Zales II
Chip Collier
Chris Kalinowski
Chris Palmer
Dave Donaldson
David Gloeckner
Donna Bellais
Doug Devries
Doug Mumford
Eric Fitzpatrick
Erik Williams
Ernst Peebles
Jeanne Boylan
Jeff Isely
Jennifer Potts
Jim Franks
Joe Cimino
Joe Smith
John Ward
Julia Byrd
Julie Defilippi
Justin Yost
Karl Brenkert
Katie Andrews
Kelly Fitzpatrick
Ken Brennan
Kevin Craig
Kevin McCarthy
Kyle Shertzer
Lew Coggins
Liz Scott-Denton
Marcel Reichert
Matt Perkinson
Meaghan Bryan
Mike Denson
Nancie Cummings
Neil Baertlein
Pearse Webster
Read Hendon
Refik Orhum
Rob Cheshire
Robert Johnson
Rusty Hudson
Shannon Calay
Stephanie McInerny
Steve Brown
Ben Hartig
Kari Fenske
Ryan Rindone
Rachael Silvas
Mike Errigo
Sue Gerhart
Gregg Waugh
Clay Porch
Todd Gedamke
Mike Larkin
Steve Saul
Adam Pollack
Steve Turner
Patrick Gilles
John Carmichael
Michael Schirripa
Julie Neer
Tanya Darden
Tim Sartwell
Tom Ogle
Vivian Matter
Walter Ingram
Danielle Chesky
Katie Drew
Erik Hiltz
Frank Hester
Peter Barile
Carly Altizer
Marin Hawk
Mark E Brown
C. Michelle Willis
Carrie Hendrix
Jon Richardsen
Patrick Biando

1.4 List of Data Workshop Working Papers

Gulf and South Atlantic Spanish Mackerel and Cobia
Workshop Document List

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR28-DW01	Cobia preliminary data analyses – US Atlantic and GOM genetic population structure	T. Darden 2012
SEDAR28-DW02	South Carolina experimental stocking of cobia *Rachycentron canadum*	M. Denson 2012
SEDAR28-DW03	Spanish Mackerel and Cobia Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Pollack and Ingram, 2012
SEDAR28-DW04	Calculated discards of Spanish mackerel and cobia from commercial fishing vessels in the Gulf of Mexico and US South Atlantic	K. McCarthy
SEDAR28-DW05	Evaluation of cobia movement and distribution using tagging data from the Gulf of Mexico and South Atlantic coast of the United States	M. Perkinson and M. Denson 2012
SEDAR28-DW06	Methods for Estimating Shrimp Bycatch of Gulf of Mexico Spanish Mackerel and Cobia	B. Linton 2012
SEDAR28-DW07	Size Frequency Distribution of Spanish Mackerel from Dockside Sampling of Recreational and Commercial Landings in the Gulf of Mexico 1981-2011	N.Cummings and J. Isely
SEDAR28-DW08	Size Frequency Distribution of Cobia from Dockside Sampling of Recreational and Commercial Landings in the Gulf of Mexico 1986-2011	J. Isely and N. Cummings
SEDAR28-DW09	Texas Parks and Wildlife Catch Per unit of Effort Abundance Information for Spanish mackerel	N. Cummings and J. Isely
SEDAR28-DW10	Texas Parks and Wildlife Catch Per unit of Effort Abundance Information for cobia	J. Isely and N. Cummings
SEDAR28-DW11	Size Frequency Distribution of Cobia and Spanish Mackerel from the Galveston, Texas, Reef Fish Observer Program 2006-2011	J Isely and N Cummings
SEDAR28-DW12	Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the South Atlantic and Gulf of Mexico in 1981-1985 with For Hire Survey estimates with application to Spanish mackerel and cobia landings	V. Matter, N Cummings, J Isely, K Brennen, and K Fitzpatrick
SEDAR28-DW13	Constituent based tagging of cobia in the Atlantic and Gulf of Mexico waters	E. Orbesen
SEDAR28-DW14	Recreational Survey Data for Spanish Mackerel	V. Matter

	and Cobia in the Atlantic and the Gulf of Mexico from the MRFSS and TPWD Surveys	
SEDAR28-DW15	Commercial Vertical Line and Gillnet Vessel Standardized Catch Rates of Spanish Mackerel in the US Gulf of Mexico, 1998-2010	N. Baertlein and K. McCarthy
SEDAR28-DW16	Commercial Vertical Line Vessel Standardized Catch Rates of Cobia in the US Gulf of Mexico, 1993-2010	K. McCarthy
SEDAR28-DW17	Standardized Catch Rates of Spanish Mackerel from Commercial Handline, Trolling and Gillnet Fishing Vessels in the US South Atlantic, 1998-2010	K. McCarthy
SEDAR28-DW18	Standardized catch rates of cobia from commercial handline and trolling fishing vessels in the US South Atlantic, 1993-2010	K. McCarthy
SEDAR28-DW19	MRFSS Index for Atlantic Spanish mackerel and cobia	Drew et al.
SEDAR28-DW20	Preliminary standardized catch rates of Southeast US Atlantic cobia (*Rachycentron canadum*) from headboat data.	NMFS Beaufort
SEDAR28-DW21	Spanish mackerel preliminary data summary: SEAMAP-SA Coastal Survey	Boylan and Webster
SEDAR28-DW22	Recreational indices for cobia and Spanish mackerel in the Gulf of Mexico	Bryan and Saul
SEDAR28-DW23	A review of Gulf of Mexico and Atlantic Spanish mackerel (*Scomberomorus maculatus*) age data, 1987-2011, from the Panama City Laboratory, Southeast Fisheries Science Center, NOAA Fisheries Service	Palmer, DeVries, and Fioramonti
SEDAR28-DW24	SCDNR Charterboat Logbook Program Data, 1993 - 2010	Errigo, Hiltz, and Byrd
SEDAR28-DW25	South Carolina Department of Natural Resources State Finfish Survey (SFS)	Hiltz and Byrd
SEDAR28-DW26	Cobia bycatch on the VIMS elasmobranch longline survey:1989-2011	Parsons et al.
Reference Documents		
SEDAR28-RD01	List of documents and working papers for SEDAR 17 (South Atlantic Spanish mackerel) – all documents available on the SEDAR website	SEDAR 17
SEDAR28-RD02	2003 Report of the mackerel Stock Assessment Panel	GMFMC and SAFMC, 2003
SEDAR28-RD03	Assessment of cobia, *Rachycentron canadum*, in the waters of the U.S. Gulf of Mexico	Williams, 2001

SEDAR28-RD04	Biological-statistical census of the species entering fisheries in the Cape Canaveral area	Anderson and Gehringer, 1965
SEDAR28-RD05	A survey of offshore fishing in Florida	Moe 1963
SEDAR28-RD06	Age, growth, maturity, and spawning of Spanish mackerel, *Scomberomorus maculates* (Mitchill), from the Atlantic Coast of the southeastern United States	Schmidt et al. 1993
SEDAR28-RD07	Omnibus amendment to the Interstate Fishery Management Plans for Spanish mackerel, spot, and spotted seatrout	ASMFC 2011
SEDAR28-RD08	Life history of Cobia, *Rachycentron canadum* (Osteichthyes: Rachycentridae), in North Carolina waters	Smith 1995
SEDAR28-RD09	Population genetics of cobia *Rachycentron canadum*: Management implications along the Southeastern US coast	Darden et al, 2012
SEDAR28-RD10	Inshore spawning of cobia (*Rachycentron canadum*) in South Carolina	Lefebvre and Denson, 2012
SEDAR28-RD11	A review of age, growth, and reproduction of cobia *Rachycentron canadum*, from US water of the Gulf of Mexico and Atlantic ocean	Franks and Brown-Peterson, 2002
SEDAR28-RD12	An assessment of cobia in Southeast US waters	Thompson 1995
SEDAR28-RD13	Reproductive biology of cobia, *Rachycentron canadum*, from coastal waters of the southern United States	Brown-Peterson et al. 2001
SEDAR28-RD14	Larval development, distribution, and ecology of cobia *Rachycentron canadum* (Family: Rachycentridae) in the northern Gulf of Mexico	Ditty and Shaw 1992
SEDAR28-RD15	Age and growth of cobia, *Rachycentron canadum*, from the northeastern Gulf of Mexico	Franks et al 1999
SEDAR28-RD16	Age and growth of Spanish mackerel, *Scomberomorus maculates*, in the Chesapeake Bay region	Gaichas, 1997
SEDAR28-RD17	Status of the South Carolina fisheries for cobia	Hammond, 2001
SEDAR28-RD18	Age, growth and fecundity of the cobia, *Rachycentron canadum*, from Chesapeake Bay and adjacent Mid-Atlantic waters	Richards 1967
SEDAR28-RD19	Cobia (*Rachycentron canadum*) tagging within Cheasapeake Bay and updating of growth equations	Richards 1977
SEDAR28-RD20	Synopsis of biological data on the cobia *Rachycentron canadum* (Pisces: Rachycentridae)	Shaffer and Nakamura 1989
SEDAR28-RD21	South Carolina marine game fish tagging program 1978-2009	Wiggers, 2010

SEDAR28-RD22	Cobia (*Rachycentron canadum*), amberjack (*Seriola dumerili*), and dolphin (*Coryphaena hipurus*) migration and life history study off the southwest coast of Florida	MARFIN 1992
SEDAR28-RD23	Sport fish tag and release in Mississippi coastal water and the adjacent Gulf of Mexico	Hendon and Franks 2010
SEDAR28-RD24	VMRC Cobia otolith preparation protocol	VMRC
SEDAR28-RD25	VMRC Cobia otolith ageing protocol	VMRC

2 Life History

2.1 Overview

State and federal biologist and industry representatives comprised the Life History Work Group (LHWG)

Jennifer Potts – NMFS, Beaufort, NC, Leader of LHWG
Doug DeVries – NMFS Panama City, Leader of Gulf cobia LHWG
Chris Palmer –NMFS Panama City, Leader of Gulf Spanish mackerel LHWG
Chip Collier – Data provider, SA SSC
Michael Denson – Data provider, SCDNR, Charleston, SC
Tanya Darden – Data provider, SCDNR, Charleston, SC
Justin Yost – Data provider, SCDNR, Charleston, SC
Karl Brenkert – Data provider, SCDNR, Charleston, SC
Matt Perkinson – Data provider, SCDNR, Charleston, SC
Jim Franks – GC Data provider, USM
Randy Gregory – Data provider, NC DMF
Read Hendon – GC Data provider, USM
Chris Kalinowski – SAC Data provider, GA DNR
Tom Ogle AP, Recreational, SC
Bill Parker – Charter, SC
Ernst Peebles – Data provider, USF
Marcel Reichert – Data provider, SA SSC
Joe Smith – SAC Data provider, NMFS Beaufort
John Ward – Gulf socioeconomics, Gulf SSC
Erik Williams – Data provider, NMFS Beaufort

The LHWG was tasked with combining age data sets from four sources: a Gulf Coast Research Lab (GCRL) study (Franks et al. 1999), a Mote Marine Lab study (Burns et al. 1998), the National Marine Fisheries Service Beaufort Laboratory, and the NMFS Panama City laboratory. In order to combine age data from all sources, the LHWG needed to be sure that aging methodology between agencies was consistent.

2.2 Review of Working Papers

(SEDAR28-DW01) Cobia Preliminary Data Analyses U.S. Atlantic and **GOM Genetic Population Structure** Author: Tanya Darden

Abstract
With available data (west FL and northern GOM have low sample sizes), GOM appears to be a genetically homogenous group continuing around the FL peninsula with a genetic break occurring around northern FL and GA. The Atlantic population segment appears to have a genetically homogenous offshore component and genetically unique inshore components.

Critique
The working paper submitted by Darden presented preliminary information on stock structure for cobia in the Gulf of Mexico and U.S. Atlantic Coast using 10 microsatellite loci. The methods and microsatellite loci were based on a report that is currently in review. The study sampled fish from April through July from 2004-2011 with most overlap coming from 2008 to 2010. There was temporal overlap in most samples and had adequate sample sizes for most areas (>100 for NC, SC, SC offshore, FL East Coast, and TX). An increase in the samples off Florida would help provide more resolution in the location of genetic break. Although there is some difference in the collection year by area, the samples were collected from fish during the spawning season and all fish were mature from multiple year classes (described by author later). The methods and data used were appropriate and results can be used for management.

(SEDAR28-DW05) Evaluation of Cobia Movements and Distribution Using Tagging Data from the Gulf of Mexico and South Atlantic Coast of the United States. Authors: Matt Perkinson and M.R. Denson

Abstract
Cobia movement and distribution in the Southeastern United States and the Gulf of Mexico was evaluated using tag-recapture information provided from recreational anglers, commercial fishermen and charterboat captains. Three data sets were provided by the South Carolina Department of Natural resources, the Mote Marine Laboratory, and the Gulf Coast Research Laboratory. A fourth data set of tagged cultured fish from the South Carolina Department of Natural Resources was also evaluated. Cobia were tagged over similar periods, with methodologies and tags that were not appreciably different between programs. Tag-recapture in all four studies yielded similar patterns. Only fish at large for greater than 30 days were included in the analysis. Approximately 79% of tagged fish were recaptured in the region in which they were tagged. Only 1% of cobia tagged in the South Atlantic north of Florida were recaptured in the Gulf, and of those tagged in the Gulf only 1% were recaptured in the Atlantic north of Florida. Cobia tagged on the east coast of Florida are caught North of Florida and in the Gulf of Mexico suggesting a mixed stock off of Florida. Datasets were pooled and partitioned by tag recapture location off of Florida beginning with the Georgia-Florida border and north (GAN), the Georgia Florida border to the Brevard/Volusia County line (N-BR), the Brevard County from Brevard/Volusia County line to Sebastian Inlet (Brevard/Indian River County line)(BR), waters offshore of Sebastian Inlet to Biscayne Bay (S-BR), from Biscayne Bay around the tip of Florida to First Bay on the Gulf side, encompassing all of the Florida Keys (Keys) and the Gulf from First Bay through the Gulf States to the Texas/Mexico line. Cobia tagged south of Brevard County are much more likely to be recaptured in the Keys or Gulf (95%). These results suggest two stocks of fish that overlap at Brevard county Florida.

Critique
Working paper 05 provides a good overview and comparison of the methods, scope, and results of the three major cobia tagging efforts conducted in the Southeast U.S. since 1974. More importantly it reported the results of an analysis using a pooled data set of all three studies which examined movement patterns between Gulf and Atlantic waters with a special emphasis on fish tagged on the east coast of Florida. The findings presented in this

document, which were widely vetted before and during SEDAR28 and well received, were very helpful and influential in defining cobia stock boundaries. This document was recommended for use by the LHWG.

(SEDAR28-DW13) Constituent based tagging of cobia in the Atlantic and Gulf of Mexico waters. Author: E. Orbesen

Abstract
Data used in this analysis were derived from the Southeast Fisheries Science Center's Cooperative Tagging Center conventional tagging program. The data set contains 1510 cobia tag releases and 148 recaptures over 58 years of data collection. Exchange and mixing were examined between six geographical regions.

Critique
Working paper 13 summarizes the tag recapture data provided by the Southeast Fisheries Science Center's Cooperative Tagging Center conventional tagging program. The time series and methods are comparable with the data included in ***SEDAR28-DW05****, v2; fish were tagged by recreational anglers using anchor or dart tags mostly during the 1990's and 2000's. Tag returns (N=148) have also been assigned to the zones (GAN, N-BR, BR, S-BR, KEYS, GULF) used in* ***SEDAR28-DW05****. The results appear to support the suggestion of separate stocks in the South Atlantic and Gulf, with mixing occurring somewhere around Brevard County, FL. Fish tagged north of Brevard County were largely recaptured north of Brevard County (91%). Fish tagged south or west of Brevard County were largely recaptured south or west of Brevard County (97%). Fish tagged in Brevard County were recaptured to the north (18%), in Brevard (35%), and to the south and west (44%). Recapture percentages are also reported for each zone, but I would be hesitant to include these data in any analyses, as recaptures are often reported without any coinciding tagging data (i.e., anglers may not report all fish they have tagged), leading to an overestimation of recapture rate. The methods appear sound and the data strongly agree with the result of other tagging datasets for the South Atlantic and Gulf of Mexico.*

(SEDAR28-DW02) South Carolina experimental stocking of cobia *Rachycentron canadum*. Author: M.R. Denson

Abstract
The South Carolina Department of Natural Resources has been experimentally spawning wild cobia adults captured in local waters, rearing larvae to a number of juvenile sizes and stocking them back in the same systems. All fish released into the wild are identifiable using a unique genetic tag (microsatellites) and differentiated from wild fish when they are collected in the recreational fishery. Size permitting; fish were also tagged with external dart tags prior to release to make them identifiable to anglers. Fish enter SC waters to spawn in April and are available to recreational anglers at a legal minimum size of 33-inch fork length. This size represents a three- year-old fish (when full recruitment occurs). In order to determine the contribution of stocked fish to the local population, fin clips are removed from fish sampled at fishing tournaments, collected from charterboat captains, recreational fishermen and from SCDNR staff. Stocking contributions are determined and analyzed as a general contribution

to the sampled population, as well as to specific yearclasses as determined by otolith-based age determination. Contributions are also evaluated by inshore and offshore collections.

Critique
The paper is a brief overview of the contribution of cobia stocked in 2007 and 2008 by SC-DNR in the Colleton River (SC) has on the wild stock in SC and Georgia, where sampling of the wild stock occurred. Genetic techniques were used to follow this contribution. The paper provides a brief but thorough overview of the data, as well as some limited other information. The data indicate that the contribution of fish stocked to fish in the wild population was at a maximum of 7.3% in 2010, 4.6% in 2011, and is expected be diminish in future years. The paper does not address the potential if and how the stocked fish may affect the population, if an effect exists at all. The information in this paper seems of limited use for the LH WG.

2.3 Stock Definition and Description

2.3.1 Population genetics

Evidence was presented by Dr. Tanya Darden regarding a genetic-based evaluation of population structure between the U.S. South Atlantic and Gulf of Mexico populations described in more detail in SEDAR 28-DW01 (Darden, 2012). Complete methods are documented in SEDAR 28-DW01 and SEDAR 28-RD09 (Darden et al., 2012). Microsatellite-based analyses demonstrated that tissue samples collected from NC, SC, the east coast of Florida (near St. Lucie), MS and TX showed disparate allele frequency distributions and subsequent analysis of molecular variance showed population structuring occurring between the states. Results showed that the Gulf of Mexico stock appears to be genetically homogeneous and that segment of the population continues around the Florida peninsula to St. Lucie, Florida, with a genetic break between where the St. Lucie samples were collected and Port Royal Sound in South Carolina (Figure 2.3.1.1). Finer-scale analyses of the sample areas in the South Atlantic segment of the population suggest a genetically homogenous offshore component and genetically unique inshore components.

Following the January 11, 2012 SEDAR28 webinar, the panel had come to consensus on key points of the South Atlantic and Gulf of Mexico stock definitions:

- Panel consensus: For South Atlantic (SA) cobia, combine estuarine and offshore stocks (data isn't fine enough to split in many cases).
- Panel consensus: Northern boundary for SA should include data through New York.
- Panel consensus: Southern boundary for SA should be Cape Canaveral (based on tagging and genetic data), subject to further review at DW if further data can be examined, Gulf would be south of Cape Canaveral through the Gulf. Consider Volusia/Flagler line for data division of recreational data.

2.3.2 Tagging

Tag-recapture data

Cobia movement and distribution in the southeastern United States and the Gulf of Mexico was evaluated using tag-recapture information provided from recreational anglers, commercial fishermen and charter boat captains. The South Carolina Department of Natural Resources (Wiggers, 2010), the Mote Marine Laboratory (Burns and Neidig, 1992) and the Gulf Coast Research Laboratory (Hendon and Franks, 2010) provided three data sets. Cobia were tagged over similar periods with methodologies and tags that were not appreciably different between programs. Only fish at large >30 days were included in the analysis. Tag-recaptures in all three studies yielded similar patterns. Approximately 78% of tagged fish were recaptured in the region in which they were tagged. Only 1% of cobia tagged in the U.S. south Atlantic north of Florida were recaptured in the Gulf, and of those tagged in the Gulf, only 1% were recaptured in the Atlantic north of Florida. Cobia tagged off the east coast of Florida were recaptured north of Florida and in the Gulf of Mexico, suggesting stocks mix in that area. Datasets were pooled and partitioned by initial tagging location beginning with the Georgia / Florida border and north (GAN), the Georgia/Florida border to the Brevard/Volusia County line (N-BR), Brevard County from the Brevard/Volusia County line to Sebastian Inlet (Brevard/Indian River County line)(BR), Sebastian Inlet to Miami (S-BR), Miami around the tip of Florida to Marco Island on the Gulf side, encompassing all of the Florida Keys (Keys), and the Gulf from Marco Island through the Gulf states to the Texas/Mexico line. The combined data show that cobia tagged north of Brevard County were primarily recaptured from Brevard County to the north (99%) (Table 2.3.2.2). Of cobia tagged in Brevard County, 25% were recaptured north of there, 39% in Brevard County and 36% in S-BR, the Keys or the Gulf (Figure 2.3.2.1). Cobia tagged in S-BR, the Keys, or the Gulf were mostly recaptured from Brevard south through the Keys and Gulf (98%)(Table 2.3.2.1). Additional tagging datasets from the Virginia Institute of Marine Science (Susanna Musick, personal communication), SCDNR stock enhancement program (Denson, 2012) and Southeast Fisheries Science Center (Orbesen, 2012) reflect a similar pattern with very little movement between the Gulf and GAN, while fish tagged in BR moved both to the north and to the south through the Keys and Gulf. These results suggest two stocks of fish that overlap at Brevard County Florida and corroborate the genetic findings presented in SEDAR 28-DW01.

It was noted that the recorded location of recaptures were not pin-pointed, but rather given a more general description (e.g., 10 miles off Cape Canaveral). A judgment call was made to assign the recaptured fish to a particular region when the reported location was between regions (e.g. Sebastian Inlet for BR vs. S-BR). A more complete evaluation of the tagging datasets can be found in SEDAR28-DW05 (Perkinson and Denson, 2012).

Discussion of cobia stock definition/delineation between South Atlantic and Gulf of Mexico.

Data workshop LHWG discussions considered specific suggestions to set a stock boundary split at Brevard county Florida based on data that fish tagged in Brevard County are caught both north and south of Brevard County. Discussions of the tagging data pointed out that the available landings data lacked the resolution to separate the stocks within a county.

- A proposal was made to separate the stocks at the FL/GA line because the genetic data suggest that the split is north of the Brevard/Indian River County line and there is no tagging data to dispute this split.
- A second proposal was made suggesting the split at the Brevard County/Indian River County line.

Neither proposal is disputed by the genetic and tagging data.

****During Plenary session the first option FL/GA line was selected based on recommendations from the commercial and recreational work groups and comments that for ease of management the FL/GA line would be the preferable stock boundary and did not conflict with the life history information available. However, there is not enough resolution in the genetic or tagging data to suggest that a biological stock boundary exists specifically at the FL/GA line, only that a mixing zone occurs around Brevard County, FL and potentially to the north. The Atlantic stock would extend northward to New York.**

2.4 Natural Mortality

Natural mortality rate (M) in many marine fish stocks is a difficult parameter to estimate. Several equations that use various life history parameters (L_∞, k, maximum age, age at 50% maturity) have been derived to attempt to estimate M. Refer to other sections of this life history report for the methodologies used to calculate each of the life history parameters. Because cobia will migrate due to changes in water temperature, cobia's preferred water temperature, 25^{o} C, was used in the Pauly M calculation. The LHWG examined point estimates of M for Gulf stock cobia from 14 equations (Table 2.4.1) and the age-varying M from Lorenzen (1996), and those estimates ranged widely.

The five methods which rely heavily on the von Bertalanffy k yielded the five highest estimates of M, ranging from 1.73 (Ralston geometric mean) to 0.64 (Pauly) (Table 2.4.2 and Figure 2.4.1). The LHWG cautions using these estimates because of the issues inherent in modeling growth of the species. L_∞ and k are inversely correlated and can be highly variable depending on the range of the input data and assumptions made when modeling growth.

The estimates of M derived from methods relying more on maximum age in the population ranged from 0.26 to 0.63, although 7 of the 8 fell between 0.26 and 0.42 (Table 2.4.2). Hoenig (1983), Hewitt and Hoenig (2005), and Alagaraja (1984), which all use maximum age exclusively, averaged 0.37. The Hoenig estimate from the "fish" equation was 0.38. Estimates of M using maximum age have been generally accepted by previous SEDARs. Before selecting a maximum age in the population, it is critical to consider how many fish were sampled to find that one, old fish; what the longevity of the species could be in an un-fished stock; and what amount of error is associated with the age readings. These questions were considered by the LHWG, and maximum age in the population was set at 11 years based on the oldest fish in the GCRL study (Franks et al.1999).

The maximum reported age of 16 yr for putative Atlantic stock cobia was 5 years older than that for the Gulf – hence the Hoenig estimate of M (0.26) for that stock was much lower. After considerable discussion, the LHWG concluded, based on the available evidence, that this difference was real. Cobia are not particularly difficult to age and the size at age data was reasonably consistent among all the groups doing the ageing, even between stocks. Sample sizes of both stocks were sufficiently large, and maximum ages were similar among studies within stocks. In the two major studies providing most of the age data for the Gulf stock in SEDAR 28, maximum reported ages for females and males, respectively, were 7 and 9 (Burns et al. 1998) and 11 and 9 (Franks et al. 1999). In the much smaller Beaufort NMFS (n=113) and Panama City NMFS (n=62) data sets, the oldest fish was a 9 yr old male in the former and a 9 yr old female in the latter. Thompson et al. (1992), whose raw data were not available for SEDAR 28, found maximum ages of 10 for both sexes in Louisiana. In contrast, among Atlantic studies north of Florida, Virginia collections (n=905) produced one 16 and four 15 yr olds, North Carolina (n=365) yielded one 14 and four 13 yr olds, and in South Carolina (n=1469) one age 13 and 7 age 12 fish were caught. It is not uncommon for the same species of fish or close congeners in the Gulf of Mexico and the Atlantic to exhibit a difference in maximum age, e.g., red drum (Beckman et al., 1989; Murphy and Taylor, 1990; Ross et al., 1995) and Gulf menhaden and Atlantic menhaden (Ahrenholz, 1991).

Consistent with the recommendations of previous SEDAR panels for other species, including king mackerel *Scomberomorus cavalla* in SEDAR 16 and Spanish mackerel *S. maculatus* in SEDAR 17, the LHWG recommends modeling the natural mortality rate of Gulf stock cobia as a declining 'Lorenzen' function of size (translated to age by use of a growth curve) (Lorenzen 1996). The growth curve used was the von Bertalanffy equation corrected for size-selection bias, inversely weighted by sample size, and for which t_0 was freely estimated. The Lorenzen curve was scaled such that the average value of M over the range of fully-selected ages (3-11 yr) was the same as the point estimate of 0.38 from Hoenig's (1983) regression. Preliminary calculations of M based on the growth information available at the data workshop, along with sensitivity runs scaled to low (0.26) and high (0.42) estimates of M are shown in Figure 2.4.2.

LHWG Recommendation:
Use an age-variable M estimated using the Lorenzen method (Lorenzen 2005) assuming a base M = 0.38 calculated from Hoenig_{fish} (1983). Sensitivity runs using a range of Lorenzen age-variable M values equating to a CV of 0.54 (MacCall 2011) of the Hoenig estimate are also recommended, though that value may be too high (Hoenig comment in MacCall in Brodziak et al., 2011). The LHWG recommends the assessment workshop explore this issue by applying a range of CVs.

2.5 Discard Mortality

Discard mortality is an important estimation included in stock assessments and rebuilding projections calculated from a stock assessment. Discard mortality rate can be impacted by several factors including: fish size, sea conditions, temperature, air exposure, handling, light conditions, and delayed mortality (Davis 2002). The longer fish are exposed to most of these factors and the more severe they are, the greater the cumulative stress on the fish (Rummer and Bennett 2007). The impacts of many of these factors are difficult to track or quantify and have lead to variability in determining discard mortality rates for a variety of species. Cobia are harvested by several gears, which have varying discard mortality rates. Currently, few data sets are published on discard mortality of cobia (Harrington et al. 2005). Data are collected by the NOAA Southeast Fisheries Science Center on discards in the commercial logbook program. This program randomly samples 20% of commercial vessels operating in the South Atlantic and Gulf of Mexico. From the commercial logbooks, discards were classified into five categories of kept, alive, mostly alive, mostly dead, and dead for gillnets, hook and line, and trolling fisheries. There few data sources that had information on discard mortality. Information was available from logbooks and one observer program. The logbooks reported most cobia released were released alive in bandit (98%) and longline (92%) fisheries. Some anecdotal information on hook and line discard mortality was brought forward during SEDAR 28 including fish recaptured in the VA Marine Resources Commission Tagging Program and SC Department of Natural Resources broodstock collection. The VMRC had 20 fish recaptured that were released in poor condition. The recaptured fish, when initially released, were reported to have been gut hooked, have broken gill arches, bleeding from deep hooking, and one fish was tied off for two hours before tagging. SC DNR collected 60 cobia for brood stock using hook and line and only had one mortality within one week of collection and transportation.

Cobia are also caught in gillnet fisheries. These fisheries target a variety of species including: Spanish mackerel, sharks, sea mullet (*Menticirrhus* spp), Atlantic croaker, and other species. Observers have been onboard boats in the gillnet fishery and reported the number of fish released dead and alive. Of 539 cobia discarded during the observer study, 51% were released dead (Table 2.5.1, Simon Gulak, Gillnet Coordinator SEFSC NOAA Fisheries, personal communication).

Discussion

There was limited discussion on the discard mortality rates of cobia. The panel felt the fish were hardy and not likely to have the barotraumas issues common to many of the snapper and grouper species in the South Atlantic and Gulf of Mexico. A 5% discard mortality rate was estimated for the hook and line fishery with a range of 2 to 8%. The gillnet fishery discard mortality was agreed to be 51% with a range of 36 to 77%. The range was developed from gillnet fisheries with 10 or greater cobia observed released. The discard mortality rate developed for the gillnet fishery may not reflect the discard mortality rate for the remaining gears in the “other gears” category. Informed judgment should be used to develop a discard mortality rate potentially weighted on the number of discards in each fishery as has been done in past SEDARs.

LHWG Recommendation: Use the following discard rates and examine sensitivities at the ranges within parentheses:

Hook 5% (2 to 8%)
Recreational and Commercial Gillnet 51% (36-77%)

2.6 Age

The final age data set for Gulf stock cobia for SEDAR 28 contains 1231 observations which came largely from two studies – one at the Gulf Coast Research Lab (GCRL) (Franks et al. 1999) (n=513, 1987-1991) and the other at Mote Marine Lab (Burns et al. 1998)(n=545, 1995-1997). In addition, 113 fish were collected by the Beaufort NMFS lab (2004-2007) and 62 by the Panama City NMFS lab (1992-2010) (Figure 2.6.1). The vast majority of fish aged were caught by hook and line: 100% of GCRL, 93% of Mote, 93% of Beaufort NMFS, and 81% of Panama City NMFS; and virtually all were from the recreational fishery, i.e., fishery dependent samples. Specimens for the GCRL and Mote studies came primarily from dockside and fishing tournament sampling. Samples for the Beaufort NMFS study came almost entirely from headboats and charter boats, while the majority of Panama City NMFS samples were about equally spread among headboats and commercial reef fish vessels, with a few from private recreational boats and scientific surveys.

Fish in the final age data set ranged from 355 to 1639 mm FL, and 98% were <1350 mm (Figure 2.6.2). The overall size distribution of the age samples was somewhat knife-edged at the lower end because of the 838 mm (33 inch) federal minimum size limit imposed in 1985 and the very high proportion of fishery dependent samples. Reflecting their sexually dimorphic growth patterns, males ranged from 365 to 1390 mm FL and females from 355 to 1639 mm; 98 % of males were <1240 mm and 98 % of females were <1390 mm (Figure 2.6.3).

The only other significant source of cobia age data (n=646 fish aged) from the Gulf of Mexico was a MARFIN-funded study conducted at Louisiana State University from 1987 through 1991 (Thompson et al. 1992). Unfortunately, the lead investigator on that study is deceased, and despite significant efforts on the part of other investigators on the project, the raw data files could not be located.

All cobia ages were derived from annulus counts taken from transverse sections of sagittal otoliths (Burns et al. 1998, Franks et al. 1999, SEDAR28-RD25). All age data included an increment count. Based on the timing of annulus formation and an estimate of the amount of translucent edge present, all increment counts were converted to calendar age (SEDAR25-RD41). Calendar ages were converted to fractional age using a May 1 birthday. Ages in the original GCRL data set were simply increment counts – not calendar ages – but the data set did include marginal increment codes which were easily converted to the Gulf States Marine Fisheries Commission system (Table 2.6.1) currently used by all Gulf states. These in turn were used to determine calendar age. For any fish caught July-December, calendar age = increment count regardless of edge code. For any fish caught Jan-Jun with an edge code of 3 or 4, calendar age = annulus count + 1. No fish with an edge code of 1 or 2 were caught during Jan-Mar, but for those caught Apr-Jun, calendar age = annulus count (i.e., ages were not advanced). In the original Mote data set, only raw annulus counts were available (i.e., there were no marginal increment codes and they did not calculate calendar age). Based on examination of monthly distribution of annulus edge types in the GCRL study, the decision was made to estimate calendar age of Mote fish using the following protocol: advance the ages of all Mote fish collected Jan-Apr by one year, i.e., final or calendar age = ring count + 1. For fish collected during May-Dec, ages were not advanced, i.e., the final or calendar age = ring count.

2.6.1 Age Reader Precision and Aging Error Matrix

Because 86% of Gulf stock cobia ages for SEDAR 28 came from the GCRL and Mote studies conducted 15-20 yr ago, it was not possible to do reader comparisons and generate an aging error matrix. However, the scientists who conducted the ageing for the Mote study were trained by those who conducted the GCRL study (primarily Jim Franks), and he was quite confident the Mote fish were aged accurately. In addition, a simple comparison between those two studies of mean size at age showed very little difference between them for all the most common ages (Figure 2.7.1). All of the Beaufort NMFS samples were aged by Beaufort lab personnel, while those from the Panama City NMFS lab were aged by the same SCDNR personnel who aged a large portion of the Atlantic stock fish for SEDAR28; and both Beaufort and SCDNR personnel are currently taking part in a reader comparison exercise to ensure there are no non-random differences in their ageing results.

2.7 Growth

Cobia, like many pelagic fishes, have very fast growth in the first few years of life. Cobia also exhibit sexually-dimorphic growth, with females attaining larger sizes-at-age and maximum sizes than males. Growth was modeled using the von Bertalanffy growth model. To account for growth of the fish throughout the year, increment counts were converted to calendar ages (Age_{cal}) based on timing of increment formation, and then a fraction of the year was added or subtracted based on the month in which the fish was caught (Age_{frac}). Most of the fish were caught during the time of increment formation, which is in May and June, or later. For those fish caught before June with a wide translucent marginal, the increment counts were bumped by one (1) to get the calendar age. For all fish caught after June, the increment count equaled the calendar age of the fish. Peak spawning in the Gulf, based on maximum GSI, was determined to be in May (Brown-Peterson et al. 2001); thus, the assumed birthdate of each fish was May 1. Fractional age of each fish was computed with the following equation:

$$Age_{frac} = Age_{cal} + ((Month_{capture} - Month_{birth})/12)$$

Because cobia have been subject to a 33 inch minimum size limit regulation since 1985, the fish that recruit to the fishery first tend to be the fastest growers at those early ages, which results in a knife edge size distribution in fishery dependent samples at those affected ages. Dias et al. (2004) developed a correction to account for that size-selection bias, and that was used for the growth models presented herein. Also, because age samples in the youngest and oldest ages are few, the model incorporated an inverse weighting by sample size at each age. The resulting growth parameters are in Table 2.7.1. Weight at age was also modeled for females only using the von Bertalanffy model both with and without inverse weighting by sample size (Table 2.7.2). The Diaz correction was not used for the weight at age models.

2.8 Reproduction

The majority of the reproductive information on cobia in the U.S. is contained in published works by Brown-Peterson et al. (2001) and Franks and Brown-Peterson (2002) and is referenced as such. All age-related results presented in this section were based on calendar age. Information below on spawning seasonality, sexual maturity, sex ratio, and spawning frequency is based on the most accurate technique (histology) utilized to assess reproductive condition in fishes.

2.8.1 Spawning Seasonality

Spawning season was determined based on the occurrence of hydrated oocytes and/or postovulatory follicles from spawning cobia collected in the Gulf of Mexico. Cobia have a protracted spawning season (April through September) throughout the southeastern United States as determined from GSI values and histological assessments (Brown-Peterson et al., 2001). There was no significant difference (P>0.05) in GSI values between corresponding months in 1996 and 1997 for males or females in any region, with the exception of males in September from the north central Gulf of Mexico (NCGOM) (P=0.049). Therefore, monthly data for 1996 and 1997 by region were combined (Fig. 2.8.1.1). GSI values for both sexes of cobia from the eastern Gulf of Mexico (EGOM) began to increase in March, peaked in July, and declined and leveled off thereafter (Fig. 2.8.1.1). GSI values for females from the NCGOM increased in March, peaked in May, and then declined through September (Fig. 2.8.1.1). In contrast, GSI values of males from NCGOM steadily increased through July, then fell precipitously in August (Fig. 2.8.1.1). Brown-Peterson et al. (2001) concluded their GSI data for females mirrored those of Lotz et al. (1996), who found peak values in May. Biesiot et al. (1994) reported peak female GSI's in April based on 115 fish collected over 2 years from Texas to Florida, and Thompson et al. (1992) reported peak female GSI values in Louisiana in June. Ditty and Shaw (1992) reported that cobia larvae were found in estuarine and shelf waters of the Gulf primarily May-September; although their conclusions were based on a very small sample size. They noted that only 70 larvae <20mmSL were collected and identified from the Gulf of Mexico between 1967 and 1988.

2.8.2 Sexual Maturity

Because cobia have been subject to a 33 inch minimum size limit since 1985, and most studies were based almost entirely on fishery dependent sampling, data on size and age at maturity for Gulf stock cobia are very limited. Only 6 of 383 females collected by Brown-Peterson et al. (2001) were sexually immature so they did not attempt to estimate size or age at maturity. From Franks and Brown-Peterson (2002), "Historically, few small and immature cobia of either sex have been captured due to a minimum retention size in state territorial waters and the EEZ. Thus, accurate estimates of length or age at 50% sexual maturity cannot be made. However, reports of the smallest sexually mature male cobia observed vary from 365 mm FL and age 0 in the eastern Gulf of Mexico (Brown-Peterson et al. 2001) to 640 mm FL and age 1 in the north central Gulf of Mexico (Lotz et al. 1996). The smallest reported sexually mature female cobia range from 700 mm FL and age 1 in the eastern Gulf of Mexico (Brown-Peterson et al. 2001) to 834 mm FL and age 2 in the north central Gulf of Mexico (Lotz et al. 1996)". Of 31 one year old cobia collected in Louisiana by Thompson et al. (1992), none were mature; while among two year olds, some females and most males appeared mature; and all three year olds of both sexes were mature.

Sexual maturity in male cobia in the South Atlantic appears to occur at a very small size. Because of the paucity of samples of cobia < 200 mm FL, it is not possible to determine the smallest size at which male cobia reach sexual maturity, but this appears to occur well before they reach age 1. The smallest histologically mature male evaluated by SCDNR using histological techniques was 207 mm FL and 2-4 mo old, corroborating findings reported by Brown-Peterson et al. (2001) and Brown-Peterson et al. (2002). Sample sizes of small female cobia were also limited. Only eight fish ages 0-1 were examined, and all were immature (including 4 samples from 2011). Of the age 2 fish (n=27), 70% were sexually mature (Table 2.8.2.1). The only caveat regarding these animals was that they were likely the fastest growing and largest two-year olds collected from the fishery. Tables 2.8.2.2 and 2.8.2.3 both suggest that female cobia above 800 mm FL are likely to be mature, regardless of age. Smith (1995) similarly found that most 2 year-old females were sexually mature, with 25% maturity at 700-800 mm FL and 100% maturity above 800 mm FL.

LHWG Recommendation:
Maturity in cobia appears to more strongly correlate with size than age. Due to the paucity of samples at the youngest ages for both stocks, and the influence of the minimum size limit on size at age of those young fish, the LHWG recommends using age-2 for age at 50% maturity for Gulf and Atlantic stocks. All fish age-3+ in the samples were mature. Again, due to the influence of the minimum size limit on the young fish, there is a chance that not all age-3 fish are mature. When back-calculating the length of the fish to age using the von Bertalanffy growth curve, not all age-3 fish would be mature. Thus, the LHWG recommends examining model sensitivity by also using the following schedule: 0% mature at ages 0 and 1, 50% mature at age-2, 75% mature at age-3, and 100% mature age-4+.

Because of the lack of samples below the minimum size limit of 838 mm FL and the fact that female cobia above 800 mm FL are likely to be mature (Tables 2.8.2.2 and 2.8.2.3), one can only guess at the size at 50% maturity. If the AW desires to use size rather than age at maturity, as a first estimate the LHWG suggests using 700 mm and examine model sensitivity by trying 650 and 750 mm as well.

2.8.3 Sex ratio

From Franks et al. (2002), "In general, most studies found a higher percentage of females than males in their samples. Along the Gulf of Mexico, Thompson et al. (1992) reported an overall sex ratio of 1.2:1 that was skewed towards males, whereas, Franks et al. (1999) reported a predominance of females (2.7:1). Since both studies were conducted concurrently in the northern Gulf, it is difficult to explain the discrepancy, except to suggest differential segregation or a higher mortality for males east of the Mississippi River Delta. Burns et al. (1998) reported an overall ratio (all areas sampled) of 2.2:1 (female:male), but noted an overwhelming number of females in the northeast Gulf of Mexico sample (3.3:1)."

Analysis of the pooled GCRL, Mote, NMFS Beaufort, and NMFS Panama City data set, composed almost entirely of fishery dependent samples subject to the minimum size limit, clearly showed steadily increasing proportions of females with size. Although sex ratios are highly variable and sample sizes are small for fish <800 mm, the data suggests a 1:1 ratio up to about that size, then the proportion of females steadily increases until about 1200 mm FL, after which basically all fish are females (Figure 2.8.3.1A, Table 2.8.3.1). By age, sex ratio in the Gulf stock appeared quite stable through at least age 6, averaging 63% females (Figure 2.8.3.1B, Table 2.8.3.2). That trend likely continues for older fish, but sample sizes were too small for ages 7-9 to clearly determine that.

LHWG Recommendation:
By length, consider using 50% females up to 800 mm FL, derive a function to describe the increasing proportion of females between 800 and 1200 mm, and use 100 % females above 1200 mm.
By age, use 60% females for all ages.

2.8.4 Spawning Frequency

Brown-Peterson et al. (2001), using both oocytes undergoing final oocyte maturation (FOMs) and postovulatory follicles (POFs) (Hunter and Macewicz 1985), estimated cobia from the north central Gulf of Mexico (NCGOM)(n=135) spawn every 4 to 5 days, while those from the southeastern U.S. Atlantic coast spawn every 5.2 days (Table 2.8.4.1). The authors estimated a spawning frequency of 9-12 days for cobia from the western Gulf, but cautioned considering that as typical for the entire Gulf of Mexico, because samples were collected in July, i.e., the latter part of the spawning season. The spawning frequency estimates for the NCGOM were based on data from April, May, and July (spawning season), and both the FOM and POF methods showed good agreement.

The SCDNR, using the presence of POFs (Hunter and Macewicz 1985), estimated an average spawning frequency of 6.4 days for Atlantic stock cobia (n=213) collected inshore and offshore of South Carolina (Table 2.8.4.2).

LHWG Recommendation:
Use a spawning frequency of 4-5 days for Gulf stock cobia.

2.8.5 Batch Fecundity

Only limited information to estimate fecundity is available for cobia along the Atlantic coast and Gulf of Mexico.

Batch fecundity (BF) estimates were taken from datasets published by Brown-Peterson et al. (2001) but the BF method was found to be difficult to apply to cobia as hydrated females were rarely sampled. Estimates were based on an indirect method (denoted as neutral buffered formalin or NBF method) as recently recommended by the lead investigator (Pers Comm. Nancy Brown-Peterson). Sample size is low (n=39) and therefore observations were combined from the S.E. U.S., eastern Gulf of Mexico, and north central Gulf. Relative batch fecundity ranged from 0.99 to 255 eggs/g ovary free body weight (mean 53.1, SD 59.1) by the NBF method. The data suggested a power- rather than a linear function for the relation of batch fecundity and body weight, but the coefficient of determination was low (r^2=0.146, Figure 2.8.5.1).

Batch fecundity alone does not fully represent reproductive investment. No size or age-based estimates are available regarding the number of spawns per year thus annual egg production can only be poorly estimated.

A simplification is to assume that egg production is proportional to biomass of spawning females such that the number of eggs or larvae produced per gram of female body mass is constant among mature females with no effect of age structure on a per-unit basis. This is the Spawning Stock Biomass (SSB) assumption which is equivalent to the exponent b equal to 1 in the generalized fecundity (F) equation $F = aW^b$ where W = female weight.

However the batch fecundity relationship, while poorly fit, suggests b is greater than one (Figure 2.8.5.1). Also, it is becoming better understood generally among fishes with indeterminate fecundity type that older and larger females are more likely to spawn more batches per year, thus further increasing the likelihood that b > 1. While difficult to estimate it is likely older cobia contribute disproportiately more to egg production.

LHWG Recommendation:
Use female SSB as an estimate of reproductive potential but apply a sensitivity analysis on outputs including F_{msy} for the fecundity-weight exponent of b in the range from 1 to 2.4 as suggested by Figure 2.8.5.1.

2.9 Meristics and conversion factors

Cobia have a strongly forked tail and fork length has been the most consistently used length measurement. Equations to make length-length and weight-length conversions were derived using the simple linear regression model and the power function, respectively (Tables 2.10.1 and 2.10.2). Data from the GCRL (n=824), Mote (n=352), and NMFS Headboat (n=5287) studies were used to derive length-weight relationships. These data were linearized by a ln-ln transformation and then converted to the power equation W = *a*TL*b*. Only GCRL data was used for length-length equations. All weights are shown in kilograms and all lengths in millimeters. Coefficients of determination (r^2) ranged from 0.913 to 0.921 for the linear length-weight regressions, and 0.952 to 0.974 for the length-length equations. There was a weak suggestion of sexually dimorphic growth in the length-weight model, although it is likely this was driven by sample size and was not biologically significant. There was no evidence of sexually dimorphic growth in the length-length model.

LHWG Recommendation:
1) Use the equations based on combined sources.

2.10 Comments on adequacy of data for assessment analyses

Included in individual sections above.

2.11 Itemized list of tasks for completion following workshop

None.

2.12 Literature Cited

Ahrenholz, D. W. 1991. Population biology and life history of the North American menhadens, *Brevoortia* spp. Marine Fisheries Review 53(4): 3 – 19.

Alagaraja, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian J. Fish. 31:177-208.

Baughman, J.L. 1950. Random notes on Texas fishes, Part II. Texas Journal of Science. 2:242-263.

Beckman, D.W., C.A. Wilson and A.L. Stanley. 1989. Age and growth of red drum, *Sciaenops ocellatus*, from offshore waters of the northern Gulf of Mexico. Fish. Bull. 87:17-28.

Biesiot, P.M., R.M. Caylor, and J.S. Franks. 1994. Biochemical and histological changes during ovarian development of cobia, *Rachycentron canadum*, from the northern Gulf of Mexico. Fish. Bull. 92:686-696.

Brown-Peterson, N.J., H.J. Grier and R.M. Overstreet. 2002. Annual changes in germinal epithelium determine male reproductive classes of the cobia. Journal of Fish Biology. 60:178-202.

Brown-Peterson, N.J., J.S. Franks, and K.M. Burns. 2001. Reproductive biology of cobia, *Rachycentron canadum*, from coastal waters of the southern United States. Fish. Bull. 99:15-28.

Brown-Peterson, N.J., D.M. Wyanski, F. Saborido-Rey, B.J. Macewicz, and S. K. Lowerre-Barbieri. 2011. A standardized terminology for describing reproductive development in fishes. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 3:1, 52-70

Burns, K.M., and C.L. Neidig. 1992. Cobia (*Rachycentron canadum*), amberjack (*Seriola dumerili*), and dolphin (*Coryphaena hipurus*) migration and life history study off the southwest coast of Florida. Final report MARFIN Award No. NA90AA-H-MF747. SEDAR28-RD22.

Burns, K.M., C. Neidig, J. Lotz and R. Overstreet. 1998. Cobia (*Rachycentron canadum*) stock assessment study in the Gulf of Mexico and in the South Atlantic. Mote Mar. Lab. Tech. Rep. 571. 108 pp.

Darden, Tanya. Cobia preliminary data analyses – US Atlantic and GOM genetic population structure. 2012. SEDAR28-DW01.

Darden, T., M.J. Walker, K. Brenkert, J.R. Yost, and M.R. Denson. 2012. Population genetics of cobia *Rachycentron canadum*: Management implications along the Southeastern US coast. SEDAR28-RD09.

Davis, M.W. 2002. Key principles for understanding fish bycatch discard mortality. Canadian Journal of Fisheries and Aquatic Sciences 59:1834-1843.

Denson, Michael. 2012. South Carolina experimental stocking of cobia *Rachycentron canadum*. SEDAR28-DW02

Diaz, G.A., C.E. Porch, and M. Ortiz. 2004. Growth models for red snapper in US Gulf of Mexico Waters estimated from landings with minimum size limit restrictions. NMFS/SFD Contribution SFD-2004-038. SEDAR7-AW1.

Ditty, J.G., and R.F. Shaw. 1992. Larval development, distribution, and ecology of cobia, *Rachycentron canadum*, (Family: Rachycentridae) in the northern Gulf of Mexico. Fish. Bull. 90:668:677.

Finucane, J.H., L.A. Collins, and L. E. Barger. 1978. Ichthyoplankton/mackerel eggs and larvae. Environmental studies of the south Texas outer continental shelf, 1977. Final report to Bureau of Land Management by NMFS (NOAA), Galveston, TX.

Franks, J.S., and N.J. Brown-Peterson. 2002. A review: age, growth and reproduction of cobia, *Rachycentron canadum*, from U.S. waters of the Gulf of Mexico and south Atlantic Ocean. Proc. of the Gulf and Caribbean Fisheries Institute 53:553-569.

Franks, J.S., J.R. Warren, M.V. Buchanan. 1999. Age and growth of cobia, *Rachycentron canadum*, from the northeastern Gulf of Mexico. Fish. Bull. 97(3):459-471.

Harrington, J.M., R.A. Myers, and A. A. Rosenberg. 2005. Wasted fishery resources: discarded by-catch in the USA. Fish and Fisheries 6: 350–361.

Hassler, W.W., and R.P. Rainville. 1975. Techniques for hatching and rearing cobia, *Rachycentron canadum*, through larval and juvenile stages. Publ. UNC-SC-75-30, University of North Carolina Sea Grant college program. Raleigh, NC. 26 pp.

Hendon, R., and J. Franks. 2010. Sport fish tag and release in Mississippi coastal water and the adjacent Gulf of Mexico. SEDAR28-RD23.

Hoenig, J.M., 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82(1):898-903.

Hunter, J.R., and B.J. Macewicz. 1985. Rates of atresia in the ovary of captive and wild northern anchovy, *Engraulis mordax*. Fish. Bull. 77:641-652.

Joseph, E.B., J.J. Norcross, and W.H. Massman. 1964. Spawning of the cobia, *Rachycentron canadum*, in the Chesapeake Bay area, with observations of juvenile specimens. Chesapeake Science. 5:67-71.

Lefebvre, L.S., and M.R. Denson. 2012. Inshore spawning of cobia (*Rachycentron canadum*) in South Carolina. In review.

Lotz, J.M., R.M. Overstreet, and J.S. Franks. 1996. Gonadal maturation in the cobia, *Rachycentron canadum*, from the north central Gulf of Mexico. Gulf Research Reports. 9:147-159.

MacCall, A. 2011. What is the precision of M? Abstract In: Brodziak, J., J. Ianelli, K. Lorenzen, and R.D. Methot Jr. (eds). 2011. Estimating natural mortality in stock assessment applications. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-119, 38 p.

Murphy, M. D. and R. G. Taylor. 1990. Reproduction, growth, and mortality of red drum *Sciaenops ocellatus* in Florida waters. Fish. Bull. 88: 531-542.

Mills, S. 2000. A cobia by any other name. Virginia Marine Resources Bulletin. 32:2-10.

Orbesen, Eric. 2012. Constituent based tagging of cobia in the Atlantic and Gulf of Mexico waters. SEDAR28-DW13.

Newcombe, R.G. 1998. Two-sided confidence intervals for the single proportion: Comparison of seven methods. Statistics in Medicine, 17, 857-872.

Perkinson, M., and M. Denson. Evaluation of cobia movements and distribution using tagging data from the Gulf of Mexico and South Atlantic coast of the United States. 2012. SEDAR28-DW05.

Richards, C.E. 1967. Age, growth and fecundity of the cobia, *Rachycentron canadum*, from the Chesapeake Bay and adjacent Mid-Atlantic waters. Trans. Am. Fish. Soc. 96:343-350.

Ross, J.L., T.M. Stevens and D.S. Vaughan. 1995. Age, growth, mortality, and reproductive biology of red drums in North Carolina waters. Trans. Am. Fish. Soc. 124: 37-54.

Rummer, J.L., and Bennett, W.A. 2005. Physiological effects of swim bladder overexpansion and catastrophic decompression on red snapper. Trans. Am. Fish. Soc. 134: 1457–1470.

Schaffer, R.V., and E.L. Nakamura. 1989. Synopsis of biological data on the cobia, *Rachycentron canadum* (Pisces: Rachycentridae). FAO Fisheries Synopsis 153. NOAA technical report NMFS 82. 33 pp.

Smith, J.W. 1995. Life history of cobia, *Rachycentron canadum* (Osteichthyes: Rachycentridae), in North Carolina waters. Brimleyana 23:1-23.

Thompson, B.A., C.A. Wilson, J.H. Render, M. Beasley, and C. Cauthron. 1992. Age, growth, and reproductive biology of greater amberjack and cobia from Louisiana waters. Final rep., MARFIN Coop. Agreement NA90AA-H-MF722 to NMFS (NOAA). Coastal Fisheries Institute, LSU Center for Coastal, Energy, and Environmental Resources, Baton Rouge, LA, 77 p.

Wiggers, Robert. 2010. South Carolina marine game fish tagging program 1978-2009. SEDAR28-RD21.

2.13 Tables – refer to numbered life history paragraphs

Table 2.3.2.1. Combined table of SC, GCRL and Mote recaptured cobia.

	Region Recap	GAN	N-BR	BR	S-BR	Keys	Gulf
Region Tagged	N						
GAN	121	110	4	6	0	0	1
N-BR	0	0	0	0	0	0	0
BR	36	5	4	14	2	4	7
S-BR	13	2	0	1	5	2	3
Keys	156	0	0	1	8	88	59
Gulf	744	4	8	12	25	78	617

Table 2.3.2.2. Combined table of SC, GCRL and Mote recaptured cobia. Percentages of cobia tagged in a region that are recaptured.

	Region Recap	GAN	N-BR	BR	S-BR	Keys	Gulf
Region Tagged	N						
GAN	121	91%	3%	5%	0%	0%	1%
N-BR	0	0%	0%	0%	0%	0%	0%
BR	36	14%	11%	39%	6%	11%	19%
S-BR	13	15%	0%	8%	38%	15%	23%
Keys	156	0%	0%	1%	5%	56%	38%
Gulf	745	1%	1%	2%	3%	10%	83%

Table 2.4.1. List of age based instantaneous natural mortality rate (M) point estimate methods. Parameters: k – von Bertalanffy growth coefficient (yr^{-1}), age mat – age at 50% maturity, tmax – maximum age (yr), L∞ - asymptotic length (mm) determined from von Bertalanffy growth model, temp – average water temperature (oC), S – survivorship. Equations provided in Microsoft Excel notation.

Method	Parameters	Equation
Alverson & Carney (1975)	k, tmax	M = 3*k/[exp(0.38*tmax*k)-1]
Beverton & Holt (1956)	k, age mat	M = 3*k/[exp(age mat*k)-1])
Hoenig fish (1983)	tmax	M=exp(1.46 - 1.01*ln(tmax))
Hoenig all taxa (1983)	tmax	M=exp(1.44-0.982*ln(tmax))
Pauly I (1980)	k, L∞, temp	M=exp[-0.0152+0.6543*ln(k)-0.279*ln(L∞)+0.4634*ln (temp)]
Pauly II (Pauly & Binohlan 1996)	k, L∞, temp	M=exp[-0.1464+0.6543*ln(k)-0.279*ln(L∞)+0.4634*ln (temp)]
Ralston I (1987)	k	M=0.0189 + 2.06*k
Ralston II (Pauly & Binohlan 1996)	k	M=-0.1778+3.1687*k
Jensen (1996)	k	M = 1.5*k
Hewitt & Hoenig (2005)	tmax	M = 4/tmax
Alagaraja (1984)	S, tmax	M=-(lnS)/tmax

Table 2.4.2. Point estimates of instantaneous natural morality rate (M) (see Table 2.4.1 for equations and citations) based on all data combined, maximum age (tmax) of 11 yr; von Bertalanffy parameter estimates: t_0 = -0.53, k = 0.42 and L_∞ = 1281.5; and mean water temperature of 25ºC.

Method	M	Method	M
Alverson & Carney	0.26	Ralston (method II)	1.51
Beverton	0.96	Hewitt & Hoenig	0.36
$Hoenig_{fish}$	0.38	Jensen	0.63
$Hoenig_{alltaxa}$	0.40	Rule of thumb	0.27
Pauly	0.64	Alagaraja 0.01	0.42
Ralston	0.88	Alagaraja 0.02	0.36
Ralston (geometric mean)	1.73	Alagaraja 0.05	0.27

Table 2.5.1. Number, percent kept, and percent discarded dead for cobia caught in gillnet fisheries based on observed trips from 1998-2011. Data were provided by Simon Gulak (Gillnet Coordinator SEFSC NOAA Fisheries).

Gear Type	Species	Total Number Caught	% Kept	% Discarded Dead
Drift	Cobia	900	69%	63%
Sink	Cobia	309	16%	39%
Strike	Cobia	6	50%	67%
Overall	Cobia	1,215	56%	51%

Table 2.6.1. Gulf States Marine Fisheries Commission otoliths margin codes used in determining calendar age of fish from the GCRL data set.

Code 1.	opaque zone present on edge
Code 2.	translucent zone forming to 1/3 complete on edge
Code 3.	translucent zone 1/3 to 2/3 complete on edge
Code 4.	translucent zone 2/3 to fully complete on edge

Table 2.7.1. Gulf of Mexico cobia von Bertalanffy growth parameters for length at age using Diaz et al. (2004) correction and inverse weighting by sample size at age.

Parameter	All fish	Females	Males
L_∞ in mm	1281.5	1362.6	1221.7
K	0.42	0.41	0.36
t_0	-0.53	-0.50	-0.50

Table 2.7.2. Weighted (inversely with sample size) and unweighted Gulf of Mexico cobia von Bertalanffy growth parameters for females (n=563) for weight at age.

Parameter	Weighted	Unweighted
W_∞ in kg	60.5972	160.7
K	0.0937	0.0249
t_0	0.4491	-0.22

Table 2.8.1.1. Published methods for assessing cobia spawning season.

Region	Spawning Season	Method	Reference
Virginia	June-August	GSI, histology	Joseph et al., 1964; Richards, 1967
Virginia	June-August	egg, larval collections	Joseph et al., 1964; Mills, 2000
North Carolina	May-July	GSI	Smith, 1995
North Carolina	May-August	egg, larval collections	Hassler and Rainville, 1975; Smith, 1995
South Carolina	May-August	egg, larval collections	Shaffer and Nakamura, 1989
North central Gulf of Mexico	April-September	GSI, histology	Biesiot et al., 1994; Lotz et al., 1996; Brown-Peterson et al., 2001
North central Gulf of Mexico	May-September	egg, larval collections	Ditty and Shaw, 1992
Louisiana	April-August	GSI, histology	Thompson et al., 1992
Texas	May-September	egg, larval collections	Baughman, 1950; Finucane et al., 1978

Table 2.8.2.1. Count of Atlantic stock female cobia by age and reproductive phase. Reproductive phase terminology from Brown-Peterson et al. (2011).

Age	**Immature**	**Developing**	**Spawning Capable**	**Regressing**	**Regenerating**	**POFs**	**Total**
0	1						1
1	7						7
2	8	15	3		1		27
3		142	69	4		25	240
4		41	63	2		30	136
5		28	57	1		28	114
6		26	44	1		21	92
7		22	32	2		11	67
8		11	23	2		1	37
9		9	13	1		4	27
10		6	11			2	19
11		3	7			5	15
12		4	7	1		1	13
13		2	1			1	4
14			2				2
15							0
16			1				1
Total	**16**	**309**	**333**	**14**	**1**	**129**	**802**

Table 2.8.2.2. Atlantic female cobia mean fork length (mm) by age and reproductive phase.

Age	Immature	Developing	Spawning Capable	Regressing	Regenerating	POFs (<24hr)	POFs (>24hr)	Total
0	440							440
1	451							451
2	701	788	847		950			771
3		946	931	969		959	945	942
4		1025	1073	1087		1040	1039	1050
5		1098	1134	1178			1097	1116
6		1129	1216	1081		1145	1170	1177
7		1179	1268	1386		1208	1202	1233
8		1249	1267	1318			1164	1261
9		1243	1254				1182	1238
10		1300	1370				1384	1345
11		1316	1422				1290	1357
12		1264	1417	1565			1448	1363
13		1380	1410				1399	1392
14			1384					1384
15								
16			1372					1372
Total	**575**	**1031**	**1133**	**1175**	**950**	**1051**	**1101**	**1076**

Table 2.8.2.3. Size at maturity for Atlantic stock female cobia fork length (mm).

Female FL (mm)	% Mature	n	Female FL (mm)	% Mature	n
≤350	0	0	1001-1050	100%	93
351-400	0%	2	1051-1100	100%	67
401-450	0%	3	1101-1150	100%	89
451-500	0%	2	1151-1200	100%	80
501-550	0	0	1201-1250	100%	55
551-600	0%	1	1251-1300	100%	52
601-650	33%	3	1301-1350	100%	27
651-700	100%	1	1351-1400	100%	18
701-750	44%	9	1401-1450	100%	8
751-800	75%	4	1451-1500	100%	10
801-850	100%	24	1501-1550		0
851-900	100%	53	1551-1600	100%	1
901-950	100%	73	1601-1650	100%	1
951-1000	100%	89	**Total**	**98%**	**765**

Table 2.8.3.1. Sex ratios and percent maturity by size (and 95% conf. limits) of female Gulf stock cobia; GCRL (n=513), Mote (n=506), NMFS Panama City (n=25), and NMFS Beaufort (n=9) combined data set. The Wilson score method without continuity correction was used to calculate 95% confidence limits (Newcombe 1998).

FL (mm)	Round FL	Females	Males	Total	%Females	F : M	Lower 95% CL	Upper 95% CL
490-509	500	1	0	1	100.0	1:1.0	20.7	100.0
510-529	520		1	1	0.0	0:1.0	0.0	79.3
530-549	540							
550-569	560		1	1	0.0	0:1.0	0.0	79.3
570-589	580							
590-609	600	4	0	4	100.0	1:1.0	51.0	100.0
610-629	620							
630-649	640	4	2	6	66.7	2:1.0	30.0	90.3
650-669	660	4	0	4	100.0	1:1.0	51.0	100.0
670-689	680	2	1	3	66.7	2:1.0	20.8	93.9
690-709	700	1	3	4	25.0	0.3:1.0	4.6	69.9
710-729	720	4	3	7	57.1	1.3:1.0	25.0	84.2
730-749	740	2	1	3	66.7	2:1.0	20.8	93.9
750-769	760	2	2	4	50.0	1:1.0	15.0	85.0
770-789	780	4	0	4	100.0	1:1.0	51.0	100.0
790-809	800	6	4	10	60.0	1.5:1.0	31.3	83.2
810-829	820	8	10	18	44.4	0.8:1.0	24.6	66.3
830-849	840	16	28	44	36.4	0.6:1.0	23.8	51.1
850-869	860	29	28	57	50.9	1.0:1.0	38.3	63.4
870-889	880	21	22	43	48.8	1.0:1.0	34.6	63.2
890-909	900	29	22	51	56.9	1.3:1.0	43.3	69.5
910-929	920	19	22	41	46.3	0.9:1.0	32.1	61.3
930-949	940	36	25	61	59.0	1.4:1.0	46.5	70.5
950-969	960	39	26	65	60.0	1.5:1.0	47.9	71.0
970-989	980	40	19	59	67.8	2.1:1.0	55.1	78.3
990-1009	1000	46	16	62	74.2	2.9:1.0	62.1	83.4
1010-1029	1020	39	14	53	73.6	2.8:1.0	60.4	83.6
1030-1049	1040	40	15	55	72.7	2.7:1.0	59.8	82.7
1050-1069	1060	34	15	49	69.4	2.3:1.0	55.5	80.5
1070-1089	1080	32	16	48	66.7	2:1.0	52.5	78.3
1090-1109	1100	37	4	41	90.2	9.3:1.0	77.5	96.1
1110-1129	1120	26	3	29	89.7	8.7:1.0	73.6	96.4
1130-1149	1140	28	8	36	77.8	3.5:1.0	61.9	88.3
1150-1169	1160	29	1	30	96.7	29:1.0	83.3	99.4
1170-1189	1180	19	3	22	86.4	6.3:1.0	66.7	95.3
1190-1209	1200	21	2	23	91.3	10.5:1.0	73.2	97.6
1210-1229	1220	25	1	26	96.2	25:1.0	81.1	99.3

1230-1249	1240	17	4	21	81.0	4.3:1.0	60.0	92.3
1250-1269	1260	7	1	8	87.5	7:1.0	52.9	97.8
1270-1289	1280	10	1	11	90.9	10:1.0	62.3	98.4
1290-1309	1300	8	0	8	100.0	1:1.0	67.6	100.0
1310-1329	1320	9	1	10	90.0	9:1.0	59.6	98.2
1330-1349	1340	5	1	6	83.3	5:1.0	43.6	97.0
1350-1369	1360	5	1	6	83.3	5:1.0	43.6	97.0
1370-1389	1380	2	0	2	100.0	1:1.0	34.2	100.0
1390-1409	1400	1	1	2	50.0	1:1.0	9.5	90.5
1410-1429	1420	5	0	5	100.0	1:1.0	56.6	100.0
1430-1449	1440	2	0	2	100.0	1:1.0	34.2	100.0
1450-1469	1460	1	0	1	100.0	1:1.0	20.7	100.0
1470-1489	1480							
1490-1509	1500							
1510-1529	1520	2	0	2	100.0	1:1.0	34.2	100.0
1530-1549	1540	1	0	1	100.0	1:1.0	20.7	100.0
1550-1569	1560							
1570-1589	1580	1	0	1	100.0	1:1.0	20.7	100.0
1590-1609	1600							
1610-1629	1620							
1630-1649	1640	1	0	1	100.0	1:1.0	20.7	100.0
Total		724	329	1053	68.8			

Table 2.8.3.2. Sex ratios and percent maturity by age (and 95% conf. limits) of female Gulf stock cobia; GCRL (n=513), Mote (n=507), NMFS Panama City (n=26), and NMFS Beaufort (n=9) combined data set. The Wilson score method without continuity correction was used to calculate 95% confidence limits (Newcombe 1998).

Final Age	Females	Males	Total	% Female	F : M	lower 95% CL	upper 95% CL
0							
1	33	15	48	68.8	2.2:1.0	54.7	80.1
2	194	80	274	70.8	2.4:1.0	65.2	75.9
3	264	122	386	68.4	2.2:1.0	63.6	72.8
4	134	60	194	69.1	2.2:1.0	62.3	75.2
5	53	28	81	65.4	1.9:1.0	54.6	74.9
6	32	9	41	78.0	3.6:1.0	63.3	88.0
7	7	8	15	46.7	0.9:1.0	24.8	69.9
8	6	3	9	66.7	2.0:1.0	35.4	87.9
9	2	4	6	33.3	0.5:1.0	9.7	70.0
Total	725	329	1,054				

Table 2.8.4.1. Mean estimated spawning frequencies of cobia from the southeastern United States and north central Gulf of Mexico. Spawning frequencies were estimated from the percentage of ovaries in the late developing ovarian class containing either postovulatory follicles (POF) or undergoing final oocyte maturation (FOM). Spawning frequency estimates were based on data from April to June in the SEUS, and from April, May, and July in the NCGOM. From Brown Peterson et al. (2001).

	Region	
	S.E. United States (SEUS)	North Central Gulf of Mexico (NCGOM)
Spawning frequency	(n=23)	(n=135)
POFs %	19.4	24.8
Frequency (POFs)	5.2 days	4.0 days
FOM %	19.4	19.8
Frequency (FOM)	5.2 days	5.0 days

Table 2.8.4.2. Mean estimated spawning frequencies of cobia from inshore and offshore collections off South Carolina. Spawning frequencies were based on presence or absence of postovulatory follicles (POF) in the late developing ovaries. Source: SCDNR.

Spawning frequency	Inshore Captures	Offshore Captures	Unknown Capture Location	All areas combined
Samples (n)	64	34	115	**213**
% POFs	15.625	35.294	11.304	**16.432**
Frequency (POFs)	6.4 days	2.8 days	8.8 days	**6.1 days**

Table 2.10.1. Linear and power functions to convert fork length (mm) of Gulf stock cobia to weight in kilograms. Overall range of weights: 0.009-53.39 kg. The LHWG recommends the combined functions (highlighted in yellow).

Sex	Model	n	FL range	a	SE a	b	SE b	MSE	R2
Male	Ln(Wt) = a+b*Ln(FL)	304	310-1450	-21.0459	0.391345	3.391908	0.057139	0.18917	0.9208
Female	Ln(Wt) = a+b*Ln(FL)	851	315-1639	-20.2313	0.23385	3.27777	0.03351	0.16409	0.9184
Combined	Ln(Wt) = a+b*Ln(FL)	6463	99-1639	-18.5393	0.079677	3.034126	0.011619	0.16839	0.91344
Combined[1]	Wt=aFL^b			9.00E-09		3.03			

[1]Ln-Ln transformed to power equation adjusting for transformation bias with 1/2 MSE

Table 2.10.2 Linear functions to convert total length (mm) of Gulf stock cobia to fork length (mm). The LHWG recommends the combined functions (highlighted in yellow).

Sex	Model	n	FL range	a	SE a	b	SE b	MSE	R2
Male	FL = a+b*TL	212	838-1450	-35.1237	15.68561	0.931389	0.014264	22.399	0.95283
Female	FL = a+b*TL	567	420-1626	4.776873	7.476194	0.895853	0.006144	24.47	0.97407
Combined	FL = a+b*TL	3105	99-1626	-10.024	3.650035	0.900559	0.0033	27.169	0.95999

2.14 Figures – refer to numbered life history paragraphs

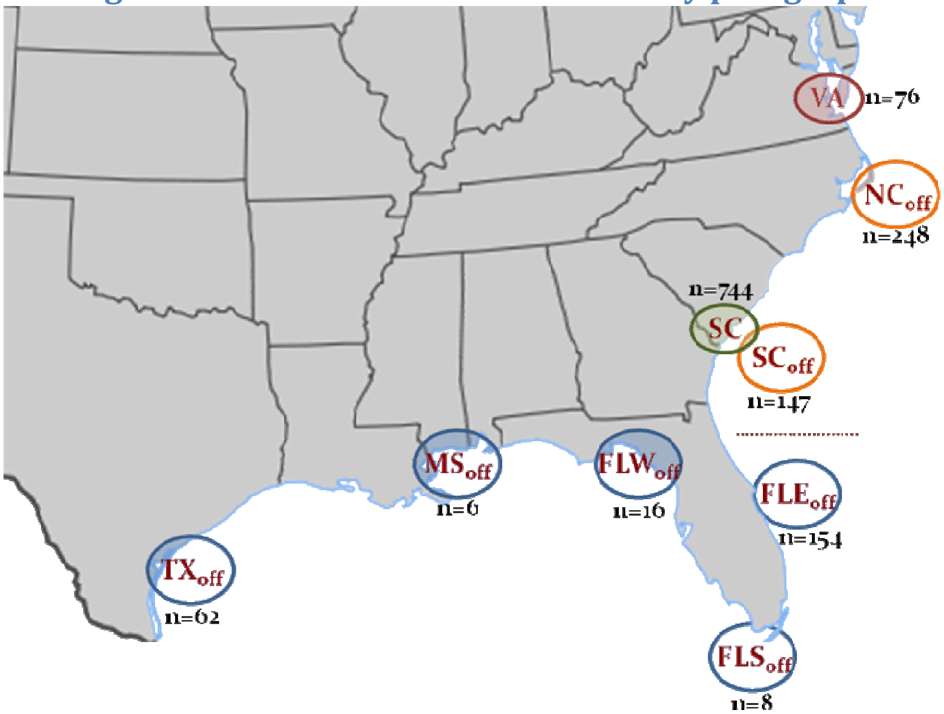

Figure 2.3.1.1. Map depicting the approximate sample sites where cobia genetic samples were taken along the south Atlantic and Gulf coast.

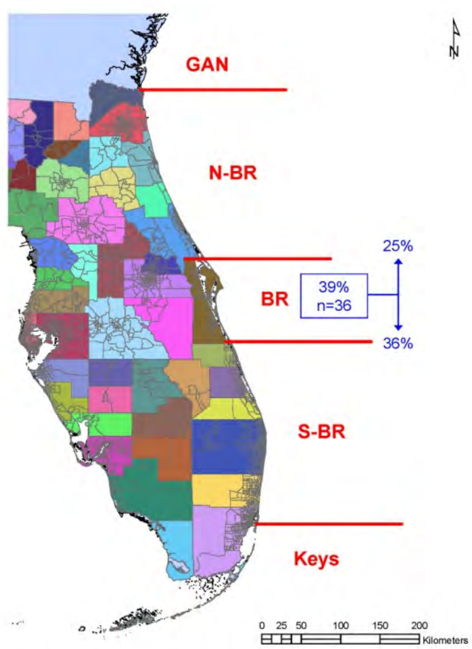

Figure 2.3.2.1. Movement of tagged cobia from Brevard County, FL (BR) to the north and south.

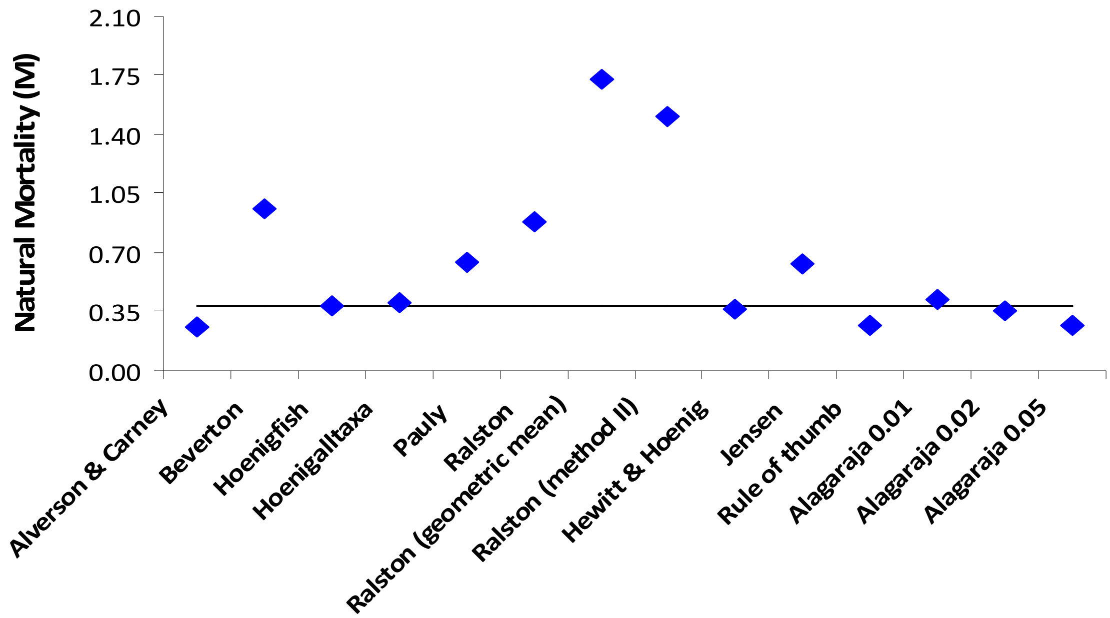

Figure 2.4.1. Point estimates of instantaneous natural mortality rates (M) for Gulf of Mexico stock cobia. The LHWG recommends using the Hoenig$_{fish}$ estimate (black line, 0.38) for scaling the age specific Lorenzen estimates.

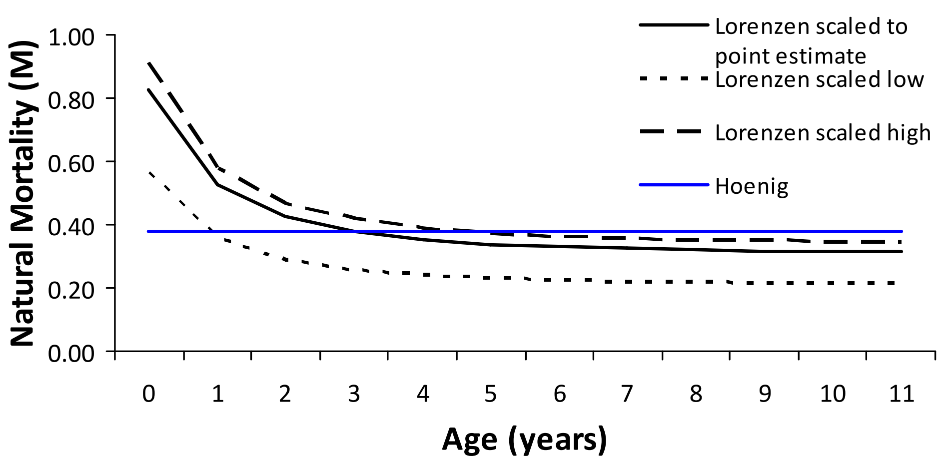

Figure 2.4.2. Age-varying instantaneous natural mortality (M) for Gulf stock cobia using the Lorenzen approach (Lorenzen 1996) and scaled to the Hoenig$_{fish}$ estimate of 0.38 with low and high sensitivity runs at 0.26 and 0.42, respectively.

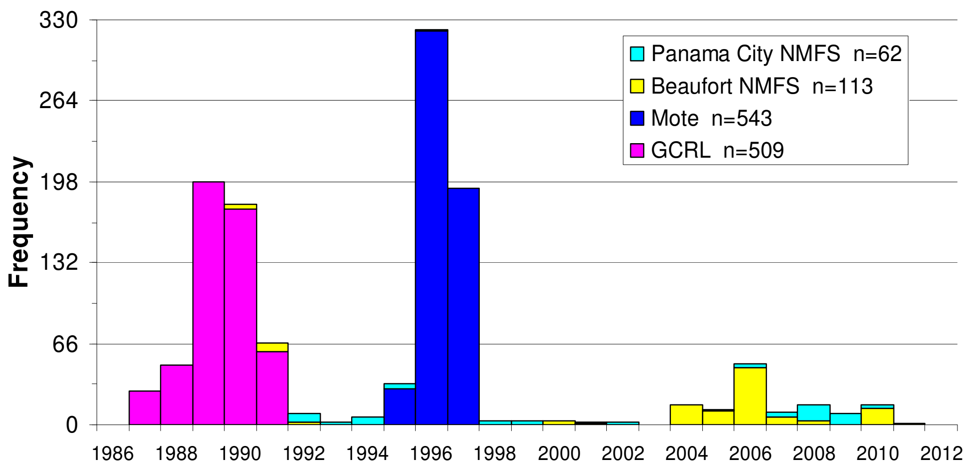

Figure 2.6.1. Overall temporal distribution by source (sexes combined) of the Gulf of Mexico cobia age samples to be used for the SEDAR28 assessment.

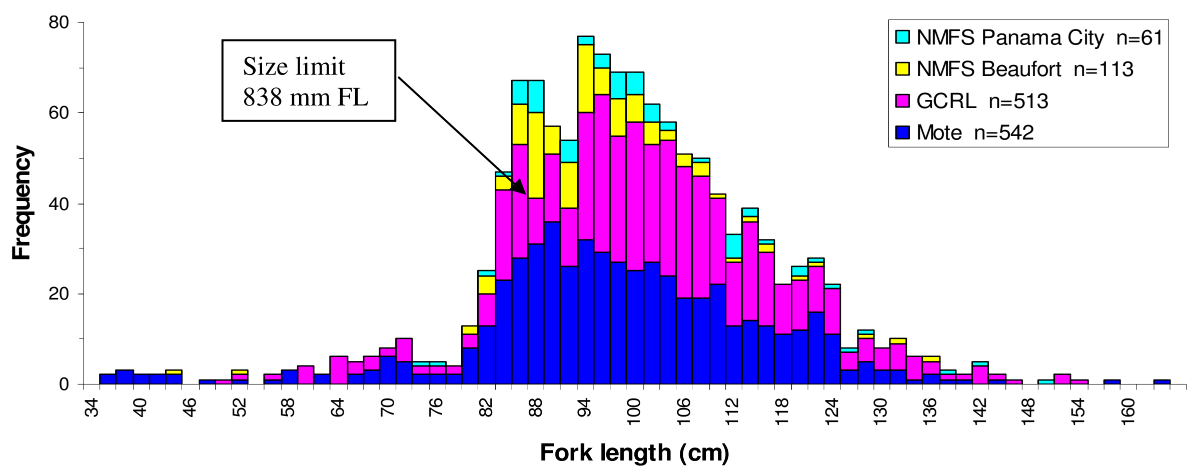

Figure 2.6.2 Overall size distribution by source (sexes combined) of the Gulf of Mexico cobia age samples to be used for the SEDAR28 assessment. The sharp increase at about 84 cm reflects the effect of the 838 mm FL minimum size limit on the mainly fishery-dependent samples.

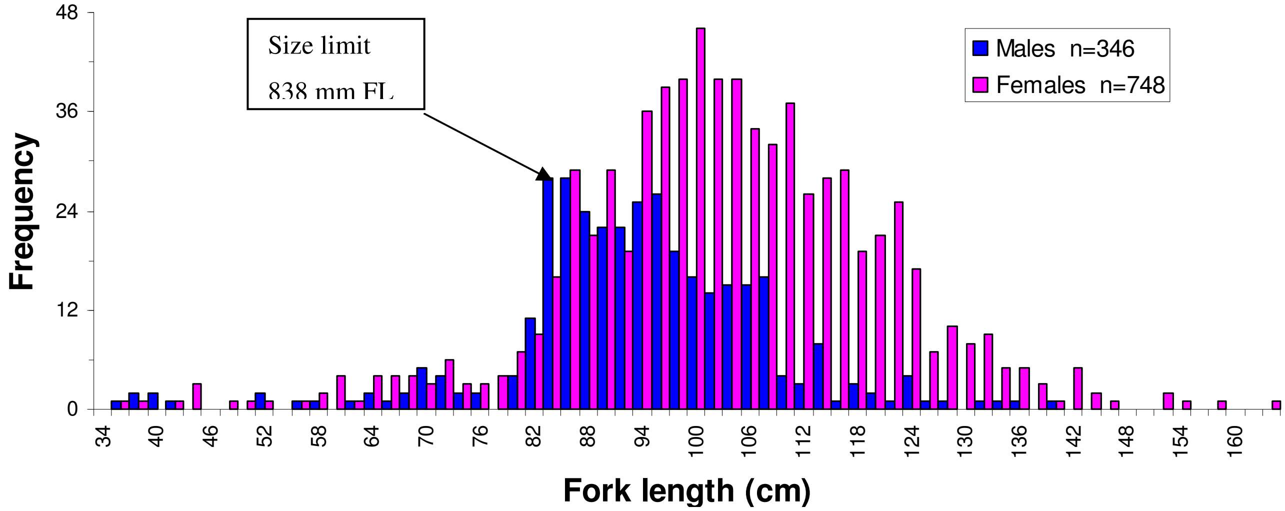

Figure 2.6.3. Overall size distributions by sex (sources combined) of the Gulf of Mexico cobia age data set to be used for the SEDAR28 assessment.

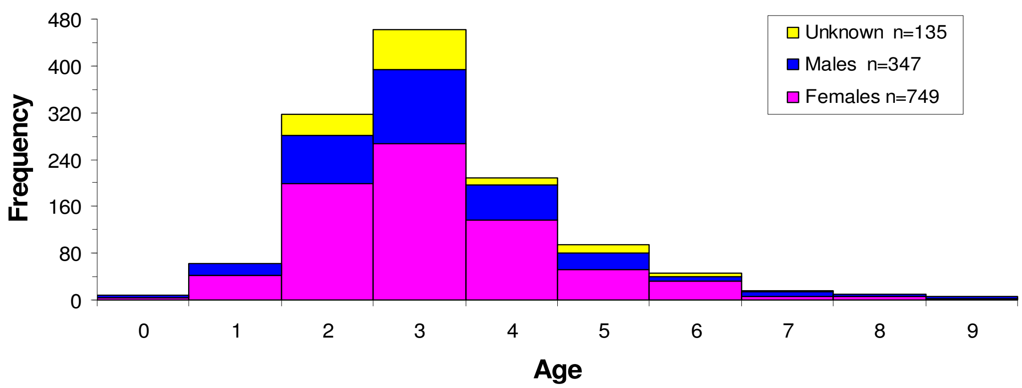

Figure 2.6.4. Overall age distributions by sex (sources combined) of the Gulf of Mexico cobia age data set to be used for the SEDAR28 assessment.

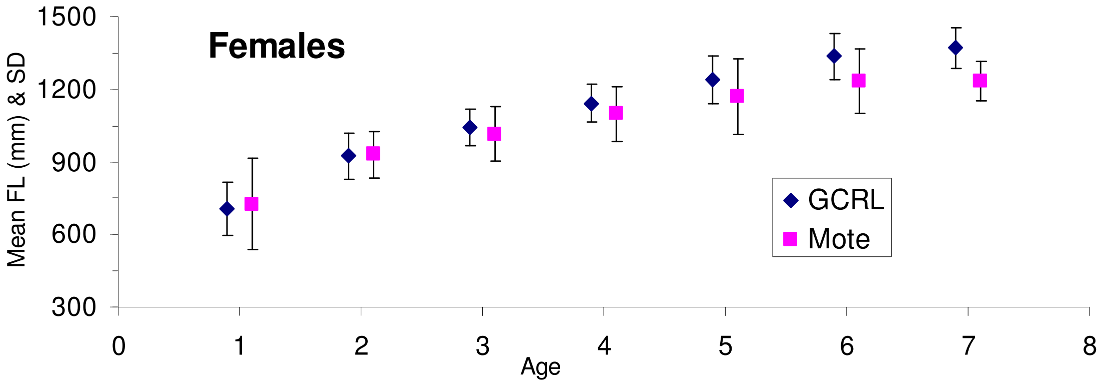

Figure 2.7.1. Mean sizes at age of Gulf stock cobia from the Gulf Coast Research Lab (GCRL) and Mote Marine Lab data sets.

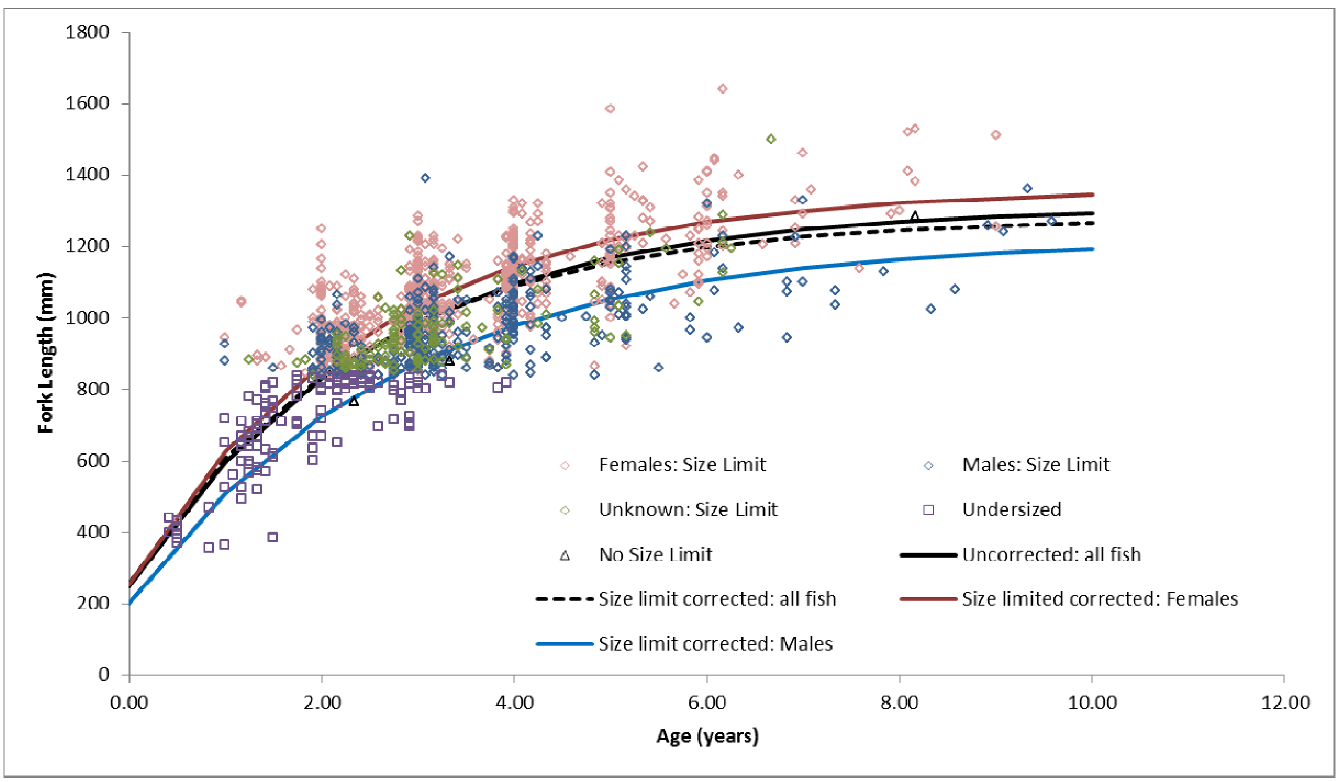

Figure 2.7.2. Gulf stock cobia raw size at age data, uncorrected, inverse-weighted Von Bertalanffy growth curves for sexes combined, and inverse-weighted Von Bertalanffy growth curves, corrected for the 33 inch size limit, for sexes combined and by sex.

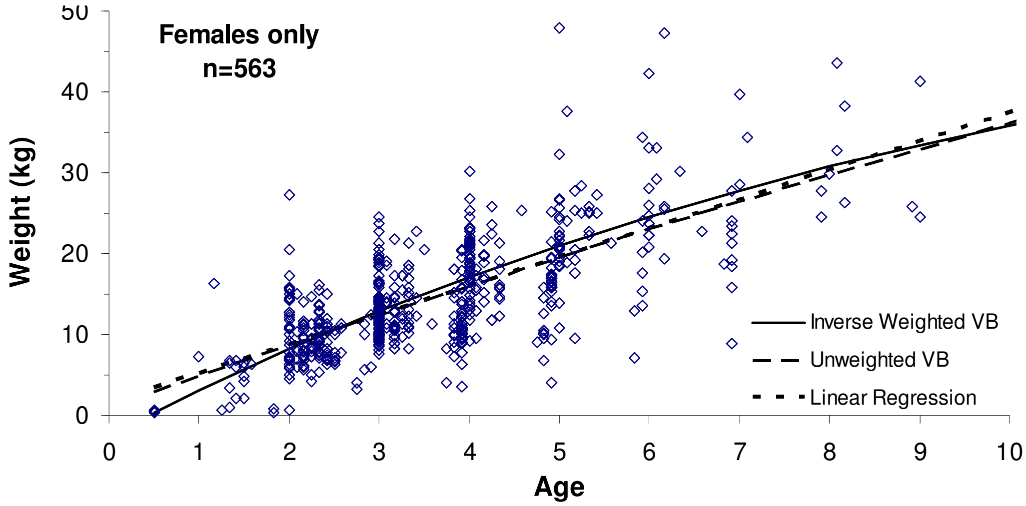

Figure 2.7.3. Gulf stock cobia raw weight at age data, and uncorrected (for size limits), inverse-weighted and unweighted Von Bertalanffy growth curves for females.

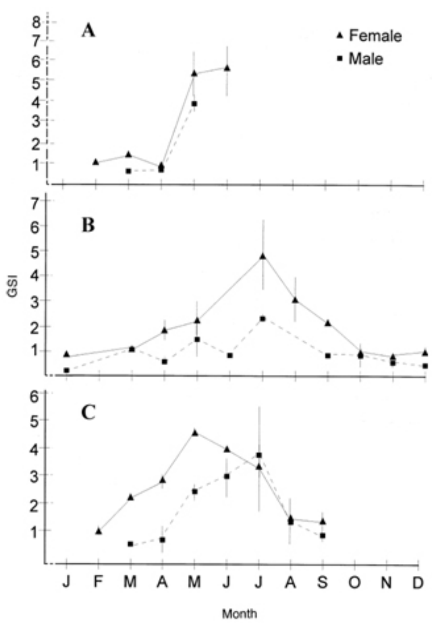

Figure 2.8.1.1. Monthly (1996 and 1997 combined) gonadosomatic index (GSI) values for cobia from the southern United States. Values represent mean ± ISE. (solid trianges=female, solid squares=male) (A) southeastern United States. (B) Eastern Gulf of Mexico. (C) North-Central Gulf of Mexico. From Brown-Peterson et al. (2001).

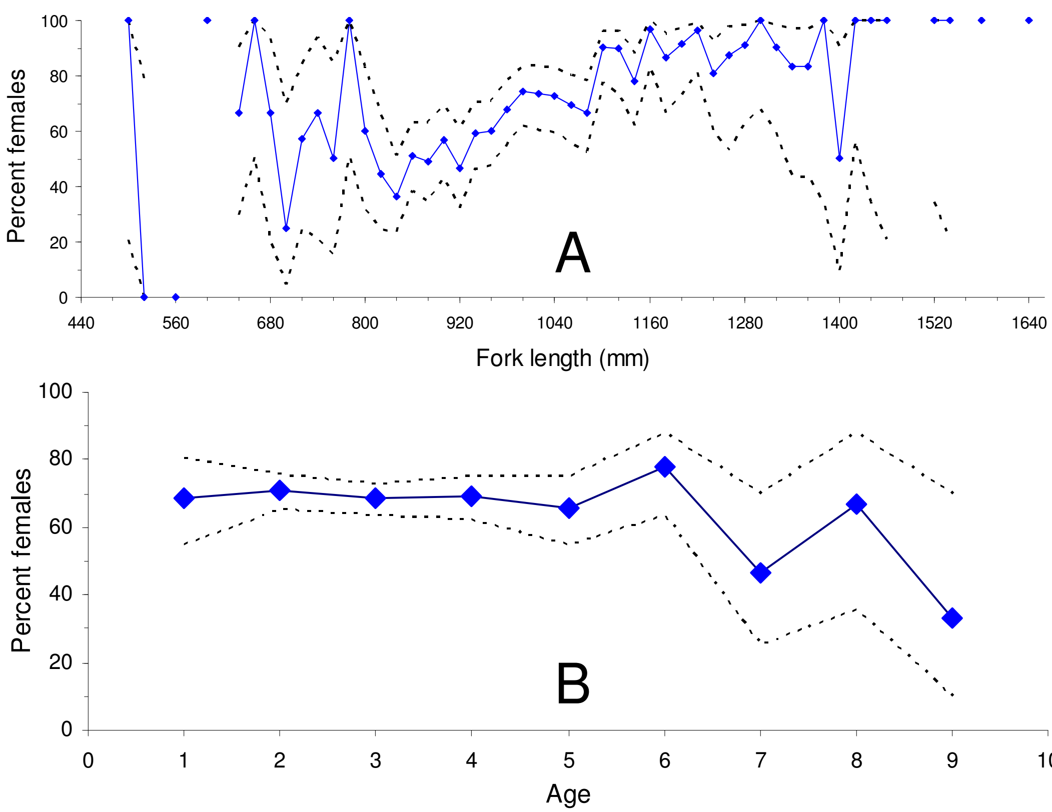

Figure 2.8.3.1. Percent Gulf of Mexico female cobia and 95% confidence limits from the pooled GCRL, Mote, NMFS Beaufort, and NMFS Panama City age data sets by 20 mm length intervals (A) and by age (B).

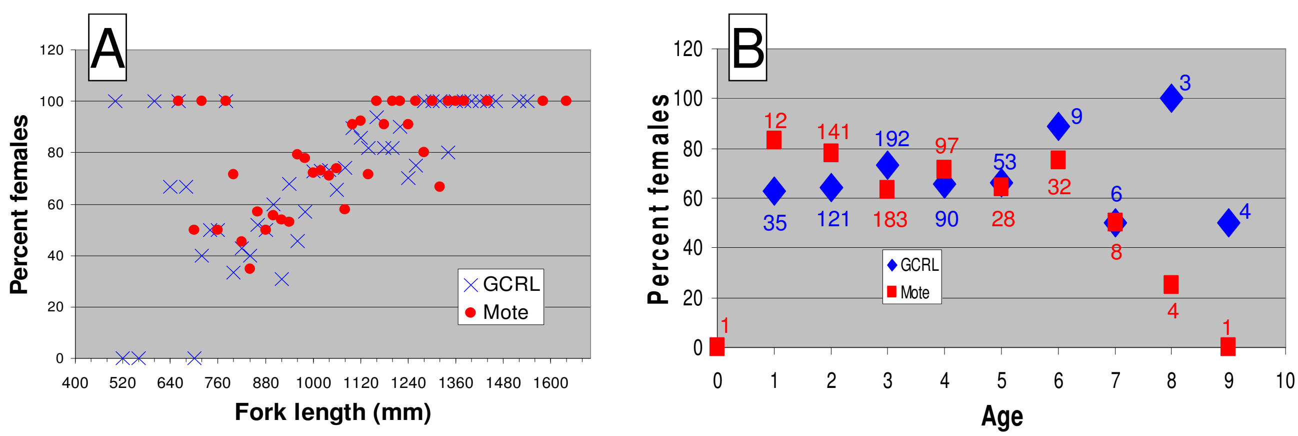

Figure 2.8.3.2. Comparison of percent Gulf of Mexico female cobia in Mote and GCRL studies by 20 mm length interval (A) and by age (B). Numbers adjacent to data points are sample sizes.

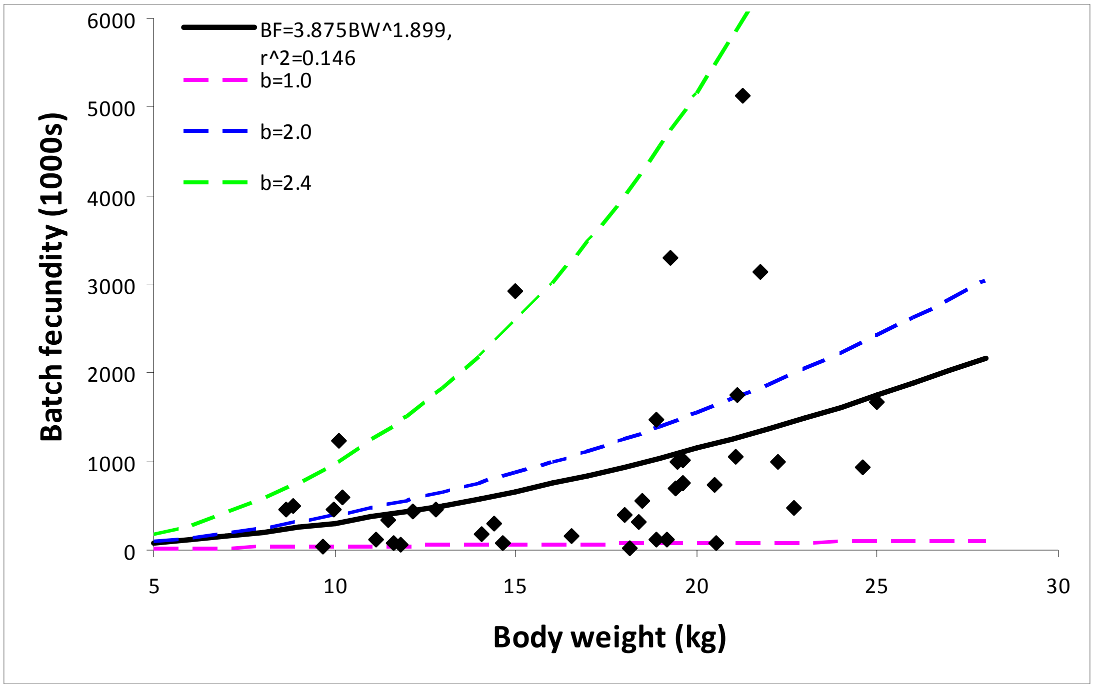

Figure 2.8.5.1. Relationship between batch fecundity and total body weight of cobia (n=39) collected in the eastern Gulf of Mexico, north central Gulf of Mexico, and in the Atlantic Ocean off the southeastern United States, April – September, 1996-97. Batch fecundity was determined from formalin-fixed oocytes > 700 um in diameter. Data from Brown-Peterson et al. (2001) and function fit by G. Fitzhugh.

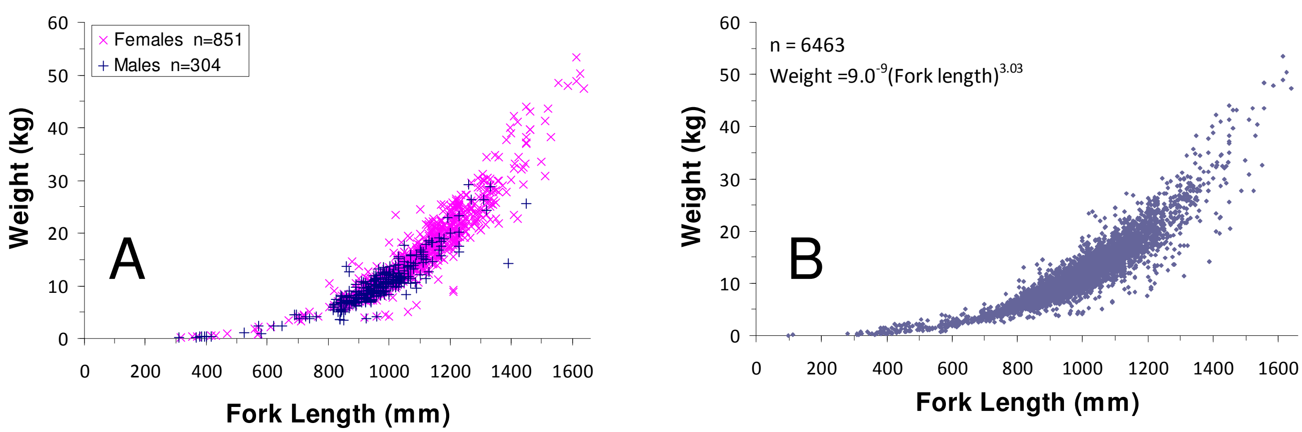

Figure 2.10.1. Gulf of Mexico cobia length-weight relationships by sex (A) and sexes combined (B).

3 Commercial Fishery Statistics

3.1 Overview

Commercial landings for the U.S. Gulf of Mexico (GoM) cobia stock were developed by gear (gill net, hand lines, and miscellaneous) in whole weight for the period 1926–2010 based on federal and state databases. Corresponding landings in numbers were based on mean weights estimated from the Trip Interview Program (TIP) by gear, state, and year.

Commercial discards were calculated from vessels fishing in the US GoM and reporting to the NMFS Coastal Logbook Program. Shrimp bycatch of cobia was estimated from observer data and SEAMAP trawl data and scaled using shrimping effort.

Sampling intensity for lengths and ages by gear and year were considered, and length and age compositions were developed by gear and year for which samples were available.

3.1.1 Participants in SEDAR 28 Data Workshop Commercial Workgroup

David Gloeckner, NMFS, Miami, FL (co-leader)
Kyle Shertzer, NMFS, Beaufort, NC (co-leader)
Donna Bellais, GulfFIN, Ocean Springs, MS
Steve Brown, FL FWC, St. Petersburg, FL
Joe Cimino, VMRC, Newport News, VA
Julie Defilippi, ACCSP, Arlington, VA
Amy Dukes, SCDNR, Charleston, SC
Stephanie McInerny, NCDMF, Morehead City, NC (rapporteur)
Tim Sartwell, ACCSP, Arlington, VA

Other contributors: Katie Andrews, Meaghan Bryan, Rob Cheshire, Ben Hartig, Rusty Hudson, Kevin McCarthy, Julie Califf, Liz Scott-Denton

3.1.2 Issues Discussed at the Data Workshop

The Workgroup (WG) discussed several issues that needed to be resolved before data could be compiled. The major issues discussed included: stock boundaries, length of time series, primary gears, discard estimates from the directed fishery and shrimp fishery, as well as length composition adequacy for characterizing size of the catch. All decisions are described in more detail in the following sections.

3.1.3 Map of Fishing Area

A map of the council boundaries is presented in Figure 3.1. The GoM cobia fishery is considered to include the area from the Georgia/Florida border around to the Texas/ Mexico border.

3.2 Review of Working Papers

The WG reviewed four working papers. All four of these papers were focused on GoM stocks.

SEDAR28-DW6: This working paper described a Bayesian approach to estimating shrimp bycatch in the GoM of both cobia and Spanish mackerel. The group found the methods to be sound, but questioned whether sample sizes for cobia were adequate to support the Bayesian model.

SEDAR28-DW7: This working paper described length frequency distributions of Spanish mackerel from commercial and recreational fleets in the GoM. Length frequencies of commercial landings were compiled from TIP data, and these data were considered adequate for use in the assessment.

SEDAR28-DW8: This working paper described length frequency distributions of cobia from commercial and recreational fleets in the GoM. Length frequencies of commercial landings were compiled from TIP data, and these data were considered adequate for use in the assessment.

SEDAR28-DW04: This working paper described the calculation of Spanish mackerel discard from the commercial gillnet, vertical line, and trolling fisheries. Discards were calculated as the product of gear-specific self-reported discard rates and total effort.

3.3 Commercial Landings

3.3.1 Time Series Duration

The WG made the decision to examine landings as far back in time as possible, because the longer time period might shed light on stock resilience and potential. Landings were compiled starting in 1926, the first year of available data, but the reliability of information improved substantially in 1950 with several additional improvements since (described along with methods).

> **Decision 1:** Landings will be presented from the earliest available year to the agreed upon terminal year. This was accepted by the plenary.

The terminal year considered for this report was 2010. However, the intent is to provide data through 2011 in time for the assessment workshop. Several data streams (e.g., discards) depend on statistics computed across years and could therefore change throughout the time series with the inclusion of 2011.

> **Decision 2:** Terminal year will be 2010 for this report, but the intent is to update with 2011 data for input to the assessment model. This decision was accepted by the plenary.

3.3.2 Fishing Year vs. Calendar Year

The WG recommended that commercial landings be aligned to the calendar year running from January 1 through December 31 because fishing years can change over time and calendar year will facilitate easier comparisons over time.

> **Decision 3:** The data will be compiled by calendar year. This was accepted by the plenary.

3.3.3 Stock Boundaries

Commercial landings were compiled from FL through TX. The eastern boundary was the GA/FL border. Landings south of the GA/FL border to the TX/Mexico border were considered to be from the GoM stock, and landings north of the GA/FL border were considered to be from the Atlantic stock (Figures 3.1 and 3.2).

Data reported as south of the GA/FL border (ALS fishing areas: 7220-7510, 0010-0219, 1121-1202, 2121-5189, 8141-9202) were included in the GoM stock. If an area fished was not specified (ALS fishing areas 0000, 9999, 7994) then the landing was assigned to the GoM if it was landed in FL, AL, MS, LA or TX (ALS states 11, 01, 21, 27, 46).

> **Decision 4:** Eastern boundary is the Georgia/Florida border and the western boundary is the Texas/Mexico border. This was accepted by the plenary.

3.3.4 Identification Issues

The commercial WG felt there was not an identification issue for cobia, so there is no need to account for misidentified cobia in the landings data.

> **Decision 5:** There is not a misidentification issue with cobia. This was accepted by the plenary.

3.3.5 Commercial Gears

The WG evaluated the distribution of gears in the landings and in the TIP data, and concluded that the data supported grouping commercial landings into two primary gears and one miscellaneous group. Thus, commercial landings were apportioned into: hand line (including trolling), long line and miscellaneous (Table 3.1). Hand lines were the dominant gear type. The WG recommended that, for the assessment model, landings from the miscellaneous gear be added to the landings for the predominant gear (hand lines).

> **Decision 6:** Landings will be aggregated by hand line, long line and miscellaneous (other) gears. For the assessment model, the miscellaneous gears should be included with the predominant (hand line) gear. This was accepted by the plenary.

Data on commercial landings from 1926-1961 are housed in a database in the National Marine Fisheries Service's Office of Science and Technology (S&T). Historical commercial landings (1962 to present) for all species on the GoM coast are maintained in the Accumulated Landings System (ALS) at the Southeast Fisheries Science Center (SEFSC). Data prior to 1968 were collected by the Bureau of Commercial Fisheries or US Fish and Fisheries Commission and are available from the database at the NMFS office of Science and Technology (NMFS personal communication). Original reports from the Bureau are available at:

http://docs.lib.noaa.gov/rescue/cof/data_rescue_fish_commission_annual_reports.html. These historical landings are also reported in NMFS, 1990.

The data collected prior to the advent of the trip ticket programs in each state were generally referred to as the NMFS General Canvass data. The General Canvass data were collected by port agents stationed in each county. The port agents would collect total landings from dealers and use local knowledge to proportion the landings into the proper fishing areas and gears. The ALS uses trip level data after the advent of trip ticket programs in each state.

Data from state trip ticket programs begin in various years, depending on the state. In the GoM, trip ticket data are available directly from the state trip ticket program or through the GoM Fisheries Information Network (GulfFIN) housed at the Gulf States Marine Fisheries Commission (GSMFC). Where data were available from state trip ticket programs, those data were used in lieu of data from ALS. Data are presented using the gear categories as determined at the workshop. The specific NMFS gears in each category are listed in Table 3.1. Commercial landings in pounds (whole weight) were developed based on methodologies for gear as defined by the WG for each state as available by gear for 1926-2010.

Florida – Prior to 1986, Florida commercial landings data were collected through the NMFS General Canvass via monthly dealer reports. In 1984, the state of Florida instituted a mandatory trip level reporting program to report harvest of commercial marine fisheries products in Florida via a marine fisheries trip ticket. The program requires seafood dealers to report all transactions of marine fisheries products purchased from commercial fishers, and to interview fishers for pertinent effort data. Trip tickets are required to be received monthly, or weekly for federally managed species. Data reported on trip tickets include participant identifiers, dates of activity, effort and location data, gear used, as well as composition and disposition of catch. The program encompasses commercial fishery activity in waters of the GoM and South Atlantic from the Alabama-Florida border to the Florida-Georgia border. The first full year of available data from Florida trip tickets is 1986.

A data set was provided to the commercial WG of summarized cobia landings by year and gear with pounds (whole weight) from Florida waters. Gear categories include hand line (including trolling), long line, and miscellaneous. Gear was not accurately reported on trip ticket data from 1986 to 1996, so for these years the landings by gear from the NMFS General Canvass data were used.

NMFS logbook data were evaluated and it was decided to use Florida trip ticket data from 1997 forward for landings, area, and gear distributions, and NMFS General Canvass landings data prior to 1997. Cobia is not required on logbooks, so commercial logbooks are not a valid source of gear information for cobia.

Alabama – Alabama trip ticket data have been collected since 2000. Those data were recoded in the FIN format and copied to the GulfFIN database every few months. GulfFIN provided the cobia landings data from AL for 2000-2010. ALS data were used for 1962-1999.

Mississippi –Mississippi finfish landings are currently collected by a NMFS port agent and housed in the ALS. Mississippi intends to begin a state trip ticket program for finfish during 2012. All MS landings for cobia were compiled from the ALS 1962-2010.

Louisiana – Louisiana trip ticket data have been collected since 1993, however, gear and fishing area were not required. In 1998 LA began to require information on gear and area of capture. Data collected since 2000 were recoded in the FIN format and copied to the GulfFIN database every few months. GulfFIN provided the cobia landings data from LA for 2000-2010. ALS data were used for 1962-1999.

Texas – Texas trip ticket data have been collected since 2009, however, TX is still developing quality control procedures to allow the data to be edited for errors before transfer to GulfFIN. Prior to the beginning of the TX trip ticket program, NMFS port agents have collected TX landings data. Because the NMFS data collection method has been in place since the 1970s, ALS was used for TX cobia landings from 1962-2010.

GoM cobia landings by gear and year are presented in Table 3.2 and Figure 3.3. The distribution of catches reported on coastal logbooks are presented in Figures 3.6 and 3.7.

Decision 7: The WG made the following decisions for reporting of commercial landings:

- Landings would be presented by calendar year/gear across all states.
- Final landings data would come from the following sources:
  - FL:
  - 1926-1949 (Bureau of Commercial Fisheries reports)
  - 1950-1961 (S&T)
  - 1962-1996 (ALS)
  - 1997-2010 (FLFWC)
  - AL:
  - 1926-1949 (Bureau of Commercial Fisheries reports)
  - 1950-1961 (S&T)
  - 1962-1999 (ALS)
  - 2000-2010 (GulfFIN)
  - MS:
  - 1926-1949 (Bureau of Commercial Fisheries reports)
  - 1950-1961 (S&T)
  - 1962-2010 (ALS)
  - LA:
  - 1926-1949 (Bureau of Commercial Fisheries reports)
  - 1950-1961 (S&T)
  - 1962-1999 (ALS)
  - 2000-2010 (GulfFIN)
  - TX:
  - 1926-1949 (Bureau of Commercial Fisheries reports)
  - 1950-1961 (S&T)
  - 1962-2010 (ALS)

Whole vs Gutted Weight – The Commercial WG discussed the topic of what units to use to report commercial landings. Cobia are typically landed whole, therefore for this analysis, landings were provided in whole weight.

> **Decision 8:** Landings will be presented in pounds whole weight. This was accepted by the plenary.

Confidentiality Issues – The Commercial WG agreed that it was necessary to hide commercial landings with fewer than three submitters. The WG recommended that landings be hidden if they fail to meet the rule of 3.

> **Decision 9:** Landings with fewer than 3 submitters should be hidden for years when the data is available to determine number of submitters. This was accepted by the plenary.

3.3.6 Converting Landings in Weight to Landings in Numbers

The weight in pounds for each sample was calculated, as was the mean weight by gear and year (weighted by weight of fish in the sample at length in pounds whole weight, trip weight in pounds whole weight, and landing weight in pounds whole weight). Where the sample size was less than 20, the mean across all years for that gear was used, if the sample size was less than 20 across all years for the gear, then the mean across all gears and years was used (Table 3.3). The landings in pounds whole weight were divided by the mean weight for that stratum to derive landings in numbers (Table 3.4 and Figure 3.4).

Remaining tasks for Commercial Landings:
Data for 2011 were not available prior to the workshop. Landings in pounds for 2011 will be added to the landings when the data have been finalized.

3.4 Commercial Discards

3.4.1 Discards from Commercial Finfish Operations

Cobia discards from the commercial vertical line, trolling, and gillnet fisheries were calculated for the US South Atlantic (statistical areas 2300-3700; Figure 3.5) and GoM (statistical areas 1-21; Figure 3.5). The number of trips that reported discards of cobia was very low (Table 3.5), limiting the complexity of any analysis. Methods for calculating discards are detailed in SEDAR 28-DW04 and are summarized below.

Cobia discard rates were calculated as the mean nominal discard rate among all trips (by gear) that reported to the discard logbook program during the period 2002–2010. Rates were separately calculated for vertical line, trolling, and gill net gears. Yearly gear specific discards were calculated as the product of the gear specific discard rate and gear specific yearly total effort (vertical line and trolling effort = total hook-hours fished; gill net effort = square yard hours fished) reported to the coastal logbook program. Discards were calculated for the years 1993–2010. Federal permits were not required to land cobia caught in federal waters, therefore, total cobia fishing effort may not have been reported to the coastal logbook program by all commercial vessels, and thus any estimates of total discards would be erroneously low.

Approximately 6.2 percent of all cobia discard reports for the period 2002–2010 were from trips reporting fishing gears other than vertical lines, trolling, and gill nets. Data reported for those other gears were not included in the discard calculations.

Yearly total gear specific discards (calculated in number of fish) from the GoM are provided in Table 3.6. Those totals include all discards reported to the discard logbook program including those reported as "kept, not sold".

The yearly calculated cobia discards from the commercial fishery (of vessels with federal permits reporting to the coastal logbook program) were relatively low. During the 18 years included in the analysis, fewer than 14,000 cobia per year were discarded in the GoM. The number of trips upon which the calculations were based, however, was very small. An additional concern was the possible under-reporting of commercial discards. The percentage of fishers returning discard logbooks with reports of "no discards" has been much greater than the percentage of observer reports of "no discards" on a commercial fishing trip suggesting that under-reporting of discards may be occurring. These results should, therefore, be used with caution. Discards calculated here may represent the minimum number of discards from the commercial fishery.

A high percentage of cobia discards were reported as "all alive" or "majority alive" in the GoM hand line and trolling fisheries (Table 3.7). The vertical line and trolling fisheries in the GoM report many fish that may have otherwise been discards as "kept" (Table 3.7). Many of those "kept" fish may have been used as bait.

> **Decision 10:** The Commercial WG supports the methodology of calculating discards and recommends the use of these data. However, the discards reported as "kept, not sold" should be added to the landings, not included with the discards. This was accepted by the plenary.

3.4.2 Discards from the Shrimp Fishery

The WG considered the estimates of cobia bycatch in the GoM shrimp fishery presented in SEDAR28-DW06 as prepared by Brian Linton. This method used a Bayesian approach to estimating bycatch, developed by Scott Nichols for the SEDAR 7 Gulf Red Snapper Assessment. The methods used and preliminary results are repeated below.

The data used in this analysis came from various shrimp observer programs, the SEAMAP groundfish survey, shrimp effort estimates and the Vessel Operating Units file. 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. Only data from 40 ft trawls by the Oregon II were used in this analysis, because these trawls were identified as being most similar to trawls conducted by the shrimp fishery. Point estimates and associated standard errors of shrimp effort were generated by the NMFS Galveston Lab using their SN-pooled method of effort estimation (Nance 2004). Most observer program CPUE data were expressed in numbers per net-hour, while the shrimp effort data were expressed in vessel-hours. Therefore, data from the NMFS Vessel Operating Units file were used to estimate the average number of nets per vessel for the shrimp fishery.

The following Bayesian model was used to estimate shrimp bycatch (i.e., model 02 from Nichols 2004a):

$Ln(CPUE)_{ijklm} = year_i + season_j + area_k + depth_l + data\_set_m + local_{ijklm}$.

The factor levels for the main effects are presented in Table 3.8. Catch in numbers for each cell was assumed to follow a negative binomial distribution. The main effects and local term, as expressed above (i.e, on the log-scale), were assigned normal prior distributions. A lognormal hyperprior was assigned to the precision (1/σ2) parameter of the local term. Therefore, the data determined the distribution of the local term in cells with data, while the distribution of the local term defaulted to the prior with fitted precision for cells without data. In effect, the local term became a fixed effect for cells with data and a random effect for cells without data.

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 the parameters and important derived quantities. Two parallel chains of 29,000 iterations each were run. The first 4,000 iterations of each chain were dropped as a burn-in period, to remove the effects of the initial parameter values. A thinning interval of five iterations (i.e., only every fifth iteration was used) was applied to each chain, to reduce autocorrelation in parameter estimates and derived quantities. The marginal posterior distributions were calculated from the remaining 10,000 iterations. Convergence of the chains was determined by visual inspection of trace plots, marginal posterior density plots, and Gelman-Rubin statistic (Brooks and Gelman, 1998) plots.

Annual observed bycatch is reported in Table 3.9. Annual estimates (predicted) of total cobia bycatch in the GoM shrimp fishery are presented in Table 3.10. The CVs associated with these estimates ranged from 66% to 208%. Only 4 of the 39 years had CVs below 100%. The marginal posterior densities of the estimates showed a high degree of skew in every year.

Since there were many years with small sample sizes and concern about the large fraction of SEAMAP samples used in this analysis, the commercial group felt that this method may not be appropriate for cobia. Additionally, it appeared as though some of the estimates were stuck on a bound, yielding the same estimate over several years. The commercial group proposed using the empirical means from the observed commercial catch as an alternative.

After the workshop the model parameters were investigated further. It was discovered that a large fraction of the cobia samples were dropped during the initial model run and these were added back to the model. This increased the sample size from 724 fish to 2,110 fish, alleviating the concerns about the small sample sizes. Additionally, it was revealed that only samples from 40ft nets fished similarly to the commercial sector were used from the

SEAMAP trawls. This alleviated concerns about using SEAMAP samples in the construction of the bycatch model. It was also discovered that some tows from SEAMAP were erroneously assigned short tow time, leading to very high discard estimates. NMFS staff are working on correcting these erroneous tow times, which should reduce the number of outliers. However, the original model still had observations that appeared to be stuck on a bound. If the new model does not display this trend, the commercial group supports using the bycatch estimates from the Bayesian model.

> **Decision 11:** The Commercial WG supports the Bayesian methodology of calculating cobia bycatch in the GoM shrimp fishery and recommends the use of these data, as long as the updated model does not appear to have a problem with the estimates getting stuck on a bound. This was accepted by the plenary on the March 14, 2012 data webinar.

3.5 Commercial Effort

The distribution of commercial effort in trips by year were compiled from the Coastal Logbook Program for 1990-2010 and supplied here for informational purposes. These data are presented in Figures 3.8 and 3.9.

3.6 Biological Sampling

Biological sample data were obtained from the TIP sample data at NMFS/SEFSC. Data that were not already in the TIP database were also incorporated from NCDMF. Data were filtered to eliminate those records that included a size or effort bias, were known to be collected non-randomly, were not from commercial trips, were selected by quota sampling, or were not collected shore-side (observer data). These data were further limited to those that could be assigned a year, gear, and state. Data that had an unknown landing year, gear, or state were deleted from the file. Additionally, samples were removed if they were drawn from market categories. This was due to the potential for bias in sampling, although a review of length data during SEDAR 17 indicated only trivial difference in the length distributions if the market categories were excluded. Further, only lengths from fish caught in the Gulf were included in the analysis.

Given the low sample sizes resulting from the strict trip limit for cobia, the commercial WG recommended that no trip weighting was needed to correct for any sampling bias. Length data were weighted spatially by the landings for the particular year, state and gear stratum, and thus were limited to where those strata could be identified in the corresponding landings. Landings and biological data were assigned a state based on landing location or sample location if there was no landing location assigned.

> **Decision 12:** The Commercial WG recommends weighting the length samples by the landings to overcome any sampling bias arising from spatial differences in sampling. This was accepted by the plenary.

3.6.1 Sampling Intensity for Lengths

The number of trips with samples used in the length compositions ranged from a high of 42 for long line gear in 2004 to a low of zero for many strata (Table 3.11). The number of trips with samples used in the length compositions was consistently greater than 10 trips for hand line gear since 2001. The number of trips with samples was greater than 10 for long line gear from 1998 to 2005. Trips using other miscellaneous gear were rarely sampled. Table 3.13 displays the number of trips with unbiased samples and number of trips with samples used (landings available).

The number of fish sampled had a high of 66 for hand line gear in 2010 to lows of zero for many of the strata (Table 3.12). The number of lengths sampled was consistently greater than 10 for hand line gear since 2000. Long line gear had over 10 lengths available for only years within 1997-2005. For other miscellaneous gears, the numbers of length samples available were never above 10. Table 3.14 displays the number of valid samples and number of samples used (landings available).

3.6.2 Length/Age Distribution

All lengths were converted to fork length (FL) in mm using the formula provided in the cobia Life History section of the SEDAR 28 Data Workshop Report and binned into one centimeter groups with a floor of 0.6 cm and a ceiling of 0.5 cm. Length was converted to weight (whole weight in pounds) using conversions provided by the life history group. The length data and landings data were divided into hand line, long line, and other miscellaneous gears. Length compositions were weighted by the landings in numbers by strata (state, year, gear). Annual length compositions of cobia are summarized in Figures 3.10-3.12.

Observer samples were provided from the Reeffish Observer Program by the NMFS Galveston Lab. These data were filtered to remove non-random samples. Of the remaining data, only nine cobia were reported as discarded. One fish was measured at 73.4 FL in cm was reported for 2006, six fish in 2007 (51.5, 65, 70, 71, 77.5, and 88.9 FL in cm), and two fish in 2008 (73.1 and 78.5 FL in cm).

Sample size of cobia ages are summarized by gear from commercial landings in the U.S. GoM for 1983-2010 (Table 3.13). Age compositions were developed for hand line (1988-2010 with exceptions in Figure 3.13), long line (1988-2010, Figure 3.14), and other miscellaneous (1988-2010, Figure 3.15) gear types. The commercial group suggests ages are weighted by the length composition with the formula:

$$RW_i = \frac{NLi \,/\, TN}{OLi \,/\, TO},$$

where *NLi* is the number of fish measured with length *i*, *TN* is the total number of fish measured in that strata, *OLi* is the number of ages sampled at length *i,* and *TO* is the total number of ages sampled within the strata and RW_i is the weight to apply to the age (Chih, 2009). This weighting corrects for a potential sampling bias of age samples relative to length samples (SEDAR, 2006). Weighting by length composition was not done at this time, pending resolution of how to correct the age data when length compositions are not available for the given year and gear strata. The age compositions presented in Figures 3.13-3.15 are unweighted.

3.7 Comments on Adequacy of Data for Assessment Analyses

Landings data appear to be adequate to support the assessment, with landings reports beginning in the 1920s. Landings have greatest certainty since the individual state's trip ticket programs were initiated. Landings prior to 1950 are considered highly uncertain.

Discard estimates have greater uncertainty than the landings, as there are very few trips where cobia discards were observed by the Reeffish Observer Program. Additionally, the NMFS logbook doesn't capture the entire fishery, so the discards reported to this program should be considered a minimum estimate. Bycatch in the shrimp fishery is difficult to determine given the low encounter rate between shrimp trawls and cobia, and because of irregular observer coverage. As a consequence, the annual variability in shrimp bycatch may be poorly estimated, although the estimated mean bycatch may be at the appropriate scale.

Commercial discards and shrimp bycatch are based on estimated encounter rates and effort. In years when multi-year averages are used to compute encounter rates, these estimates do not account for year-specific age structure in the cobia stock.

Sample sizes for developing length compositions were inadequate for a considerable number of year and gear strata. This may impact the ability in those years to use length compositions to correct for potential biases in age compositions. The annual proportion of commercial landings sampled for lengths is typically less than 1% in all years (Table 3.14). Age compositions were inadequate for all years, which will limit the ability to construct catch at age.

3.8 Literature Cited

Chih, C. 2009. The effects of otolith sampling methods on the precision of growth curves, North American Journal of Fisheries Management *in press*.

Nance, J. 2004. Estimation of effort in the offshore shrimp trawl fishery of the Gulf of Mexico. NOAA Southeast Fisheries Science Center, Galveston Laboratory. SEDAR7-DW-24.

Nichols, S. 2004a. Some Bayesian approaches to estimation of shrimp fleet bycatch. NOAA Southeast Fisheries Science Center, Pascagoula Laboratory. SEDAR7-DW-3.

Nichols, S. 2004b. Update for the Bayesian estimation of shrimp fleet bycatch. NOAA Southeast Fisheries Science Center, Pascagoula Laboratory. SEDAR7-DW-54.

NMFS (National Marine Fisheries Service). 1990. Historical Catch Statistics, Atlantic and Gulf Coast States: 1879-1989; Current Fishery Statistics No. 9010; Historical Series Nos. 5-9 revised. Washington, DC: U.S. Government Printing Office.

SEDAR. 2006. SEDAR 10 Stock Assessment Report1 South Atlantic Gag Grouper. (http://www.sefsc.noaa.gov/sedar/download/S10_SAR1_SA_Gag_updated_ALL.pdf?id=DOCUMENT).

U.S. Fish and Fisheries Commission. 2012. Report of the Commissioner. (http://docs.lib.noaa.gov/rescue/cof/data_rescue_fish_commission_annual_reports.html).

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Addendum to Commercial Landings (Section 3.3):

NMFS SEFIN Accumulated Landings (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 SEFIN database management system 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, this ancillary data are not available.

Commercial landings statistics have been collected and processed by various organizations during the 1962-to-present period that the SEFIN data set covers. During the 16 years from 1962 through 1978, these data were collected by port agents employed by the Federal government and stationed at major fishing ports in the southeast. The program was run from the Headquarters Office of the Bureau of Commercial Fisheries in Washington DC. 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 SEFIN database.

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

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

Because the data collection procedures (regulations) are different for each state, the type and detail of data varies throughout the Region. The commercial landings database maintained in 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
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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
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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 SEFIN Annual Canvas Data for Florida
The Florida Annual Data files from 1976 – 1996 represent annual landings by county (from dealer reports) which are broken out on a percentage estimate by species, gear, area of capture, and distance from shore. These estimates are submitted by Port agents, which were assigned responsibility for the particular county, from interviews and discussions from dealers and fishermen collected throughout the year. The estimates are processed against the annual landings totals by county on a percentage basis to create the estimated proportions of catch by the gear, area and distance from shore. (The sum of percentages for a given Year, State, County, Species combination will equal 100.)

Area of capture considerations: ALS is considered to be a commercial landings 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.

3.9 Tables

Table 3.1. NMFS gears in each gear category for cobia commercial landings.

NMFS GEAR CODE	GEAR DESCRIPTION	GEAR CATEGORY
0	Not Coded	OTHER
20	Haul Seines, Beach	OTHER
30	Haul Seines, Long	OTHER
32	Haul Seines, Long(Danish)	OTHER
40	Stop Seines	OTHER
50	Stop Nets	OTHER
100	Encircling Nets (Purse)	OTHER
103	Purse Seines, Anchovy	OTHER
105	Purse Seines, Barracuda	OTHER
110	Purse Seines, Herring	OTHER
120	Purse Seines, Mackerel	OTHER
125	Purse Seines, Menhaden	OTHER
130	Purse Seines, Salmon	OTHER
135	Purse Seines, Sardine	OTHER
140	Purse Seines, Tuna	OTHER
145	Purse Seines, Other	OTHER
150	Nets Unc, Hawaii	OTHER
151	Nets, excluding trawls	OTHER
155	Lampara & Ring Nets, Mackerel	OTHER
160	Lampara & Ring Nets, Sardine	OTHER
165	Lampara & Ring Nets, Squid	OTHER
170	Lampara & Ring Nets, Tuna	OTHER
175	Lampara & Ring Nets, Other	OTHER
180	Bag Nets	OTHER
185	Paranella Nets	OTHER
187	Skimmer Nets	OTHER
189	Butterfly Nets	OTHER
191	Beam Trawls, Crab	OTHER
192	Beam Trawls, Shrimp	OTHER
193	Beam Trawls, Other	OTHER
194	BEAM TRAWLS, CHOPSTICKS	OTHER
200	Trawls, Unspecified	OTHER

205	Otter Trawl Bottom, Crab	OTHER
210	Otter Trawl Bottom, Fish	OTHER
212	Otter Trawl Bottom, Lobster	OTHER
214	Otter Trawl Bottom, Scallop	OTHER
215	Otter Trawl Bottom, Shrimp	OTHER
217	Otter Trawl Bottom, Twin	OTHER
220	Otter Trawl Bottom, Other	OTHER
230	Otter Trawl Midwater	OTHER
233	Trawl Midwater, Paired	OTHER
235	Trawl Bottom, Paired	OTHER
240	Scottish Seine	OTHER
250	Weirs	OTHER
275	Pound Nets, Fish	OTHER
280	Pound Nets, Crab	OTHER
285	Pound Nets, Horseshoe Crab	OTHER
289	Pound Nets, Other	OTHER
290	Trap Nets	OTHER
295	Floating Traps (Shallow)	OTHER
300	Pots And Traps, Cmb	OTHER
305	Fyke And Hoop Nets, Crab	OTHER
310	Fyke And Hoop Nets, Fish	OTHER
315	Fyke And Hoop Nets, Turtle	OTHER
320	Fyke Net, Other	OTHER
325	Pots And Traps, Conch	OTHER
330	Pots And Traps, Crab, Blue	OTHER
331	Pots And Traps, Crab, Dungens	OTHER
332	Pots And Traps, Crab, King	OTHER
333	Pots And Traps, Crab, Other	OTHER
334	Pots and Traps, Crab, Blue Peeler	OTHER
335	Pots And Traps,Crayfsh(frhwa)	OTHER
340	Pots And Traps, Eel	OTHER
345	Pots And Traps, Fish	OTHER
350	Pots And Traps, Lobster Inshore	OTHER
351	Pots And Traps, Lobster Offshore	OTHER
355	Pots And Traps, Spiny Lobster	OTHER
360	Pots And Traps, Octopus	OTHER
365	Pots And Traps, Perwkle Or	OTHER

	Ckle	
370	Pots And Traps, Shrimp	OTHER
375	Pots And Traps, Turtle	OTHER
379	Pots And Traps, Other	OTHER
380	Pots And Traps, Box Trap	OTHER
385	Pots And Traps, Wire Baskets	OTHER
387	Pots, Unclassified	OTHER
390	Slat Traps (Virginia)	OTHER
400	Entangling Nets (Gill) Unspc	OTHER
405	Gill Nets, California Halibut	OTHER
410	Gill Nets, Crab	OTHER
415	Gill Nets, Salmon	OTHER
420	Gill Nets, Sea Bass	OTHER
425	Gill Nets, Other	OTHER
430	Gill Nets, Sink/Anchor, Other	OTHER
450	Gill Nets, Drift, Barracuda	OTHER
455	Gill Nets, Drift, Salmon	OTHER
460	Gill Nets, Drift, Sea Bass	OTHER
465	Gill Nets, Drift, Shad	OTHER
470	Gill Nets, Drift, Other	OTHER
475	Gill Nets, Drift, Runaround	OTHER
480	Gill Nets, Stake	OTHER
490	Gill Nets, Gl Shoal	OTHER
500	Gill Nets, Gl 1 - 2 Inch	OTHER
505	Gill Nets, Gl 2 - 4 Inch	OTHER
510	Gill Nets, Gl 4 - 7 Inch	OTHER
515	Gill Nets, Gl 7 - 14 Inch	OTHER
520	Gill Nets, Drift Large Pelagic	OTHER
530	Trammel Nets	OTHER
600	Troll & Hand Lines Cmb	HOOK & LINE
601	Lines Hand, Albacore	HOOK & LINE
605	Lines Hand, Rockfish	HOOK & LINE
607	Lines Hand, Yellowfish	HOOK & LINE
610	Lines Hand, Other	HOOK & LINE
611	Rod and Reel	HOOK & LINE
612	Reel, Manual	HOOK & LINE
613	Reel, Electric or Hydraulic	HOOK & LINE
614	BUOY GEAR, VERTICAL	LONG LINE
616	Rod and Reel, Electric (Hand)	HOOK & LINE

621	Lines Jigging Machine	HOOK & LINE
650	Lines Troll, Salmon	HOOK & LINE
651	Lines Power Troll Salmon	HOOK & LINE
655	Lines Troll, Tuna	HOOK & LINE
656	Lines Power Troll Tuna	HOOK & LINE
657	LINES TROLL, GREEN-STICK	HOOK & LINE
660	Lines Troll, Other	HOOK & LINE
661	Lines Power Troll Other	HOOK & LINE
665	Lines Troll, Mackerel	HOOK & LINE
675	Lines Long Set With Hooks	LONG LINE
676	Lines Long, Reef Fish	LONG LINE
677	Lines Long, Shark	LONG LINE
678	Lines Long Drift With Hooks	LONG LINE
680	Lines Trot With Baits	OTHER
685	Lines Snag	OTHER
690	Lines Electrical Devices	OTHER
703	Dip Nets, Common	OTHER
705	Dip Nets, Drop	OTHER
710	Brail Or Scoop	OTHER
715	Lift Net	OTHER
720	Reef Net	OTHER
725	Push Net	OTHER
730	Wheels	OTHER
735	Cast Nets	OTHER
751	Harpoons, Swordfish	OTHER
752	Harpoons, Turtle	OTHER
753	Harpoons, Whale	OTHER
754	Harpoons, Other	OTHER
760	Spears	OTHER
765	Powerheads (Bangsticks)	OTHER
770	Scrapes	OTHER
781	Water Pump,Sand Shrimp	OTHER
785	Barge Kelp	OTHER
802	Dredge Clam Hydraulic	OTHER
803	Dredge Clam	OTHER
804	Dredge Conch	OTHER
805	Dredge Crab	OTHER
810	Dredge Mussel	OTHER
815	Dredge Oyster, Common	OTHER
820	Dredge Oyster, Suction	OTHER
823	Dredge Scallop, Bay	OTHER

825	Dredge Scallop, Sea	OTHER
827	Dredge Urchin, Sea	OTHER
830	Dredge Other	OTHER
840	Tongs and Grabs, Oyster	OTHER
841	Tongs Patent, Oyster	OTHER
845	Tongs and Grabs, Other	OTHER
846	Tongs Patent, Clam Other	OTHER
853	Rakes, Oyster	OTHER
855	Rakes, Other	OTHER
860	Hoes	OTHER
865	Forks	OTHER
870	Shovels	OTHER
875	Picks	OTHER
880	Brush Trap	OTHER
890	Crowfoot Bars	OTHER
895	Frog Grabs	OTHER
925	Hooks, Sponge	OTHER
930	Hooks, Abalone	OTHER
935	Hooks, Other	OTHER
941	Diving Outfits, Abalone	OTHER
942	Diving Outfits, Sponge	OTHER
943	Diving Outfits, Other	OTHER
944	Diving with Nets	OTHER
951	By Hand, Oyster	OTHER
955	By Hand, Other	OTHER
966	Other Gear, Hawaii	OTHER
967	Various Gear, Fishponds Hawaii	OTHER
989	Unspecified Gear	OTHER
999	Combined Gears	OTHER

Table 3.2. Cobia landings (pounds whole weight) by gear from the U.S. Gulf of Mexico, 1926-2010.

	GEAR		
YEAR	HAND LINE	LONG LINE	OTHER
1927	5,511	0	3,939
1928	13,312	0	9,515
1929	8,588	0	6,139
1930	8,365	0	5,979
1931	6,093	0	4,355
1932	3,385	0	2,420
1933			
1934	4,315	0	3,085
1935			
1936	3,441	0	2,459
1937	1,166	0	834
1938	4,315	0	3,085
1939	3,732	0	2,668
1940	816	0	584
1941			
1942			
1943			
1944			
1945	175	0	125
1946			
1947			
1948	2,508	0	1,792
1949	15,978	0	11,422
1950	25,717	0	18,383
1951	29,041	0	20,759
1952	21,926	0	15,674
1953	16,853	0	12,047
1954	15,337	0	10,963
1955	17,844	0	12,756
1956	8,747	0	6,253
1957	15,045	0	10,755
1958	14,229	0	10,171
1959	24,084	0	17,216
1960	33,123	0	23,677
1961	20,352	0	14,548
1962	33,700	0	5,800
1963	42,000	0	2,800
1964	27,400	0	600
1965	22,700	0	2,800
1966	31,400	0	11,200
1967	24,300	0	23,800
1968	51,000	0	38,300
1969	42,900	0	32,600

1970	59,900	0	59,700
1971	66,100	0	44,300
1972	51,200	0	36,300
1973	35,400	0	52,200
1974	45,600	0	55,300
1975	47,800	0	49,900
1976	69,100	127	47,900
1977	64,500	0	47,810
1978	62,356	0	51,106
1979	58,144	0	42,842
1980	71,258	0	47,845
1981	86,138	0	56,922
1982	79,806	0	47,328
1983	98,561	0	51,986
1984	124,268	0	33,979
1985	135,223	**	37,615
1986	159,649	4,238	30,013
1987	174,586	8,646	49,772
1988	163,172	13,395	56,628
1989	225,910	11,793	66,115
1990	169,632	6,619	64,171
1991	161,148	19,210	93,502
1992	191,904	22,664	132,256
1993	184,195	24,864	144,023
1994	174,849	19,345	157,620
1995	183,322	13,722	133,997
1996	222,452	27,020	116,387
1997	174,026	20,195	107,602
1998	177,084	16,957	94,333
1999	155,769	24,159	104,689
2000	142,489	26,150	43,370
2001	117,670	19,320	40,876
2002	130,631	24,148	28,752
2003	141,183	29,757	23,892
2004	124,077	27,601	27,612
2005	91,243	19,531	26,077
2006	90,134	24,910	36,001
2007	108,604	15,073	23,511
2008	99,241	19,084	21,089
2009	102,707	9,462	25,135
2010	173,107	5,920	15,906

** = indicates confidential data withheld.

Table 3.3. Mean weights in pounds whole weight used to derive cobia landings in numbers by year and gear. Source indicates the level of aggregation used: GEAR_MEANS = mean weight for the gear across all years, STRATA = mean weight within the gear and year strata.

	GEAR								
	HAND LINE			LONG LINE			OTHER		
YEAR	MEAN WEIGHT	STANDARD DEVIATION	SOURCE	MEAN WEIGHT	STANDARD DEVIATION	SOURCE	MEAN WEIGHT	STANDARD DEVIATION	SOURCE
1927	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1928	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1929	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1930	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1931	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1932	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1933	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1934	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1935	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1936	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1937	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1938	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1939	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1940	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1941	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1942	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1943	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1944	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1945	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1946	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1947	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1948	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1949	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1950	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1951	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1952	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1953	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1954	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS

1955	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1956	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1957	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1958	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1959	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1960	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1961	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1962	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1963	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1964	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1965	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1966	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1967	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1968	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1969	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1970	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1971	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1972	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1973	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1974	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1975	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1976	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1977	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1978	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1979	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1980	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1981	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1982	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1983	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1984	22.388	38.167	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1985	39.832	90.649	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1986	20.878	41.797	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1987	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1988	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1989	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS

1990	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1991	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1992	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1993	27.407	59.325	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1994	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1995	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1996	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1997	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1998	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
1999	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2000	33.395	91.365	GEAR_MEANS	44.074	116.257	STRATA	33.764	79.631	GEAR_MEANS
2001	44.181	85.472	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2002	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2003	39.370	117.017	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2004	35.400	60.989	STRATA	36.458	87.262	STRATA	33.764	79.631	GEAR_MEANS
2005	27.666	58.409	STRATA	39.321	108.323	STRATA	33.764	79.631	GEAR_MEANS
2006	28.735	56.703	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2007	26.780	55.542	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2008	33.395	91.365	GEAR_MEANS	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2009	25.622	47.069	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS
2010	28.325	63.084	STRATA	40.158	106.344	GEAR_MEANS	33.764	79.631	GEAR_MEANS

Table 3.4. Gulf of Mexico cobia commercial landings by gear and year in numbers.

	GEAR		
YEAR	HAND LINE	LONG LINE	OTHER
1927	165		117
1928	399		282
1929	257		182
1930	250		177
1931	182		129
1932	101		72
1933			
1934	129		91
1935			
1936	103		73
1937	35		25
1938	129		91
1939	112		79
1940	24		17
1941			
1942			
1943			
1944			
1945	5		4
1946			
1947			
1948	75		53
1949	478		338
1950	770	0	544
1951	870	0	615
1952	657	0	464
1953	505	0	357
1954	459	0	325
1955	534	0	378
1956	262	0	185
1957	451	0	319
1958	426	0	301
1959	721	0	510
1960	992	0	701
1961	609	0	431
1962	1,009	0	172
1963	1,258	0	83
1964	820	0	18
1965	680	0	83
1966	940	0	332
1967	728	0	705
1968	1,527	0	1,134
1969	1,285	0	966
1970	1,794	0	1,768
1971	1,979	0	1,312
1972	1,533	0	1,075
1973	1,060	0	1,546
1974	1,365	0	1,638
1975	1,431	0	1,478
1976	2,069	3	1,419
1977	1,931	0	1,416

1978	1,867	0	1,514
1979	1,741	0	1,269
1980	2,134	0	1,417
1981	2,579	0	1,686
1982	2,390	0	1,402
1983	2,951	0	1,540
1984	5,551	0	1,006
1985	3,395	**	1,114
1986	7,647	106	889
1987	5,228	215	1,474
1988	4,886	334	1,677
1989	6,765	294	1,958
1990	5,080	165	1,901
1991	4,825	478	2,769
1992	5,746	564	3,917
1993	6,721	619	4,266
1994	5,236	482	4,668
1995	5,489	342	3,969
1996	6,661	673	3,447
1997	5,211	503	3,187
1998	5,303	422	2,794
1999	4,664	602	3,101
2000	4,267	593	1,285
2001	2,663	481	1,211
2002	3,912	601	852
2003	3,586	741	708
2004	3,505	757	818
2005	3,298	497	772
2006	3,137	620	1,066
2007	4,055	375	696
2008	2,972	475	625
2009	4,009	236	744
2010	6,112	147	471

** = indicates confidential data withheld

Table 3.5. Number of trips reporting cobia discards by region and gear fished; all years combined (2002-2010). "Other species" totals include all other reports to the discard logbook program. Also included in "other species" totals are trips with no reported discards. Trips with multiple gears fished reported or that fished in both regions may be counted more than once. Totals include only those vessels with federal fishing permits.

Region	Species	Gillnet	Vertical line	Trolling	All other gears
GOM	Cobia	0	349	83	29
	Other species (cobia boundaries)	586	32,072	13,224	4,203
SA	Cobia	43	44	13	6
	Other species (cobia boundaries)	1,952	6,049	2,165	1,838

Table 3.6. Cobia yearly total calculated discards from commercial gill net, vertical line, and trolling vessels with federal fishing permits in the Gulf of Mexico. Discards are reported as number of fish. No cobia discards were reported from gill net trips in the Gulf of Mexico, although discards of other species were reported.

Year	Gillnet	Vertical line	Trolling	Calculated discards
1993		9,131	42	9,173
1994		10,877	43	10,919
1995		10,246	48	10,293
1996		11,080	71	11,151
1997		12,350	64	12,415
1998	0	11,854	273	12,127
1999	0	13,569	276	13,845
2000	0	12,743	265	13,008
2001	0	11,847	236	12,083
2002	0	12,522	198	12,720
2003	0	13,385	189	13,574
2004	0	11,715	142	11,858
2005	0	11,421	111	11,532
2006	0	11,327	143	11,471
2007	0	10,728	158	10,886
2008	0	9,482	159	9,641
2009	0	11,769	163	11,932
2010	0	9,557	141	9,698

Table 3.7. Self-reported discard mortality/disposition of cobia caught on commercial fishing vessels with federal fishing permits, 2002-2010. No cobia discards were reported from gill net vessels in the Gulf of Mexico.

Region	Gear	Disposition							Number of fish
		All Dead	Majority Dead	All Alive	Majority Alive	Kept	Unable to Determine	Unreported	
South Atlantic	Gillnet	3%	23%	43%	28%	3%	0%	3%	87
	Handline/Electric	5%	2%	88%	6%	0%	0%	5%	65
	Trolling	0%	0%	93%	0%	7%	0%	0%	27
Gulf of Mexico	Gillnet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0
	Handline/Electric	0%	1%	86%	4%	9%	0%	0%	774
	Trolling	1%	0%	66%	5%	29%	0%	1%	132

Table 3.8. List of factor levels for the main effects of the shrimp bycatch estimation model.

Main Effect	Levels	Description
Year	39	1972-2010
Season	3	Jan-Apr, May-Aug, Sep-Dec
Area	4	Stat grids 1-9, 10-12, 13-17, 18-21
Depth	2	Inside 10 fm, Outside 10 fm
Data Set	2	Observer program, Research vessel

Table 3.9. Observed shrimp bycatch of cobia in the Gulf of Mexico from the observer program and SEAMAP groundfish survey. Bycatch is reported in numbers of fish.

Year	Cobia bycatch
1972	8
1973	3
1974	32
1975	34
1976	16
1977	5
1978	8
1979	10
1980	164
1981	6
1982	13
1983	16
1984	9
1985	5
1986	1
1987	3
1988	0
1989	4
1990	5
1991	6
1992	65
1993	39
1994	50
1995	10
1996	16
1997	24
1998	9
1999	17
2000	2
2001	18
2002	34
2003	11
2004	17
2005	9
2006	10
2007	6
2008	19
2009	7
2010	13

Table 3.10. Predicted annual shrimp bycatch (millions of fish) of cobia in the Gulf of Mexico.

year	mean	sd	MC error	2.50%	25.00%	median	75.00%	97.50%	start	sample
1972	1.244	1.753	0.05454	0.1671	0.4659	0.8064	1.419	5.08	4001	10000
1973	0.2121	0.258	0.007769	0.03364	0.08707	0.1481	0.2501	0.7686	4001	10000
1974	1.737	1.906	0.06236	0.3185	0.7509	1.224	2.047	6.272	4001	10000
1975	0.506	0.5604	0.01377	0.1117	0.2402	0.3688	0.5898	1.71	4001	10000
1976	0.3027	0.3229	0.008143	0.08088	0.1568	0.2293	0.3528	0.9417	4001	10000
1977	0.1424	0.1349	0.003506	0.03105	0.06922	0.1074	0.17	0.463	4001	10000
1978	0.188	0.1884	0.004405	0.04033	0.09085	0.1411	0.2232	0.5986	4001	10000
1979	2.704	3.312	0.09374	0.3463	0.9971	1.748	3.189	10.5	4001	10000
1980	0.6132	0.4181	0.01206	0.2153	0.3734	0.5108	0.7286	1.582	4001	10000
1981	0.2806	0.3764	0.009106	0.04663	0.1167	0.1902	0.3272	1.049	4001	10000
1982	1.025	1.493	0.04325	0.1777	0.4286	0.7015	1.18	3.745	4001	10000
1983	1.534	1.763	0.0566	0.2654	0.6522	1.063	1.793	5.61	4001	10000
1984	0.9985	1.424	0.03663	0.1608	0.3975	0.6644	1.162	3.783	4001	10000
1985	1.187	1.436	0.03371	0.181	0.4737	0.8142	1.407	4.403	4001	10000
1986	1.271	1.825	0.04377	0.1367	0.428	0.7761	1.482	5.314	4001	10000
1987	1.968	2.471	0.05831	0.2287	0.6957	1.25	2.353	8.177	4001	10000
1988	0.7849	1.016	0.02604	0.07888	0.2659	0.4874	0.9271	3.355	4001	10000
1989	1.797	2.587	0.06434	0.2483	0.6807	1.181	2.092	7.01	4001	10000
1990	1.445	1.723	0.04351	0.205	0.5653	0.9971	1.707	5.42	4001	10000
1991	1.781	2.182	0.05984	0.2459	0.6668	1.159	2.044	7.193	4001	10000
1992	1.053	0.6917	0.01574	0.3664	0.641	0.8837	1.251	2.703	4001	10000
1993	0.751	0.6681	0.01453	0.2103	0.4002	0.5731	0.8687	2.363	4001	10000
1994	1.081	1.081	0.02497	0.2475	0.534	0.8122	1.289	3.539	4001	10000
1995	3.936	4.779	0.1273	0.5401	1.511	2.612	4.6	15.24	4001	10000
1996	4.843	6.439	0.1674	0.6576	1.816	3.114	5.576	19.58	4001	10000
1997	8.827	11.74	0.3109	1.259	3.313	5.77	10.29	34.75	4001	10000

1998	3.502	4.734	0.1125	0.4319	1.269	2.251	4.119	13.99	4001	10000
1999	4.044	4.454	0.1243	0.6899	1.676	2.766	4.791	15.02	4001	10000
2000	1.271	1.813	0.05021	0.1508	0.4327	0.795	1.445	5.339	4001	10000
2001	3.074	4.714	0.1099	0.4582	1.201	2.053	3.566	11.32	4001	10000
2002	0.476	0.5503	0.01354	0.1114	0.226	0.3451	0.5399	1.669	4001	10000
2003	2.712	3.809	0.08589	0.3775	1.044	1.788	3.159	10.26	4001	10000
2004	4.407	6.559	0.1545	0.616	1.645	2.878	5.122	17.25	4001	10000
2005	4.023	8.383	0.1464	0.4599	1.358	2.419	4.502	16.06	4001	10000
2006	2.182	3.282	0.07989	0.2966	0.7888	1.373	2.43	8.716	4001	10000
2007	8.272	10.05	0.264	0.8996	2.9	5.338	9.87	33.55	4001	10000
2008	19.2	21.47	0.5524	2.868	7.902	13.49	23	69.45	4001	10000
2009	0.8531	1.04	0.028	0.1161	0.3287	0.5635	0.9894	3.31	4001	10000
2010	0.05572	0.07236	0.001798	0.00741	0.02039	0.03628	0.06586	0.222	4001	10000

Table 3.11. Number of Gulf of Mexico cobia trips with valid samples (no biases) and number of trips with samples usable for analysis (landings available) by year and gear.

	GEAR					
	HAND LINE		LONG LINE		OTHER	
YEAR	SAMPLES USED	VALID SAMPLES	SAMPLES USED	VALID SAMPLES	SAMPLES USED	VALID SAMPLES
1983	2	2	0	0	0	0
1984	10	10	0	1	0	0
1985	7	7	0	0	1	2
1986	11	11	0	0	5	5
1987	1	1	3	3	1	1
1988	0	0	0	0	0	0
1989	2	2	0	0	0	0
1990	0	22	1	1	0	0
1991	3	39	0	0	0	1
1992	10	34	2	6	0	0
1993	6	27	9	12	2	2
1994	3	31	14	14	3	3
1995	13	27	9	13	1	1
1996	3	11	7	12	0	0
1997	1	19	9	13	0	0
1998	2	6	19	19	2	2
1999	8	8	17	17	1	1
2000	8	8	23	23	2	2
2001	23	24	12	12	0	0
2002	10	10	14	14	3	3
2003	25	25	15	15	0	0
2004	33	33	42	42	0	0
2005	21	21	24	24	0	0
2006	21	21	4	4	2	2
2007	29	29	1	1	2	2
2008	15	15	5	5	4	4
2009	26	26	2	2	0	0
2010	34	34	1	1	4	4

**=data deemed confidential have been removed

Table 3.12. Number of cobia length samples used for analysis and number of valid (no biases) length samples collected by year and gear.

	GEAR					
	HAND LINE		LONG LINE		OTHER	
YEAR	SAMPLES USED	VALID SAMPLES	SAMPLES USED	VALID SAMPLES	SAMPLES USED	VALID SAMPLES
1983	10	10	0	0	0	0
1984	31	31	0	1	0	0
1985	35	35	0	0	1	2
1986	36	36	0	0	6	6
1987	1	1	3	3	2	2
1988	0	0	0	0	0	0
1989	2	2	0	0	0	0
1990	0	46	1	1	0	0
1991	3	87	0	0	1	1
1992	10	70	2	26	0	0
1993	20	56	11	20	2	2
1994	3	76	16	16	5	5
1995	13	41	9	21	1	1
1996	3	18	8	21	0	0
1997	1	25	10	18	0	0
1998	2	8	19	19	2	2
1999	9	9	17	17	1	1
2000	10	10	24	24	3	3
2001	47	48	14	14	0	0
2002	13	13	16	16	3	3
2003	31	31	18	18	0	0
2004	63	63	62	62	0	0
2005	34	34	41	41	0	0
2006	37	37	5	5	3	3
2007	54	54	2	2	2	2
2008	18	18	7	7	4	4
2009	45	45	2	2	0	0
2010	66	66	2	2	6	6

Table 3.13. U.S. Gulf of Mexico commercial cobia age samples by gear and year.

	GEAR		
YEAR	HAND LINE	LONG LINE	OTHER
1998	3	0	0
2000	3	0	0
2001	1	0	0
2007	1	0	0
2008	7	4	1
2009	2	2	0
2010	1	0	0

Table 3.14. Gulf of Mexico cobia commercial length sampling fractions (length samples used/landings in numbers) by gear and year.

	GEAR		
YEAR	HAND LINE	LONG LINE	OTHER
1983	0.003	0.000	0.000
1984	0.006	0.000	0.000
1985	0.010	0.000	0.001
1986	0.005	0.000	0.007
1987	0.000	0.014	0.001
1988	0.000	0.000	0.000
1989	0.000	0.000	0.000
1990	0.000	0.006	0.000
1991	0.001	0.000	0.000
1992	0.002	0.004	0.000
1993	0.003	0.018	0.000
1994	0.001	0.033	0.001
1995	0.002	0.026	0.000
1996	0.000	0.012	0.000
1997	0.000	0.020	0.000
1998	0.000	0.045	0.001
1999	0.002	0.028	0.000
2000	0.002	0.040	0.002
2001	0.018	0.029	0.000
2002	0.003	0.027	0.004
2003	0.009	0.024	0.000
2004	0.018	0.082	0.000
2005	0.010	0.083	0.000
2006	0.012	0.008	0.003
2007	0.013	0.005	0.003
2008	0.006	0.015	0.006
2009	0.011	0.008	0.000
2010	0.011	0.014	0.013

3.11 Figures

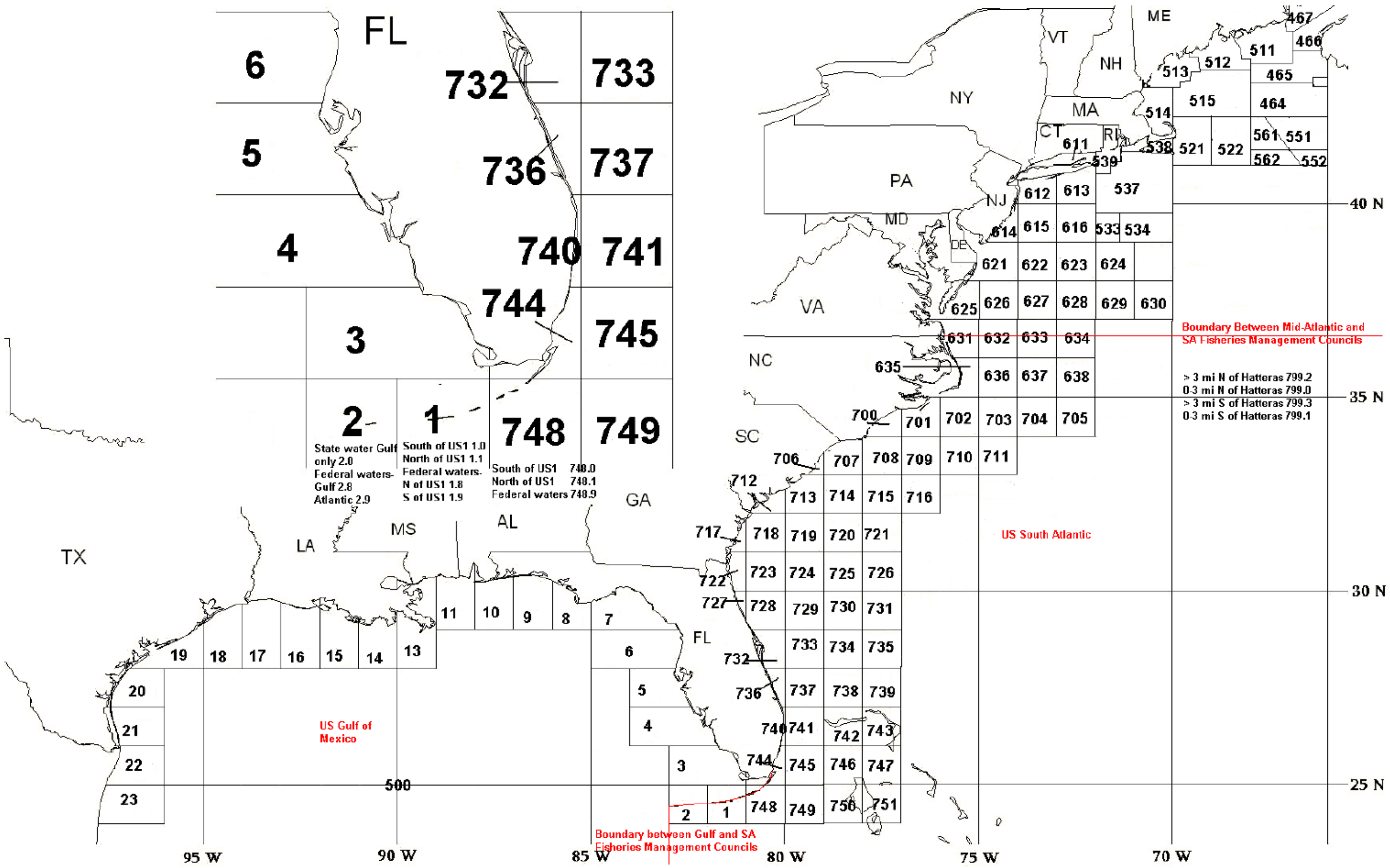


Figure 3.1. Map of U.S. Atlantic and Gulf coast with shrimp area designations and council boundaries. Boundary used for Gulf and Atlantic cobia is the GA/FL border and data were separated by the line of latitude between area 717 and 722.

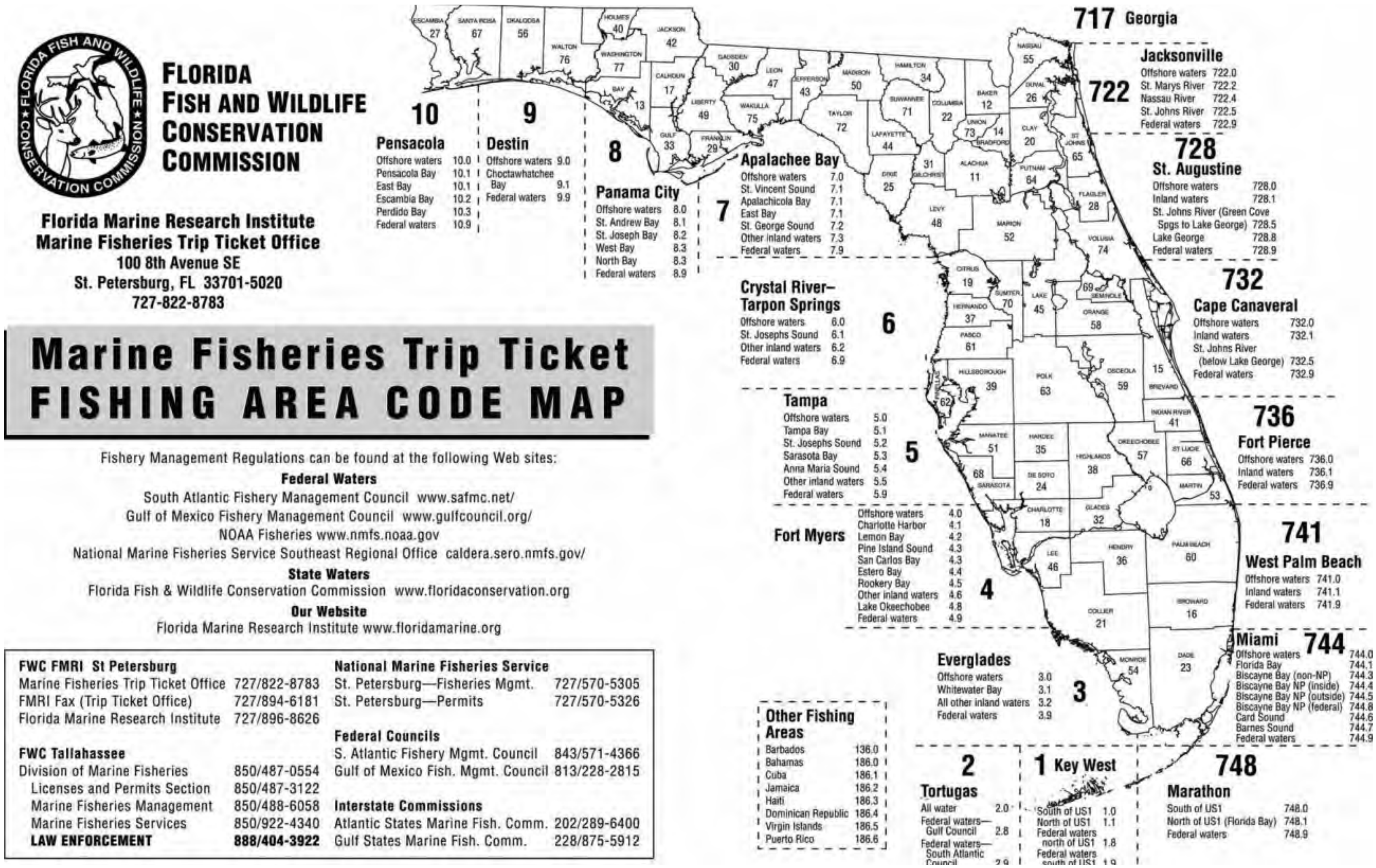


Figure 3.2. Map showing marine fisheries trip ticket fishing area code map for Florida.

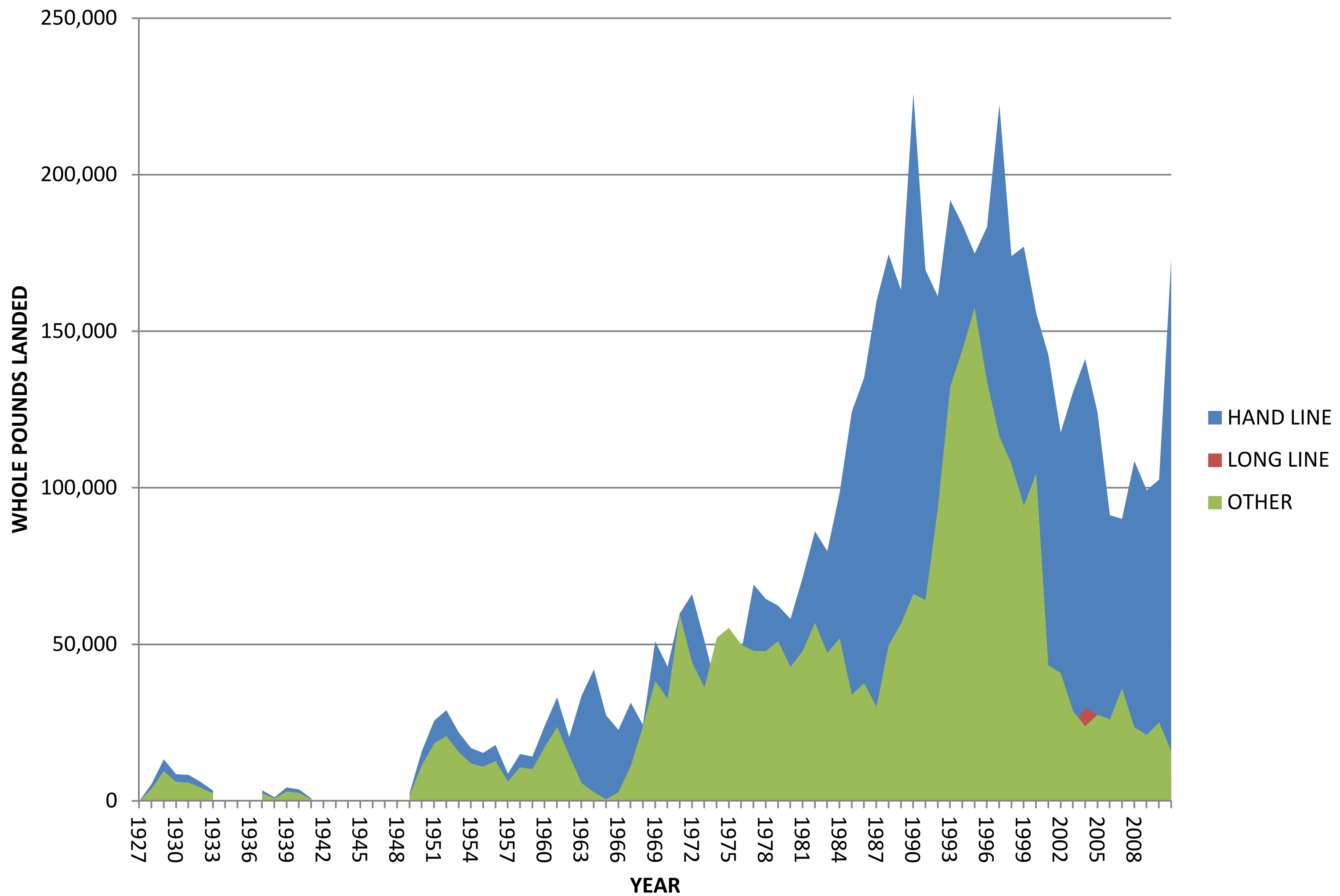


Figure 3.3. Cobia landings in pounds (whole weight) by gear (hand line, long line, and other) from the Gulf of Mexico, 1926-2010.

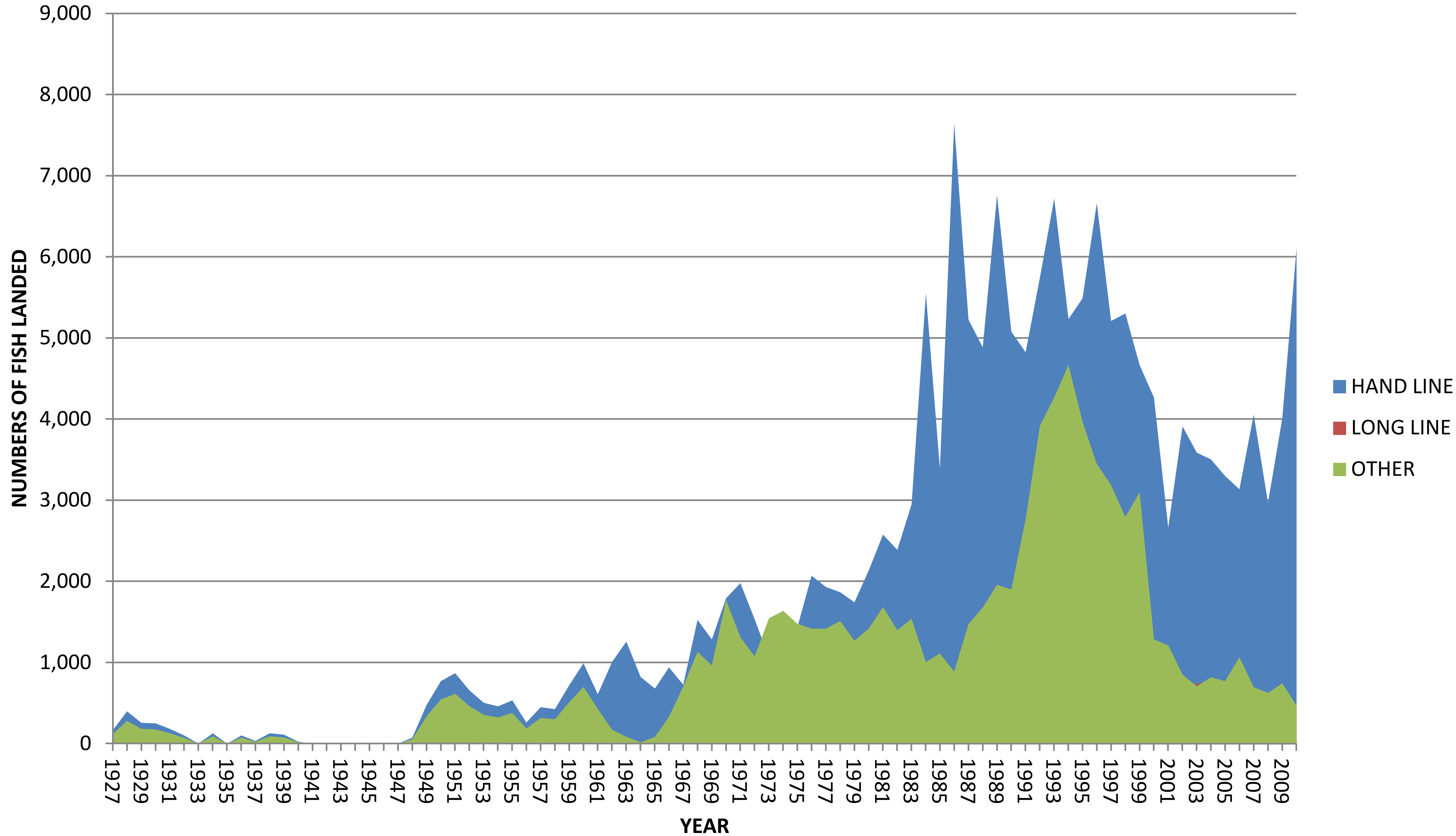


Figure 3.4. Cobia landings in numbers of fish by gear (hand line, long line, and other) from the Gulf of Mexico, 1926-2010.

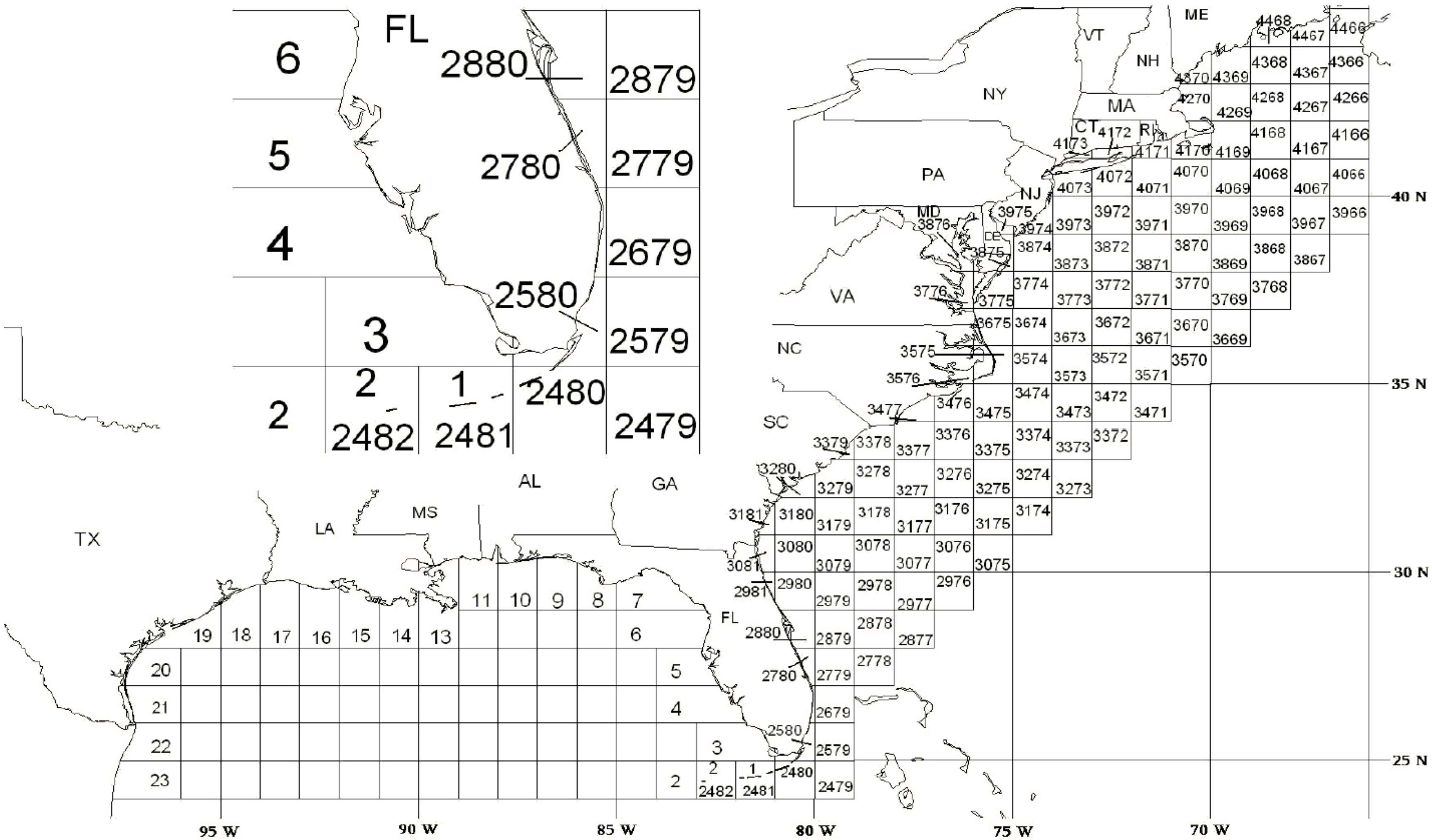


Figure 3.5. Map of U.S. Atlantic and Gulf coast logbook areas.

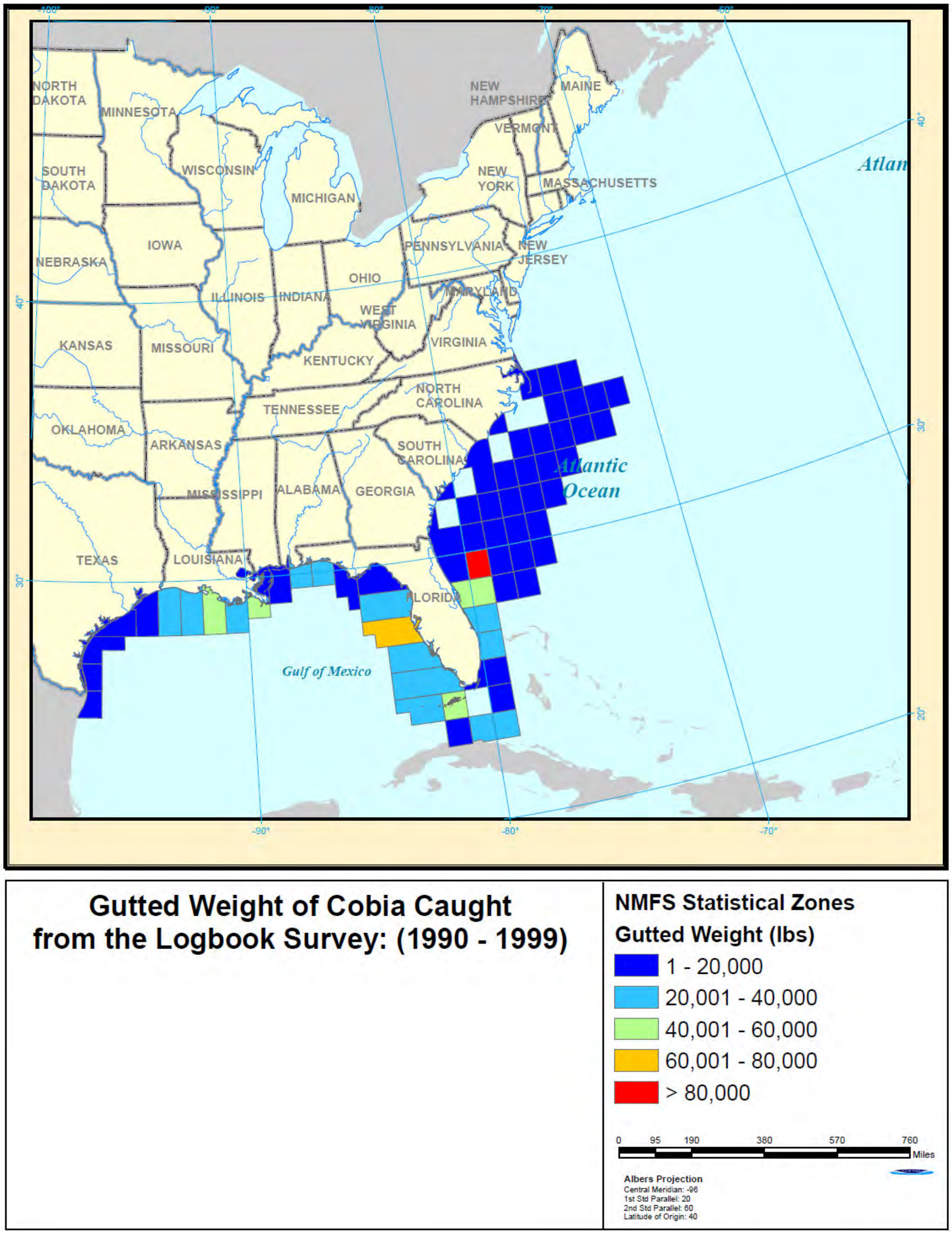


Figure 3.6. Map of cobia catches reported to the Coastal Logbook Program for the U.S. Atlantic and Gulf coast areas (1990-1999).

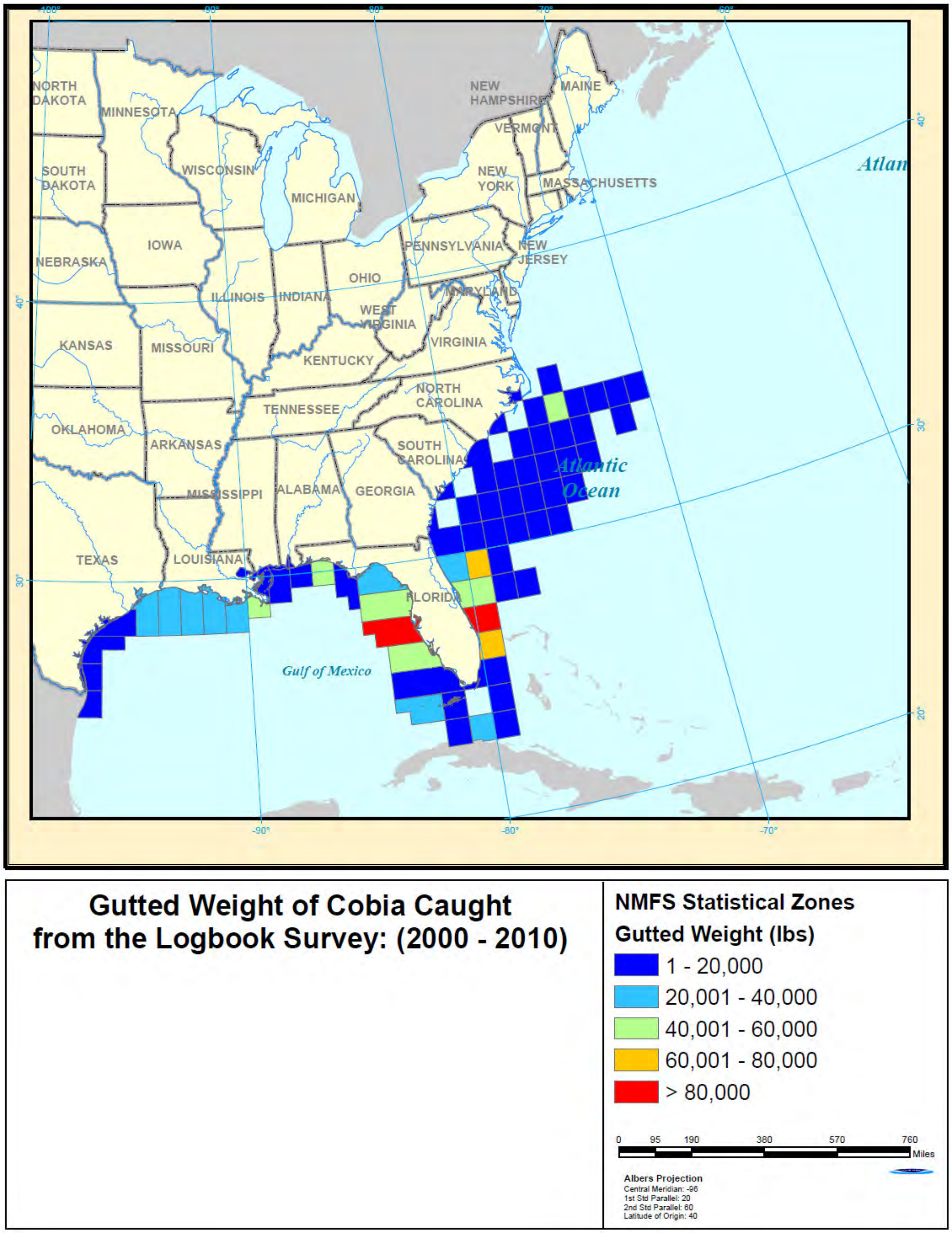


Figure 3.7. Map of cobia catches reported to the Coastal Logbook Program for the U.S. Atlantic and Gulf coast areas (2000-2010).

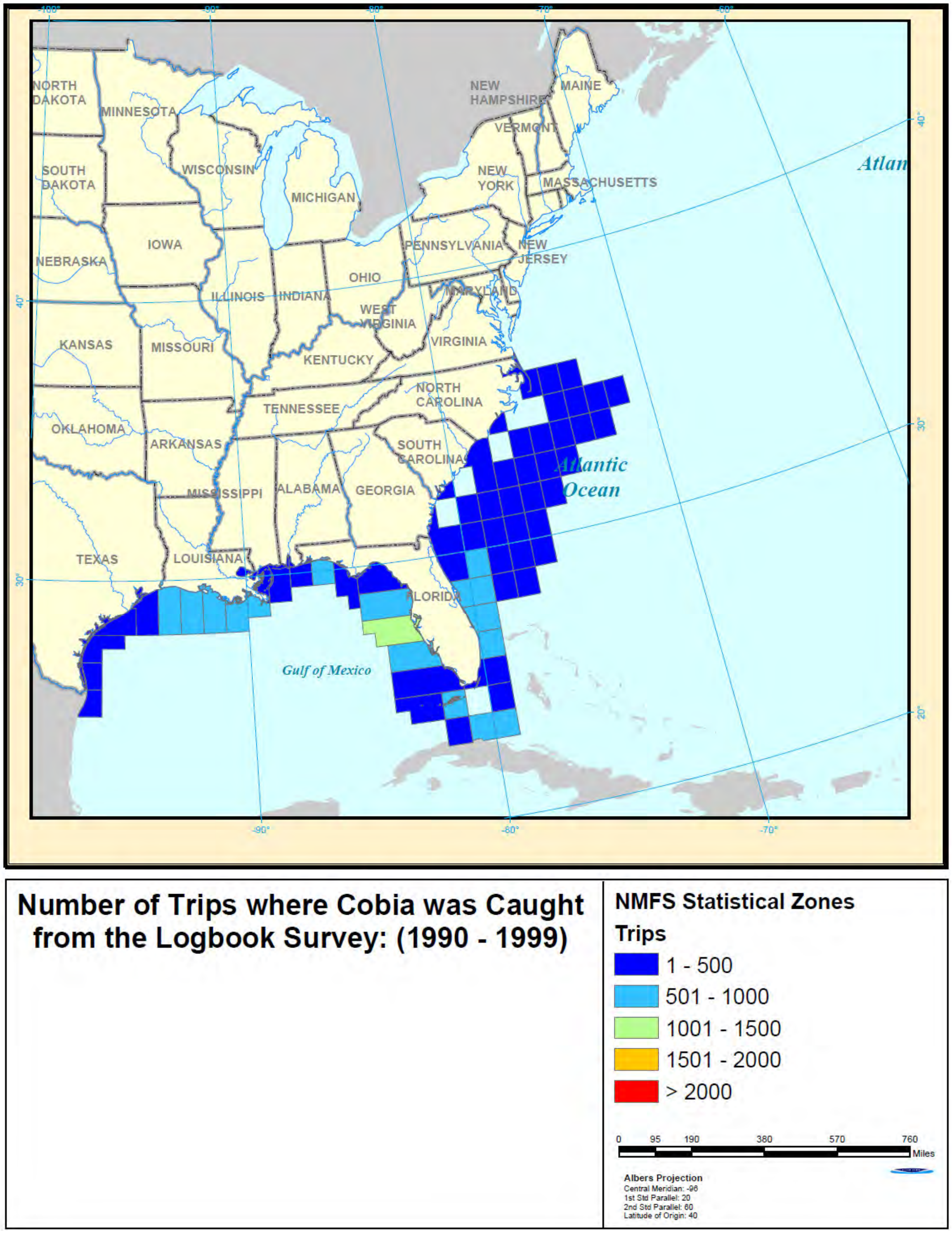


Figure 3.8. Map of cobia trips reported to the Coastal Logbook Program for the U.S. Atlantic and Gulf coast areas (1990-1999).

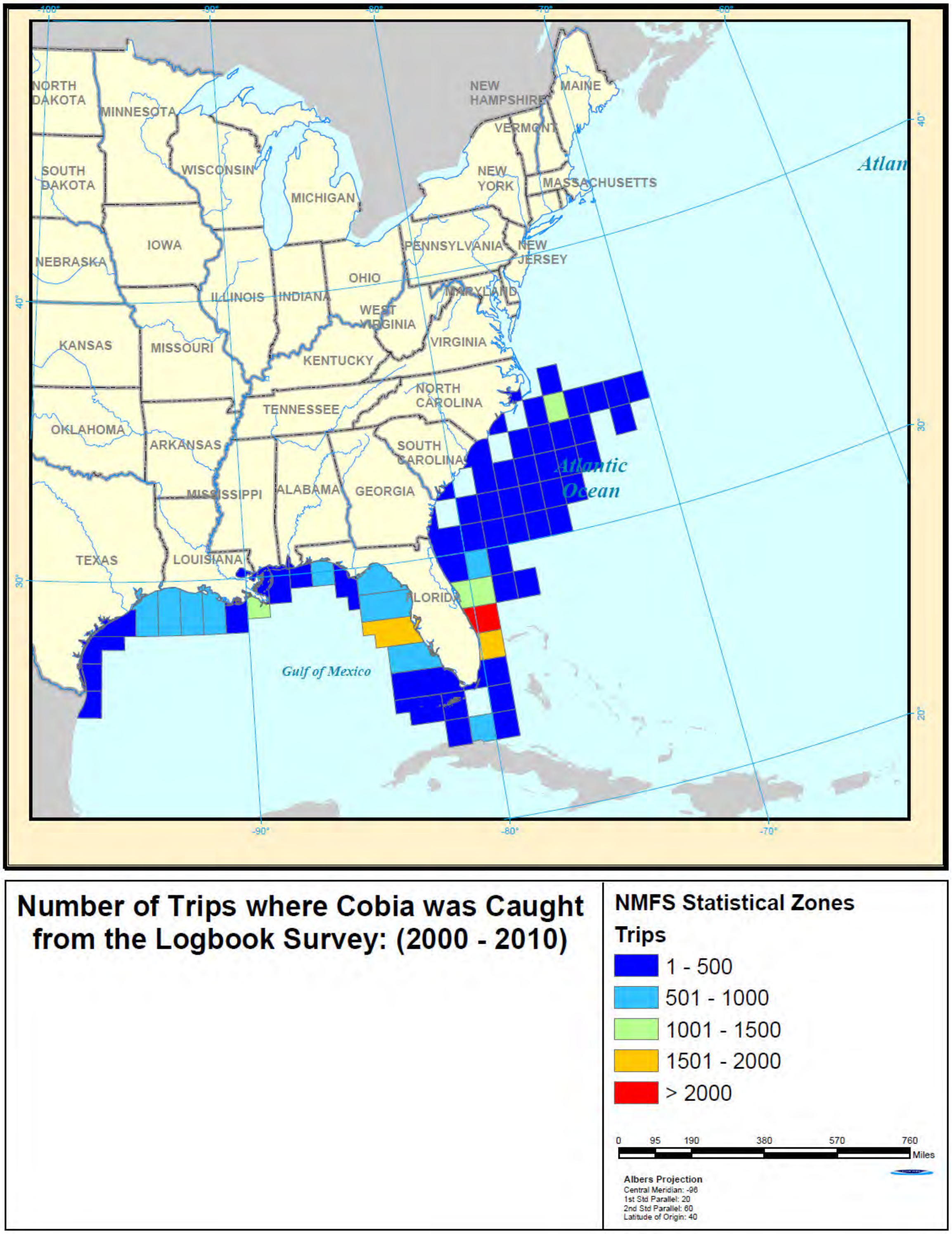


Figure 3.9. Map of cobia trips reported to the Coastal Logbook Program for the U.S. Atlantic and Gulf coast areas (2000-2010).

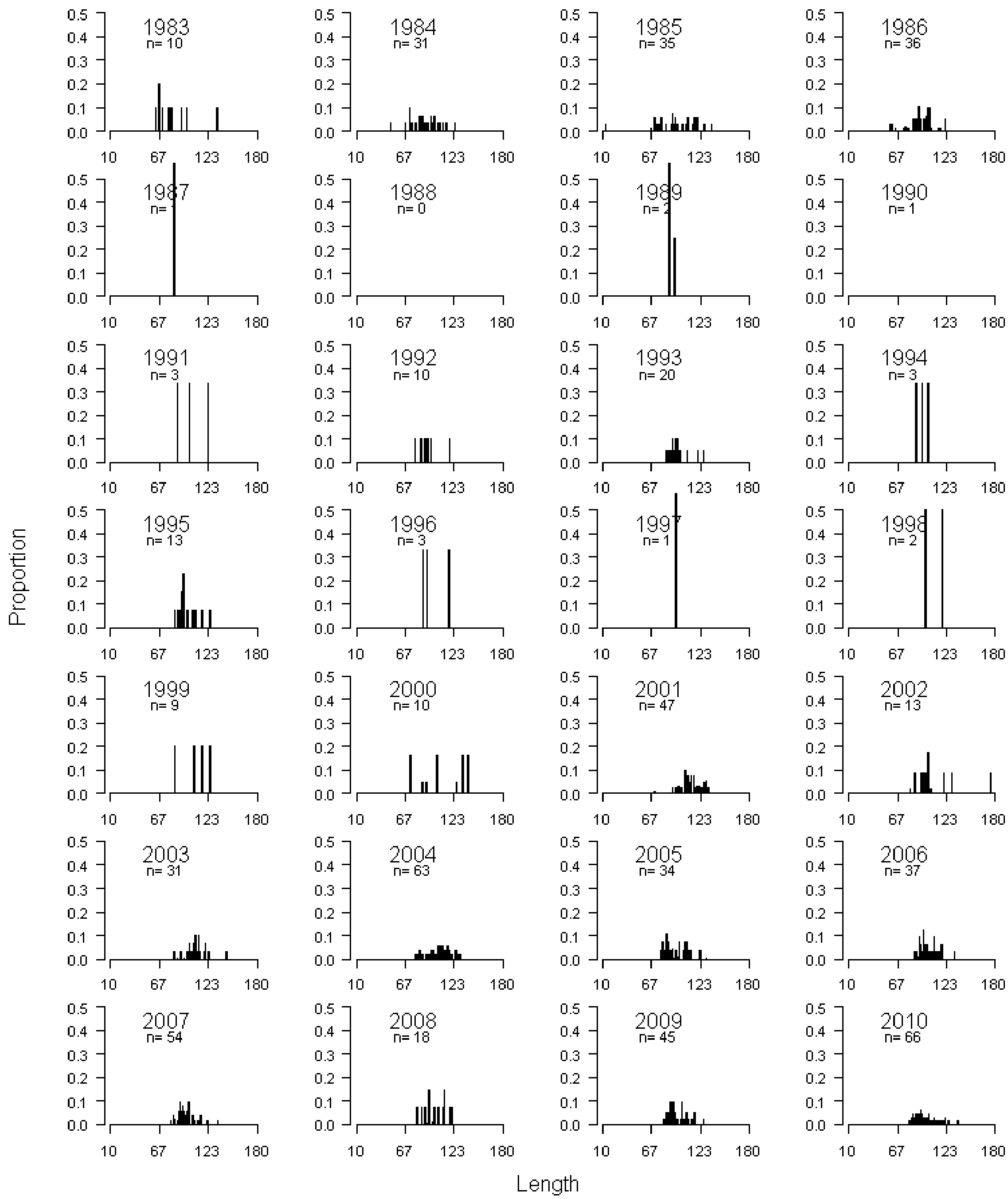


Figure 3.10. Relative length composition of commercial length (FL in mm) samples by year for hand line gear (n = number of fish).

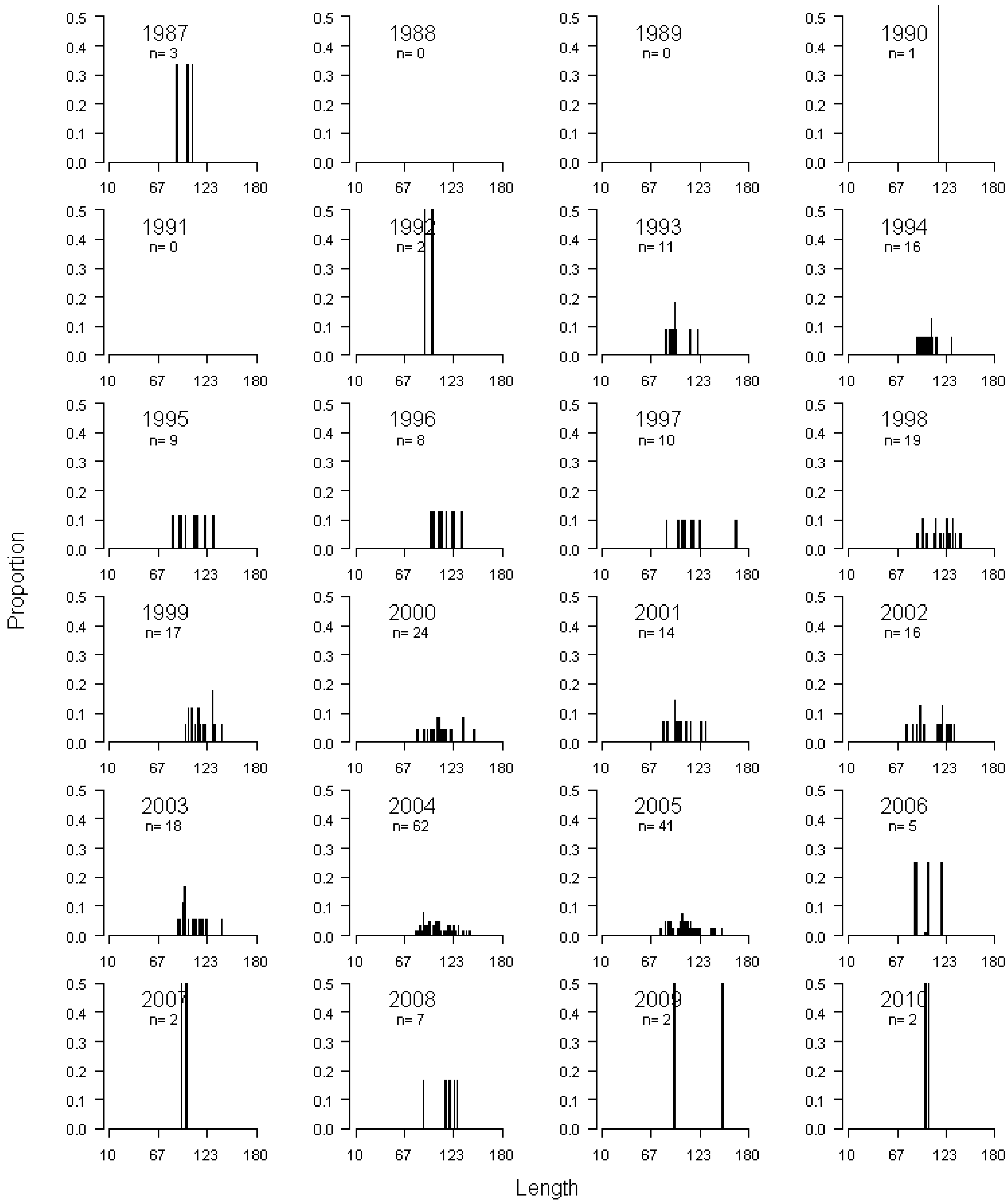


Figure 3.11. Relative length composition of commercial length (FL in mm) samples by year for long line gear (n = number of fish).

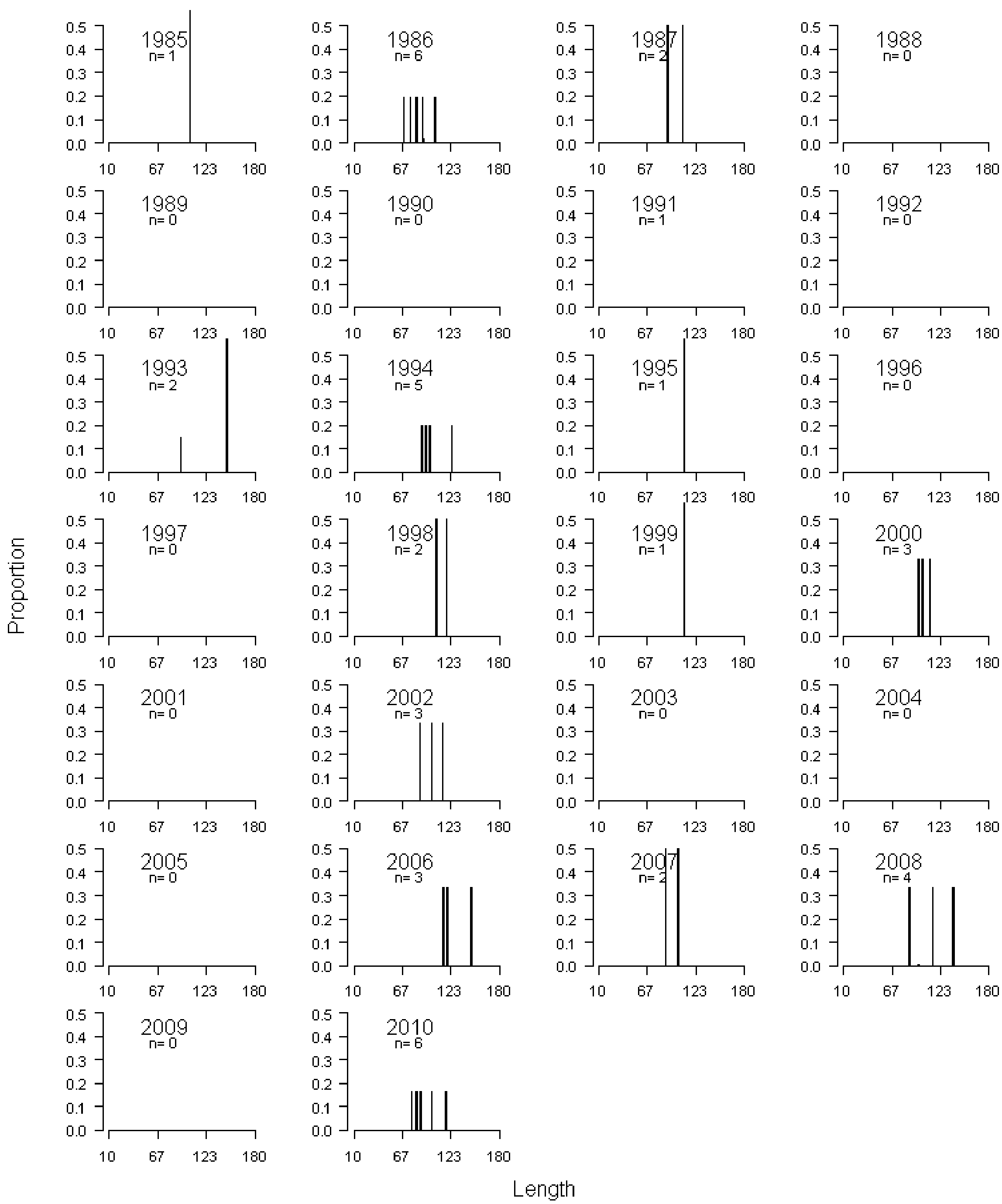


Figure 3.12. Relative length composition of commercial length (FL in mm) samples by year for other miscellaneous gear (n = number of fish).

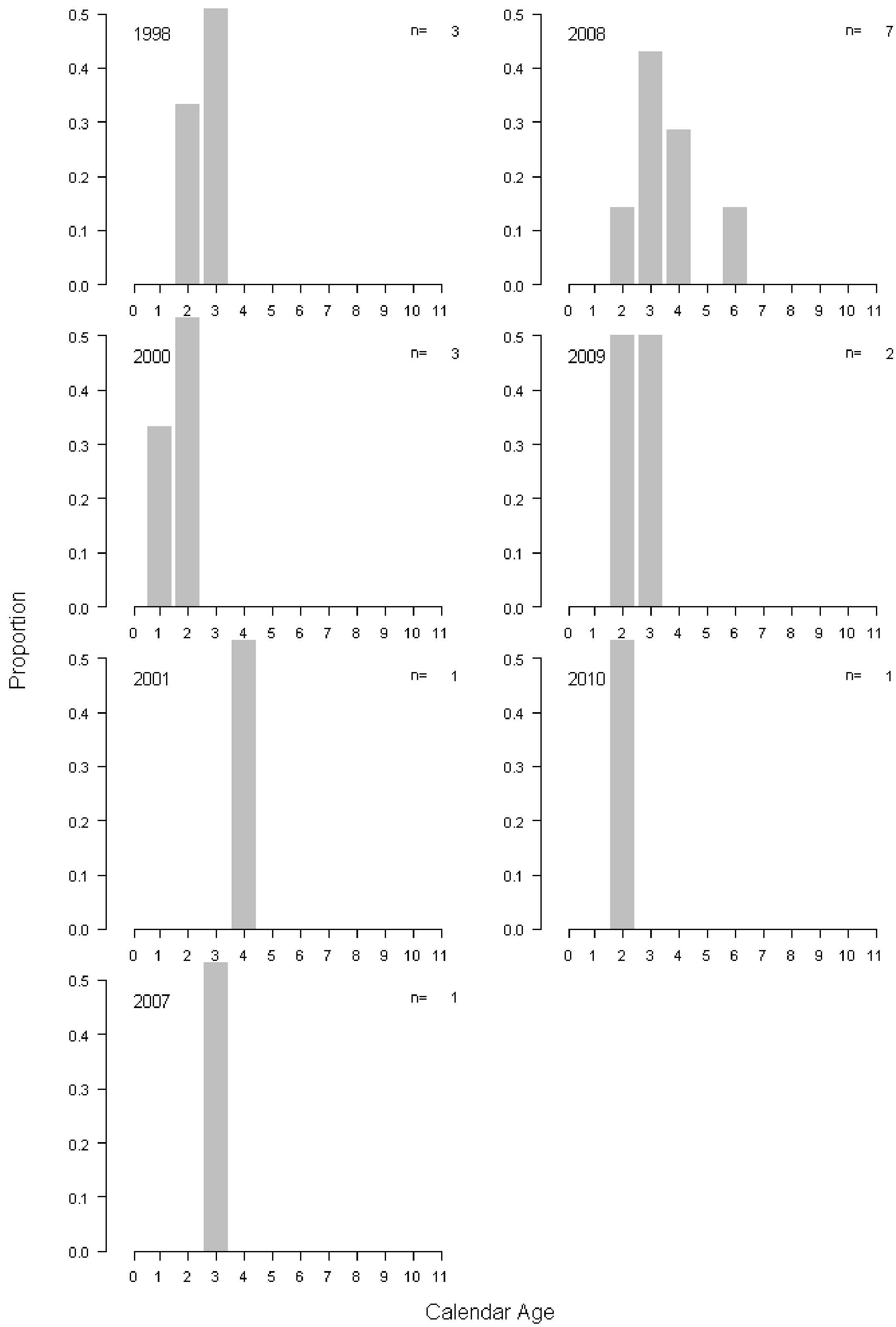


Figure 3.13. Unweighted relative age composition of commercial age (calendar years) samples by year for hand line gear (n = number of fish).

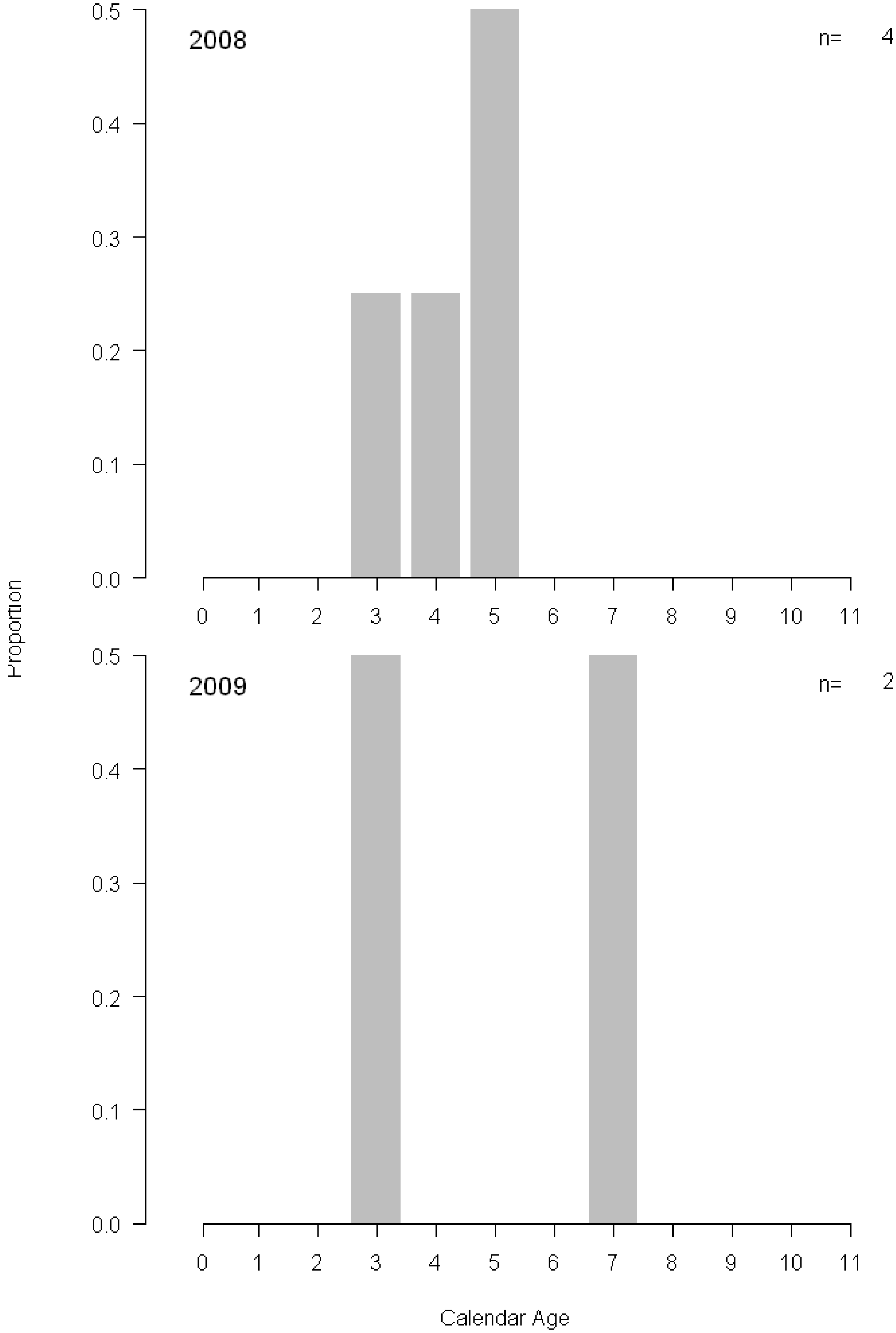


Figure 3.14. Unweighted relative age composition of commercial age (calendar years) samples by year for long line gear (n = number of fish).

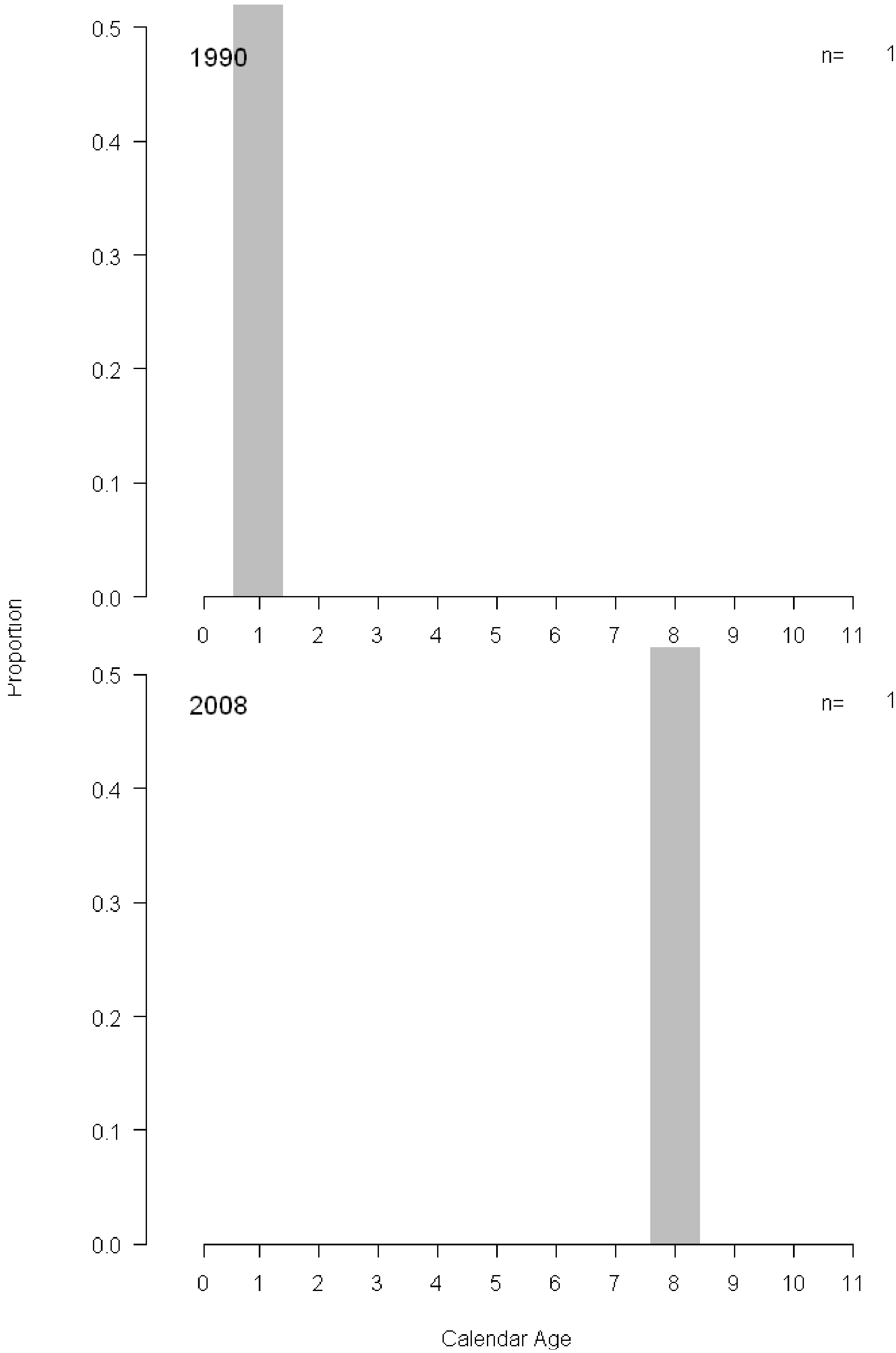


Figure 3.15. Unweighted relative age composition of commercial age (calendar years) samples by year for other miscellaneous gear (n = number of fish).

4 Recreational Fishery Statistics

4.1 Overview

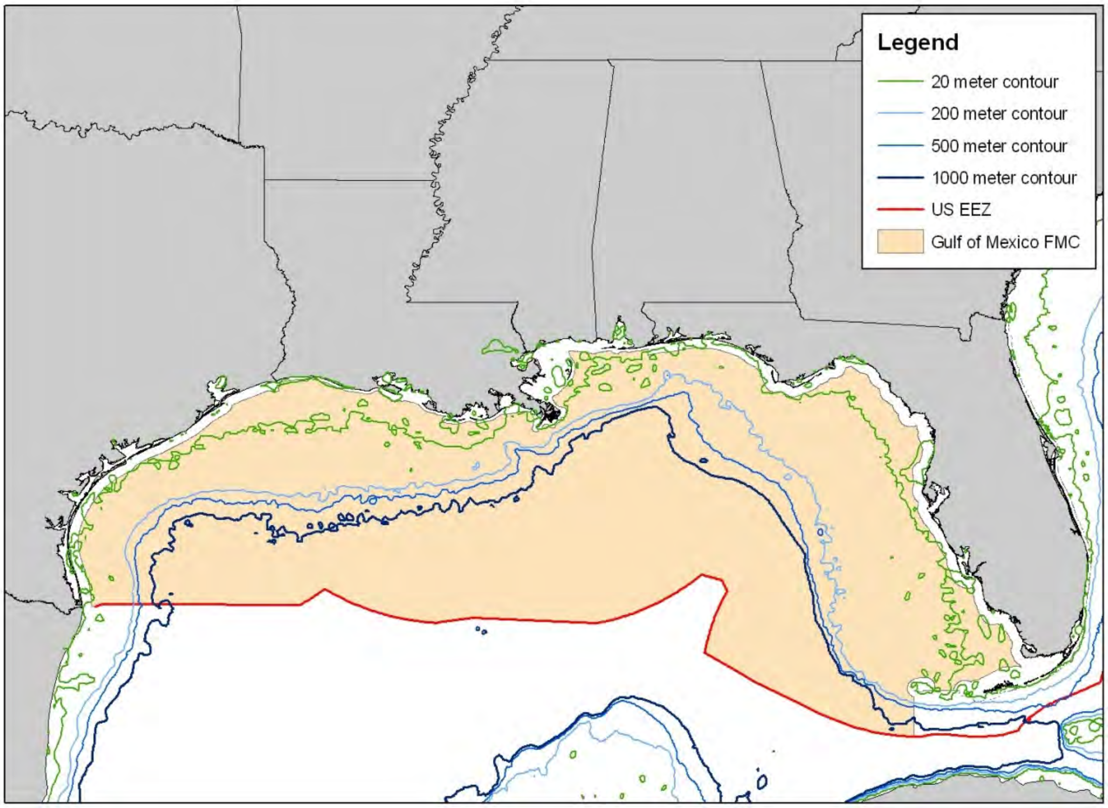
4.1.1 Group membership

Members- Ken Brennan (Leader South Atlantic\NMFS Beaufort), Julia Byrd (SCDNR), Kelly Fitzpatrick (NMFS Beaufort), Eric Hiltz (SCDNR), Robert Johnson (SAFMC Appointee\ Industry rep FL), Vivian Matter (Leader Gulf of Mexico\NMFS SEFSC), Bill Parker (SAFMC Appointee/Industry rep SC), Tom Ogle (SAFMC Appointee/Industry rep SC), Bob Zales (GMFMC Appointee/Industry rep FL).

4.1.2 Issues

1) Division of the stock between the Atlantic and Gulf of Mexico along the East Florida coast: may vary by data source depending on differing spatial resolutions of the datasets.
2) Headboat logbook forms did not include cobia on a universal form until 1984 in the South Atlantic. This affects East Florida cobia landings.
3) Missing weight estimates for some recreational "cells" (i.e., specific year, state, fishing mode, wave combinations).
4) Headboat discards. Data are available from the SRHS since 2004. Review whether they are reliable for use, and determine if there are other sources of data prior to 2004 that could be used as a proxy to estimate headboat discards.
5) Charter boat landings: MRFSS charter survey methods changed in 1998 in the Gulf of Mexico and in 2003 in East Florida.
6) Combined charter boat/headboat landings, East Florida 1981-1985: Official headboat landings are available from the SRHS. Therefore, the headboat component of the MRFSS combined charter boat/headboat mode must be parsed out.
7) New MRIP weighted estimates are available for 2004-2011: Determine appropriate use of datasets to cover the entire period from 1981-2011.
8) Texas estimates in the MRFSS is only available from 1981-1985 and is sporadic, not covering all modes and waves.
9) TPWD survey does not estimate landings in weight or discards.
10) Usefulness of historical data sources such as the 1960, 1965, and 1970 U.S. Fish and Wildlife Service (FWS) surveys to generate estimates of landings prior to 1981. Review whether other data sources also available.

4.1.3 Gulf of Mexico Fishery Management Council Jurisdictional Boundaries



4.2 Review of Working Papers

SEDAR28-DW12, *Estimated conversion factors for calibrating MRFSS charter boat landings and effort estimates for the South Atlantic and Gulf of Mexico in 1981-1985 with For Hire Survey estimates with application to Spanish mackerel and cobia landings. Vivian M. Matter, Nancie Cummings, John Jeffrey Isely, Kenneth Brennan, and Kelly Fitzpatrick.*

This working paper presents correction factors to calibrate the traditional MRFSS charter boat/headboat combined mode estimates with the For-Hire Survey for 1981-1985. These calibration factors are based on equivalent units of effort and consistent methodologies across both sub regions.

SEDAR28-DW14, *Recreational Survey Data for Spanish Mackerel and Cobia in the Atlantic and the Gulf of Mexico from the MRFSS and TPWD Surveys. Vivian Matter*

This working paper presents recreational survey data for Spanish mackerel and cobia from the Marine Recreational Fishery Statistics Survey (MRFSS) and the Texas Parks and Wildlife Department (TPWD) surveys in the Atlantic and the Gulf of Mexico. Issues addressed include the allocation of the Spanish mackerel landings in the Keys into the Gulf of Mexico or Atlantic

Ocean, the split of cobia landings along the east coast of Florida, the calibration of MRFSS charter boat estimates back in time, 1981-1985 adjustments and substitutions, MRIP vs MRFSS estimates for 2004-2011, and estimating recreational landings in weight from the surveys.

4.3 Recreational Landings

4.3.1 Marine Recreational Fisheries Statistics Survey (MRFSS)

Introduction

The Marine Recreational Fisheries Statistics Survey (MRFSS) provides a long time series of estimated catch per unit effort, total effort, landings, and discards for six two-month periods (waves) each year. The survey 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 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 design incorporates three complementary survey methods for estimating catch and effort. Catch data are collected through angler interviews during dockside intercept surveys of recreational fishing trips after they have been completed. Effort data are collected using two telephone surveys. The Coastal Household Telephone Survey (CHTS) uses random digit dialing of coastal households to obtain detailed information about the previous two months of recreational fishing trips from the anglers. The weekly For-Hire Survey interviews charter boat operators (captains or owners) to obtain the trip information with only one-week recall period. These effort data and estimates are aggregated to produce the wave estimates. 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 on the MRFSS website 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 two pilot years' estimates are considered unofficial but have been used in many SEDARs (SEDAR 7 red snapper, SEDAR 16 king mackerel, etc). The FHS was pilot tested in east Florida in 2000 and officially adopted in 2003.

A further improvement in the FHS method was the pre-stratification of Florida into smaller sub-regions for estimating effort. Pre-stratification defines the sample unit on a sub-state level to produce separate effort estimates by these finer geographical regions. The FHS sub-regions include five distinct regions: NW Florida panhandle from Escambia to Dixie counties (sub-region 1), SW Florida peninsula from Levy to Collier counties (sub-region 2), Monroe county (sub-region 3), SE Florida from Dade through Indian River counties (sub-region 4), and NE Florida from Martin through Nassau counties (sub-region 5). The coastal household telephone survey method for the for-hire fishing mode continues to run concurrently with the newer FHS method.

Calibration of traditional MRFSS charter boat estimates
Conversion factors have been estimated to calibrate the traditional MRFSS charter boat estimates with the FHS for 1986-1997 in the Gulf of Mexico (SEDAR7-AW03, Diaz and Phares, 2004), for 1986-2003 in the South Atlantic (SEDAR16-DW15, Sminkey, 2008), and for 1981-2003 in the mid-Atlantic (SEDAR 17-Data Workshop Report, 2008). 1986-2003 South Atlantic calibration factors were updated in 2011 (SEDAR 25-Data Workshop Report, 2011). These calibration factors are tabulated in SEDAR28-DW14. The relationship between the old charter boat method estimates of angler trips and the FHS estimates of angler trips was used to estimate the conversion factors. Since these factors are based on effort, they can be applied to all species' landings. In the Gulf of Mexico and South Atlantic, the period of 1981-1985 could not be calibrated with the same ratios developed for 1986+ because in the earlier 1981-1985 time period, MRFSS considered charter boat and headboat as a single combined mode in both regions. Thus, in order to properly calibrate the estimates from 1981-1985, headboat data from the Southeast Region Head-boat Survey (SRHS) must be included in the analysis. To calibrate the MRFSS combined charter boat and headboat mode effort estimates in 1981-1985, conversion factors were estimated using 1986-1990 effort estimates from both modes, in equivalent effort units, an angler trip (SEDAR 28-DW12).

New MRIP weighted estimates
Revised catch and effort estimates, based on an improved estimation method, were released on January 25, 2012. These estimates are available for the Atlantic and Gulf Coasts for January 2004 through October 2011. This new estimation method, developed as part of the Marine Recreational Information Program (MRIP), provides more accurate data by removing potential biases that were included in the previous estimates. Since new MRIP estimates are only available for a portion of the recreational time series that the MRFSS covers, calibration factors between the MRFSS estimates and the MRIP estimates must be developed in order to maintain one consistent time series for the recreational estimates. To that end a calibration workshop is planned for the spring that will address this important data need.

Figure 4.12.1 shows the comparison of the MRIP and MRFSS estimates for 2004-2011. At the SEDAR 28 DW plenary, the MRFSS estimates were identified as the best available data for 1981-2003. The MRIP estimates were identified as the best available data for 2004-2011. If the calibration workshop is able to produce correction factors that can be applied to the data in time for the SEDAR 28 Assessment Workshop in May, then these correction factors will be used to adjust the MRFSS estimates from 1981-2003. If the calibration workshop is not able to produce results in time then MRFSS estimates will be used from 1981-2003 and MRIP estimates will be used from 2004-2011.

Division of stock along East Florida coast
The MRFSS Florida estimates can be post-stratified into finer scale geographical regions. Post-stratification proportionally distributes the state-wide (FLE and FLW) effort into finer scale sub-regions and then produces effort estimates at this finer geographical scale. This is needed for the private and shore modes (all years) and charter boat mode (prior to FHS). FHS charter boat mode estimates are already pre-stratified, as discussed above. East Florida can be post-stratified into two Florida sub_regions: SE Florida from Dade through Indian River counties (sub-region 4) and NE Florida from Martin through Nassau counties (sub-region 5). It was decided at the SEDAR 28 DW plenary to split the stock at the Georgia/Florida border. Therefore, no post-stratified estimates are required. Official MRFSS East Florida estimates are included in the Gulf of Mexico stock.

Separation of East Florida combined charter boat/headboat mode
In East Florida, 1981-1985 charter and headboat modes were combined into one single mode for estimation purposes. Since the NMFS Headboat Survey (HBS) began in this region in 1981, the MRFSS combined charter boat/headboat mode must be split in order to not double estimate the headboat mode for these years. MRFSS charter boat/headboat mode was split in these years by using a ratio of HBS headboat angler trip estimates to MRFSS charter boat angler trip estimates for 1986-1990. A similar method (using landings data instead of effort data) has been used in the past (SEDAR 25- black sea bass). The mean ratio was calculated by state (or state equivalent to match HBS areas to MRFSS states) and then applied to the 1981-1985 estimates to strip out the headboat component when needed.

For cobia, which is considered a high profile species in headboat catch, the SRHS estimates will start in 1981 since captains were more likely to include this species as a write-in. Cobia MRFSS charter/headboat mode from East Florida was split for all years 1981-1985 and the headboat component was deleted from the MRFSS dataset to avoid duplication with the SRHS.

Missing cells in MRFSS weight estimates
MRFSS landings estimates in weight must be treated with caution due to the occurrence of missing fish mean weight estimates in some strata. MRFSS weight estimates are calculated by multiplying the estimated number harvested in a cell (year/wave/state/mode/area/species) by the mean weight of the measured fish in that cell. When there are no fish measured in the cell (fish were gutted or too big for the sampler to weigh, harvest was all self-reported, etc.) estimates of landings in number are provided but there are no corresponding estimates of landings in weight.

The MRFSS cobia estimates of landings in weight are used when provided by the survey. In cases where there is an estimate of landings in number but not weight, the Southeast Fisheries Science Center has used the MRFSS sample data to obtain an average weight using the following hierarchy: species, region, year, state, mode, and wave (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 some cases, the MRFSS sample data records length, but not weight. These lengths were converted to weights using length weight equations developed by the Life History Working Group. These converted weights were used only in cases where having these additional converted weights would increase the number of weights available at each hierarchy level to meet the 30 fish minimum. Average weights are 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 and east coast of Florida, catch needs to be estimated for 1981, wave 1. This gap was filled by determining the proportion of wave 1 to other waves in years 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. (SEDARs 10 and 12, gag and red grouper).

Texas
Texas data from the MRFSS is only available from 1981-1985 and is sporadic, not covering all modes and waves. Boat mode estimates from Texas were eliminated from the MRFSS. Instead, TPWD data, which covers charter and private modes, was used to fill in theses modes prior to the start of the TPWD survey in May 1983. This method has been used in past SEDARs (king mackerel, red snapper). The only shore mode estimates available from Texas from any data source are from the MRFSS.

Catch Estimates
Final MRFSS/MRIP landings estimates are shown in tables 4.11.1 and 4.11.2 by year and mode and in Figure 4.12.2.

Maps
Figures 4.12.3, 4.12.4, and 4.12.5 show the number of cobia intercepted by the MRFSS from 1981-1989, 1990-1999, and 2000-2010 respectively. Numbers of fish mapped are intercepted by the survey as an A fish (seen by the interviewer) or a B1 fish (reported dead but not seen by the interviewer). Latitude and longitudes of the intercept site are mapped when available; otherwise, the mid-point of the county of intercept is mapped. Intercepted fish are shown for the Gulf of Mexico and Atlantic Ocean.

4.3.2 Southeast Region Headboat Survey (SRHS)

Introduction
The Southeast Region Headboat Survey estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. The Headboat Survey was started in 1972 but only included vessels from North Carolina and South Carolina until 1975. In 1976 the survey was expanded to northeast Florida (Nassau-Indian River counties) and Georgia, followed by southeast Florida (St.

Lucie-Monroe counties) in 1978. The SRHS began in the Gulf of Mexico in 1986 and extends from Naples, FL to South Padre Island, TX. Due to headboat area definitions, West Florida and Alabama landings are combined. 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. These logbooks are summarized by vessel to generate estimated landings by species, area, and time strata.

Issue 1: Gulf of Mexico cobia headboat landings prior to 1986: From 1981-1985 headboat landings were combined with MRFSS charter boat landings for FLW to LA.

Option 1: Start headboat time series in 1986 when the SRHS began in the Gulf of Mexico.

Option 2: Use combined MRFSS charter\headboat mode estimates for FLW to LA to take headboat estimates back to 1981 for recreational cobia in the Gulf of Mexico.

Decision: Option 2

Issue 2: FLE headboat landings 1981-1983: From 1981 to 1983 cobia was not listed on all versions of the headboat survey form. If cobia were not listed, any landings would have been written in voluntarily. Cobia is considered a high profile species in headboat catches. Cobia estimated headboat landings are consistent coast wide from 1981-1983. Cobia was routinely written in by captains, this was evident by examining numerous logbooks from 1981 to 1983.

Option 1: Start FLE headboat time series in 1984 when a universal form was in use in all areas from NC- FL.

Option 2: Start FLE headboat landings time series in 1981 when the SRHS began in FLE.

Decision: Option 2

Issue 3: Texas cobia headboat landings 1981 to 1985: From 1981 to 1985 Texas was not included in the MRFSS charter\headboat combined landings 1981 -1985.

Option 1: Use the average Texas headboat landings for cobia from 1986 to 1988 for years prior to the start of the SRHS, 1981 to 1985.

Option 2: Start headboat landings time series in 1986 when the SRHS began in the Gulf of Mexico.

Decision: Option 1

Catch Estimates
Final SRHS landings estimates are shown in Table 4.11.3. by year and state, and in Figure 4.12.6. SRHS areas 7-8 and 11-28 are included in the Gulf of Mexico cobia stock. Figures 4.12.7, 4.12.8, and 4.12.9 show the Gulf of Mexico cobia headboat landings from 1981-1989, 1990-1999, and 2000-2011 respectively. Headboat landings of cobia in the Gulf of Mexico, from the 1980's to present, have mostly been concentrated in 3 areas: southwest Florida, Louisiana, and Texas. Catch of cobia was evenly distributed between these areas in the 1980s (Figure 4.12.7), however, since 1990 headboat landings of cobia have declined and shifted between these areas in the Gulf of Mexico (Figures 4.12.8 and 4.12.9).

Mississippi headboats were added to the SRHS in 2010. These headboats are smaller vessels that carry 10-15 anglers and combine trolling trips with bottom fishing trips. The MS vessels running these types of trips accounted for the increased landings of cobia in the GOM for 2011.

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 includes 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 disaggregates the TPWD seasonal estimates into waves (2 month period) using the TPWD intercept data, in order to be compatible with MRFSS. Only private boat and charter boat fishing are surveyed. Most of the sampled trips are private boats fishing in bay/pass because these represent most of the fishing effort, but all trips (private, charter boat, ocean, bay/pass) are sampled. Charter boat 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. TPWD length-weight equations were applied to the lengths in order to obtain weights. In order to obtain estimated landings in weight, a similar method used to fill in the missing weights in MRFSS (described above) is applied to the TPWD landings. The hierarchy used for TPWD is expanded to include area fished (species, region, year, state, mode, wave, and area). This is equivalent to the MRFSS estimate of weight provided by that survey.

1981-1983 Texas estimates
The TPWD survey begins with the high-use season in 1983 (May15, 1983). Charter and private mode estimates need to be filled in for this state and these modes back to 1981. Averages from TPWD 1983-1985 were used by mode and wave to fill in the missing estimates. In addition, headboat landings from TX from 1981-1985 are not covered by any survey. As discussed above, SRHS 1986-1988 average landings were used to fill in this time period.

Catch Estimates
Final TPWD landings estimates are shown in table 4.11.4 by year and mode and in Figure 4.12.10.

Maps
Figures 4.12.11, 4.12.12, and 4.12.13 show the number of cobia intercepted by the TPWD from 1983-1989, 1990-1999, and 2000-2010 respectively. Numbers of fish intercepted by the survey are mapped by Texas major bay areas. They are Sabine Lake, Galveston, Matagorda, San Antonio, Aransas, Corpus Christi, Upper Laguna Madre, and Lower Laguna Madre.

4.3.4 Historic Recreational Landings

Introduction
The historic recreational landings time period is defined as pre-1981 for the charter boat, headboat, private boat, and shore fishing modes, which represents the start of the Marine Recreational Fisheries Statistics Survey (MRFSS) and availability of landings estimates for cobia. The Recreational Working Group was tasked with evaluating other potential historical sources and methods to compile landings of cobia prior to the available time series of MRFSS and headboat estimated landings.

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

- Salt Water Angler Surveys (SWAS),1960, 1965 &1970.
- The U.S Fish and Wildlife Service (USFWS), 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey (FHWAR).

SWAS
During the SEDAR 28 data workshop the RWG reviewed the Salt Water Angler Surveys (SWAS) from 1960, 1965 &1970. Cobia was not listed on the SWAS for the Gulf of Mexico until 1965 and 1970 for the South Atlantic. Cobia estimates in the 1965 and 1970 SWAS were subject to a 1 year recall bias, similar to the 1960 SWAS. The average interview sample size for the 3 surveys was 0.0002% of total estimated saltwater anglers in the United States.

FHWAR census method
The 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey presented summary tables of U.S. population estimates, along with estimates of hunting and fishing participation and effort from surveys conduct by the USFWS every 5 years from 1955 to 1985 (Table 4.11.5). This information was used to develop an alternative method for estimating recreational landings prior to 1981.

The two key components from these FHWAR surveys that were used in the census method were the estimates of U.S. saltwater anglers and the estimates of U.S. saltwater days. The first objective was to determine the total saltwater anglers and saltwater days for the Gulf of Mexico (GOM) by using the summary information of U.S. anglers and U.S. saltwater anglers from the FHWAR surveys. The ratio of U.S saltwater anglers to the total U.S anglers was applied to the total number of anglers for the GOM to yield the total saltwater anglers for the GOM. The same method was used to calculate the total saltwater days for the GOM from the FHWAR surveys from 1955-1985.

The FHWAR surveys included the entire state of Florida, east and west coasts, and the South Atlantic. In order to address the management boundaries for cobia the saltwater angler days for Florida's west coast (FLW) were separated from Florida's east coast (FLE) saltwater angler days using the ratio of the MRFSS total angler trips for FLW to the MRFSS total angler trips for the GOM (TX to AL). The average ratio from 1983-1985 was applied to the total saltwater days for the 1955-1985 to include FLW effort.

Similar to the SWAS there was a 12 month recall period for respondents, which resulted in greater reporting bias. Research concluded this bias resulted in overestimates of both the catch and effort estimates in the FHWAR surveys from 1955 to 1985. Consequently, an adjustment for recall bias was necessary. The total saltwater days for the GOM 1955-1985 were adjusted for recall bias in the FHWAR surveys. The MRFSS total angler trips for the GOM 1983 to1985 was averaged and divided by the total saltwater days for 1985 from the FHWAR survey. This multiplier was then applied to the total GOM saltwater days 1955-1985 to adjust for recall bias.

The mean CPUE for cobia in the Gulf of Mexico from the MRFSS estimates from 1981 to 1985 was then applied to the adjusted saltwater angler days for the GOM 1955-1985 to estimate the historical cobia landings for those years (Table 4.11.5).

A bootstrap analysis was used to capture the range of uncertainty in the historic recreational catch estimates. More specifically, the historic catch estimates are based on the average CPUE and the ratio of MRFSS effort to historic effort estimates. These two quantities were bootstrapped 200 times using the empirical estimates that went into each of them. The 5th and 95th percentiles were then computed from the distribution of bootstrap estimates to characterize the uncertainty (Figure 4.12.14).

Issue: Available historical cobia landings limited 1950-1980.

Option 1: Use the Adjusted SWAS cobia estimated landings.

Option 2: Use average ratio from entire time series (1981-2010) applied to commercial landings to estimate recreational landings (1950-1980).

Option 3: Use available recreational time series for the MRFSS\MRIP and headboat estimates 1981- 2010.

Option 4: Total cobia landings using the FHWAR census method (GOM 1955-1980) are presented with the total estimated cobia landings (MRFSS/MRIP and SRHS landings) (GOM 1981-2011) in Table 4.11.6 and Figure 4.12.15.

Decision: *Option 4*

4.4 Recreational Discards

4.4.1 MRFSS discards

Discarded live fish are reported by the anglers interviewed by the MRFSS so both the identity and quantities reported are unverified. Discarded fish size is unknown for all modes of fishing covered by the MRFSS. At-sea sampling of headboat discards was initiated as part of the improved for-hire surveys to characterize the size distribution of live discarded fishes in the headboat fishery, however, the Beaufort, NC Logbook program (SRHS) produces estimates of total discards in the headboat fishery since that class of caught fish was added to their logbook (2004). All estimates of live released fish (B2 fish) in charter or charter boat/headboat combined mode were adjusted in the same manner as the landings (calibration factors, substitutions, etc. described above in section 4.3.1). Size or weight of discarded fishes is not estimated by the MRFSS. Final MRFSS/MRIP discard estimates are shown in Table 4.11.7 by year and mode and in Figure 4.12.16.

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. Due to low cobia sample sizes in the MRFSS At-Sea Observer Headboat program, it was determined that the logbook discard data would be used from 2004-2011. The RWG further concluded that a proxy should be used to estimate the headboat cobia discards for previous years. The RWG considered the following two possible data sources to be used as a proxy for estimated headboat discards for 1981-2003 (Figure 4.12.17).

- MRFSS charter boat discard estimates (corrected for FHS adjustment) applied – Extend back to 1981.
- MRFSS private boat discard ratio estimates – Extend back to 1981 and follows the pattern exhibited in the Southeast Region Headboat Survey in later years.

Issue: Proxy for estimated headboat discards from 1981-2003.

Option 1: Apply the MRFSS charter boat discard:landings ratio to estimated headboat landings in order to estimate headboat discards from 1981-2003.

Option 2: Apply the MRFSS private boat discard:landings ratio to estimated headboat landings in order to estimate headboat discards from 1981-2003.

Option 3: Calculate a ratio of the mean ratio of SRHS discard:landings (2004-2011) to the mean ratio of MRFSS CH discard:landings (2004-2011). Apply this ratio to the yearly MRFSS charter boat discard:landings ratio (1981-2003) in order to estimate the yearly SRHS discard:landings ratio (1981-2003). This ratio is then applied to the SRHS landings (1981-2003) in order to estimate headboat discards (1981-2003).

Decision: Option 3. Calculate a ratio of the mean ratio of SRHS discard:landings (2004-2010) to the mean MRFSS CH discard:landings ratio (2004-2010). Apply this ratio to the yearly MRFSS charter boat discard:landings ratio (1981-2003) in order to estimate the yearly SRHS discard:landings ratio (1981-2003). This ratio is then applied to the SRHS landings (1981-2003) in order to estimate headboat discards (1981-2003). The MRFSS charter boat discard estimates followed the pattern exhibited in the SRHS in later years. Because the MRFSS charter boat discard ratio was greater than the SRHS discard ratio, using the MRFSS charter boat ratio without the adjustment described in Option 3 could result in overestimating the SRHS discards. Headboat discard estimates for Texas in 1981-1985 were estimated in the same manner as the landings, using the mean of the resulting discard estimates from 1986-1988. The resulting discard estimates for headboats from 1981 to 2003 are represented in Table 4.11.8. The final estimated headboat discard estimates 1981-2011 as well as the discards:landings ratio are presented in Figure 4.11.18.

4.4.3 Headboat At-Sea Observer Survey Discards

An observer survey of the recreational headboat fishery was run in some Gulf region states to collect more detailed information on recreational headboat catch, particularly for discarded fish. The survey was conducted in Alabama from 2004 to 2007, in West Florida from 2005-2007, and in East Florida from 2005 to the present. Headboat vessels are randomly selected throughout the year in each state, and the east coast of Florida is further stratified into northern and southern sample regions. Biologists board selected vessels with permission from the captain and observe anglers as they fish on the recreational trip. Data collected include number and species of fish landed and discarded, size of landed and discarded fish, and the release condition of discarded fish (FL only). Biological samples such as scales, otoliths, spines, stomachs and gonads, are not typically collected as part of this protocol. Data are also collected on the 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 run trips that span more than 24 hours are also sampled to collect information on trips that fish farther offshore and for longer durations, primarily in the vicinity of the Dry Tortugas. Due to low cobia sample sizes the MRFSS At-Sea Observer data was not used in this assessment.

4.4.4 Texas Parks and Wildlife Department Discards

The TPWD recreational survey does not estimate discards. The recreational workgroup looked at the data available and decided to use a Gulf wide ratio from the MRFSS by mode (charter and private) and apply it to the TPWD landings in order to estimate discards from Texas. Similar methods have been used in past SEDARs (red snapper). Discard estimates for Texas charter and private modes are shown in Table 4.11.9 by year and mode and in Figure 4.12.19.

4.4.5 Alternatives for characterizing discards

Due to low cobia sample sizes in the MRFSS At-Sea Observer data it was concluded that the headboat logbook discard estimates should be used from 2004-2011 for the Gulf of Mexico headboat fishery. Further, the group decided to use the charter mode as a proxy to calculate headboat discards for 1981-2003, since the discard rates from the longer time series of MRFSS reflect historic changes in discard rates. These rates include the impacts from changes in recreational size limits and bag limits for cobia over time.

4.5 Biological Sampling

4.5.1 Sampling Intensity Length/Age/Weight

MRFSS Charter, Private, and Shore

The MRFSS' angler intercept survey includes the collection 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, e.g., cobia, 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 assignments because of concerns over the introduction of bias to survey data collection.

The number of cobia measured or weighed in the Gulf of Mexico (FLE-TX) in the MRFSS charter fleet, private-rental mode, and shore mode are summarized by year and state in tables 4.11.10, 4.11.11, and 4.11.12, respectively. The number of angler trips with measured or weighed cobia in the Gulf of Mexico (FLE-TX) in the MRFSS charter fleet, private-rental mode, and shore mode are summarized by year and state in tables 4.11.13, 4.11.14, and 4.11.15, respectively. The number of MRFSS intercept trips conducted in the Gulf of Mexico (FLE-TX) and the percentage of intercepts that encountered cobia are summarized by year and mode in Table 4.11.16. Dockside mean weights of cobia weighed from the MRFSS in the Gulf of Mexico (FLE-TX) are tabulated for 1981-2011 in Table 4.11.17.

Headboat Survey Biological Sampling

Lengths were collected from 1986 to 2011 by headboat dockside samplers in the Gulf of Mexico. Mississippi was added to the survey in 2010. Weights are typically collected for the same fish measured during dockside sampling. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely and processed for aging, diet studies, and maturity studies.

Annual numbers of cobia measured for length in the headboat fleet and the number of trips from which cobia were measured are summarized in Table 4.11.18. The number of cobia aged from the headboat fleet by year and state are summarized in Table 4.11.19. Dockside mean weights for the headboat fishery are tabulated for 1986-2011 in Table 4.11.20.

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. Weight of sampled fish is not recorded.

The number of cobia measured in the TPWD charter and private-rental modes are summarized by year in table 4.11.21. The number of trips with measured cobia in the TPWD charter and private-rental modes are summarized by year in table 4.11.22. The number of TPWD intercept trips conducted in Texas and the percentage of intercepts that encountered cobia are summarized by year and mode in Table 4.11.23.

Aging data
The number of cobia aged from the SRHS by year and state is summarized in Table 4.11.19. Age samples collected from the private/rental boat, charter boat, and shore modes are not typically collected as part of the MRFSS sampling protocol. These samples come from a number of sources including state agencies, special projects, and sometimes as add-ons to the MRFSS survey. The number of cobia aged from the charter boat fleet by year and state is summarized in Table 4.11.24. The number of cobia aged from the private fleet by year and state is summarized in Table 4.11.25. The number of cobia aged from the recreational fishery (mode unknown) by year and state is summarized in Table 4.11.26. In some cases mode of catch was either not recorded or the samples were taken from freezers or coolers left outside of fishing centers or marinas and trip information was not collected. Therefore the number of trips with aged samples was not reported in any mode.

4.5.2 Length – Age distributions

MRFSS and TPWD Length Frequency Analysis Protocol
The angler intercept survey is stratified by wave (2-month period), state, and fishing mode (shore, charter boat, party boat, private or rental boat) so simple aggregations of fish lengths across strata cannot be used to characterize a regional, annual length distribution of landed fish; a weighting scheme is needed to representatively include the distributions of each stratum value. The MRFSS' angler intercept length frequency analysis produces unbiased estimates of length-class frequencies for more than one stratum by summing respectively weighted relative length-class frequencies across strata. The steps used are:

1) Output a distribution of measured fish among state/mode /wave strata,
2) Output a distribution of estimated catch among state/mode/wave strata,
3) Calculate and output relative length-class frequencies for each state/mode/wave stratum,
4) Calculate appropriate relative weighting factors to be applied to the length-class frequencies for each state/mode/wave stratum prior to pooling among strata,
5) Sum across strata as defined, e.g., annual, sub-region length frequencies, by year in 1-cm length bins.
6) Convert to annual proportion in each size bin (Figure 4.12.20).

Lengths were taken from the MRFSS (charter boat, private/rental boat, and shore modes) during 1981 to 2011. The number of vessel trips sampled was not available from the MRFSS. Lengths from the TPWD survey were converted to fork length using the equation FL = 0.8816*(TL) – 11.82 as recommended by the SEDAR 28 DW panel.

Southeast Region Headboat Survey Length Frequency Analysis Protocol

Headboat landings (1983 to 2011) were pooled across five time intervals (Jan-May, Jun, July, Aug, Sep-Dec) because landings were not estimated by month until 1996. Spatial weighting was developed by region for the headboat survey by pooling landings by region; eastern FL, western FL and AL, MS, LA, and TX. For each measured fish a landings value was assigned based on month of capture and region. The landings associated with each length measurement were summed by year in 1-cm length bins. These landings are typically then converted to annual proportion in each size bin (Figure 4.12.21).

Recreational Age Frequency
Age compositions were calculated for the charter, private/rental, and recreational (unknown mode) fisheries (Figure 4.12.22) and for the headboat fishery (Figure 4.12.23). Ages 0-9 were plotted for the charter, private/rental, and recreational (unknown mode) fisheries. Ages 0-8 were plotted for the headboat fishery.

In some cases mode of catch was either not recorded or the samples were taken from freezers or coolers left outside of fishing centers or marinas and trip information was not collected. Therefore the number of trips with aged samples was not reported in any mode.

4.6 Recreational Catch-at-Age/Length; directed and discard

Catch at age is handled within the assessment model and does not require discussion or presentation here.

4.7 Recreational Effort

4.7.1 MRFSS Recreational & Charter Effort

Effort estimation for the recreational fishery surveys are produced via telephone surveys of both anglers (private/rental boats and shore fishers) and for-hire boat operators (charter boat anglers, and in early years, party or charter anglers). The methods have changed during the full time series (see section 4.3 for descriptions of survey method changes and adjustments to survey estimates for uniform time-series of catch estimates). Angler trip estimates are tabulated in table 4.11.27 by year and mode. An angler-trip is a single day of fishing in the specified mode, not to exceed 24 hours.

Figures 4.12.24, 4.12.25, and 4.12.26 show the number of angler trips that intercepted cobia from the MRFSS from 1981-1989, 1990-1999, and 2000-2010 respectively. Latitude and longitudes of the intercept site are mapped when available; otherwise, the mid-point of the county of intercept is mapped. Intercepted trips that caught cobia are shown for the Gulf of Mexico and Atlantic Ocean.

4.7.2 Headboat Effort

Catch and effort data are reported on logbooks provided to all headboats in the survey. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Data on effort are provided as number of anglers on a given trip. Numbers of anglers are standardized, depending on the type of trip (length in hours), by converting number of anglers to "angler days" (e.g., 40 anglers on a half-day trip would yield 40 * 0.5 = 20 angler days). Angler days are summed by month for individual vessels. Each month, port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is not 100% and is variable by location. To account for non-reporting, a correction factor is developed based on sampler observations, angler numbers from office books and all available information. This information is used to provide estimates of total catch by month and area, along with estimates of effort.

SRHS areas 7-8 and 11-28 are included in the Gulf of Mexico cobia stock. Figures 4.12.27, 4.12.28, and 4.12.29 show the Gulf of Mexico cobia positive headboat trips from 1980-1989, 1990-1999, and 2000-2011 respectively. During the 1980s and 1990s, Louisiana and north Texas showed concentrations of cobia positive trips on headboats (Figures 4.12.27 and 4.12.28). In more recent years from 2000-2011, positive cobia trips were concentrated off Louisiana and the west coast of Florida (Figures 4.12.29).

Estimated headboat angler days have decreased in the Gulf of Mexico in recent years (Table 4.11.28). 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 noticeable decrease in effort in Louisiana, Alabama and west Florida due to the Deepwater Horizon oil spill in the Gulf of Mexico in 2010.

4.7.3 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 boat and charter boat fishing are surveyed. Most of the sampled trips are private boats fishing in bay/pass because these represent most of the fishing effort, but all trips (private, charter boat, ocean, bay/pass) are sampled. Charter boat trips in ocean waters are the least encountered in the survey.

Estimates of TPWD angler trips are shown in table 4.11.29 by year, season, and mode. Figures 4.12.30, 4.12.31, and 4.12.32 show the number of angler hours from trips that intercepted cobia from the TPWD from 1983-1989, 1990-1999, and 2000-2010 respectively. Angler hours are mapped by Texas major bay areas. They are Sabine Lake, Galveston, Matagorda, San Antonio, Aransas, Corpus Christi, Upper Laguna Madre, and Lower Laguna Madre.

4.8 Comments on adequacy of data for assessment analyses

Regarding the adequacy of the available recreational data for assessment analyses, the RWG discussed the following:

- Landings, as adjusted, appear to be adequate for the time period covered.

- Size data appear to adequately represent the landed catch for the charter and headboat sector.

4.9 Literature Cited

Clark, J.R. 1962. The 1960 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Circular 153, 36 pp.

Deuel, D.G. 1973. The 1970 Salt-Water Angling Survey. U.S. Department of Commerce, National Marine Fisheries Service, Current Fishery Statistics No. 6200, 54 pp.

Deuel, D.G. and J.R. Clark. 1968. The 1965 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Resource Publication 67, 51 pp.

Historical Fisheries Working Group (HFWG) 2010. SEDAR24-DW11, Estimation of Historic Recreational Landings 2010

Matter, V. and S. Turner 2010. Estimated Recreational Catch in Weight: Method for Filling in Missing Weight Estimates from the Recreational Surveys with Application to Yellowedge Grouper, Tilefish (golden), and Blueline Tilefish (SEDAR 22-DW-16), National Marine Fisheries Service, Southeast Fisheries Science Center, Sustainable Fisheries Division (SFD-2010-003).

4.10 Tables

Table 4.11.1. Gulf of Mexico (FLE-LA) cobia landings (numbers of fish and whole weight in pounds) for charter boat mode and charterboat/headboat mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2011). CH and CH/HB mode adjusted for FHS conversion prior to 1997. CH/HB mode landings from 1981-1985 only. 2011 data is preliminary and through October.

	Estimated CH Landings			Estimated CH/HB Landings		
YEAR	Number	CV	Pounds	Number	CV	Pounds
1981	0	0.00	0	18,049	0.47	294,487
1982	0	0.00	0	15,299	0.35	150,367
1983	310	0.94	7,046	19,773	0.29	338,571
1984	839	0.93	17,107	14,511	0.31	231,588
1985	629	1.38	13,507	11,381	0.27	155,648
1986	7,925	0.30	141,906			
1987	10,543	0.42	194,098			
1988	13,942	0.43	236,488			
1989	7,337	0.28	166,865			
1990	8,272	0.38	152,840			
1991	25,739	0.28	522,789			
1992	9,505	0.32	188,843			
1993	23,632	0.38	534,309			
1994	16,089	0.28	344,958			
1995	11,949	0.44	319,191			
1996	27,739	0.33	622,612			
1997	20,934	0.29	531,678			
1998	8,710	0.15	215,761			
1999	7,819	0.18	237,435			
2000	6,505	0.26	152,332			
2001	12,470	0.18	271,898			
2002	8,937	0.14	219,238			
2003	12,439	0.21	299,953			
2004	15,218	0.19	405,891			
2005	12,456	0.30	316,564			
2006	10,287	0.27	264,956			
2007	11,216	0.23	263,479			
2008	12,357	0.33	285,129			
2009	7,455	0.34	164,110			
2010	4,946	0.22	103,686			
2011	10,285	0.25	267,316			

Table 4.11.2. Gulf of Mexico (FLE-LA) cobia landings (numbers of fish and whole weight in pounds) for private/rental boat mode and shore mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2011). 2011 data is preliminary and through October.

	Estimated PR Landings			Estimated SH Landings		
YEAR	Number	CV	Pounds	Number	CV	Pounds
1981	69,670	0.31	753,995	1,723	1.00	35,889
1982	123,718	0.20	1,097,256	11,502	0.45	113,156
1983	75,493	0.22	858,628	3,397	1.00	64,909
1984	55,385	0.23	1,119,444	6,740	0.53	103,860
1985	46,865	0.26	672,098	11,420	0.43	148,947
1986	69,609	0.19	1,265,404	0	0.00	0
1987	57,313	0.17	1,040,789	2,101	1.00	53,663
1988	68,545	0.16	1,280,483	2,503	1.00	80,009
1989	64,027	0.27	1,682,264	3,181	0.71	73,180
1990	46,764	0.19	1,025,760	0	0.00	0
1991	38,228	0.22	793,723	7,939	1.00	140,895
1992	62,656	0.11	1,141,810	13,859	0.35	272,458
1993	46,757	0.15	863,039	6,316	0.38	134,534
1994	54,875	0.11	1,085,134	6,618	0.36	146,406
1995	40,194	0.21	733,169	4,665	0.46	95,866
1996	46,414	0.16	908,621	14,964	0.56	316,751
1997	91,550	0.17	2,047,330	7,345	0.47	211,418
1998	48,914	0.13	1,076,964	1,926	0.80	46,193
1999	56,590	0.12	1,280,079	4,097	0.40	102,551
2000	49,153	0.13	1,135,946	7,213	0.41	141,844
2001	46,935	0.15	1,066,534	5,690	0.50	136,704
2002	37,225	0.13	812,414	5,910	0.41	129,467
2003	67,106	0.11	1,625,953	2,435	0.60	64,980
2004	51,775	0.24	1,616,452	538	1.00	6,287
2005	43,317	0.20	1,077,500	0	0.00	0
2006	48,883	0.18	1,180,439	2,874	0.51	54,813
2007	58,441	0.15	1,343,956	0	0.00	0
2008	37,419	0.18	848,465	4,723	0.59	87,737
2009	34,184	0.18	732,994	0	0.00	0
2010	46,228	0.18	1,030,204	3,329	0.70	103,390
2011	47,816	0.25	1,224,253	4,429	0.61	133,966

Table 4.11.3. Estimated headboat landings of cobia in the Gulf of Mexico 1981-2011. Due to headboat area definitions, West Florida and Alabama landings are combined.

	FLE		FLW/AL		MS*		LA**		TX†	
Year	N	Weight (lb)	N	Weight (lb)	N	Weight (lb)	N	Weight (lb)	N	Weight (lb)
1981	1,373	28,059							371	7,643
1982	2,174	36,360							371	7,643
1983	1,644	36,561							371	7,643
1984	1,782	34,581							371	7,643
1985	1,669	30,474							371	7,643
1986	1,653	30,493	465	7,879			44	1,024	388	9,428
1987	1,953	54,949	316	3,415			68	796	317	5,902
1988	2,145	44,298	150	3,742			107	2,870	407	10,383
1989	2,130	45,473	264	4,382			60	1,131	290	5,650
1990	1,923	48,146	478	10,115			257	6,153	222	5,027
1991	2,589	49,292	417	9,173			364	7,667	227	5,184
1992	2,470	58,981	285	6,426			730	15,327	473	9,821
1993	2,956	58,748	635	13,706			794	15,661	842	13,140
1994	1,937	42,321	369	7,657			1,783	39,882	944	20,681
1995	1,471	33,359	365	10,431			2,182	48,624	850	15,447
1996	1,130	30,223	141	3,111			1,972	42,861	1,033	21,562
1997	1,071	19,949	116	2,978			2,135	54,670	1,190	26,209
1998	959	24,690	179	4,271			714	17,899	1,114	20,524
1999	1,074	23,548	117	3,105			1,155	29,434	551	11,438
2000	962	21,274	72	2,043			547	15,837	538	15,117
2001	1,091	25,145	109	3,161			647	16,692	472	7,689
2002	1,084	20,799	142	3,550			655	16,343	510	9,408
2003	708	13,962	120	2,395			971	18,817	465	7,418
2004	648	15,763	99	1,571					760	11,762
2005	1,664	32,216	71	1,673					776	12,053
2006	885	19,564	116	2,167					802	15,579
2007	1,411	27,975	97	1,712			505	8,693	737	10,787
2008	1,167	29,120	148	3,045			202	4,410	421	9,336
2009	1,143	24,831	271	5,010			227	4,038	684	15,434
2010	1,570	38,127	103	2,331	11	261	7	166	671	15,015
2011	1,165	29,209	138	2,606	20	310	132	2,075	599	9,376

*MS added to survey in 2010.
**LA not sampled during 2004-2005 due to Hurricane Katrina.
†TX 1981-1985 landings estimated using the mean landings 1986-1988.

Table 4.11.4 Texas cobia landings (numbers of fish and whole weight in pounds) for charter boat mode and private mode (TPWD). 2011 data is through mid-May.

	Estimated CH Landings		Estimated PR Landings		Total Landings	
year	Number	Pounds	Number	Pounds	Number	Pounds
1981	27	486	823	13,991	850	14,477
1982	27	486	823	13,991	850	14,477
1983	81	1,458	1,192	21,462	1,273	22,921
1984	0	0	533	8,577	533	8,577
1985	43	691	743	11,932	786	12,623
1986	10	177	316	5,609	326	5,786
1987	151	2,389	670	10,601	821	12,990
1988	0	0	521	8,328	521	8,328
1989	0	0	312	5,877	312	5,877
1990	0	0	440	9,572	440	9,572
1991	0	0	1,005	19,327	1,005	19,327
1992	0	0	2,735	64,611	2,735	64,611
1993	285	5,563	229	4,470	514	10,033
1994	0	0	1,166	19,339	1,166	19,339
1995	0	0	817	15,795	817	15,795
1996	489	10,892	2,693	62,558	3,182	73,450
1997	446	9,939	2,033	43,931	2,479	53,870
1998	266	6,008	1,964	42,814	2,230	48,822
1999	813	18,206	927	19,759	1,740	37,965
2000	135	2,930	956	21,166	1,091	24,096
2001	192	3,965	1,173	23,868	1,365	27,833
2002	357	5,887	643	10,602	1,000	16,489
2003	178	3,439	1,140	23,506	1,318	26,945
2004	203	4,615	1,225	28,084	1,428	32,699
2005	109	2,079	972	18,954	1,081	21,033
2006	146	3,168	1,519	31,950	1,665	35,119
2007	422	8,475	982	20,325	1,404	28,800
2008	405	8,197	1,776	36,687	2,181	44,884
2009	319	7,318	1,665	42,370	1,984	49,688
2010	261	6,033	759	18,515	1,020	24,548
2011	27	486	823	13,991	850	14,477

Table 4.11.5. FHWAR estimation method for historical cobia landings (1955-1985).

Year	US saltwater angler days	Proportion anglers TX-FLE	Saltwater angler days (TX-FLE)	Mean CPUE (MRFSS 1981-1985)	Recall bias adjustment	Adjusted saltwater angler days (TX-FLE)	Adjusted cobia landings (n)
1955	58,621,000	0.19	19,285,109	0.0037	0.52	9,952,808	36,996
1960	80,602,000	0.21	29,825,532	0.0037	0.52	15,392,592	57,217
1965	95,837,000	0.19	32,503,369	0.0037	0.52	16,774,590	62,354
1970	113,694,000	0.20	38,928,690	0.0037	0.52	20,090,620	74,680
1975	167,499,000	0.19	56,621,809	0.0037	0.52	29,221,822	108,622
1980	164,040,000	0.20	57,119,017	0.0037	0.52	29,478,425	109,576
1985	171,055,000	0.20	59,654,586	0.0037	0.52	30,787,001	114,440

Table 4.11.6. Estimated cobia landings (number) using FHWAR census method (1955-1980), MRFSS (1981-2003), MRIP (2004-2011), TPWD (81-11), and SRHS (81-11) estimation methods.

Year	Estimated landings (n)	Year	Estimated landings (n)
1955	36,996	1984	13,779
1956	41,040	1985	20,758
1957	45,084	1986	32,593
1958	49,128	1987	12,515
1959	53,172	1988	11,881
1960	57,217	1989	17,131
1961	58,244	1990	17,538
1962	59,271	1991	25,550
1963	60,299	1992	18,681
1964	61,326	1993	15,485
1965	62,354	1994	14,495
1966	64,819	1995	20,912
1967	67,284	1996	29,847
1968	69,749	1997	20,202
1969	72,215	1998	15,278
1970	74,680	1999	15,324
1971	81,468	2000	15,637
1972	88,257	2001	15,707
1973	95,045	2002	12,451
1974	101,833	2003	31,053
1975	108,622	2004	30,773
1976	108,813	2005	31,612
1977	109,003	2006	33,112
1978	109,194	2007	27,526
1979	109,385	2008	19,161
1980	109,576	2009	28,400
1981	92,036	2010	29,320
1982	9,514	2011	13,329
1983	2,852		

Table 4.11.7. Gulf of Mexico (FLE-TX) cobia discards for the recreational fishing modes by year (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2011). CH and CH/HB mode adjusted for FHS conversion prior to 1997. CH/HB mode discards from 1981-1985 only. 2011 data is preliminary and through October. TX estimates for 1981-1985 shore mode only.

	Estimated CH Discards		Estimated CH/HB Discards		Estimated PR Discards		Estimated SH Discards	
YEAR	Number	CV	Number	CV	Number	CV	Number	CV
1981	0	0.00	0	0.00	8,114	0.59	3,115	1.00
1982	0	0.00	2,837	1.00	15,582	0.44	0	0.00
1983	0	0.00	354	1.00	0	0.00	0	0.00
1984	107	1.90	1,602	0.48	39,097	0.87	1,878	0.83
1985	0	0.00	112	1.01	1,013	1.00	0	0.00
1986	1,409	0.72			41,084	0.42	0	0.00
1987	4,089	0.85			20,112	0.24	0	0.00
1988	14,080	0.58			58,742	0.23	0	0.00
1989	2,726	0.55			65,203	0.27	4,629	0.65
1990	12,722	0.52			76,403	0.18	1,580	0.84
1991	40,839	0.52			167,199	0.22	32,968	0.56
1992	12,988	0.53			100,155	0.13	4,949	0.60
1993	14,605	0.59			65,590	0.15	7,319	0.39
1994	21,742	0.27			84,197	0.13	13,566	0.32
1995	19,030	0.33			59,299	0.20	8,786	0.32
1996	34,243	0.35			69,600	0.18	7,351	0.45
1997	16,924	0.38			105,676	0.14	8,366	0.38
1998	6,760	0.35			83,145	0.12	22,301	0.32
1999	10,598	0.27			88,778	0.10	13,399	0.25
2000	11,657	0.36			97,436	0.11	15,069	0.33
2001	5,436	0.21			105,311	0.10	33,088	0.27
2002	7,358	0.15			115,516	0.10	15,325	0.25
2003	5,956	0.15			66,730	0.12	14,288	0.31
2004	10,224	0.31			77,726	0.16	4,685	0.60
2005	4,157	0.23			49,648	0.20	3,287	0.60
2006	7,576	0.30			52,950	0.17	12,985	0.43
2007	10,526	0.30			65,103	0.18	4,669	0.59
2008	11,042	0.29			88,784	0.18	31,120	0.44
2009	6,317	0.25			73,029	0.16	4,001	0.58
2010	1,858	0.26			59,819	0.22	7,108	0.54
2011	8,137	0.37			80,750	0.19	3,913	0.70

Table 4.11.8. Estimated Gulf of Mexico cobia discards for SRHS by year and state.† Due to headboat area definitions, West Florida and Alabama discards are combined.

Year	FLE	FLW/AL	MS*	LA**	TX†	Gulf of Mexico
1981	-				439	439
1982	-				439	439
1983	-				439	439
1984	137				439	577
1985	-				439	439
1986	-	189		-	-	189
1987	-	161		2	33	196
1988	-	103		26	364	494
1989	-	169		-	-	169
1990	222	610		126	399	1,357
1991	-	1,299		5	11	1,315
1992	443	637		10	24	1,114
1993	-	609		3	10	621
1994	-	920		51	100	1,071
1995	-	1,150		102	146	1,398
1996	934	272		70	134	1,410
1997	1,292	43		436	892	2,662
1998	1,450	105		40	227	1,822
1999	104	380		33	58	575
2000	-	389		32	114	535
2001	278	59		26	69	432
2002	72	306		14	40	432
2003	101	153		12	21	288
2004	56	15			20	91
2005	556	15			38	609
2006	390	16		-	61	467
2007	282	53		7	151	493
2008	762	109		13	138	1,022
2009	1,051	147		14	161	1,373
2010	857	17	1	-	93	968
2011	514	241	9	3	50	817

*MS added to survey in 2010.
**LA not sampled during 2004-2005 due to Hurricane Katrina.
†TX 1981-1985 discards estimated using the mean discards 1986-1988.

Table 4.11.9 Texas cobia discards (numbers of fish) for charter boat mode and private mode (TPWD). No cobia data from 2011 through mid-May.

year	Estimated CH Discards	Estimated PR Discards	Total Discards
1981	0	58	58
1982	0	58	58
1983	1	25	27
1984	0	47	47
1985	1	100	101
1986	1	167	168
1987	41	106	148
1988	0	163	163
1989	0	106	106
1990	0	282	282
1991	0	421	421
1992	0	1,160	1,160
1993	153	134	287
1994	0	690	690
1995	0	548	548
1996	203	1,381	1,584
1997	128	815	943
1998	99	1,137	1,236
1999	249	667	917
2000	61	1,077	1,138
2001	42	816	859
2002	271	516	787
2003	35	1,097	1,132
2004	87	1,397	1,485
2005	23	957	980
2006	44	1,804	1,847
2007	161	850	1,011
2008	163	1,406	1,569
2009	179	1,366	1,544
2010	112	736	847
2011	0	0	0

Table 4.11.10. Number of cobia measured or weighed in the Gulf of Mexico (FLE-LA) in the MRFSS charter fleet by year and state.

YEAR	LA	MS	AL	FLW	FLE	TOTAL
1981	2	2	1	2		7
1982		1	5			6
1983	9	8	1			18
1984	21			7		28
1985	3			12		15
1986	50	4	2	4	3	63
1987	13	10	4	9		36
1988	7	3	3	10		23
1989			4	8	5	17
1990	8		10			18
1991	46	1	6	19		72
1992	13	3	18	11	6	51
1993	15	2	7	9	3	36
1994	28	2	5	12	3	50
1995	11	2		7	3	23
1996	9	1	3	22	1	36
1997	7	1	1	44	3	56
1998	5	1	2	55	4	67
1999	9	5	3	61	19	97
2000		2	3	54	5	64
2001	1	1	10	60	29	101
2002	34	11	11	31	22	109
2003	60		5	49	33	147
2004	77		8	44	19	148
2005	47			36	9	92
2006	39		4	22	27	92
2007	71		3	32	14	120
2008	3			25	11	39
2009	13	1	3	10	10	37
2010			5	28	28	61
2011	6	3	4	29	34	76
Grand Total	607	64	131	712	291	1,805

Table 4.11.11. Number of cobia measured or weighed in the Gulf of Mexico (FLE-LA) in the MRFSS private fleet by year and state.

YEAR	LA	MS	AL	FLW	FLE	TOTAL
1981	5		5	4		14
1982	23	8	8	16	14	69
1983	8	3		5	4	20
1984	4	1	2	7	7	21
1985	7		3	2	6	18
1986	5	3	3	33	2	46
1987	3	3	14	16	7	43
1988	7	1	2	18	5	33
1989	8	1		5	9	23
1990	8	1	3	10	3	25
1991	2		3	8	3	16
1992	1	7	7	22	30	67
1993	1	2	3	12	17	35
1994	8	4	7	26	11	56
1995	7	4		21	4	36
1996	5		2	14	17	38
1997	10	9	3	20	13	55
1998	2	7	5	27	18	59
1999	5	3	14	34	52	108
2000	3	7	6	18	17	51
2001	3	4	8	25	14	54
2002	1	2	5	23	15	46
2003	1	1	5	39	25	71
2004	3	5	6	15	6	35
2005	3	1	5	24	5	38
2006	6	1	3	9	28	47
2007	4	1	4	20	18	47
2008	1	4	3	19	19	46
2009	1	3	6	15	21	46
2010	2			17	36	55
2011	5	4	5	6	33	53
Grand Total	152	90	140	530	459	1,371

Table 4.11.12. Number of cobia measured or weighed in the Gulf of Mexico (FLE-LA) in the MRFSS shore mode by year and state.

YEAR	LA	AL	FLW	FLE	TOTAL
1982	5		6		11
1984				2	2
1985		1		5	6
1987			1		1
1988			1		1
1991			1		1
1992			2	3	5
1993			3		3
1994			4		4
1995			2		2
1996			6		6
1997			5	1	6
1998			2		2
1999			6	1	7
2000			3		3
2001			2		2
2002			1	1	2
2003			2	1	3
2004			1		1
2005			1		1
2006			1	1	2
2008			3		3
2010			3	1	4
2011			1	2	3
Grand Total	5	1	57	18	81

Table 4.11.13. Number of angler trips with measured or weighed cobia in the Gulf of Mexico (FLE-LA) in the MRFSS charter fleet by year and state.

YEAR	LA	MS	AL	FLW	FLE	TOTAL
1981	2	2	1	1		6
1982		1	4			5
1983	7	1	1			9
1984	7			6		13
1985	2			5		7
1986	18	3	2	2	3	28
1987	7	5	4	7		23
1988	3	2	1	6		12
1989			4	5	4	13
1990	5		5			10
1991	19	1	5	10		35
1992	9	3	9	8	6	35
1993	7	2	3	8	2	22
1994	12	2	5	7	2	28
1995	7	2		3	3	15
1996	5	1	2	15	1	24
1997	4	1	1	22	3	31
1998	5	1	2	36	4	48
1999	4	4	2	45	13	68
2000		2	3	42	5	52
2001	1	1	8	47	18	75
2002	16	5	11	25	17	74
2003	22		5	35	18	80
2004	23		8	38	16	85
2005	13			30	7	50
2006	18		4	17	16	55
2007	20		3	27	6	56
2008	3			23	10	36
2009	5	1	3	8	7	24
2010			2	19	17	38
2011	3	1	4	21	15	44
Grand Total	247	41	102	518	193	1,101

Table 4.11.14. Number of angler trips with measured or weighed cobia in the Gulf of Mexico (FLE-LA) in the MRFSS private fleet by year and state.

YEAR	LA	MS	AL	FLW	FLE	TOTAL
1981	3		4	4		11
1982	13	7	8	11	11	50
1983	4	2		2	4	12
1984	2	1	2	4	7	16
1985	2		3	2	6	13
1986	4	2	2	14	2	24
1987	1	3	7	11	6	28
1988	4	1	1	13	5	24
1989	2	1		4	7	14
1990	2	1	3	7	3	16
1991	2		3	8	3	16
1992	1	6	3	19	24	53
1993	1	2	3	12	13	31
1994	6	2	7	22	11	48
1995	2	3		17	4	26
1996	2		2	11	16	31
1997	6	9	2	18	11	46
1998	2	5	5	24	17	53
1999	5	3	12	29	32	81
2000	3	3	6	15	16	43
2001	1	3	7	20	13	44
2002	1	2	5	21	12	41
2003	1	1	5	37	24	68
2004	2	1	6	13	5	27
2005	2	1	5	19	4	31
2006	3	1	3	9	22	38
2007	4	1	4	17	14	40
2008	1	2	1	13	17	34
2009	1	3	5	13	17	39
2010	1			15	32	48
2011	3	1	2	5	20	31
Grand Total	87	67	116	429	378	1,077

Table 4.11.15. Number of trips with measured or weighed cobia in the Gulf of Mexico (FLE-LA) in the MRFSS shore mode by year and state.

YEAR	LA	AL	FLW	FLE	TOTAL
1982	1		4		5
1984				2	2
1985		1		5	6
1987			1		1
1988			1		1
1991			1		1
1992			2	2	4
1993			3		3
1994			4		4
1995			2		2
1996			6		6
1997			4	1	5
1998			2		2
1999			6	1	7
2000			3		3
2001			2		2
2002			1	1	2
2003			2	1	3
2004			1		1
2005			1		1
2006			1	1	2
2008			3		3
2010			3	1	4
2011			1	2	3
Grand Total	1	1	54	17	73

Table 4.11.16. Number of MRFSS intercept trips conducted in the Gulf of Mexico (FLE-LA) by year and mode with the percentage of intercepts that encountered cobia.

	Shore			Cbt			Priv		
YEAR	TOT int	COB int	%cob	TOT int	COB int	%cob	TOT int	COB int	%cob
1981	2,985	2	0.07%	410	10	2.44%	2,674	16	0.60%
1982	6,393	5	0.08%	365	6	1.64%	5,968	60	1.01%
1983	5,295	1	0.02%	1,038	19	1.83%	3,125	15	0.48%
1984	5,844	5	0.09%	1,250	25	2.00%	3,980	22	0.55%
1985	6,245	7	0.11%	724	12	1.66%	4,232	20	0.47%
1986	2,919		0.00%	3,342	41	1.23%	12,952	41	0.32%
1987	3,075	1	0.03%	2,736	32	1.17%	12,543	65	0.52%
1988	5,625	1	0.02%	2,556	34	1.33%	12,967	59	0.46%
1989	4,535	7	0.15%	2,190	23	1.05%	9,530	47	0.49%
1990	4,124	2	0.05%	1,745	33	1.89%	8,454	67	0.79%
1991	4,843	6	0.12%	2,403	67	2.79%	9,849	71	0.72%
1992	9,910	10	0.10%	4,370	78	1.78%	21,082	156	0.74%
1993	15,367	14	0.09%	2,493	38	1.52%	16,444	103	0.63%
1994	17,450	20	0.11%	2,570	70	2.72%	19,302	136	0.70%
1995	16,043	15	0.09%	2,379	34	1.43%	17,061	76	0.45%
1996	10,361	21	0.20%	2,684	68	2.53%	21,011	124	0.59%
1997	10,516	22	0.21%	4,158	69	1.66%	21,012	203	0.97%
1998	11,448	22	0.19%	7,513	78	1.04%	24,086	176	0.73%
1999	14,900	24	0.16%	12,017	127	1.06%	31,527	248	0.79%
2000	12,084	16	0.13%	15,114	134	0.89%	27,650	170	0.61%
2001	12,913	23	0.18%	14,065	166	1.18%	30,345	181	0.60%
2002	14,423	24	0.17%	14,628	173	1.18%	32,239	211	0.65%
2003	14,252	15	0.11%	14,851	181	1.22%	30,359	184	0.61%
2004	12,131	6	0.05%	14,641	199	1.36%	30,603	137	0.45%
2005	12,463	9	0.07%	12,658	144	1.14%	28,175	119	0.42%
2006	12,129	10	0.08%	10,132	125	1.23%	31,696	145	0.46%
2007	12,708	3	0.02%	10,237	135	1.32%	31,234	138	0.44%
2008	11,769	20	0.17%	9,233	137	1.48%	30,787	164	0.53%
2009	12,797	4	0.03%	7,784	30	0.39%	30,549	90	0.29%
2010	12,408	10	0.08%	8,140	81	1.00%	29,507	146	0.49%

Table 4.11.17. Mean weight (lb) of cobia weighed from the MRFSS in the Gulf of Mexico (FLE-LA) by year and mode, 1981-2011.

	Cbt				Priv				Shore			
YEAR	N	Mean (lbs)	Min (lbs)	Max (lbs)	N	Mean (lbs)	Min (lbs)	Max (lbs)	N	Mean (lbs)	Min (lbs)	Max (lbs)
1981	6	17.23	13.23	27.56	13	12.38	2.43	33.07				
1982	6	12.90	4.19	28.66	59	10.59	0.88	44.97	7	6.68	1.10	27.12
1983	9	19.45	4.41	45.19	17	7.53	0.88	22.05				
1984	26	19.50	0.22	52.47	19	18.80	2.65	43.21	2	10.36	10.36	10.36
1985	13	20.18	12.13	33.95	10	9.50	1.98	21.83	6	12.93	5.51	20.06
1986	37	17.73	1.32	46.30	38	17.42	1.10	44.09				
1987	33	20.84	1.54	77.16	41	14.43	0.88	38.58	1	18.74	18.74	18.74
1988	19	16.85	10.14	29.10	29	15.56	3.53	33.07	1	36.60	36.60	36.60
1989	15	25.24	9.70	60.63	16	25.39	9.92	56.00				
1990	9	20.99	16.53	26.46	12	20.06	1.10	50.26				
1991	44	22.50	12.35	45.19	11	16.09	5.51	36.38	1	13.45	13.45	13.45
1992	34	22.08	5.73	64.15	53	18.65	1.32	82.23	5	14.81	9.92	20.72
1993	21	20.39	9.48	37.48	25	17.54	8.82	29.98	1	18.74	18.74	18.74
1994	31	22.37	10.58	48.94	37	19.53	5.07	46.30	1	11.68	11.68	11.68
1995	12	28.01	8.16	56.77	23	15.35	0.66	27.12	2	17.53	16.53	18.52
1996	21	23.68	14.33	69.00	31	19.05	12.57	28.88	1	20.39	20.39	20.39
1997	43	24.59	6.83	67.90	38	19.00	3.31	50.71	5	24.71	13.67	40.34
1998	59	27.25	5.51	96.01	37	18.63	7.05	34.17	2	8.27	5.51	11.02
1999	92	32.57	12.13	90.94	90	21.72	4.41	54.01	7	25.21	10.47	37.48
2000	54	23.74	9.92	52.27	49	23.91	6.44	65.08	2	6.48	1.72	11.24
2001	98	24.48	9.92	92.70	47	21.70	6.17	95.08	2	16.89	12.83	20.94
2002	107	25.53	10.23	89.02	37	21.13	6.17	33.91	2	15.12	14.81	15.43
2003	131	24.14	9.57	49.56	58	23.74	5.40	50.44	2	18.19	13.89	22.49
2004	143	25.44	12.13	55.12	29	24.77	4.19	45.68	1	11.68	11.68	11.68
2005	89	26.17	10.47	52.34	36	21.44	5.51	44.09	1	9.70	9.70	9.70
2006	85	22.51	11.57	41.89	40	21.73	9.57	38.85	2	14.57	13.05	16.09
2007	103	22.49	9.92	58.80	42	24.84	8.51	50.26				
2008	36	23.15	12.04	46.52	41	24.06	12.79	50.04	3	18.85	12.79	24.85
2009	35	24.04	11.33	52.47	44	19.86	6.08	41.27				
2010	55	22.33	10.63	48.02	50	22.34	11.42	51.15	4	26.18	14.46	34.83
2011	68	23.22	10.19	47.84	52	23.04	12.57	46.30	1	1.01	1.01	1.01

Table 4.11.18. Number of cobia measured and positive trips in the SRHS by year and area. Due to headboat area definitions, West Florida and Alabama data are combined.

	Fish (N)						Trips (N)					
YEAR	FLE	FLW/AL	MS	LA	TX	Total	FLE	FLW/AL	MS	LA	TX	Total
1972	-					-	-					-
1973	-					-	-					-
1974	-					-	-					-
1975	-					-	-					-
1976	-					-	-					-
1977	-					-	-					-
1978	-					-	-					-
1979	23					23	20					20
1980	15					15	15					15
1981	31					31	27					27
1982	28					28	24					24
1983	29					29	27					27
1984	47					47	41					41
1985	24					24	21					21
1986	39	28		7	18	92	34	22		6	17	79
1987	42	15		3	8	68	33	13		2	6	54
1988	34	7		9	6	56	24	7		8	6	45
1989	36	11		19	4	70	27	10		19	4	60
1990	40	9		6	3	58	32	8		3	3	46
1991	25	12		11	3	51	18	11		9	3	41
1992	53	9		52	10	124	33	7		29	8	77
1993	53	10		74	21	158	35	5		36	15	91
1994	23	22		58	40	143	21	14		27	26	88
1995	16	12		109	37	174	11	7		54	27	99
1996	10	1		115	36	162	7	1		33	23	64
1997	19	1		127	8	155	15	1		62	5	83
1998	31	13		185	14	243	25	8		77	13	123
1999	28	2		182	8	220	26	2		68	8	104
2000	18	7		67	1	93	15	4		41	1	61
2001	32	3		59	34	128	28	1		36	13	78
2002	47	1		33	8	89	36	1		18	8	63
2003	43	1		51	10	105	26	1		26	4	57
2004	31	-		-	18	49	20	-		-	16	36
2005	16	1		10	10	37	14	1		8	9	32
2006	45	4		1	19	69	27	3		1	13	44
2007	43	2		26	15	86	27	2		16	8	53
2008	41	5		18	-	64	28	1		11	0	40
2009	40	6		25	2	73	33	5		17	2	57
2010	77	8	-	-	1	86	37	5	-	-	1	43
2011	54	2	-	3	-	59	41	2	-	3	0	46

*MS added to survey in 2010. **LA not sampled during 2004-2005 due to Hurricane Katrina.

Table 4.11.19. Number of Gulf of Mexico cobia aged from the SRHS by year and state. Due to headboat area definitions, West Florida and Georgia data are combined.

Year	FLE	FLW/AL	MS	LA	TX
1981	-	-	-	-	-
1982	-	-	-	-	-
1983	-	-	-	-	-
1984	-	-	-	-	-
1985	-	-	-	-	-
1986	-	-	-	-	-
1987	-	-	-	-	-
1988	-	-	-	-	-
1989	-	-	-	-	-
1990	-	-	-	-	-
1991	-	-	-	-	-
1992	-	7	-	-	-
1993	-	2	-	-	-
1994	-	6	-	-	-
1995	-	4	-	-	-
1996	-	1	-	-	-
1997	-	-	-	-	-
1998	-	-	-	-	-
1999	-	-	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	4	-	-	-	-
2006	22	1	-	-	-
2007	4	-	-	-	-
2008	-	-	-	-	-
2009	-	1	-	-	-
2010	13	1	-	-	-
2011	1	-	-	-	-

*MS added to survey in 2010.
**LA not sampled during 2004-2005 due to Hurricane Katrina.

Table 4.11.20. Mean weight (kg) of cobia measured in the SRHS by year and state, 1986-2011. Due to headboat area definitions, West Florida and Georgia data are combined.

	FLE				FLW/AL				MS				LA				TX			
Year	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)
1972	-	-	-	-																
1973	-	-	-	-																
1974	-	-	-	-																
1975	-	-	-	-																
1976	-	-	-	-																
1977	-	-	-	-																
1978	-	-	-	-																
1979	23	10.76	2.26	20.43																
1980	15	6.21	0.24	15.89																
1981	31	8.54	3.90	24.55																
1982	28	7.78	1.85	23.15																
1983	29	8.24	1.40	18.36																
1984	47	8.68	0.53	23.61																
1985	25	7.87	0.45	18.90																
1986	39	8.53	0.47	18.91	28	8.36	0.62	20.80					7	10.55	6.20	22.50	18	10.53	6.00	32.66
1987	42	9.50	2.07	24.43	15	5.12	1.50	11.30					3	6.77	1.60	10.20	8	9.08	5.93	12.00
1988	34	10.56	4.05	32.72	7	8.68	3.96	19.61					9	13.42	1.53	46.54	6	9.08	5.25	13.39
1989	36	9.69	0.91	21.97	11	7.36	3.73	12.56					19	8.52	0.03	29.23	4	10.34	8.32	14.12
1990	40	12.75	5.55	32.01	9	9.94	5.22	14.15					6	10.95	4.73	18.23	3	8.96	6.00	12.03
1991	25	9.23	4.62	17.97	12	10.68	5.98	17.48					11	9.56	5.35	16.82	3	8.31	6.84	10.21
1992	53	10.93	0.88	28.67	9	10.22	1.86	17.15					52	9.29	5.43	17.68	10	12.96	6.59	28.36
1993	53	9.87	4.72	20.66	10	9.90	5.80	14.90					74	8.83	4.53	17.50	21	8.60	5.67	18.08
1994	23	10.22	6.11	19.98	22	9.57	4.85	16.12					58	10.07	4.37	18.68	40	10.35	5.52	22.01
1995	16	9.51	0.77	21.38	12	15.37	4.54	32.70					109	10.16	5.54	19.71	37	9.63	5.29	22.20
1996	10	13.08	6.93	19.55	1	10.34	10.34	10.34					115	11.31	5.65	31.25	36	10.68	5.20	24.01
1997	19	10.08	4.39	24.97	1	12.42	12.42	12.42					127	11.38	4.25	28.70	8	7.86	5.65	11.52
1998	31	11.33	4.85	18.91	13	10.92	6.43	17.82					185	11.52	5.57	39.53	14	9.05	6.02	15.25
1999	28	9.61	4.64	22.13	2	12.63	12.13	13.12					182	12.11	3.47	30.02	8	6.14	5.46	7.90

2000	18	9.29	5.07	15.46	7	10.27	5.28	21.56					67	13.04	5.35	26.70	1	14.92	14.92	14.92
2001	33	9.95	5.26	20.62	3	22.38	20.43	25.09					59	11.37	5.52	19.21	34	8.23	0.00	17.40
2002	47	8.96	5.55	20.26	1	8.94	8.94	8.94					33	11.95	5.12	21.33	8	6.27	5.69	7.15
2003	43	9.24	5.34	17.01	1	6.05	6.05	6.05					51	9.97	5.49	18.57	10	7.24	5.66	8.91
2004	31	11.04	6.45	16.33	-	-	-	-									18	7.06	4.18	10.16
2005	16	8.28	4.59	16.92	1	7.32	7.32	7.32					10	11.0	6.6	20.9	10	7.05	4.54	10.80
2006	45	9.94	4.04	21.98	4	11.03	7.97	17.64					1	9.7	9.7	9.7	19	9.19	6.12	15.74
2007	44	9.28	1.69	20.36	2	8.12	7.97	8.26					28	8.7	0.0	33.6	15	8.71	4.69	16.24
2008	41	10.12	4.88	26.21	5	10.38	7.71	15.11					18	9.9	0.5	18.4	-	-	-	-
2009	40	9.64	5.53	23.38	6	8.44	6.20	10.73					25	12.2	5.5	21.4	2	11.48	10.70	12.27
2010	77	9.46	5.41	23.32	8	11.42	6.47	19.14	-	-	-	-	-	-	-	-	1	8.50	8.50	8.50
2011	54	11.37	6.52	21.27	2	9.71	6.63	12.79	-	-	-	-	3	10.0	6.2	13.7	-	-	-	-

Table 4.11.21. Number of cobia measured in Texas in the TPWD survey by year and mode. No cobia data from 2011 through mid-May.

YEAR	Cbt	Priv	Grand Total
1983	1	24	25
1984		21	21
1985		27	27
1986	1	18	19
1987	2	29	31
1988		19	19
1989		20	20
1990		18	18
1991	2	20	22
1992		34	34
1993	3	20	23
1994	1	45	46
1995	1	46	47
1996	21	101	122
1997	9	76	85
1998	14	70	84
1999	13	35	48
2000	7	45	52
2001	6	41	47
2002	6	28	34
2003	8	68	76
2004	10	53	63
2005	6	44	50
2006	7	64	71
2007	17	47	64
2008	27	64	91
2009	11	75	86
2010	12	37	49
2011			
Grand Total	185	1,189	1,374

Table 4.11.22. Number of trips with measured cobia in Texas from the TPWD survey by year and mode. No cobia data from 2011 through mid-May.

YEAR	Cbt	Priv	Grand Total
1983	1	20	21
1984		18	18
1985		24	24
1986	1	13	14
1987	2	21	23
1988		14	14
1989		15	15
1990		14	14
1991	1	19	20
1992		26	26
1993	2	15	17
1994	1	36	37
1995	1	41	42
1996	7	81	88
1997	8	65	73
1998	10	55	65
1999	10	31	41
2000	3	37	40
2001	5	34	39
2002	5	24	29
2003	5	53	58
2004	6	37	43
2005	4	32	36
2006	5	55	60
2007	12	40	52
2008	18	47	65
2009	6	53	59
2010	7	26	33
2011			
Grand Total	120	946	1,066

Table 4.11.23 Number of TPWD intercept trips conducted in Texas by year and mode with the percentage of intercepts that encountered cobia.

	Cbt			Priv			Total		
YEAR	TOT int	COB int	%cob	TOT int	COB int	%cob	TOT int	COB int	%cob
1983	367	1	0.27%	14,223	20	0.14%	14,590	21	0.14%
1984	247		0.00%	9,149	18	0.20%	9,396	18	0.19%
1985	403		0.00%	12,149	24	0.20%	12,552	24	0.19%
1986	474	1	0.21%	12,306	13	0.11%	12,780	14	0.11%
1987	498	2	0.40%	16,333	21	0.13%	16,831	23	0.14%
1988	570		0.00%	14,929	14	0.09%	15,499	14	0.09%
1989	665		0.00%	12,285	15	0.12%	12,950	15	0.12%
1990	425		0.00%	9,740	14	0.14%	10,165	14	0.14%
1991	694	1	0.14%	12,090	19	0.16%	12,784	20	0.16%
1992	991		0.00%	15,294	26	0.17%	16,285	26	0.16%
1993	968	2	0.21%	16,538	15	0.09%	17,506	17	0.10%
1994	1,045	1	0.10%	18,654	36	0.19%	19,699	37	0.19%
1995	1,089	1	0.09%	17,727	41	0.23%	18,816	42	0.22%
1996	1,264	7	0.55%	16,780	81	0.48%	18,044	88	0.49%
1997	1,194	8	0.67%	17,032	65	0.38%	18,226	73	0.40%
1998	1,355	10	0.74%	17,064	55	0.32%	18,419	65	0.35%
1999	1,538	10	0.65%	20,017	31	0.15%	21,555	41	0.19%
2000	1,731	3	0.17%	18,950	37	0.20%	20,681	40	0.19%
2001	1,861	5	0.27%	16,853	34	0.20%	18,714	39	0.21%
2002	1,561	5	0.32%	15,623	24	0.15%	17,184	29	0.17%
2003	1,799	5	0.28%	17,339	53	0.31%	19,138	58	0.30%
2004	1,703	6	0.35%	17,175	37	0.22%	18,878	43	0.23%
2005	1,705	4	0.23%	16,632	32	0.19%	18,337	36	0.20%
2006	2,072	5	0.24%	18,468	55	0.30%	20,540	60	0.29%
2007	2,067	12	0.58%	16,864	40	0.24%	18,931	52	0.27%
2008	1,797	18	1.00%	17,045	47	0.28%	18,842	65	0.34%
2009	1,891	6	0.32%	18,204	53	0.29%	20,095	58	0.29%
2010	1,963	7	0.36%	16,796	26	0.15%	18,759	33	0.18%

Table 4.11.24. Number of cobia aged in the Gulf of Mexico (FLE-TX) from the charter boat fleet by year and state.

Year	FLE	FLW/AL	MS	LA	TX
1981	-	-	-	-	-
1982	-	-	-	-	-
1983	-	-	-	-	-
1984	-	-	-	-	-
1985	-	-	-	-	-
1986	-	-	-	-	-
1987	-	-	-	-	-
1988	-	-	-	-	-
1989	-	-	-	-	-
1990	-	-	-	-	-
1991	-	-	-	-	-
1992	-	-	-	-	-
1993	-	-	-	-	-
1994	-	-	-	-	-
1995	-	-	-	-	-
1996	-	-	-	-	-
1997	-	-	-	-	-
1998	-	-	-	-	-
1999	-	3	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	15	-	-	-	-
2005	7	-	-	-	-
2006	19	-	-	-	-
2007	2	1	-	-	-
2008	1	3	-	-	-
2009	-	2	-	-	-
2010	-	-	-	-	-
2011	-	-	-	-	-

Table 4.11.25. Number of cobia aged in the Gulf of Mexico (FLE-TX) from the private/rental fleet by year and state.

Year	FLE	FLW/AL	MS	LA	TX
1981	-	-	-	-	-
1982	-	-	-	-	-
1983	-	-	-	-	-
1984	-	-	-	-	-
1985	-	-	-	-	-
1986	-	-	-	-	-
1987	-	-	-	-	-
1988	-	-	-	-	-
1989	-	-	-	-	-
1990	-	-	-	-	-
1991	-	-	-	-	-
1992	-	-	-	-	-
1993	-	-	-	-	-
1994	-	-	-	-	-
1995	-	-	-	-	-
1996	-	-	-	-	-
1997	-	-	-	-	-
1998	-	-	-	-	-
1999	-	-	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	1	-	-	-	-
2005	-	1	-	-	-
2006	5	2	-	-	-
2007	-	2	-	-	-
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	1	-	-	-
2011	-	-	-	-	-

Table 4.11.26. Number of cobia aged in the Gulf of Mexico (FLE-TX) from the recreational fishery (mode unknown) by year and state.

Year	FLE	FLW/AL	MS	LA	TX
1981	-	-	-	-	-
1982	-	-	-	-	-
1983	-	-	-	-	-
1984	-	-	-	-	-
1985	-	-	-	-	-
1986	-	-	-	-	-
1987	-	-	11	4	-
1988	-	8	19	5	-
1989	-	56	61	57	-
1990	2	45	43	50	15
1991	7	11	23	18	-
1992	2	-	-	-	-
1993	-	-	-	-	-
1994	-	-	-	-	-
1995	-	22	-	-	3
1996	54	109	52	37	69
1997	18	67	78	30	-
1998	-	-	-	-	-
1999	-	-	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	-	-	-	-
2006	-	-	-	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	-	-	-

Table 4.11.27. Gulf of Mexico (FLE-TX) estimated number of angler trips for charter boat mode, charter boat/headboat mode, private/rental mode, and shore mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2011). CH and CH/HB mode adjusted for FHS conversion prior to 1997. CH/HB mode estimates from 1981-1985 only. TX estimates for 1981-1985 only. 2011 data is preliminary and through October.

	Estimated CH Angler Trips		Estimated CH/HB Angler Trips		Estimated PR Angler Trips		Estimated SH Angler Trips	
YEAR	Trips	CV	Trips	CV	Trips	CV	Trips	CV
1981			510,073	0.08	9,737,473	0.16	10,505,491	0.07
1982			1,236,550	0.07	8,413,743	0.05	14,882,315	0.07
1983			970,566	0.08	10,323,717	0.05	21,053,558	0.09
1984			919,543	0.08	11,843,394	0.05	17,987,255	0.08
1985			1,229,933	0.07	12,671,766	0.06	15,361,270	0.07
1986	853,851	0.12			12,516,657	0.04	15,403,850	0.05
1987	897,982	0.13			13,562,422	0.03	12,107,471	0.08
1988	1,032,633	0.11			15,785,242	0.02	14,272,536	0.04
1989	871,175	0.11			13,595,335	0.03	11,880,871	0.04
1990	649,101	0.11			11,192,600	0.02	9,532,145	0.04
1991	656,047	0.09			13,825,224	0.02	14,740,042	0.03
1992	700,526	0.07			14,092,539	0.01	13,598,016	0.02
1993	1,092,434	0.06			13,203,731	0.01	12,722,408	0.02
1994	1,243,458	0.06			14,720,803	0.01	13,344,650	0.02
1995	1,436,657	0.05			14,813,126	0.01	12,822,863	0.02
1996	1,444,312	0.05			14,408,301	0.01	11,788,722	0.02
1997	1,529,432	0.06			15,817,256	0.01	12,619,577	0.02
1998	1,134,248	0.03			13,828,925	0.02	11,631,034	0.02
1999	999,895	0.03			13,293,853	0.02	9,545,549	0.02
2000	1,045,150	0.03			17,481,153	0.02	13,925,312	0.02
2001	949,859	0.02			18,365,263	0.02	15,995,653	0.02
2002	947,643	0.03			17,064,823	0.02	11,923,474	0.02
2003	878,041	0.03			20,322,073	0.02	13,200,343	0.02
2004	1,035,123	0.03			21,188,067	0.02	15,098,692	0.04
2005	884,084	0.02			19,648,863	0.02	14,105,901	0.04
2006	1,007,073	0.03			19,533,380	0.02	14,380,029	0.04
2007	1,020,877	0.03			22,137,137	0.02	13,734,361	0.04
2008	955,752	0.03			21,647,123	0.02	13,426,797	0.04
2009	971,013	0.03			18,837,137	0.02	12,909,041	0.04
2010	698,546	0.03			18,390,788	0.02	12,175,814	0.04
2011	807,950	0.02			15,527,520	0.02	11,936,047	0.04

Table 4.11.28. Gulf of Mexico headboat estimated angler days by year and state, 1986-2011.

YEAR	FLE	FLW/AL	MS*	LA**	TX
1981	597,408				
1982	586,266				
1983	555,726				
1984	577,988				
1985	561,689				
1986	634,119	480,154		11,782	113,136
1987	666,082	434,098		12,724	126,726
1988	603,549	391,896		15,382	140,792
1989	633,728	416,650		5,734	126,778
1990	645,790	427,812		13,796	116,288
1991	560,044	348,624		12,746	119,938
1992	529,047	369,604		19,822	152,436
1993	473,945	415,793		22,512	161,809
1994	484,591	409,123		25,302	201,555
1995	405,898	364,821		20,996	180,929
1996	394,344	309,826		21,976	183,706
1997	340,729	298,884		18,016	164,415
1998	306,678	370,666		15,709	155,303
1999	324,390	352,234		16,052	116,470
2000	360,194	318,662		9,904	116,790
2001	322,102	314,486		12,444	110,722
2002	298,548	283,662		12,444	133,902
2003	287,170	288,422		13,272	127,164
2004	347,402	316,860			129,980
2005	342,156	260,466			119,714
2006	347,237	248,125		10,010	141,577
2007	310,363	273,755		5,044	127,524
2008	244,728	260,349		5,889	82,373
2009	268,654	284,873		6,536	101,470
2010	243,404	222,035	995	434	94,304
2011	244,948	314,046	3,541	3,772	94,566

*MS added to survey in 2010.
**LA not sampled during 2004-2005 due to Hurricane Katrina.

Table 4.11.29. Texas estimated angler trips by year, season, and mode, 1983-2011.

	Estimated CH trips		Estimated PR trips		Total
year	High	Low	High	Low	
1983	31,710		637,416		669,126
1984	19,292	3,287	540,420	172,321	735,321
1985	23,578	6,852	587,673	254,969	873,072
1986	23,137	6,772	553,830	346,804	930,542
1987	24,636	11,866	751,020	350,008	1,137,530
1988	23,674	4,778	705,650	335,498	1,069,600
1989	35,518	9,580	678,535	234,013	957,645
1990	30,298	4,319	620,597	215,878	871,092
1991	38,340	10,997	637,275	214,490	901,102
1992	35,486	11,501	730,467	252,919	1,030,374
1993	40,419	15,111	681,545	313,340	1,050,415
1994	73,902	17,829	719,053	375,014	1,185,798
1995	51,984	21,696	675,113	404,477	1,153,270
1996	58,813	19,753	741,427	357,446	1,177,440
1997	80,733	19,298	694,991	305,589	1,100,611
1998	90,497	22,903	668,794	303,733	1,085,927
1999	91,571	25,287	796,383	407,326	1,320,566
2000	109,834	53,419	718,916	441,329	1,323,498
2001	109,895	53,006	681,733	306,038	1,150,672
2002	116,305	25,583	632,336	332,565	1,106,789
2003	96,782	26,336	665,238	343,297	1,131,654
2004	85,355	35,320	665,287	340,596	1,126,558
2005	86,159	22,429	616,715	336,175	1,061,479
2006	121,298	41,601	602,954	390,877	1,156,730
2007	120,344	33,387	599,832	304,208	1,057,770
2008	122,555	28,351	557,073	349,425	1,057,404
2009	88,148	33,703	619,872	293,770	1,035,493
2010	97,303	25,859	604,487	259,673	987,323
2011		35,471		346,716	382,188

4.11 Figures

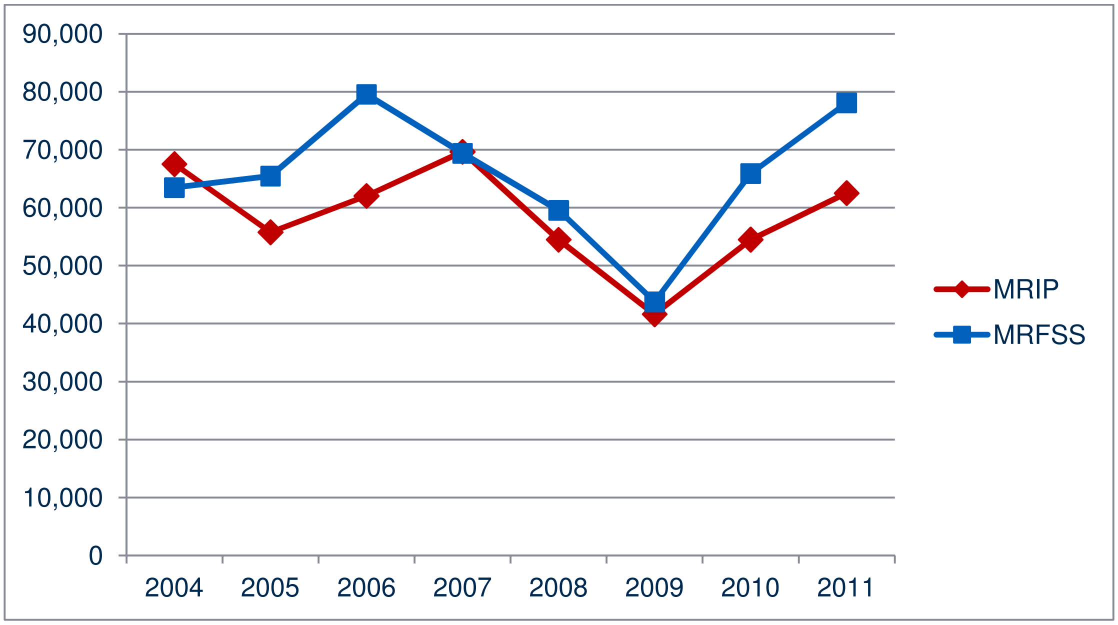


Figure 4.12.1. Comparison of MRIP and MRFSS landings (A+B1) for Gulf of Mexico cobia (FLE-LA).

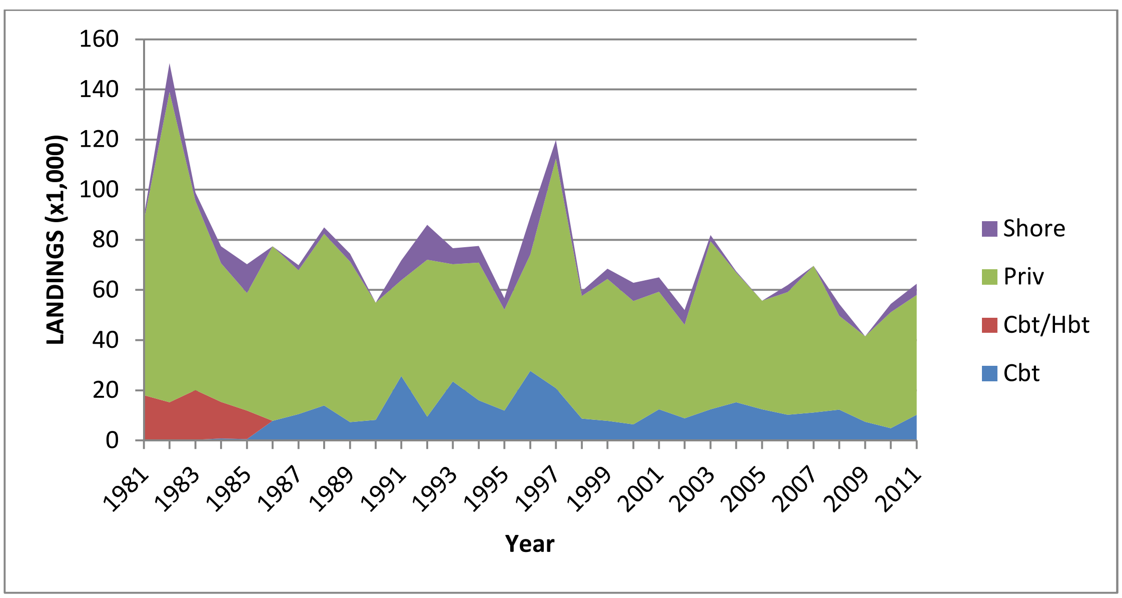


Figure 4.12.2. Gulf of Mexico (FLE-LA) cobia landings (numbers of fish) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2011). 2011 data is preliminary and through October.

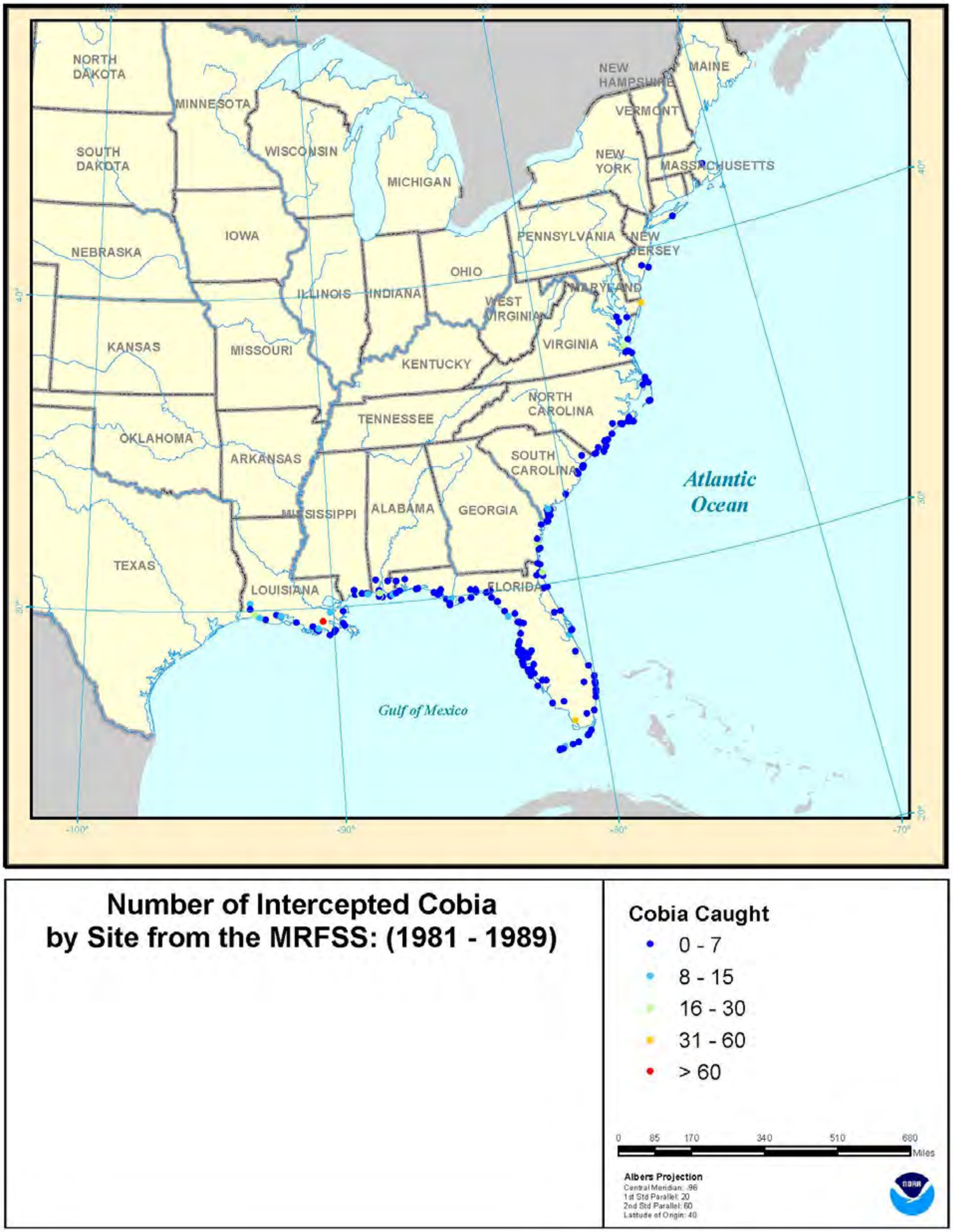


Figure 4.12.3. The number of cobia intercepted by the MRFSS from 1981-1989.

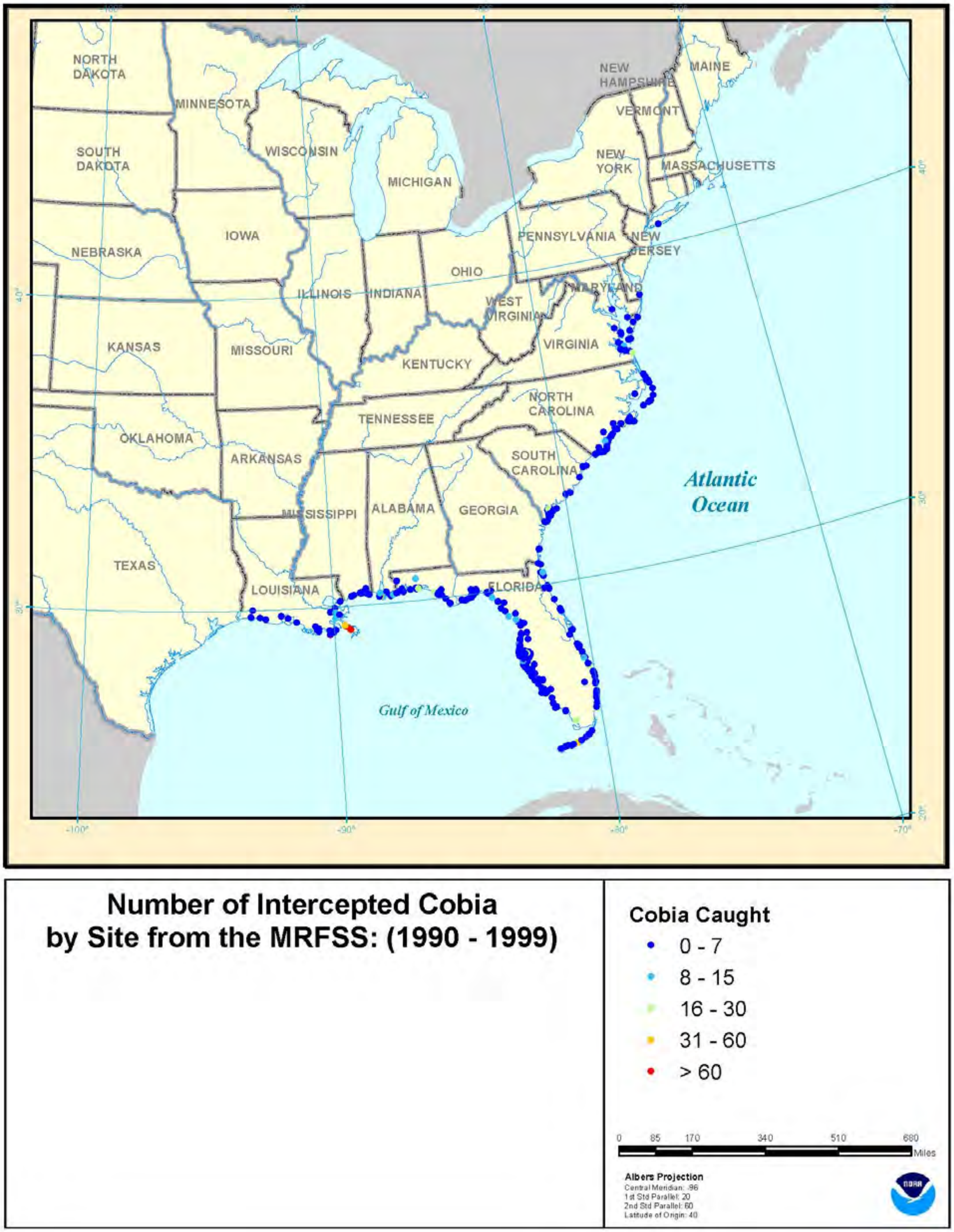


Figure 4.12.4. The number of cobia intercepted by the MRFSS from 1990-1999.

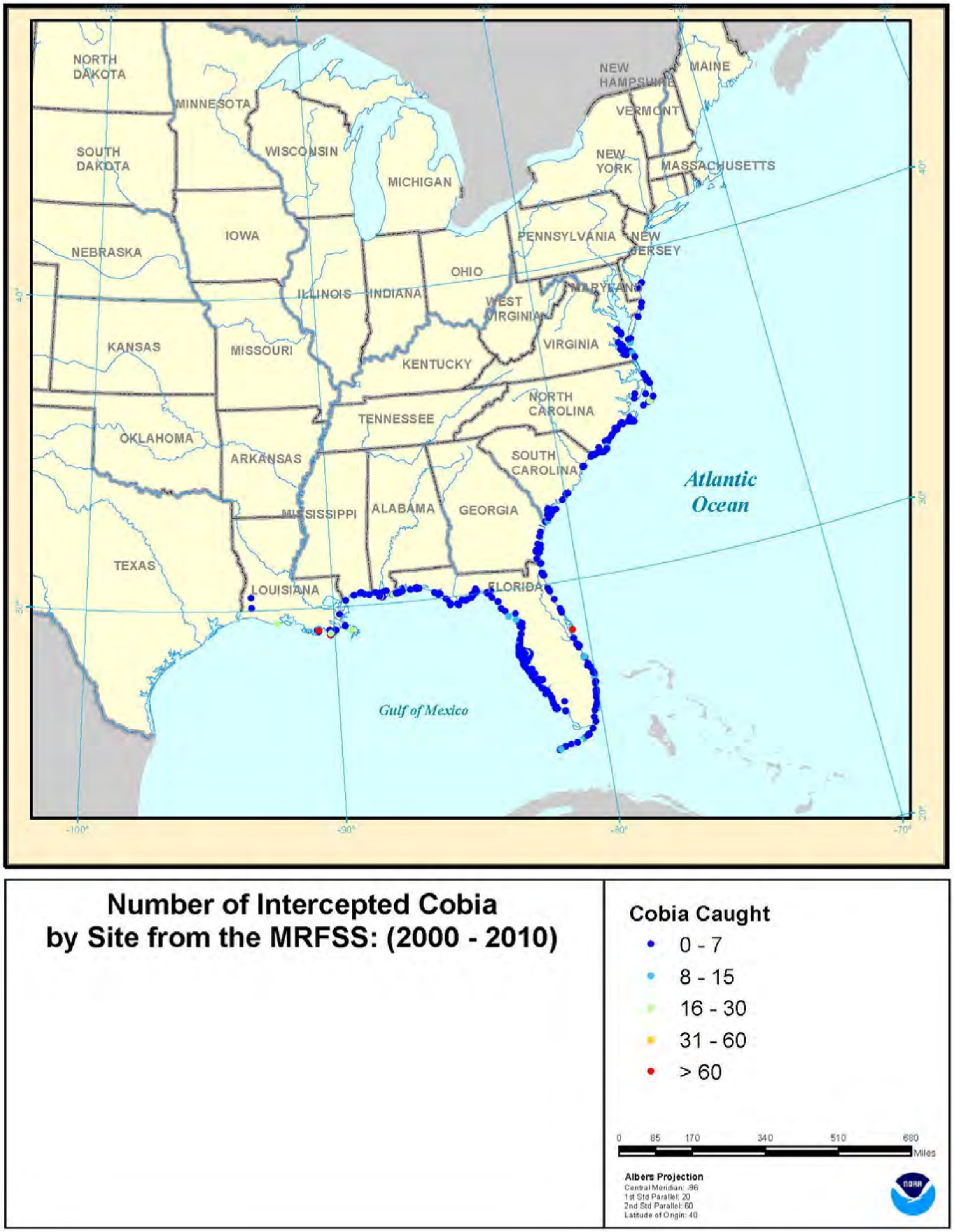


Figure 4.12.5. The number of cobia intercepted by the MRFSS from 2000-2010.

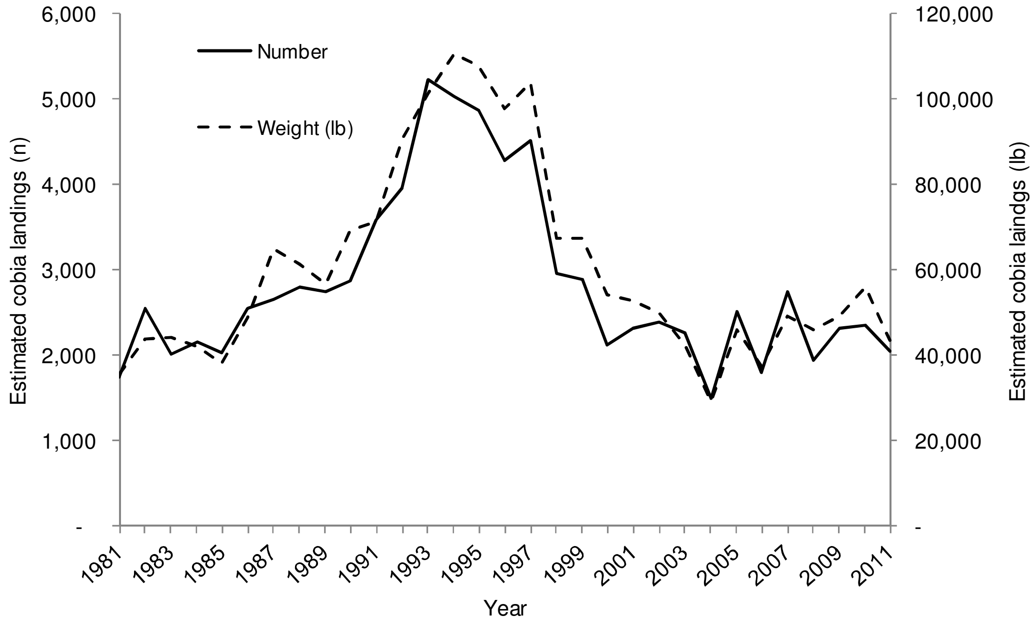


Figure 4.12.6. Gulf of Mexico estimated cobia landings (number and pounds) for the headboat fishery, 1981-2011.

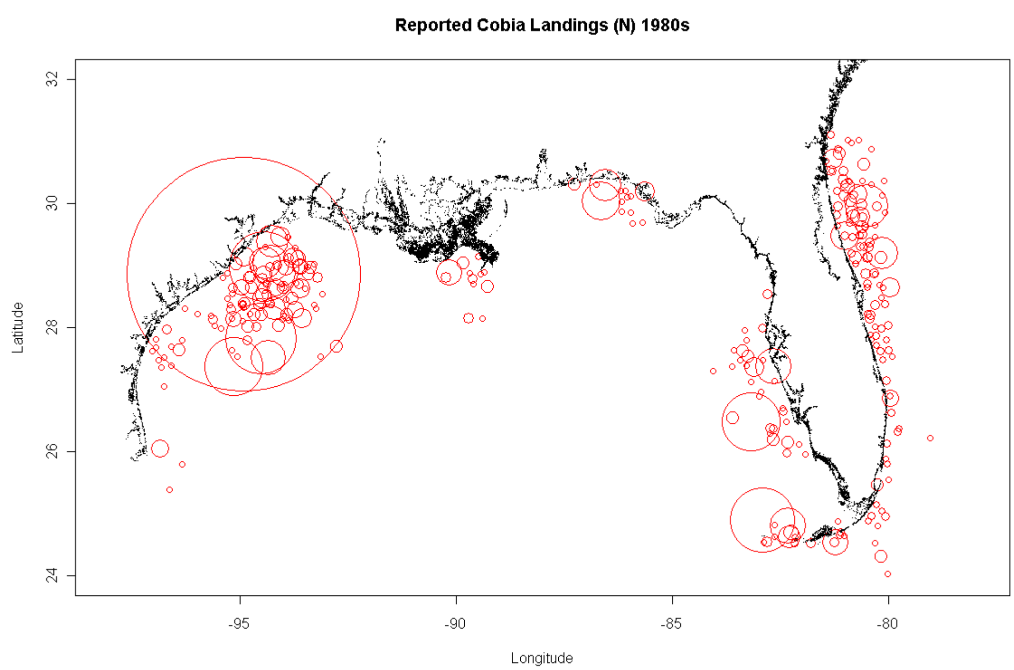


Figure 4.12.7. Reported cobia landings (numbers of fish) from SRHS, 1981-1989. The size of each point is proportional to the reported landings (N) at the given location.

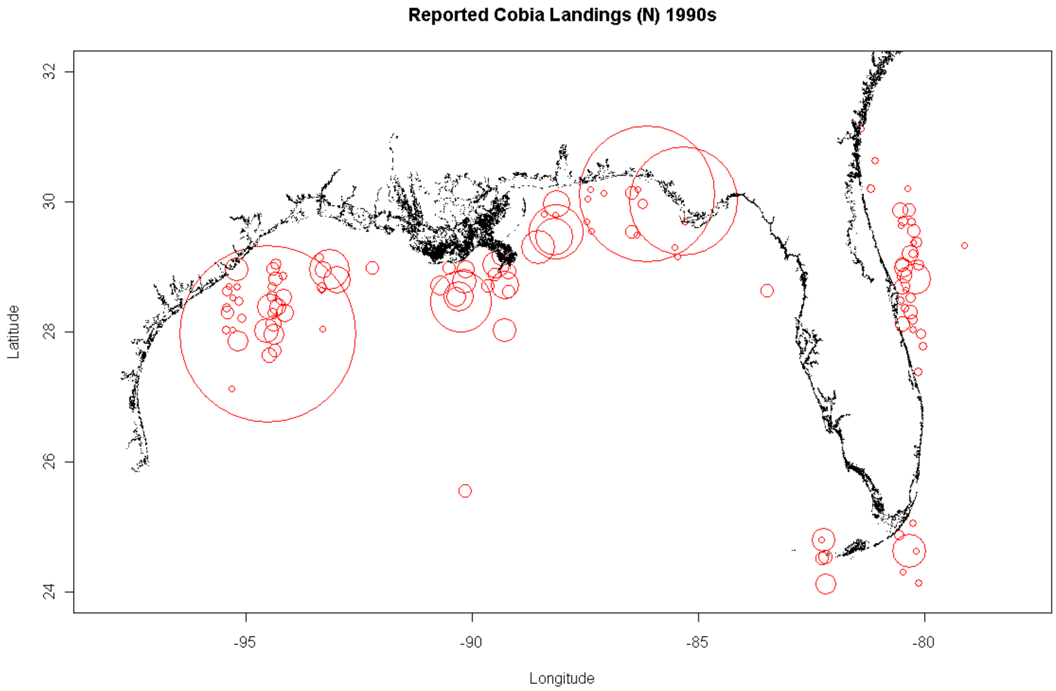


Figure 4.12.8. Reported cobia landings (numbers of fish) from SRHS, 1990-1999. The size of each point is proportional to the reported landings (N) at the given location.

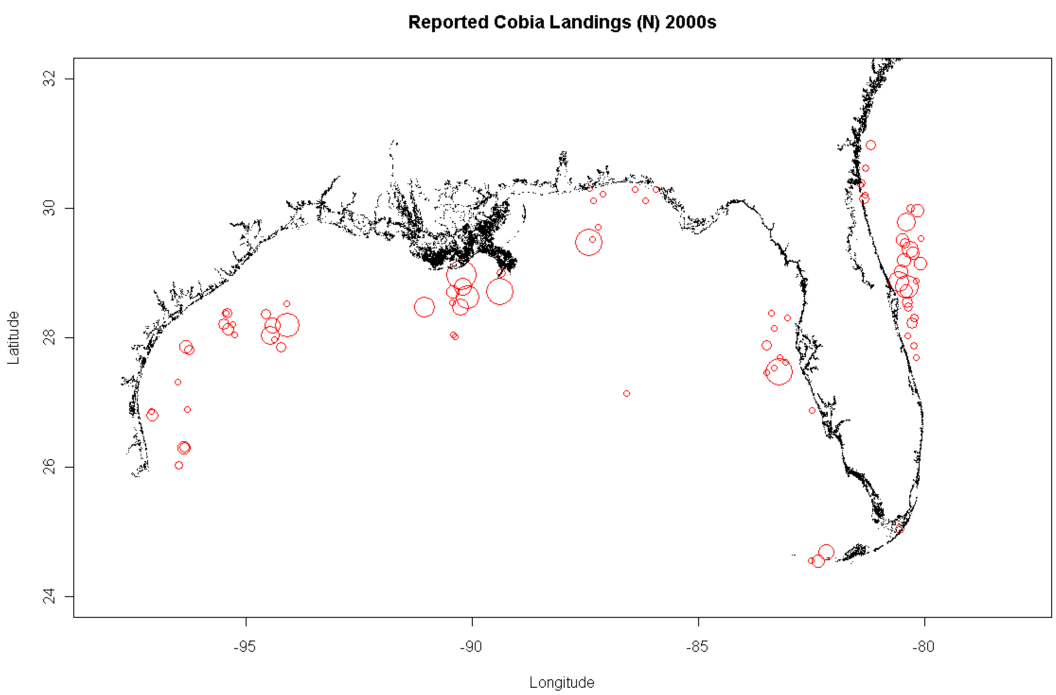


Figure 4.12.9. Reported cobia landings (numbers of fish) from SRHS, 2000-2011. The size of each point is proportional to the reported landings (N) at the given location.

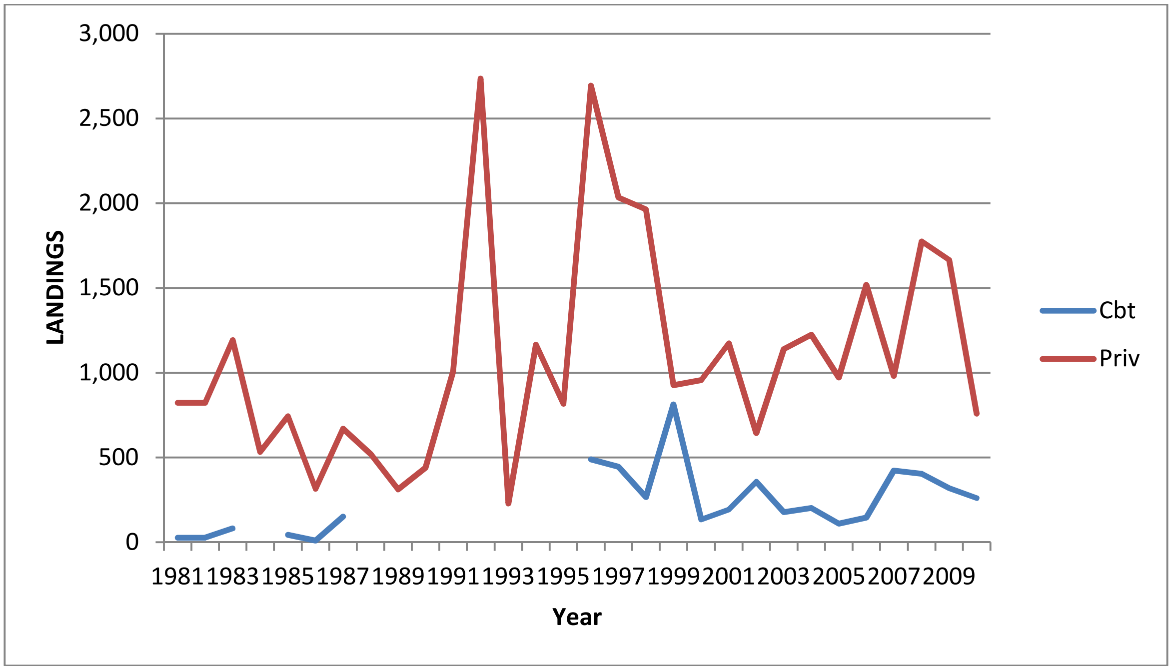


Figure 4.12.10 Texas cobia landings (numbers of fish) for charter boat mode and private mode (TPWD). 2011 data is through mid-May.

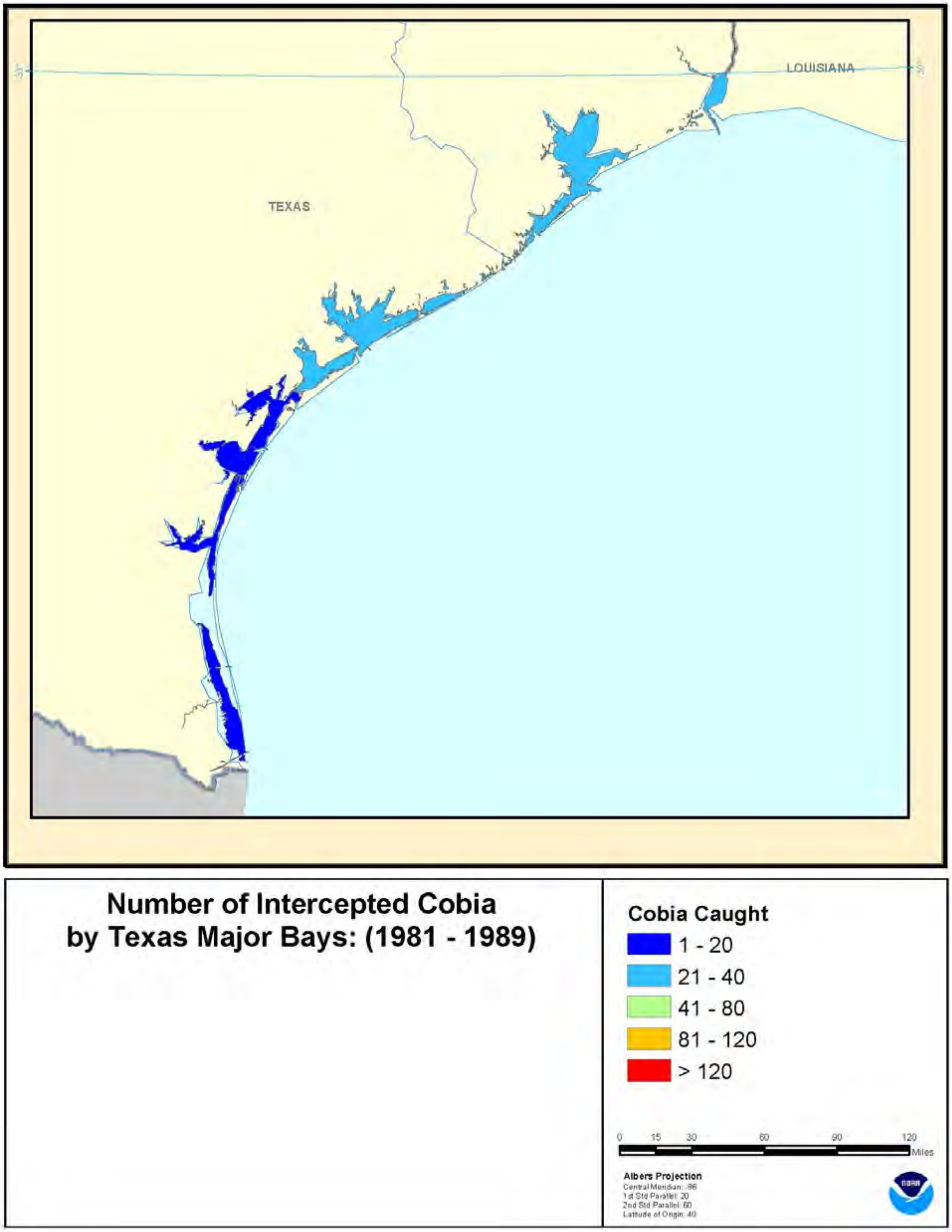


Figure 4.12.11. The number of cobia intercepted by the TPWD from 1983-1989.

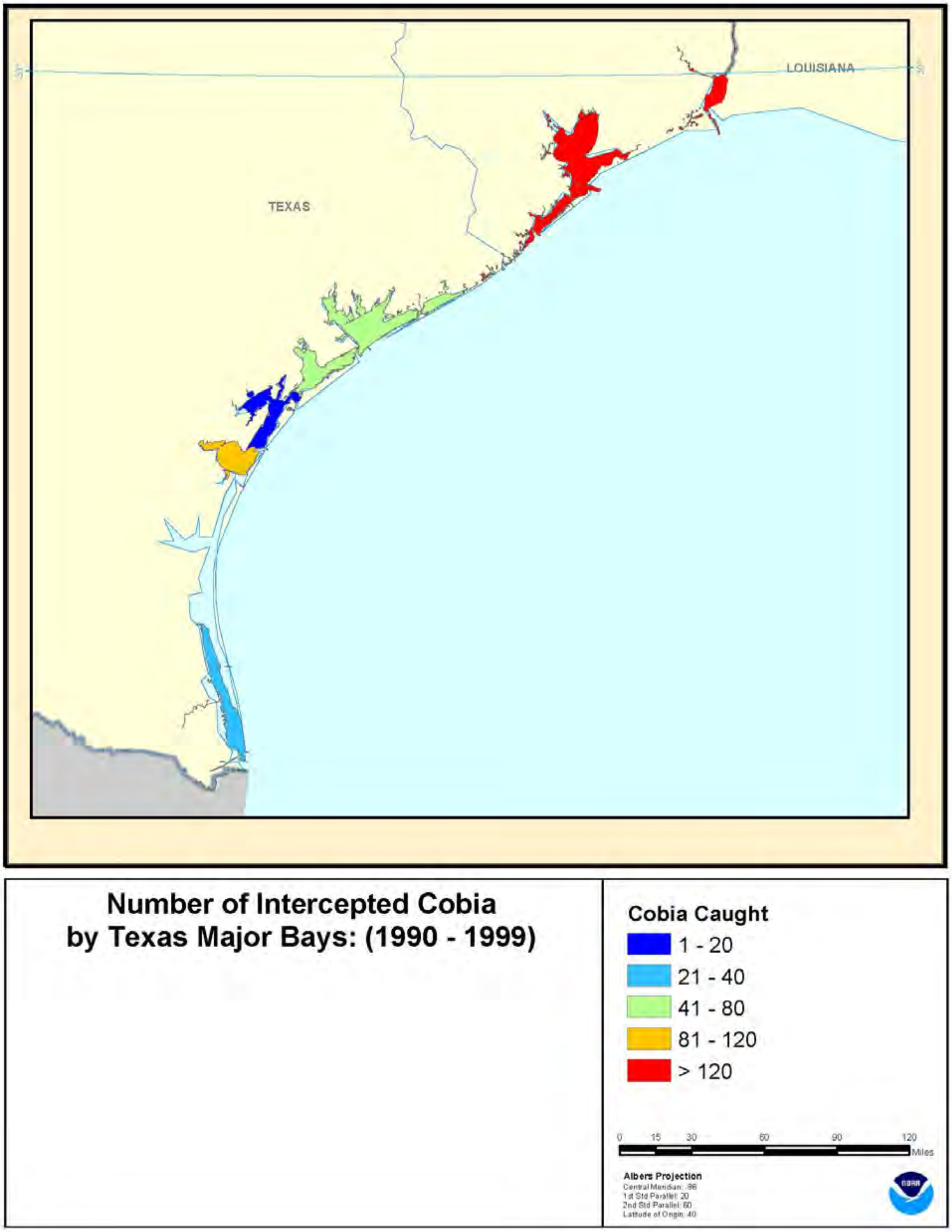


Figure 4.12.12. The number of cobia intercepted by the TPWD from 1990-1999.

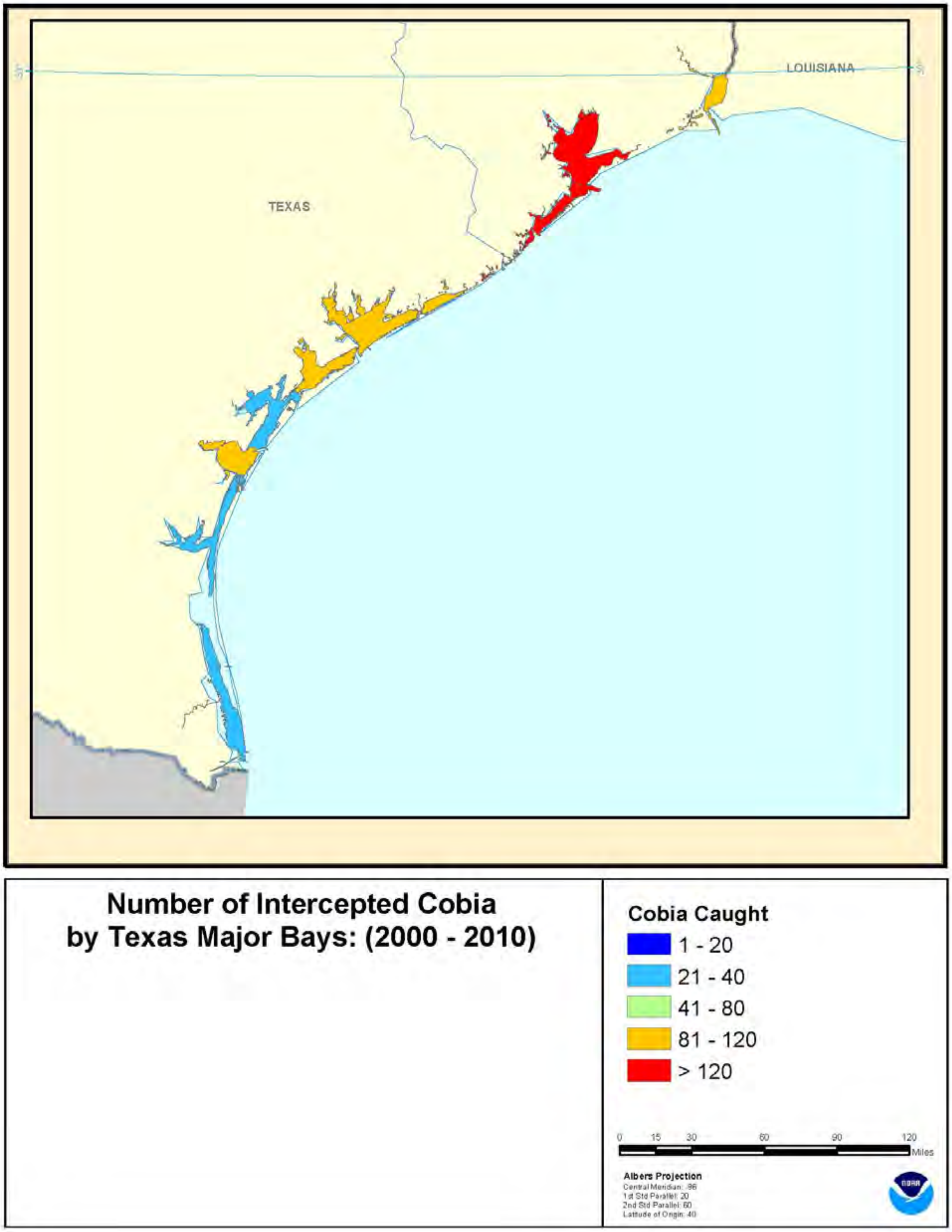


Figure 4.12.13. The number of cobia intercepted by the TPWD from 2000-2010.

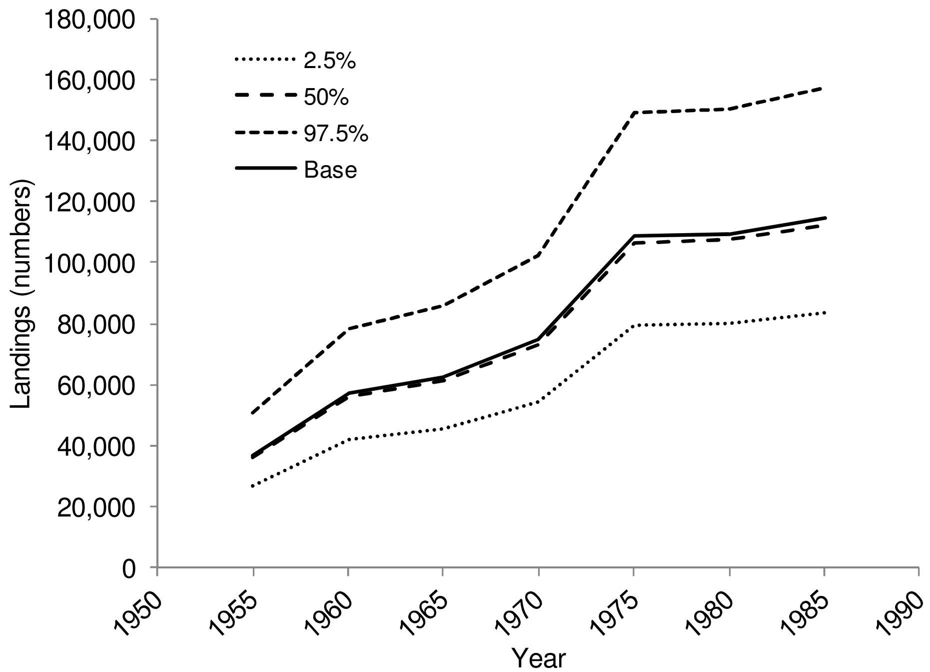


Figure 4.12.14. Bootstrap analysis of FHWAR census method (1955-1984) cobia landings estimates.

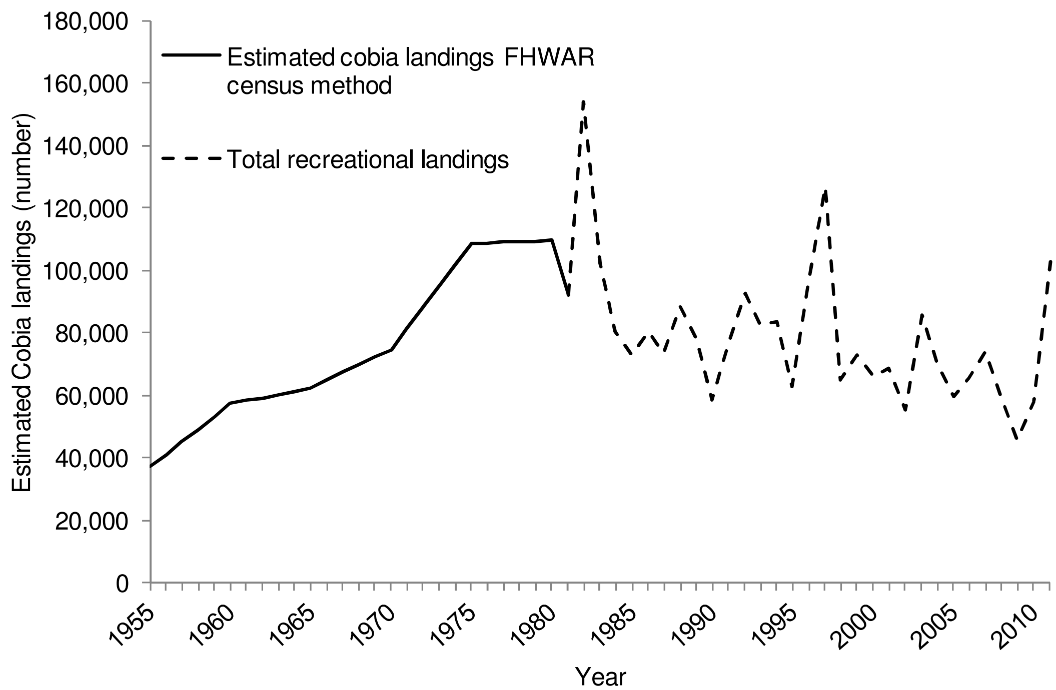


Figure 4.12.15. Estimated cobia landings (number) using FHWAR census method (1955-1980), MRFSS (1981-2003), MRIP (2004-2011), TPWD (81-11), and SRHS (81-11) estimation methods.

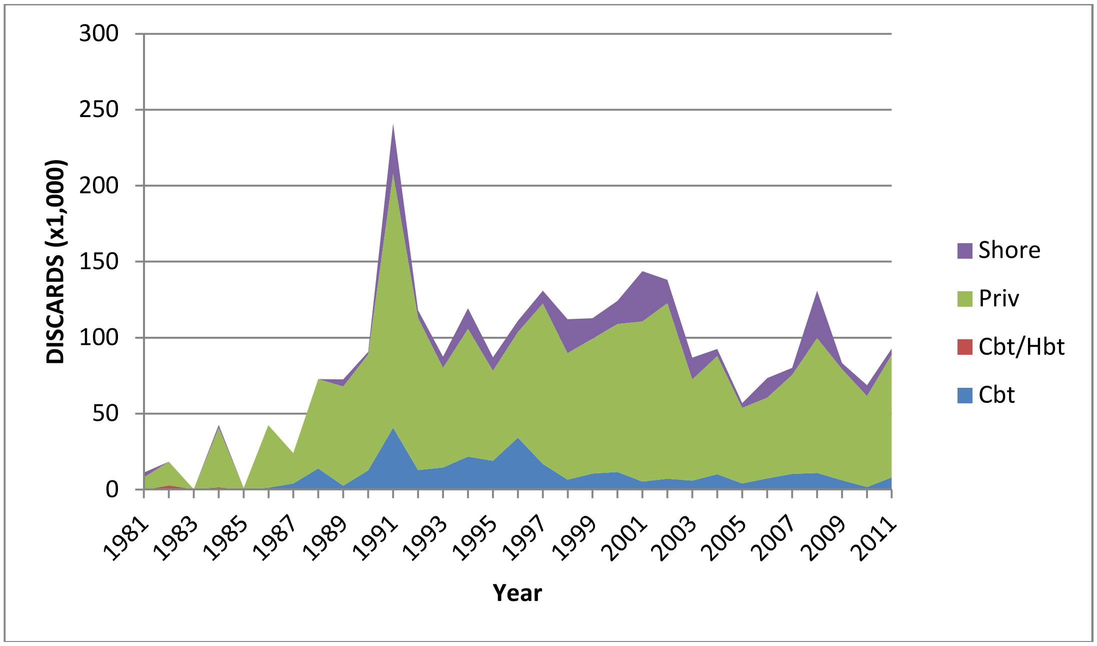


Figure 4.12.16. Gulf of Mexico (FLE-TX) cobia discards (numbers of fish) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2011). 2011 data is preliminary and through October. TX estimates for 1981-1985 shore mode only.

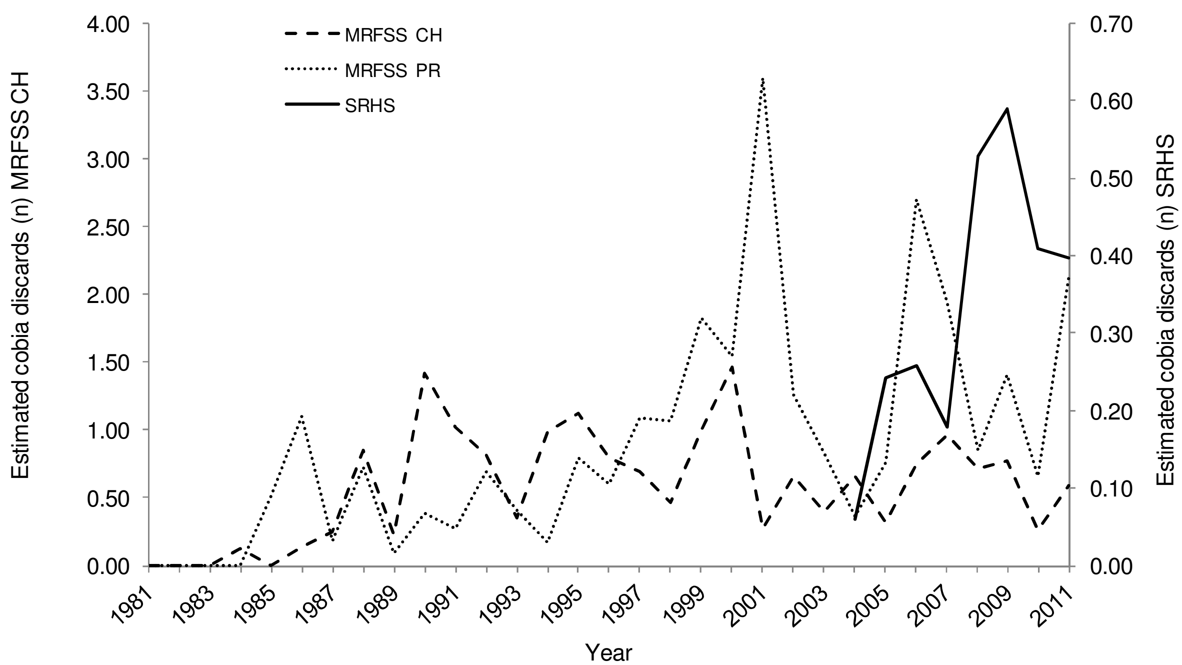


Figure 4.12.17. Percentage of cobia discards in the recreational fishery, 1981-2011.

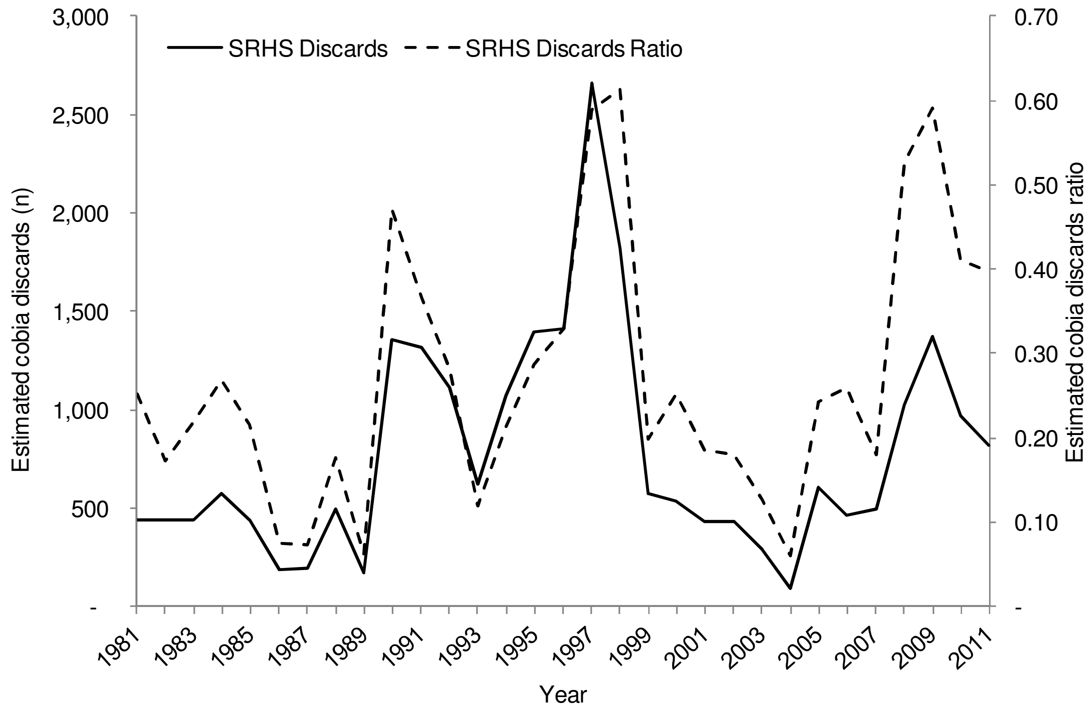


Figure 4.12.18. Gulf of Mexico estimated cobia discards and discard ratio for the headboat fishery (MRFSS proxy 1981-2003; SRHS 2004-2011).

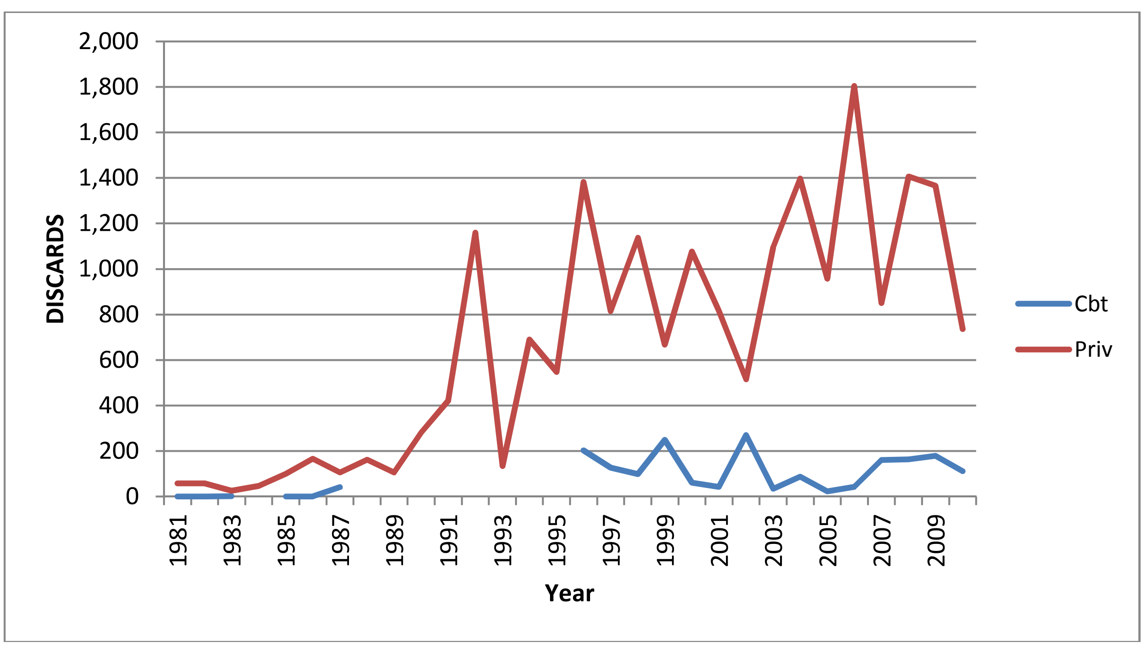


Figure 4.12.19 Texas cobia discards (numbers of fish) for charter boat mode and private mode (TPWD). 2011 data is through mid-May.

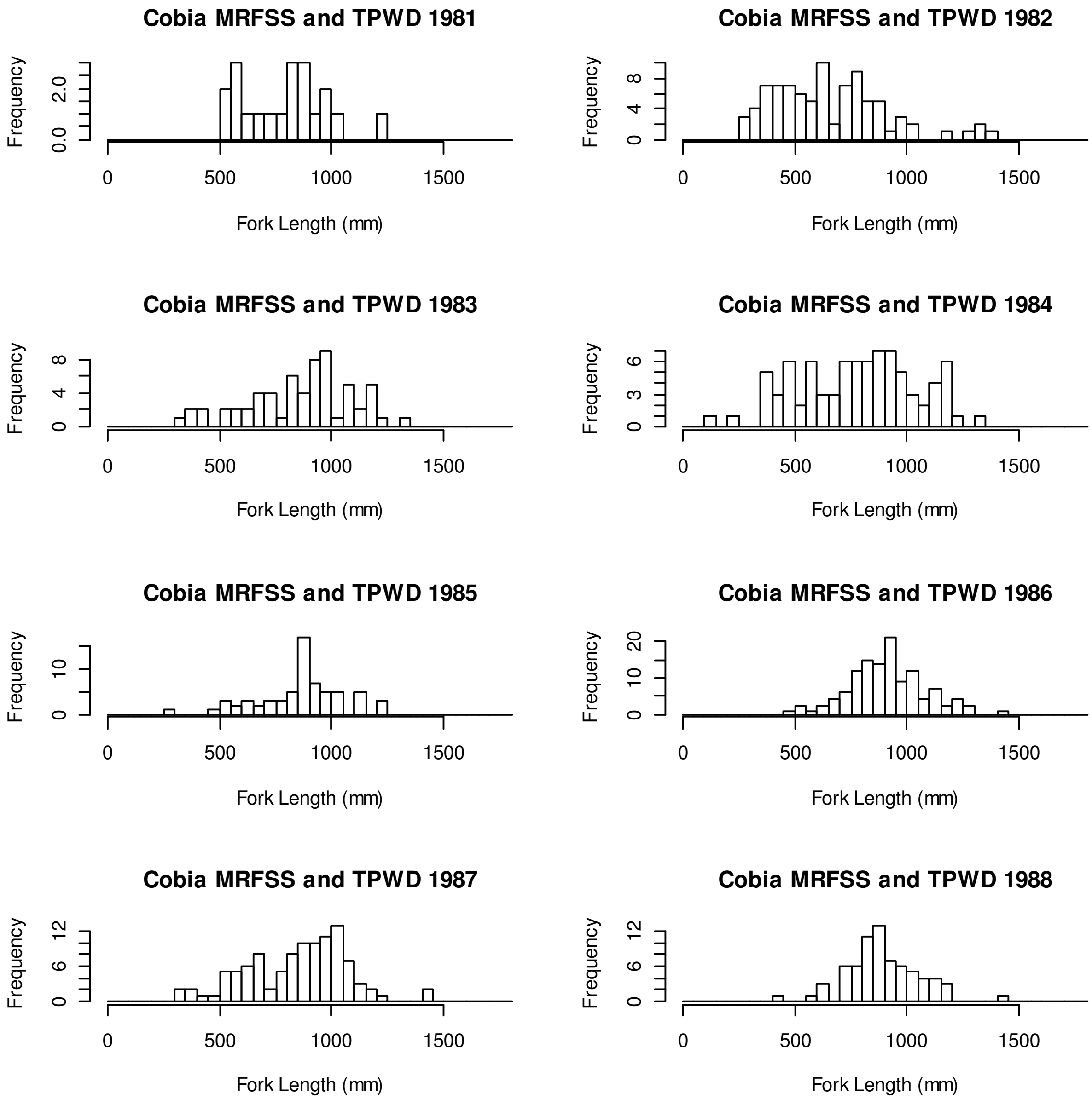


Figure 4.12.20. Length composition from the MRFSS (1981-2011) and TPWD (1983-2011).

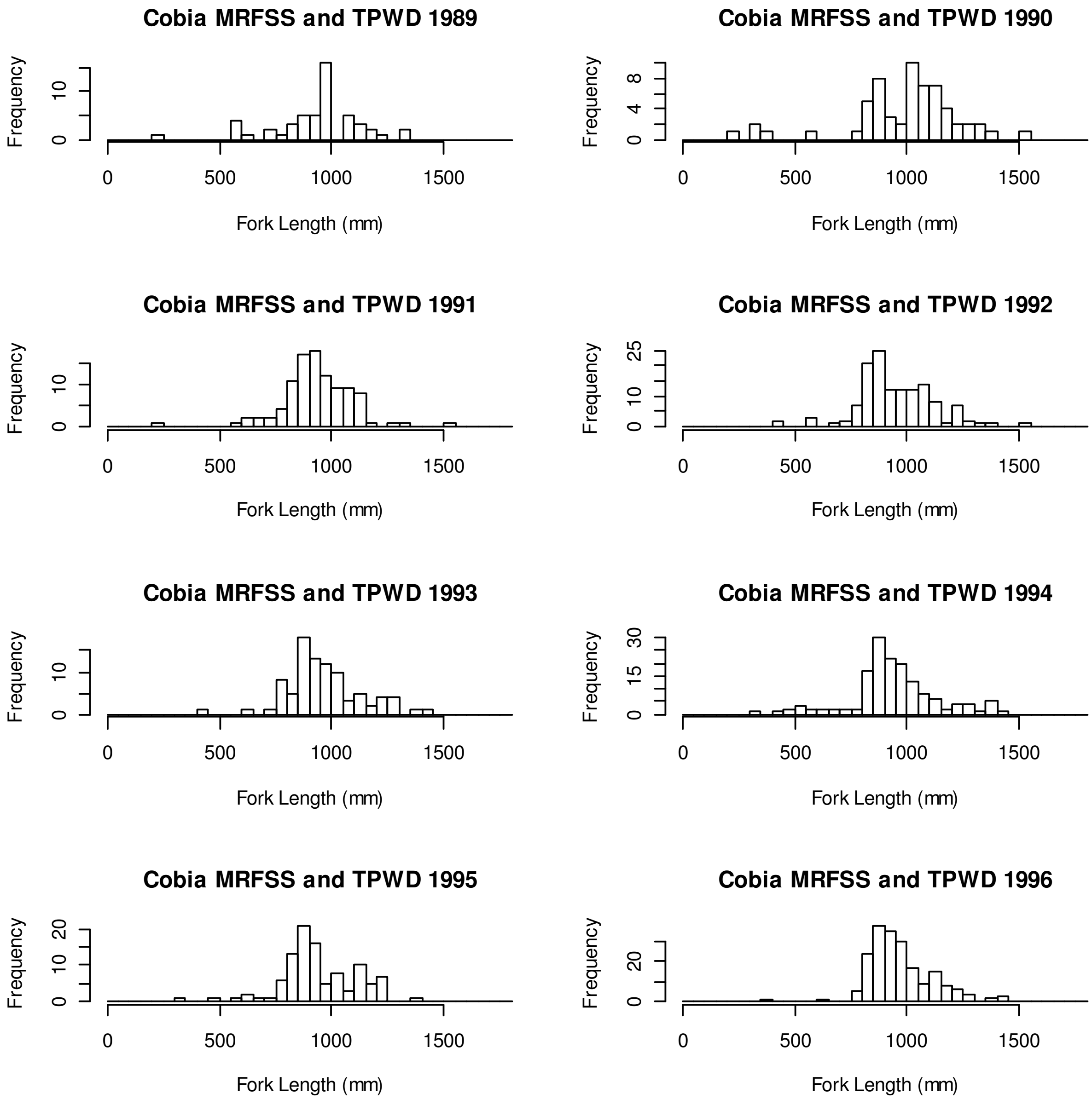


Figure 4.12.20. Length composition from the MRFSS (1981-2011) and TPWD (1983-2011) (continued).

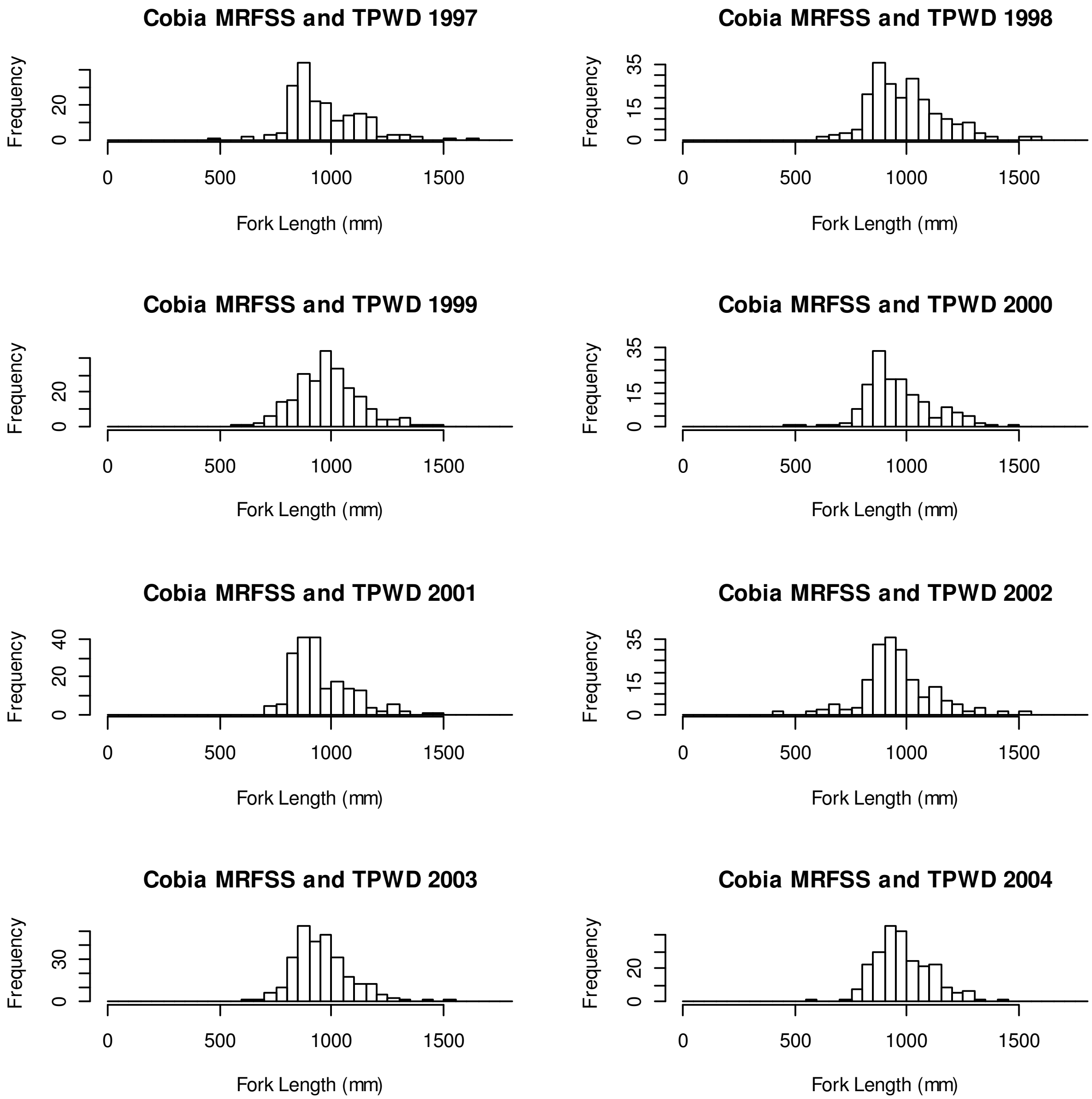


Figure 4.12.20. Length composition from the MRFSS (1981-2011) and TPWD (1983-2011) (continued).

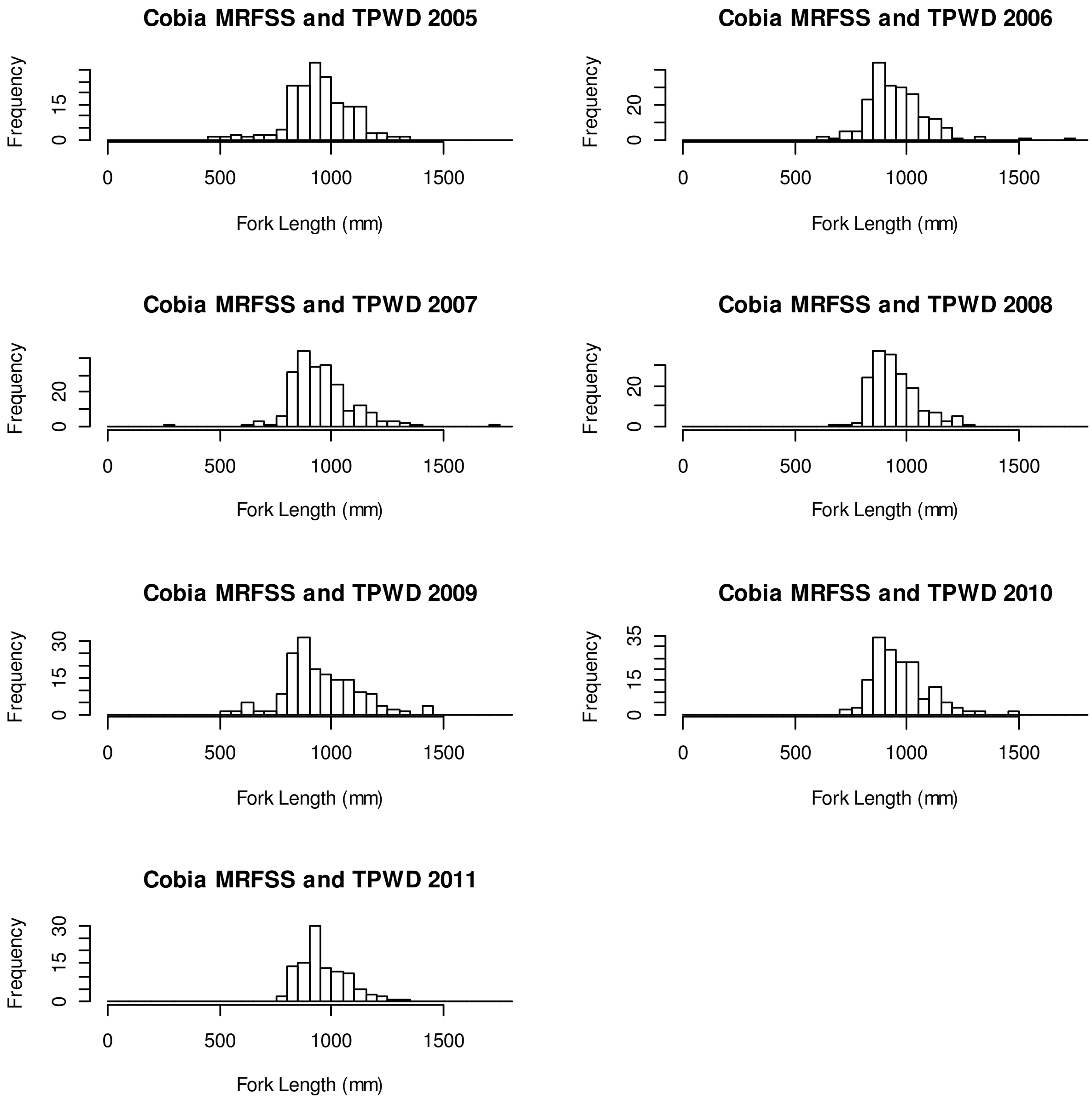


Figure 4.12.20. Length composition from the MRFSS (1981-2011) and TPWD (1983-2011) (continued).

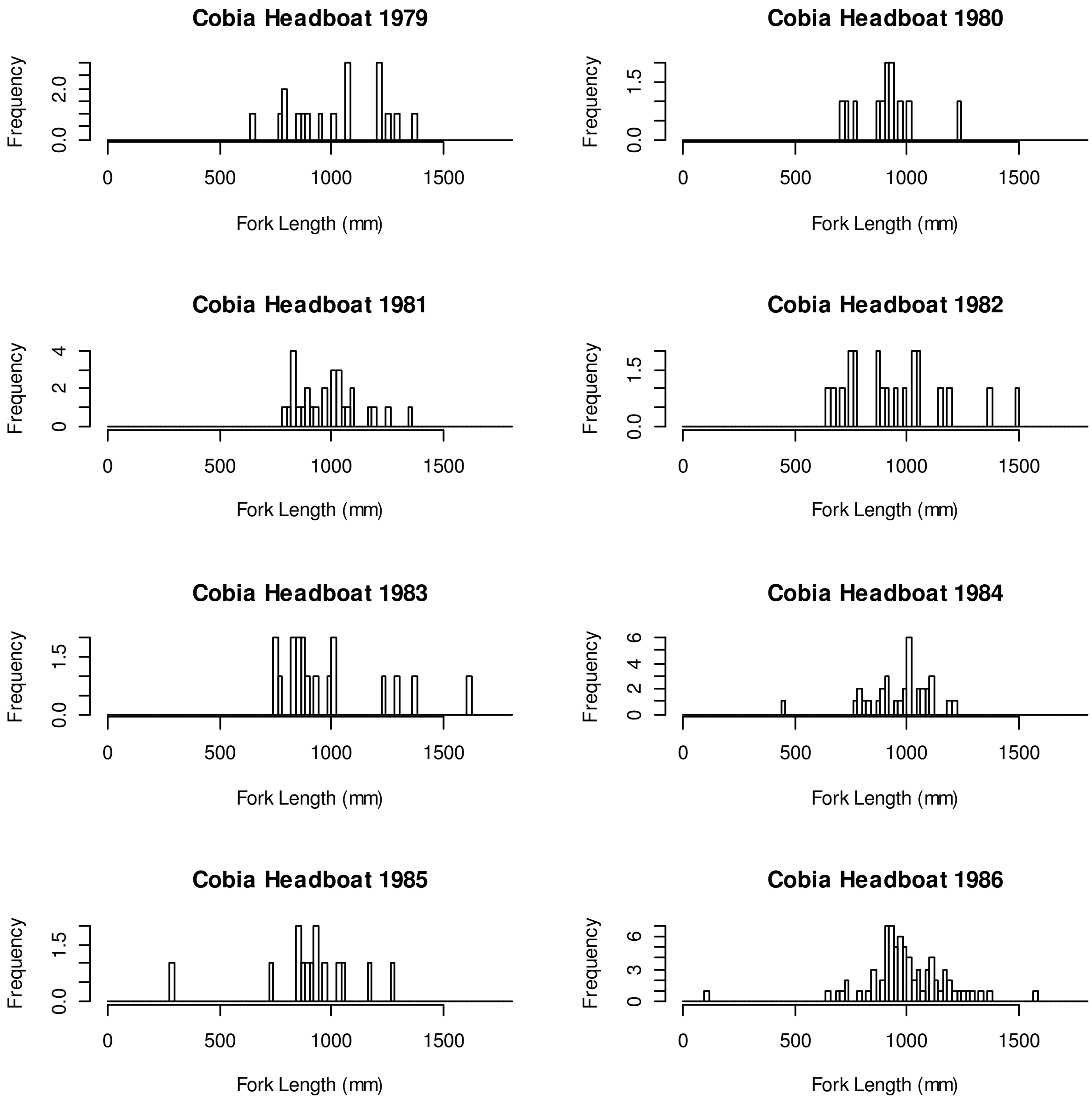


Figure 4.12.21. Headboat length composition 1979-2011 (1979-1985 lengths from East Florida).

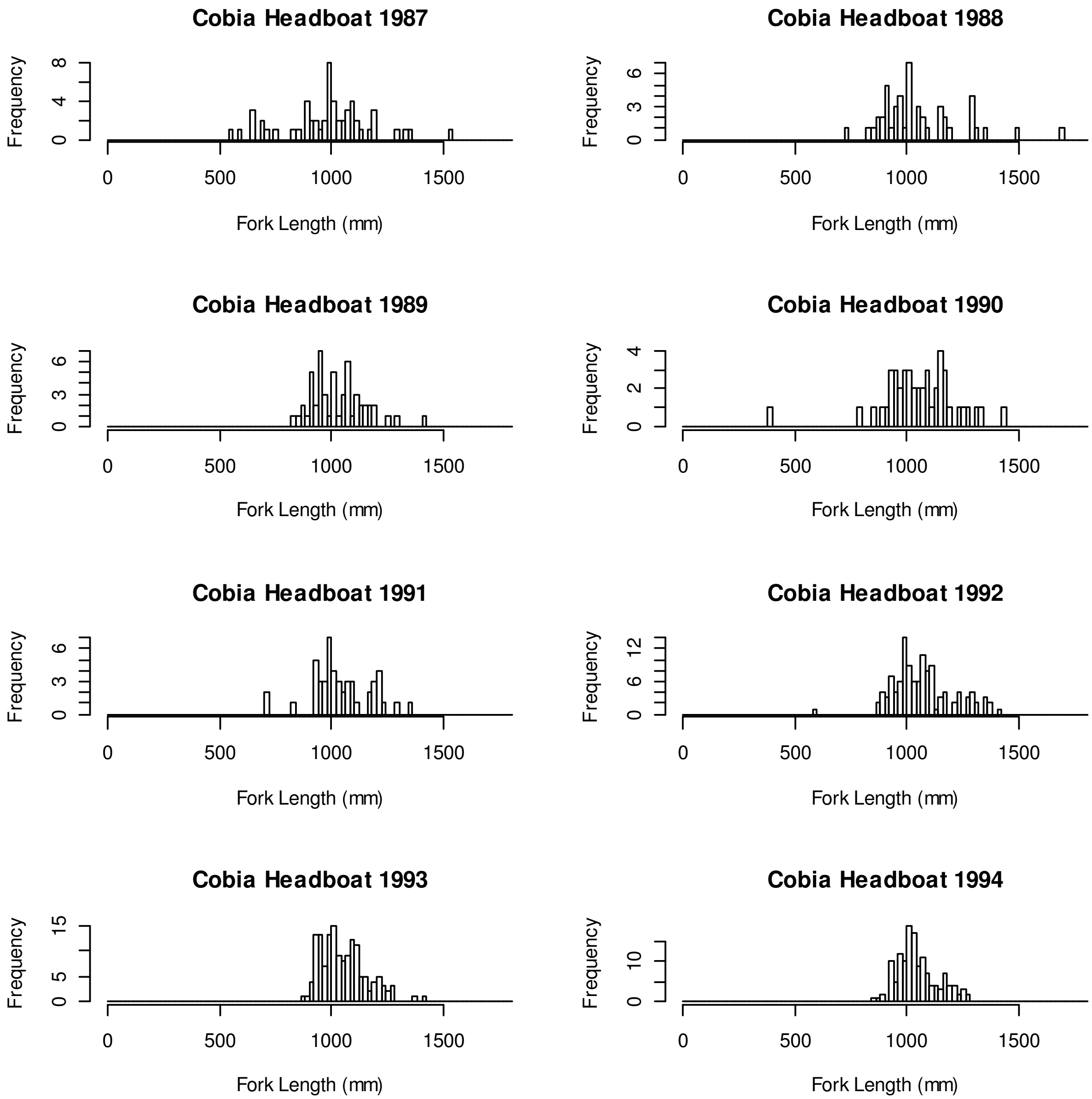


Figure 4.12.21. Headboat length composition 1979-2011 (1979-1985 lengths from East Florida). (Continued).

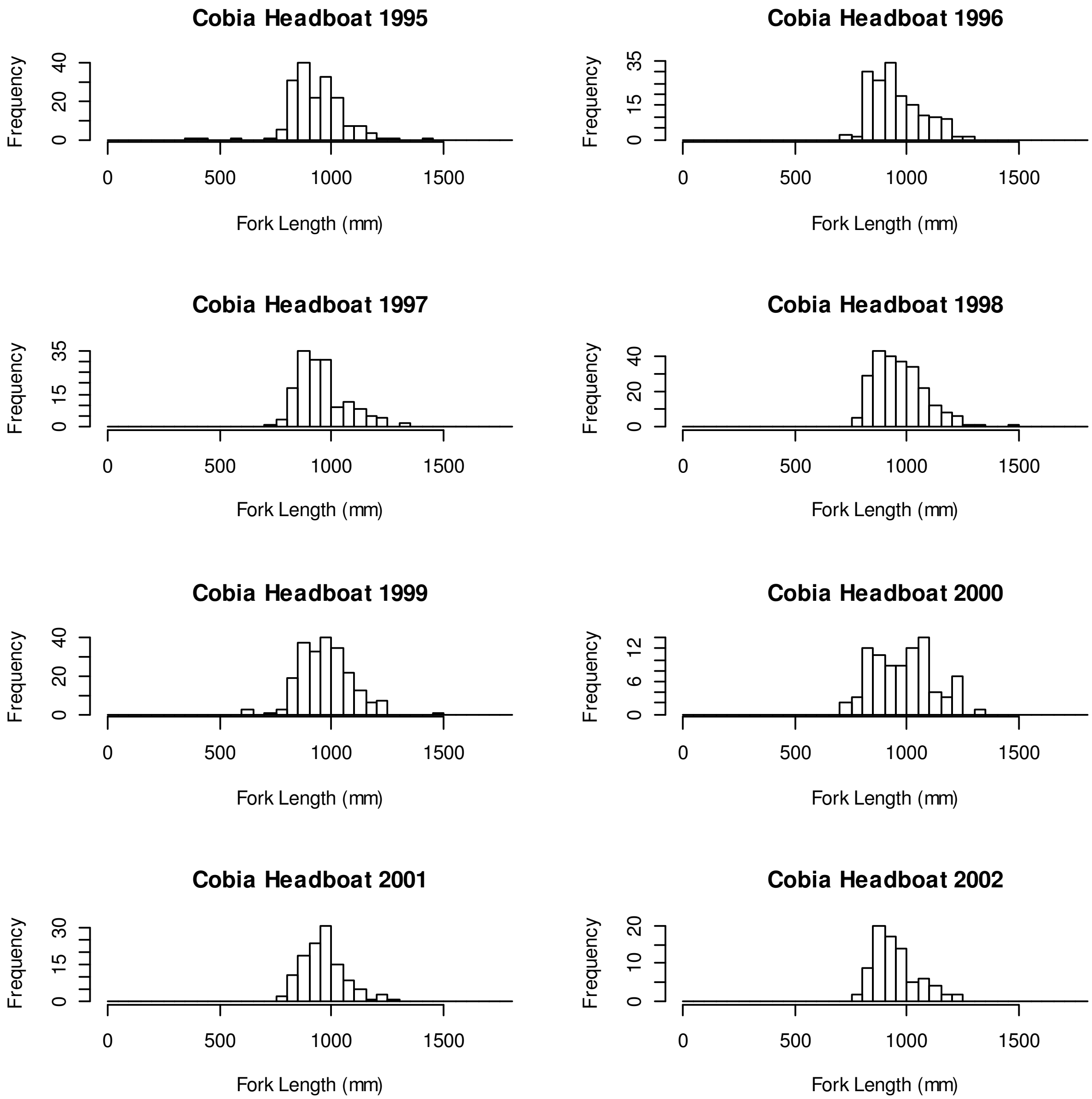


Figure 4.12.21. Headboat length composition 1979-2011 (1979-1985 lengths from East Florida). (Continued).

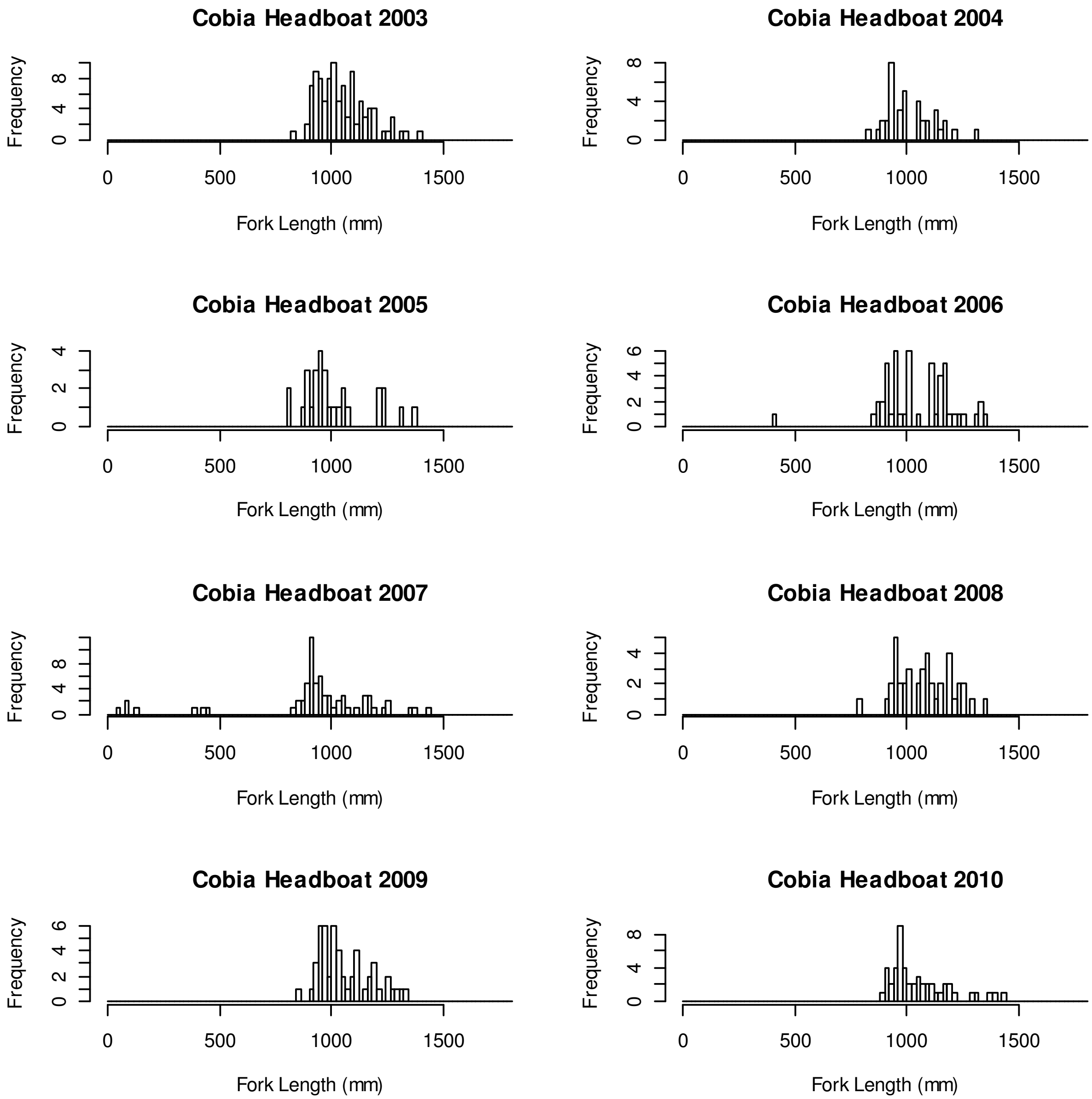


Figure 4.12.21. Headboat length composition 1979-2011 (1979-1985 lengths from East Florida). (Continued).

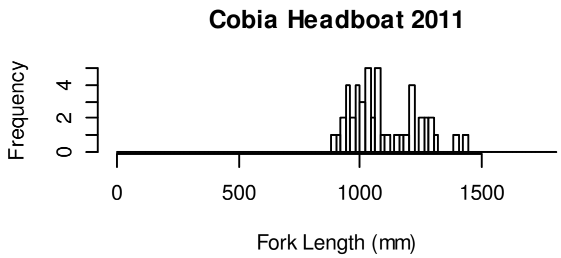


Figure 4.12.21. Headboat length composition 1979-2011 (1979-1985 lengths from East Florida). (Continued).

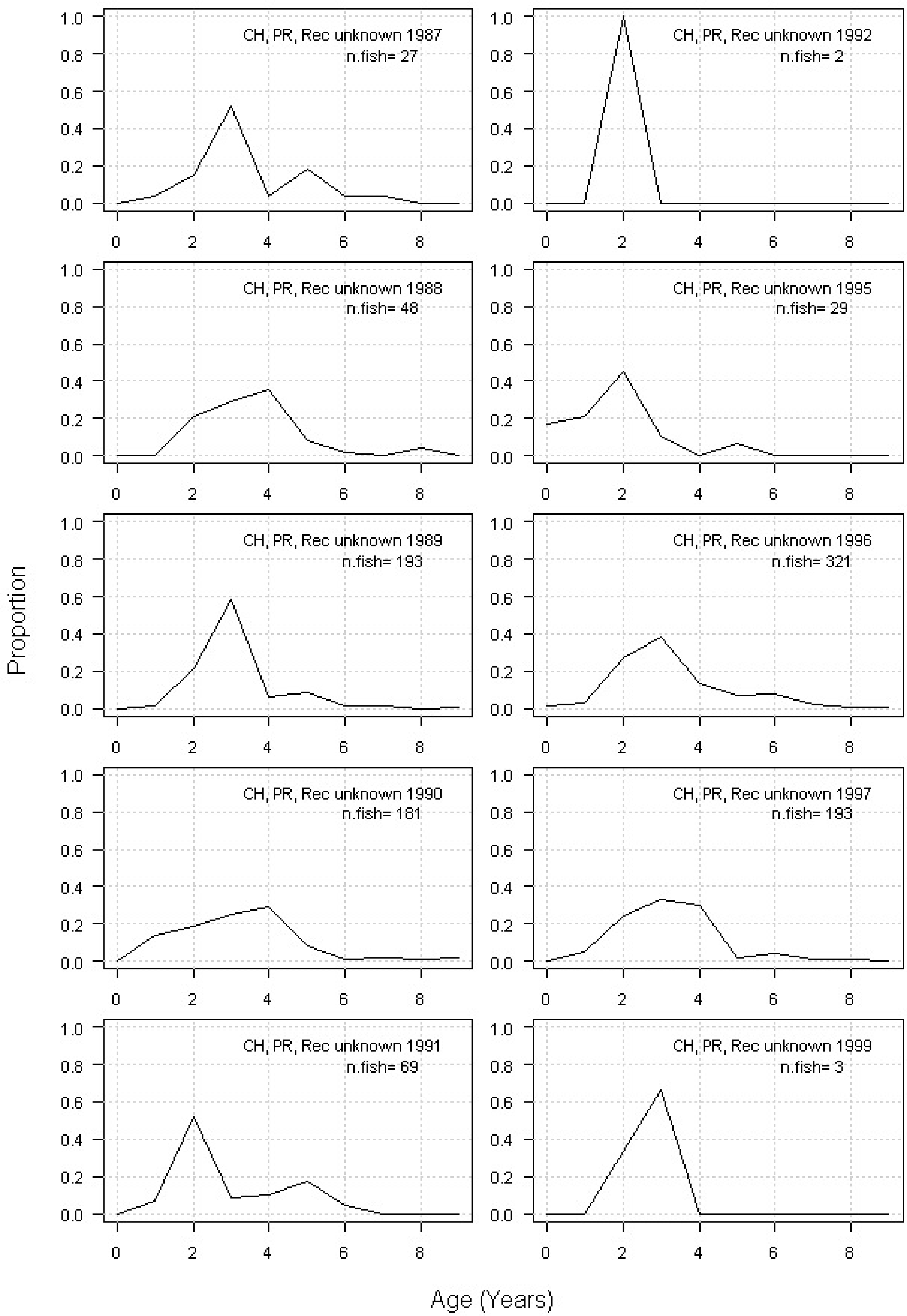


Figure 4.12.22. Age composition of cobia from the charter boat, private/rental boat, recreational fishery (mode unknown) (1987-1992, 1995-1999, 2004-2010).

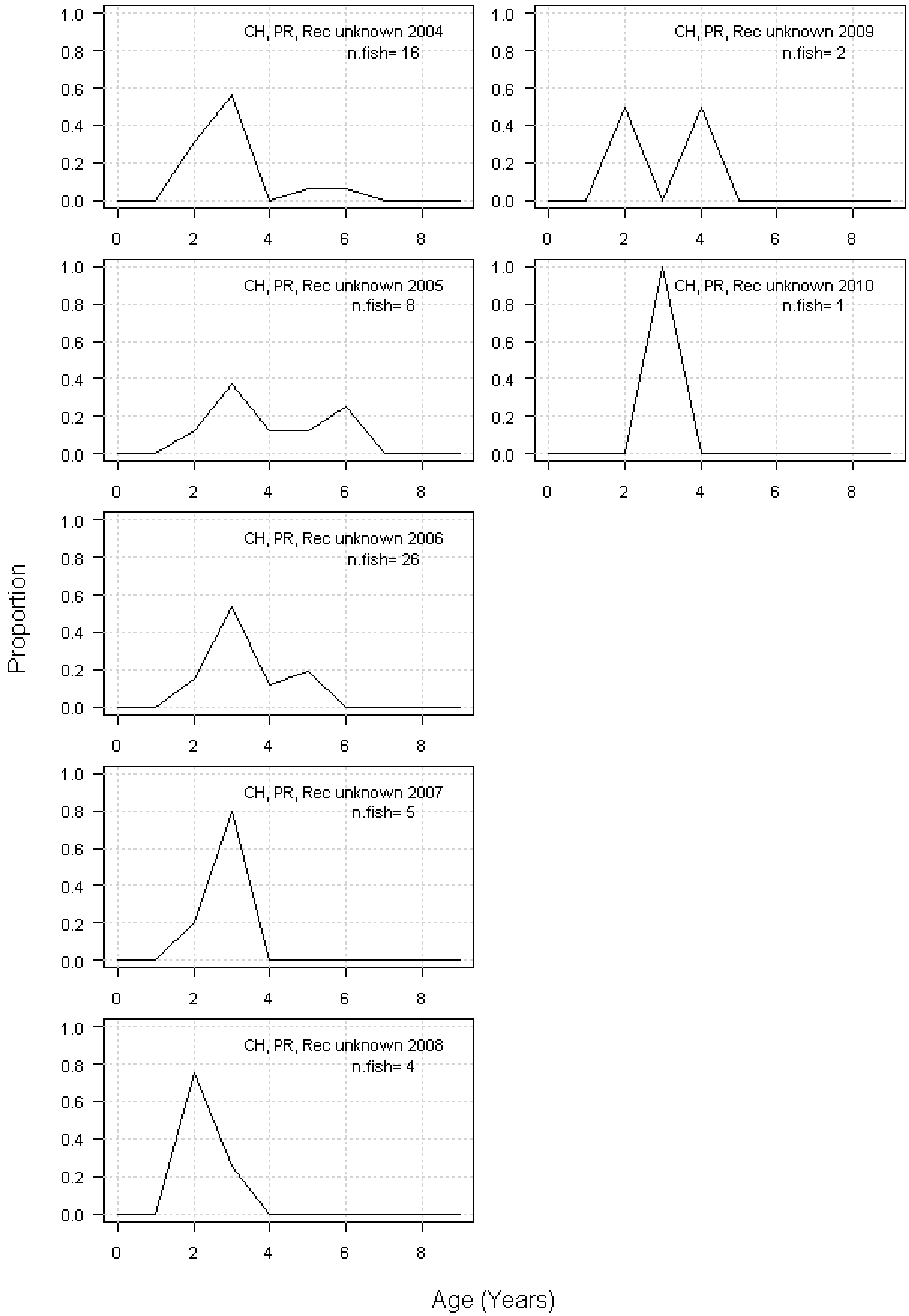


Figure 4.12.22. Age composition of cobia from the charter boat, private/rental boat, recreational fishery (mode unknown) (1987-1992, 1995-1999, 2004-2010) (continued).

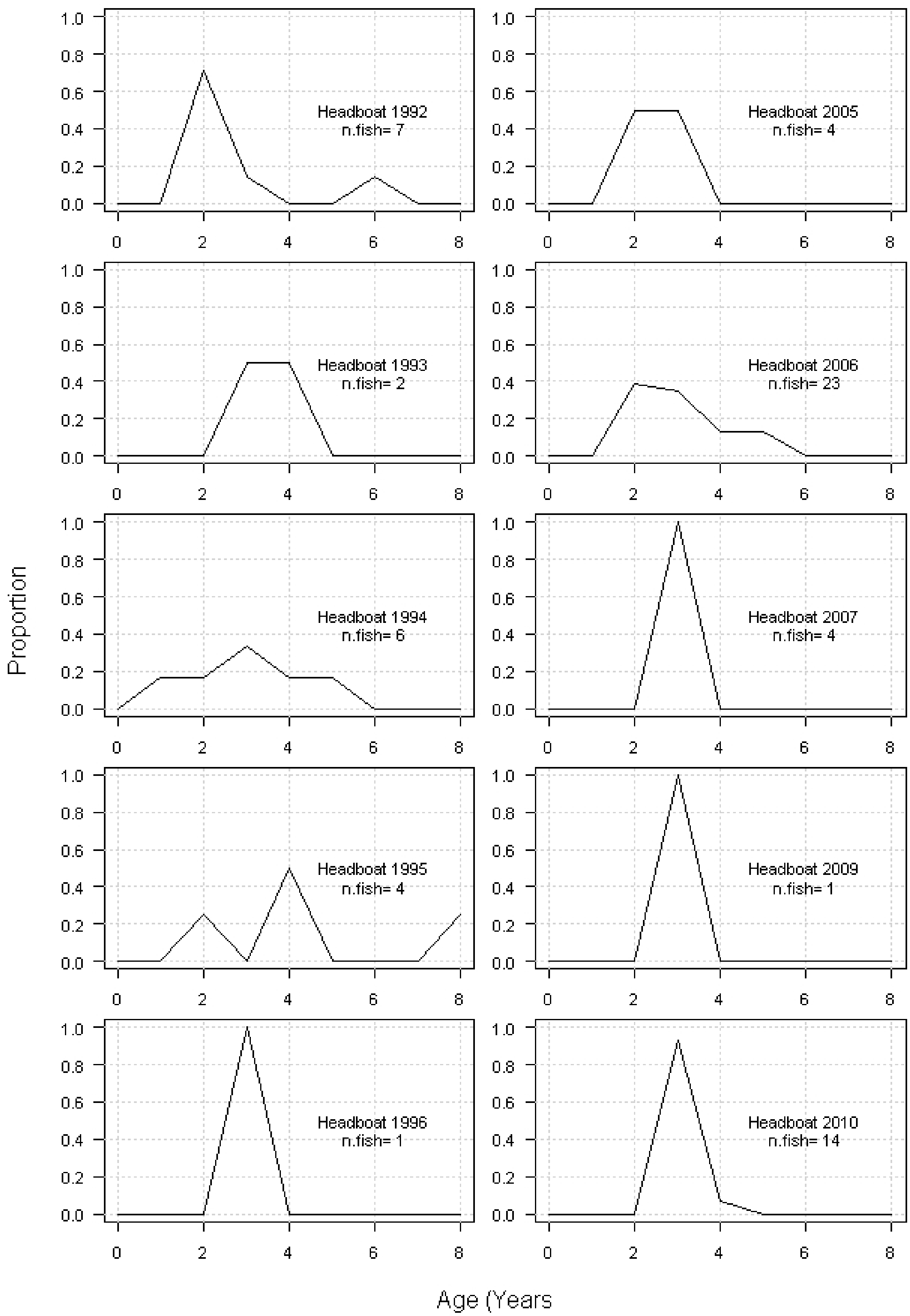


Figure 4.12.23. Age composition of cobia from the headboat fishery (1992-1996, 2005-2007, 2009-2011).

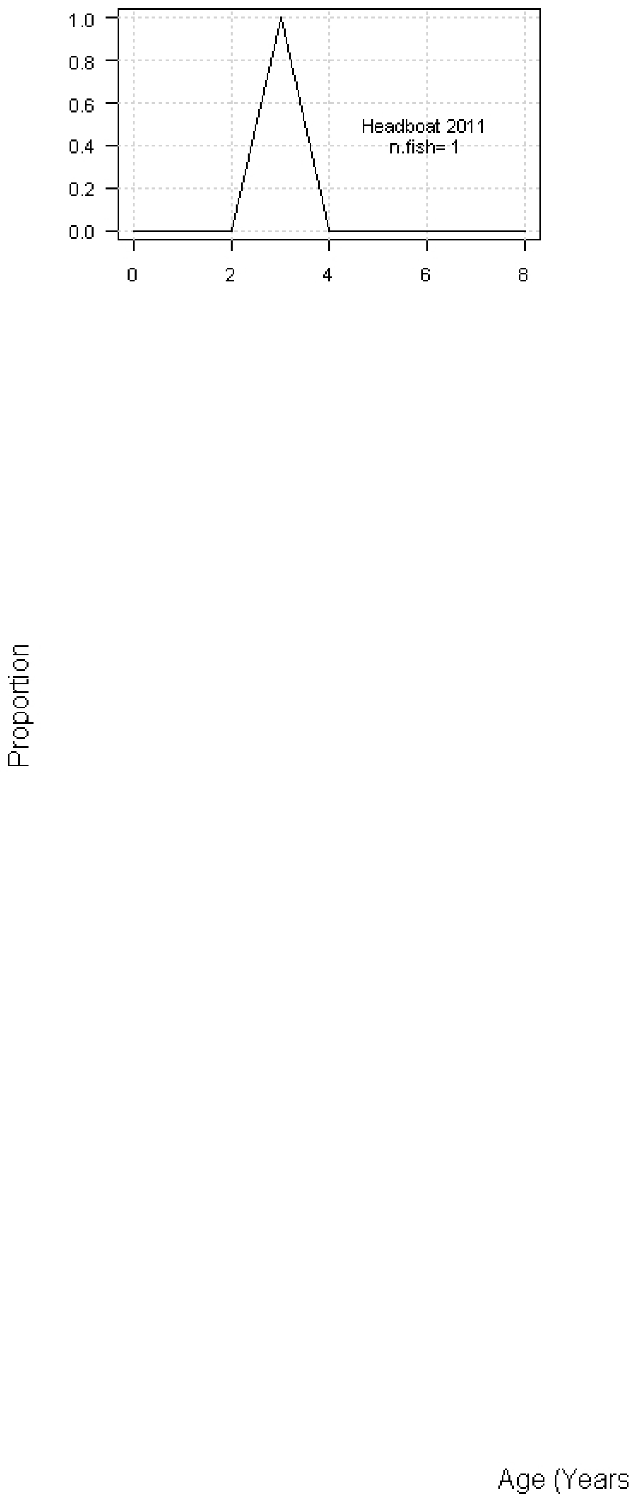


Figure 4.12.23. Age composition of cobia from the headboat fishery (1992-1996, 2005-2007, 2009-2011) (continued).

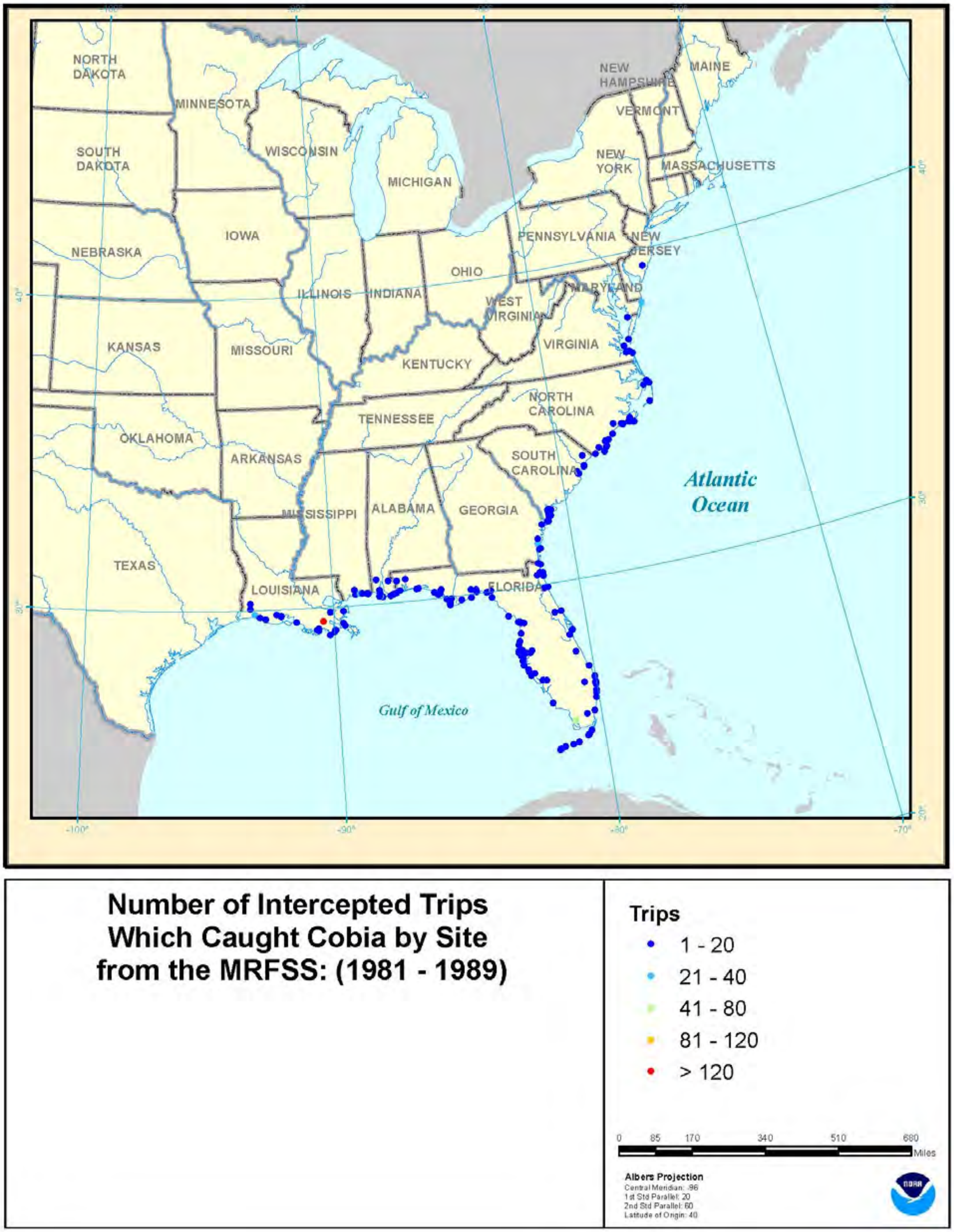


Figure 4.12.24. The number MRFSS intercepted trips which caught cobia from 1981-1989.

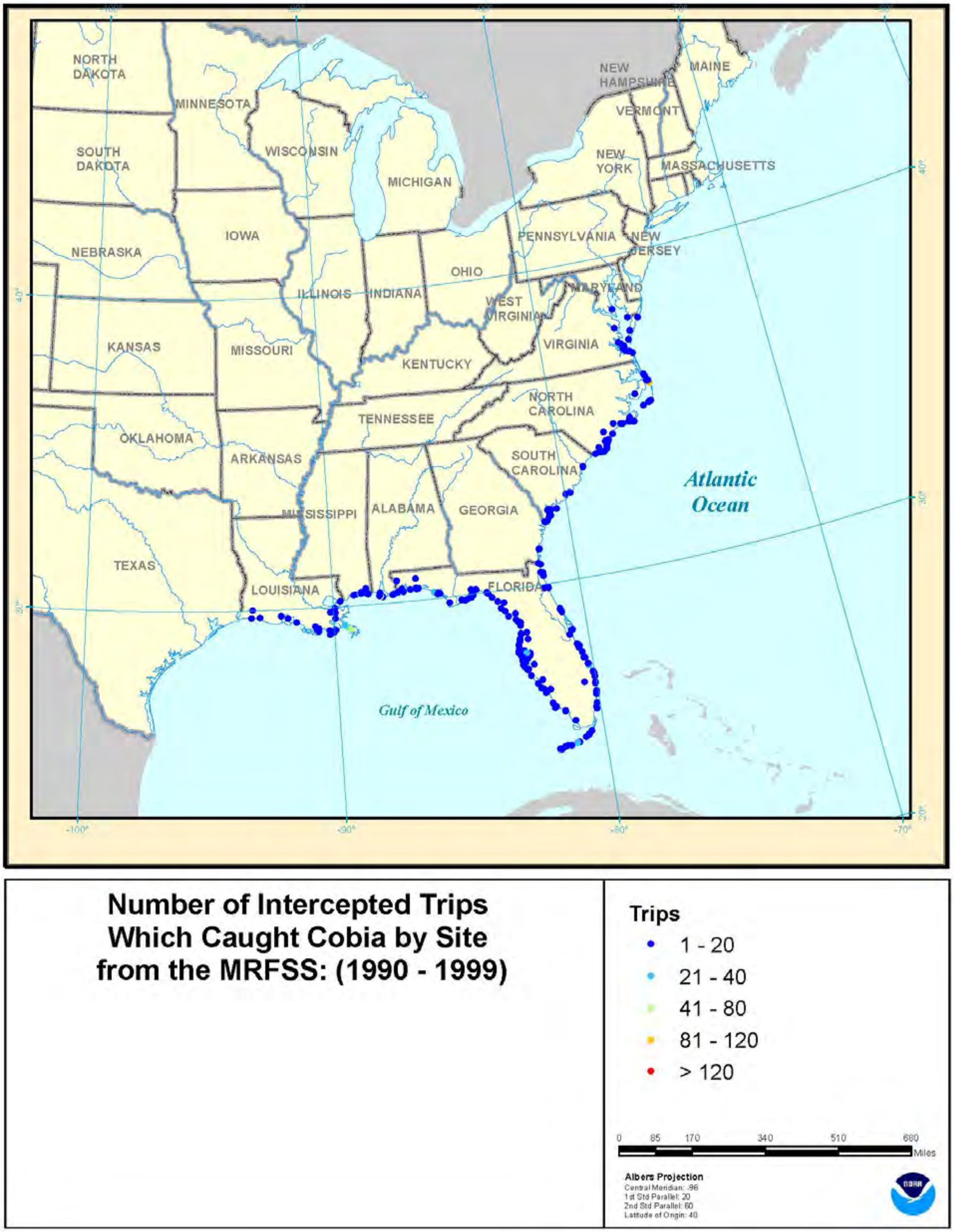


Figure 4.12.25. The number MRFSS intercepted trips which caught cobia from 1990-1999.

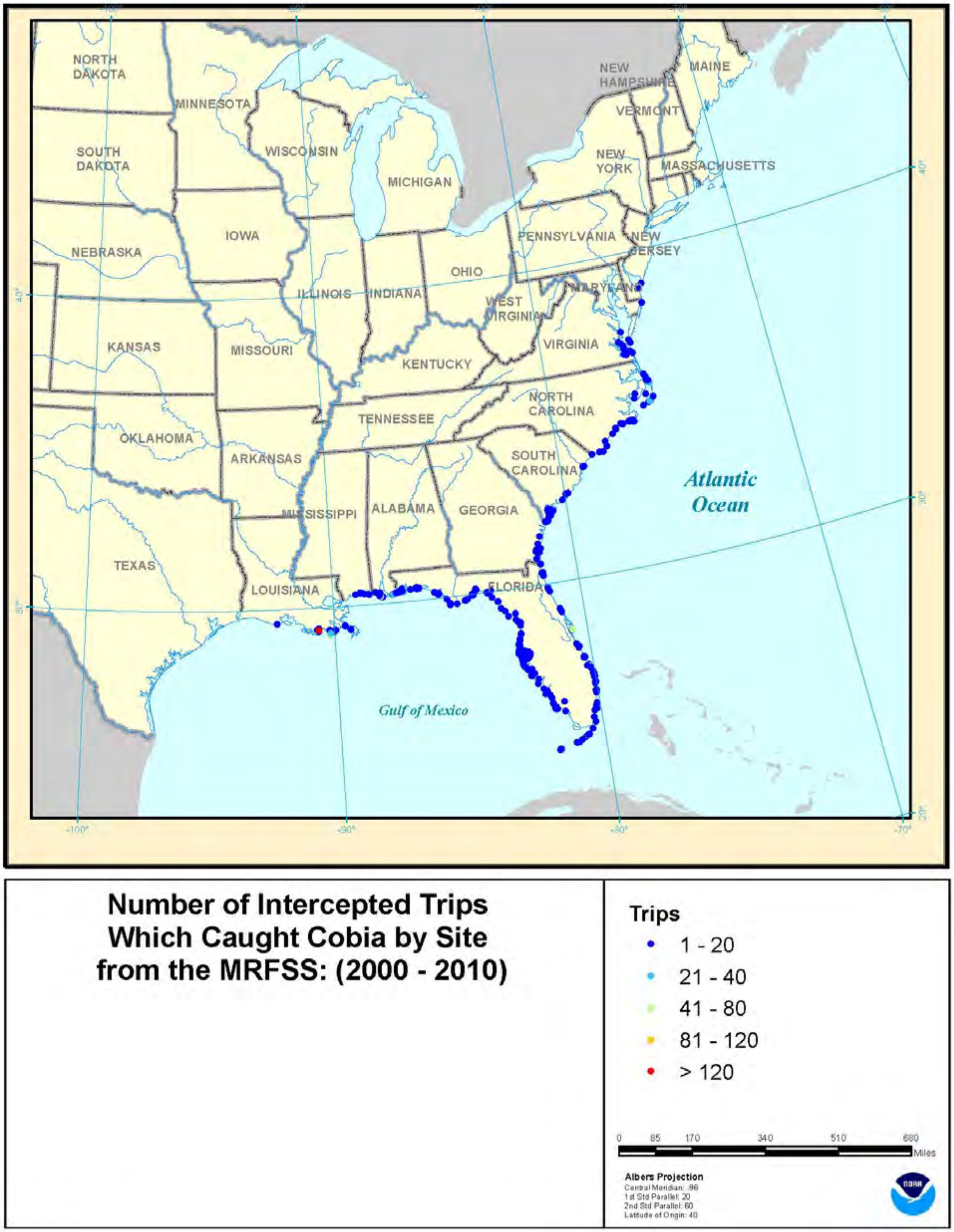


Figure 4.12.26. The number MRFSS intercepted trips which caught cobia from 2000-2010.

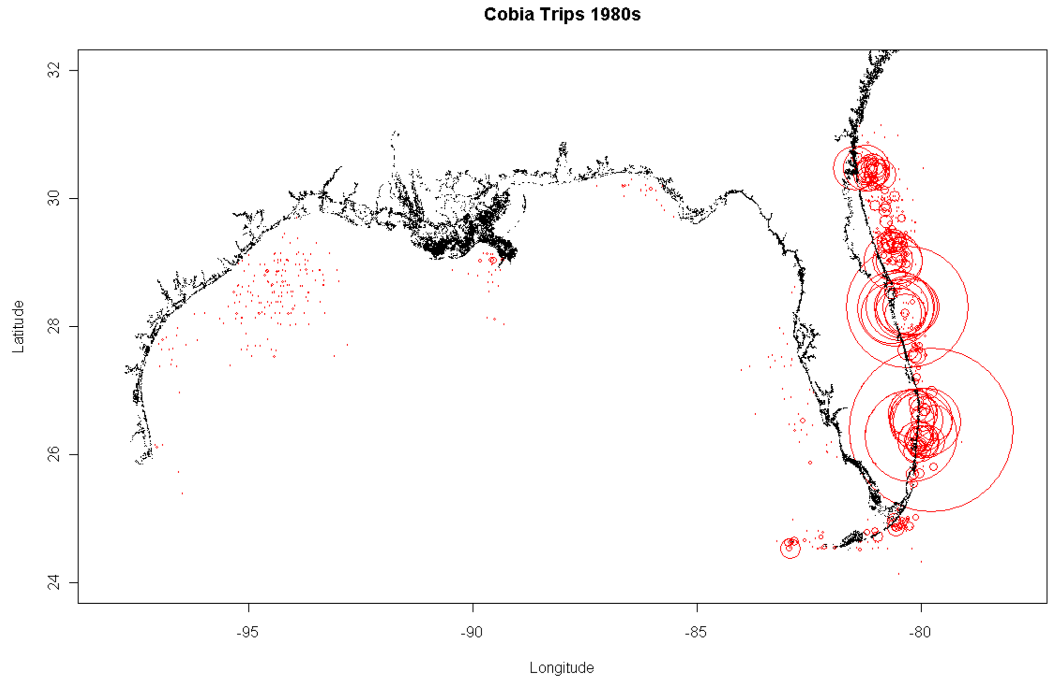


Figure 4.12.27. Reported cobia trips in the Gulf of Mexico from the SRHS, 1981-1989. The size of each point is proportional to the frequency of reported trips at the given location.

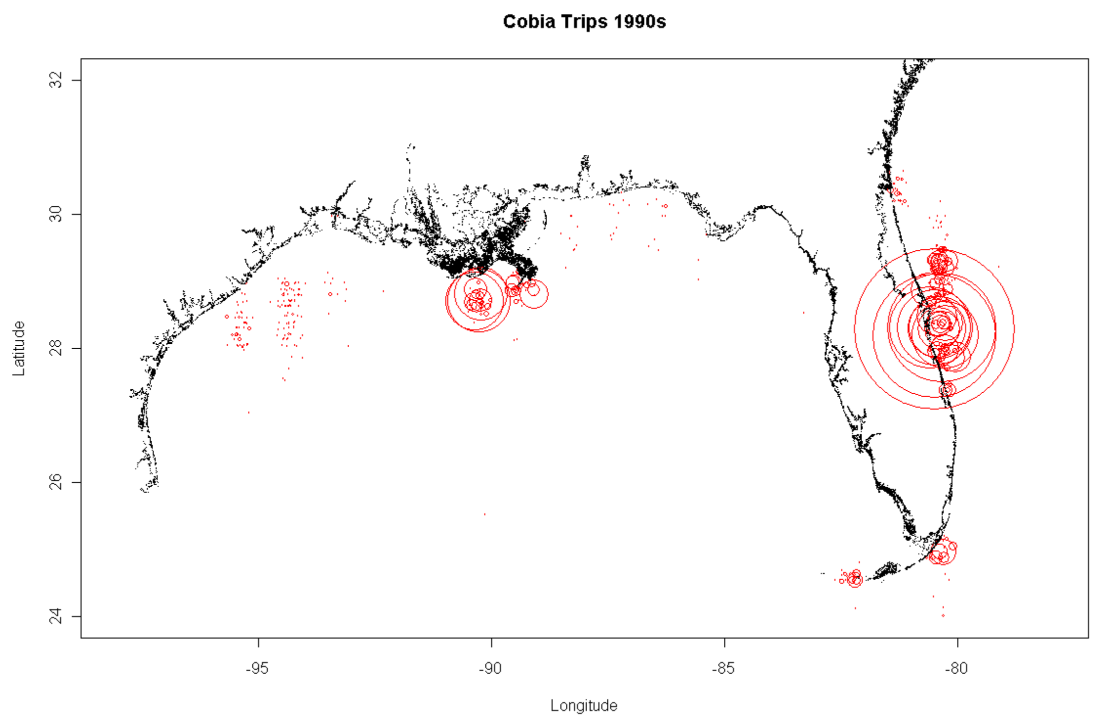


Figure 4.12.28. Reported cobia trips in the Gulf of Mexico from the SRHS, 1990-1999. The size of each point is proportional to the frequency of reported trips at the given location.

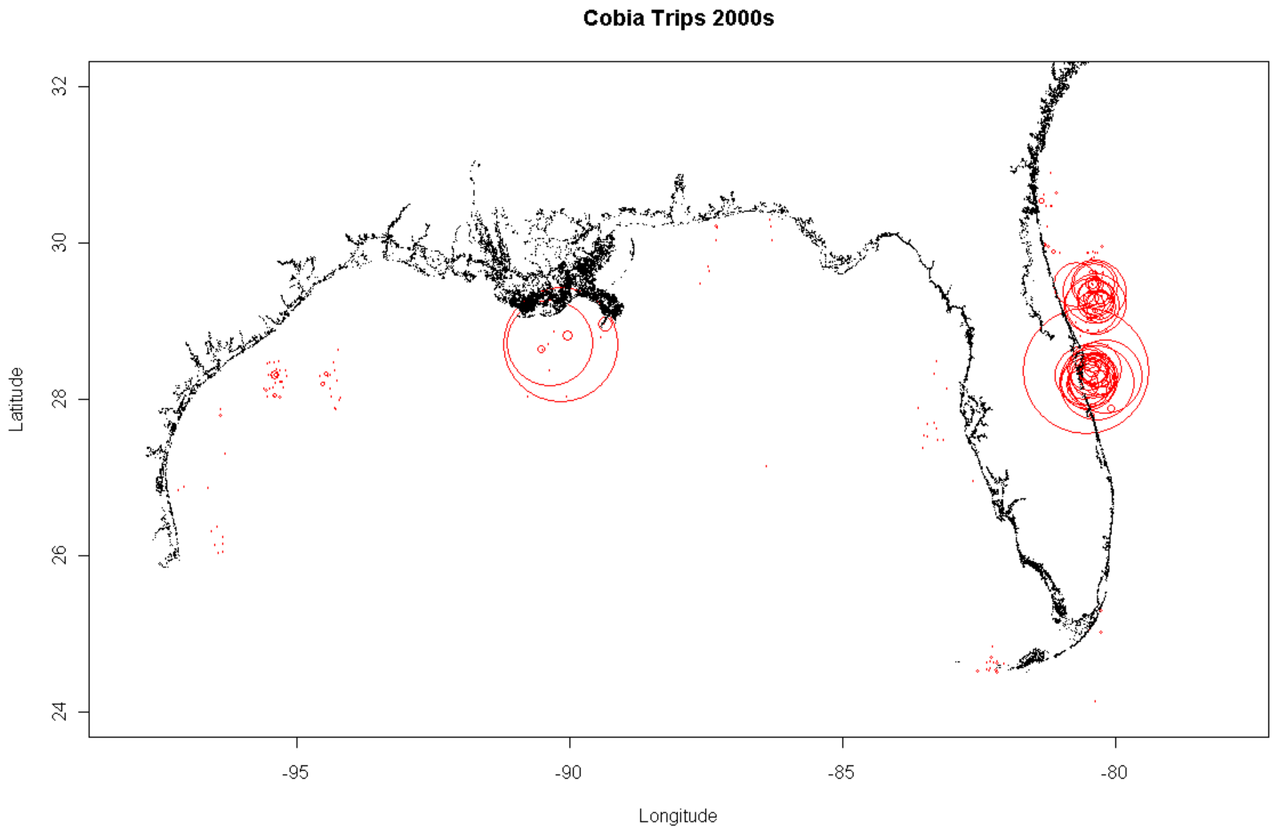


Figure 4.12.29. Reported cobia trips in the Gulf of Mexico from the SRHS, 2000-2011. The size of each point is proportional to the frequency of reported trips at the given location.

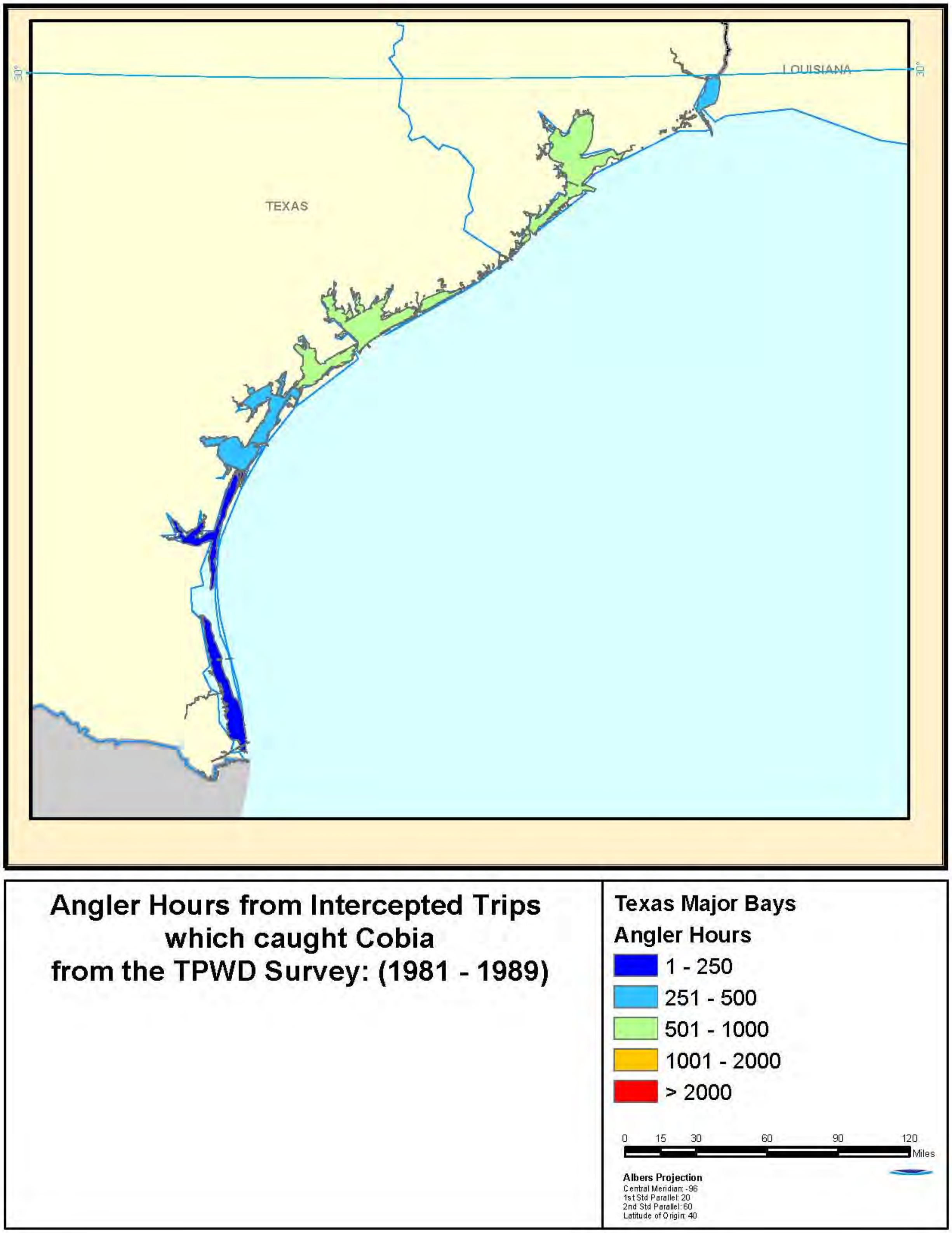


Figure 4.12.30 Angler hours from trips which intercepted cobia in the TPWD, 1983-1989.

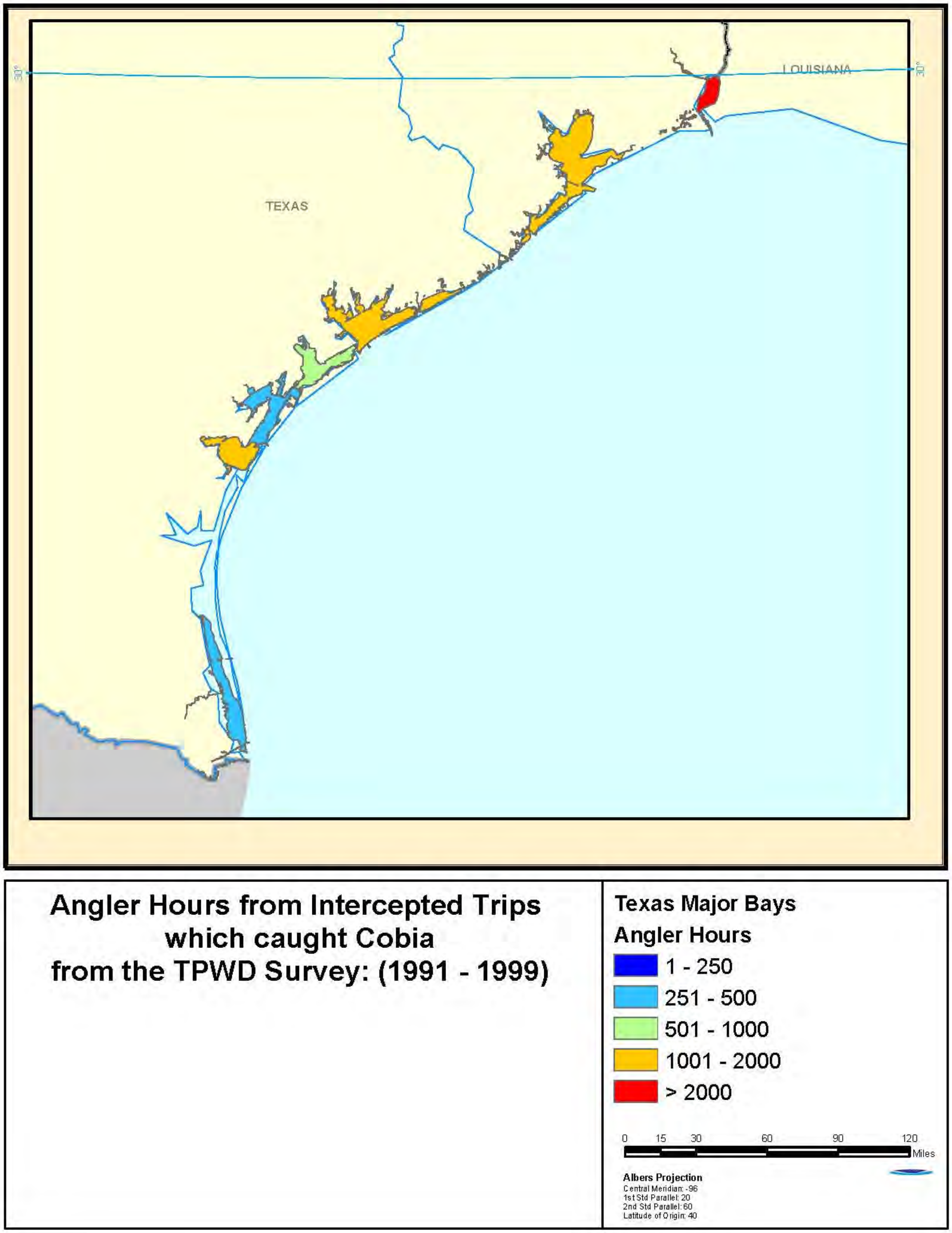


Figure 4.12.31 Angler hours from trips which intercepted cobia in the TPWD, 1990-1999.

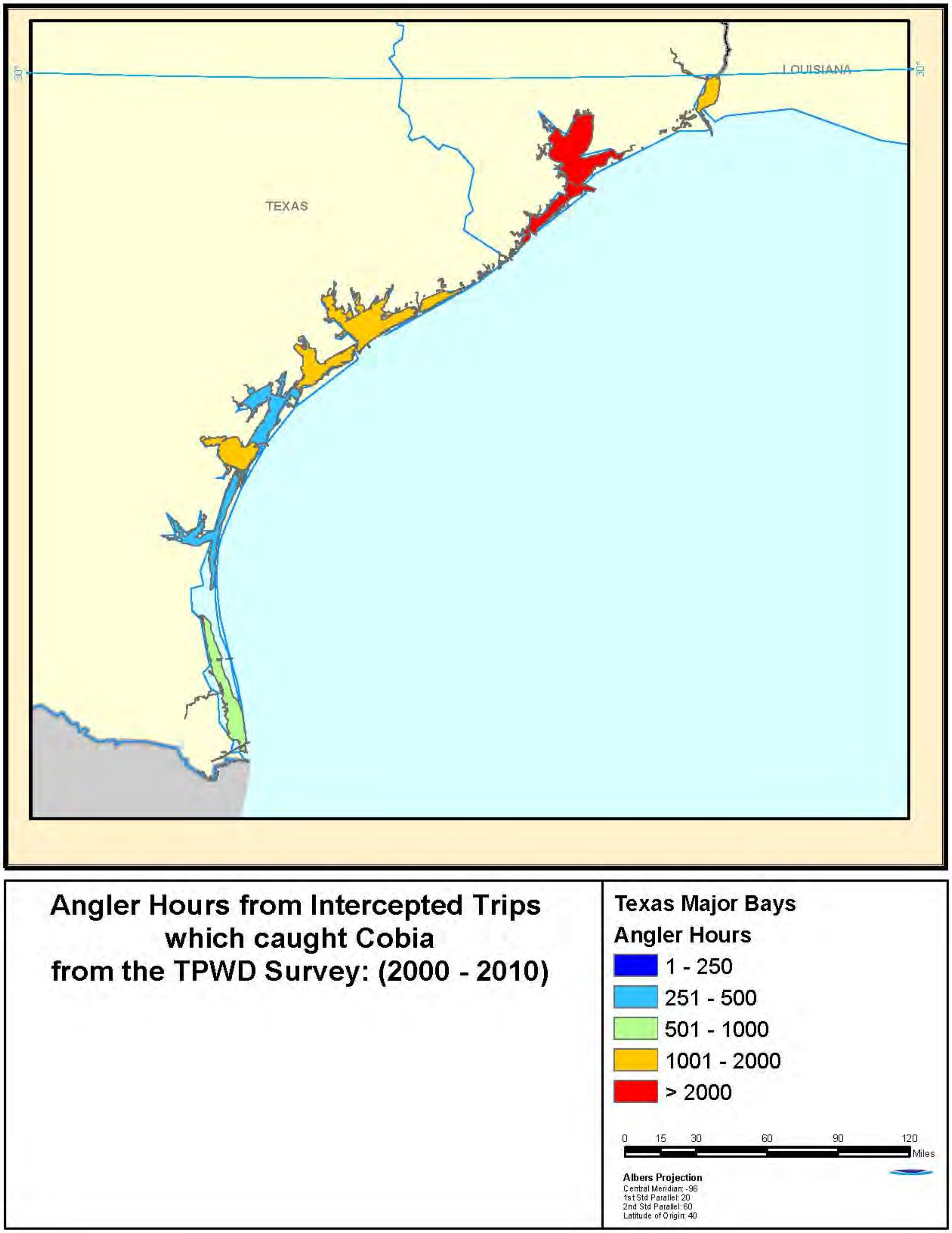


Figure 4.12.32 Angler hours from trips which intercepted cobia in the TPWD, 2000-2010.

5 Measures of Population Abundance

5.1 Overview

Analytical results of five data sets were presented to the Index Working Group (IWG). Four of the data sets were of fishery-dependent origin and one was of fishery-independent origin.

- Texas sport boat angler survey (*Not recommended for use*)
- SEAMAP groundfish survey (*Not recommended for use*)
- Commercial logbooks – handline/trolling (*Not recommended for use*)
- Headboat (*Recommended for use*)
- MRFSS (*Recommended for use*)

At the final plenary it was noted that the two indices recommended for potential use would be considered the same rank when prioritizing for use in the stock assessment. Also, index adequacies and inadequacies are in report card comments.

Group Membership
IWG members included Walter Ingram, Jeanne Boylan, Pearse Webster, Clay Porch, Neil Baertlein, Kevin McCarthy, Steve Saul, Meaghan Bryan, Katie Andrews, Kevin Craig, Michael Schirripa, Nancie Cummings, Julia Byrd, Amy Schueller, Eric Fitzpatrick, and Mike Errigo, as well as other DW participants as needed for discussions throughout the week.

5.2 Review of Working Papers

Not provided.

5.3 Fishery Independent Indices

5.3.1 SEAMAP Groundfish Survey

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories have 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 about the abundance and distribution of demersal organisms in the northern GOM. This survey, which is conducted semi-annually (summer and fall), provides an important source of fisheries independent information on many commercially and recreationally important species throughout the GOM.

A full review of the survey design and methodologies are described in SEDAR28-DW03. The appendix of the document provides the index for Cobia requested by the IWG. Initially, the authors did not provide an index for cobia based on the low frequency of occurrence. The indices group requested an attempt at the development of abundance indices of cobia using the zero-inflated delta-lognormal method of Ingram et al. (2010). The results of that model run are listed in Table 5.3.1.1. Ultimately, the index was not recommended for use in the GOM cobia stock assessment due to the low number of cobia collected each year during the surveys.

5.4 Fishery Dependent Indices

5.4.1 Texas Parks and Wildlife Departments Sport-boat Angling Survey

Information on catch per unit of effort for recreational sport-boat fisheries in Texas was summarized. These data were evaluated for the use of calculating catch per unit of effort (CPUE) abundance trends for cobia (*Rachycentrum cendrum*) in the Gulf of Mexico for use in SEDAR 28 stock evaluations. The Texas Parks and Wildlife Departments Sport-boat Angling Survey (TPWD) index included interviews from May through September, private and charterboat modes, Gulf areas off major bay systems in nearshore and offshore waters only. Observations of recreational catch and effort were available for sport-boat fisheries in Texas from 1983 - 2010. The TPWD Sport-boat Angling Survey samples fishing trips made by sport-boat anglers fishing in Texas marine waters; these include private and charterboat fisheries. All sampling takes place at recreational boat access sites. The primary focus of the TPWD survey is on private boats fishing in bays and passes because this accounts for most of the coastwide fishing pressure and landings in TX (78% of fishing effort and 67% of landings during May15, 2002 to May 14, 2003). Private boats in gulf waters (7% of effort), charterboats in bays and passes (14% of effort), and charterboats in gulf waters (<2% of effort) are also included in the TPWD survey, but special surveys are added to increase the precision of trips fishing in gulf areas since they are not encountered frequently in the normal survey. In addition, the survey is designed to estimate landings and effort during high-use seasons (May15-November 20) and low-use seasons (November 21-May 14). More details regarding the TPWD sport-boat fishing surveys are provided in Appendices I and II. For all analyses CPUE was calculated as catch (number fish caught) divided by effort (number of anglers x triplength).

The development of the CPUE index was described in more detail in SEDAR28-DW10. The appendix to the working paper describes decisions made by the SEDAR 28 DW panel with updated tables and figures. The SEDAR 28 DW IWG decisions are summarized in SEDAR28-DW10 (Appendix 1).

5.4.1.1 Methods of Estimation

Data Filtering Techniques

While exploring TPWD data to develop a standardized index for cobia in the Gulf of Mexico, the following methods were investigated.

Stephens & MacCall

First the Stephens and MacCall (2004) method was explored in an attempt to identify directed cobia trips in the complete TPWD recreational data CPUE data set. This method uses the species composition information on a trip to subset the complete data or to help identify trips or set to only those trips on which the species of interest (the target species, cobia in this case) could occur. The analysis involves fitting a logistic regression to the presence-absence of each trip's species catch. Routinely, the species composition included in the regression includes only those species occurring in at least 1% of all the trips combined. The analysis results include a critical probability value that predicts the target species presence or absence in the study data set, which is used to select trips on an objective basis. In the Stephens and MacCall analysis of the TPWD data, 329,616 unique trips were evaluated for cobia targeting preference. The species that occurred in at least 1% of all the trips were TPWD species codes: 614, 629, 616, 625, 613, 602, 621, 772, 758, 818, 611, and 681. Cobia did not occur on at least 1% of all the trips but was included in the list. These species were then included in the logistic regression with cobia included as the target species.

The results of the Stephens MacCall analyses of the TPWD recreational CPUE data were not successful in identifying a suite of trips targeting cobia. We found that on the majority of the 329,616 fishing trips, only one or two species were caught making it difficult to identify a group of species that might associate with the target species (cobia). In total, across all the time series from 1983 to 2010, cobia occurred on only 0.24% (n=804) of all trips. Thus, we considered two datasets for the CPUE standardization analyses. The first set of observations included all the data, as in the previous Mackerel Stock Assessment Panel (MSAP) 2003 analyses of TPWD CPUE for cobia. The second data set that was evaluated for CPUE was formed by excluding inshore fishing trips from the CPUE standardizations. We found that the majority of the recreational fishing effort for cobia did not occur inshore but rather in waters <10 miles (TTS, NEWAREA 3) or in waters >10 miles (EEZ, NEWAREA area 4), thus inshore effort in the bays and passes (NEWAREA 5) was excluded from subsequent analyses. The total number of trips in these two areas was 25,337 of which cobia occurred in 798 or 3.2% across all years.

Positive Trips

Applying methods described by Stephens & MacCall (2004) to cobia resulted in a 67% reduction in positive cobia trips while identifying approximately 11,000 trips that were unsuccessful at catching cobia. A large reduction in positive cobia trips and an inflation of zero cobia trips was anticipated due to the infrequency of cobia in the Texas recreational sportboat fishery, therefore a more appropriate method was pursued.

Analytic Approach

For each analysis data set (Set 1: all observations (n=329, 616 trips) and Set 2: areas 3 and 4 only (n=25,337 trips), we attempted to construct standardized CPUE indices using the delta-lognormal modeling approach (Lo et al. 1992). This method applies two separate models, fitting a lognormal model to the positive CPUE observations and a separate binomial model to the proportion of successful (positive) observations and combines results from the two models to obtain a single index. Parameter estimates were obtained using a general linear modeling (GLM) procedure (SAS GLIMMIX and MIXED procedures; SAS v.9.2 2004 of the SAS System, SAS Institute Inc.; Cary, NC, USA) to develop the binomial and lognormal sub-models. Factor (covariate) significance was evaluated using Type 3 residual analysis and overall performance was assessed from residual analysis graphics. Residuals by year were plotted and reviewed and QQ plots of the residuals against a normal distribution were plotted. In applying the GLM procedure we assumed the proportion of successful trips per stratum approximated a binomial distribution, where the estimated probability was a linearized function of the fixed factors. We used a second generalized linear model to examine the influence the fixed factors on log(CPUE) of successful trips assuming a normal error distribution for the positive catch rates. As defined earlier, catch rate was calculated as number fish caught divided by (number anglers x triplength).

5.4.1.2 Sampling Intensity

The resulting data set contained n=329,616 trips for all areas, and n=25,337 trips for areas 3 and 4 only.

5.4.1.3 Size/Age data
The sizes/ages represented in this index should be the same as those of landings from the corresponding fleet.

5.4.1.4 Catch Rates
Standardized catch rates and associated error bars are shown in SEDAR28-DW10.

5.4.1.6 Comments on Adequacy for Assessment
The index of abundance created from the TPWD data was not recommended for potential use in the cobia stock assessment. Although the data set has an adequately large sample size and has a long enough time series to provide potentially meaningful information for the assessment, the survey covers only a small portion of the stock as described for the Gulf of Mexico and mostly surveys an area where cobia are not abundant or targeted. In addition, catch rates were extremely low and the index was derived from fishery dependent data.

5.4.2 Commercial Vertical line Index
Using the Coastal Fisheries Logbook Program's (CFLP) available CPUE data, an index of abundance for cobia was constructed for the U.S. GOM from 1993 through 2010. The index was constructed using data submitted by federally permitted commercial vertical line vessels. Commercial fishing activity reported by fishers to the CFLP is at the trip level. For each fishing trip, the CFLP database includes a unique trip identifier, the landing date, fishing gear deployed, areas, number of days at sea, number of crew, gear specific fishing effort, species caught, and weight of the landings.

Using only one day trips, an index was constructed using a delta-lognormal approach. The catch per unit effort for vertical lines was defined as gutted pounds per hook hour fished. Complete details concerning the methods and results of the analyses are described in SEDAR28-DW16.

5.4.2.1 Methods
Data Filtering Techniques

Multiple areas fished and multiple gears fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations or gears was not always possible; therefore, only trips which reported one area category and one gear fished were included in these analyses. Data were further restricted to include only those trips with landings and effort data received by the CFLP within 45 days of the completion of the trip. Reporting delays beyond 45 days likely results in less accurate effort data. Trips in which errant or missing data were present were removed from the analyses. These included missing number lines, number of hooks, and hours fished for vertical gear. Vertical gear trips reporting 24 or more hours per day fishing were also excluded.

Following the exclusion of trips listed above, outliers were removed in which number of lines, hooks, number of days fished, and number of crew fell outside the upper 99.5 percentile. Additional vertical line trips were removed from consideration when trips caught deep water grouper by trolling. For this analysis, only one-day trips were used from 1993 through 2010. Only one day trips were used as the cobia trip limit is two per person per day with a maximum 1 day possession limit. The Gulf of Mexico for this region includes South Atlantic areas south of the 28th parallel, off of Florida, around southern Florida and into the Gulf of Mexico.

Subsetting trips
All available one day vertical line trips from 1993 through 2010 were used in the construction of the index.

Model Input
Effects on the proportion of positive trips and on the CPUE of positive trips were tested using general linear model (GLM) analyses. For the GLM analysis of proportion positive trips, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. For the analyses of catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. The linking function selected was normal, and the response variable was log(CPUE). The response variable was calculated as: log(CPUE) = ln(pounds of cobia/hook hour) for vertical lines. All 2-way interactions among significant main effects were examined. Higher order interaction terms were not examined.

The final models for the binomial on proportion positive trips (PPT) and the lognormal on CPUE of successful trips were:

PPT = Year + Subregion

LOG(CPUE) = Year + Subregion + Crew + Gear_type + Subregion*Crew + Subregion*Year + Crew*Year

Standardization
The final delta-lognormal model was fit using a SAS macro, GLMMIX (Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR which were examined as random effects to be included in the final model. 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). For comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the series.

The standardized index of abundance, number of trips, and relative nominal CPUE for vertical lines are shown in Table 5.4.2.1. The relative nominal CPUE and standardized index, with 95% confidence intervals, are shown in Figure 5.4.2.1.

5.4.2.2 Sampling Intensity
The final dataset for the vertical lines index contained 269,988 one day vertical line trips.

5.4.2.3 Size/Age data
The sizes and ages represented in these indices would likely be reflective of those in the GOM commercial landings.

5.4.2.4 Catch Rates
The relative nominal CPUE and standardized indices, with 95% confidence intervals, are shown in Figure 5.4.2.1.

5.4.2.5 Comments on Adequacy for Assessment
Due to the two fish per person, per day, trip limit, there is a good reason to believe the index is not a true reflection of population abundance. Since the cobia fishery tends to be an opportunistic fishery, there is no way to determine how much of a trip's effort is directed toward catching cobia. In addition, if the cobia landed were unintended catch, the commercial logbook does not reflect total cobia caught as there is a possibility of an indeterminate amount of cobia discarded after the trip limit was met. Therefore, the index of abundance based on vertical lines reported to the CLFP program was not recommended for potential use in the GOM cobia stock assessment.

5.4.3 Recreational Headboat Index - Cobia
The Headboat Survey in the GOM started sampling headboats in 1986, and the data collected were used to develop standardized catch per unit effort (CPUE) indices of abundance for the recreational fishery for cobia (*Rachycentron canadum*) in the GOM (SEDAR28-DW22). A delta-lognormal modeling approach was used to develop the indices and a species association approach (Stephens and MacCall 2004) was explored to identify directed cobia trips.

5.4.3.1 Methods for Estimation
Sample sizes were assessed across different strata for both total trips and positive trips. Shore mode was removed because less than 0.1 percent of the shore mode trips reported catching a cobia, and cobia are typically not caught from shore.
The datasets were spatially partitioned according to the decisions made during the SEDAR 28 data workshop plenary sessions. The stock boundary dividing the GOM stock from the South Atlantic stock for cobia was defined as the state boarder between Florida and Georgia. Therefore, all FL waters were considered to be part of the GOM. The dataset was partitioned where fish surveyed in areas 1,2,3,4,5,6,9 and 10 were considered to be part of the South Atlantic stock, while fish in all other areas were considered to be part of the GOM stock (Figure 5.4.3.1).

Data filtering techniques
Stephens and McCall
The Stephens and MacCall (2004) approach was explored to identify directed cobia trips. This approach resulted in an 83% reduction in the cobia trips on average and was therefore not used to define cobia directed trips.

Core vessels
The IWG discussed subsetting the dataset by identifying individual vessels that tend to target cobia and taking a subset of the data that only uses the trips taken by these vessels. Although this approach was possible for the South Atlantic where there are fewer vessels and more information was known about the boats, the approach could not be implemented in the GOM. The larger volume of vessels fishing in the GOM and the inability to track individual vessels given the frequent change in a vessel's unique identifying number precluded the ability to follow individual vessels.

All trips versus positive trips
The SEDAR 28 DW IWG and panel discussed the various alternatives to identifying targeted trips, and agreed that they served little utility for the GOM subset of the data. The working group also noted that there was little difference in the indices that were estimated for the entire dataset and the indices estimated for the subset of only positive trips. Therefore, it was reluctantly decided at the data workshop, that fishing effort for cobia would be based on all trips. This decision was made because cobia is rarely a species fishers target, and cobia are opportunistically captured fish while targeting other species. Therefore, most trips in the Headboat database represent potential fishing effort for cobia.

Model Input
Response and explanatory variables
CPUE- Catch per unit effort (CPUE) has units of the number of cobia caught to the number of fish caught on a given trip divided by the effort, where effort was calculated as the product of the number of people on the headboat and the hours fished.
Year – A summary of the total number of trips, the number of positive trips, and the percent of positive trips per year is presented in Table 5.4.3.1.
Month – Tables 5.4.3.2-5.4.3.4 summarize the total number of trips, the number of positive trips, and the percent of positive trips per month and year. There was a significant interaction between month and year.
Area –Tables 5.4.3.5-5.4.3.7 summarize the total number of trips, the number of positive trips, and the percent of positive trips per area and month due to their significant interaction.

Standardization
For the indices constructed on the complete datasets, the delta-lognormal model approach (Lo et al. 1992) was used. This method combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed cobia) and the catch rates on successful trips to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA). The GLM procedure was fitted to the observed proportion positive trips using a type-3 model with a binomial error distribution and a logit link function. The second component of the delta lognormal approach is to estimate the natural log of the CPUE using a type-3 model with a lognormal error distribution and a normal link function.

A stepwise approach was used to quantify the relative importance of the explanatory factors. First a GLM model was fit on year. These results reflect the distribution of the nominal data. Next, each potential explanatory 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. All 2-way interactions among significant main effects were examined, however higher order interaction terms were not examined. The final delta-lognormal model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing year which were modeled as random effects. To facilitate visual comparison, a relative standardized index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the entire time-series.

The model used for standardization was:

$$Success = \mu + (Year)\alpha_1 + (Area)\alpha_2 + \varepsilon$$

$$\ln(CPUE) = \mu + (Year)\alpha_1 + (Area)\alpha_2 + (Month)\alpha_3 + (Area * Month)\alpha_4 + (Year * Area)\alpha_5 + (Year * Month)\alpha_6 + \varepsilon$$

5.4.3.2 Sampling Intensity

The resulting data set contained 366,378 trips with 7% positive cobia trips (Table 5.4.3.1).

5.4.3.3 Size/Age data

The sizes and ages represented in this index should be the same as those of landings from the corresponding fleet.

5.4.3.4 Catch Rates

Standardized catch rates and confidence intervals are shown in Figure 5.4.3.2 and tabulated in Table 5.4.3.8. Figure 5.4.3.3 shows the Q-Q plot of the CPUE observations and Figure 5.4.3.4 shows the binomial fit to the observed proportion positive cobia trips.

5.4.3.5 Uncertainty and Measures of Precision

95% confidence intervals were calculated from the mean square error output from the GLM procedures.

5.4.3.6 Comments on Adequacy for Assessment

The IWG recommended this index for potential use in the GOM cobia stock assessment because it represents a fairly long time-series and the number of positive cobia trips was relatively large. Also, the data cover the entire management area.

5.4.4 MRFSS Index - Cobia

The Marine Recreational Fishery Statistics Survey (MRFSS) conducted by the NOAA Fisheries (NMFS) 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 state, except TX. MRFSS was conducted in TX through 1985 and did not include all modes in all years. Starting in 1986, MRFSS no longer covered headboats in the Gulf of Mexico and South Atlantic. Catch estimates were made for strata used in the intercepts: fish landed whole and observed by the samplers (Type A), fish reported as killed by the fishers (Type B1) and fish reported as released alive by the fishers (Type B2).

This work uses the catch and effort observations from MRFSS to develop standardized CPUE indices of abundance for the recreational fishery for cobia in the GOM. A delta-lognormal modeling approach was used to develop these indices. Details are given in SEDAR28-DW22.

5.4.4.1 Methods for Estimation

Sample sizes in the MRFSS data set were explored across different strata for both total trips and positive trips. Data from Texas, present in the years 1981 through 1985, were removed from the MRFSS data because the State of Texas has its own survey.

The dataset was partitioned according to the decisions that were made during the SEDAR 28 data workshop plenary sessions. For cobia, the stock boundary dividing the GOM from the South Atlantic stock during the data workshop was determined to be the state boarder between Florida and Georgia. For cobia, the MRFSS data was split using the state code designations at the Florida-Georgia state border.

For the MRFSS data, if there were anglers on a trip that actively fished but were not interviewed, the data were adjusted to account for the catch and effort of these non-interviewed anglers. This adjustment was made by dividing the total catch made by those individuals who were interviewed by the number of people interviewed. This average catch per person was then multiplied by the number of anglers that were not interviewed and the resulting catch was then added to the total catch for that trip.

Data filtering techniques

Stephens and MacCall

The Stephens and MacCall (2004) approach was explored to identify cobia directed trips. The results of this exploration were similar to those found when applied to the Headboat data, which precluded applying this approach to the MRFSS data.

Model Input

Response and explanatory variables

CPUE- catch per unit effort (CPUE) has units of the number of cobia caught to the number of fish caught on a given trip divided by the effort, where effort was calculated as the product of the number of people on the headboat and the hours fished.

Year – A summary of the total number of trips, the number of positive trips, and the percent of positive trips per year is presented in Table 5.4.4.1.

State – Table 5.4.4.2 summarizes the total number of trips, the number of positive trips, and the percent of positive trips per year and state due to the significant interaction between area and month.

Month – Tables 5.4.4.3-5.4.4.5 summarize the total number of trips, the number of positive trips, and the percent of positive trips per month and year due to the significant interaction between month and year.

Area- Table 5.4.4.6 summarizes of the total number of trips, the number of positive trips, and the percent of positive trips per area and year. Area signifies fishing locations inshore and offshore.

Mode - Table 5.4.4.7 summarizes the total number of trips, the number of positive trips, and the percent of positive trips per mode and year. Fishing mode signifies whether fishing was done off a private boat as compared to for hire outfits.

Standardization

For the indices constructed on the complete datasets, the delta-lognormal model approach (Lo et al. 1992) was used. This method combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed cobia) and the catch rates on successful trips to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA). The GLM procedure was fitted to the observed proportion positive trips using a type-3 model with a binomial error distribution and a logit link function. The second component of the delta-lognormal approach is to estimate the natural log of the CPUE using a type-3 model with a lognormal error distribution and a normal link function.

A stepwise approach was used to quantify the relative importance of the explanatory factors. First a GLM model was fit on year. These results reflect the distribution of the nominal data. Next, each potential explanatory 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. All 2-way interactions among significant main effects were examined, however higher order interaction terms were not examined. The final delta-lognormal model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing year which were modeled as random effects. To facilitate visual comparison, a relative standardized index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the entire time-series.

The model used for CPUE standardization was:

$$Success = \mu + (Year)\alpha_1 + (Area)\alpha_2 + (State)\alpha_3 + (Mode)\alpha_4 + (Month)\alpha_5 + \varepsilon$$

$$\ln(CPUE) = \mu + (Year)\alpha_1 + (Mode)\alpha_2 + (Month)\alpha_3 + (Area)\alpha_4 + (Year * Area)\alpha_5 + (Year * Month)\alpha_6 + (Mode * Month)\alpha_7 + \varepsilon$$

5.4.4.2 Sampling Intensity

The resulting data set contained 596,828 trips with less than 1% positive cobia trips (Table 5.4.4.1).

5.4.4.3 Size/Age data

The sizes and ages represented in this index should be the same as those of landings from the corresponding fleet.

5.4.4.4 Catch Rates

Standardized catch rates and confidence intervals are shown in Figure 5.4.4.1 and tabulated in Table 5.4.3.8. Figure 5.4.4.2 shows the Q-Q plot of the CPUE observations and Figure 5.4.4.3 shows the binomial fit to the observed proportion positive cobia trips.

5.4.4.5 Uncertainty and Measures of Precision

95% confidence intervals were calculated from the mean square error output from the GLM procedures.

5.4.4.6 Comments on Adequacy for Assessment

The index was recommended for use due to the long length of the time series, and the fact that cobia was listed as a known target during the MRFSS interviews.

5.5 Tables

Table 5.3.1.1. Index values and associated statistics for Cobia collected during Gulf SEAMAP Groundfish Trawl Surveys.

Survey Year	*Nominal Frequency*	*N*	*Index*	*Scaled_Index*	*Scaled_Nominal*	*CV*	*LCL*	*UCL*
1987	0.01724	116	0.04507	0.38953	0.24074	0.87708	0.08599	1.76453
1988	0	.	0	0	0	.	.	.
1989	0.02158	139	0.03627	0.31352	0.27179	0.71563	0.08664	1.13452
1990	0.03378	148	0.10494	0.90708	1.62447	0.56133	0.31846	2.58364
1991	0.02857	140	0.05787	0.50024	0.43699	0.62916	0.15761	1.58776
1992	0.04380	137	0.10986	0.94959	1.12444	0.51284	0.36126	2.49602
1993	0.09697	165	0.26910	2.32595	2.63955	0.31458	1.25830	4.29951
1994	0.08966	145	0.14044	1.21389	1.13015	0.35055	0.61444	2.39817
1995	0.05036	139	0.09468	0.81836	0.56318	0.47622	0.33133	2.02131
1996	0.07857	140	0.23139	2.00003	1.57674	0.37939	0.96055	4.16442
1997	0.10072	139	0.35074	3.03168	3.66417	0.33497	1.57917	5.82022
1998	0.01370	146	0.02346	0.20279	0.19078	0.87946	0.04463	0.92152
1999	0.08392	143	0.14889	1.28698	1.03974	0.36422	0.63535	2.60692
2000	0.00699	143	0.00508	0.04387	0.05543	1.20879	0.00657	0.29274
2001	0.10156	128	0.23665	2.04554	1.69754	0.34639	1.04332	4.01049
2002	0.04196	143	0.10369	0.89624	0.81252	0.51212	0.34138	2.35294
2003	0.03681	163	0.09970	0.86176	1.08391	0.51213	0.32824	2.26247
2004	0.07031	128	0.10428	0.90131	0.91148	0.41752	0.40428	2.00939
2005	0.05594	143	0.08650	0.74766	0.84892	0.44696	0.31843	1.75546
2006	0.06207	145	0.14883	1.28644	1.06249	0.42076	0.57373	2.88450
2007	0.02963	135	0.06583	0.56898	0.54014	0.62426	0.18064	1.79214
2008	0.01843	217	0.04907	0.42410	0.40003	0.62668	0.13414	1.34087
2009	0.01339	224	0.03502	0.30266	0.25858	0.72172	0.08289	1.10508
2010	0.04286	140	0.11359	0.98180	0.82621	0.31029	0.53540	1.80041

Table 5.4.2.1. Gulf of Mexico vertical line relative nominal CPUE, number of trips, proportion positive trips, relative abundance indices, and associated confidence intervals and CVs.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.97427	6,764	0.033856	0.62834	0.28600	1.38044	0.40928
1994	0.69071	10,586	0.029378	0.82735	0.41124	1.66452	0.36048
1995	0.75282	11,017	0.029318	0.76212	0.37851	1.53454	0.36093
1996	1.50812	10,156	0.039976	1.60522	0.85752	3.00487	0.32135
1997	1.22542	14,822	0.038254	1.09536	0.59495	2.01667	0.31243
1998	1.13343	19,967	0.034757	1.02538	0.56675	1.85513	0.30308
1999	0.96548	20,177	0.030133	0.91652	0.49748	1.68854	0.31279
2000	1.07147	19,418	0.029148	0.83320	0.44646	1.55497	0.31971
2001	0.87077	19,648	0.027942	0.78473	0.41783	1.47378	0.32311
2002	1.11941	18,262	0.038495	0.98875	0.54612	1.79011	0.30345
2003	1.22733	19,531	0.028007	0.96326	0.51959	1.78575	0.31613
2004	1.27146	17,321	0.029040	1.03168	0.55320	1.92401	0.31933
2005	0.76224	14,317	0.023469	0.64348	0.31682	1.30694	0.36569
2006	0.98464	13,876	0.031637	0.91683	0.48065	1.74884	0.33150
2007	0.86062	13,539	0.029470	1.31593	0.69288	2.49925	0.32915
2008	0.75687	13,635	0.025376	1.01992	0.52074	1.99763	0.34584
2009	0.73253	14,636	0.028833	1.08207	0.56834	2.06014	0.33048
2010	1.09241	12,316	0.031991	1.55988	0.82068	2.96490	0.32958

Table 5.4.3.1. Annual number of total headboat trips, number of trips catching cobia (i.e., positive trips), and the percentage of trips capturing cobia in the Gulf of Mexico. The GOM region includes all Florida fishing regions.

Year	Total Number of Trips	Positive Trips	Percentage Positive
1986	15832	947	5.98
1987	15831	988	6.24
1988	15678	906	5.78
1989	15976	785	4.91
1990	19856	908	4.57
1991	17979	1008	5.61
1992	22707	1653	7.28
1993	21854	1802	8.25
1994	20689	1634	7.90
1995	18515	1461	7.89
1996	14878	1158	7.78
1997	15689	1299	8.28
1998	13880	1189	8.57
1999	11833	923	7.80
2000	11178	824	7.37
2001	10545	933	8.85
2002	9713	883	9.09
2003	9671	727	7.52
2004	10339	812	7.85
2005	10031	1015	10.12
2006	9449	940	9.95
2007	10176	1028	10.10
2008	13320	924	6.94
2009	16073	1309	8.14
2010	14686	1220	8.31
Total	366378	27276	

Table 5.4.3.2. Annual number of headboat trips catching cobia in the GOM per month. The GOM includes all Florida fishing regions.

	Month											
Year	1	2	3	4	5	6	7	8	9	10	11	12
1986	40	26	55	79	109	163	164	148	55	33	45	30
1987	31	36	46	113	151	186	157	110	52	26	34	46
1988	31	45	55	119	126	131	125	99	41	49	41	44
1989	54	55	87	84	99	73	110	81	44	41	36	21
1990	68	45	82	119	91	91	79	79	64	59	70	61
1991	67	61	76	108	106	87	135	98	79	72	40	79
1992	74	113	176	148	174	194	230	174	110	100	67	93
1993	94	137	145	196	235	207	253	169	125	94	66	81
1994	68	82	104	175	268	215	217	150	111	97	87	60
1995	73	65	58	133	199	216	216	168	139	80	63	51
1996	44	64	52	65	143	176	186	147	118	84	38	41
1997	38	48	79	80	148	168	211	178	118	86	99	46
1998	70	47	70	115	168	173	204	122	57	63	49	51
1999	51	63	58	100	154	154	133	83	32	27	32	36
2000	30	27	22	80	143	157	145	92	40	48	22	18
2001	23	35	35	70	112	137	180	134	82	41	39	45
2002	45	27	64	82	119	120	155	130	47	38	24	32
2003	18	31	51	65	125	115	83	97	41	49	15	37
2004	26	21	34	81	106	128	172	124	33	41	36	10
2005	25	40	33	79	168	187	172	143	43	52	35	38
2006	25	39	46	82	129	163	148	115	93	50	25	25
2007	29	41	52	73	82	194	185	161	86	43	43	39
2008	33	58	66	86	115	176	152	81	22	52	44	39
2009	41	46	59	104	134	263	264	166	80	71	45	36
2010	33	31	70	107	237	240	159	118	69	57	45	54
Total	1131	1283	1675	2543	3641	4114	4235	3167	1781	1453	1140	1113

Table 5.4.3.3. Annual number of headboat trips fishing in the GOM per month. The GOM includes all Florida fishing regions.

	Month											
Year	1	2	3	4	5	6	7	8	9	10	11	12
1986	861	952	1015	1171	1197	1897	2219	2002	1238	1057	1236	987
1987	1122	1190	1301	1660	1549	1703	1815	1677	1134	850	815	1015
1988	899	1102	1320	1590	1695	1836	1947	1644	849	1016	775	1005
1989	1175	1106	1411	1437	1378	1498	1752	1704	1206	1270	1156	883
1990	1364	1240	1731	1858	1756	2143	2144	2172	1540	1339	1280	1289
1991	1459	1368	1525	1604	1578	1928	2084	1926	1311	1126	973	1097
1992	1226	1423	2112	2141	2396	2313	2938	2391	1686	1512	1156	1413
1993	1516	1608	1812	1961	1977	2233	2747	2288	1619	1582	1254	1257
1994	1173	1508	2002	1992	2110	2105	2455	2146	1396	1404	1193	1205
1995	1237	1430	1778	1909	1881	2069	2389	1759	1352	845	1037	829
1996	953	1152	1092	1310	1416	1675	1927	1695	1198	896	655	909
1997	1012	1252	1443	1142	1382	1662	1835	1921	1195	1088	1017	740
1998	1181	913	1303	1360	1420	1551	1964	1497	627	762	718	584
1999	738	1007	1127	1101	1267	1407	1598	1238	595	578	578	599
2000	633	762	920	1093	1213	1347	1610	1176	694	721	582	427
2001	515	723	811	1049	1073	1265	1536	1279	765	618	456	455
2002	589	547	841	935	938	1250	1474	1142	556	710	401	330
2003	445	577	811	848	1124	1290	1395	1074	599	724	371	413
2004	625	628	987	1078	1162	1449	1588	1030	367	666	426	333
2005	574	630	785	1002	1340	1343	1383	1014	504	550	471	435
2006	489	554	992	965	1062	1223	1262	909	645	540	441	367
2007	547	627	1001	955	941	1458	1514	1080	589	514	430	520
2008	505	845	1146	1387	1462	1845	2072	1237	482	740	712	887
2009	1034	1106	1318	1388	1498	2160	2446	1797	918	887	706	815
2010	771	744	1329	1569	1510	1820	1640	1395	876	1258	984	790
Total	22643	24994	31913	34505	36325	42470	47734	39193	23941	23253	19823	19584

Table 5.4.3.4. Annual percentage of headboat trips catching cobia in the GOM per month. The GOM includes all Florida fishing regions.

	Month											
Year	1	2	3	4	5	6	7	8	9	10	11	12
1986	4.65	2.73	5.42	6.75	9.11	8.59	7.39	7.39	4.44	3.12	3.64	3.04
1987	2.76	3.03	3.54	6.81	9.75	10.92	8.65	6.56	4.59	3.06	4.17	4.53
1988	3.45	4.08	4.17	7.48	7.43	7.14	6.42	6.02	4.83	4.82	5.29	4.38
1989	4.60	4.97	6.17	5.85	7.18	4.87	6.28	4.75	3.65	3.23	3.11	2.38
1990	4.99	3.63	4.74	6.40	5.18	4.25	3.68	3.64	4.16	4.41	5.47	4.73
1991	4.59	4.46	4.98	6.73	6.72	4.51	6.48	5.09	6.03	6.39	4.11	7.20
1992	6.04	7.94	8.33	6.91	7.26	8.39	7.83	7.28	6.52	6.61	5.80	6.58
1993	6.20	8.52	8.00	9.99	11.89	9.27	9.21	7.39	7.72	5.94	5.26	6.44
1994	5.80	5.44	5.19	8.79	12.70	10.21	8.84	6.99	7.95	6.91	7.29	4.98
1995	5.90	4.55	3.26	6.97	10.58	10.44	9.04	9.55	10.28	9.47	6.08	6.15
1996	4.62	5.56	4.76	4.96	10.10	10.51	9.65	8.67	9.85	9.38	5.80	4.51
1997	3.75	3.83	5.47	7.01	10.71	10.11	11.50	9.27	9.87	7.90	9.73	6.22
1998	5.93	5.15	5.37	8.46	11.83	11.15	10.39	8.15	9.09	8.27	6.82	8.73
1999	6.91	6.26	5.15	9.08	12.15	10.95	8.32	6.70	5.38	4.67	5.54	6.01
2000	4.74	3.54	2.39	7.32	11.79	11.66	9.01	7.82	5.76	6.66	3.78	4.22
2001	4.47	4.84	4.32	6.67	10.44	10.83	11.72	10.48	10.72	6.63	8.55	9.89
2002	7.64	4.94	7.61	8.77	12.69	9.60	10.52	11.38	8.45	5.35	5.99	9.70
2003	4.04	5.37	6.29	7.67	11.12	8.91	5.95	9.03	6.84	6.77	4.04	8.96
2004	4.16	3.34	3.44	7.51	9.12	8.83	10.83	12.04	8.99	6.16	8.45	3.00
2005	4.36	6.35	4.20	7.88	12.54	13.92	12.44	14.10	8.53	9.45	7.43	8.74
2006	5.11	7.04	4.64	8.50	12.15	13.33	11.73	12.65	14.42	9.26	5.67	6.81
2007	5.30	6.54	5.19	7.64	8.71	13.31	12.22	14.91	14.60	8.37	10.00	7.50
2008	6.53	6.86	5.76	6.20	7.87	9.54	7.34	6.55	4.56	7.03	6.18	4.40
2009	3.97	4.16	4.48	7.49	8.95	12.18	10.79	9.24	8.71	8.00	6.37	4.42
2010	4.28	4.17	5.27	6.82	15.70	13.19	9.70	8.46	7.88	4.53	4.57	6.84

Table 5.4.3.5. The number of headboat trips catching cobia in the Gulf of Mexico per month and area. The Gulf of Mexico region includes all Florida fishing regions.

	Month											
Area	1	2	3	4	5	6	7	8	9	10	11	12
NORTH-EAST_FLORIDA	36	29	127	308	389	528	513	358	164	160	182	96
EAST_CENTRAL_FLORID	641	744	846	679	675	756	826	660	388	332	404	623
SOUTHEAST_FLORIDA	166	170	301	646	664	344	244	181	89	97	105	130
FL_KEYS_ATL_VESS	66	94	119	169	96	74	92	60	30	24	51	60
DRY_TORTUGAS	36	41	36	49	21	8	13	10	5	18	14	27
NAPLES-CRYSTAL_RIVER	63	59	79	81	52	54	52	43	53	97	51	81
FL_MIDDLE_GROUNDS	10	11	9	12	13	8	13	12	12	8	4	5
NW_FLORDIA_&_ALABAMA	10	8	9	105	186	271	318	216	125	90	38	8
LOUISIANA	12	21	33	117	392	499	470	334	297	264	157	44
NE_TX_SABNE-FREEPORT	22	25	39	100	431	672	744	594	253	157	40	5
CENTRAL_TX_PTARANSAS	63	70	71	253	656	766	791	550	304	171	58	28
SOUTH_TX_PTISABEL	6	11	6	24	66	134	159	149	61	35	36	6
	1131	1283	1675	2543	3641	4114	4235	3167	1781	1453	1140	1113

Table 5.4.3.6. The number of headboat trips in the Gulf of Mexico per month and area. The Gulf of Mexico region includes all Florida fishing regions.

	Month											
Area	1	2	3	4	5	6	7	8	9	10	11	12
NORTH-EAST_FLORIDA	242	381	880	1251	1344	1679	1792	1377	758	612	516	350
EAST_CENTRAL_FLORID	2137	2568	3439	3800	3811	4432	4952	4095	2295	1912	1829	2049
SOUTHEAST_FLORIDA	6324	6336	6954	7653	7712	7174	8001	7400	5638	5499	5333	5737
FL_KEYS_ATL_VESS	5168	4949	5303	4813	3768	4710	5351	4447	2136	2569	3535	3998
DRY_TORTUGAS	170	181	171	164	121	87	76	61	38	61	83	120
NAPLES-CRYSTAL_RIVER	6177	7005	8621	8111	6953	7088	7893	6589	4206	5223	5493	5526
FL_MIDDLE_GROUNDS	103	99	104	107	126	134	124	82	50	48	52	35
NW_FLORDIA_&_ALABAMA	570	1143	3170	5071	6617	9073	9753	6951	4019	3414	1044	613
LOUISIANA	121	149	258	416	806	965	1003	820	612	590	423	181
NE_TX_SABNE-FREEPORT	280	394	775	918	1536	2072	2524	2256	1332	877	310	132
CENTRAL_TX_PTARANSAS	957	1208	1687	1708	2713	3745	4567	3745	2163	1950	974	554
SOUTH_TX_PTISABEL	394	581	551	493	818	1311	1698	1370	694	498	231	289
	22643	24994	31913	34505	36325	42470	47734	39193	23941	23253	19823	19584

Table 5.4.3.7. The percentage of headboat trips catching cobia in the Gulf of Mexico per month and area. The Gulf of Mexico region includes all Florida fishing regions.

	Month											
Area	1	2	3	4	5	6	7	8	9	10	11	12
NORTH-EAST_FLORIDA	14.88	7.61	14.43	24.62	28.94	31.45	28.63	26.00	21.64	26.14	35.27	27.43
EAST_CENTRAL_FLORID	30.00	28.97	24.60	17.87	17.71	17.06	16.68	16.12	16.91	17.36	22.09	30.41
SOUTHEAST_FLORIDA	2.62	2.68	4.33	8.44	8.61	4.80	3.05	2.45	1.58	1.76	1.97	2.27
FL_KEYS_ATL_VESS	1.28	1.90	2.24	3.51	2.55	1.57	1.72	1.35	1.40	0.93	1.44	1.50
DRY_TORTUGAS	21.18	22.65	21.05	29.88	17.36	9.20	17.11	16.39	13.16	29.51	16.87	22.50
NAPLES-CRYSTAL_RIVER	1.02	0.84	0.92	1.00	0.75	0.76	0.66	0.65	1.26	1.86	0.93	1.47
FL_MIDDLE_GROUNDS	9.71	11.11	8.65	11.21	10.32	5.97	10.48	14.63	24.00	16.67	7.69	14.29
NW_FLORDIA_&_ALABAMA	1.75	0.70	0.28	2.07	2.81	2.99	3.26	3.11	3.11	2.64	3.64	1.31
LOUISIANA	9.92	14.09	12.79	28.13	48.64	51.71	46.86	40.73	48.53	44.75	37.12	24.31
NE_TX_SABNE-FREEPORT	7.86	6.35	5.03	10.89	28.06	32.43	29.48	26.33	18.99	17.90	12.90	3.79
CENTRAL_TX_PTARANSAS	6.58	5.79	4.21	14.81	24.18	20.45	17.32	14.69	14.05	8.77	5.95	5.05
SOUTH_TX_PTISABEL	1.52	1.89	1.09	4.87	8.07	10.22	9.36	10.88	8.79	7.03	15.58	2.08

Table 5.4.3.8. Fitted indices of abundance for the recreational surveys where effort represents all trips.

	HEADBOAT SURVEY								MRFSS SURVEY							
	Cobia				Spanish Mackerel				Cobia				Spanish Mackerel			
Year	Index	Lower CI	Uppder CI	CV	Index	Lower CI	Uppder CI	CV	Index	Lower CI	Uppder CI	CV	Index	Lower CI	Uppder CI	CV
1981									0.705	0.349	1.424	0.363	0.974	0.523	1.814	0.318
1982									0.898	0.546	1.476	0.252	1.292	0.784	2.131	0.254
1983									0.627	0.324	1.211	0.339	0.826	0.451	1.515	0.310
1984									0.605	0.335	1.092	0.302	0.631	0.325	1.223	0.340
1985									0.532	0.278	1.018	0.333	0.701	0.380	1.293	0.313
1986	0.576	0.411	0.808	0.170	0.816	0.432	1.544	0.327	0.495	0.316	0.775	0.227	1.906	1.256	2.892	0.211
1987	0.560	0.402	0.780	0.166	1.624	0.894	2.949	0.305	0.604	0.394	0.926	0.216	1.395	0.920	2.115	0.210
1988	0.563	0.403	0.785	0.168	0.505	0.263	0.970	0.335	0.860	0.554	1.336	0.223	0.802	0.514	1.252	0.225
1989	0.541	0.384	0.764	0.173	0.789	0.419	1.486	0.324	0.889	0.558	1.417	0.236	1.138	0.717	1.807	0.234
1990	0.709	0.513	0.979	0.162	0.998	0.556	1.793	0.299	1.350	0.885	2.059	0.213	1.851	1.199	2.856	0.219
1991	0.799	0.587	1.089	0.155	2.023	1.145	3.572	0.290	1.505	1.034	2.191	0.190	1.350	0.871	2.092	0.222
1992	0.910	0.700	1.183	0.132	1.288	0.722	2.301	0.296	1.032	0.747	1.425	0.163	1.408	0.976	2.031	0.185
1993	1.259	0.982	1.612	0.124	0.960	0.533	1.732	0.301	1.007	0.695	1.459	0.187	0.657	0.427	1.011	0.218
1994	1.136	0.879	1.467	0.129	1.292	0.726	2.298	0.294	1.440	1.021	2.030	0.173	0.613	0.406	0.926	0.208
1995	1.194	0.914	1.561	0.135	0.777	0.423	1.427	0.311	0.673	0.446	1.014	0.207	0.420	0.262	0.673	0.239
1996	1.147	0.860	1.530	0.145	0.777	0.422	1.431	0.313	1.406	1.004	1.970	0.170	0.736	0.477	1.134	0.219
1997	1.309	0.995	1.723	0.138	0.685	0.367	1.279	0.320	1.734	1.274	2.360	0.155	0.627	0.414	0.950	0.210
1998	1.069	0.801	1.427	0.145	0.353	0.181	0.686	0.342	1.241	0.914	1.686	0.154	0.772	0.521	1.146	0.199
1999	0.955	0.687	1.327	0.165	0.705	0.374	1.329	0.325	1.129	0.852	1.495	0.141	1.315	0.922	1.875	0.179
2000	0.777	0.554	1.089	0.170	1.044	0.568	1.916	0.311	0.915	0.679	1.233	0.150	0.960	0.667	1.383	0.184
2001	1.043	0.750	1.450	0.166	0.401	0.201	0.801	0.357	1.019	0.765	1.356	0.144	0.998	0.688	1.449	0.188
2002	0.980	0.702	1.367	0.168	0.789	0.421	1.481	0.323	1.030	0.777	1.365	0.142	0.912	0.630	1.320	0.186
2003	0.931	0.657	1.319	0.176	0.569	0.292	1.108	0.343	1.158	0.870	1.542	0.144	0.987	0.676	1.440	0.191
2004	1.005	0.718	1.408	0.169	0.523	0.273	1.003	0.334	0.978	0.729	1.312	0.148	1.063	0.738	1.532	0.184
2005	1.271	0.939	1.719	0.152	0.542	0.285	1.031	0.330	0.967	0.705	1.325	0.159	0.712	0.478	1.059	0.201
2006	1.105	0.802	1.522	0.161	1.011	0.544	1.880	0.318	0.889	0.650	1.216	0.158	0.871	0.594	1.277	0.193
2007	1.205	0.884	1.641	0.155	1.552	0.861	2.798	0.301	0.984	0.721	1.343	0.156	0.902	0.620	1.310	0.189
2008	1.153	0.845	1.575	0.157	1.961	1.099	3.498	0.296	1.164	0.864	1.569	0.150	1.003	0.687	1.464	0.191
2009	1.304	0.992	1.714	0.137	1.916	1.088	3.374	0.289	0.960	0.693	1.330	0.164	0.822	0.570	1.187	0.185
2010	1.498	1.133	1.981	0.140	1.098	0.603	2.001	0.307	1.205	0.871	1.666	0.163	1.354	0.923	1.987	0.193

Table 5.4.4.1. Annual number of trips catching cobia (i.e., positive trips), total trips, and the percent of trips capturing cobia in the GOM obtained from MRFSS, with the MRFSS dataset subset according to the cobia stock boundaries.

Year	Positive Trips	Total Trips	Percent Positive
1981	26	2469	1.05
1982	63	4636	1.36
1983	33	3066	1.08
1984	40	4003	1.00
1985	31	3963	0.78
1986	78	12548	0.62
1987	89	11939	0.75
1988	80	12904	0.62
1989	69	9660	0.71
1990	92	8614	1.07
1991	127	9635	1.32
1992	216	19914	1.08
1993	132	15728	0.84
1994	172	17778	0.97
1995	101	16040	0.63
1996	174	19946	0.87
1997	246	20791	1.18
1998	244	24399	1.00
1999	356	33054	1.08
2000	276	30764	0.90
2001	316	32193	0.98
2002	354	34225	1.03
2003	331	32963	1.00
2004	298	32771	0.91
2005	231	29855	0.77
2006	236	31840	0.74
2007	239	31553	0.76
2008	272	30309	0.90
2009	198	29717	0.67
2010	204	29551	0.69
Total	5324	596828	

Table 5.4.4.2. Annual number of trips catching cobia (i.e., positive trips), total trips, and the percentage of trips capturing cobia by year and state in the GOM obtained from MRFSS as partitioned for cobia.

	All Trips					Positive Trips					Percent Positive Trips				
Year	LA	MS	AL	West FL	East FL	LA	MS	AL	West FL	East FL	LA	MS	AL	West FL	East FL
1981	395	235	185	1008	646	9	2	5	10	0	2.28	0.85	2.70	0.99	0.00
1982	521	543	517	1564	1491	13	9	14	15	12	2.50	1.66	2.71	0.96	0.80
1983	434	196	266	860	1310	18	4	5	2	4	4.15	2.04	1.88	0.23	0.31
1984	690	300	295	960	1758	12	5	4	12	7	1.74	1.67	1.36	1.25	0.40
1985	910	179	339	1087	1448	7	1	6	10	7	0.77	0.56	1.77	0.92	0.48
1986	3417	709	674	3821	3927	24	8	4	36	6	0.70	1.13	0.59	0.94	0.15
1987	1256	804	855	5425	3599	10	11	18	36	14	0.80	1.37	2.11	0.66	0.39
1988	1804	938	613	5576	3973	6	11	4	48	11	0.33	1.17	0.65	0.86	0.28
1989	1212	668	548	3640	3592	2	5	7	41	14	0.17	0.75	1.28	1.13	0.39
1990	1156	528	386	3204	3340	21	9	13	35	14	1.82	1.70	3.37	1.09	0.42
1991	1275	609	626	3178	3947	27	12	21	55	12	2.12	1.97	3.35	1.73	0.30
1992	2886	1370	922	7900	6836	24	35	25	82	50	0.83	2.55	2.71	1.04	0.73
1993	1708	638	568	6915	5899	11	11	16	62	32	0.64	1.72	2.82	0.90	0.54
1994	1860	805	704	7723	6686	22	10	34	81	25	1.18	1.24	4.83	1.05	0.37
1995	1692	602	577	6827	6342	13	9	11	58	10	0.77	1.50	1.91	0.85	0.16
1996	2129	888	866	8760	7303	31	8	11	84	40	1.46	0.90	1.27	0.96	0.55
1997	2392	939	862	9036	7562	77	19	7	108	35	3.22	2.02	0.81	1.20	0.46
1998	2491	1021	1152	11092	8643	14	14	12	163	41	0.56	1.37	1.04	1.47	0.47
1999	3444	1457	1431	15735	10987	17	18	15	234	72	0.49	1.24	1.05	1.49	0.66
2000	3525	1202	1339	13846	10852	18	11	28	180	39	0.51	0.92	2.09	1.30	0.36
2001	3218	1003	1335	14385	12252	9	5	26	210	66	0.28	0.50	1.95	1.46	0.54
2002	3517	859	1222	15630	12997	28	16	22	228	60	0.80	1.86	1.80	1.46	0.46
2003	3262	1025	1223	15769	11684	36	8	14	196	77	1.10	0.78	1.14	1.24	0.66
2004	3787	1010	1086	16814	10074	38	8	15	187	50	1.00	0.79	1.38	1.11	0.50
2005	3217	693	1148	14677	10120	27	2	10	149	43	0.84	0.29	0.87	1.02	0.42
2006	3851	1029	1138	13928	11894	34	3	17	106	76	0.88	0.29	1.49	0.76	0.64
2007	3826	1071	1234	14595	10827	33	7	15	135	49	0.86	0.65	1.22	0.92	0.45
2008	4237	1116	1159	14501	9296	16	8	12	188	48	0.38	0.72	1.04	1.30	0.52
2009	3819	1137	1302	14950	8509	10	6	13	110	59	0.26	0.53	1.00	0.74	0.69
2010	3395	919	1165	14844	9228	1	1	6	117	79	0.03	0.11	0.52	0.79	0.86
Total	71326	24493	25737	268250	207022	608	276	410	2978	1052	0.85	1.13	1.59	1.11	0.51

Table 5.4.4.3. Annual number of total trips per month in the GOM from the MRFSS database as subset for cobia.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1981				197	223	248	232	616	199	441	238	75
1982			165	254	615	662	790	747	250	595	324	234
1983	139	156	219	367	314	545	255	292	143	302	231	103
1984	54	530	373	337	570	533	439	133	394	192	351	97
1985	109	176	471	212	417	493	367	287	373	339	411	308
1986	398	932	673	1157	1094	1412	1445	1137	1177	1026	1079	1018
1987	703	998	941	1224	1243	1278	1414	1014	1163	821	685	455
1988	457	627	692	609	1004	904	1548	1386	1416	1880	1217	1164
1989	733	569	870	665	1301	604	1108	1025	911	649	898	327
1990	148	769	729	808	890	856	859	763	850	525	764	653
1991	622	604	594	817	935	1170	905	828	904	826	825	605
1992	958	1406	1422	2458	2527	1272	2321	1384	1303	2095	1381	1387
1993		1872	1521	981	1645	1507	1591	1622	1348	1146	1530	965
1994	1330	1722	1426	1307	1600	2013	1845	1450	1415	1306	1228	1136
1995	1370	1293	1378	1170	1514	1692	1452	1490	1462	1129	1099	991
1996	992	1093	1409	1887	1825	1967	1654	2118	1526	2266	1667	1542
1997	1233	1256	1788	1466	2179	2118	1888	1726	1882	2007	1869	1379
1998	1593	1358	1602	1868	2056	1944	2513	2794	1037	2042	2840	2752
1999	3313	3202	3685	3956	2286	2590	3111	2801	1817	2178	2356	1759
2000	1812	2548	2244	3278	3225	3337	2914	2577	2425	2417	2171	1816
2001	2404	2287	2595	2810	2951	3144	3186	2997	2832	2140	2487	2360
2002	2256	2085	3193	3370	3206	3309	3386	3183	2602	2981	2381	2273
2003	2051	2989	3267	3113	3488	3401	3326	2685	2251	2338	2281	1773
2004	2030	2172	2965	3134	3299	3367	3407	2842	1698	3433	2419	2005
2005	2391	2036	2766	3059	3535	3052	2911	2645	1762	1725	1889	2084
2006	2349	2182	2704	3335	2795	2978	3030	2949	2698	2393	2187	2240
2007	2114	1992	2653	2778	3047	3330	3029	2917	2515	2190	2647	2341
2008	1859	2497	2928	2455	2965	3247	2935	2346	2071	2529	2350	2127
2009	2221	1998	2281	2962	3245	2754	2902	2712	2507	2476	2303	1356
2010	1552	1739	2308	3036	3386	2949	2750	2628	2863	2473	2379	1488
Total	37191	43088	49862	55070	59380	58676	59513	54094	45794	48860	46487	38813

Table 5.4.4.4. Annual number of trips capturing cobia per month in the GOM from the MRFSS database.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1981				0	2	8	6	5	1	3	1	0
1982			2	3	14	9	18	7	5	2	1	2
1983	0	0	0	1	8	9	7	2	0	2	4	0
1984	1	5	0	4	6	11	7	2	2	2	0	0
1985	1	4	0	2	5	2	10	3	2	2	0	0
1986	1	3	5	6	13	10	8	8	11	7	1	5
1987	3	3	2	7	21	16	8	13	11	5	0	0
1988	1	2	0	2	10	14	9	13	13	7	7	2
1989	1	4	8	5	19	7	5	5	11	3	1	0
1990	0	2	5	7	11	14	8	13	16	9	3	4
1991	6	8	2	7	15	18	24	8	16	14	9	0
1992	9	6	8	26	31	16	55	28	10	16	7	4
1993		2	6	7	27	20	14	19	20	7	6	4
1994	3	3	5	19	14	44	31	21	19	5	6	2
1995	1	2	5	13	21	11	8	11	21	3	3	2
1996	5	3	8	27	24	17	13	20	6	28	13	10
1997	4	3	33	21	45	18	36	20	34	16	11	5
1998	6	4	18	13	28	21	34	43	16	18	28	15
1999	12	27	30	71	46	27	44	29	31	15	15	9
2000	4	9	13	48	47	27	29	31	29	12	18	9
2001	13	20	27	42	31	41	36	44	27	12	14	9
2002	26	11	23	49	46	65	43	25	25	26	10	5
2003	12	12	45	37	56	40	34	27	28	19	18	3
2004	6	11	13	57	40	29	39	33	11	31	18	10
2005	5	4	20	31	43	27	33	21	15	9	14	9
2006	3	18	16	27	29	35	35	33	19	10	8	3
2007	4	9	11	36	27	35	27	30	22	15	9	14
2008	10	25	7	27	29	40	34	24	27	22	18	9
2009	2	2	20	15	26	40	23	24	24	13	5	4
2010	11	6	10	26	47	41	17	15	14	10	2	5
Total	150	208	342	636	781	712	695	577	486	343	250	144

Table 5.4.4.5. Annual percentage of trips capturing cobia per month in the GOM from the MRFSS database.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1981	0.00	0.00	0.00	0.00	0.90	3.23	2.59	0.81	0.50	0.68	0.42	0.00
1982	0.00	0.00	1.21	1.18	2.28	1.36	2.28	0.94	2.00	0.34	0.31	0.85
1983	0.00	0.00	0.00	0.27	2.55	1.65	2.75	0.68	0.00	0.66	1.73	0.00
1984	1.85	0.94	0.00	1.19	1.05	2.06	1.59	1.50	0.51	1.04	0.00	0.00
1985	0.92	2.27	0.00	0.94	1.20	0.41	2.72	1.05	0.54	0.59	0.00	0.00
1986	0.25	0.32	0.74	0.52	1.19	0.71	0.55	0.70	0.93	0.68	0.09	0.49
1987	0.43	0.30	0.21	0.57	1.69	1.25	0.57	1.28	0.95	0.61	0.00	0.00
1988	0.22	0.32	0.00	0.33	1.00	1.55	0.58	0.94	0.92	0.37	0.58	0.17
1989	0.14	0.70	0.92	0.75	1.46	1.16	0.45	0.49	1.21	0.46	0.11	0.00
1990	0.00	0.26	0.69	0.87	1.24	1.64	0.93	1.70	1.88	1.71	0.39	0.61
1991	0.96	1.32	0.34	0.86	1.60	1.54	2.65	0.97	1.77	1.69	1.09	0.00
1992	0.94	0.43	0.56	1.06	1.23	1.26	2.37	2.02	0.77	0.76	0.51	0.29
1993	0.00	0.11	0.39	0.71	1.64	1.33	0.88	1.17	1.48	0.61	0.39	0.41
1994	0.23	0.17	0.35	1.45	0.88	2.19	1.68	1.45	1.34	0.38	0.49	0.18
1995	0.07	0.15	0.36	1.11	1.39	0.65	0.55	0.74	1.44	0.27	0.27	0.20
1996	0.50	0.27	0.57	1.43	1.32	0.86	0.79	0.94	0.39	1.24	0.78	0.65
1997	0.32	0.24	1.85	1.43	2.07	0.85	1.91	1.16	1.81	0.80	0.59	0.36
1998	0.38	0.29	1.12	0.70	1.36	1.08	1.35	1.54	1.54	0.88	0.99	0.55
1999	0.36	0.84	0.81	1.79	2.01	1.04	1.41	1.04	1.71	0.69	0.64	0.51
2000	0.22	0.35	0.58	1.46	1.46	0.81	1.00	1.20	1.20	0.50	0.83	0.50
2001	0.54	0.87	1.04	1.49	1.05	1.30	1.13	1.47	0.95	0.56	0.56	0.38
2002	1.15	0.53	0.72	1.45	1.43	1.96	1.27	0.79	0.96	0.87	0.42	0.22
2003	0.59	0.40	1.38	1.19	1.61	1.18	1.02	1.01	1.24	0.81	0.79	0.17
2004	0.30	0.51	0.44	1.82	1.21	0.86	1.14	1.16	0.65	0.90	0.74	0.50
2005	0.21	0.20	0.72	1.01	1.22	0.88	1.13	0.79	0.85	0.52	0.74	0.43
2006	0.13	0.82	0.59	0.81	1.04	1.18	1.16	1.12	0.70	0.42	0.37	0.13
2007	0.19	0.45	0.41	1.30	0.89	1.05	0.89	1.03	0.87	0.68	0.34	0.60
2008	0.54	1.00	0.24	1.10	0.98	1.23	1.16	1.02	1.30	0.87	0.77	0.42
2009	0.09	0.10	0.88	0.51	0.80	1.45	0.79	0.88	0.96	0.53	0.22	0.29
2010	0.71	0.35	0.43	0.86	1.39	1.39	0.62	0.57	0.49	0.40	0.08	0.34
Total	0.40	0.48	0.69	1.15	1.32	1.21	1.17	1.07	1.06	0.70	0.54	0.37

Table 5.4.4.6. Annual number of total trips, trips catching cobia (i.e., positive trips), and the percentage of trips capturing cobia by year and area in the GOM obtained from MRFSS as partitioned for cobia

	Total number of trips					Positive trips					Percent positive trips				
Year	ocean <3 miles	ocean > 3miles	ocean <10 miles	ocean>1 0miles	inshore	ocean <3 miles	ocean > 3miles	ocean <10 miles	ocean>1 0miles	inshore	ocean <3 miles	ocean > 3miles	ocean <10 miles	ocean>1 0miles	inshore
1981	1156	482	2135	461	2309	3	13	10	2	0	0.26	2.70	0.47	0.43	0.00
1982	3615	774	3706	283	3173	22	30	18	2	1	0.61	3.88	0.49	0.71	0.03
1983	3019	1233	2984	588	2385	5	34	1	1	0	0.17	2.76	0.03	0.17	0.00
1984	3337	1164	3323	554	3122	13	22	11	2	2	0.39	1.89	0.33	0.36	0.06
1985	2703	888	3461	819	3745	10	14	7	5	0	0.37	1.58	0.20	0.61	0.00
1986	2809	2033	3449	713	5118	9	30	23	13	1	0.32	1.48	0.67	1.82	0.02
1987	2416	1684	4621	923	4175	13	29	25	8	6	0.54	1.72	0.54	0.87	0.14
1988	2786	1907	4574	1002	6970	10	18	28	16	7	0.36	0.94	0.61	1.60	0.10
1989	2616	1891	2969	557	5044	11	19	20	12	12	0.42	1.00	0.67	2.15	0.24
1990	2694	1630	2353	472	4326	13	38	15	6	18	0.48	2.33	0.64	1.27	0.42
1991	3378	1697	2325	397	4821	12	51	34	15	15	0.36	3.01	1.46	3.78	0.31
1992	5038	3135	4823	1087	13172	14	82	48	19	32	0.28	2.62	1.00	1.75	0.24
1993	5154	2156	5666	1208	13748	19	44	38	15	22	0.37	2.04	0.67	1.24	0.16
1994	6603	2323	6553	1054	14827	13	69	40	22	44	0.20	2.97	0.61	2.09	0.30
1995	5829	2099	5412	1091	14563	11	29	52	6	15	0.19	1.38	0.96	0.55	0.10
1996	4788	2529	4789	1549	14051	27	49	55	17	45	0.56	1.94	1.15	1.10	0.32
1997	5011	2833	5396	1089	14096	21	70	67	23	84	0.42	2.47	1.24	2.11	0.60
1998	4933	3137	5450	1944	17812	20	52	76	45	65	0.41	1.66	1.39	2.31	0.36
1999	6365	3969	8313	3831	22634	25	91	138	49	68	0.39	2.29	1.66	1.28	0.30
2000	5706	3739	7260	3581	20114	18	68	83	61	57	0.32	1.82	1.14	1.70	0.28
2001	6096	3846	7626	3420	20922	30	69	95	67	71	0.49	1.79	1.25	1.96	0.34
2002	7335	3982	7584	3739	22516	26	88	117	63	71	0.35	2.21	1.54	1.68	0.32
2003	6999	3695	7714	3964	22367	24	99	78	88	48	0.34	2.68	1.01	2.22	0.21
2004	5930	3043	7812	3925	21953	21	79	70	85	43	0.35	2.60	0.90	2.17	0.20
2005	5613	2626	7065	3083	21825	14	62	77	56	23	0.25	2.36	1.09	1.82	0.11
2006	5650	3129	7715	2586	22451	29	94	61	37	17	0.51	3.00	0.79	1.43	0.08
2007	6167	2544	7243	2558	23507	14	81	73	39	31	0.23	3.18	1.01	1.52	0.13
2008	4740	2275	7435	2485	22752	18	55	108	54	53	0.38	2.42	1.45	2.17	0.23
2009	4760	1995	6604	1806	24501	9	36	37	15	16	0.19	1.80	0.56	0.83	0.07
2010	5434	1568	5964	1904	24204	31	46	73	25	28	0.57	2.93	1.22	1.31	0.12

Table 5.4.4.7. Annual number of trips catching cobia (i.e., positive trips) and total trips per mode in the Gulf of Mexico obtained from MRFSS as partitioned for cobia. Modes are as follows: 3 - Charter and 4 – Private/Rental.

	All Trips		Positive Trips		Percentage Positive Trips	
Year	Charter	Private/ Rental	Charter	Private/ Rental	Charter	Private/ Rental
1981	278	2191	10	16	3.60	0.73
1982	206	4430	6	57	2.91	1.29
1983	598	2468	18	15	3.01	0.61
1984	793	3210	20	20	2.52	0.62
1985	479	3484	12	19	2.51	0.55
1986	2027	10521	40	38	1.97	0.36
1987	1317	10622	29	60	2.20	0.56
1988	1576	11328	24	56	1.52	0.49
1989	1361	8299	22	47	1.62	0.57
1990	1154	7460	28	64	2.43	0.86
1991	1280	8355	60	67	4.69	0.80
1992	2281	17633	67	149	2.94	0.85
1993	1480	14248	33	99	2.23	0.69
1994	1413	16365	50	122	3.54	0.75
1995	1255	14785	28	73	2.23	0.49
1996	1555	18391	57	117	3.67	0.64
1997	2381	18410	61	185	2.56	1.00
1998	3641	20758	75	169	2.06	0.81
1999	5770	27284	118	238	2.05	0.87
2000	6523	24241	118	158	1.81	0.65
2001	5723	26470	143	173	2.50	0.65
2002	6208	28017	151	203	2.43	0.72
2003	6308	26655	155	176	2.46	0.66
2004	6000	26771	169	129	2.82	0.48
2005	5181	24674	116	115	2.24	0.47
2006	4165	27675	105	131	2.52	0.47
2007	4266	27287	108	131	2.53	0.48
2008	4055	26254	119	153	2.93	0.58
2009	3364	26353	61	137	1.81	0.52
2010	3670	25881	73	131	1.99	0.51
Total	86308	510520	2076	3248	2.41	0.64

5.6 Figures

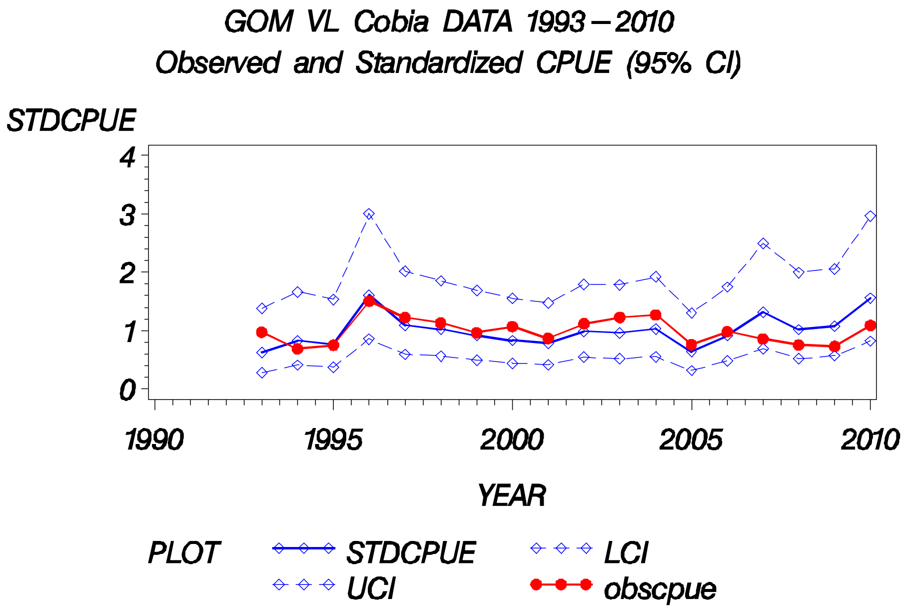


Figure 5.4.2.1. Cobia nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing Vertical line gear in the Gulf of Mexico.

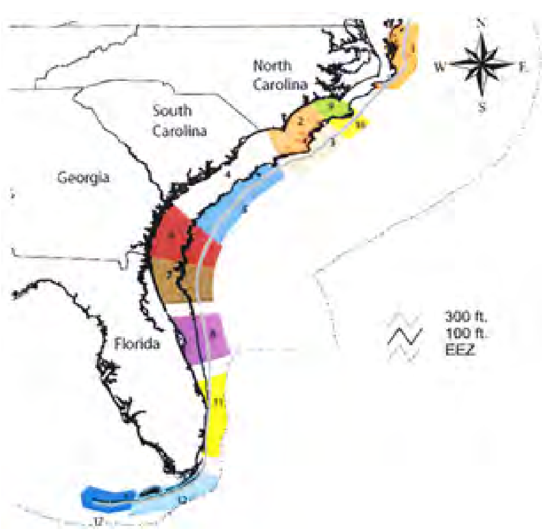


Figure 5.4.3.1. Map of headboat statistical areas.

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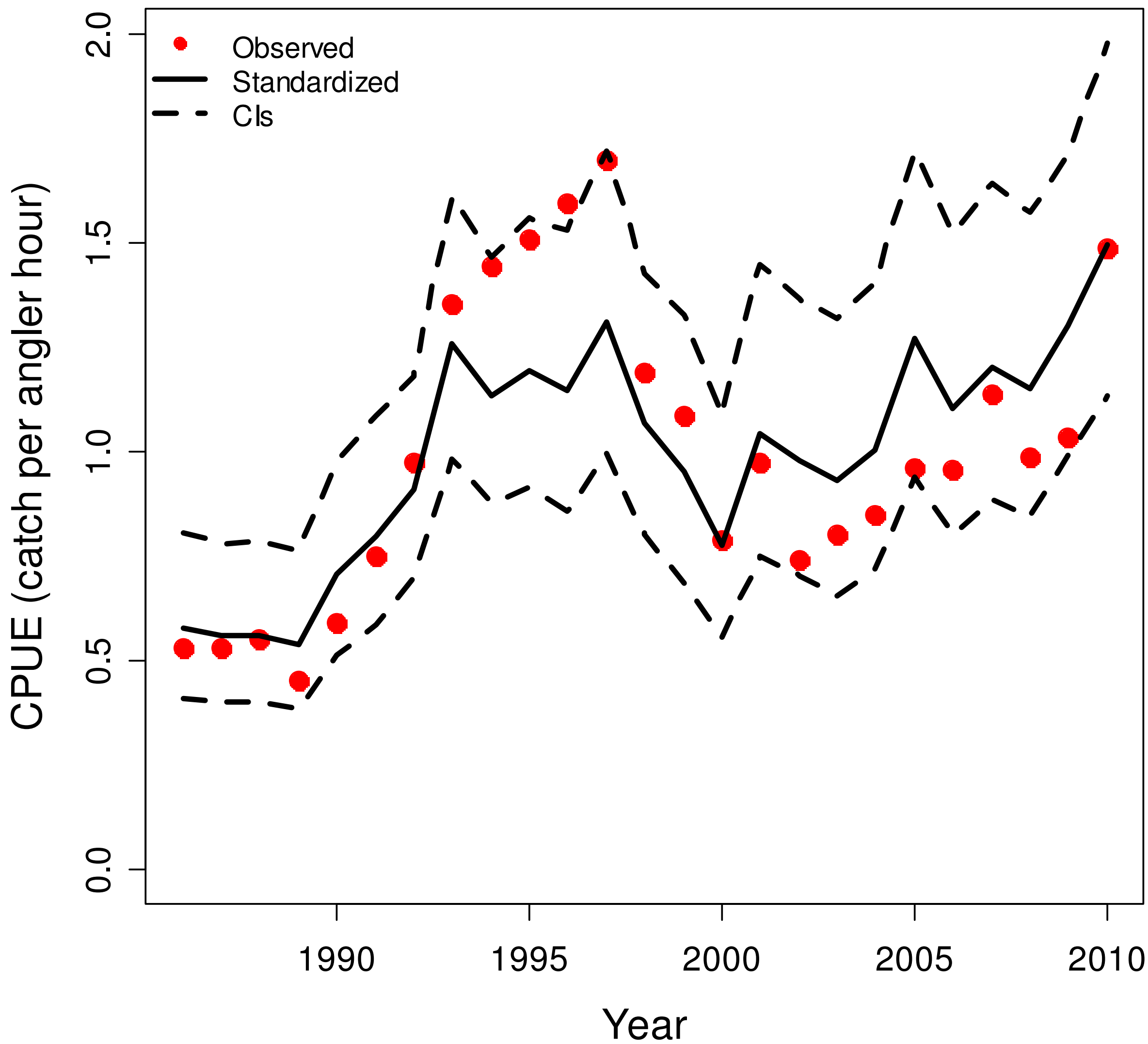


Figure 5.4.3.2. Nominal (observed) and standardized CPUE and the 95% confidence intervals for cobia from the Headboat Survey in the GOM. CPUE values were normalized by the mean.

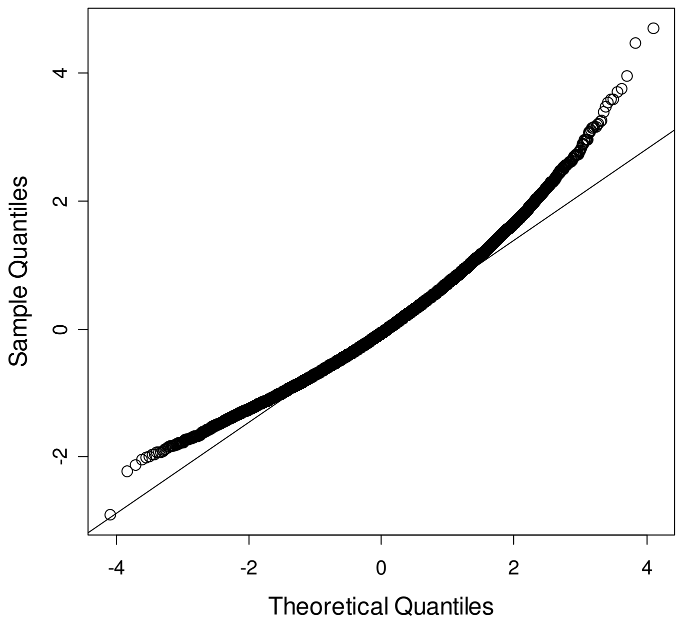


Figure 5.4.3.3. Q-Q plot of CPUE for cobia in the GOM Headboat Survey.

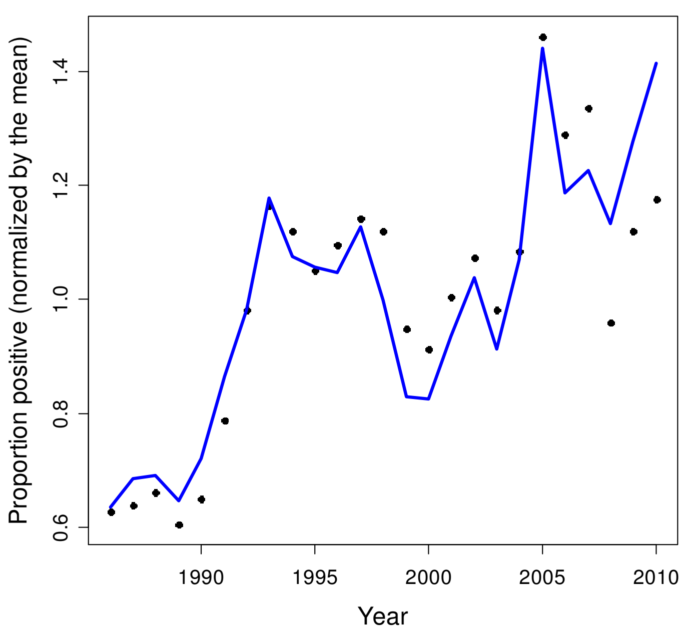


Figure 5.4.3.4. Observed proportion of trips catching cobia (black points) and the binomial model fit (blue line) to the data normalized by the mean for the Headboat Survey.

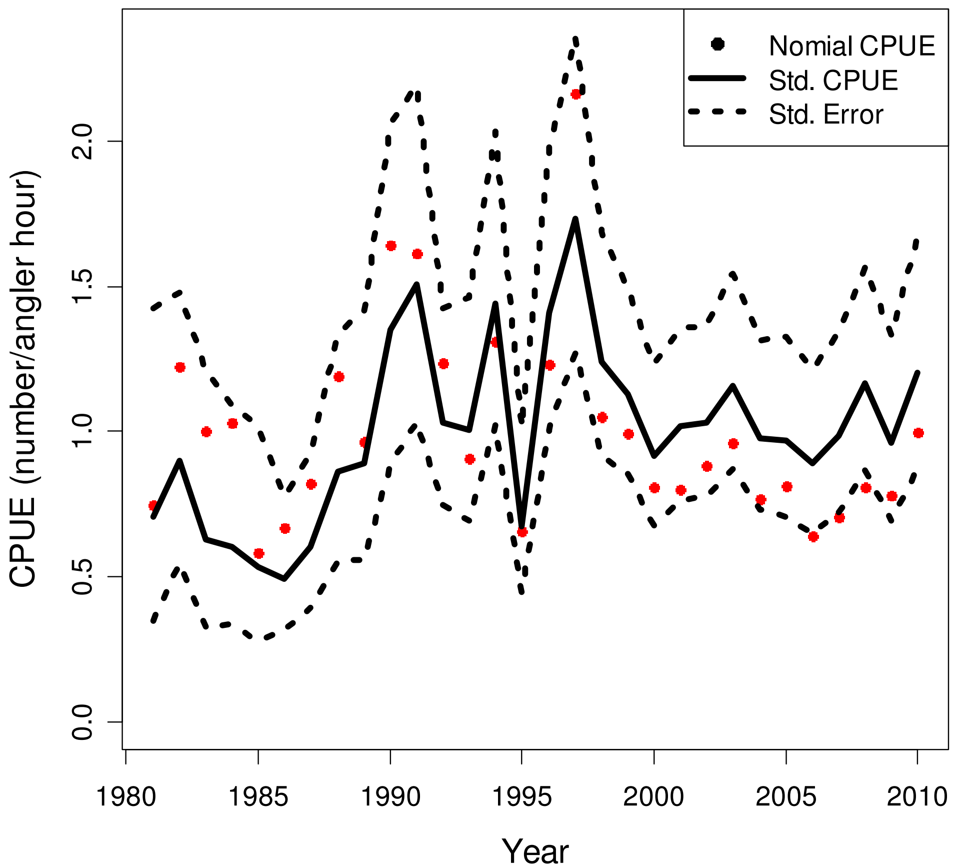


Figure 5.4.4.1. Nominal (observed) and standardized CPUE and the 95% confidence intervals for cobia from MRFSS in the GOM. CPUE values were normalized by the mean.

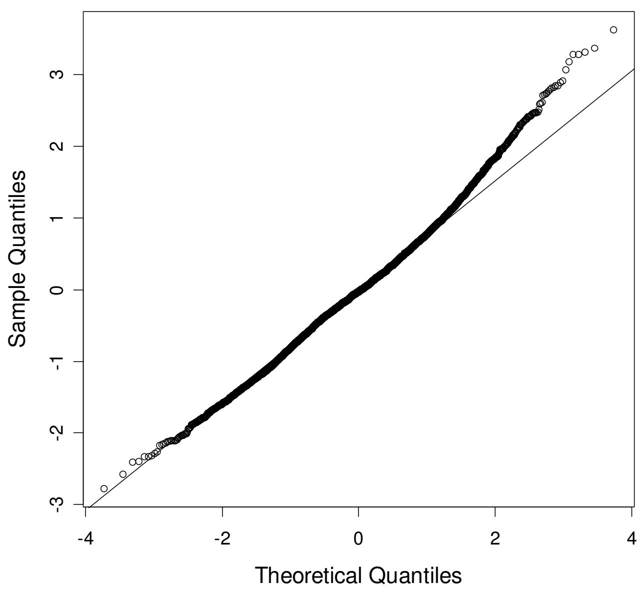


Figure 5.4.4.2. Q-Q plot of CPUE for cobia in the GOM MRFSS Survey.

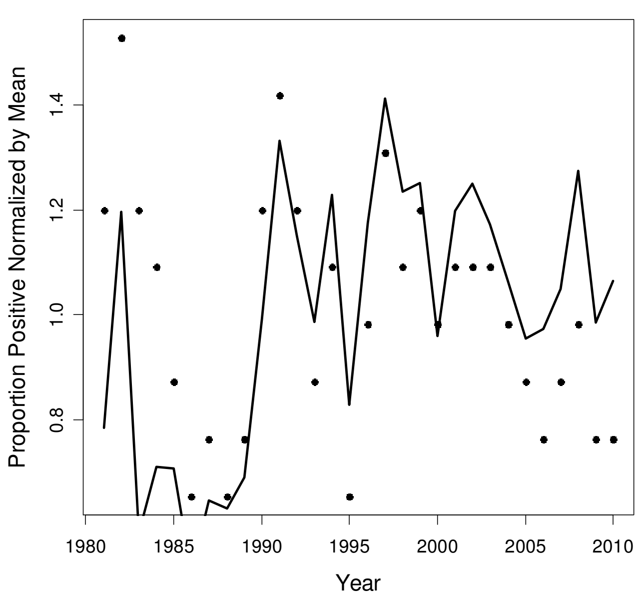


Figure 5.4.4.3. Observed proportion of trips catching cobia (black points) and the binomial model fit (blue line) to the data normalized by the mean for MRFSS.

6 Analytic Approach

Suggested analytic approach given the data –Gulf of Mexico cobia

The data workshop panel discussed data sources, data quality and data quantity. We determined that landings data are complete from 1981 through 2010, and that preliminary landings for 2011 would be available for the assessment workshop for recreational and commercial fisheries. However, the panel concluded that size composition and age composition data were lacking. Consequently, the analysts recommended updated population analyses should be conducted using the ASPIC production model (ASPIC 5.0 Suite of software). ASPIC data inputs will be limited to updated time series of landings and discards over the period of corresponding CPUE abundance trends. The ASPIC model requires initial estimates for the parameters: B1/K, MSY, K and fishery specific selectivities (q's). All initial runs should allow the program to estimate the above mentioned parameters. ASPIC estimates BMSY as K/2 and FMSY as MSY/BMSY. Prager et al. 1996 and Prager 1994 provide describe the parameter estimating equations and the model fitting process in detail. Time series of abundance trends, fisheries landings and discard data used in the ASPIC model corresponded to 1) the recreational headboat, charter and private angler (MRFSS + headboat + TPWD landings; MRFSS cpue index), 2) the commercial fishery (all gears combined landings; vertical line cpue index), and 3) the shrimp bycatch (Bayesian estimates of median age 1+ shrimp bycatch; SEMAP cpue index) . The analyses will include the years 1981-2011. The Continuity case evaluations will be conducted using updated data presented in the previous cobia assessment (Williams 2002) and will be conducted using SS3. Initial ASPIC model analyses will assume equal index weighting and a penalty term for the B1/K >1.0 (penalty term=10). Sensitivity analyses will be conducted to evaluate the ASPIC model results to a variety of scenario inputs that included: 1) varying assumptions for discard release mortality (0 % and 30%), 2) varying the initial input values for beginning stock size to virgin stock size level (i.e., the B1/K ASPIC model parameter), and 3) evaluating the impact on ASPIC model results to choice of index weighting options (i.e., equal index weighting or relative catch proportional index weighting).

7 Research Recommendations

7.1 Life History

1. Implement a tagging study along the entire east coast of Florida and evaluate genetic samples from the same to determine more precise stock boundaries.
2. Explore the feasibility of satellite tags for Cobia movement studies.
3. Provide genetic sampling kits to interested groups to better understand the stock division line between the Gulf and Atlantic Cobia stocks. Possible collectors of genetic samples could include Charter operators, fishing clubs and state fisheries personnel.
4. Recommend developing a tagging program for inshore and offshore South Atlantic Cobia populations. The goal would be to deploy tags inshore during the spring migration and offshore during the fall and winter to get a clearer picture of fall and spring migrations and to better identify spawning areas and aggregations.
5. Conduct research on cobia release mortality.

6. To increase overall amount of data available, have port samplers do complete workups when sampling, including otolith removal for aging, length, weight, sex, genetic sampling and record a catch location.

7.2 Commercial Statistics

Decision 10. The WG determined the following recommendations be added to any pending recommendations issued in SEDAR 17 that have not been addressed.

•Need expanded observer coverage for the fisheries encountering cobia
 – 5-10% allocated by strata within states
 – get maximum information from fish
•Need research methods that capture cobia in large enough numbers to create a reasonable index for young (age 0) cobia
•Expand TIP sampling to better cover all statistical strata
 – Predominantly from Florida and by hand line
 – Greater emphasis on collecting unbiased samples
•Establish a mechanism for identifying age samples that were collected by length or market categories, so as to better address any potential bias in age compositions.
•Need better information on migration patterns
•Need to address issue of fish retained for bait (undersized) or used for food by crew (how to capture in landings)
•Compiling commercial data is surprisingly complex. As this is the 28th SEDAR, one might expect that many of the complications would have been resolved by now through better coordination among NMFS, ACCSP, and the states. Increased attention should be given toward the goal of "one-stop shopping" for commercial data.

7.3 Recreational Statistics

1) Increase proportion of fish with biological data within MRFSS sampling.

2) Continue to develop methods to collect a higher degree of information on released fish (length, condition, etc.) in the recreational fishery.

3) Require mandatory reporting for all charter boats state and federal.

4) Continue development of electronic mandatory reporting for for-hire sector.

5) Continued research efforts to incorporate/require logbook reporting from recreational anglers.

6) Establish a review panel to evaluate methods for reconstructing historical landings (SWAS, FWS, etc.).

7) Quantify historical fishing photos for use in reconstructing recreational historical landings.

8) Narrow down the sampling universe. Identify angler preference and 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. This would allow the managers to identify what anglers were fishing for.

9) Continue and expand fishery dependent at-sea-observer surveys to collect discard information, which would provide for a more accurate index of abundance.

7.4 Indices

None provided.

Section 5 Appendix – Index Report Cards

Appendix 5.1 SEAMAP Groundfish Trawl Index

Appendix 5.2 Texas Parks and Wildlife Index

Appendix 5.3 Commercial Logbook, Vertical Line

Appendix 5.4 Headboat Index

Appendix 5.5 MRFSS Index

Appendix 5.1
Gulf of Mexico Cobia
SEAMAP Trawl Index

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

Item	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

Item	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

Item	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:

SEDAR28-DW03

SEAMAP Groundfish Survey - Cobia

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
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)

Item	Not Applicable	Absent	Incomplete	Complete
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

Item	Not Applicable	Absent	Incomplete	Complete
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-E. Available on Demand

4A. Ingram et al. method

4B-G. Available on Demand.

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

	Not Applicable	Absent	Incomplete	Complete
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

	Not Applicable	Absent	Incomplete	Complete
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

	Not Applicable	Absent	Incomplete	Complete
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

	Not Applicable	Absent	Incomplete	Complete
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:

2A-B,D-F. Available on Demand.

4A-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	02/07/2012	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 indices group requested an attempt at the development of abundance indices of cobia using the zero-inflated delta-lognormal method of Ingram et al. (2010). Due to timing of the request, the diagnostics were not provided in the document, but are available on request. Ultimately, the index was deemed unusable due to the low number of cobia collected each year during groundfish surveys.

Ingram, G.W., Jr., W.J. Richards, J.T. Lamkin and B. Muhling. 2010. Annual indices of Atlantic bluefin tuna (Thunnus thynnus) larvae in the Gulf of Mexico developed using delta-lognormal and multivariate models. Aquat. Living Resour. Vol. 23, Issue 1, pp. 35-47.

Reset Fields

Appendix 5.2
Gulf of Mexico Cobia
TPWD Index

DESCRIPTION OF THE DATA SOURCE

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
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.).				✓	Rec, bay, creel, TX
B. Describe any changes to reporting requirements, variables reported, etc.				✓	consistent
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓	date, catch, effort
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓	see size comp report

METHODS

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
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.				✓	eliminated bays
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓	Ran w/ and w/o S&M
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓	Plotted, 2 SE.

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓	Management was constant over index period
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)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓	Data set description provided.
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

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe model structure (e.g. delta-lognormal)				✓	
B. Describe construction of GLM components (e.g. forward selection from null etc.)			✓		Details provided upon questioning.
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.				✓	

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	Working Group Comments:
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					Poisson component not explored.
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.	✓				***The feasibility of this diagnostic is still under review.***
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.	✓				

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	2/15/2012	Do not include		
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 TPWD Survey is dominated by bay samples. However, no cobia were caught in bays. The data set was reduced to the nearshore Gulf of Mexico habitat samples, reducing the number of trips by over 90%. The Species Association Approach (Stephens and McCall 2004) was explored to try and identify directed cobia trips; however, this approach did not converge. A number of “ad hoc” approaches to subset directed trips for cobia from the TPWD Survey data were explored; however, these approaches were abandoned because either appropriate subsets could not be identified, they eliminated too many trips leading to the same conclusion as the Species Association Approach, or were not thought to be empirically defensible. An index was constructed using the Delta lognormal approach for the database of nearshore trips, and an index was constructed using a subset of only positive trips using a lognormal model.

The number of cobia observed in the survey was extremely small. Consequently, the addition or deletion of a single fish had a drastic impact on the index. Due to the low cpue and high sensitivity of the index, the working group voted to not include the index in the assessment.

Appendix 5.3
Gulf of Mexico Cobia
Comm. Logbook, Vert Line Index

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

Item	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

Item	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

Item	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:

2D unknown, data are pounds landed no size data reported - presume legal size with few sublegal

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
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)

	Not Applicable	Absent	Incomplete	Complete
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

	Not Applicable	Absent	Incomplete	Complete
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:

2D. Only 1 day trips were used to accommodate 2 fish/person trip limit.

3A-E. confidential data.

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:

1.B,C. 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	2/6/12	not recommended		
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

This index was not recommended for use. There was concern that with the 2 fish per person/per day(and trip) trip limit that the total legal-sized cobia landed during the trip could not be accounted for. This would mask any changes in abundance. There was also concern that since cobia most often an opportunistic fishery, that the effort could not be apportioned to the time spent targeting cobia.

Reset Fields

Appendix 5.4
Gulf of Mexico Cobia
Headboat Index

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

Item	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

Item	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

Item	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:

2D. Absent, but available

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
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)

	Not Applicable	Absent	Incomplete	Complete
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

	Not Applicable	Absent	Incomplete	Complete
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.				✓

3A-D. Confidential data

4F. Available on Demand

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
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.	✓				***The feasibility of this diagnostic is still under review.***
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.	✓				

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	02/06/2012	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 Species Association Approach (Stephens and McCall 2004) was explored to try and identify directed cobia trips however this approach did not properly converge for either of these species and eliminated too many trips indiscriminately. Some possible reasons for this could be because cobia are often not targeted directly. Instead, these species are caught more opportunistically, meaning they are either encountered by chance when targeting another species, or may be caught by making a brief stop while in transit between ports and offshore fishing grounds. A number of "ad hoc" approaches to subset directed trips for cobia from the Headboat Survey data were explored by the Indices Group at the data workshop, however, these approaches were abandoned because either appropriate subsets could not be identified, they eliminated too many trips leading to the same conclusion as the Species Association Approach, or were not thought to be empirically defensible. Due to the inability to use this approach, an index was constructed using the Delta lognormal approach for the entire database of all trips, and an index was constructed using a subset of only positive trips using a lognormal model. The Indices Group decided to use the indices of all trips and accepted the Gulf Headboat Survey index for cobia for recommendation.

Appendix 5.5
Gulf of Mexico Cobia
MRFSS Index

DESCRIPTION OF THE DATA SOURCE

Working Group Comments:

1. Fishery Independent Indices

Item	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

Item	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

Item	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?				✓

2. Management Regulations (for FD Indices)	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
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.				✓	

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
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.	✓				***The feasibility of this diagnostic is still under review.***
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.	✓				

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	02/06/2012	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 Species Association Approach (Stephens and McCall 2004) was explored to try and identify directed cobia trips however this approach did not properly converge for either of these species and eliminated too many trips indiscriminately. A number of "ad hoc" approaches to subset directed trips for cobia from the MRFSS Survey data were explored by the Indices Group at the data workshop, however, these approaches were abandoned because either appropriate subsets could not be identified, they eliminated too many trips leading to the same conclusion as the Species Association Approach, or were not thought to be empirically defensible. Due to the inability to use this approach, an index was constructed using the Delta lognormal approach for the entire database of all trips, and an index was constructed using a subset of only positive trips using a lognormal model. The Indices Group decided to use the indices of all trips and accepted the cobia MRFSS index for recommendation. This index was particularly favored because it presents a long time series.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 28

Gulf of Mexico Cobia

SECTION III: Assessment Process Report

December 2012

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

Table of Contents

1. WORKSHOP PROCEEDINGS

1.1. Introduction

1.1.1 Workshop time and Place

1.1.2 Terms of Reference

1. Review and provide justifications for any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model.
2. Recommend a model configuration which is deemed most reliable for providing management advice using available compatible data. Document all input data, assumptions, and equations.
3. Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.
4. Provide estimates of stock population parameters
   - Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as appropriate given data availability and modeling approaches
   - Include appropriate and representative measures of precision for parameter estimates.
5. Characterize uncertainty in the assessment and estimated values
   - Consider components such as input data, modeling approach, and model configuration.
   - Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
6. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.
7. Provide estimates of stock status relative to management criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards for each model run presented for review.
8. Project future stock conditions and develop rebuilding schedules if warranted; include estimated generation time. Develop stock projections in accordance with the following:

   A) If stock is overfished:

      F=0, F=current, F=Fmsy, Ftarget (OY),

      F=Frebuild (max that rebuild in allowed time)

   B) If stock is undergoing overfishing

      F=Fcurrent, F=Fmsy, F= Ftarget (OY)

   C) If stock is neither overfished nor overfishing

      F=Fcurrent, F=Fmsy, F=Ftarget (OY)

   D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice
9. Provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.
   - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments for use with the Tier 1 ABC control rule

- Provide justification for the weightings used in producing combinations of models

10. Provide recommendations for future research and data collection. Be as specific as possible in describing sampling design and intensity, and emphasize items which will improve assessment capabilities and reliability. Recommend the interval and type for the next assessment.
11. Prepare a spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.
12. Complete the Assessment Workshop Report (Section III: SEDAR Stock Assessment Report).

1.2. Panel recommendations and comments

1.2.1. Term of Reference 1

Review and provide justifications for any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model.

All changes to the data following the data workshop are reviewed in Section 2. The primary changes include 1) aggregating landings, discard, and length composition data into three fishing fleets; commercial, recreational and shrimping bycatch, 2) making the age composition data conditional on length, 3) removing a number of samples from the length composition data that were either mis-specified units or not representative of the fishery, and 4) adding the reef fish observer length composition data.

1.2.2. Term of Reference 2

Recommend a model configuration which is deemed most reliable for providing management advice using available compatible data. Document all input data, assumptions, and equations.

A fully integrated length based statistical-catch-at-age model configured using Stock Synthesis was used for the assessment. The model configuration and data inputs are described in Section 3.1.1. See Section 2 for a complete description of all data inputs. Appendices A-D include all input files necessary to run the Stock Synthesis model.

1.2.3. Term of Reference 3

Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.

No applicable environmental covariates were recommended by the data or assessment workshop panels.

1.2.4. Term of Reference 4

Provide estimates of stock population parameters

- *Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as appropriate given data availability and modeling approaches*
- *Include appropriate and representative measures of precision for parameter estimates.*

Estimates of assessment model parameters and their associated standard errors are reported in Section 3.1.4 and Table 3.1. Estimates of assessment model parameters and standard deviations from the bootstrap analysis are presented in Table 3.2. Estimates of stock biomass, spawning stock biomass, recruitment, and fishing mortality are presented in Tables 3.4-3.6.

1.2.5. Term of Reference 5

Characterize uncertainty in the assessment and estimated values

- *Consider components such as input data, modeling approach, and model configuration.*
- *Provide appropriate measures of model performance, reliability, and 'goodness of fit'.*

Model performance and reliability are characterized in Section 3.2. Uncertainty in the assessment and estimated values was characterized using sensitivity analyses and a parametric bootstrap approach. Results of the sensitivity analyses are characterized in Section 3.2.7 and Tables 3.7-3.8. Uncertainty in the assessment parameters and estimated values is characterized in Section 3.2 and Table 3.1-3.2.

1.2.6. Term of Reference 6

Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.

Yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations are provided in Section 3.2.8.

1.2.7. Term of Reference 7

Provide estimates of stock status relative to management criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards for each model run presented for review.

Stock status relative to a management criteria of $F_{SPR30\%}$ are presented in Tables 3.2.8.

1.2.8. Term of Reference 8

Project future stock conditions and develop rebuilding schedules if warranted; include estimated generation time.

Stock biomass and yield projections for 2013-2019 are presented in Section 3.2.9 and Table 3.9. Projections were run at three levels of fishing mortality: 1) $F_{SPR30\%}$ (F_{MSY} proxy), 2) F_{OY}, and $F_{CURRENT}$ (geometric mean of F 2009-2011) (Tables 3.10-3.12).

1.2.9. Term of Reference 9

Provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.

Ten sensitivity runs were presented to characterize uncertainty in model specification. Of the ten runs presented, three were used for projections and represent alternate states of nature. These runs include uncertainty in the natural mortality rate. Probability distribution functions were developed for the subset of three runs and will be made available to the Scientific and Statistical Committee (SSC) for the development of management advice, including OFL and ABC.

1.2.10. Term of Reference 10

Provide recommendations for future research and data collection. Be as specific as possible in describing sampling design and intensity, and emphasize items which will improve assessment capabilities and reliability. Recommend the interval and type for the next assessment.

Recommendations for future research and data collection were made in the SEDAR 22 Data Workshop report. Additional recommendations are made in Section 3.3.

1.2.11. Term of Reference 11

Prepare a spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.

All assessment model inputs are presented in Appendix A-D. All model parameter estimates and their associated standard errors are reported in Table 3.1.

2 DATA REVIEW AND UPDATE

Processing of data for this assessment is described in the SEDAR 28 Gulf of Mexico Cobia Data Workshop Report (SEDAR 2011). This section summarizes the data input for the Stock Synthesis (SS) base run and describes additional processing prior to and during the Assessment Workshop (AW). In particular, data for 2011, which were not available at the DW, were added. In some cases the addition of the final year of data changed estimates for earlier years.

2.1 Life history

Life history data used in the assessment included natural mortality, growth, maturity, and fecundity. Some of the life history data were input in the Stock Synthesis model as fixed values, while others were treated as estimable parameters. For the estimable parameters, the initial parameter values were taken from the data workshop.

A single von Bertalanffy equation was used in the assessment model to model growth of cobia for both sexes. The von Bertalanffy parameters L_{inf} and K were estimated within the SS model. The recommended values from the DW were used as initial starting guesses for L_{inf} and K. Stock synthesis does not use t_0 as an input parameter; rather SS uses a parameterization that includes the parameters L_{min}, and A_{min} to describe the growth of fish from age 0.0 to A_{min}.

The relationship between weight and length ($W=aFL^b$) for sexes combined was developed at the DW and used as a fixed model input. The length-weight coefficient, a, had to be adjusted due to differences in units used in the DW (mm) and assessment model (cm) (Table 2.1).

An age-specific maturity vector was developed at the DW and used as a fixed model input. The DW recognized that maturity was more strongly correlated with size than age but lack of samples of young fish precluded the determination of a size at 50% maturity. The assessment model used age-2 for age at 50% maturity and assumed that all age-3+ fish were fully mature. The relationship between female weight and batch fecundity was developed at the DW. Fecundity was assumed to be directly proportion to female weight in the SS model.

The DW recommended that a skewed sex ratio be incorporated into the assessment model. Two recommendations for the skewed sex ratio were proposed by the DW: 1) by age, use 60% females for all ages, and 2) by length, consider using 50% females up to 80 cm FL, derive a function to describe the increasing proportion of females between 80 and 120 cm, and use 100% females above 120 cm. Since there was little information to accomplish (2), the first recommendation, 60% females for all ages, was incorporated into the assessment model.

A scaled Lorenzen age-specific natural mortality vector was developed at the DW but was updated after the DW due to an error in the ages used for scaling the estimates. The cumulative survival of ages 3-11 based on a point estimate of natural mortality (M=0.38 y^{-1}) was used to scale the age-based estimates of natural mortality (Table 2.2).

2.2 Landings

2.2.1 Commercial landings

Commercial landings data (1927-2011) used in the assessment are presented in Table 2.3 and Figures 2.1-2.2. Final commercial landings were computed following the data workshop (DW), but a full description of the landings and how they were calculated is given in the SEDAR 22 Data Workshop Report. Commercial landings were originally stratified by gear and included handline, longline and miscellaneous (other) gears. For the assessment, commercial landings were aggregated across gears. Handline landings represented approximately 67% of total commercial landings since 1981. Commercial landings were reported in 1000s lbs whole weight and converted to metric tons for input into the assessment model.

2.2.2 Recreational landings

Recreational landings data (1950-2011) used in the assessment are presented in Table 2.4 and Figures 2.1-2.2. Final recreational landings were computed following the data workshop (DW), but a full description of the landings and how they were calculated is given in the SEDAR 22 Data Workshop Report. Recreational landings were originally reported by mode and included charterboat, headboat, private/rental boat, and shore modes. In addition, recreational landings from Texas were calculated separately from the rest of the Gulf of Mexico. For the assessment, recreational landings were aggregated across modes and regions. Private/rental boat landings represented approximately 75% of the total recreational landings by numbers since 1981. Recreational landings were reported in numbers of fish and input into the assessment model as 1000s of fish.

2.3 Discards

2.3.1 Commercial discards

Commercial discard data (1993-2011) used in the assessment are presented in Table 2.5. Final commercial discards were computed following the data workshop (DW), but a full description of the discards and how they were calculated is given in the SEDAR 22 Data Workshop Report. Commercial discards were reported as numbers of fish and converted to metric tons for the assessment. The weight of a commercially discarded fish was determined from length composition data from the reef fish observer program. The mean length of a discarded cobia from the reef fish observer program was estimated at 70 cm; the average weight of a 70 cm cobia is 3.76 kg (8.28 lbs).

The DW recommended a discard mortality rate of 5% for all hook and line fisheries and 51% for the gillnet fishery. Estimates of discard mortality came from data collected by observers as part of the commercial logbook programs for commercial vessels operating in the South Atlantic and Gulf of Mexico. However, of the 586 reported gill net trips that occurred in the Gulf of Mexico between 2002 and 2010 none reported cobia discards. Thus, a discard mortality rate of 5% was used for the commercial fishery.

2.3.2 Recreational discards

Recreational discard data used in the assessment is presented in Table 2.6. Final recreational discards were computed following the data workshop (DW), but a full description of the discards and how they were calculated is given in the SEDAR 22 Data Workshop Report. Recreational discards were reported as numbers of fish and input into the assessment as 1000s of fish. A discard mortality rate of 5%, as recommended by the DW, was used for the recreational fishery.

2.3.3 Shrimp discards

Final shrimp fishery discards were computed following the data workshop (DW), but a full description of the discards and how they were calculated is given in the SEDAR 22 Data Workshop Report (Table 2.7). Due to concerns about the accuracy and precision of the annual estimates of cobia bycatch from the shrimp fishery the AP agreed to not use annual point estimates of bycatch in the assessment model. The AP recommended that shrimp fishery effort be used as a proxy for cobia bycatch trends since shrimp fishery effort is known with more certainty (Table 2.8). The median estimate of shrimp bycatch over the time series, 1972-2011, was used to represent the magnitude of cobia removals from the shrimp fleet and input into Stock Synthesis using the super-year approach of Methot (2011). See section 3.1.3 for a complete description on how shrimp discards were estimated in the assessment model.

2.4 Length composition

2.4.1 Commercial length composition

Commercial length composition data were updated to include 2011 following the DW. Commercial length composition data used in the assessment are presented in Table 2.9. Annual length compositions were combined into 3-cm bins with a minimum size of 6 cm and maximum size of 165 cm (Figure 2.3). Following the DW a number of errors were identified in the commercial length composition data. Samples with mis-specified units were identified by plotting observed length-weight data and eliminating any samples with length-weight observations that fell outside the 95% confidence intervals for the length-weight relationship. Annual sample sizes for length composition data were set equal to the number of fish measured if less than 100 fish were measured. If more than 100 fish were measured, sample size was fixed at 100 to avoid over-weighting the length composition data.

Length composition data collected independently from the reef fish observer program were also included to characterize the composition of the commercial catch. Data were collected from 2006-2011 and included all fish captured (Table 2.10). This data set provided the only information available on the size of cobia that were captured and released for any of the fisheries (Figure 2.4).

2.4.2 Recreational length composition

Recreational length composition data were updated to include 2011 following the DW. Recreational length composition data used in the assessment are presented in Table 2.11. Annual length compositions were combined into 3-cm bins with a minimum size of 6 cm and maximum size of 165 cm (Figure 2.5). Following the DW a number of errors were identified in the recreational length composition data. Samples with mis-specified units were identified by plotting observed length-weight data and eliminating any samples with length-weight observations that fell outside the 95% confidence intervals for the length-weight relationship.

Annual sample sizes for length composition data were set equal to the number of fish measured if less than 100 fish were measured. If more than 100 fish were measured, sample size was fixed at 100 to avoid over-weighting the length composition data.

2.4.3 SEAMAP trawl survey length composition

SEAMAP trawl survey length composition data used in the assessment are presented in Table 2.12. Due to small annual sample sizes, the length composition data from the SEAMAP trawl survey was aggregated over years into a single length distribution and assumed to be representative of the shrimp fishery (Figure 2.6). This was handled in SS using the super-year approach (Methot 2011).

2.5 Age composition

2.5.1 Commercial age composition

Commercial age composition data was not used in the assessment. Small samples precluded the use of the commercial age composition data. Between 1987 and 2011 only 64 age samples were collected. The maximum number of samples collected in any single year was 19 (1989) and no age samples have been collected since 1999 (Figure 2.7).

2.5.2 Recreational age composition

Recreational age composition data used in the assessment is presented in Figure 2.8 and Appendix A. The age compositions were made conditional on length. In other words, a separate age composition was specified for each 3 cm length bin containing fish whose ages had been estimated (Figures 2.8a-2.8c). Using these conditional age compositions has the advantage of linking age data directly to length data (essentially creating an age-length key). As a result, the data contain more detailed information about the relationship between size and age and so provides a stronger ability to estimate growth parameters, especially the variance of size-at-age.

In SS, all cohorts of fish graduate to the age of 1 when they first reach January 1, regardless of when they are born. This means that SS operates under the assumption that all age data have been adjusted so that fish graduate to the next age on January 1.

Cobia spawning occurs between the months of April and September in the Gulf of Mexico. The DW used a birthday of May 1 for converting calendar ages to fractional ages. Determination of calendar age from increment counts of sagittal otoliths was based on the timing of annulus formation and an estimate of the amount of translucent edge present. For any fish caught July-December, calendar age = increment count regardless of edge code. For any fish caught January-June with an edge code of 3 or 4, calendar age = annulus count + 1. No fish with an edge code of 1 or 2 were caught during January-March, but for those caught April-June, calendar age = annulus count (i.e., ages were not advanced). In the original Mote data set, only raw annulus counts were available (i.e., there were no marginal increment codes and they did not calculate calendar age). Based on examination of monthly distribution of annulus edge types in the GCRL study, the decision was made to estimate calendar age of Mote fish using the following protocol: advance the ages of all Mote fish collected Jan-Apr by one year, i.e., final or calendar age = ring count + 1. For fish collected during May-December, ages were not advanced, i.e., the final or calendar age = ring count. The protocol followed by the DW conformed to the required age input into SS; see Tables 2.13-2.16 for the increment count, calendar age, fractional age, and model age of fish within each age cohort in the model.

2.5.3 SEAMAP trawl survey age composition

SEAMAP age composition data was not used in the assessment.

2.6 Indices

Five indices of abundance were presented to the DW Index working group. Three of the five indices were rejected due to inadequacies. The DW Index working group rejected the fishery dependent commercial logbook index due to concerns that the index did not provide a true reflection of population abundance. The Texas Park and Wildlife Department fishery dependent index of abundance was rejected due to concerns over the lack of spatial coverage of the index. The fishery-independent SEAMAP Groundfish survey was rejected due to low frequency of occurrence of cobia in the samples.

The DW recommended the use of two indices for the assessment: the Marine Recreational Fishery Statistics Survey (MRFSS) and the Headboat Survey (see SEDAR 28 Data Workshop Report). Both indices are fishery-dependent and both provide indices of abundance for the recreational fishery for cobia in the Gulf of Mexico. The MRFSS survey tracks total catches of cobia (landed plus discards), whereas the Headboat survey tracks only landed fish (Figures 2.9 and 2.10).

Both indices and their associated CVs were updated following the DW, but a full description of the indices and how they were calculated is given in the SEDAR 22 Data Workshop Report. The standardized indices of relative abundance and associated CVs used in the assessment are presented in Table 2.17. The coefficients of variation (CV) associated with the standardized indices were converted to log-scale standard errors by:

$$\log(SE) = \sqrt{\log_e\left(1 + CV^2\right)},$$

for input into the Stock Synthesis assessment model.

2.7 Tables

Table 2.1. Length-weight function used to convert fork length of Gulf stock cobia to weight in kilograms.

Sex	Model	FL units	n	a	b
Combined	Wt=a*FL^b	mm	6463	9.00E-09	3.03
Combined	Wt=a*FL^b	cm	6463	9.64E-06	3.03

Table 2.2. Age-specific natural mortality of Gulf of Mexico cobia based on the Lorenzen (1996) method for all data combined.

Age	Scaled Lorenzen base (y^{-1})
0	0.942
1	0.599
2	0.485
3	0.432
4	0.404
5	0.387
6	0.376
7	0.370
8	0.366
9	0.363
10	0.361
11	0.360

Table 2.3. Gulf of Mexico cobia commercial landings in pounds whole weight and metric tons.

Year	Handline	Longline	Other	Total (lbs)	Total (mt)
1927	5,511	0	3,939	9,450	4.29
1928	13,312	0	9,515	22,827	10.35
1929	8,588	0	6,139	14,727	6.68
1930	8,365	0	5,979	14,344	6.51
1931	6,093	0	4,355	10,448	4.74
1932	3,385	0	2,420	5,805	2.63
1933	0	0	0	0	0.00
1934	4,315	0	3,085	7,400	3.36
1935	0	0	0	0	0.00
1936	3,441	0	2,459	5,900	2.68
1937	1,166	0	834	2,000	0.91
1938	4,315	0	3,085	7,400	3.36
1939	3,732	0	2,668	6,400	2.90
1940	816	0	584	1,400	0.64
1941	0	0	0	0	0.00
1942	0	0	0	0	0.00
1943	0	0	0	0	0.00
1944	0	0	0	0	0.00
1945	175	0	125	300	0.14
1946	0	0	0	0	0.00
1947	0	0	0	0	0.00
1948	2,508	0	1,792	4,300	1.95
1949	15,978	0	11,422	27,400	12.43
1950	25,717	0	18,383	44,100	20.00
1951	29,041	0	20,759	49,800	22.59
1952	21,926	0	15,674	37,600	17.06
1953	16,853	0	12,047	28,900	13.11
1954	15,337	0	10,963	26,300	11.93
1955	17,844	0	12,756	30,600	13.88
1956	8,747	0	6,253	15,000	6.80
1957	15,045	0	10,755	25,800	11.70
1958	14,229	0	10,171	24,400	11.07
1959	24,084	0	17,216	41,300	18.73
1960	33,123	0	23,677	56,800	25.76
1961	20,352	0	14,548	34,900	15.83
1962	33,700	0	5,800	39,500	17.92
1963	42,000	0	2,800	44,800	20.32
1964	27,400	0	600	28,000	12.70
1965	22,700	0	2,800	25,500	11.57
1966	31,400	0	11,200	42,600	19.32
1967	24,300	0	23,800	48,100	21.82
1968	51,000	0	38,300	89,300	40.51
1969	42,900	0	32,600	75,500	34.25

Table 2.3. Gulf of Mexico cobia commercial landings in pounds whole weight and metric tons (continued).

Year	Handline	Longline	Other	Total (lbs)	Total (mt)
1970	59,900	0	59,700	119,600	54.25
1972	51,200	0	36,300	87,500	39.69
1973	35,400	0	52,200	87,600	39.73
1974	45,600	0	55,300	100,900	45.77
1975	47,800	0	49,900	97,700	44.32
1976	69,100	127	47,900	117,127	53.13
1977	64,500	0	47,810	112,310	50.94
1978	62,356	0	51,106	113,462	51.47
1979	58,144	0	42,842	100,986	45.81
1980	71,258	0	47,845	119,103	54.02
1981	86,138	0	56,922	143,060	64.89
1982	79,806	0	47,328	127,134	57.67
1983	98,561	0	51,986	150,547	68.29
1984	124,268	0	33,979	158,247	71.78
1985	135,223	0	37,615	172,838	78.40
1986	159,649	4,238	30,013	193,900	87.95
1987	174,586	8,646	49,772	233,004	105.69
1988	163,172	13,395	56,628	233,195	105.78
1989	225,910	11,793	66,115	303,818	137.81
1990	169,632	6,619	64,171	240,422	109.05
1991	161,148	19,210	93,502	273,860	124.22
1992	191,904	22,664	132,256	346,824	157.32
1993	184,195	24,864	144,023	353,082	160.16
1994	174,849	19,345	157,620	351,814	159.58
1995	183,322	13,722	133,997	331,041	150.16
1996	222,452	27,020	116,387	365,859	165.95
1997	174,026	20,195	107,602	301,823	136.90
1998	177,084	16,957	94,333	288,374	130.80
1999	155,769	24,159	104,689	284,617	129.10
2000	142,489	26,150	43,370	212,009	96.17
2001	117,670	19,320	40,876	177,866	80.68
2002	130,631	24,148	28,752	183,531	83.25
2003	141,183	29,757	23,892	194,832	88.37
2004	124,077	27,601	27,612	179,290	81.32
2005	91,243	19,531	26,077	136,851	62.07
2006	90,134	24,910	36,001	151,045	68.51
2007	108,604	15,073	23,511	147,188	66.76
2008	99,241	19,084	21,089	139,414	63.24
2009	102,707	9,462	25,135	137,304	62.28
2010	173,107	5,920	15,906	194,933	88.42
2011	205,240	10,241	23,319	238,799	108.32

Table 2.4. Gulf of Mexico cobia recreational landings (numbers).

Year	CH	CH/HB	Private	Shore	Headboat	TPWD	Total (N)
1950	-	-	-	-	-	-	1,000
1951	-	-	-	-	-	-	5,000
1952	-	-	-	-	-	-	10,000
1953	-	-	-	-	-	-	20,000
1954	-	-	-	-	-	-	30,000
1955	-	-	-	-	-	-	36,996
1956	-	-	-	-	-	-	41,040
1957	-	-	-	-	-	-	45,084
1958	-	-	-	-	-	-	49,128
1959	-	-	-	-	-	-	53,172
1960	-	-	-	-	-	-	57,217
1961	-	-	-	-	-	-	58,244
1962	-	-	-	-	-	-	59,271
1963	-	-	-	-	-	-	60,299
1964	-	-	-	-	-	-	61,326
1965	-	-	-	-	-	-	62,354
1966	-	-	-	-	-	-	64,819
1967	-	-	-	-	-	-	67,284
1968	-	-	-	-	-	-	69,749
1969	-	-	-	-	-	-	72,215
1970	-	-	-	-	-	-	74,680
1971	-	-	-	-	-	-	81,468
1972	-	-	-	-	-	-	88,257
1973	-	-	-	-	-	-	95,045
1974	-	-	-	-	-	-	101,833
1975	-	-	-	-	-	-	108,622
1976	-	-	-	-	-	-	108,813
1977	-	-	-	-	-	-	109,003
1978	-	-	-	-	-	-	109,194
1979	-	-	-	-	-	-	109,385
1980	-	-	-	-	-	-	109,576
1981	0	18,049	69,670	1,723	1,373	850	91,665
1982	0	15,299	123,718	11,502	2,174	850	153,543
1983	310	19,773	75,493	3,397	1,644	1,273	101,890
1984	839	14,511	55,385	6,740	1,782	533	79,790
1985	629	11,381	46,865	11,420	1,669	786	72,750
1986	7,925	0	69,609	0	2,162	326	80,022
1987	10,543	0	57,313	2,101	2,337	821	73,115
1988	13,942	0	68,545	2,503	2,402	521	87,913
1989	7,337	0	64,027	3,181	2,454	312	77,311

Table 2.4. Gulf of Mexico cobia recreational landings (numbers) (continued).

Year	CH	CH/HB	Private	Shore	Headboat	TPWD	Total (N)
1990	8,272	0	46,764	0	2,658	440	58,134
1992	9,505	0	62,656	13,859	3,485	2,735	92,240
1993	23,632	0	46,757	6,316	4,385	514	81,604
1994	16,089	0	54,875	6,618	4,089	1,166	82,837
1995	11,949	0	40,194	4,665	4,018	817	61,643
1996	27,739	0	46,414	14,964	3,243	3,182	95,542
1997	20,934	0	91,550	7,345	3,322	2,479	125,630
1998	8,710	0	48,914	1,926	1,852	2,230	63,632
1999	7,819	0	56,590	4,097	2,346	1,740	72,592
2000	6,505	0	49,153	7,213	1,581	1,091	65,543
2001	12,470	0	46,935	5,690	1,847	1,365	68,307
2002	8,937	0	37,225	5,910	1,881	1,000	54,953
2003	12,439	0	67,106	2,435	1,799	1,318	85,097
2004	15,218	0	51,775	538	747	1,428	69,706
2005	12,456	0	43,317	0	1,735	1,081	58,589
2006	10,287	0	48,883	2,874	1,001	1,665	64,710
2007	11,216	0	58,441	0	2,013	1,404	73,074
2008	12,357	0	37,419	4,723	1,517	2,181	58,197
2009	7,455	0	34,184	0	1,641	1,984	45,264
2010	4,946	0	46,228	3,329	1,691	1,020	57,214
2011	10,285	0	47,816	4,429	1,455	850	64,835

Table 2.5. Gulf of Mexico cobia commercial discards (mt).

Year	Gillnet	Vertical Line	Trolling	Total (N)	Avg. Weight (lbs)	Total (mt)
1993	0	9,131	42	9,173	8.28	34.45
1994	0	10,877	43	10,919	8.28	41.01
1995	0	10,246	48	10,293	8.28	38.66
1996	0	11,080	71	11,151	8.28	41.88
1997	0	12,350	64	12,415	8.28	46.63
1998	0	11,854	273	12,127	8.28	45.55
1999	0	13,569	276	13,845	8.28	52.00
2000	0	12,743	265	13,008	8.28	48.85
2001	0	11,847	236	12,083	8.28	45.38
2002	0	12,522	198	12,720	8.28	47.77
2003	0	13,385	189	13,574	8.28	50.98
2004	0	11,715	142	11,858	8.28	44.54
2005	0	11,421	111	11,532	8.28	43.31
2006	0	11,327	143	11,471	8.28	43.08
2007	0	10,728	158	10,886	8.28	40.89
2008	0	9,482	159	9,641	8.28	36.21
2009	0	11,769	163	11,932	8.28	44.81
2010	0	9,557	141	9,698	8.28	36.42
2011	0	11241	123	11,364	8.28	42.68

Table 2.6. Gulf of Mexico cobia recreational discards (numbers).

Year	MRFSS	Headboat	TPWD	Total (N)
1981	11,229	439	58	11,726
1982	18,419	439	58	18,916
1983	354	439	27	820
1984	42,684	577	47	43,308
1985	1,125	439	101	1,665
1986	42,493	189	168	42,850
1987	24,201	196	148	24,545
1988	72,822	494	163	73,479
1989	72,558	169	106	72,833
1990	90,705	1,357	282	92,344
1991	241,006	1,315	421	242,742
1992	118,092	1,114	1,160	120,366
1993	87,514	621	287	88,422
1994	119,505	1,071	690	121,266
1995	87,115	1,398	548	89,061
1996	111,194	1,410	1,584	114,188
1997	130,966	2,662	943	134,571
1998	112,206	1,822	1,236	115,264
1999	112,775	575	917	114,267
2000	124,162	535	1,138	125,835
2001	143,835	432	859	145,126
2002	138,199	432	787	139,418
2003	86,974	288	1,132	88,394
2004	92,635	91	1,485	94,211
2005	57,092	609	980	58,681
2006	73,511	467	1,847	75,825
2007	80,298	493	1,011	81,802
2008	130,946	1,022	1,569	133,537
2009	83,347	1,373	1,544	86,264
2010	68,785	968	847	70,600
2011	92,800	817	0	93,617

Table 2.7. Annual shrimp bycatch estimates for Gulf of Mexico cobia.

Year	Estimated Shrimp Bycatch (N)
1972	225,600
1973	41,650
1974	282,100
1975	128,900
1976	105,800
1977	442,00
1978	42,450
1979	445,300
1980	285,200
1981	56,630
1982	165,400
1983	203,000
1984	143,100
1985	161,800
1986	149,600
1987	221,200
1988	100,800
1989	195,500
1990	173,500
1991	189,100
1992	586,100
1993	166,900
1994	164,700
1995	119,800
1996	411,800
1997	494,900
1998	376,000
1999	491,100
2000	151,100
2001	455,600
2002	209,400
2003	98,590
2004	44,570
2005	87,340
2006	176,800
2007	47,030
2008	13,340
2009	18,980
2010	5,759
2011	41,260

Table 2.8. Annual standardized estimates of Gulf of Mexico cobia shrimp fishery effort.

Year	Standardized Shrimp Effort
1945	0.000
1946	0.004
1947	0.023
1948	0.060
1949	0.097
1950	0.173
1951	0.220
1952	0.260
1953	0.268
1954	0.349
1955	0.345
1956	0.443
1957	0.518
1958	0.670
1959	0.721
1960	0.720
1961	0.445
1962	0.767
1963	0.868
1964	1.023
1965	0.662
1966	0.559
1967	0.671
1968	0.786
1969	0.861
1970	0.605
1971	0.685
1972	0.958
1973	0.975
1974	1.006
1975	0.772
1976	1.073
1977	1.333
1978	1.855
1979	1.953
1980	1.436
1981	1.483
1982	1.418

Table 2.8. Annual standardized estimates of Gulf of Mexico cobia shrimp fishery effort (continued).

Year	Standardized Shrimp Effort
1983	1.536
1985	1.696
1986	1.786
1987	2.076
1988	1.568
1989	1.874
1990	1.825
1991	1.745
1992	1.515
1993	1.418
1994	1.553
1995	1.333
1996	1.430
1997	1.461
1998	1.587
1999	1.653
2000	1.478
2001	1.435
2002	1.272
2003	1.036
2004	0.799
2005	0.480
2006	0.638
2007	0.625
2008	0.540
2009	0.629
2010	0.446
2011	0.417

Table 2.9. Gulf of Mexico cobia commercial length composition data by 3cm length bins.

Year	Samples	60	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111
1983	7	0	0	0	1	0	2	1	0	0	0	1	0	1	0	0	0	0	0
1984	42	0	0	1	3	3	1	2	4	4	2	3	2	4	4	1	2	2	0
1985	36	0	0	0	2	0	0	2	0	1	0	1	1	1	2	5	4	3	0
1986	32	0	0	1	0	2	3	2	1	0	5	4	2	1	3	4	1	0	0
1987	9	0	0	0	0	0	1	1	1	0	0	2	0	0	1	0	1	1	0
1988	7	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	2	0	0
1989	3	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
1990	47	0	0	0	0	0	0	2	4	9	3	7	9	4	4	2	0	0	0
1991	96	0	0	0	0	0	1	2	6	12	16	9	8	8	5	4	7	9	3
1992	99	0	0	0	0	1	1	2	2	11	6	15	14	7	8	7	4	4	8
1993	83	0	0	0	0	0	0	2	6	6	10	13	17	9	6	1	3	0	3
1994	100	0	0	0	0	0	0	0	3	11	8	10	11	7	11	7	8	9	7
1995	60	0	0	0	0	0	0	0	3	7	3	4	5	5	5	5	4	5	4
1996	47	0	0	0	0	0	0	0	3	5	3	1	7	3	2	4	2	2	3
1997	40	0	0	0	0	0	0	0	1	5	2	2	4	3	2	3	3	1	4
1998	29	0	0	0	0	0	0	0	1	0	0	1	1	2	3	0	1	2	2
1999	30	0	0	0	0	0	0	0	1	0	1	0	1	2	3	0	6	2	2
2000	37	0	0	0	1	0	0	0	2	1	1	2	2	3	3	5	4	2	3
2001	65	0	0	0	0	0	1	1	3	2	0	0	6	3	4	2	7	4	9
2002	33	0	0	0	0	0	1	1	2	0	3	2	3	3	4	1	1	0	2
2003	50	0	0	0	0	0	0	0	1	0	1	2	4	4	4	4	5	9	5
2004	129	0	0	0	0	0	0	2	4	5	8	5	9	6	12	13	11	11	6
2005	86	0	0	0	0	0	1	3	3	6	6	6	1	6	9	8	10	5	8
2006	49	0	0	0	0	0	0	0	0	1	4	7	6	8	7	2	1	3	3
2007	66	0	0	0	0	0	1	1	5	4	10	7	10	5	9	4	1	1	2
2008	38	0	0	0	0	0	0	1	0	1	6	3	2	3	3	2	2	2	3
2009	48	0	0	0	0	0	0	2	4	4	7	7	4	1	3	6	2	1	2
2010	73	0	0	0	0	0	2	1	7	5	7	7	7	6	5	8	2	2	2
2011	80	0	0	0	0	0	0	2	4	20	6	9	12	7	4	6	5	1	1

Table 2.9. Gulf of Mexico cobia commercial length composition data by 3cm length bins (continued).

Year	Samples	114	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162	165
1983	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1984	42	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	36	1	0	4	0	0	2	3	0	0	1	1	0	1	1	0	0	0	0
1986	32	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	7	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	47	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1991	96	0	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
1992	99	3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	83	1	1	2	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
1994	100	2	1	0	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1995	60	2	0	2	3	0	2	0	0	1	0	0	0	0	0	0	0	0	0
1996	47	5	0	0	3	0	0	2	2	0	0	0	0	0	0	0	0	0	0
1997	40	2	2	2	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1998	29	2	2	1	4	2	2	2	0	1	0	0	0	0	0	0	0	0	0
1999	30	2	1	2	1	1	3	1	0	1	0	0	0	0	0	0	0	0	0
2000	37	1	0	1	0	0	0	2	1	1	0	1	1	0	0	0	0	0	0
2001	65	4	2	4	4	2	6	1	0	0	0	0	0	0	0	0	0	0	0
2002	33	1	4	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0
2003	50	2	3	3	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0
2004	129	8	8	3	8	4	3	1	0	1	1	0	0	0	0	0	0	0	0
2005	86	1	2	5	1	0	1	0	2	1	0	0	1	0	0	0	0	0	0
2006	49	1	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2007	66	3	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2008	38	2	3	1	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0
2009	48	2	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
2010	73	3	3	3	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
2011	80	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.10. Gulf of Mexico cobia length composition data from the reef fish observer program by 3cm length bins.

Year	Samples	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96	99	102
2006	5	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	2	0	0
2007	9	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	4	0
2008	15	0	2	0	0	0	1	1	0	0	1	0	0	1	1	1	1	3	0	1	1	0
2009	25	0	0	0	0	0	0	0	0	2	3	0	2	1	0	3	2	2	3	0	2	1
2010	24	0	0	0	0	0	0	0	1	1	1	0	0	2	1	2	2	2	1	2	2	2
2011	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	2	1	1	1	1

Year	Samples	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162	165
2006	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	25	2	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2010	24	2	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
2011	14	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0

Table 2.11. Gulf of Mexico cobia recreational length composition data by 3cm length bins.

Year	Samples	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96
1979	16	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	2	1	0	1	1	0	2	0
1980	11	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3	2	1	1	0	0	0
1981	36	0	0	0	0	0	0	0	0	0	1	1	0	0	2	5	2	4	2	4	1	7	1	2
1982	65	1	0	0	0	1	1	3	1	1	2	6	4	4	5	3	8	5	2	2	4	2	2	3
1983	63	0	0	0	0	0	0	1	1	0	0	1	1	4	4	4	3	3	3	2	5	4	3	8
1984	105	0	0	1	4	1	2	3	1	1	5	1	2	3	4	5	5	6	2	5	7	5	10	8
1985	69	0	0	0	0	0	0	0	2	1	1	2	2	0	3	2	6	3	7	6	10	5	3	3
1986	145	0	0	0	0	0	0	0	0	0	2	2	2	4	2	5	6	15	10	14	17	16	9	8
1987	143	0	0	0	0	0	0	0	2	1	4	6	4	9	1	1	5	6	5	9	17	11	10	16
1988	101	0	0	0	0	0	0	0	0	0	0	1	1	0	1	5	5	12	9	13	11	6	12	3
1989	95	0	0	0	0	0	0	0	0	2	2	1	0	0	1	2	3	2	9	9	10	6	10	7
1990	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	5	10	7	7	3	3
1991	104	0	0	0	0	0	0	0	0	0	0	3	1	0	3	1	1	5	9	14	17	14	10	6
1992	188	0	0	0	0	0	0	0	0	1	2	0	0	1	1	1	3	11	21	19	29	19	16	14
1993	188	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	12	18	28	27	23	21	18
1994	231	0	0	0	0	0	0	0	1	2	1	2	0	0	2	3	1	4	26	23	43	30	26	21
1995	227	0	0	0	0	0	0	0	0	0	1	0	1	0	1	2	4	9	22	27	38	26	14	28
1996	272	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	7	31	34	35	29	40	23
1997	283	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	3	6	33	36	39	30	30	25
1998	394	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	4	10	23	57	40	37	36	28
1999	403	0	0	0	0	0	0	0	0	0	1	0	1	1	1	5	8	9	23	21	47	23	37	51
2000	225	0	0	0	0	0	0	0	1	0	0	1	0	0	2	2	6	8	16	27	25	22	9	19
2001	289	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	5	27	35	31	28	41	25
2002	235	0	0	0	0	0	0	0	0	0	1	1	0	3	2	1	3	3	15	25	32	32	22	25
2003	340	0	0	0	0	0	0	0	0	0	0	0	1	0	2	6	6	16	31	32	49	35	23	38
2004	261	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	11	22	26	18	29	30	23
2005	188	0	0	0	0	0	0	0	0	0	2	1	0	2	1	2	5	5	17	21	20	20	22	16
2006	248	0	0	0	0	0	0	0	0	0	0	2	0	0	2	4	7	8	17	33	27	28	24	19
2007	261	0	0	0	0	0	0	0	0	0	0	1	0	2	0	3	6	12	33	30	34	32	13	18
2008	209	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	4	18	34	17	27	24	21
2009	199	0	0	0	0	0	0	0	1	0	1	4	1	1	0	1	4	9	17	29	25	19	12	12
2010	224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	18	21	36	25	29	16
2011	154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	15	12	27	20	19

Table 2.11. Gulf of Mexico cobia recreational length composition data by 3cm length bins (continued).

Year	Samples	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162	165
1979	16	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	11	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	36	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	65	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	63	2	0	0	4	2	3	2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1984	105	6	5	1	1	3	5	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1985	69	2	6	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	145	10	7	4	3	2	1	3	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1987	143	14	7	6	1	2	4	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1988	101	6	4	3	2	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	95	15	3	4	4	0	2	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1990	73	5	6	2	9	3	1	3	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0
1991	104	2	3	8	2	1	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	188	10	6	4	5	7	3	1	7	4	1	0	1	0	1	0	0	0	0	0	0	0	0	0
1993	188	13	7	2	8	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	231	12	10	11	5	3	2	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
1995	227	12	14	6	7	4	4	2	1	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0
1996	272	17	6	7	8	10	8	3	4	1	2	0	0	1	1	0	0	0	0	0	0	0	0	0
1997	283	11	9	9	12	9	7	7	6	1	0	3	2	0	0	0	0	0	0	0	0	0	0	0
1998	394	29	38	22	21	14	4	10	8	2	1	3	1	0	0	0	0	1	0	0	0	0	0	0
1999	403	40	43	17	27	16	10	8	5	2	2	1	3	0	0	0	1	0	0	0	0	0	0	0
2000	225	17	14	14	12	5	10	3	6	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
2001	289	25	13	17	8	10	6	1	1	4	2	1	1	0	0	0	0	1	0	0	0	0	0	0
2002	235	20	7	9	10	8	5	4	3	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0
2003	340	32	13	14	9	10	10	5	4	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2004	261	25	18	14	8	15	8	5	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	188	10	11	5	7	10	5	2	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2006	248	20	16	15	6	8	6	4	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2007	261	29	12	7	4	5	6	6	2	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2008	209	17	12	7	10	4	2	4	3	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2009	199	14	6	10	7	7	8	4	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0
2010	224	21	16	5	6	7	6	4	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	154	10	7	9	8	6	4	2	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.12. Gulf of Mexico cobia shrimp fishery length composition data by 3cm length bins.

Year	Samples	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96
1989	5	0	0	0	0	0	0	1	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	9	0	0	0	0	1	0	2	0	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	5	0	0	0	0	0	1	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	9	0	0	0	0	3	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
1993	28	1	0	0	1	0	2	5	11	5	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1994	17	0	0	0	1	0	0	1	3	4	5	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	13	0	1	0	2	1	0	0	0	1	2	0	0	0	0	0	0	1	2	1	0	0	0	1	0	0	0	1	0
1996	16	0	0	1	1	0	3	6	2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	28	0	0	0	1	0	6	6	6	5	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1998	8	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	2	1	1	0	0	0	0	0
1999	15	1	0	0	0	0	2	1	1	3	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	16	0	0	0	1	0	3	7	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	6	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
2003	9	0	1	1	1	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	16	0	0	1	0	0	2	3	4	2	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	22	4	2	1	1	1	3	1	1	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	13	0	0	1	0	0	1	1	2	2	0	4	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
2007	9	0	0	2	2	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	19	0	0	0	0	1	0	2	3	1	4	1	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0
2009	12	1	0	0	1	1	0	0	1	0	2	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	17	0	2	2	3	1	1	3	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.12. Gulf of Mexico cobia shrimp fishery length composition data by 3cm length bins (continued).

Year	Samples	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162	165
1989	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	22	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	19	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.13. Otolith increment counts of fish for each SS age cohort based on month of collection.

	Month collected											
Cohort	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Age 0					0	0	0	0	0	0	0	0
Age 1	0	0	0	0	1	1	1	1	1	1	1	1
Age 2	1	1	1	1	2	2	2	2	2	2	2	2
Age 3	2	2	2	2	3	3	3	3	3	3	3	3
Age 4	3	3	3	3	4	4	4	4	4	4	4	4
Age 5	4	4	4	4	5	5	5	5	5	5	5	5
Age 6	5	5	5	5	6	6	6	6	6	6	6	6
Age 7	6	6	6	6	7	7	7	7	7	7	7	7
Age 8	7	7	7	7	8	8	8	8	8	8	8	8
Age 9	8	8	8	8	9	9	9	9	9	9	9	9
Age 10	9	9	9	9	10	10	10	10	10	10	10	10

Table 2.14. Calendar age of fish for each SS age cohort based on month of collection.

	Month collected											
Cohort	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Age 0					0	0	0	0	0	0	0	0
Age 1	1	1	1	1	1	1	1	1	1	1	1	1
Age 2	2	2	2	2	2	2	2	2	2	2	2	2
Age 3	3	3	3	3	3	3	3	3	3	3	3	3
Age 4	4	4	4	4	4	4	4	4	4	4	4	4
Age 5	5	5	5	5	5	5	5	5	5	5	5	5
Age 6	6	6	6	6	6	6	6	6	6	6	6	6
Age 7	7	7	7	7	7	7	7	7	7	7	7	7
Age 8	8	8	8	8	8	8	8	8	8	8	8	8
Age 9	9	9	9	9	9	9	9	9	9	9	9	9
Age 10	10	10	10	10	10	10	10	10	10	10	10	10

Table 2.15. Fractional age of fish for each SS age cohort.

Cohort	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Age 0					0.00	0.08	0.17	0.25	0.33	0.42	0.50	0.58
Age 1	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58
Age 2	1.67	1.75	1.83	1.92	2.00	2.08	2.17	2.25	2.33	2.42	2.50	2.58
Age 3	2.67	2.75	2.83	2.92	3.00	3.08	3.17	3.25	3.33	3.42	3.50	3.58
Age 4	3.67	3.75	3.83	3.92	4.00	4.08	4.17	4.25	4.33	4.42	4.50	4.58
Age 5	4.67	4.75	4.83	4.92	5.00	5.08	5.17	5.25	5.33	5.42	5.50	5.58
Age 6	5.67	5.75	5.83	5.92	6.00	6.08	6.17	6.25	6.33	6.42	6.50	6.58
Age 7	6.67	6.75	6.83	6.92	7.00	7.08	7.17	7.25	7.33	7.42	7.50	7.58
Age 8	7.67	7.75	7.83	7.92	8.00	8.08	8.17	8.25	8.33	8.42	8.50	8.58
Age 9	8.67	8.75	8.83	8.92	9.00	9.08	9.17	9.25	9.33	9.42	9.50	9.58
Age 10	9.67	9.75	9.83	9.92	10.00	10.08	10.17	10.25	10.33	10.42	10.50	10.58

Table 2.16. Model age of fish for each SS age cohort

Cohort	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Age 0	0.00	0.08	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92
Age 1	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92
Age 2	2.00	2.08	2.17	2.25	2.33	2.42	2.50	2.58	2.67	2.75	2.83	2.92
Age 3	3.00	3.08	3.17	3.25	3.33	3.42	3.50	3.58	3.67	3.75	3.83	3.92
Age 4	4.00	4.08	4.17	4.25	4.33	4.42	4.50	4.58	4.67	4.75	4.83	4.92
Age 5	5.00	5.08	5.17	5.25	5.33	5.42	5.50	5.58	5.67	5.75	5.83	5.92
Age 6	6.00	6.08	6.17	6.25	6.33	6.42	6.50	6.58	6.67	6.75	6.83	6.92
Age 7	7.00	7.08	7.17	7.25	7.33	7.42	7.50	7.58	7.67	7.75	7.83	7.92
Age 8	8.00	8.08	8.17	8.25	8.33	8.42	8.50	8.58	8.67	8.75	8.83	8.92
Age 9	9.00	9.08	9.17	9.25	9.33	9.42	9.50	9.58	9.67	9.75	9.83	9.92
Age 10	10.00	10.08	10.17	10.25	10.33	10.42	10.50	10.58	10.67	10.75	10.83	10.92

Table 2.17. Standardized indices of relative abundance and associated log-scale standard errors for Gulf of Mexico cobia.

	MRFSS		Headboat	
Year	Std CPUE	log SE	Std CPUE	log SE
1981	0.8473	0.33	-	-
1982	1.1959	0.21	-	-
1983	0.8716	0.29	-	-
1984	0.7475	0.27	-	-
1985	0.6671	0.30	-	-
1986	0.5511	0.19	0.4691	0.27
1987	0.7546	0.18	0.4015	0.28
1988	0.9446	0.19	0.3755	0.29
1989	1.0279	0.20	0.5335	0.26
1990	1.5867	0.18	0.7100	0.25
1991	1.6207	0.15	0.8692	0.23
1992	1.0814	0.12	0.8649	0.23
1993	1.0354	0.15	1.1310	0.21
1994	1.3619	0.13	1.1147	0.21
1995	0.6666	0.17	0.9744	0.23
1996	1.3853	0.13	1.0415	0.23
1997	1.9183	0.11	1.2572	0.22
1998	1.1846	0.11	1.0947	0.22
1999	1.0917	0.09	1.6814	0.20
2000	0.7838	0.10	0.9681	0.22
2001	0.9087	0.10	1.2529	0.22
2002	0.9308	0.09	1.0083	0.24
2003	1.0102	0.10	1.2268	0.21
2004	0.8415	0.10	0.9729	0.24
2005	0.7870	0.11	1.0257	0.23
2006	0.7349	0.11	0.9857	0.24
2007	0.8082	0.11	1.2373	0.21
2008	0.9602	0.11	1.1913	0.21
2009	0.7509	0.12	1.2268	0.21
2010	0.9009	0.12	1.0998	0.22
2011	1.0428	0.11	1.2856	0.21

2.8 Figures

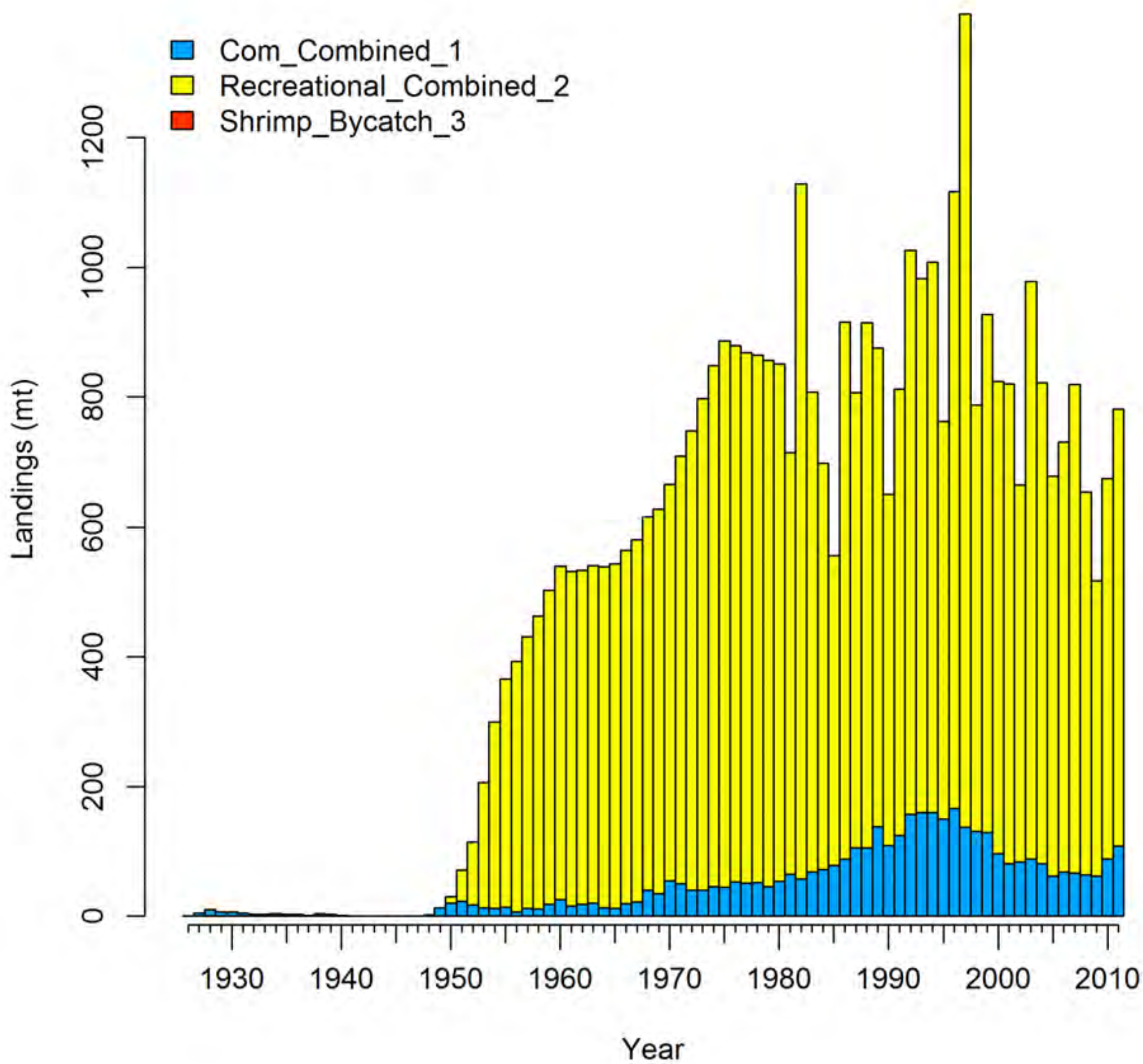


Figure 2.1. Gulf of Mexico Cobia estimated landings history, 1926-2011.

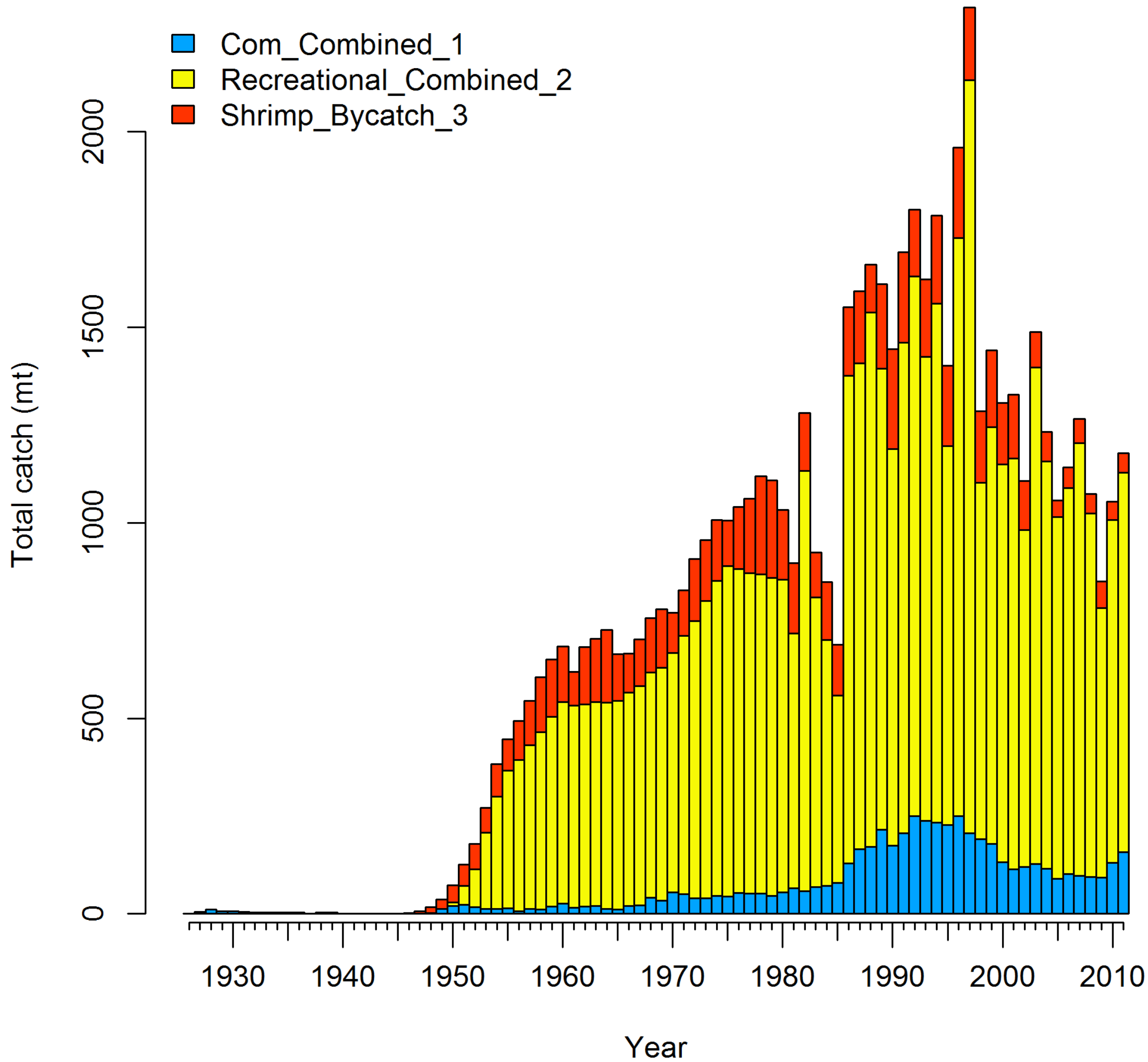


Figure 2.2. Gulf of Mexico Cobia estimated catch history, 1926-2011. Estimated catch includes both landings and discards.

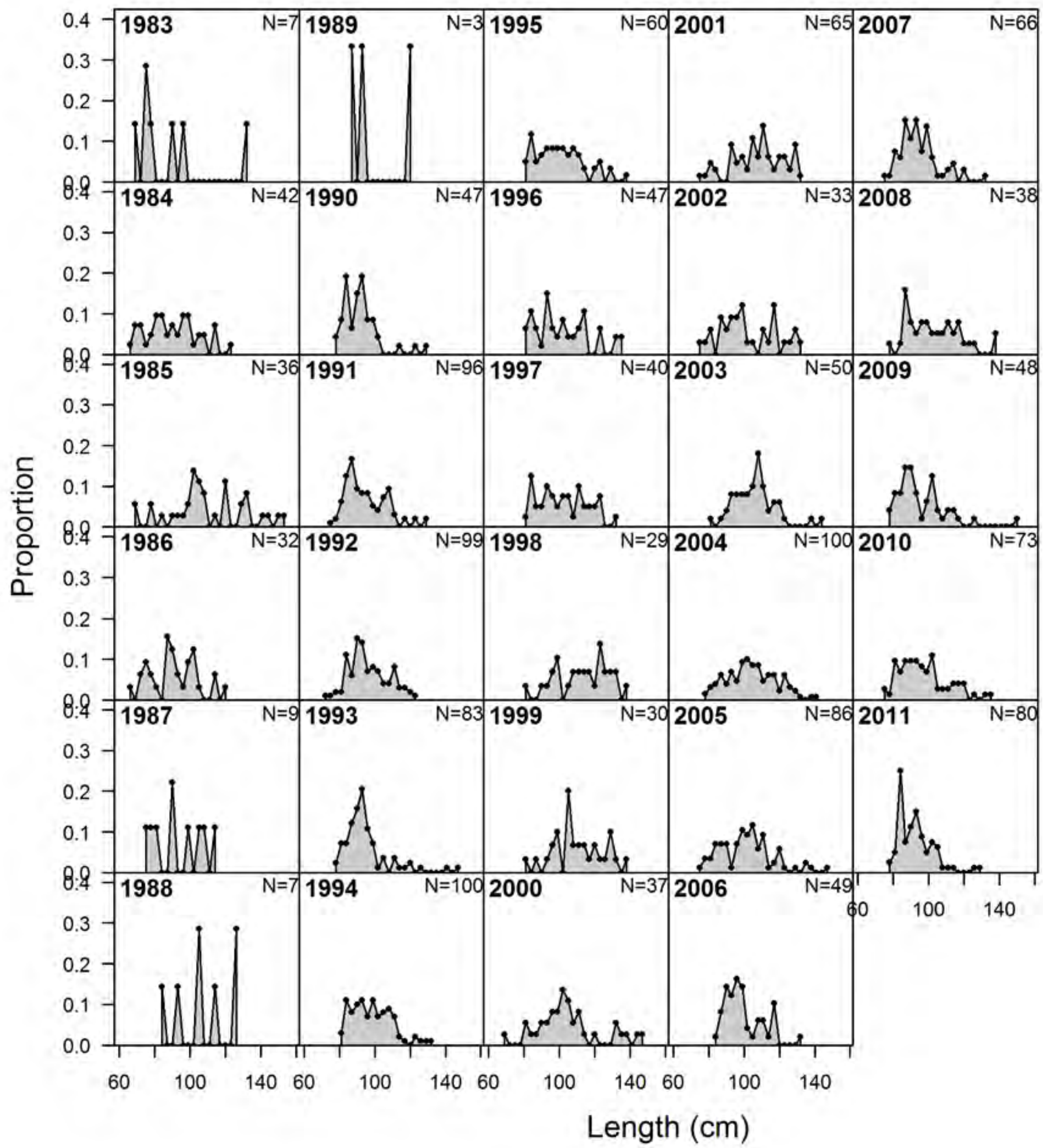


Figure 2.3. Observed length composition data of Gulf of Mexico Cobia from the commercial fishing fleet, 1983-2011.

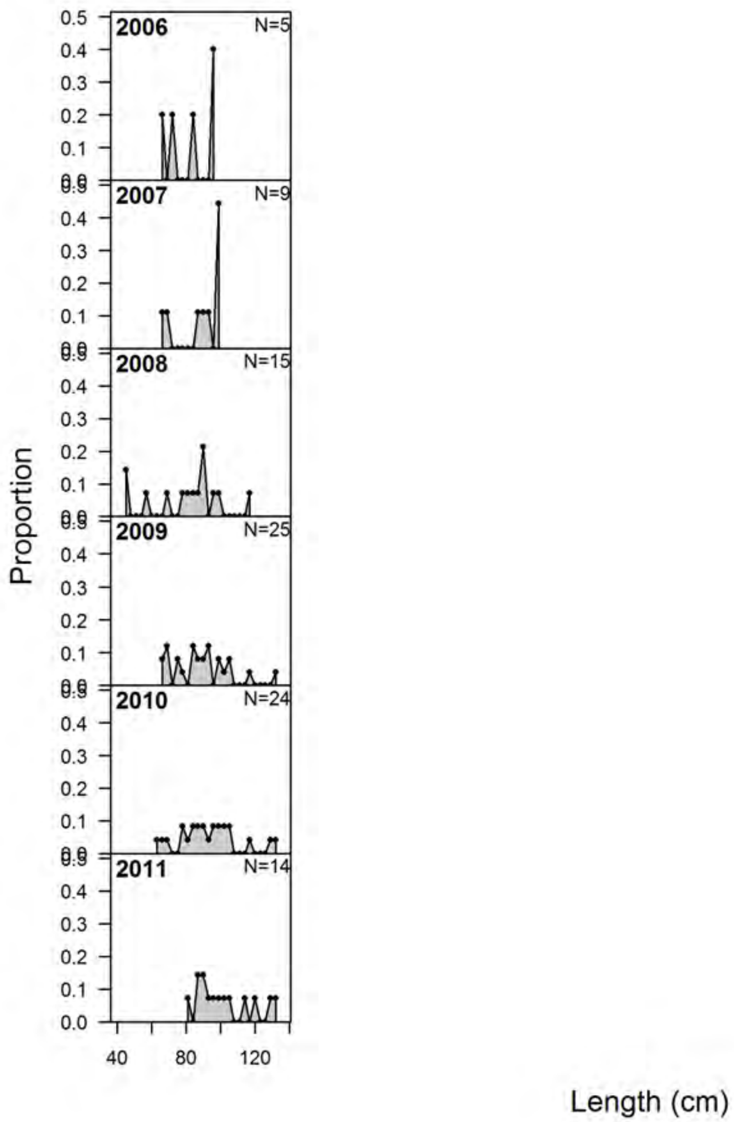


Figure 2.4. Length composition data from the reef fish observer program, 2006-2011.

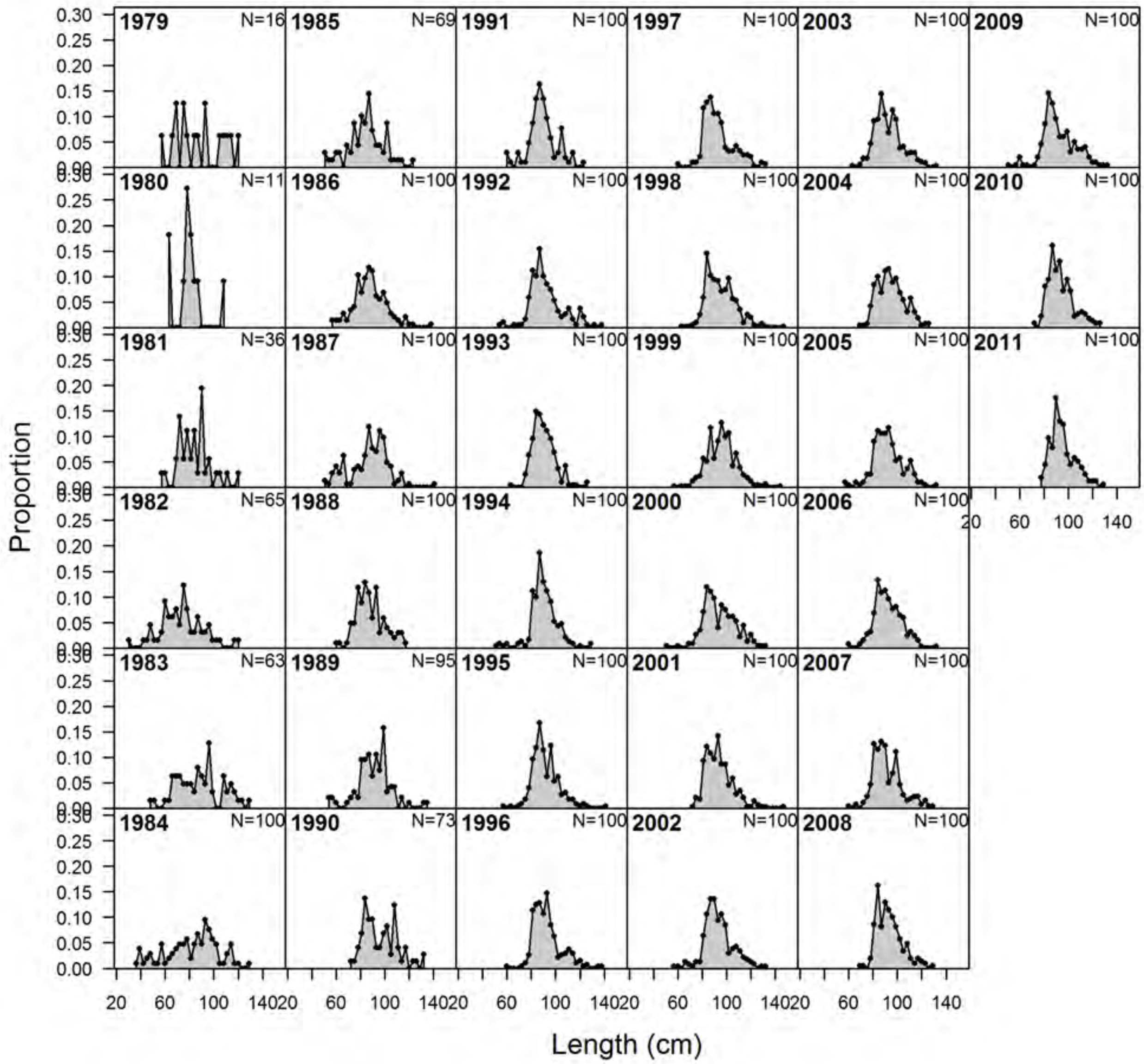


Figure 2.5. Observed length composition data of Gulf of Mexico Cobia from the recreational fishing fleet, 1979-2011.

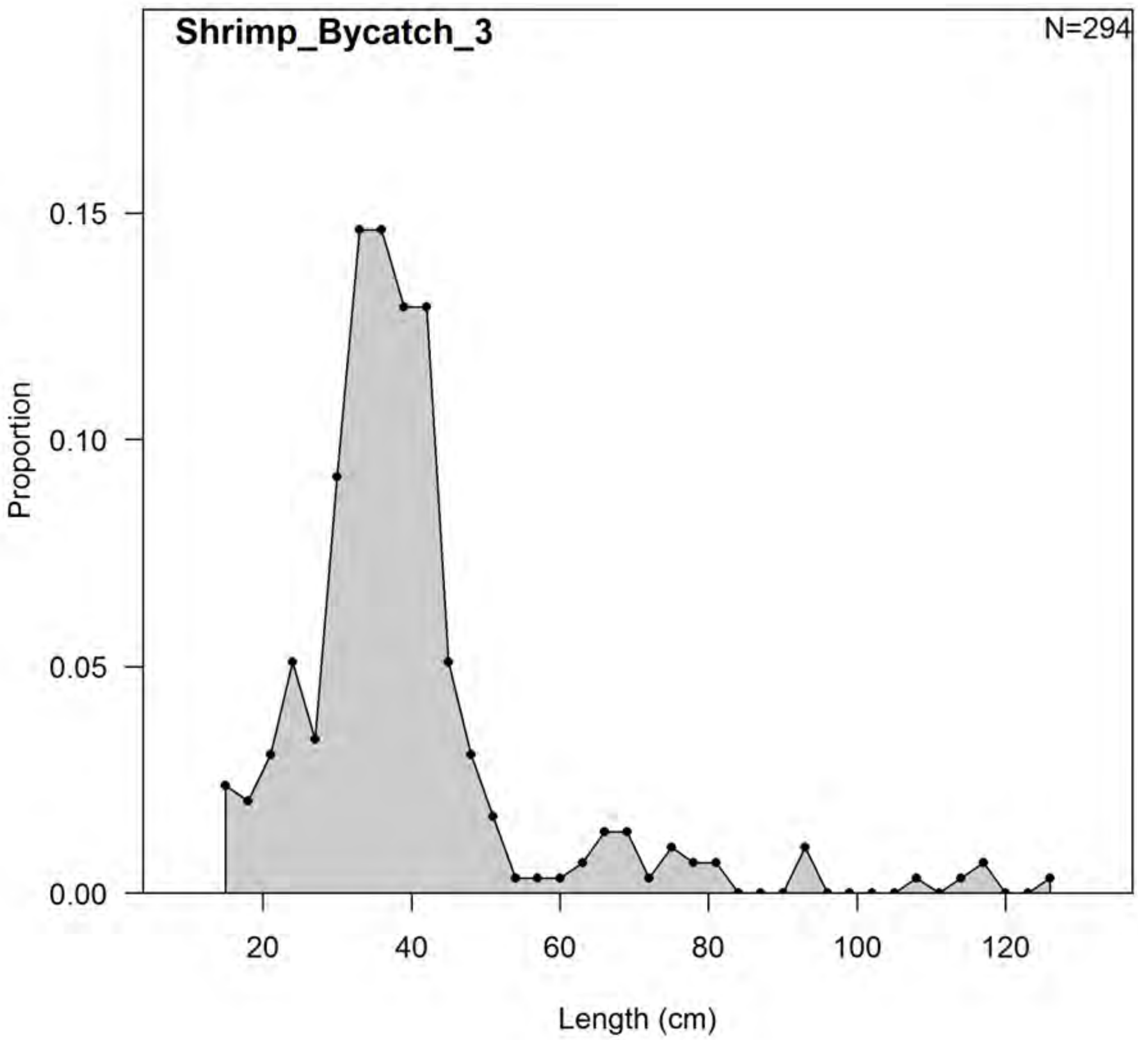


Figure 2.6. Observed length composition data of Gulf of Mexico Cobia from the shrimp fishing fleet, 1979-2011.

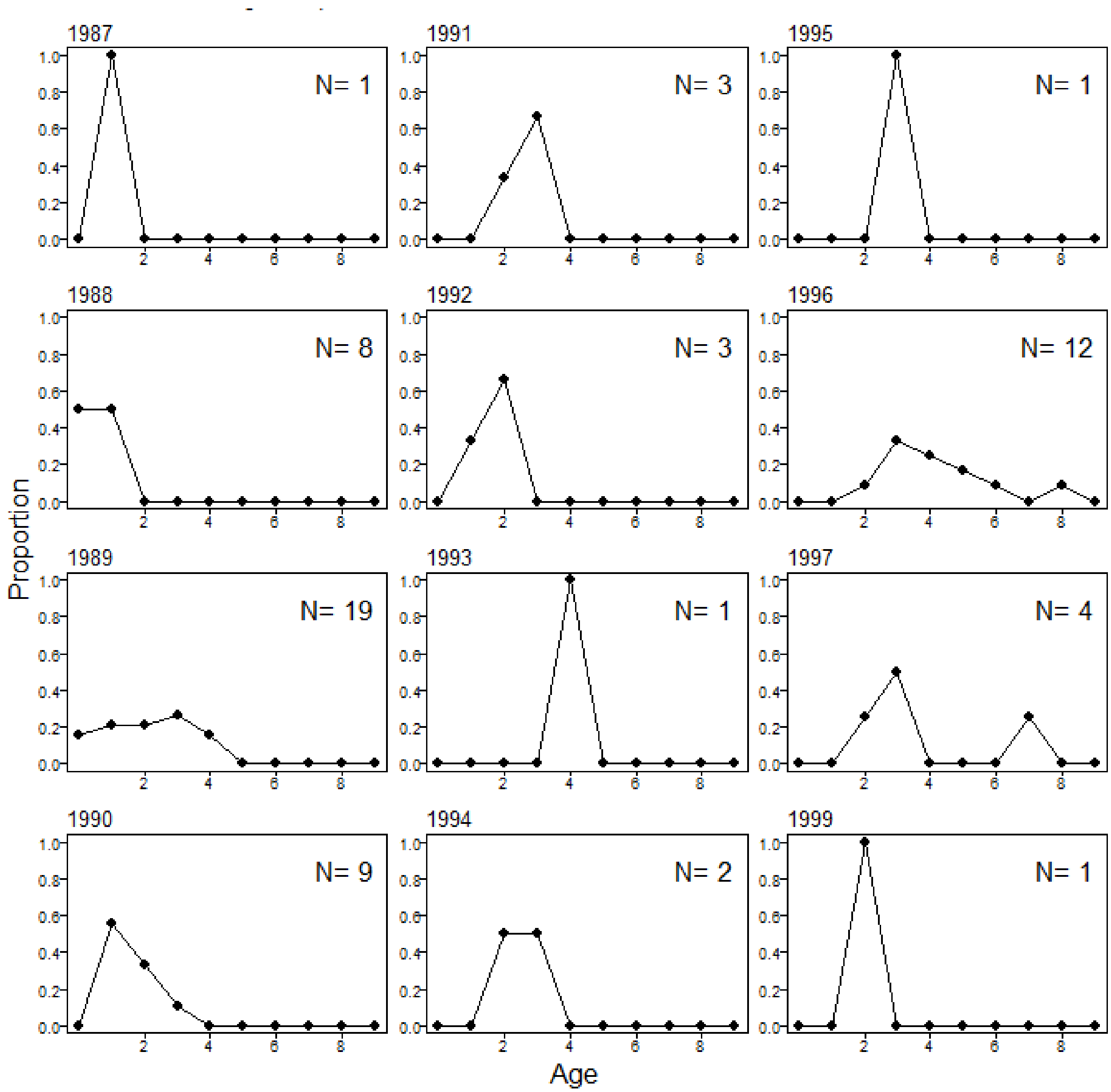


Figure 2.7. Observed age composition data of Gulf of Mexico Cobia from the commercial fishing fleet, 1987-1999.

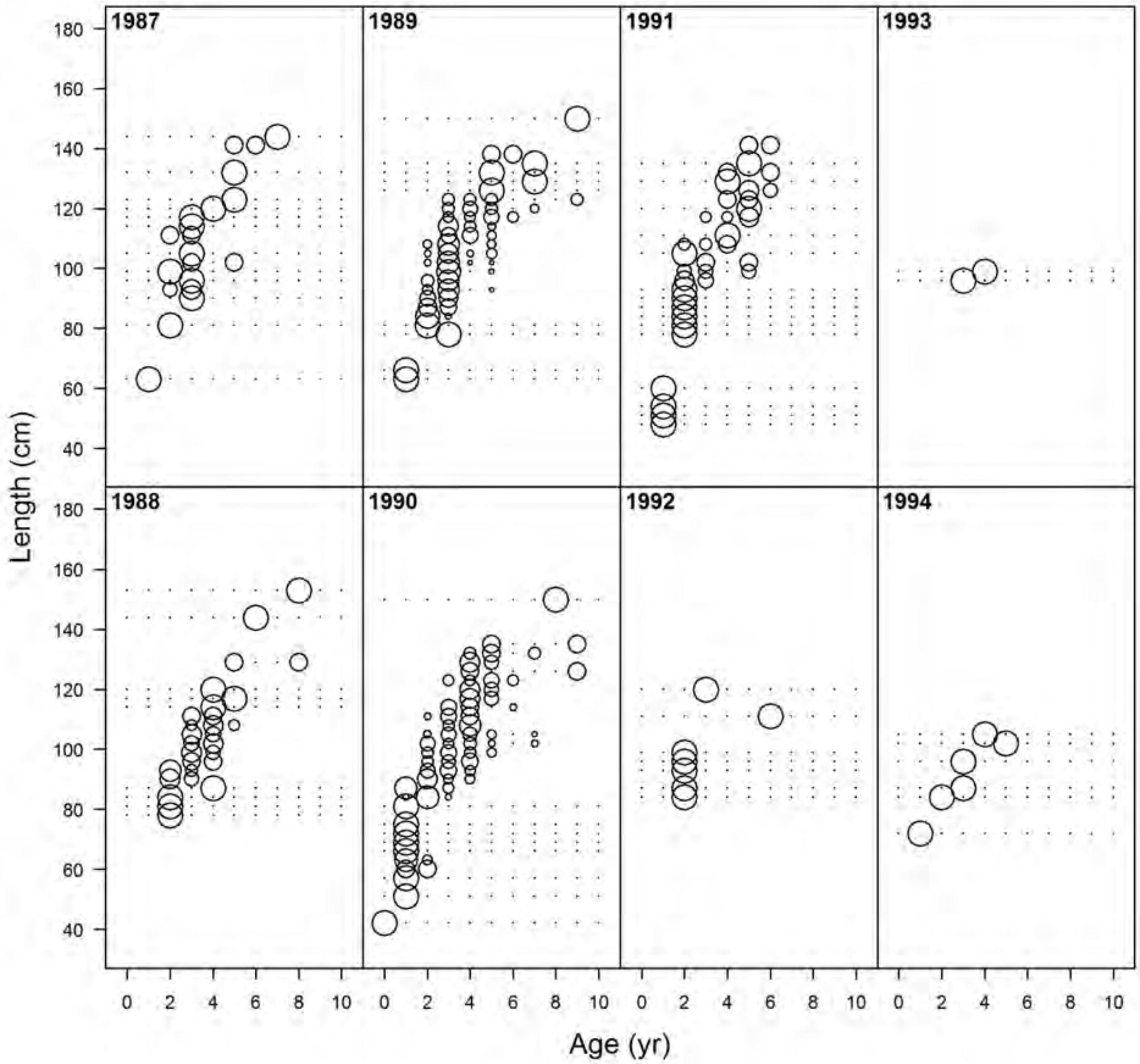


Figure 2.8a. Observed conditional age-at-length data of Gulf of Mexico Cobia from the recreational fishing fleet, 1987-2011.

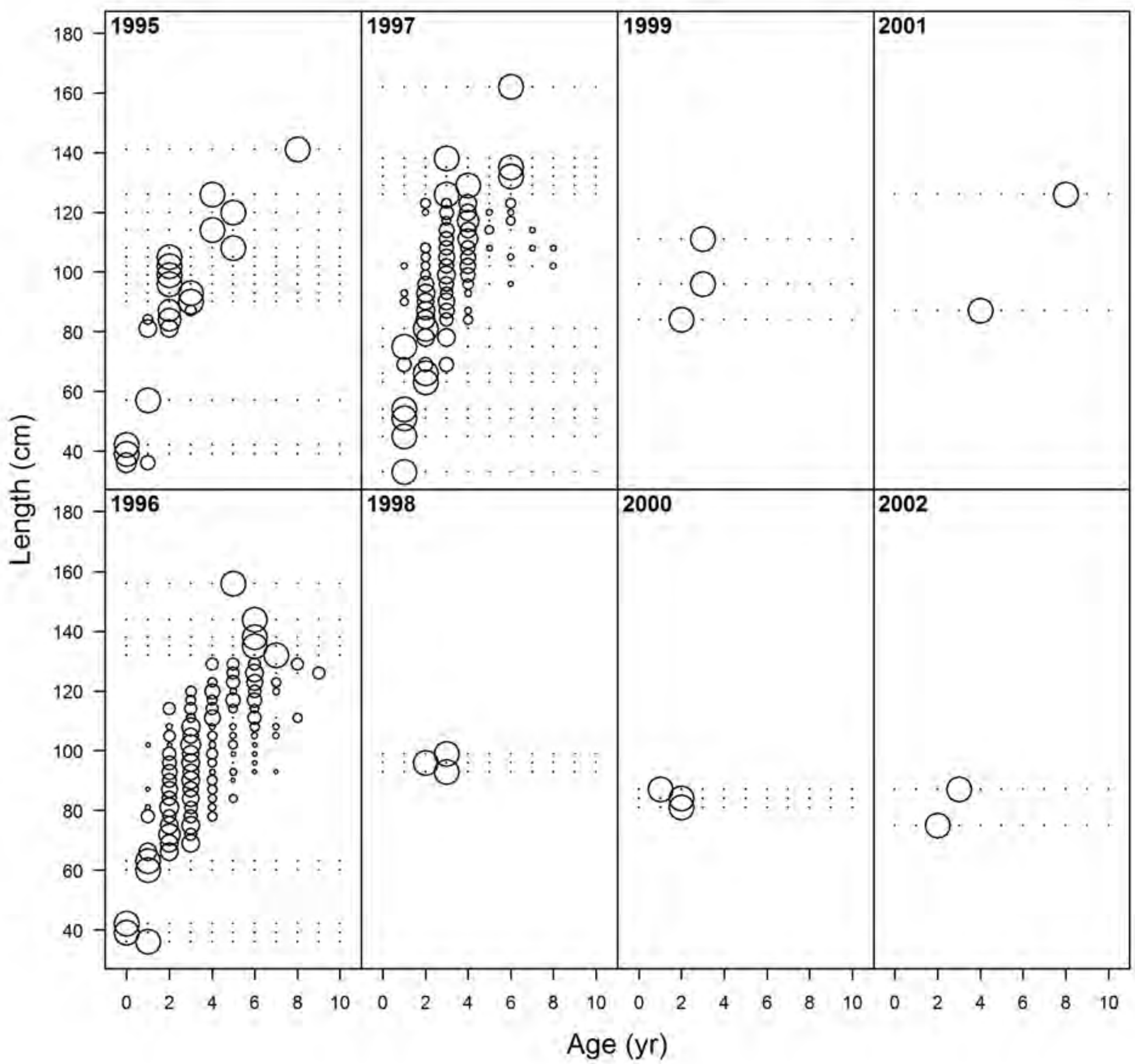


Figure 2.8b. Observed conditional age-at-length data of Gulf of Mexico Cobia from the recreational fishing fleet, 1987-2011.

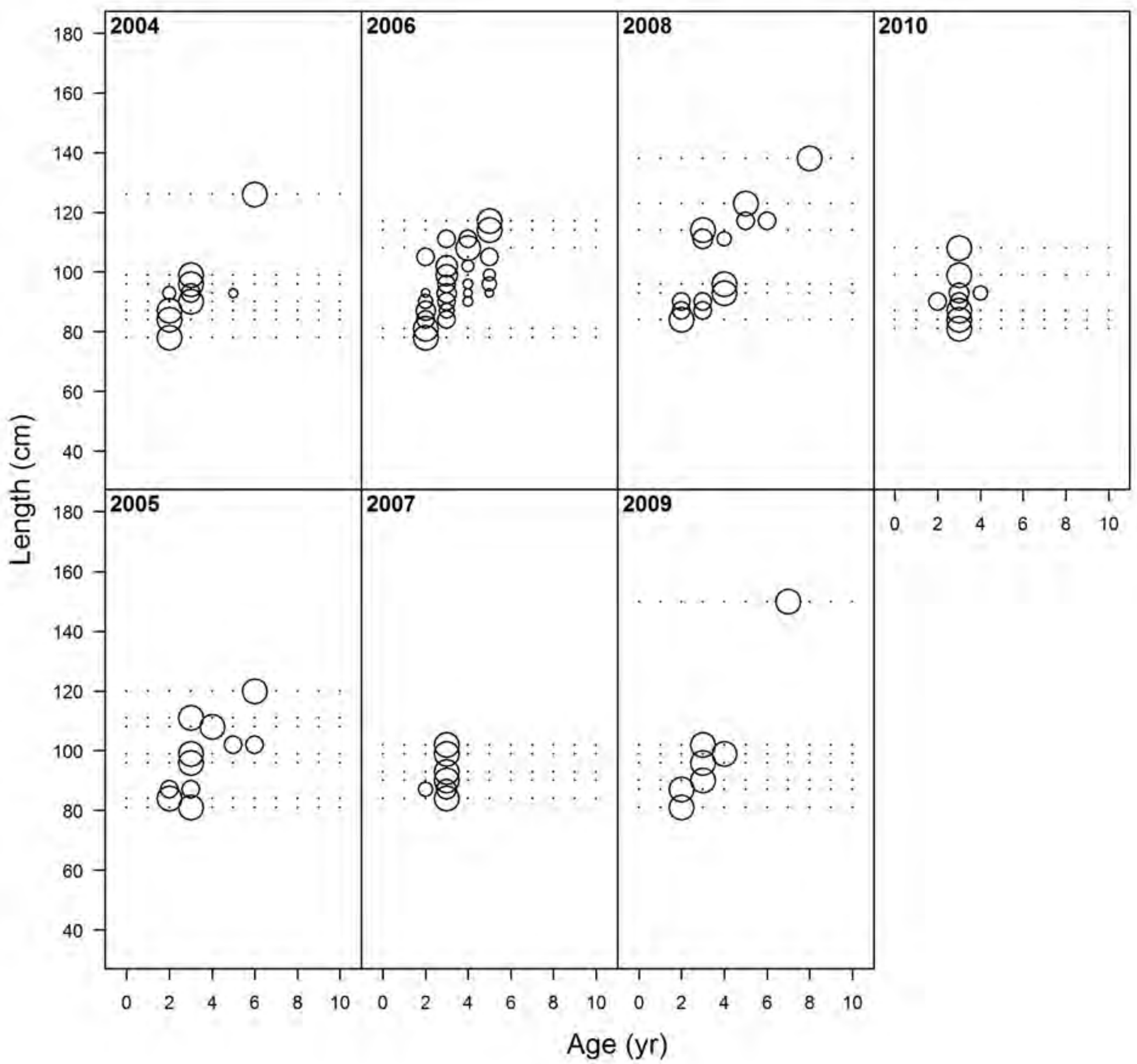


Figure 2.8c. Observed conditional age-at-length data of Gulf of Mexico Cobia from the recreational fishing fleet, 1987-2011.

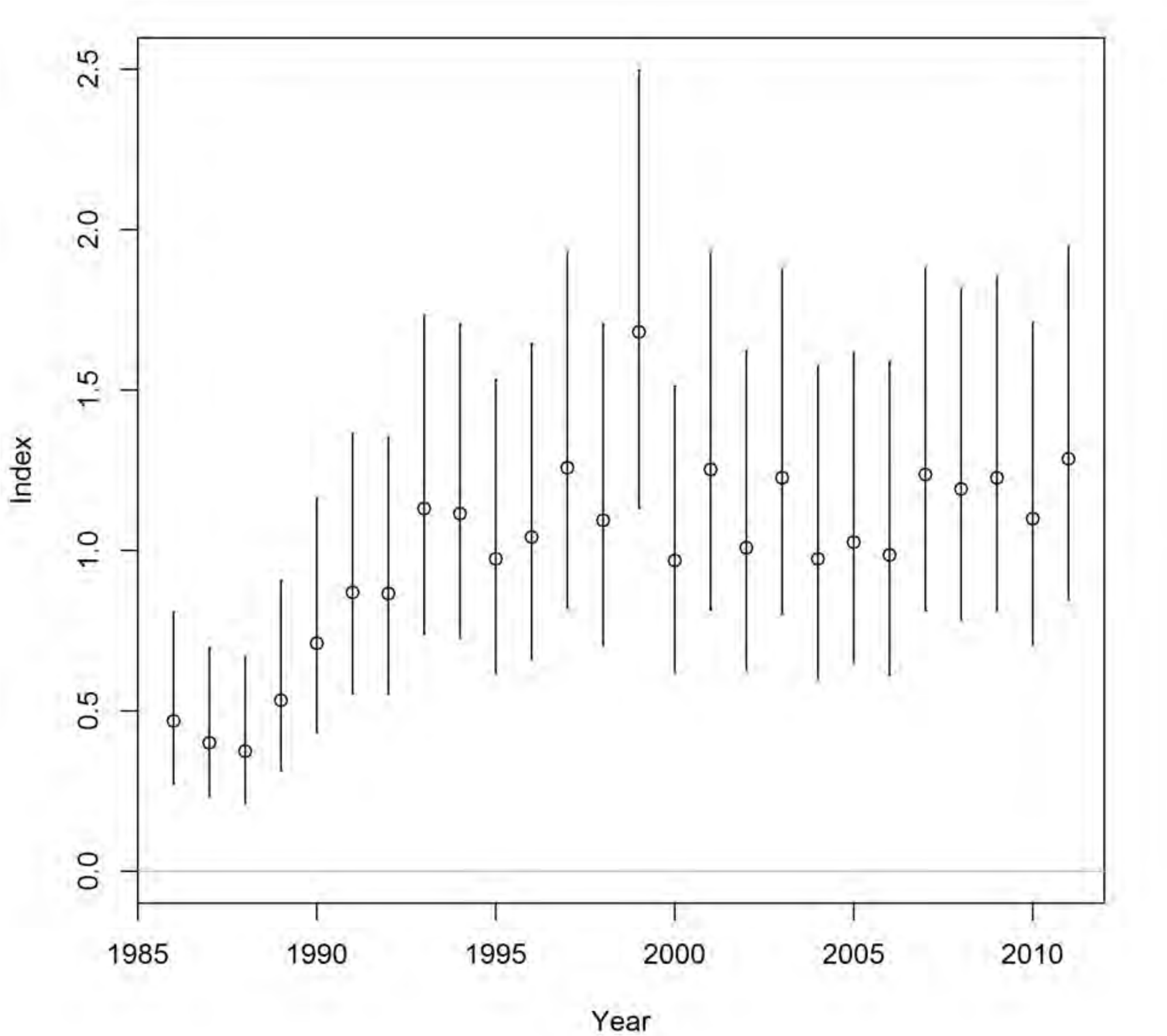


Figure 2.9. Standardized index of relative abundance and associated standard errors from the Gulf of Mexico recreational headboat fishery, 1985-2011.

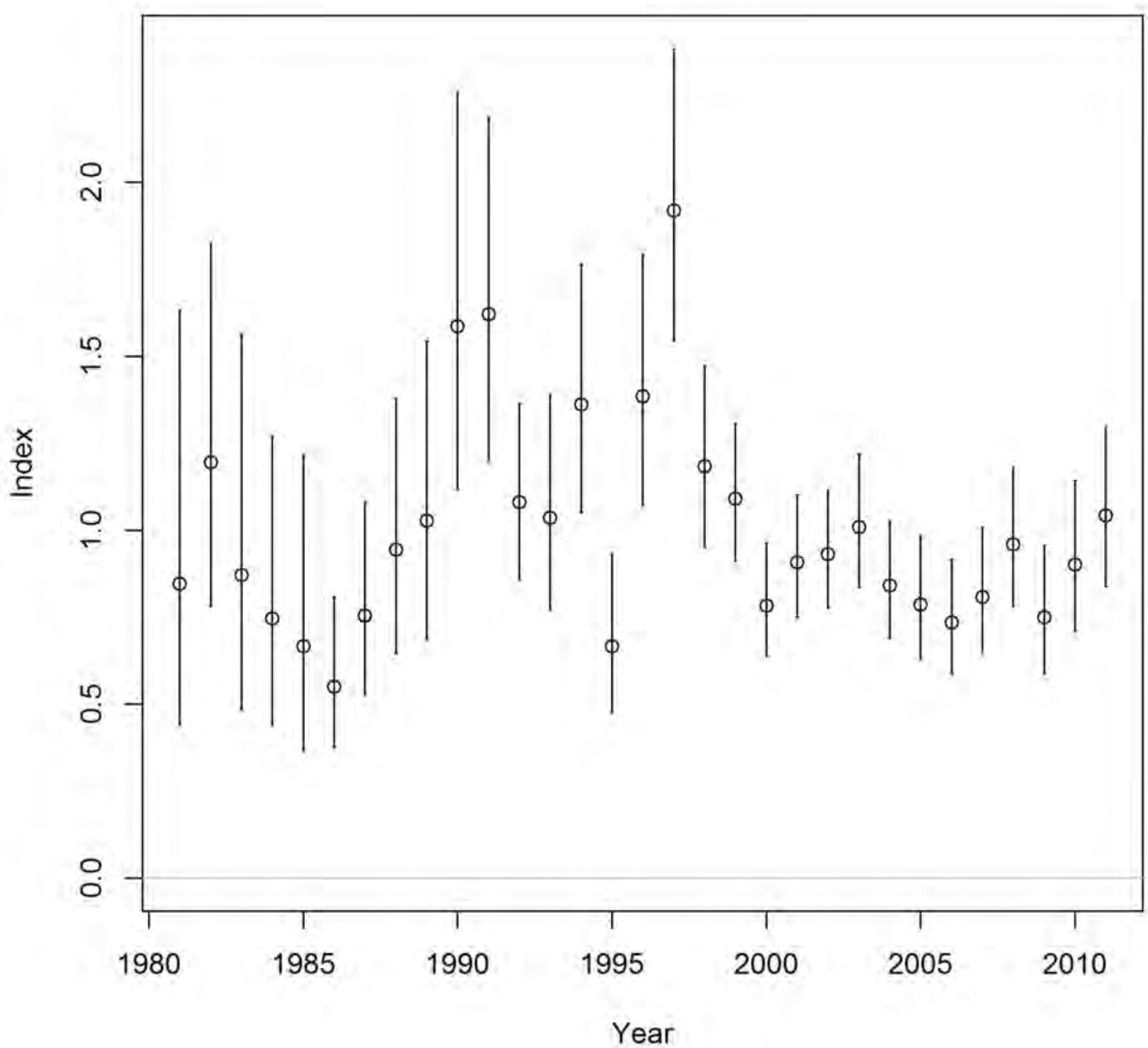


Figure 2.10. Standardized index of relative abundance and associated standard errors from the Gulf of Mexico recreational fishery (MRFSS), 1981-2011.

3 STOCK ASSESSMENT MODELS AND RESULTS

3.1 Stock Synthesis

3.1.1 Overview

The primary assessment model selected for the Gulf of Mexico cobia assessment was Stock Synthesis (Methot 2011) version 3.4d. Stock Synthesis (SS) has been widely used and tested for assessment evaluations, particularly in the US west coast NMFS centers (Methot 2011). Descriptions of SS algorithms and options are available in the SS user's manual (Methot 2011) and at the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/).

Stock Synthesis is an integrated statistical catch-at-age model which is widely used for stock assessments in the United States and throughout the world. SS takes relatively unprocessed input data and incorporates many of the important processes (mortality, selectivity, growth, etc) that operate in conjunction to produce observed catch, size and age composition and CPUE indices. Because many of these inputs are correlated, the concept behind SS is that they should be modeled together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment. SS has the ability to incorporate an early, data poor time period for which only catch data are available and a more recent, data-rich time period for which indices and length and age observations are available. SS also offers a lot of flexibility for constructing models of varying complexity. Data inputs and model parameters can be easily turned on or off to create alternative models of varying degrees of complexity. For this assessment SS was first constructed as a simple production model with minimal parameters. The model was then extended to an age-structured production model. Finally, length and age composition data was added to construct a length-structured catch-at-age model. General trends in estimated stock biomass over time remained similar as model complexity was increased. The model presented is the fully parameterized length based statistical-catch-at-age model. This model was selected because it incorporates all available data sources and is best suited for providing management advice.

3.1.2 Data sources

The landings, discards, length composition, age composition, and indices of abundance used in SS are described in Section 2 (Figure 3.1). Appendix A contains the data file for Stock Synthesis.

3.1.3 Model configuration and equations

The primary assessment model selected for the Gulf of Mexico cobia assessment was Stock Synthesis (Methot 2011) version 3.4d. Stock Synthesis version 3.4d was amended to deal with particular issues raised during the SEDAR 28 stock assessments for Gulf of Mexico Cobia and Gulf of Mexico Spanish mackerel. The major addition in Stock Synthesis 3.4d was the ability to explicitly model fisheries for which the only source of mortality is discarding of bycatch. Changes in Stock Synthesis 3.4d allowed for the approach explained in Section 2.3.3 for modeling shrimp bycatch of cobia explicitly as a bycatch fishery.

The Gulf of Mexico cobia population was modeled as a single stock that occurred from the Georgia-Florida border in the South Atlantic through the Northern Gulf of Mexico to the Mexico-Texas border. The assessment uses data through 2011 and the time period of the assessment is 1926-2011. Model projections were run for 2013-2019. A general description of the assessment model follows.

The assessment was set up to include three fishing fleets and two indices of abundance. The three fishing fleets were commercial, recreational, and the shrimp bycatch fishery. The two indices of abundance used in the assessment were the marine recreational fishing statistical survey (MRFSS) and headboat survey.

The stock is assumed to be in equilibrium at the beginning of the modeled period in 1926. Commercial landings of cobia were first reported in 1927. Recreational landings were hindcast to 1950 and estimates of shrimp effort were available back to 1945. Recreational landings data were collected from 1981-2011 through the Marine Recreational Fishing Statistical Survey (MRFSS). The data workshop report provides details on how recreational landings were estimated for 1950-1980. Substantial removals of cobia did not occur until after WWII for any of the fisheries. An initial equilibrium fishing mortality rate of zero was assumed for all fleets. The model estimated annual fishing mortality rates for each fishery. Annual fishing mortality rates are adjusted within the model so that the calculated retained catches will nearly exactly match the observed retained catches. No seasons are used to structure removals or biological predictions, so data collection is assumed to be relatively continuous throughout the year.

The natural mortality rate (*M*) was assumed constant over time, but decreasing with age. The form of *M* as a function of age was based on Lorenzen (1996). The DW life history working group recommended using a base $M = 0.38$ y^{-1} and a reference age of 3. The base *M* of 0.38 y^{-1} was developed using the relationship between maximum age (11) and *M* (Hoenig 1983). The age-specific natural mortality vector developed at the DW was input into SS as a fixed vector. Sensitivity runs using a range of Lorenzen age-variable *M* values that represented a CV of 0.54 were recommended by the DW life history working group. However, this range of *M* values was considered too high by the AW. Sensitivity runs with *M* scaled at 0.50 y^{-1} for a high estimate and 0.26 y^{-1} for a low estimate were used (Figure 3.2).

In SS, all cohorts of fish graduate to the age of 1 when they first reach January 1, regardless of when they are born. This means that SS operates under the assumption that all age data have been adjusted so that fish graduate to the next age on January 1. The DW used a birthday of May 1 for converting calendar ages to fractional ages. Thus, age-0 fish are graduated to age-1 in the model after only 7 months of biological life (May 1 – January 1). To resolve this accounting discrepancy we had to adjust the natural mortality rate for age-0 fish. Instead of undergoing a full year of instantaneous natural mortality, we reduced the estimated *M* for age-0 fish so that age-0 fish underwent 7 months of instantaneous natural mortality.

Growth rates were estimated in the assessment model using a single growth curve for both sexes. Growth was modeled with a three parameter von Bertalanffy equation (L_{min}, L_{max}, and *K*). In SS, when fish recruit at the real age of 0.0 they have a body size equal to the lower edge of the first population bin (L_{bin}; fixed at 6 cm FL). Fish then grow linearly until they reach a real age equal to the input value of A_{min} (growth age for L_{min}) and have a size equal to the L_{min}. As they age further, they grow according to the von Bertalanffy growth equation. The value of A_{min} was fixed at 0.75 which is representative of a fractional age of 0.42 (lifespan: May 1 – October 1). This value was chosen for A_{min} because there were 10 observations of length-at-age data for age-0 fish collected in the months of October and November to inform the model estimate of L_{min}. L_{max} was specified as equivalent to L_{∞}. Variation in the size-at-age was estimated in the model for ages 0.5 and 10. For intermediate ages a linear interpolation of the CV on mean size-at-age is used.

A fixed length-weight relationship was used to convert body length (cm) to body weight (kg). Fecundity was assumed to be proportional to female biomass. Maturity was input as a fixed function of age, with age-2 fish being 50% mature and age-3+ fish being full mature.

A single Beverton-Holt stock-recruitment function was estimated in SS. Spawning stock was assumed to be total mature female biomass. Two parameters of the stock recruitment relationship were estimated; the log of unexploited equilibrium recruitment (R_0) and steepness (*h*). A third parameter representing the standard deviation in recruitment (*sigmaR*) was input as a fixed value of 0.6. Rarely is *sigmaR* directly estimable from the given data and hence it is often necessary to input as a fixed parameter. There were no applicable environmental covariates to link to recruitment.

Annual deviations from the stock-recruit function from 1982-2010 were estimated in SS as a vector of deviations forced to sum to zero. Prior to 1982, recruitment is estimated as a function of spawning stock biomass based on the stock-recruit parameters. Stock synthesis assumes a lognormal error structure for recruitment. Therefore, expected recruitments were bias adjusted. Methot and Taylor (2011) recommend that the full bias adjustment only be applied to data-rich years in the assessment and few years into the data-rich period. This is done so SS will apply the full bias-correction only to those recruitment deviations that have enough data to inform the model about the full range of recruitment variability (Method 2011). Full bias adjustment was used from 1984 to 2009 when length and age composition data are available. Bias adjustment was phased in from no bias adjustment prior to 1982 to full bias adjustment in 1984 linearly. Bias adjustment was phased out over the last two years (2010-2011), decreasing from full bias adjustment to no bias adjustment. The years selected for full bias adjustment were estimated following the methods of Methot and Taylor (2011). The proportion of female recruits was set at 0.60.

SS provides the option to model the age composition as a set of conditional ages at length. This modeling framework operates similarly to an age-length key where a distribution of ages is input for a given length bin. This modeling approach is recommended (Methot 2011) and avoids double use of fish for both age and size information because the age information is considered conditional on the length information, contains more detailed information on the variance of size-at-age and provides better ability to estimate growth parameters and the age composition need not be selected completely at random. Thus, data collected in a length-stratified program can be incorporated, provided there is no bias for a particular age within a length bin. The age composition data was input in this manner with ages assigned to 3 cm length bins with the length bins ranging from 6 to 165 cm and ages from 0-11 where 11 represents a plus group age.

Size based selectivity patterns were specified for each fishery and survey in SS. Four selectivity patterns were defined in SS: 1) commercial fishery, 2) recreational fishery, 3) shrimp trawl fishery, and 4) MRFSS survey. The AP decided to constrain the selectivity patterns for the commercial and recreational fisheries to be asymptotic. A two parameter logistic function was used to model selectivity for the commercial and recreational fisheries. The selectivity for the shrimp trawl fishery was modeled using a six parameter double-normal function. The double normal can model dome-shaped selectivity, but it also can model asymptotic selectivity by holding several of the function's parameters at fixed values. The selectivity for the shrimp trawl fishery was modeled with all six parameters of the double-normal allowed to vary which resulted in a dome-shaped selectivity pattern. The selectivity pattern of the MRFSS index was assumed to mirror the selectivity pattern of the recreational fishery. Selectivity patterns were assumed to be constant over time for each fishery and survey.

Retention curves were used to account for discards and incorporate the impact of a minimum size limit for the commercial and recreational fisheries. A minimum size limit of 33 inches (83.8 cm FL) was enacted in 1984 in both federal and state waters for all fisheries. Time blocks on the retention curves were specified to create separate retention curves for the time period of 1927-1984 and 1985-2011. Prior to the minimum size limit, it was assumed that some discarding occurred in both the commercial and recreational fishery. The MRFSS data set estimated low levels of discards prior to the size limit; no information was available on commercial discards prior to 1993. To account for discarding prior to the size limit, a retention curve with an inflection point of 40 cm FL and slope of 2 (almost knife-edge) was used for both fisheries. The retention curves were fixed because there was no length composition data of discarded fish available to inform the model on their shape. Length composition data collected before 1984 shows that approximately 50% of retained fish were less than 33 inches. The smallest observed fish in the recreational length composition data prior to 1984 was 32 cm FL. The smallest observed fish in the headboat length composition data prior to 1984 was 57 cm FL. Less than 2% of fish in the recreational length composition data were less than 50 cm prior to the size limit. Only one year of commercial length composition data was available prior to the size limit; the smallest fish in the length composition data was 55 cm FL. Retention parameters for the time period 1984-2011 were estimated by the model for both the commercial and recreational fisheries.

An update in SS 3.4d allowed for the shrimp fishery to be modeled explicitly as a bycatch fishery. Due to concerns about the accuracy and precision of the annual estimates of cobia bycatch from the shrimp fishery the AP agreed to not use annual point estimates of bycatch in the assessment model. The AP recommended that shrimp fishery effort be used as a proxy for cobia bycatch trends since shrimp fishery effort is known with more certainty. In SS, an annual estimate of shrimp fishery effort (1945-2011) was input as an index of fishing mortality. SS interprets effort data as being proportional to the level of the fishery *F* values. A catchability coefficient (*Q*) was required to scale the shrimp effort time series, the resultant proportionality constant has units of 1/*Q*. Shrimp fishing effort was scaled to an estimate of cobia bycatch by assuming that the median estimate of cobia bycatch from 1972-2011 was representative of the level of bycatch from the fishery. This median estimate of cobia bycatch was input in SS as a discard time series using a super-year approach and represents the observed level of shrimp bycatch (Method 2011). The magnitude of the bycatch was estimated in SS by minimizing the difference between the observed and model predicted mean bycatch for the time period of 1972-2011. Stock synthesis used the model predicted mean bycatch for 1972-2011 and input levels of shrimp fishing effort to predict the annual number of removals from the shrimp bycatch fishery.

The SS input files are presented in Appendices A-D.

3.1.4 Parameters estimated

A total of 268 parameters were estimated for the base case model (Table 3.1). Table 3.1 includes predicted parameter values and their associated standard errors from SS, initial parameter values, and minimum and maximum values a parameter could take. Parameters designated as fixed were held at their initial values. Uniform, non-informative priors were applied to all estimated parameters in the base model. Parameter bounds were selected to be sufficiently wide to avoid truncating the searching procedure during maximum likelihood estimation. The soft bounds option in SS was utilized when fitting the assessment model. This option creates a weak symmetric beta penalty on selectivity parameters to move parameters away from the bounds (Methot 2011).

Of the 268 parameters estimated, 5 were used to model growth, 16 were used to estimate selectivity and retention curves, 2 were used to model the stock-recruit relationship, 1 catchability coefficient for shrimp fishing effort was used, 30 annual recruitment deviations were estimated, and 214 fishing mortality rate parameters were estimated.

3.1.5 Model convergence

To test for convergence, 50 trials were performed using a 'jitter' value (Methot 2011) of 0.1 for the base case model. In large statistical models the solution surface tends to be very complex. To ensure that the model converged to a "global" solution, rather than a local minimum, it is important to start the model using alternative starting values for the model parameters. This test perturbs the initial values used for minimization with the intention of causing the search to traverse a broader region of the likelihood surface.

3.1.6 Uncertainty and Measures of Precision

Uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter (Table 3.2). Asymptotic standard errors are calculated by inverting the Hessian matrix (i.e., the matrix of second derivatives of the likelihood with respect to the parameters) after the model fitting process. Asymptotic standard errors are based upon the model's analytical estimate of the variance near the converged solution.

Uncertainty in parameter estimates was further investigated using a parametric bootstrap approach. Bootstrapping is a standard technique used to estimate confidence intervals for model parameters or other quantities of interest. There is a built-in option to create bootstrapped data-sets using SS. This feature performs a parametric bootstrap using the error assumptions and sample sizes from the input data to generate new observations about the fitted model expectations. The model was refit to 1000 bootstrapped data-sets and the distribution of the parameter estimates was used to represent the uncertainty in the parameters and derived quantities of interest.

Likelihood profiles were completed for two key model parameters: steepness of the stock-recruit relationship (*h*) and unexploited equilibrium recruitment (R_0). Likelihood profiles are commonly used to elucidate conflicting information among various data sources, to determine how asymmetric the likelihood surfaces surrounding point estimates may be, and to provide an additional evaluation of how precisely parameters are being estimated.

3.1.7 Sensitivity analysis

Uncertainty in data inputs and model configuration was examined through sensitivity analyses. The models reported in this section are by no means meant to be a comprehensive comparison of all possible aspects of model uncertainty, nor do they reflect even the full range of models considered in developing the base case. These scenarios are intended to provide more information about sensitivity to key model parameters and potential conflict in signal among data sources. The order in which they are presented is not intended to reflect their importance; each run included here provided important information for developing or evaluating the base case model and alternate states of nature. Ten alternative runs are included in this report.

Run 1: The central run off which the sensitivity runs were based. This run used the model configuration and initial parameter values described in Section 3.1.3 and Table 3.1.

Run 2: Low *M* run. The Lorenzen natural mortality rate at age was rescaled to provide the same cumulative survival through the oldest observed age as would a constant $M = 0.26\ y^{-1}$ (Figure 3.1). This *M* is equal to the base *M* used in the South Atlantic cobia stock assessment. The maximum age reported for Atlantic cobia was 16 yr which was 5 years older than the maximum age for the Gulf of Mexico – hence the *M* estimate for the South Atlantic was much lower than the Gulf of Mexico.

Run 3: High *M* run. The Lorenzen natural mortality rate at age was rescaled to provide the same cumulative survival through the oldest observed age as would a constant $M = 0.50\ y^{-1}$ (Figure 3.1).

Run 4: High discard mortality run. For this run discard mortality rates for both commercial and recreational fisheries were doubled from 0.05 to 0.10.

Run 5: Steepness fixed at 0.70. The base run estimated steepness at 0.92 and the likelihood profile of steepness was relatively flat between values of 0.80 and 1.0. However, a steepness of 0.70 is biologically feasible and this run represents a scenario given a lower bound on stock productivity.

Run 6: Steepness fixed at 0.80. The base run estimated steepness at 0.92 and the likelihood profile of steepness was relatively flat between values of 0.80 and 1.0. Given the relatively flat profile for steepness, fixing steepness at 0.80 represents an alternative state where the stock is slightly less productive.

Run 7-8: MRFSS index only or Headboat index only. Only two indices of abundance were used in the assessment model. Both indices of abundance were linked to the recreational fishery. The two indices have structural differences as the MRFSS index is an index of all fish captured whereas the Headboat index is an index of only legal fish. There were slight differences in their annual signals and their overall trend. The MRFSS index tended to have greater inter-annual deviations but annual point estimates had lower CVs, especially in the most recent years. In addition, the MRFSS index displayed more patterns in stock size fluctuation over time whereas the Headboat index displayed a general trend of increasing stock size over time.

Run 9: Data component weights iteratively re-weighted using SS approach. The goal of data weighting is to achieve consistency between the degree of uncertainty in each data set and the model's ability to fit those data. Variances and samples sizes for data components are first derived from the raw data sources. Variances and samples can then be iteratively re-weighted to ensure consistency between the input sample sizes (or standard errors) and the effective sample sizes based on model fit. SS allows for iterative reweighting of data components using variance adjustment factors. For data components, these weights are applied by either adjusting CVs of the abundance indices or adjusting effective sample sizes of composition data. SS calculates a root mean squared error (RMSE) for the fit to abundance indices and an effective sample size for fits to composition data. Weights are applied to data components so that the CVs of the abundance indices match the RMSE and sample sizes for composition data match effective sample sizes estimated by SS. This approach attempts to reduce the potential for particular data sources to have a disproportionate effect of total model fit, while creating estimates of uncertainty that are commensurate with the uncertainty inherent in the input data.

Run 10: Data components iteratively re-weighted following Francis (2011). The implementation of the Francis (2011) approach is similar to approach described above for SS: weights are applied by either adjusting CVs of the abundance indices or adjusting effective sample sizes of composition data using variance adjustment factors to ensure consistency between the degree of uncertainty in each data set and the model's ability to fit those data. However, the calculation of data weights differs between the approaches. Most notably, the Francis (2011) approach tends to down-weight age- and length-composition data relative to the SS approach.

Run 11-16: In addition, a retrospective analysis of Run 1 was conducted, in which the model was refit while sequentially dropping the last six years of data. Retrospective analysis is used to look for systematic bias in key model output quantities over time.

3.1.8 Benchmark/Reference points methods

Benchmark and reference points for fishing mortality and stock biomass were estimated relative to SPR 30% levels. Benchmarks and reference points are calculated in SS. The user can select reference points based on MSY, SPR, and spawning biomass. Stock Synthesis calculates SPR as the equilibrium spawning biomass per recruit that would result from a given year's pattern and intensity of *F*s. For SPR-based reference points, SS searches for an *F* that will produce the specified level of spawning biomass per recruit relative to the unfished value. For spawning biomass-based reference points, SS searches for an *F* that produces the specified level of spawning biomass relative to the unfished value. Both MSY and spawning biomass-based reference points are dependent on the stock-recruit relationship.

3.1.9 Projection methods

Projections were run from 2013 to 2019 for the three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}. $F_{CURRENT}$ was defined as the geometric mean *F* of the three most recent years (2009-2011). F_{SPR30} was used as the F_{MSY} proxy. F_{OY} was defined as 75% of F_{SPR30}.

Projections were run assuming that selectivity, discarding, and retention were the same as the five most recent years. Recruitment deviations for the projection period were derived from the stock-recruitment relationship and did not include inter-annual variation. Catch allocation used for the projections reflects the average distribution of fishing intensity among fleets during 2009-2011. A fixed level of fishing mortality rate equal to the geometric mean *F* of the three most recent years (2009-2011) was used to predict removals for each of the fisheries for 2012 since 2012 data was not available. A fixed level of fishing mortality equal to the geometric mean *F* of the three most recent years (2009-2011) was input for the shrimp fishery for the entire projection period (2013-2019) as recommended by the AP. Thus, it is assumed that recent levels of shrimp fishing effort (2009-2011) are representative of future fishing effort levels. This approach was used since cobia bycatch from the shrimp fishery is assumed to be a function shrimp fishing effort and is independent of cobia management regulations.

3.2 Model Results

3.2.1 Measures of overall model fit

Stock Synthesis effectively treats the landings data as being known without error. Therefore, the landings are fit precisely.

Predicted discards for the commercial fleet were within the observed confidence intervals across all years but did not fit observed estimates well, especially in the early time period (1993-1998) (Figure 3.3). Predicted discards are higher than the observed estimates from 1993-1998 and slightly lower than observed estimates from 1999-2009. The model predicted that the discard proportion (discards/(landings+discards)) would remain relatively stable over time given that selectivity and retention were assumed to be constant over the time period. Thus, model predicted discards generally tracked observed changes in the landings data. However, the observed discards are relatively stable over time despite a corresponding reduction in landings, which peaked in the mid-1990's, suggesting an increase in the discard rate over time from 1993-2011. One potential reason for this mismatch is that the observed discard data contains high uncertainty while the observed landings are treated as being known without error. Given that selectivity and retention are assumed to be constant, the model would require a strong signal in the length composition data to predict an increase in the discard proportion over time. However, the length composition data of the landings are relatively stable over time and the observed mean length of cobia landed in the commercial fishery has not changed over time. Thus, there is nothing in the data or model parameterization to corroborate the observed increase in discard rate over time.

The fit to the recreational discards was better than the commercial discards but showed a similar pattern. Following the implementation of the size limit, predicted discards for the recreational fleet are higher than the observed estimates from 1986-1997 (except 1991), then lower than observed estimates from 1998-2002 and then fit well in the most recent years (2003-2011) (Figure 3.4). The model predicted discard rates were very similar to the observed discard rates from 1990-2011 (Figure 3.5). The model predicted discards and discard rate was higher than the observed estimates from 1986-1990 as the model estimated a large increase in the discard rate from the implementation of the minimum size limit in 1985. However, the observed recreational discard data does not show a rapid change in discards following 1984; in fact, the data shows almost no discards in 1985 (0.02). The recreational length composition data shows some evidence that the size limit was not effective for a few years after implementation as a number of sub-legal fish are observed in the sampled landings from 1984-1987. Following 1990, the observed and predicted discard rates are very similar. In 1990, a two-fish bag limit was instituted for cobia for U.S. federal waters. There is evidence of a large increase in discards between 1989 and 1991 suggesting the bag limit had an effect on discard rate. However, the bag limit was not implemented in the assessment model. The models ability to fit the recreational discard data well despite not accounting for the two-fish bag limit suggests that the bag limit is rarely filled by recreational fisheries. Of the trips with positive catches of cobia in the MRFSS data set, only 2% filled the bag limit.

Predicted cobia bycatch from the shrimp fishery was appropriately scaled and followed the patterns of shrimp fishing effort input into the model (Figure 3.6). The model predicted mean bycatch level was very similar to the input estimate used for the super-year approach (Figure 3.6). The model predicted annual cobia bycatch estimates were not fit to the annual estimates of cobia bycatch from the data workshop. Instead, the model predicted annual cobia bycatch using the model predicted mean bycatch level and the input estimate of shrimp fishing effort.

The indices of abundance were fit well by the model (Figures 3.7 and 3.8). The model fit to the MRFSS index was somewhat better than the model fit to the Headboat index. The root mean squared error (RMSE) for the MRFSS and Headboat index was 0.222 and 0.236, respectively. These values were very similar to the input average annual variance estimates, 0.156 and 0.234, for the MRFSS and Headboat indices. The MRFSS index started earlier (1981) relative to the Headboat index (1985) and has lower CVs in the most recent years. The MRFSS index is characterized by two periods of stock decline (1981-1986, 1996-2006) and two periods of subsequent stock recovery (1986-1996, 2006-2011). The model was unable to fit some the drastic inter-annual changes in abundance but fit the overall pattern of the index well. The Headboat index is characterized by an initial increase from the late 1980's through the early 1990's followed by a relatively stable trend from 1995-2011. The model fit the overall trend in the index well but predicted greater fluctuations in abundance than the Headboat index suggested. The shrimp fishery effort which was input as an index of fishing mortality was fit almost precisely by the model (Figure 3.9). The model configuration did not require an exact match to the shrimp fishing effort; a CV of 0.10 was used for the index.

The length compositions were fit well by the model, especially given the low sample sizes in some years (Figures 3.10-3.14). The fit to the recreational length composition data was generally superior to the fit of the commercial length compositions owing to the relatively greater sample sizes. Length compositions were fit better later in the time series for both the commercial and recreational length compositions. Sample sizes for the commercial length compositions were low from 1983-1990 (Figure 3.10). Only one year of commercial data had greater than 100 length samples. The model underestimated small fish (<70 cm FL) early in the time series (1983-1987) and underestimated large fish (> 110 mm FL) in the middle of the time series (1996-2004) (Figure 3.11). There does appear to be a slight pattern in the residuals with a shift towards larger catches in the middle of the time series when the model predicts stock biomass was highest.

The recreational length compositions were fit very well by the model, especially from 1991-2011. There were high sample sizes (>100) every year from 1985-2011 (Figure 3.12). The predicted distribution is slightly wider than the observed distribution leading to some positive residuals in the middle of the distribution and negative residuals at the tails. The model underestimated the number of fish less than 60 cm FL throughout the time series (Figure 3.13). The model estimated the asymptote of the retention curve used for 1985-2011 to be right at the size limit of 83 cm FL, however, the model did allow for some retention under the size limit by widening the slope of the curve relative to a knife-edge slope. The higher slope improved the fit to the length composition data given the number of samples under the size limit. It is unclear why so many sublegal fish were in the observed length composition data.

The model fit the SEAMAP trawl survey length composition data well (Figure 3.14). The SEAMAP trawl survey length composition data consisted of 295 cobia measured from 1987-2011 which were combined into a single length composition using the super-year approach and assumed to representative of the shrimp fishery. The predicted length composition effectively fit the mode of fish observed in the SEAMAP trawl survey between 30-50 cm FL.

The conditional age compositions were fit well by the model given the small sample sizes (Figure 3.15a-3.15c). The largest residuals tended to occur for older fish with the model under-estimating the mean length-at-age of older fish. This occurred because the model predicted very strong size selection effects from the recreational and commercial fisheries (Figure 3.16). The input conditional-length-at-age data were exclusively fishery-dependent samples from the recreational fishery which has a minimum size limit of 83.8cm FL. Of the 1229 length-at-age samples, 1114 were fish greater than the minimum size limit. SS accounts for the size-selection of the fishery when estimating the population growth curve. The estimated population growth curve from SS was lower than the growth curve estimated at the DW (Figure 3.17). The DW growth curve was supposed to account for the effects of size-selection using the Diaz et al. (2004) approach. However, SS predicted greater size-selection bias than the DW model.

3.2.2 Parameter estimates & associated measures of uncertainty

A list of all model parameters is presented in Table 3.1. The table includes predicted parameter values and their associated standard errors from SS, initial parameter values, minimum and maximum values a parameter could take, and whether the parameter was fixed or estimated. Parameters designated as fixed were held at their initial values.

The standard errors are low for the majority of parameters with a few exceptions. The standard errors are high for a number of the recruitment deviations, indicating that the recruit deviations are poorly estimated (Figure 3.18). Standard errors for recruitment deviations increased over time with standard errors generally less than 0.2 prior to 1996 and increasing to around 0.3 from 1996-2010. The two most recent years of recruitment deviations had the greatest uncertainty with recruitment for 2011 being the most uncertain parameter estimated. There was not a lot of data available to inform the recruitment deviations; the age composition data was too sparse to track cohorts through time and the length composition data are not particularly informative about historical recruitment patterns because cobia have very fast and variable growth and a minimum size limit has existed over the entire data-rich period.

Two of the parameters used to model the double-normal selectivity pattern for the shrimp fishery had high standard errors. These two parameters controlled the initial selectivity at the minimum size and the ascending width of the selectivity curve (see Section 3.2.3). All other parameters had relative standard errors less than 20%.

In general, estimates of uncertainty from the bootstrap procedure were very similar to estimates of asymptotic standard errors calculated by inverting the Hessian matrix. A list of the mean and standard deviation from the distribution of parameter estimates for the 1000 bootstrap samples is presented in Table 3.2.

To test for convergence, 50 trials were performed using a 'jitter' value (Method 2011) of 0.1 for the base case model. Forty-eight of these trials returned converged on a solution that was within 2 likelihood units of the base case, inverting the Hessian and producing small gradients (Table 3.3). Only one trial failed to converge. Results of trials that converged on a solution show almost identical levels of ending depletion and spawning biomass. This test cannot prove convergence of the model, but it did not provide any evidence to the contrary.

3.2.3 Fishery Selectivity

Fishery size selectivity patterns for the commercial and recreational fisheries were modeled using logistic functions (Figures 3.19-3.21). As expected, the recreational fishery selects for smaller fish than the commercial fishery. The estimated selectivity curve for the commercial fishery was much steeper than the recreational fishery. Both abundance indices were assumed to have the same selectivity patterns as the recreational fishery.

Two retention functions were modeled for both the commercial and recreational fisheries to account for the implementation of a minimum size limit in 1984 (Figures 3.22-3.23). Retention was modeled to change starting in 1985. Prior to the size limit, the retention curve was fixed so that fish less than 40 cm FL were discarded. The two parameters used to model retention curve for both the commercial and recreational fisheries following the size limit were estimated by the model. The estimated asymptote for the retention curve was 92 cm FL for the commercial fishery and 82 cm FL for the recreational fishery. The model predicted the commercial fishery would release some legal size fish, while the model estimated the recreational retention less right at the size limit.

Size selectivity for the shrimp fishery was modeled using a 6 parameter double-normal function (Figure 3.24). The double-normal allows for a large range of potential shapes to the selectivity curve. All sizes of fish were predicted to be vulnerable to the shrimp fishery. The selectivity of fish less than 30cm FL was predicted to be 45%. Length composition data from the SEAMAP trawl survey show that fish begin to be captured at 16cm FL. There was some evidence of differences in composition in length composition from samples collected in the summer verse samples collected in the fall (Figure 3.25). Sample sizes of cobia collected in the summer were small but the distribution shows a mode around 20cm FL. These fish are likely fast growing or early spawned age-0 fish. Beyond 30cm FL selectivity increases rapidly with a peak between 35 and 40cm FL and then quickly descends. This peak corresponds with the majority of the samples collected during the fall SEAMAP surveys. Selectivity for the shrimp fishery was predicted to be constant at a low level for fish greater 50 cm FL. Observations of large cobia in the SEAMAP trawl survey support this pattern. The standard errors for two of the selectivity parameters were high and indicate that this selectivity pattern was not well estimated. The correlation matrix shows that the parameters describing the initial pattern of the selectivity curve were highly correlated. A number of model configurations were attempted to alleviate this issue. Reducing the bin size for the length composition data from 5cm bins to 3cm bins had the biggest impact on reducing the uncertainty in these parameters. The distribution of parameter estimates from the bootstrapping procedure show high uncertainty in the models ability to estimate these parameters (Figure 3.26).

3.2.4 Recruitment

Steepness is estimated to be 0.925 and virgin recruitment is 1,033,130 age 0 recruits for the base model. The asymptotic standard errors for steepness and unexploited equilibrium recruitment ($\ln(R_0)$) are 0.13 and 0.10, respectively. The standard deviation from the bootstrap samples for steepness and $\ln(R_0)$ are 0.08 and 0.07, respectively (Table 3.2). The distribution of estimates from the 1000 bootstrap samples support that equilibrium recruitment was well estimated by the model (Figure 3.27). The bootstrap analysis revealed that steepness was not well estimated and that the model tended to approach the upper bound of steepness for a large proportion of model runs (Figure 3.27). The distribution of estimates from the bootstrap analysis suggests that steepness is likely to greater than 0.8 but estimates between 0.85 and 1.0 were equally likely.

The plot of the stock-recruitment relationship shows little contrast over time in terms of spawning biomass (Figure 3.28). Spawning biomass is predicted to have been relatively stable over the past 30 years (relative to virgin biomass) leading to little variation in stock size. Two of the highest recruitment years were predicted to occur directly following the year with the lowest spawning stock biomass. In addition, the landings data and MRFSS index both show patterns of rapid stock increase following decreases suggesting a relatively productive stock.

Predicted age-0 recruits are presented in Figure 3.29 and Table 3.4. The model predicts a number of poor recruitment years starting in 1982, the first year the model can estimate recruitment deviations. The model predicts higher than average or average recruitment from 1989-1996. The landings data and abundance indices all show a similar pattern of increasing abundance over this time period. The model predicts a number of lower than average recruitment years from 1996-2007. This coincides with a decrease in the landings data and decrease in the MRFSS index. Predicted recruitment over the past several years is average but highly uncertain. An uptick in landings for both the commercial and recreational fishery as well as the MRFSS index supports the higher than average recruitments during the most recent years.

The likelihood profile of steepness shows that steepness is relatively flat between 0.80 and 1.0 (Figure 3.30). However, there is a minimum between 0.85 and 0.95 and the profile increases rapidly for steepness values less than 0.70. There is some discrepancy in the estimate of steepness from the alternative likelihood components. The recruitment component of the likelihood shows a strong preference towards a value of steepness that approaches the limit of 1.0. The length data and discard data both have minima around 0.8. The age composition data favors a steepness value around 0.65. There appears to be little information in any of the abundance indices for steepness. When the likelihood profile of steepness was rerun at a finer scale it was revealed that the point estimate of steepness may not be well defined in the model. This is illustrated by the bouncing up and down of the length- and age-composition likelihood components when the profile is run at a finer scale (Figure 3.31). The bouncing of the likelihood components occurs because the model is settling on two alternative model solutions with slightly different point estimates of growth and selectivity parameters. This occurs due to confounding between the growth parameters and selectivity parameters. In particular, the model has trouble estimating the growth of young fish and selectivity of the shrimp fishery. Despite this 'chatter' in the likelihood, the alternative solutions are very similar and point estimates of growth and selectivity parameters are only slightly different. In addition, the patterns of stock dynamics are not different between the alternative solutions.

The likelihood profile of equilibrium recruitment shows that this parameter is well estimated (Figure 3.32). All likelihood components show a similar signal favoring a value near 7 for equilibrium recruitment (base model = 6.94).

3.2.5 Stock Biomass

Predicted total biomass and spawning biomass are presented in Table 3.4 and Figures 3.33 and 3.34, respectively. The bootstrap distributions of estimates of biomass show these values were well estimated by the model (Figure 3.35). The general biomass trend is a steady decline starting in 1950 as the recreational and shrimp fisheries begin to build up. Biomass is predicted to have reached a minimum from 1984-1989 and then increased rapidly from 1989 to 1997. The predicted biomass declines from 1997 to 2007 and then is followed by a steady increase over the past four years. Total stock biomass in the most recent year is predicted to be 34% of the unfished total biomass. Spawning stock biomass is predicted to be 30.5% of the unfished spawning stock biomass (Table 3.5). Spawning stock biomass is predicted to have exceeded the target spawning biomass ($SSB_{SPR30\%}$) in the two most recent years. Spawning stock biomass was less than $SSB_{SPR30\%}$ from 1983-1991 with a minimum of 0.57 in 1986. Spawning stock biomass exceeded $SSB_{SPR30\%}$ from 1992-2003 but then decreased to levels less than $SSB_{SPR30\%}$ again from 2004-2009.

Predicted abundance at age is presented in Figure 3.36. Mean age was predicted to be 1.76 years at unfished conditions. Mean age steadily declines from 1950 to 1980 to just over 1 years as the fisheries developed. The minimum predicted mean age over the time series was 0.48 in 1989. Predicted mean at age has been increasing since 1989 with some oscillation; mean age in 2010 is predicted to be 1.22.

3.2.6 Fishing Mortality

Predicted fishing mortality rates are presented in Table 3.6. Fishing mortality shows a steady increase for all fleets following 1950 (Figure 3.37). The commercial fishery F increases at a slower rate than the other fisheries but shows a rapid increase in the 1980's with a peak instantaneous fishing mortality rate of 0.50 y^{-1} occurring in 1989. The fishing mortality rate for commercial fishery declines rapidly following 1989 and has been steady around 0.075 y^{-1} since 2000. The recreational fishery shows an exponential pattern of increase from 1950 to 1986. Recreational F peaks at 1.44 y^{-1} in 1986. Recreational fishing mortality has oscillated around 0.40 y^{-1} since the late 1990's with lower rates over the past few years. Fishing mortality from the recreational fishery in 2009 was at its lowest level since the late 1970's. The patterns of fishing mortality in the shrimp fishery follow the patterns in shrimp effort input into the model. Shrimp fishery F peaks in the late 1980's similar to the other fisheries. A large decrease in shrimp effort since 2000 leads to predictions of low Fs over the most recent years.

Fishing mortality rate was predicted to exceed the target fishing mortality rate of $F_{SPR30\%}$ from 1984-1989 (Table 3.6; Figure 3.38). Fishing mortality rates have been less than $F_{SPR30\%}$ since 1989. The average fishing mortality relative to $F_{SPR30\%}$ over the past three years is 0.63. Results of the bootstrap analysis show that overfishing was likely occurring in the mid to late 1980's and overfishing is no longer occurring (Figure 3.39).

3.2.7 Evaluation of Uncertainty

Estimates of asymptotic standard errors for all model parameters are presented in Table 3.1. A list of the mean and standard deviation from the distribution of parameter estimates for the 1000 bootstrap samples is presented in Table 3.2. In general, estimates of uncertainty were very similar between the two methods.

Results of the sensitivity analysis are summarized in Table 3.7.

Run 2: Low *M* run. Decreasing the natural mortality rate led to a stock that was experiencing greater fishing mortality and more depressed relative to stock reference points. This was the only scenario in which the stock was predicted to be overfished or undergoing overfishing. Given this level of natural mortality, the model predicted a higher virgin spawning stock biomass and lower current spawning stock biomass relative to the base model (Figure 3.40). In addition, the stock is predicted to have been overfished since 1980 and to have been undergoing overfishing every year from 1978-2011 except 2010 (Figure 3.41).

Run 3: High *M* run. Increasing the natural mortality rate led to a stock that was experiencing less fishing mortality and was in improved shape relative to reference points. This scenario resulted in the best stock status of all sensitivity runs. Given this level of natural mortality, the model predicted a lower virgin spawning stock biomass and higher current spawning stock biomass relative to the base model (Figure 3.40). In addition, the stock is predicted to have been fished at levels less than F_{SPR30} over the entire time series (Figure 3.41).

Run 4: High discard mortality run. Increasing the discard mortality rate from 0.05 to 0.10 had little impact on the stock dynamics or stock status (Table 3.7). The model predicted slightly greater productivity and slightly higher fishing mortality rates under this scenario.

Run 5: Steepness fixed at 0.70. Fixing the steepness at a lower level of 0.70 resulted in a predicted stock biomass that was more depressed relative to unfished levels compared to the base model (Figure 3.42). In addition, the model predicted the stock to be experiencing slightly lower fishing mortality. Under this scenario, the stock status relative to reference levels was similar to the base run with the stock neither overfished nor undergoing overfishing (Figure 3.43).

Run 6: Steepness fixed at 0.80. Fixing the steepness at a lower level of 0.80 resulted in a predicted stock biomass that was more depressed relative to unfished levels compared to the base model (Figure 3.42). In addition, the model predicted the stock to be experiencing slightly lower fishing mortality. Under this scenario, the stock status relative to reference levels was similar to the base run with the stock neither overfished nor undergoing overfishing (Figure 3.43).

Run 7: MRFSS index only. Removing the Headboat index from the assessment led to a stock that was less productive and experiencing greater fishing mortality. Removing the Headboat index had the greatest influence on predicted spawning biomass and fishing mortality rates over the past 11 years; historical patterns prior to 2000 were very similar to the base model (Figure 3.44). The MRFSS index suggests that the relative abundance of cobia throughout the 2000's is depressed relative to the relative abundance throughout the 1990's. Under this scenario the model predicted lower current spawning biomass and higher fishing mortality rate compared to the base model (Figure 3.44). In addition, the model predicted *F* exceeded F_{SPR30} in 2003 and 2007 and that the spawning biomass has been less than SSB_{SPR30} since 2001 (Figure 3.45).

Run 8: Headboat index only. Removing the MRFSS index from the assessment led to a stock that was more productive and experiencing lower fishing mortality. The model estimated steepness to be at the upper bound of 1.0 when the MRFSS index was removed. The Headboat index shows an increasing trend in stock size over the survey period of 1985-2011 with no signal of stock decline. Under this scenario the model predicted higher current spawning biomass and lower fishing mortality rates compared to the base model (Figures 3.44).

Run 9: Data component weights iteratively re-weighted using SS approach. The model fit the abundance indices very well. A small additional variance component was added to the MRFSS and Headboat index, 0.0644 and 0.0028, respectively. The model fit to the recreational length composition data was better than expected and was up-weighted slightly (1.138). The commercial and shrimp fishery length composition data were down-weighted by a factor of 0.846 and 0.688, respectively. Reweighting of the model components led to a stock that was slightly more productive and experiencing lower fishing mortality rates. However, patterns of stock dynamics over time (Figure 3.46) and current status relative to benchmark levels are very similar to the base model (Figure 3.47).

Run 10: Data components iteratively re-weighted following Francis (2011). The Francis (2011) approach up-weighted the Headboat index (-0.02) and down-weighted the MRFSS index slightly (0.067). The model fits to the index data and weights were very similar between the two methods. In contrast to the SS weighting approach, the Francis (2011) approach down-weighted all length composition data. The recreational and commercial length composition data were down-weighted by a factor of 0.41 and 0.53, respectively. This approach did not estimate a weighting factor for the shrimp length composition data because only one year of data was available. Reweighting of the model components led to a stock that was slightly more productive and experiencing lower fishing mortality rates. The stock status and dynamics were very similar between the two weighting approaches (SS and Francis (2011)) and the base case model (Figures 3.46-3.47). The reweighting of data components did not reveal any conflicting information among alternative data sources.

Results of the retrospective analysis are also presented in Table 3.7. In general, there were no major patterns or systematic bias revealed from the retrospective analysis. Removing the past two years of data led to predictions of higher steepness. Predicted spawning stock biomass over time was relatively consistent for each of the data sets analyzed (Figure 3.48). Predicted age-0 recruits showed divergence between the models starting in 2002 (Figure 3.49). The data set ending in 2008 predicted a spike in recruitment in the final year that was not predicted for the 2009-2011 data sets. The final two years of recruitment had high uncertainty in the base model and thus divergence in predicted recruitments was expected since there is no data to inform the most recent years in any of the models. Fishing mortality rate patterns were consistent between the data sets and no bias was revealed (Figure 3.50).

3.2.8 Benchmarks/Reference points

Stock status and benchmarks relative to the SPR 30% reference point are presented in Table 3.8 for each of the sensitivity runs. The maximum fishing mortality threshold (MFMT) was the fishing mortality rate that produced a SPR of 30%, $F_{SPR30\%}$. The minimum stock size threshold (MSST) was calculated as $(1\text{-}M)*SSB_{SPR30\%}$, where $M = 0.38\ y^{-1}$ for the base model. For the base case model the stock is not considered overfished nor undergoing overfishing. For the base model the current fishing mortality rate (2009-2011) relative to MFMT was 0.63 and the current spawning biomass (2011) relative to MSST was 1.73. All 1000 estimates from bootstrap analysis predicted that current fishing mortality was less than $F_{SPR30\%}$ (Figure 3.51) and current stock size was greater than MSST (Figure 3.52). The status of the stock relative to $F_{SPR30\%}$ and $SSB_{SPR30\%}$ over the time series for the base model is presented in Figure 3.53. The status of the stock relative to MFMT and MSST over the time series for the base model is presented in Figure 3.54. For all sensitivity runs except the low natural mortality rate scenario (Run 2) the stock was is not considered overfished or undergoing overfishing (Figure 3.55). For the low natural mortality rate scenario the stock was considered both overfished and undergoing overfishing.

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 3.56). The yield per recruit curve peaked at $F_{max} = 0.63$. The F that provides 30% SPR is 0.38 and F_{msy} is 0.51. SPR at F_{msy} is estimated at 21%. Equilibrium catch was also computed as function of F (Figure 3.56). By definition, the F that maximizes equilibrium catch is F_{msy}, and the corresponding level of catch is MSY. Equilibrium catch was estimated in terms of total removals (landings plus dead discards) for this analysis. Equilibrium catch as a function of stock depletion is presented in Figure 3.57. MSY, in terms of total removals from all fleets, was estimated at 1335 (mt) and occurs when the stock is at 19% of virgin biomass.

3.2.9 Projection

Benchmarks for the SPR 30% reference point and projections are presented in Tables 3.9. Only a subset of the sensitivity runs was selected for use in projections. The AP felt that the entire set of sensitivity runs was not necessary for projections and only a subset designed to represent possible alternative states of nature were used. The AP decided to use three values of natural mortality rate (base, low and high) to evaluate alternative states of nature. For the base model, current exploitation rate is less than the target exploitation rate for achieving an SPR of 30% (Figure 3.59). Fishing at either F_{SPR30} or F_{OY} levels would require an increase in the fishing mortality rate. The current spawning biomass is greater than the minimum stock size threshold but close to a target biomass of $SSB_{SPR30\%}$ (Figure 3.60). Fishing at a F_{SPR30} would lead to a decrease in stock biomass relative to current levels. Fishing at either F_{OY} or $F_{CURRENT}$ levels would lead to an increase in the spawning stock biomass. The projected yield stream for the base model suggests that the stock can sustain a greater yield relative to yield at current exploitation rates (Figure 3.61). Under all three fishing mortality scenarios, the model projects an increase in the level of yield compared to recent levels. One reason for the projected increase in yield even under the $F_{CURRENT}$ scenario, is that the model predicts sustained levels of recruitment that are greater than the average recruitment from 2001-2011 (Figure 3.62). The model uses the stock-recruitment relationship to predict recruitments during the projection period. Uncertainty in projected yield from the bootstrap analysis for the base model at F_{SPR30} is presented in Figure 3.63.

The sensitivity run with a lower natural mortality rate (Run 2) predicted that the stock was both overfished and undergoing overfishing. However, stock biomass was predicted to be increasing in recent years and fishing mortality rate was very close to F_{SPR30} (Figure 3.64). Both the F_{SPR30} and F_{OY} scenarios led to the stock that was neither undergoing overfishing nor overfished by 2014 (Figures 3.64-3.65). The $F_{CURRENT}$ scenario resulted in stock that was no longer overfished by 2014 but was still undergoing overfishing over the entire projection period. Under all three fishing mortality scenarios, the model projects an increase in the level of yield compared to recent levels (Figure 3.66). One reason for the projected increase in spawning biomass and yield is that the model predicts sustained levels of recruitment that are greater than the average recruitment from 2001-2011 (Figure 3.67).

The sensitivity run with a higher natural mortality rate (Run 3) predicted that the current spawning stock biomass exceeded $SSB_{SPR30\%}$ and that current fishing mortality was less than $F_{SPR30\%}$. Fishing at either F_{SPR30} or F_{OY} levels would require over the fishing mortality rate to be over twice as high relative to current levels (Figure 3.68). Both the F_{SPR30} and F_{OY} fishing mortality scenarios led to a decrease in spawning biomass closer to $SSB_{SPR30\%}$ levels (Figure 3.69). Fishing at either F_{SPR30} or F_{OY} levels would also lead to substantially greater yields relative to current yields (Figure 3.70).

Tables 3.10-3.12 show projected yield, fishing mortality rate, fishing mortality rate relative to $F_{SPR30\%}$, spawning biomass, and spawning biomass relative to $SSB_{SPR30\%}$ for 2013 to 2019 for three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

3.3 Discussion and Recommendations

Gulf of Mexico cobia suffers some of the same problems that make assessments of data poor species so difficult. There is not a large targeted fishery for cobia and they tend to occur mostly as an opportunistic catch. For this reason, many sources of data lacked sufficient sample sizes to be included in the assessment. Given the low frequency of positive catches pre trip, both of the fishery dependent indices of abundance and the annual estimates of recreational discards were sensitive to individual positive catches.

The majority of the length composition data, all of the age-composition data, and both indices of abundance came from the recreational fishery which is the primary fishery. The landings data are dominated by the recreational fishery; however, catches prior to 1981 are likely highly uncertain. Uncertainty in the hindcast estimates of recreational landings was not incorporated into the model and should be evaluated in future assessments.

Data on the size of discarded fish was lacking for the recreational fishery. The reef fish observer program provided some information on the size composition of released fish for the commercial fishery in recent years. This information helped in estimating the selectivity and retention parameters of the commercial fishery. Length composition data of discarded fish for the recreational fishery would have improved the assessment model.

Lack of age composition data restricted the assessment from being able to track cohorts through time or identify strong year classes. A systematic age sampling program for the recreational fishing sector would improve future assessments.

The parameters describing early growth of cobia and the selectivity pattern of the shrimp fishery had the greatest uncertainty and required extensive model diagnostics to reconcile. Additional information on the size selectivity patterns for the shrimp fishery would have improved the assessment model.

3.4 Acknowledgements

Many people at various state and federal agencies assisted with assembling the data sources included in this stock assessment. The assessment panel was instrumental in guiding the assessment configuration and dealing with the nuances of the data. Jeff Isely was the original lead analyst for this assessment and completed the majority of the ground work for the assessment. Nancie Cummings was part of the SEDAR 28 analyst team and provided significant input along the way. The assessment was greatly improved with help of Clay Porch, Shannon Cass-Calay, Michael Schirripa, Brian Linton, and John F. Walter. Richard Methot provided an updated version of Stock Synthesis 3 exclusively to deal with issues which arose during the assessment and helped answer a number of questions along the way. Ian Taylor has greatly improved the R code for plotting and diagnostics of Stock Synthesis models (http://code.google.com/p/r4ss/) with which many of the figures in this document were created.

3.5 References

Diaz, G.A., C.E. Porch, and M. Ortiz. 2004. Growth models for red snapper in US Gulf of Mexico Waters estimated from landings with minimum size limit restrictions. NMFS/SFD Contribution SFD-2004-038. SEDAR7-AW1.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68: 1124-1138.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fisheries Bulletin 82:898-903.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology 49:627-642.

Methot, R.D. 2011. User manual for Stock Synthesis: model version 3.23b. Nov 7, 2011. NOAA Fisheries Service, Seattle, WA.

Method, R.D., and I.G. Taylor. 2011. Adjusting for bias due to variability of estimated recruitments in fishery assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68: 1744-1760.

3.6 Tables

Table 3.1. List of SS parameters for Gulf of Mexico cobia. The list includes predicted parameter values and their associated standard errors from SS Run 1, initial parameter values, minimum and maximum values a parameter could take, and prior densities assigned to parameters. Parameters designated as fixed were held at their initial values.

Label	Value	SD	Initial	Min	Max	Status	Description
L_at_Amin_Fem_GP_1	46.599	1.666	41	15	60	Estimated	Length at age 0.5
L_at_Amax_Fem_GP_1	133.304	9.161	128.1	100	150	Estimated	Linf
VonBert_K_Fem_GP_1	0.209	0.037	0.3	0.08	0.8	Estimated	K
CV_young_Fem_GP_1	0.223	0.010	0.1	0.001	0.5	Estimated	Young growth CV
CV_old_Fem_GP_1	0.115	0.021	0.1	0.001	0.5	Estimated	Old growth CV
Wtlen_1_Fem	0.000	_	9.64E-06	_	_	Fixed	Weight-length scalar
Wtlen_2_Fem	3.030	_	3.03	_	_	Fixed	Weight-length exponent
Eggs/kg_inter_Fem	1.000	_	1	_	_	Fixed	Fecundity scalar
Eggs/kg_slope_wt_Fem	1.000	_	0	_	_	Fixed	Fecundity exponent
SR_LN(R0)	6.940	0.108	7	1	20	Estimated	Virgin recruit
SR_BH_steep	0.925	0.130	0.8	0.2	1	Estimated	Steepness
SR_sigmaR	0.600	_	0.6	_	_	Fixed	Stock -recruit standard deviation
SR_envlink	0.100	_	0.1	_	_	Fixed	Stock-recruit environmental link
SR_R1_offset	0.000	_	0	_	_	Fixed	Stock-recruit offset
SR_autocorr	0.000	_	0	_	_	Fixed	Stock-recruit autocorrelation
Main_RecrDev_1982	-0.253	0.194	_	_	_	Estimated	1982 recruit deviation
Main_RecrDev_1983	-1.163	0.291	_	_	_	Estimated	1983 recruit deviation
Main_RecrDev_1984	0.489	0.098	_	_	_	Estimated	1984 recruit deviation
Main_RecrDev_1985	-0.690	0.185	_	_	_	Estimated	1985 recruit deviation
Main_RecrDev_1986	0.510	0.116	_	_	_	Estimated	1986 recruit deviation
Main_RecrDev_1987	-0.143	0.142	_	_	_	Estimated	1987 recruit deviation
Main_RecrDev_1988	-0.259	0.166	_	_	_	Estimated	1988 recruit deviation
Main_RecrDev_1989	0.740	0.129	_	_	_	Estimated	1989 recruit deviation
Main_RecrDev_1990	0.707	0.166	_	_	_	Estimated	1990 recruit deviation
Main_RecrDev_1991	0.226	0.175	_	_	_	Estimated	1991 recruit deviation
Main_RecrDev_1992	-0.180	0.146	_	_	_	Estimated	1992 recruit deviation
Main_RecrDev_1993	0.675	0.088	_	_	_	Estimated	1993 recruit deviation
Main_RecrDev_1994	0.456	0.102	_	_	_	Estimated	1994 recruit deviation
Main_RecrDev_1995	0.537	0.137	_	_	_	Estimated	1995 recruit deviation
Main_RecrDev_1996	0.545	0.176	_	_	_	Estimated	1996 recruit deviation
Main_RecrDev_1997	-0.580	0.367	_	_	_	Estimated	1997 recruit deviation
Main_RecrDev_1998	-0.054	0.278	_	_	_	Estimated	1998 recruit deviation
Main_RecrDev_1999	0.211	0.240	_	_	_	Estimated	1999 recruit deviation
Main_RecrDev_2000	-0.202	0.317	_	_	_	Estimated	2000 recruit deviation

Main_RecrDev_2001	0.317	0.160	_	_	_	Estimated	2001 recruit deviation
Main_RecrDev_2002	-0.365	0.206	_	_	_	Estimated	2002 recruit deviation
Main_RecrDev_2003	-0.283	0.188	_	_	_	Estimated	2003 recruit deviation
Main_RecrDev_2004	0.107	0.155	_	_	_	Estimated	2004 recruit deviation
Main_RecrDev_2005	-0.465	0.251	_	_	_	Estimated	2005 recruit deviation
Main_RecrDev_2006	-0.292	0.225	_	_	_	Estimated	2006 recruit deviation
Main_RecrDev_2007	0.236	0.171	_	_	_	Estimated	2007 recruit deviation
Main_RecrDev_2008	-0.091	0.276	_	_	_	Estimated	2008 recruit deviation
Main_RecrDev_2009	-0.181	0.314	_	_	_	Estimated	2009 recruit deviation
Main_RecrDev_2010	-0.556	0.402	_	_	_	Estimated	2010 recruit deviation
Late_RecrDev_2011	0.311	0.602	_	_	_	Estimated	2011 recruit deviation
InitF_1Commercial	0.000	_	0	0	1	Fixed	Commercial initial F
InitF_2Recreational	0.000	_	0	0	1	Fixed	Recreational initial F
InitF_3Shrimp_Bycatch	0.000	_	0	0	1	Fixed	Shrimp initial F
Q_base_3_Shrimp_Bycatch	1.709	0.148	1	-10	20	Estimated	Catchability coefficient for shrimp effort
SizeSel_P1_Commercial	88.006	1.209	80	40	150	Estimated	Commercial size select peak
SizeSel_P2_Commercial	16.123	1.138	10	1	50	Estimated	Commercial size select slope
DiscMort_P1_Commercial	-5.000	_	-5	-10	10	Fixed	Commercial discard inflection
DiscMort_P2_Commercial	1.000	_	1	-1	2	Fixed	Commercial discard slope
DiscMort_P3_Commerical	0.050	_	0.05	-1	2	Fixed	Commercial discard asymptotic mortality
DiscMort_P4_Commerical	0.000	_	0	-1	2	Fixed	Commercial male offset
SizeSel_P1_Recreational	71.624	2.375	70	40	150	Estimated	Recreational size select peak
SizeSel_P2_Recreational	33.411	2.160	10	1	60	Estimated	Recreational size select slope
DiscMort_P1_Recreational	-5.000	_	-5	-10	10	Fixed	Recreational discard inflection
DiscMort_P2_Recreational	1.000	_	1	-1	1	Fixed	Recreational discard slope
DiscMort_P3_Recreational	0.050	_	0.05	-1	2	Fixed	Recreational discard asymptotic mortality
DiscMort_P4_Recreational	0.000	_	0	-1	2	Fixed	Recreational male offset
SizeSel_P1_Shrimp_Bycatch	34.485	0.345	35	20	50	Estimated	Shrimp size select peak
SizeSel_P2_Shrimp_Bycatch	-3.041	0.253	-3	-15	15	Estimated	Shrimp size select top
SizeSel_P3_Shrimp_Bycatch	-9.738	6.904	-2	-15	15	Estimated	Shrimp size select ascending width
SizeSel_P4_Shrimp_Bycatch	3.646	0.445	5	-15	15	Estimated	Shrimp size select descending width
SizeSel_P5_Shrimp_Bycatch	-0.286	0.470	-10	-15	15	Estimated	Shrimp size select initial
SizeSel_P6_Shrimp_Bycatch	-2.050	0.258	10	-15	15	Estimated	Shrimp size select final
SizeSel_P1_MRFSS_4	1.000	_	1	1	32	Fixed	MRFSS size select initial bin
SizeSel_P2_MRFSS_4	57.000	_	32	1	32	Fixed	MRFSS size select final bin
AgeSel_P1_Commercial	0.000	_	0	0	15	Fixed	Commercial age select min
AgeSel_P2_Commercial	15.000	_	15	0	15	Fixed	Commercial age select max
AgeSel_P1_Shrimp_Bycatch	0.000	_	0	0	15	Fixed	Shrimp age select min
AgeSel_P2_Shrimp_Bycatch	15.000	_	15	0	15	Fixed	Shrimp age select max
Retain_Commerical_TB1	40.000	_	40	_	_	Fixed	Commercial retention peak pre size limit
Retain_Commercial_TB2	92.337	1.476	83.8	70	100	Estimated	Commercial retention peak post size limit
Retain_Commercial_TB1	2.000	_	2	_	_	Fixed	Commercial retention slope pre size limit

Retain_Commercial_TB2	12.122	1.439	2	0.1	20	Estimated	Commercial retention slope post size limit
Retain_Recreational_TB1	40.000	_	40	_	_	Fixed	Recreational retention peak pre size limit
Retain_Recreational_TB2	82.444	0.493	83.8	70	100	Estimated	Recreational retention peak post size limit
Retain_Recreational_TB1	3.900	2.332	2	0.1	20	Estimated	Recreational retention slope pre size limit
Retain_Recreational_TB2	4.856	0.218	2	0.1	20	Estimated	Recreational retention slope post size limit

Table 3.2. Mean and standard deviation of parameter estimates from 1000 bootstrap samples for Gulf of Mexico cobia.

Label	Value	SD	Status	Description
L_at_Amin_Fem_GP_1	47.77	1.58	Estimated	Length at age 0.5
L_at_Amax_Fem_GP_1	129.54	9.38	Estimated	Linf
VonBert_K_Fem_GP_1	0.21	0.04	Estimated	K
CV_young_Fem_GP_1	0.22	0.01	Estimated	Young growth CV
CV_old_Fem_GP_1	0.15	0.03	Estimated	Old growth CV
Wtlen_1_Fem	9.64E-09	_	Fixed	Weight-length scalar
Wtlen_2_Fem	3.03	_	Fixed	Weight-length exponent
Eggs/kg_inter_Fem	1.00	_	Fixed	Fecundity scalar
Eggs/kg_slope_wt_Fem	1.00	_	Fixed	Fecundity exponent
SR_LN(R0)	6.98	0.07	Estimated	Virgin recruit
SR_BH_steep	0.93	0.08	Estimated	Steepness
SR_sigmaR	0.60	_	Fixed	Stock -recruit standard deviation
SR_envlink	0.10	_	Fixed	Stock-recruit environmental link
SR_R1_offset	0.00	_	Fixed	Stock-recruit offset
SR_autocorr	0.00	_	Fixed	Stock-recruit autocorrelation
Main_RecrDev_1982	-0.38	0.19	Estimated	1982 recruit deviation
Main_RecrDev_1983	-0.93	0.21	Estimated	1983 recruit deviation
Main_RecrDev_1984	0.41	0.10	Estimated	1984 recruit deviation
Main_RecrDev_1985	-0.65	0.17	Estimated	1985 recruit deviation
Main_RecrDev_1986	0.49	0.09	Estimated	1986 recruit deviation
Main_RecrDev_1987	-0.17	0.13	Estimated	1987 recruit deviation
Main_RecrDev_1988	-0.28	0.15	Estimated	1988 recruit deviation
Main_RecrDev_1989	0.72	0.13	Estimated	1989 recruit deviation
Main_RecrDev_1990	0.71	0.15	Estimated	1990 recruit deviation
Main_RecrDev_1991	0.14	0.17	Estimated	1991 recruit deviation
Main_RecrDev_1992	-0.21	0.14	Estimated	1992 recruit deviation
Main_RecrDev_1993	0.68	0.09	Estimated	1993 recruit deviation
Main_RecrDev_1994	0.49	0.10	Estimated	1994 recruit deviation
Main_RecrDev_1995	0.45	0.15	Estimated	1995 recruit deviation
Main_RecrDev_1996	0.49	0.18	Estimated	1996 recruit deviation
Main_RecrDev_1997	-0.37	0.24	Estimated	1997 recruit deviation
Main_RecrDev_1998	-0.14	0.22	Estimated	1998 recruit deviation
Main_RecrDev_1999	0.11	0.21	Estimated	1999 recruit deviation
Main_RecrDev_2000	-0.04	0.21	Estimated	2000 recruit deviation
Main_RecrDev_2001	0.18	0.17	Estimated	2001 recruit deviation
Main_RecrDev_2002	-0.33	0.20	Estimated	2002 recruit deviation
Main_RecrDev_2003	-0.27	0.19	Estimated	2003 recruit deviation
Main_RecrDev_2004	0.04	0.16	Estimated	2004 recruit deviation
Main_RecrDev_2005	-0.38	0.21	Estimated	2005 recruit deviation

Main_RecrDev_2006	-0.34	0.22	Estimated	2006 recruit deviation
Main_RecrDev_2007	0.22	0.17	Estimated	2007 recruit deviation
Main_RecrDev_2008	-0.11	0.24	Estimated	2008 recruit deviation
Main_RecrDev_2009	-0.20	0.22	Estimated	2009 recruit deviation
Main_RecrDev_2010	-0.34	0.22	Estimated	2010 recruit deviation
Late_RecrDev_2011	-0.02	0.19	Estimated	2011 recruit deviation
InitF_1Commercial	0.00	_	Fixed	Commercial initial F
InitF_2Recreational	0.00	_	Fixed	Recreational initial F
InitF_3Shrimp_Bycatch	0.00	_	Fixed	Shrimp initial F
Q_base_3_Shrimp_Bycatch	1.82	0.14	Estimated	Catchability coefficient for shrimp effort
SizeSel_P1_Commercial	88.88	1.33	Estimated	Commercial size select peak
SizeSel_P2_Commercial	16.51	0.98	Estimated	Commercial size select slope
DiscMort_P1_Commercial	-5.00	_	Fixed	Commercial discard inflection
DiscMort_P2_Commercial	1.00	_	Fixed	Commercial discard slope
DiscMort_P3_Commerical	0.05	_	Fixed	Commercial discard asymptotic mortality
DiscMort_P4_Commerical	0.00	_	Fixed	Commercial male offset
SizeSel_P1_Recreational	73.05	3.68	Estimated	Recreational size select peak
SizeSel_P2_Recreational	33.35	3.19	Estimated	Recreational size select slope
DiscMort_P1_Recreational	-5.00	_	Fixed	Recreational discard inflection
DiscMort_P2_Recreational	1.00	_	Fixed	Recreational discard slope
DiscMort_P3_Recreational	0.05	_	Fixed	Recreational discard asymptotic mortality
DiscMort_P4_Recreational	0.00	_	Fixed	Recreational male offset
SizeSel_P1_Shrimp_Bycatch	34.55	2.64	Estimated	Shrimp size select peak
SizeSel_P2_Shrimp_Bycatch	-3.81	2.36	Estimated	Shrimp size select top
SizeSel_P3_Shrimp_Bycatch	-4.59	5.20	Estimated	Shrimp size select ascending width
SizeSel_P4_Shrimp_Bycatch	2.17	2.96	Estimated	Shrimp size select descending width
SizeSel_P5_Shrimp_Bycatch	0.16	1.51	Estimated	Shrimp size select initial
SizeSel_P6_Shrimp_Bycatch	-1.99	0.27	Estimated	Shrimp size select final
SizeSel_P1_MRFSS_4	1.00	_	Fixed	MRFSS size select initial bin
SizeSel_P2_MRFSS_4	57.00	_	Fixed	MRFSS size select final bin
AgeSel_P1_Commercial	0.00	_	Fixed	Commercial age select min
AgeSel_P2_Commercial	15.00	_	Fixed	Commercial age select max
AgeSel_P1_Shrimp_Bycatch	0.00	_	Fixed	Shrimp age select min
AgeSel_P2_Shrimp_Bycatch	15.00	_	Fixed	Shrimp age select max
Retain_Commerical_TB1	40.00	_	Fixed	Commercial retention peak pre size limit
Retain_Commercial_TB2	92.02	1.46	Estimated	Commercial retention peak post size limit
Retain_Commercial_TB1	2.00	0.00	Fixed	Commercial retention slope pre size limit
Retain_Commercial_TB2	12.93	1.98	Estimated	Commercial retention slope post size limit
Retain_Recreational_TB1	40.00	0.00	Fixed	Recreational retention peak pre size limit
Retain_Recreational_TB2	82.87	0.74	Estimated	Recreational retention peak post size limit
Retain_Recreational_TB1	5.03	2.05	Estimated	Recreational retention slope pre size limit
Retain_Recreational_TB2	5.07	0.29	Estimated	Recreational retention slope post size limit

Table 3.3. Model total likelihood, predicted unfished spawning biomass (mt) and predicted 2011 spawning biomass from 50 model runs from the jitter analysis.

Run	Likelihood	SSB unfished	SSB 2011	Depletion
Base model	1127.22	7235	2213	0.31
1	1127.85	7277	2180	0.30
2	1127.85	7277	2180	0.30
3	1126.94	7253	2212	0.30
4	1127.85	7277	2180	0.30
5	1127.85	7277	2180	0.30
6	1126.68	7260	2240	0.31
7	1126.68	7260	2240	0.31
8	1126.94	7253	2212	0.30
9	1127.85	7277	2180	0.30
10	1126.94	7253	2212	0.30
11	1126.68	7260	2240	0.31
12	1127.22	7235	2213	0.31
13	1127.85	7277	2180	0.30
14	1126.94	7253	2212	0.30
15	1126.94	7253	2212	0.30
16	1127.85	7277	2180	0.30
17	1126.94	7253	2212	0.30
18	1127.85	7277	2180	0.30
19	1126.68	7260	2240	0.31
20	1127.22	7235	2213	0.31
21	1127.22	7235	2213	0.31
22	1127.85	7277	2180	0.30
23	1126.94	7253	2212	0.30
24	1127.22	7235	2213	0.31
25	1126.68	7260	2240	0.31
26	1126.94	7253	2212	0.30
27	1126.94	7253	2212	0.30
28	1127.85	7277	2180	0.30
29	1127.22	7235	2213	0.31
30	1126.68	7260	2240	0.31
31	1127.22	7235	2213	0.31
32	1127.22	7235	2213	0.31
33	1126.94	7253	2212	0.30
34	1127.22	7235	2213	0.31
35	1127.22	7235	2213	0.31
36	1126.68	7260	2240	0.31
37	1127.85	7277	2180	0.30
38	1127.85	7277	2180	0.30
39	1126.68	7260	2240	0.31
40	1131.13	7257	2195	0.30
41	1126.94	7253	2212	0.30
42	1127.85	7277	2180	0.30
43	1126.68	7260	2240	0.31
44	1127.22	7235	2213	0.31
45	1126.68	7260	2240	0.31
46	1126.94	7253	2212	0.30
47	1127.85	7277	2180	0.30
48	1127.85	7277	2180	0.30
49	1132.46	7295	2168	0.30
50	1127.22	7235	2213	0.31

Table 3.4. Predicted total biomass (mt), spawning biomass (mt), and age-0 recruits (thousand fish), for Gulf of Mexico cobia from the base model run (Run 1).

Year	Total Biomass	Spawning Biomass	Recruits
1927	8821	7235	1033
1928	8818	7232	1033
1929	8810	7225	1033
1930	8808	7222	1033
1931	8805	7220	1033
1932	8805	7220	1033
1933	8807	7221	1033
1934	8808	7223	1033
1935	8808	7223	1033
1936	8809	7224	1033
1937	8810	7225	1033
1938	8812	7227	1033
1939	8812	7226	1033
1940	8812	7226	1033
1941	8813	7228	1033
1942	8815	7230	1033
1943	8816	7231	1033
1944	8817	7232	1033
1945	8818	7233	1033
1946	8819	7233	1033
1947	8817	7233	1033
1948	8810	7228	1033
1949	8789	7214	1033
1950	8748	7182	1033
1951	8672	7120	1033
1952	8554	7016	1032
1953	8403	6876	1032
1954	8197	6677	1031
1955	7925	6422	1030
1956	7649	6154	1029
1957	7376	5898	1028
1958	7102	5644	1027
1959	6810	5382	1026
1960	6523	5116	1024
1961	6260	4860	1023
1962	6131	4695	1022
1963	5958	4552	1021
1964	5783	4413	1020
1965	5598	4257	1019
1966	5526	4148	1018
1967	5492	4080	1017

1968	5438	4037	1017
1969	5342	3965	1016
1970	5232	3874	1015
1971	5171	3786	1014
1972	5077	3691	1013
1973	4905	3565	1012
1974	4711	3394	1010
1975	4498	3193	1007
1976	4344	3017	1004
1977	4167	2872	1002
1978	3970	2728	999
1979	3695	2534	995
1980	3436	2317	990
1981	3309	2145	985
1982	3316	2132	650
1983	2754	1865	255
1984	2134	1677	1318
1985	2413	1288	396
1986	2033	1186	1302
1987	2353	1196	678
1988	2263	1251	607
1989	2070	1325	1658
1990	2632	1127	1576
1991	3373	1513	1005
1992	3572	2167	688
1993	3311	2349	1625
1994	3736	2134	1298
1995	3922	2195	1410
1996	4421	2710	1440
1997	4629	2851	468
1998	3836	2839	793
1999	3593	2764	1032
2000	3393	2254	675
2001	3089	2113	1129
2002	3178	1980	568
2003	3022	2059	618
2004	2681	1903	909
2005	2747	1670	507
2006	2675	1768	606
2007	2588	1792	1029
2008	2804	1592	735
2009	2978	1803	678
2010	3150	2175	517
2011	3030	2213	1347

Table 3.5. Predicted spawning biomass (mt), spawning biomass relative to unfished spawning biomass (mt), and spawning biomass relative to the reference spawning biomass ($SSB_{SPR30\%}$).

Year	Spawning Biomass	$SSB/SSB_{unfished}$	$SSB/ SSB_{SPR30\%}$
1927	7235	1.00	3.50
1928	7232	1.00	3.50
1929	7225	1.00	3.50
1930	7222	1.00	3.50
1931	7220	1.00	3.50
1932	7220	1.00	3.50
1933	7221	1.00	3.50
1934	7223	1.00	3.50
1935	7223	1.00	3.50
1936	7224	1.00	3.50
1937	7225	1.00	3.50
1938	7227	1.00	3.50
1939	7226	1.00	3.50
1940	7226	1.00	3.50
1941	7228	1.00	3.50
1942	7230	1.00	3.50
1943	7231	1.00	3.50
1944	7232	1.00	3.50
1945	7233	1.00	3.50
1946	7233	1.00	3.50
1947	7233	1.00	3.50
1948	7228	1.00	3.50
1949	7214	1.00	3.49
1950	7182	0.99	3.48
1951	7120	0.98	3.45
1952	7016	0.97	3.40
1953	6876	0.95	3.33
1954	6677	0.92	3.23
1955	6422	0.89	3.11
1956	6154	0.85	2.98
1957	5898	0.82	2.86
1958	5644	0.78	2.73
1959	5382	0.74	2.61
1960	5116	0.71	2.48
1961	4860	0.67	2.35
1962	4695	0.65	2.27
1963	4552	0.63	2.20
1964	4413	0.61	2.14
1965	4257	0.59	2.06
1966	4148	0.57	2.01

1967	4080	0.56	1.98
1968	4037	0.56	1.95
1969	3965	0.55	1.92
1970	3874	0.54	1.88
1971	3786	0.52	1.83
1972	3691	0.51	1.79
1973	3565	0.49	1.73
1974	3394	0.47	1.64
1975	3193	0.44	1.55
1976	3017	0.42	1.46
1977	2872	0.40	1.39
1978	2728	0.38	1.32
1979	2534	0.35	1.23
1980	2317	0.32	1.12
1981	2145	0.30	1.04
1982	2132	0.29	1.03
1983	1865	0.26	0.90
1984	1677	0.23	0.81
1985	1288	0.18	0.62
1986	1186	0.16	0.57
1987	1196	0.17	0.58
1988	1251	0.17	0.61
1989	1325	0.18	0.64
1990	1127	0.16	0.55
1991	1513	0.21	0.73
1992	2167	0.30	1.05
1993	2349	0.32	1.14
1994	2134	0.29	1.03
1995	2195	0.30	1.06
1996	2710	0.37	1.31
1997	2851	0.39	1.38
1998	2839	0.39	1.37
1999	2764	0.38	1.34
2000	2254	0.31	1.09
2001	2113	0.29	1.02
2002	1980	0.27	0.96
2003	2059	0.28	1.00
2004	1903	0.26	0.92
2005	1670	0.23	0.81
2006	1768	0.24	0.86
2007	1792	0.25	0.87
2008	1592	0.22	0.77
2009	1803	0.25	0.87
2010	2175	0.30	1.05
2011	2213	0.31	1.07

Table 3.6. Predicted fishing mortality rate, fishing mortality rate relative to the reference fishing mortality rate ($F_{SPR30\%}$), and spawning potential ratio.

Year	F	F/ $F_{SPR30\%}$	SPR
1927	0	0	1
1928	0	0	1
1929	0	0	1
1930	0	0	1
1931	0	0	1
1932	0	0	1
1933	0	0	1
1934	0	0	1
1935	0	0	1
1936	0	0	1
1937	0	0	1
1938	0	0	1
1939	0	0	1
1940	0	0	1
1941	0	0	1
1942	0	0	1
1943	0	0	1
1944	0	0	1
1945	0	0	1
1946	0	0	1
1947	0	0	0.99
1948	0	0.01	0.98
1949	0	0.01	0.97
1950	0.01	0.02	0.94
1951	0.01	0.04	0.91
1952	0.02	0.05	0.88
1953	0.03	0.09	0.84
1954	0.05	0.12	0.78
1955	0.06	0.15	0.75
1956	0.06	0.17	0.72
1957	0.07	0.2	0.69
1958	0.08	0.22	0.64
1959	0.1	0.25	0.62
1960	0.1	0.28	0.6
1961	0.1	0.26	0.63
1962	0.11	0.29	0.58
1963	0.12	0.31	0.56
1964	0.12	0.33	0.53
1965	0.12	0.31	0.57
1966	0.12	0.32	0.58

1967	0.13	0.34	0.55
1968	0.14	0.36	0.53
1969	0.14	0.38	0.51
1970	0.15	0.39	0.52
1971	0.16	0.42	0.5
1972	0.18	0.47	0.45
1973	0.19	0.51	0.43
1974	0.21	0.56	0.4
1975	0.22	0.58	0.4
1976	0.24	0.62	0.37
1977	0.25	0.66	0.34
1978	0.28	0.73	0.29
1979	0.29	0.78	0.27
1980	0.3	0.78	0.29
1981	0.27	0.71	0.32
1982	0.38	1.01	0.23
1983	0.33	0.87	0.25
1984	0.39	1.04	0.25
1985	0.41	1.09	0.22
1986	0.52	1.37	0.21
1987	0.42	1.12	0.2
1988	0.47	1.24	0.21
1989	0.54	1.44	0.2
1990	0.35	0.93	0.25
1991	0.32	0.84	0.26
1992	0.34	0.9	0.28
1993	0.36	0.96	0.3
1994	0.34	0.89	0.28
1995	0.25	0.67	0.36
1996	0.31	0.82	0.31
1997	0.35	0.92	0.28
1998	0.26	0.68	0.36
1999	0.32	0.84	0.32
2000	0.29	0.77	0.33
2001	0.32	0.86	0.32
2002	0.25	0.67	0.36
2003	0.36	0.95	0.31
2004	0.34	0.9	0.34
2005	0.26	0.7	0.39
2006	0.3	0.79	0.37
2007	0.35	0.93	0.34
2008	0.26	0.69	0.39
2009	0.2	0.53	0.45
2010	0.23	0.62	0.44
2011	0.29	0.76	0.41

Table 3.7. Summary of SS results from sensitivity runs for Gulf of Mexico cobia. Results include virgin recruitment (thousand fish; R0), steepness, virgin total biomass (mt; B0), total biomass in final year (mt; Bcurrent), virgin spawning biomass (mt; SSB0), spawning biomass in final year (mt; SSBcurrent), and SPR in final year (SPRcurrent). For model runs 1-10, current refers to 2011. For the retrospective analyses (R), current relates to the final year of data used.

Run	Model	R0	Steepness	B0	Bcurrent	SSB0	SSB	SSBcurrent/SSB0	SPRcurrent
1	Base model	1033	0.92	8821	3030	7235	2213	0.31	0.41
2	M_Low	604	0.96	12536	2454	11259	1872	0.17	0.26
3	M_High	1857	0.92	7776	3845	5634	2587	0.46	0.55
4	D_High	1007	0.98	8659	3048	7089	2197	0.31	0.40
5	Steepness=0.7	1303	0.70	10774	2797	8749	2121	0.24	0.41
6	Steepness=0.8	1157	0.80	9765	2911	8000	2167	0.27	0.40
7	MRFSS only	1047	0.88	9139	2720	7479	1921	0.26	0.38
8	HB only	1008	1.00	8496	3722	6994	2940	0.42	0.47
9	Stock synthesis weighted	1003	0.94	8886	3189	7112	2340	0.33	0.41
10	Francis (2011) weighting	1024	0.95	8790	3346	7244	2415	0.33	0.43
11	Retrospective 2010	1011	0.92	9074	3172	7277	2093	0.29	0.41
12	Retrospective 2009	1001	0.96	8670	2862	7061	1779	0.25	0.44
13	Retrospective 2008	996	1.00	8642	2619	7021	1720	0.24	0.39
14	Retrospective 2007	976	0.99	8514	2642	6934	1803	0.26	0.34
15	Retrospective 2006	952	0.99	8581	2588	6856	1829	0.27	0.36
16	Retrospective 2005	1025	0.94	8185	2622	6562	1716	0.26	0.43

Table 3.8. Reference points and benchmarks from sensitivity runs for Gulf of Mexico cobia from SS. Benchmarks are reported for SPR 30%. *Current* refers to the geometric mean of 2009-2011 for *F*. MSST = (1-*M*)*$SSB_{SPR30\%}$ with *M* = 0.38 y^{-1} for all models except runs 2 (*M* = 0.26 y^{-1}) and 3 (*M* = 0.50 y^{-1}).

Run	Model	Fcurrent	SSB2011	$F_{SPR30\%}$	$SSB_{SPR30\%}$	MFMT	MSST	F/MFMT	$SSB/SSB_{SPR30\%}$	SSB/MSST
1	Base model	0.24	2213	0.38	2065	0.38	1280	0.63	1.07	1.73
2	M_Low	0.30	1872	0.29	3302	0.29	2443	1.05	0.57	0.77
3	M_High	0.18	2587	0.45	1608	0.45	804	0.40	1.61	3.22
4	D_High	0.24	2197	0.37	2099	0.37	1302	0.65	1.05	1.69
5	Steepness=0.7	0.24	2121	0.39	1894	0.39	1174	0.63	1.12	1.81
6	Steepness=0.8	0.24	2168	0.38	2027	0.38	1257	0.64	1.04	1.73
7	MRFSS only	0.26	1921	0.37	2060	0.37	1277	0.70	0.93	1.50
8	HB only	0.19	2940	0.37	2098	0.37	1301	0.52	1.40	2.26
9	Stock synthesis weighted	0.22	2340	0.35	2053	0.35	1273	0.58	1.15	1.85
10	Francis (2011) weighting	0.22	2415	0.38	2105	0.38	1305	0.61	1.14	1.84

Table 3.9. Required SFA and MSRA evaluations using SPR 30% reference point for Gulf of Mexico cobia SS runs 1-3. Biomass units are in mt.

Criteria	Definition	Run 1	Run 2	Run 3
Base M		0.38	0.26	0.50
Steepness		0.92	0.96	0.92
Virgin Recruitment		1033	604	1857
SSB unfished		7235	11259	5634
	Mortality Rate Criteria			
$F_{MSY\ or\ proxy}$	$F_{SPR30\%}$	0.378	0.287	0.452
MFMT	$F_{SPR30\%}$	0.378	0.287	0.452
F_{OY}	75% of $F_{SPR30\%}$	0.284	0.215	0.339
$F_{CURRENT}$	$F_{2009-F2011}$	0.236	0.302	0.180
$F_{CURRENT}$/MFMT	$F_{2009-F2011}$	0.624	1.053	0.398
	Biomass Criteria			
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPR30\%}$	2065	3302	1608
MSST	(1-M)*$SSB_{SPR30\%}$	1280	2443	804
$SSB_{CURRENT}$	SSB_{2011}	2213	1872	2587
$SS_{CURRENT}$/MSST	SSB_{2011}/MSST	1.729	0.766	3.218
Equilibrium MSY	Equilibrium Yield @ $F_{SPR30\%}$	1208	1111	1500
Equilibrium OY	Equilibrium Yield @ F_{OY}	1108	1021	1362
OFL	Annual Yield @ MFMT			
	OFL 2013	1292	709	2184
	OFL 2014	1289	840	1828
	OFL 2015	1271	946	1648
	OFL 2016	1243	1014	1557
	OFL 2017	1226	1055	1523
	OFL 2018	1217	1079	1510
	OFL 2019	1213	1092	1504
Annual OY (ACT)	Annual Yield @ F_{OY}			
	OY 2013	1017	548	1754
	OY 2014	1085	680	1594
	OY 2015	1116	793	1488
	OY 2016	1118	874	1417
	OY 2017	1114	928	1385
	OY 2018	1111	963	1372
	OY 2019	1109	985	1367
Annual Yield	Annual Yield @ $F_{CURRENT}$			
	Y 2013	765	801	736
	Y 2014	869	925	816
	Y 2015	931	1021	857
	Y 2016	959	1078	868
	Y 2017	971	1110	868
	Y 2018	977	1128	867
	Y 2019	979	1138	865

Table 3.10. Projected yield (mt), fishing mortality rate, and spawning stock biomass at F_{SPR30} (F_{MSY} proxy) for the base model and two sensitivity runs. *Ref* refers to the reference point of SPR 30%.

	Run 1					Run 2					Run 3				
Year	Yield	F	F/Fref	SSB	SSB/SSBref	Yield	F	F/Fref	SSB	SSB/SSBref	Yield	F	F/Fref	SSB	SSB/SSBref
2013	1292	0.36	0.95	2292	1.11	709	0.26	0.89	1967	0.60	2184	0.47	1.04	2675	1.66
2014	1289	0.37	0.97	2412	1.17	840	0.26	0.92	2466	0.75	1828	0.45	1.01	2316	1.44
2015	1271	0.37	0.97	2340	1.13	946	0.27	0.95	2756	0.83	1648	0.44	0.98	2028	1.26
2016	1243	0.37	0.97	2282	1.10	1014	0.28	0.97	2942	0.89	1557	0.43	0.96	1905	1.18
2017	1226	0.36	0.96	2249	1.09	1055	0.28	0.97	3055	0.93	1523	0.43	0.95	1860	1.16
2018	1217	0.36	0.96	2232	1.08	1079	0.28	0.98	3122	0.95	1510	0.43	0.95	1843	1.15
2019	1213	0.36	0.96	2224	1.08	1092	0.28	0.98	3161	0.96	1504	0.43	0.95	1835	1.14

Table 3.11. Projected yield (mt), fishing mortality rate, and spawning stock biomass at F_{OY} for the base model and two sensitivity runs. *Ref* refers to the reference point of SPR 30%.

	Run 1					Run 2					Run 3				
Year	Yield	F	F/Fref	SSB	SSB/SSBref	Yield	F	F/Fref	SSB	SSB/SSBref	Yield	F	F/Fref	SSB	SSB/SSBref
2013	1017	0.29	0.76	2292	1.11	548	0.20	0.71	1967	0.60	1754	0.38	0.84	2675	1.66
2014	1085	0.30	0.79	2592	1.26	680	0.21	0.74	2585	0.78	1594	0.38	0.83	2549	1.59
2015	1116	0.30	0.80	2624	1.27	793	0.22	0.76	2988	0.90	1488	0.37	0.82	2323	1.44
2016	1118	0.30	0.80	2618	1.27	874	0.22	0.78	3272	0.99	1417	0.36	0.81	2204	1.37
2017	1114	0.30	0.80	2608	1.26	928	0.23	0.79	3463	1.05	1385	0.36	0.80	2153	1.34
2018	1111	0.30	0.80	2602	1.26	963	0.23	0.80	3587	1.09	1372	0.36	0.80	2133	1.33
2019	1109	0.30	0.80	2599	1.26	985	0.23	0.80	3666	1.11	1367	0.36	0.80	2124	1.32

Table 3.12. Projected yield (mt), fishing mortality rate, and spawning stock biomass at $F_{CURRENT}$ for the base model and two sensitivity runs. *Ref* refers to the reference point of SPR 30%.

	Run 1					Run 2					Run 3				
Year	Yield	F	F/Fref	SSB	SSB/SSBref	Yield	F	F/Fref	SSB	SSB/SSBref	Yield	F	F/Fref	SSB	SSB/SSBref
2013	765	0.22	0.58	2292	1.09	801	0.29	0.99	1967	0.60	736	0.17	0.37	2675	1.66
2014	869	0.23	0.61	2759	1.33	925	0.29	1.03	2399	0.73	816	0.18	0.39	3136	1.95
2015	931	0.24	0.63	2909	1.41	1021	0.30	1.05	2630	0.80	857	0.18	0.40	3208	2.00
2016	959	0.24	0.63	2979	1.44	1078	0.31	1.07	2769	0.84	868	0.18	0.40	3223	2.00
2017	971	0.24	0.64	3012	1.46	1110	0.31	1.08	2849	0.86	868	0.18	0.40	3220	2.00
2018	977	0.24	0.64	3029	1.46	1128	0.31	1.08	2893	0.88	867	0.18	0.40	3215	2.00
2019	979	0.24	0.64	3037	1.47	1138	0.31	1.08	2917	0.88	865	0.18	0.40	3210	2.00

3.7 Figures

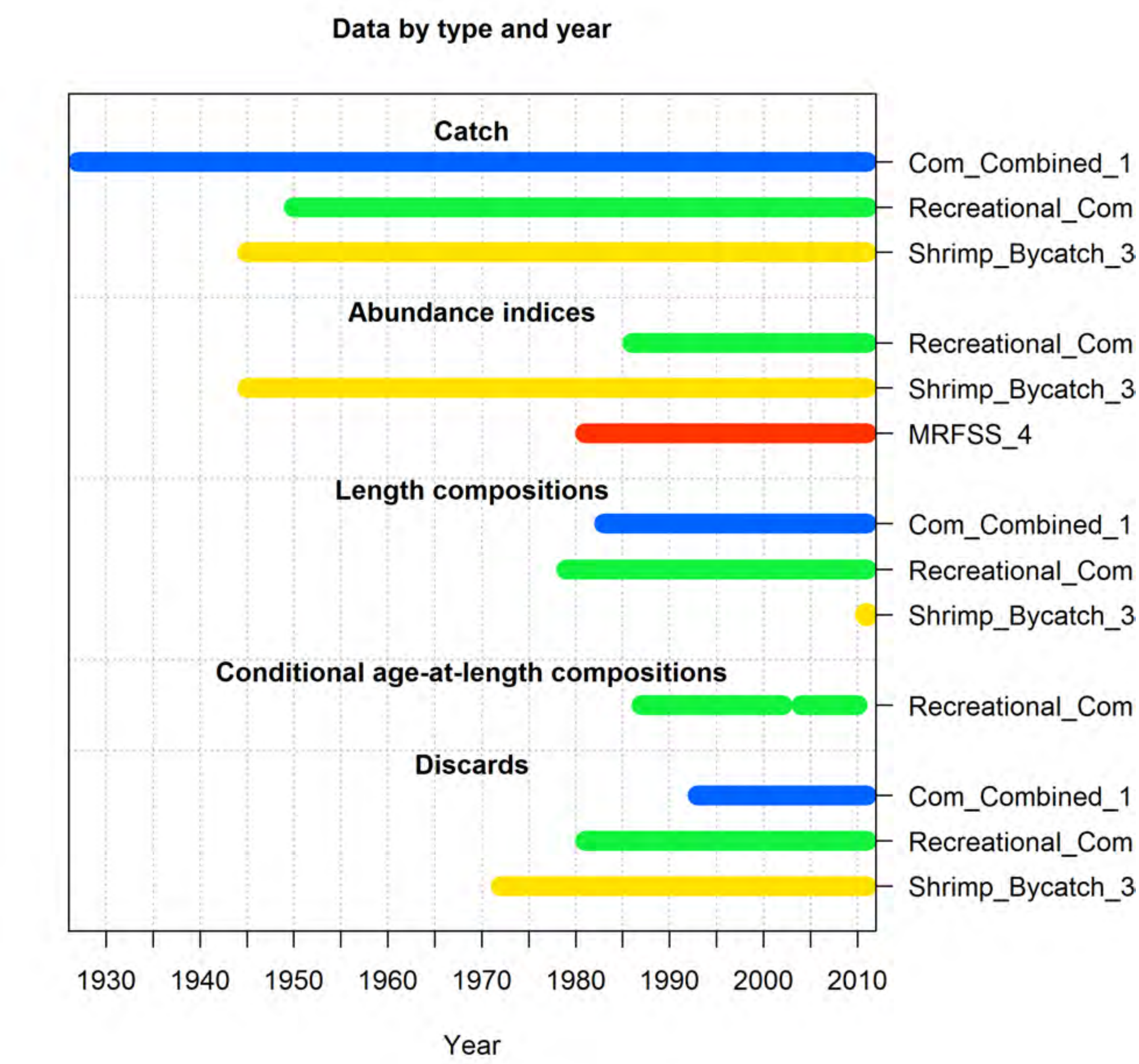


Figure 3.1. Data sources used in the assessment model.

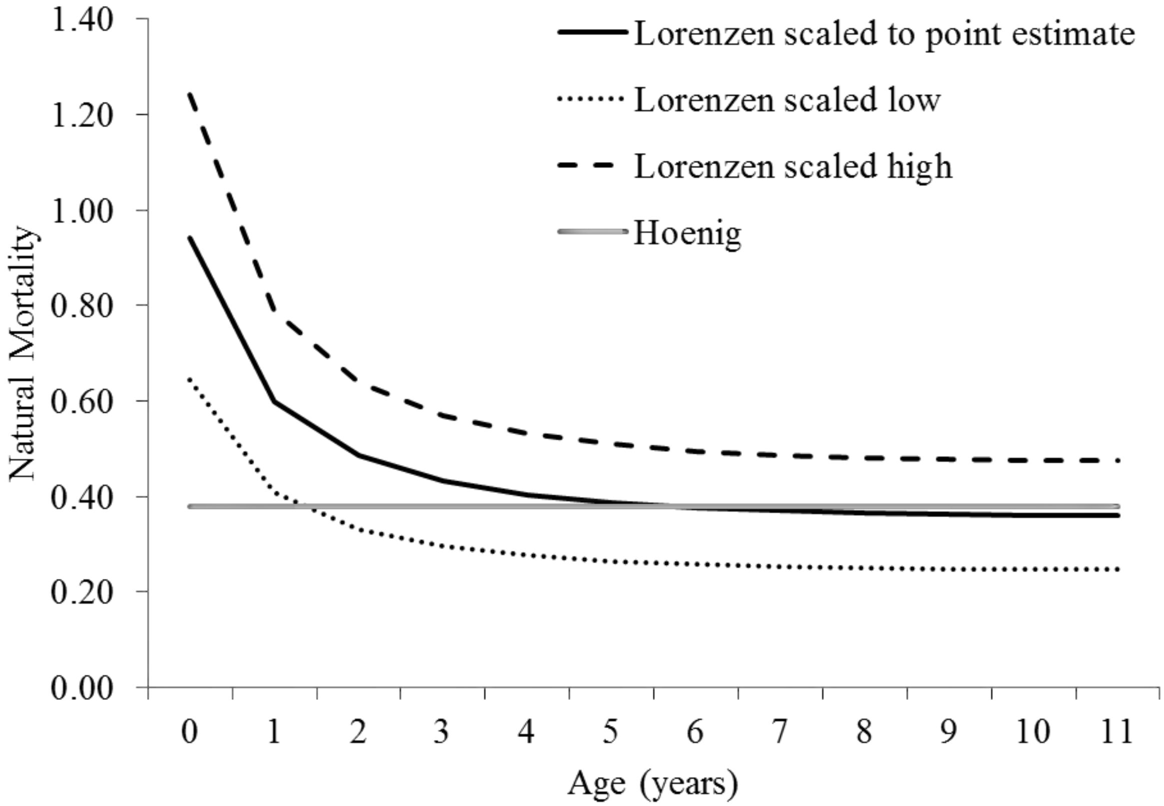


Figure 3.2. Age-specific natural mortality of Gulf of Mexico cobia based on the Lorenzen (1996) method. The three lines represent estimates of natural mortality for the base case model (Run 1; solid line), a low estimate (Run 2; dotted line), and high estimate (Run 3; dashed line).

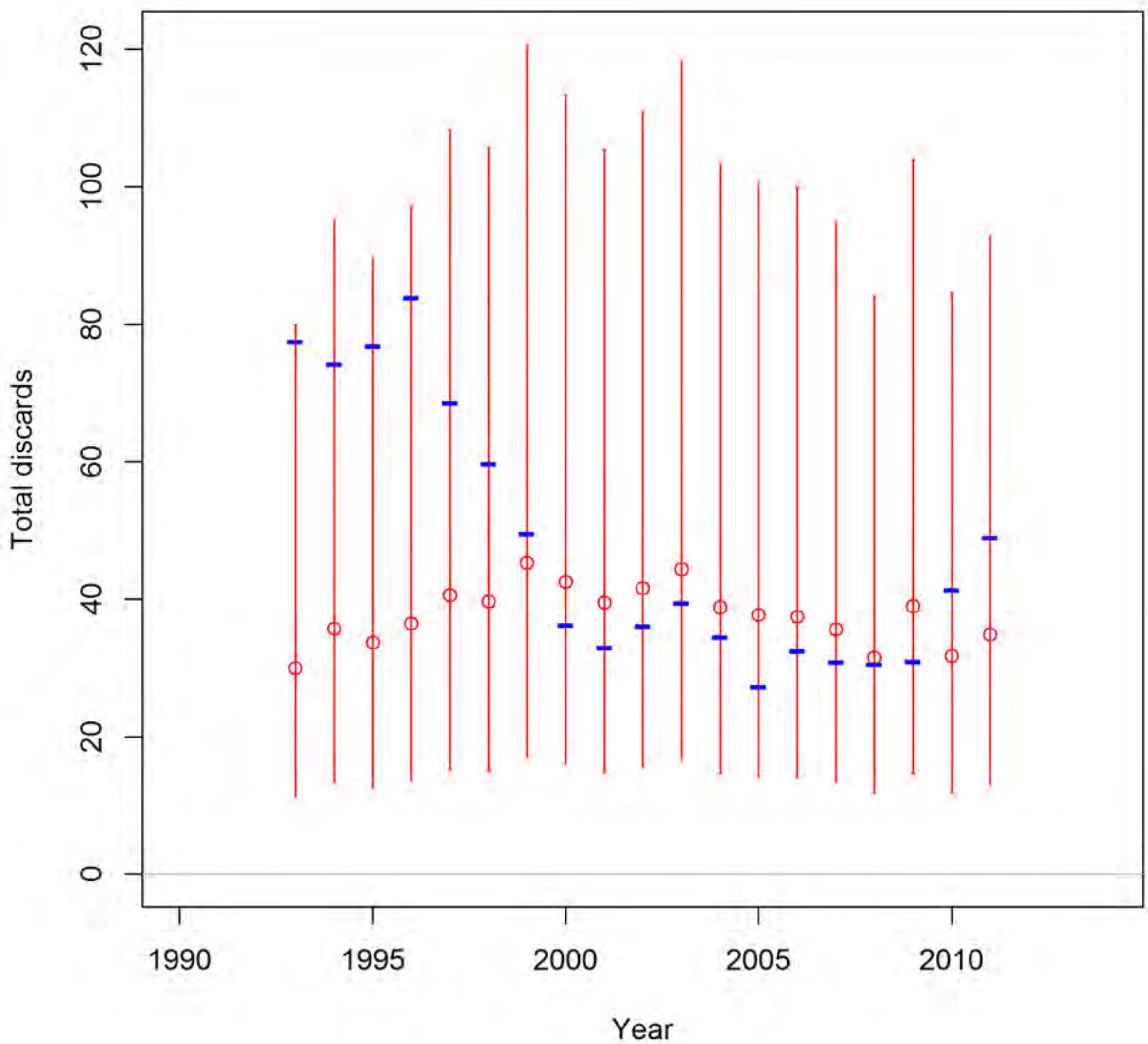


Figure 3.3. Observed (red dots) and predicted discards (blue dashes) (mt) of Gulf of Mexico Cobia from the commercial fishing fleet, 1993-2011.

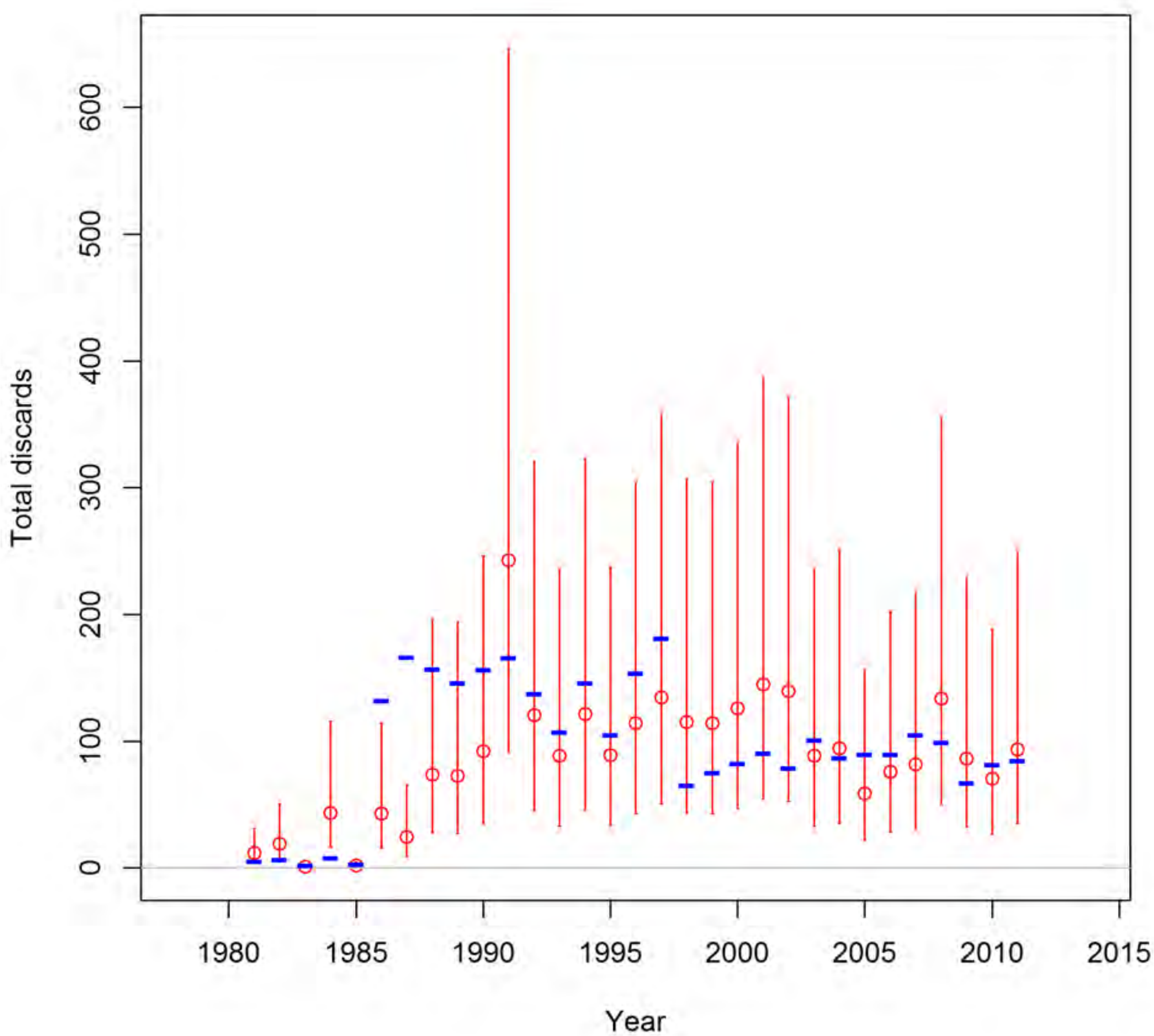


Figure 3.4. Observed (red dots) and predicted discards (blue dashes) (1000's of fish) of Gulf of Mexico cobia from the recreational fishing fleet, 1981-2011.

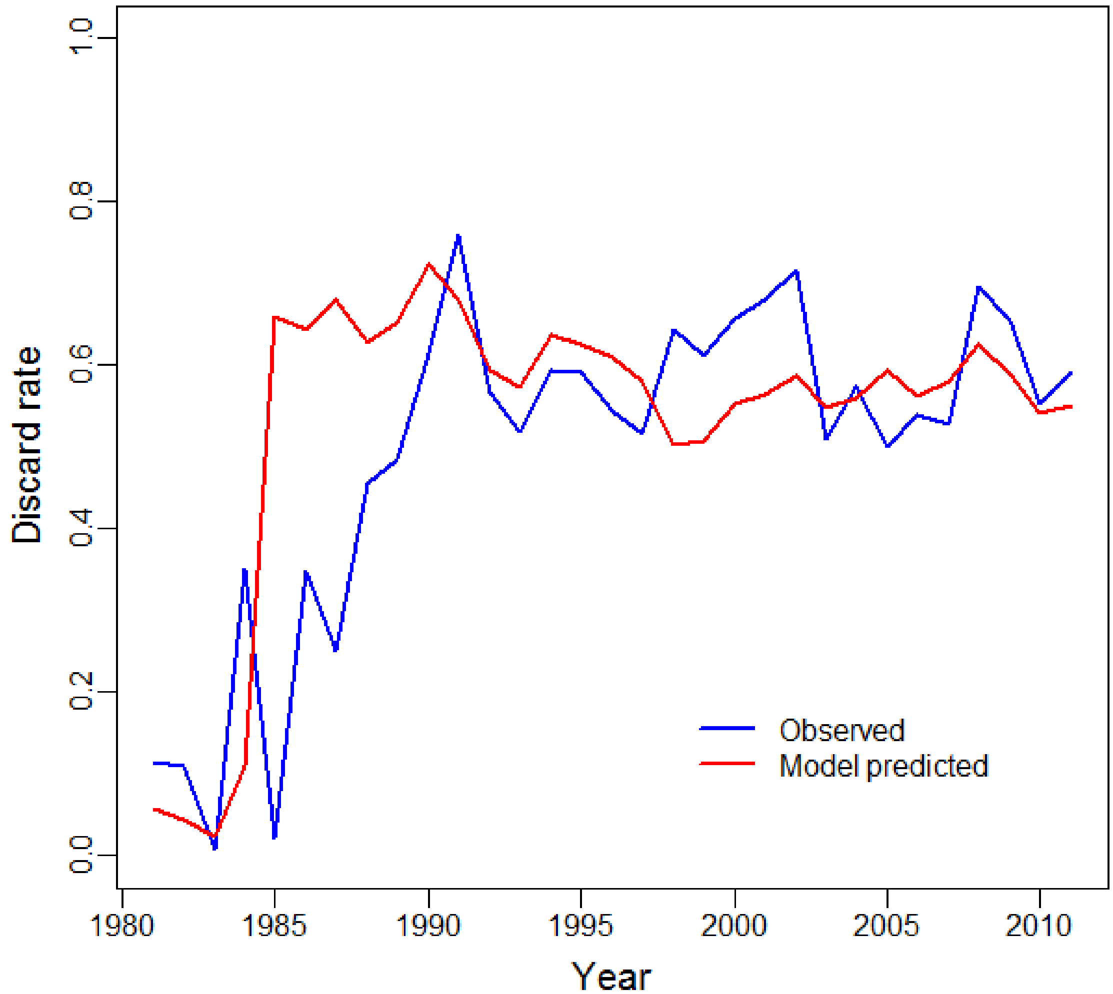


Figure 3.5. Observed and model predicted discard proportion of Gulf of Mexico cobia from the recreational fishing fleet, 1981-2011.

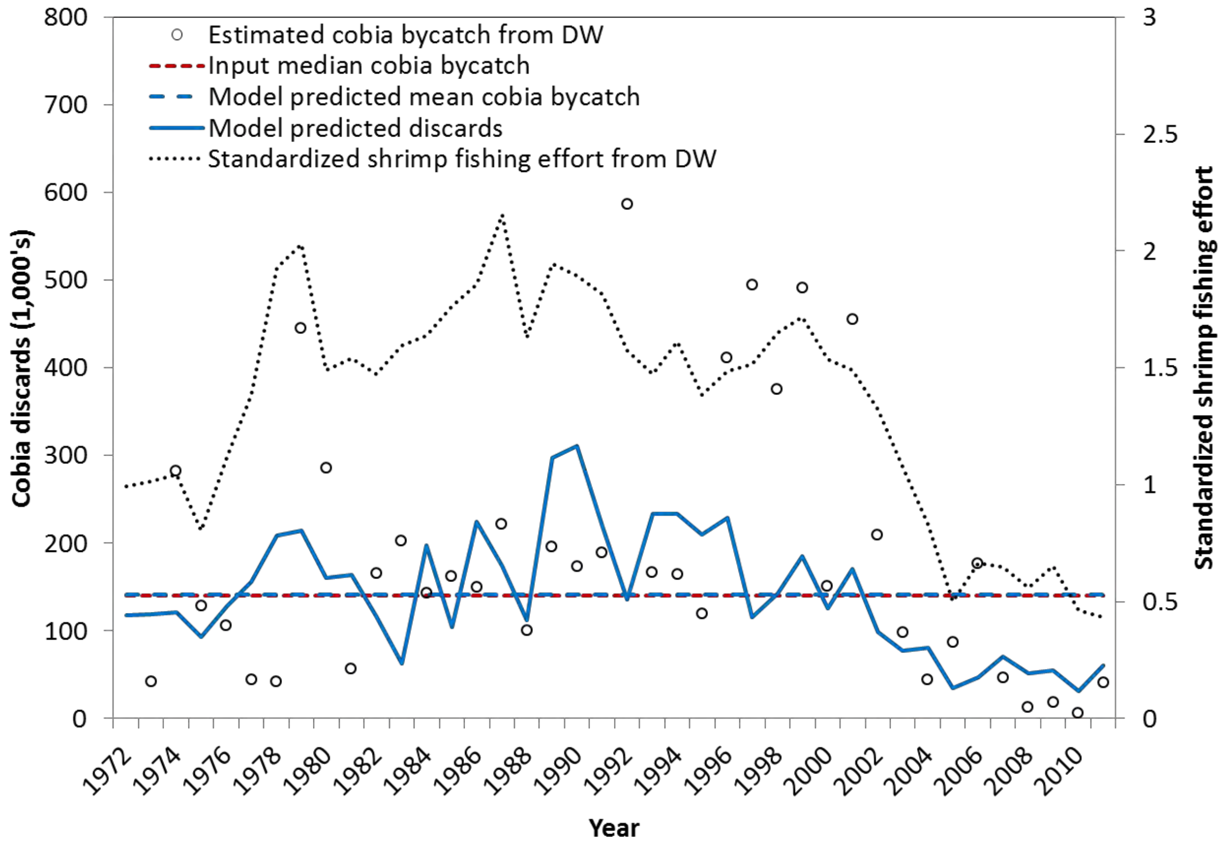


Figure 3.6. Observed and predicted discards (1000's of fish) of Gulf of Mexico cobia from the shrimp fishery, 1972-2011. Open circles represent annual estimates of cobia bycatch from the data workshop. The red dashed line represents the input estimate of shrimp bycatch used for the super-year approach. The blue dashed line represents the model predicted mean shrimp bycatch for 1972-2011. The solid blue line represents model predicted annual cobia bycatch. The black dotted line represents the standardized estimate of shrimp fishing effort from the data workshop. It is important to note that the model predicted annual cobia bycatch (blue line) was not fit to the annual estimates of cobia bycatch (open circles).

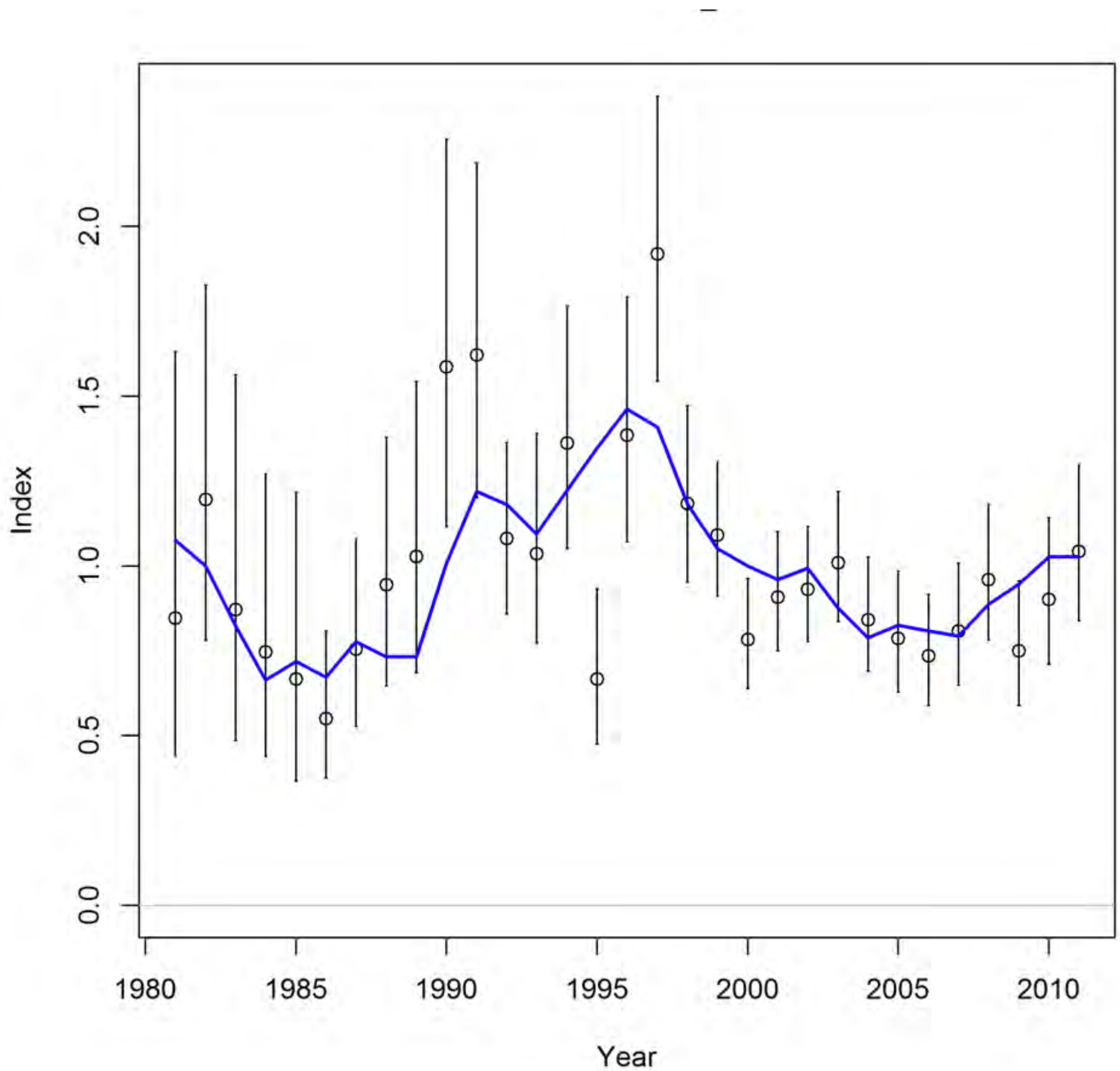


Figure 3.7. Observed and predicted index of CPUE for Gulf of Mexico cobia from SS Run 1.

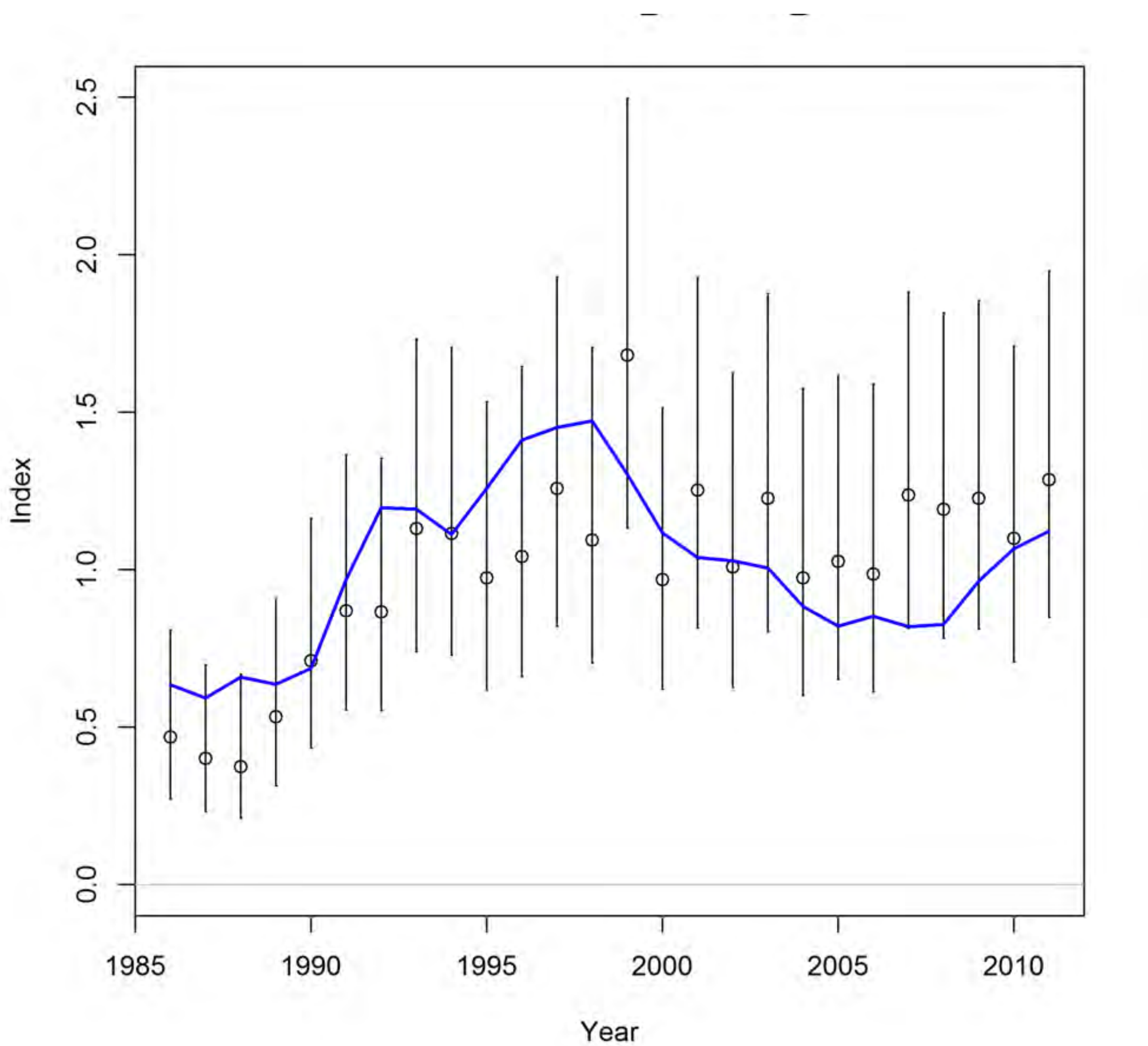


Figure 3.8. Observed and predicted index of CPUE for Gulf of Mexico cobia from SS Run 1.

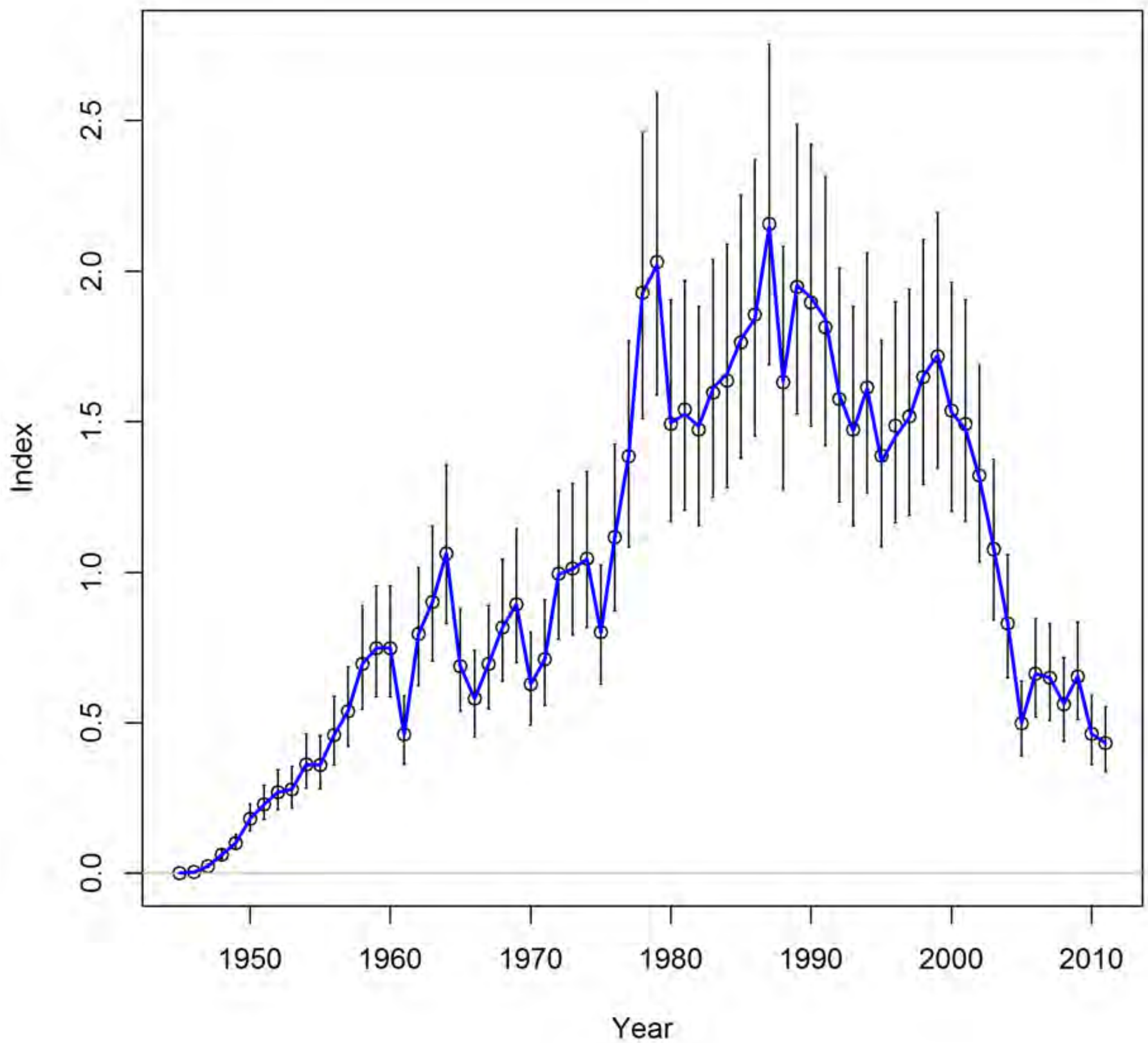


Figure 3.9. Observed and predicted index of shrimp fishing effort from SS Run 1.

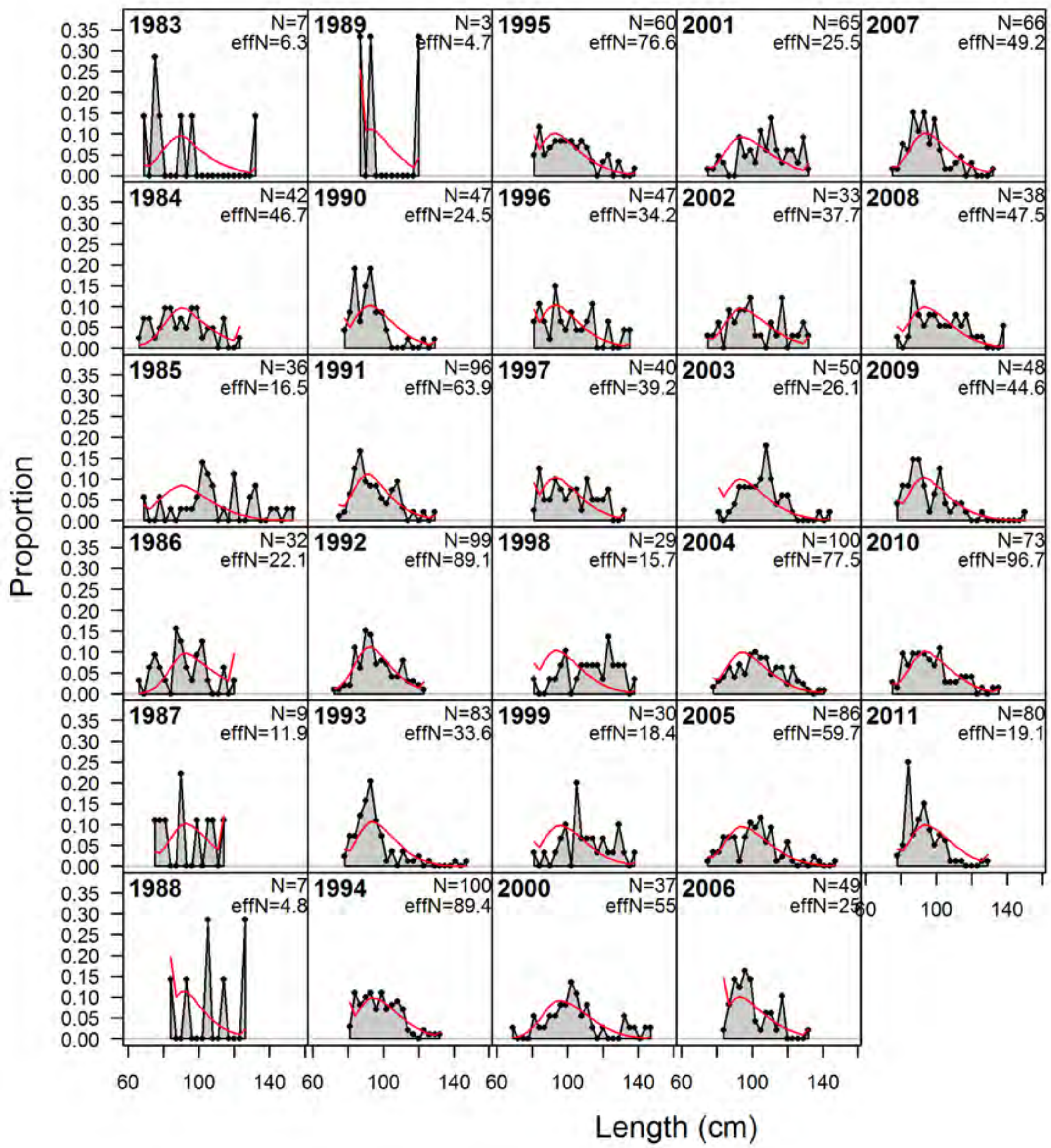


Figure 3.10. Observed and predicted length compositions for Gulf of Mexico cobia in the commercial fishery from SS Run 1. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 100 fish.

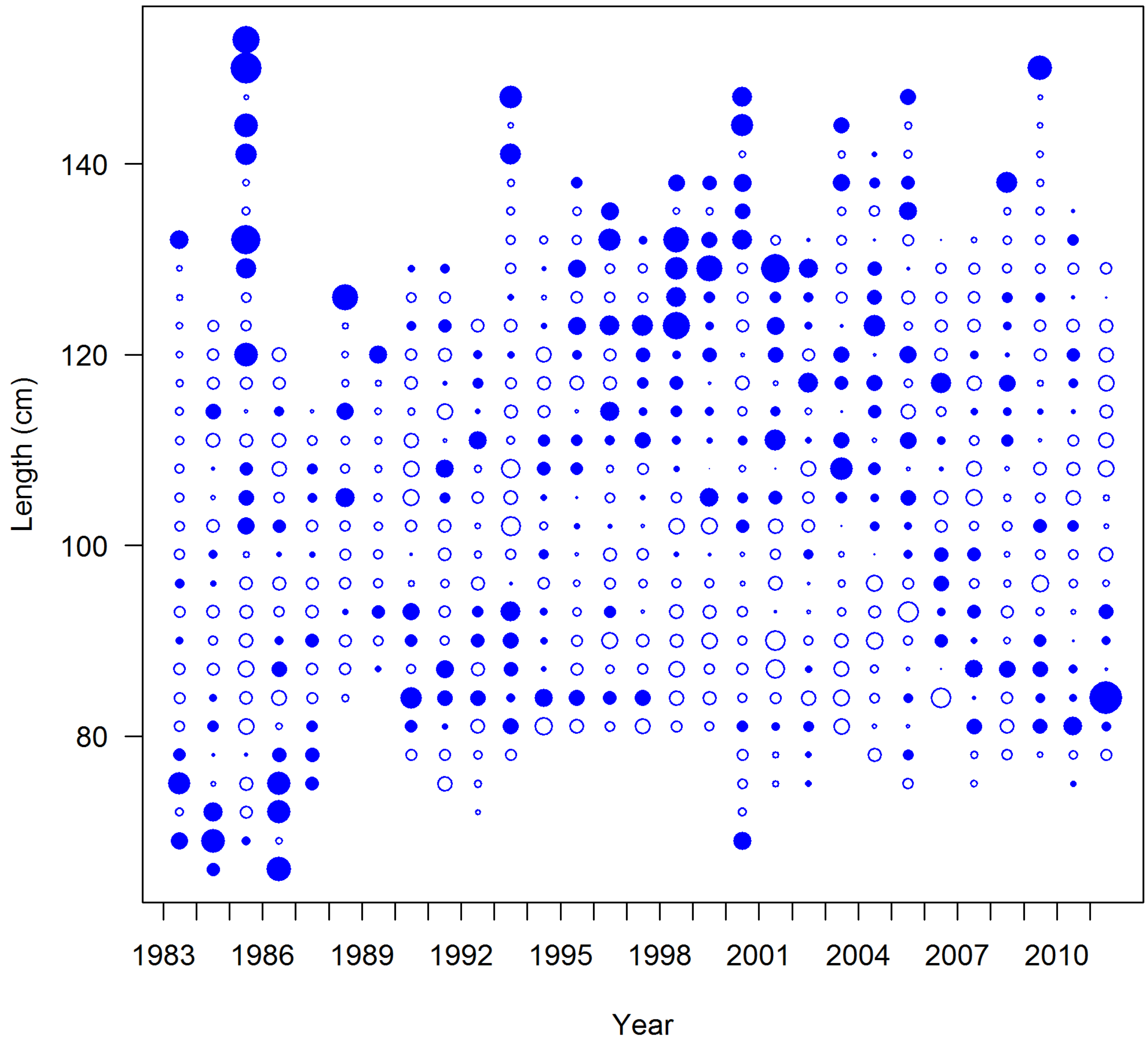


Figure 3.11. Pearson residuals of length composition fits for Gulf of Mexico cobia in the commercial fishery from SS Run 1. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed) (max=7.5).

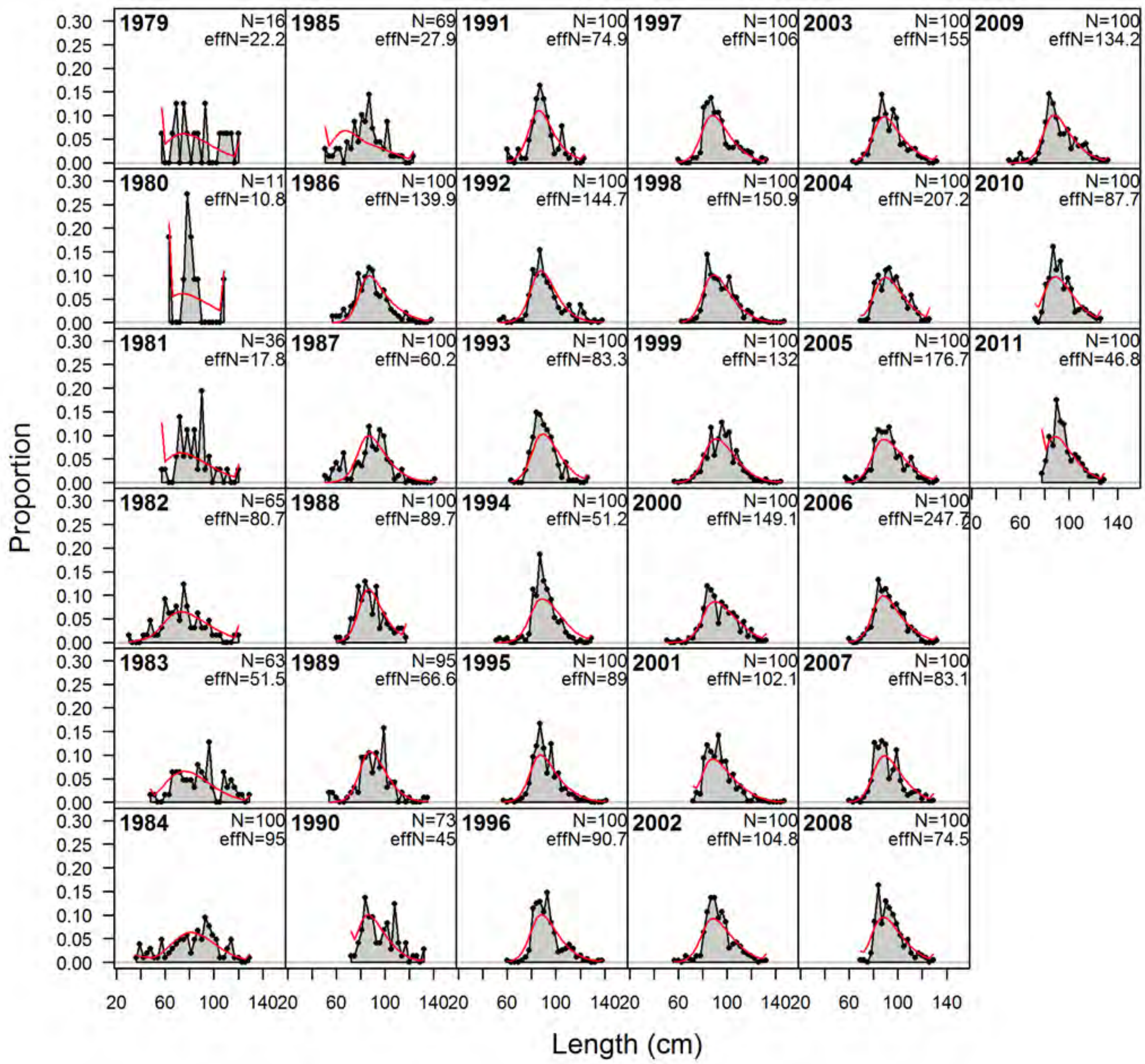


Figure 3.12. Observed and predicted length compositions for Gulf of Mexico cobia in the recreational fishery from SS Run 1. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 100 fish.

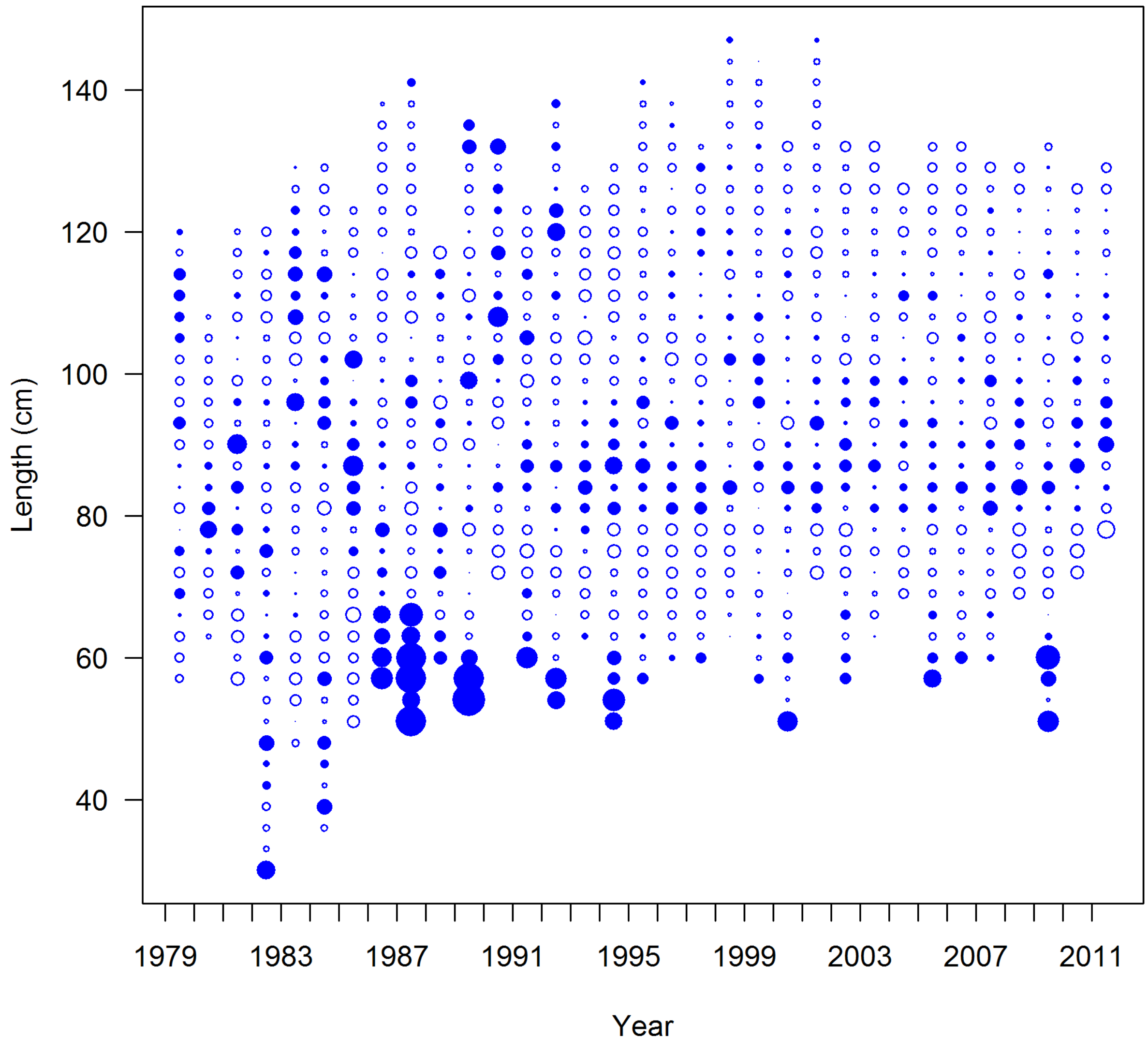


Figure 3.13. Pearson residuals of length composition fits for Gulf of Mexico cobia in the recreational fishery from SS Run 1. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed) (max=11).

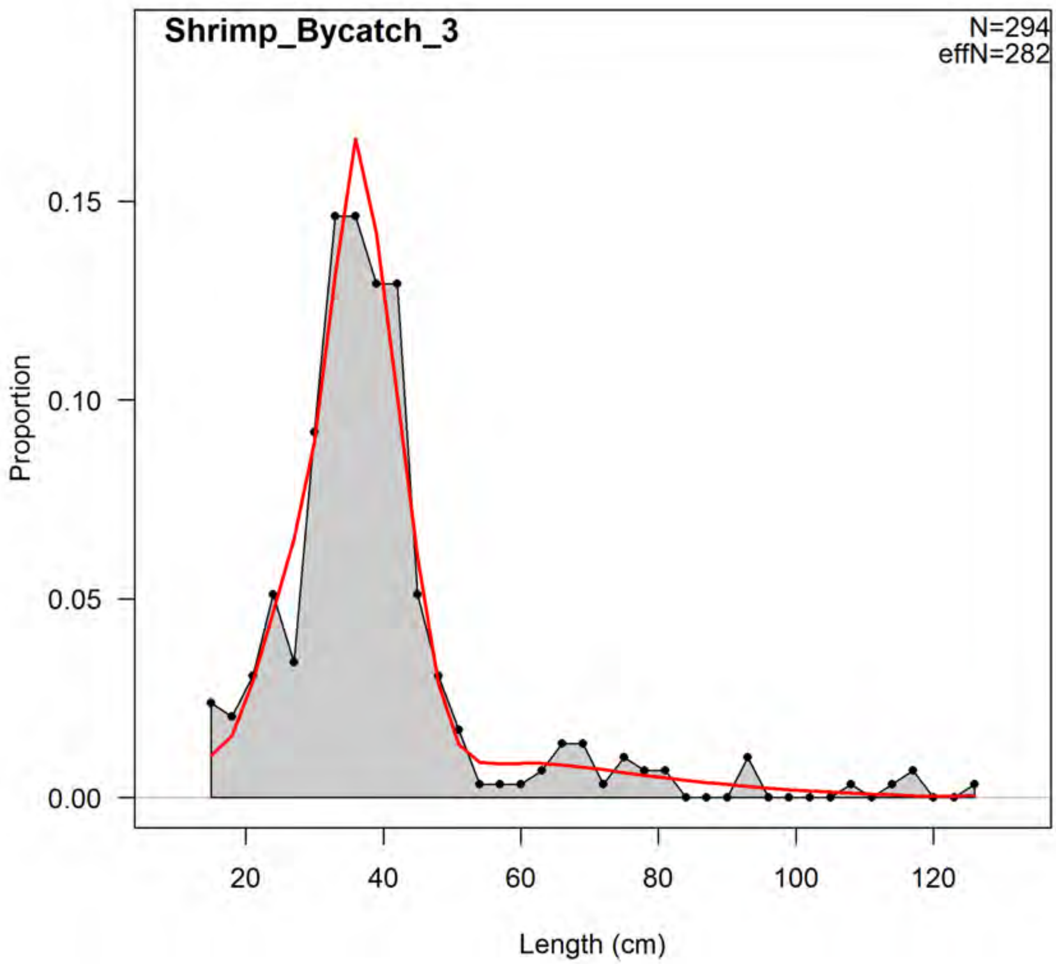


Figure 3.14. Observed and predicted length compositions for Gulf of Mexico cobia in the SEAMAP trawl survey from SS Run 1. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Length composition data was aggregated over years into a single distribution.

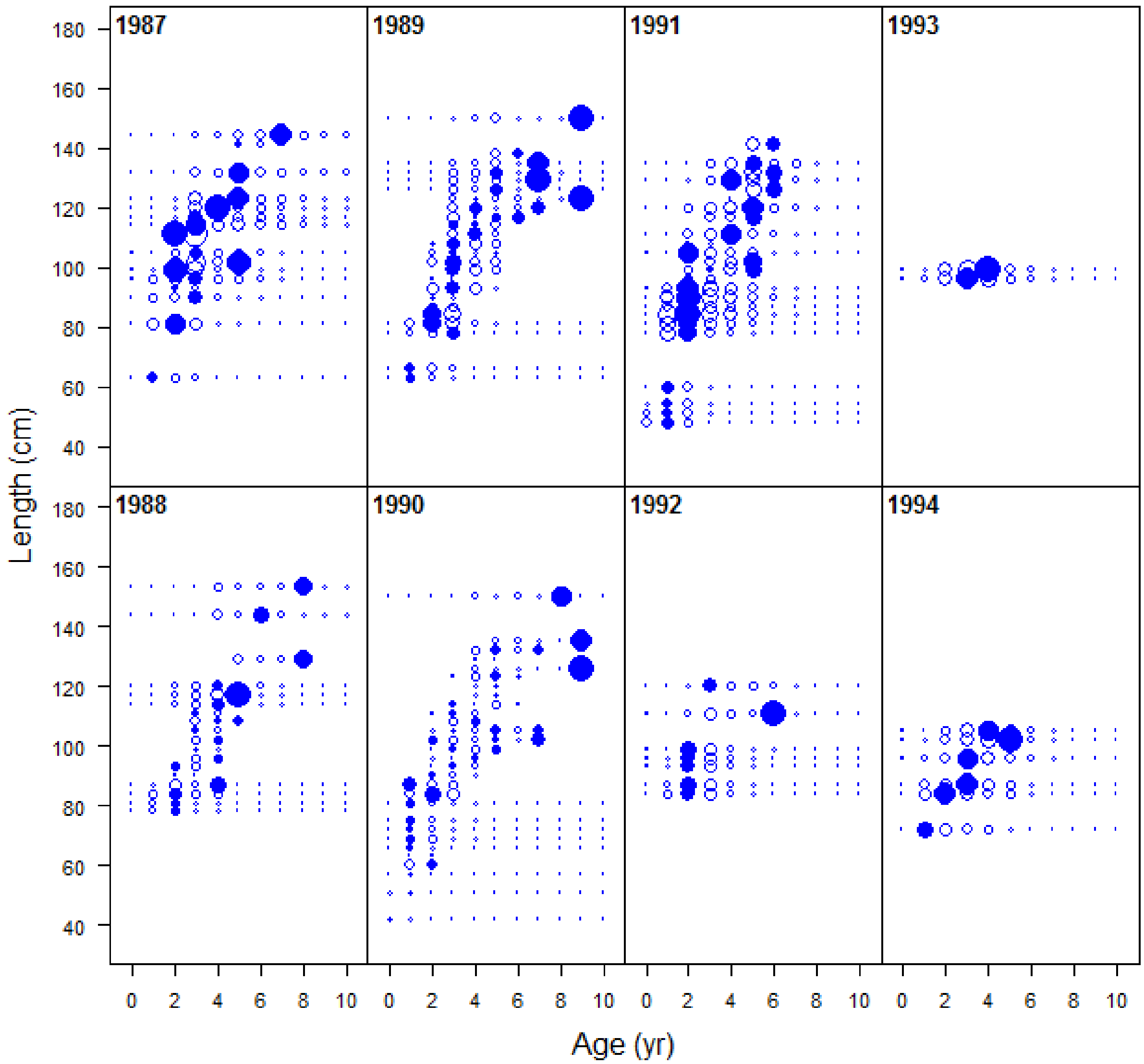


Figure 3.15a. Pearson residuals of conditional age composition fits for Gulf of Mexico cobia in the recreational fishery from SS Run 1. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed) (max=10).

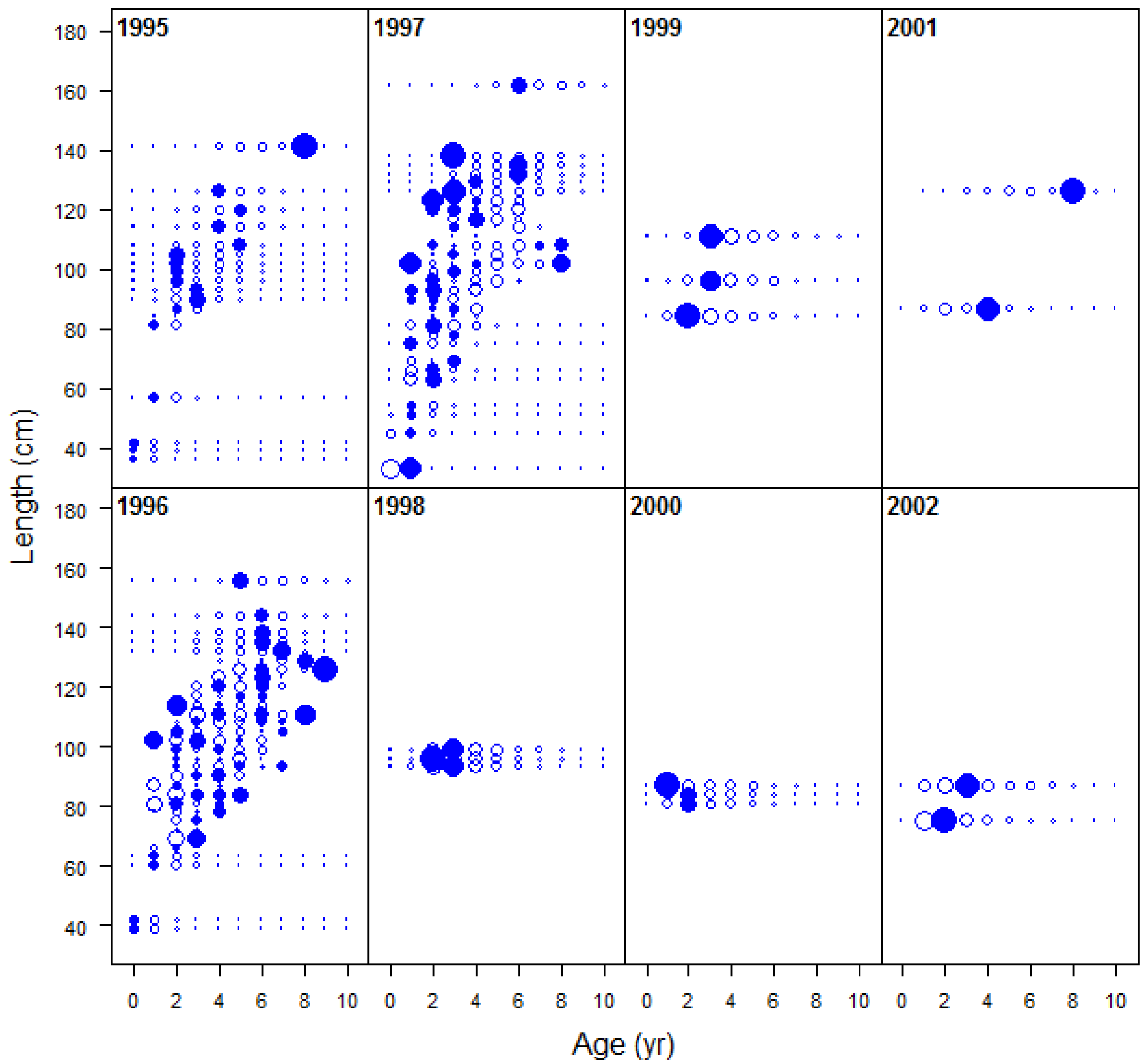


Figure 3.15b. Pearson residuals of conditional age composition fits for Gulf of Mexico cobia in the recreational fishery from SS Run 1. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed) (max=10).

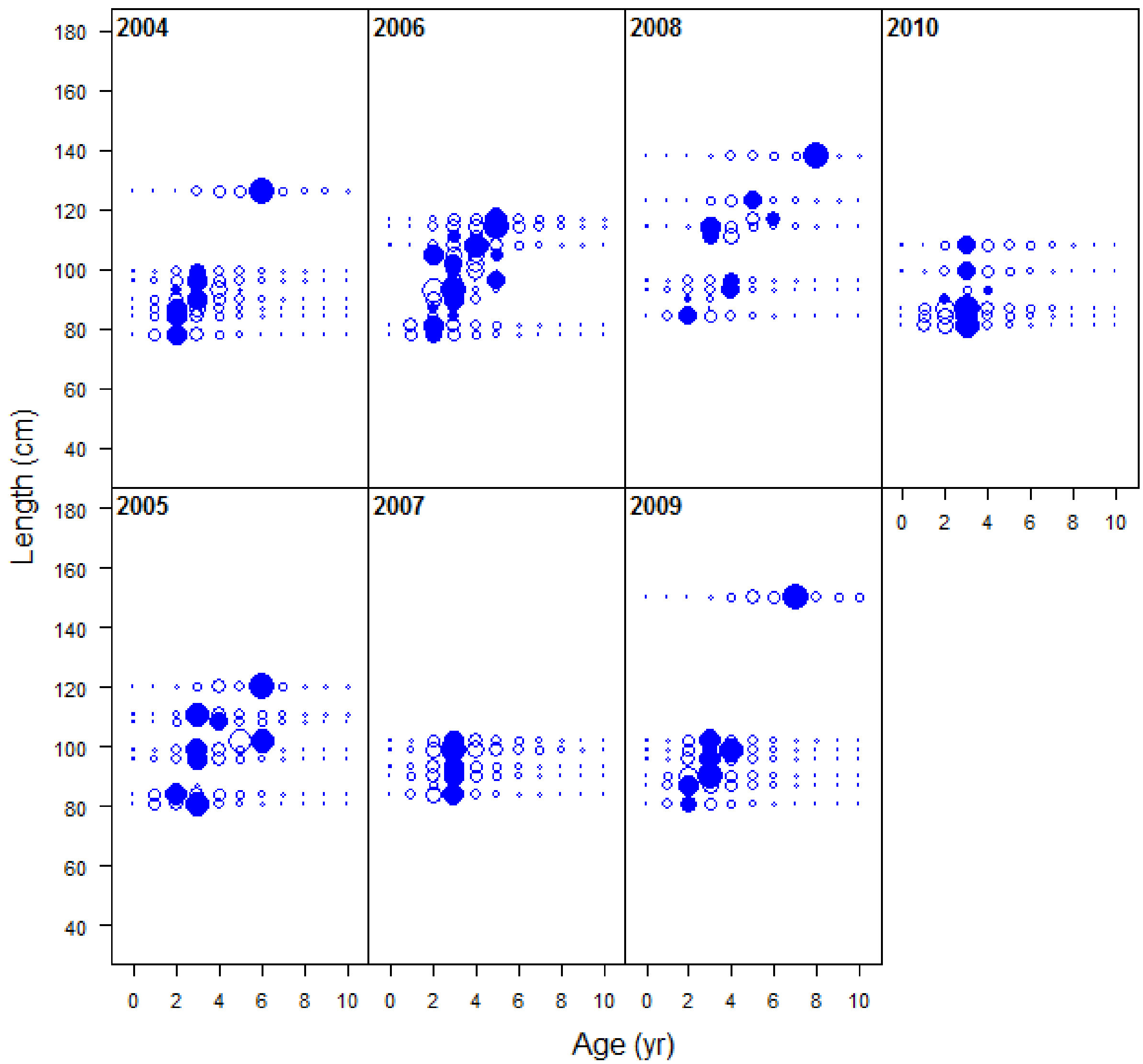


Figure 3.15c. Pearson residuals of conditional age composition fits for Gulf of Mexico cobia in the recreational fishery from SS Run 1. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed) (max=10).

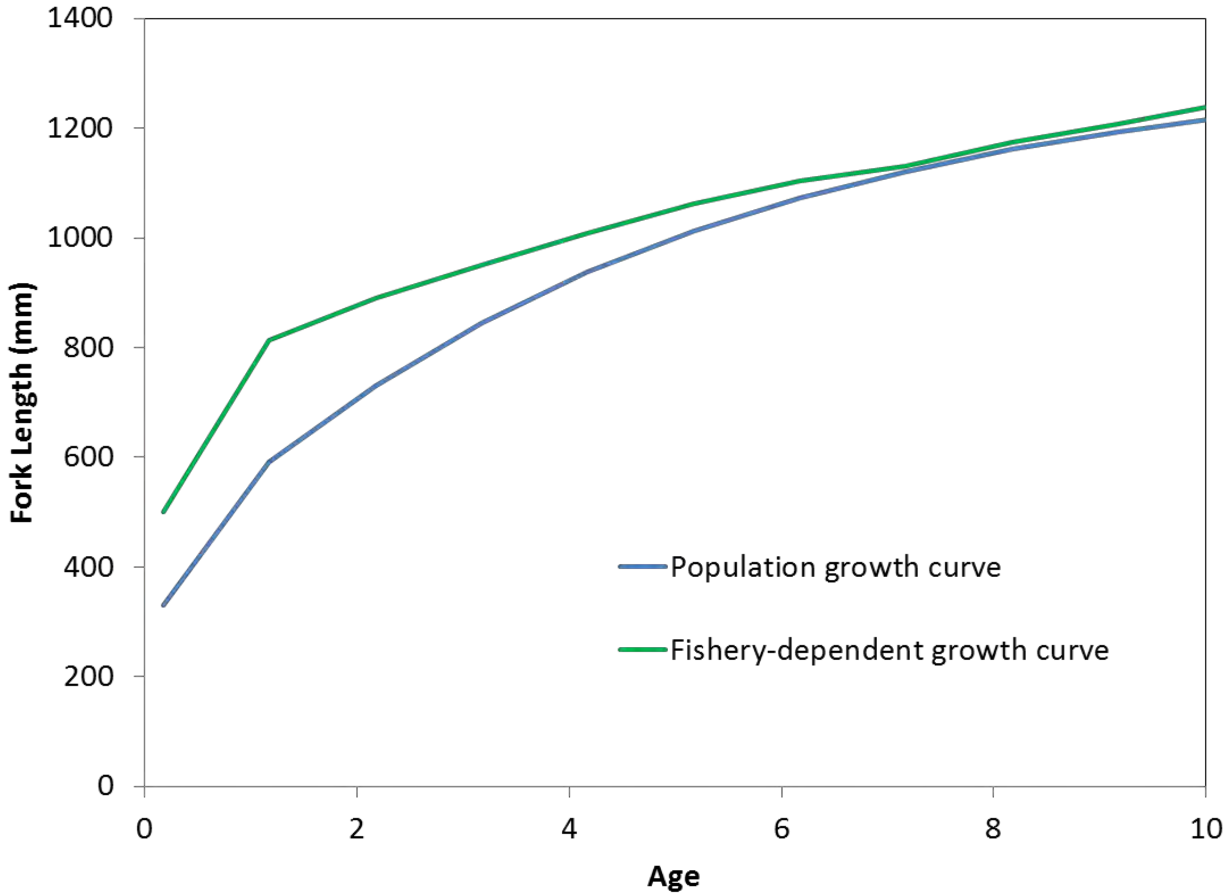


Figure 3.16. Predicted population growth curve and predicted growth curve from fishery-dependent samples from the recreational fishery.

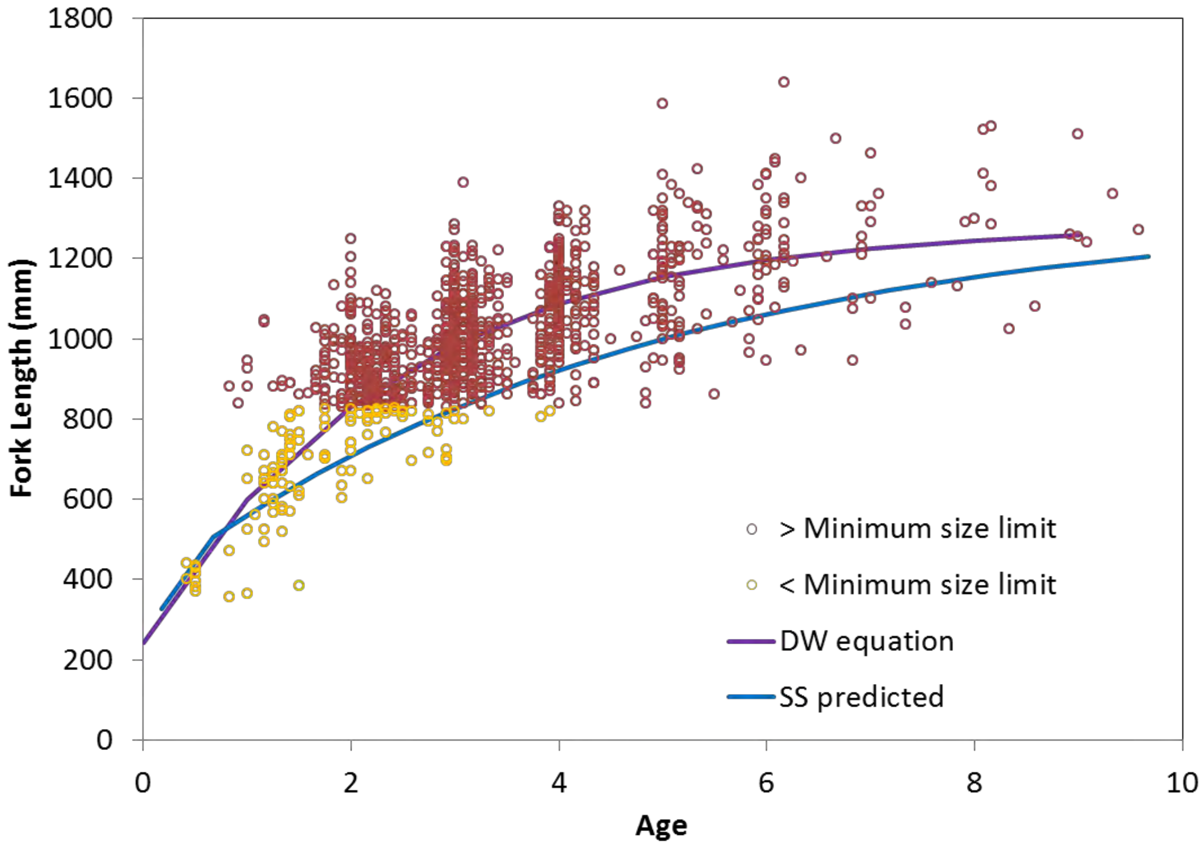


Figure 3.17. Observed length-at-age data (points), predicted growth curve from the data workshop (purple line), and predicted population growth curve from Stock Synthesis (blue line).

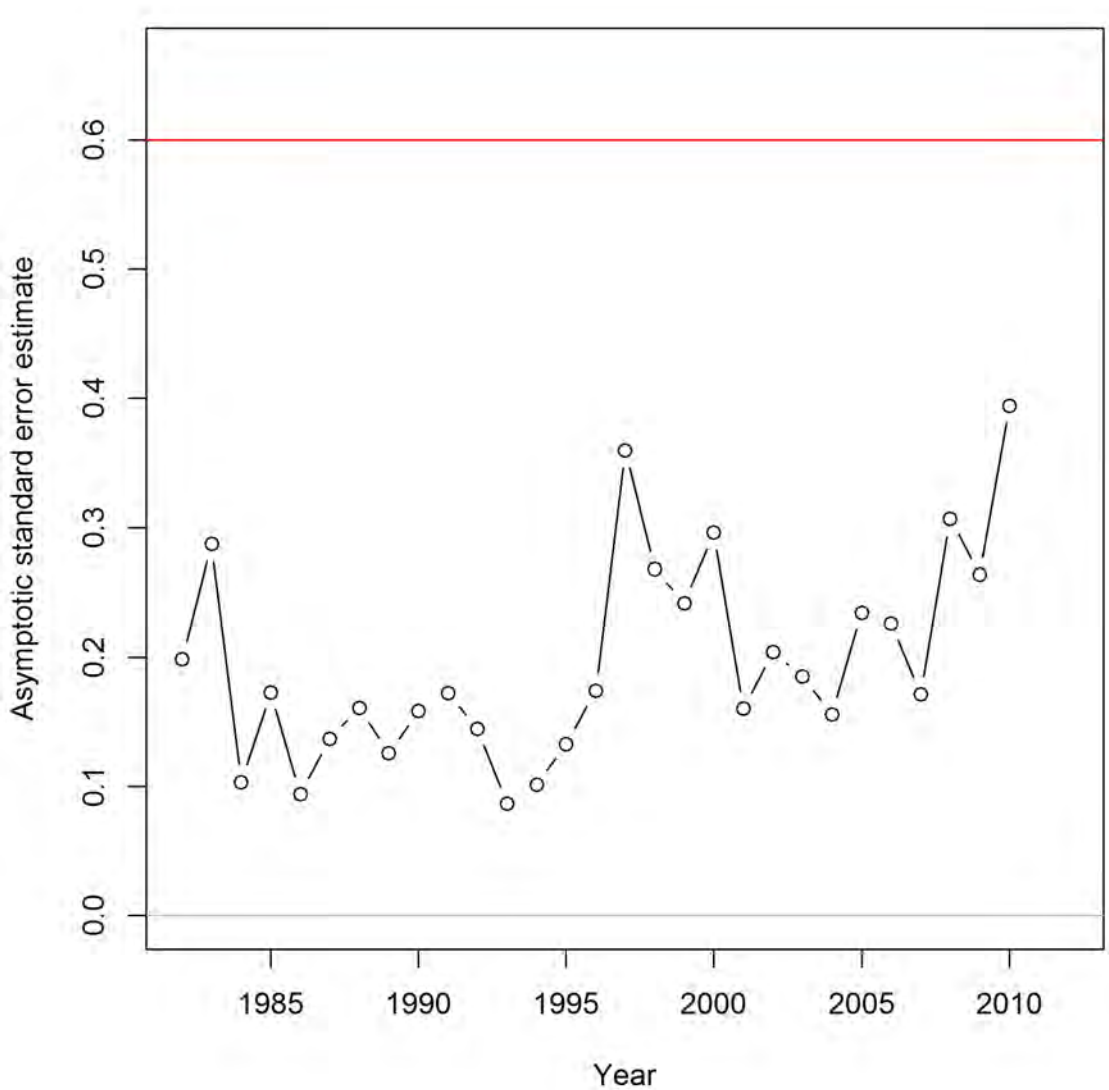


Figure 3.18. Asymptotic standard errors for recruitment deviations, 1982-2010. The red line represents the fixed value for sigma R used in the model.

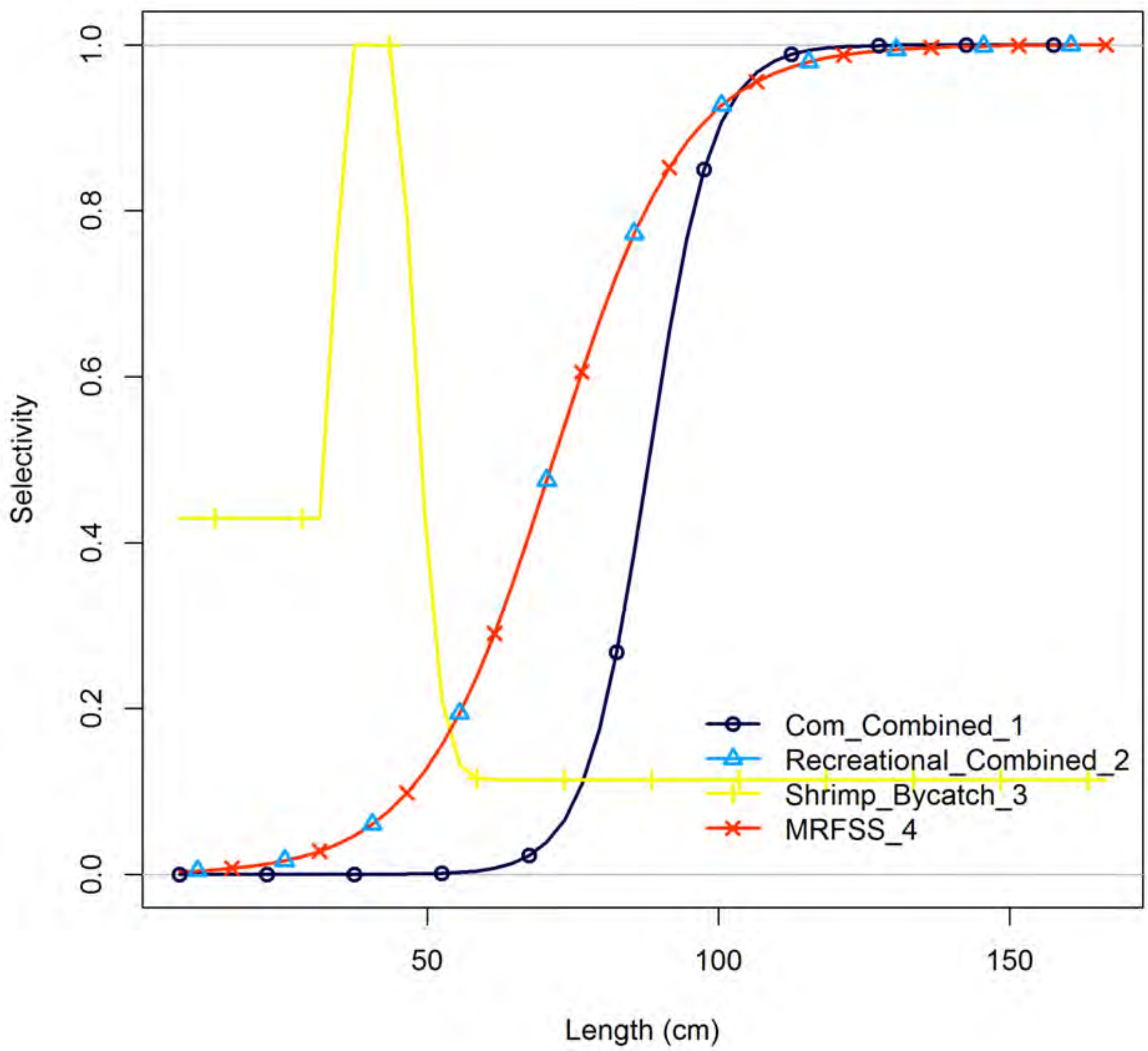


Figure 3.19. Length-based selectivity for each fleet. Selectivity is assumed to be constant over the entire assessment time period, 1927-2011.

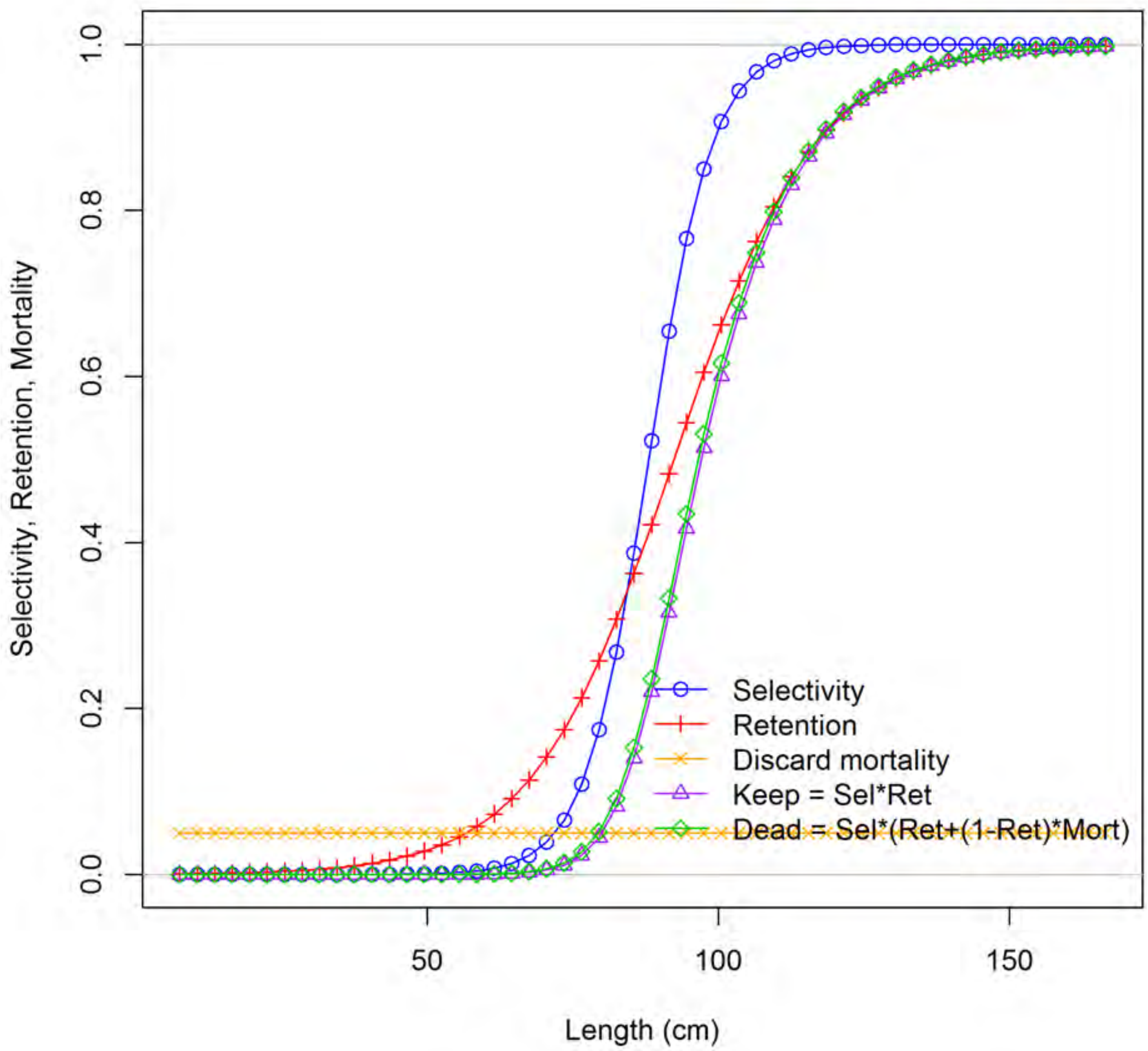


Figure 3.20. Length-based selectivity for the commercial fishery. Selectivity (blue line) is constant over the entire assessment time period (1927-2011). Retention (red line) is shown for time period 1985-2011. Discard mortality (orange line) is constant at 0.05.

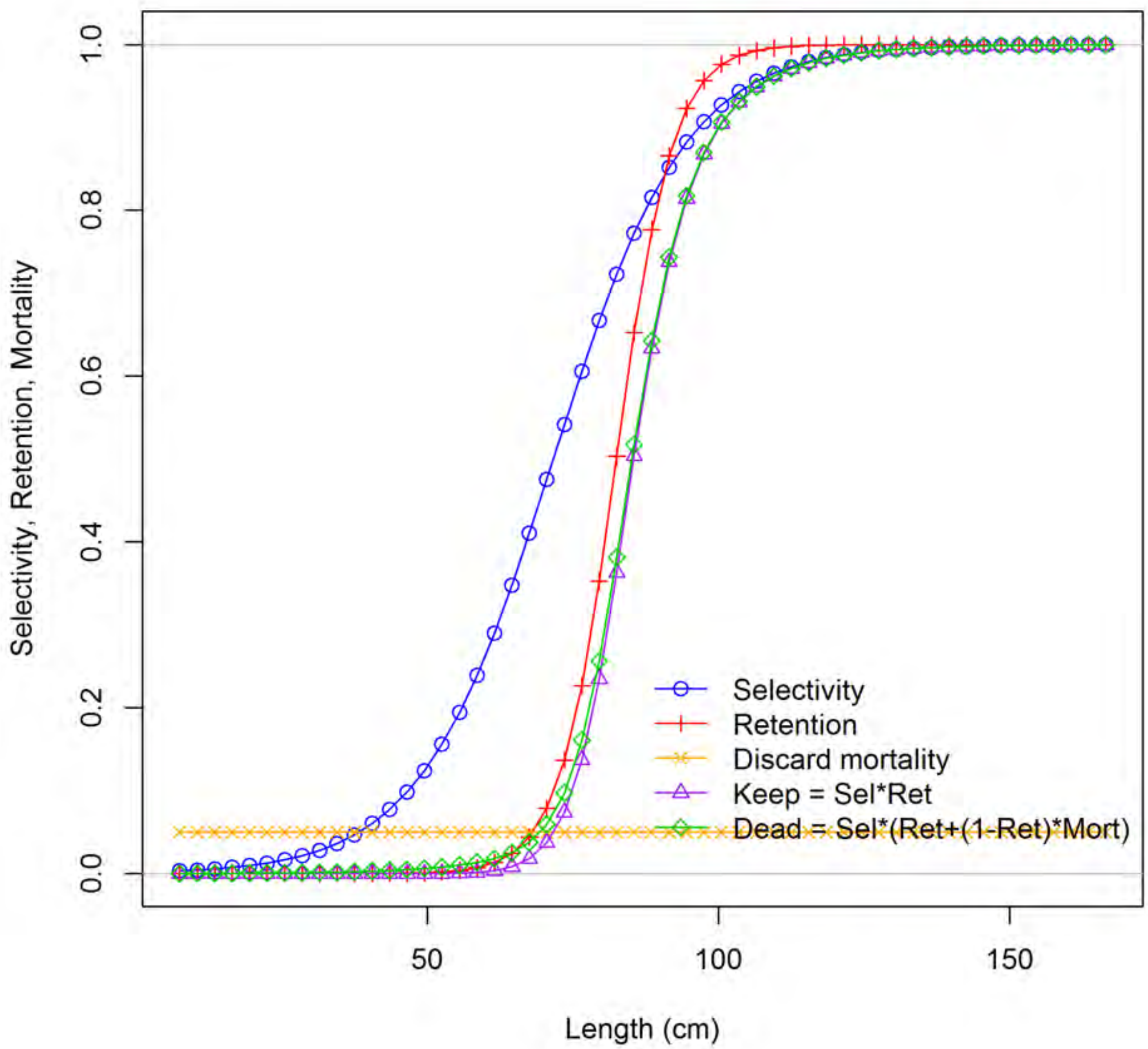


Figure 3.21. Length-based selectivity for the recreational fishery. Selectivity (blue line) is constant over the entire assessment time period (1927-2011). Retention (red line) is shown for time period 1985-2011. Discard mortality (orange line) is constant at 0.05.

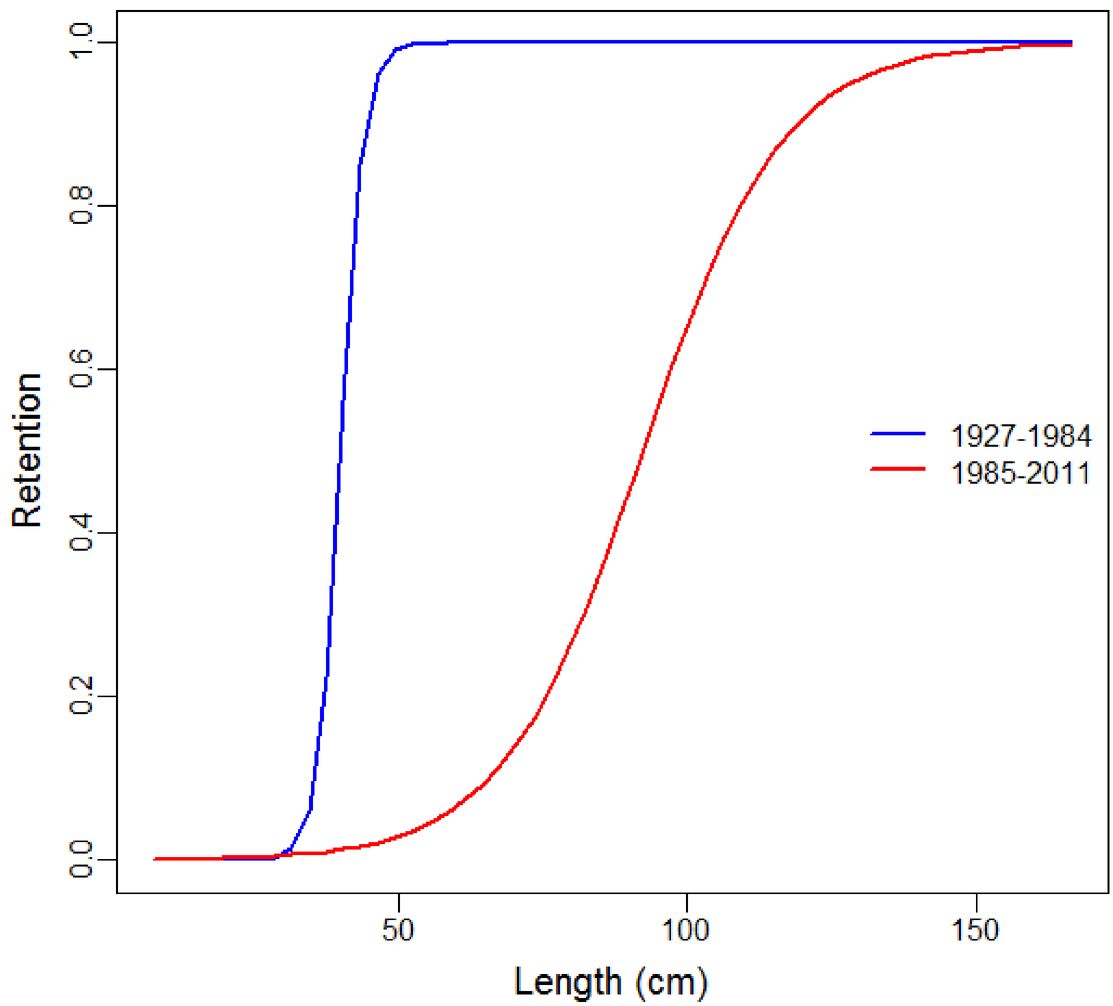


Figure 3.22. Retention patterns for the commercial fishery before and after the implementation of a minimum size limit of 33in FL in 1984.

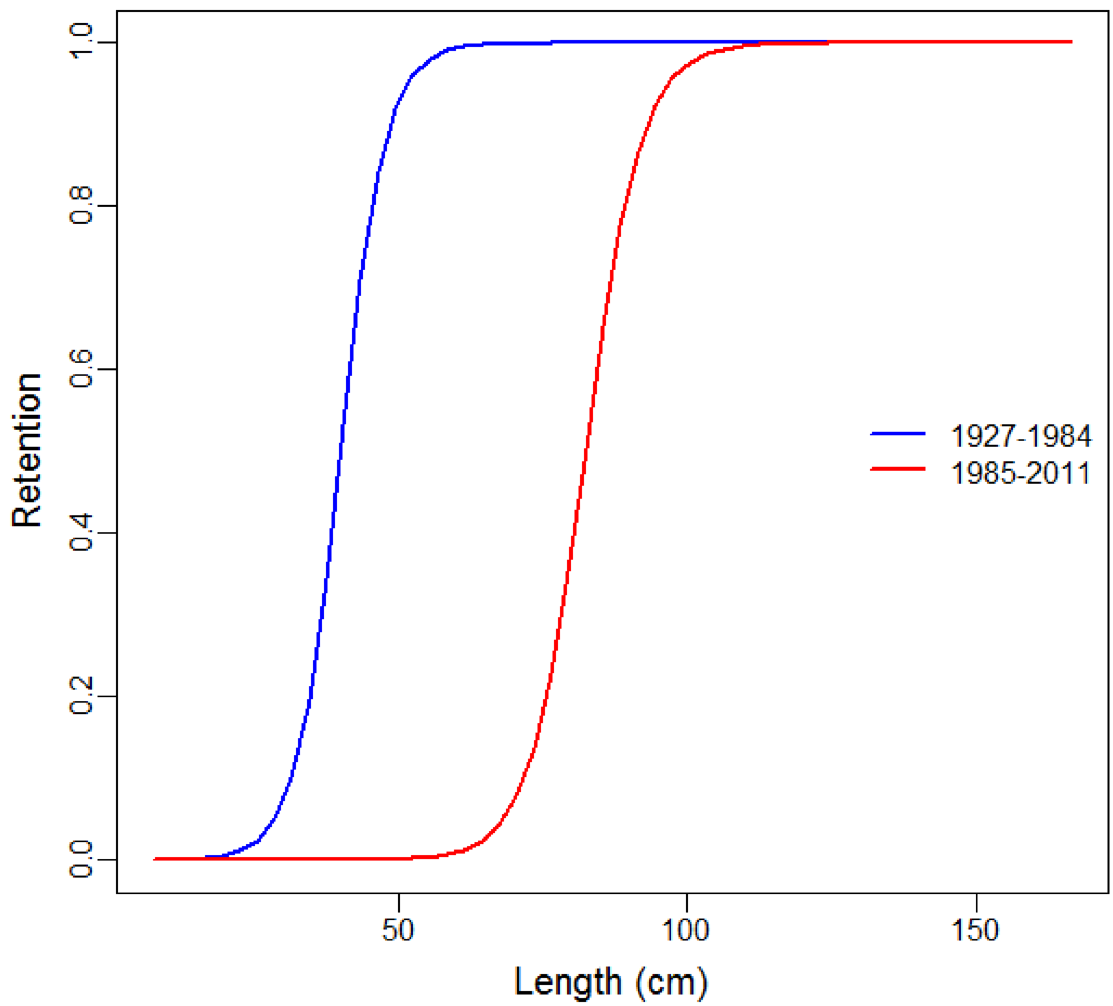


Figure 3.23. Retention patterns for the recreational fishery before and after the implementation of a minimum size limit of 33in FL in 1984.

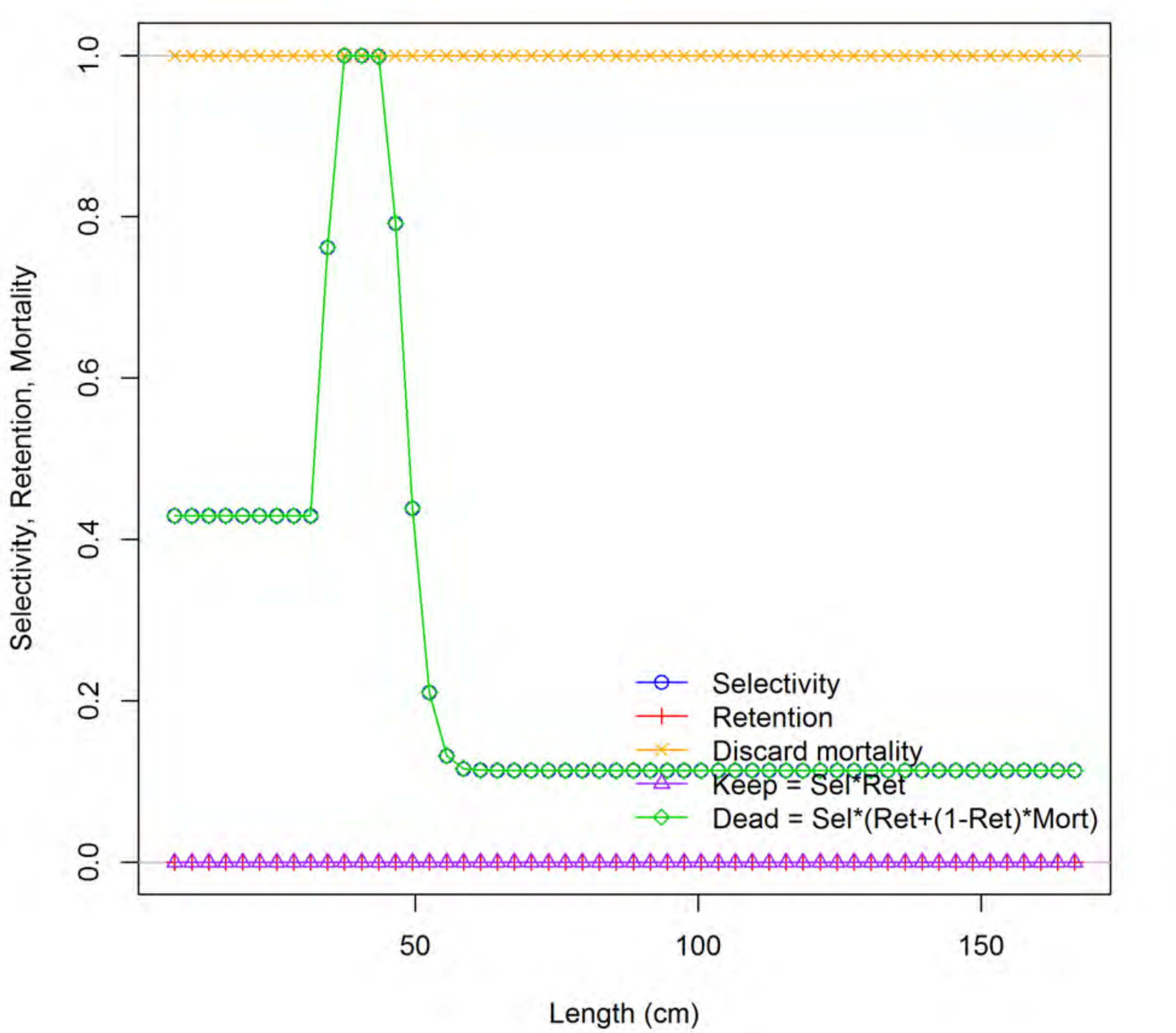


Figure 3.24. Length-based selectivity for the shrimp fishery. Selectivity (blue line) is constant over the entire assessment time period (1927-2011). All selected fish are assumed to be discarded dead.

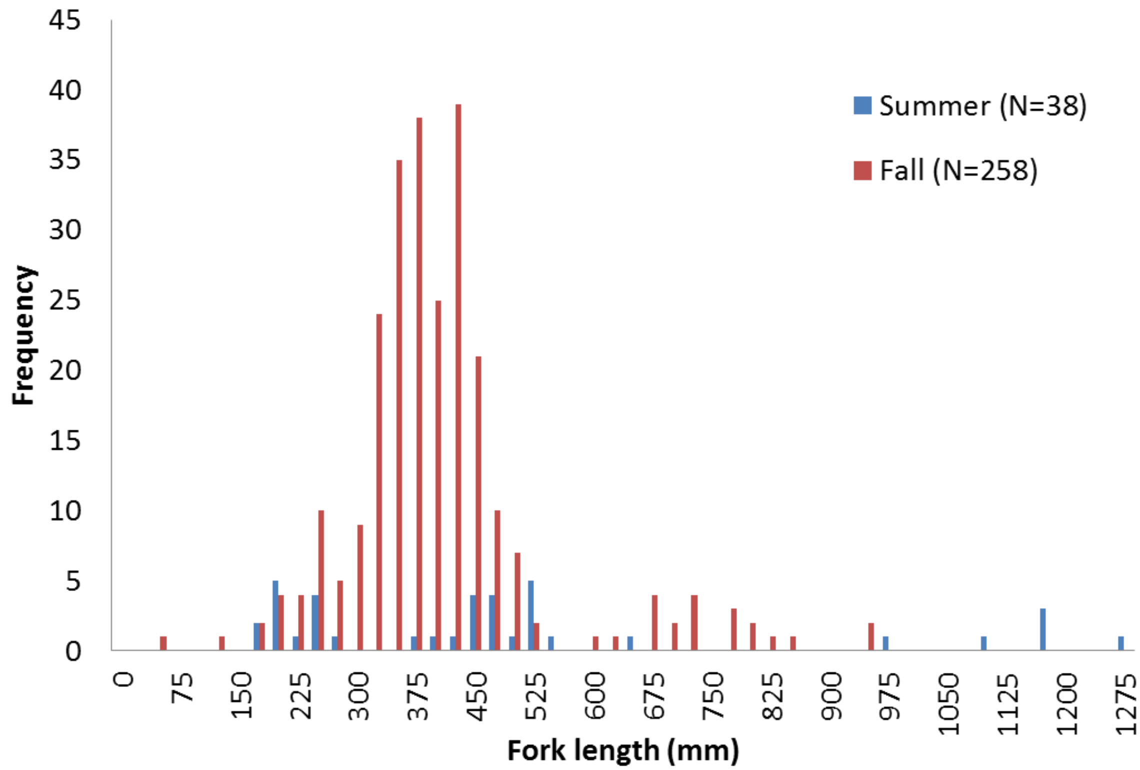


Figure 3.25. Length composition of Gulf of Mexico Cobia from the SEAMAP trawl survey by season.

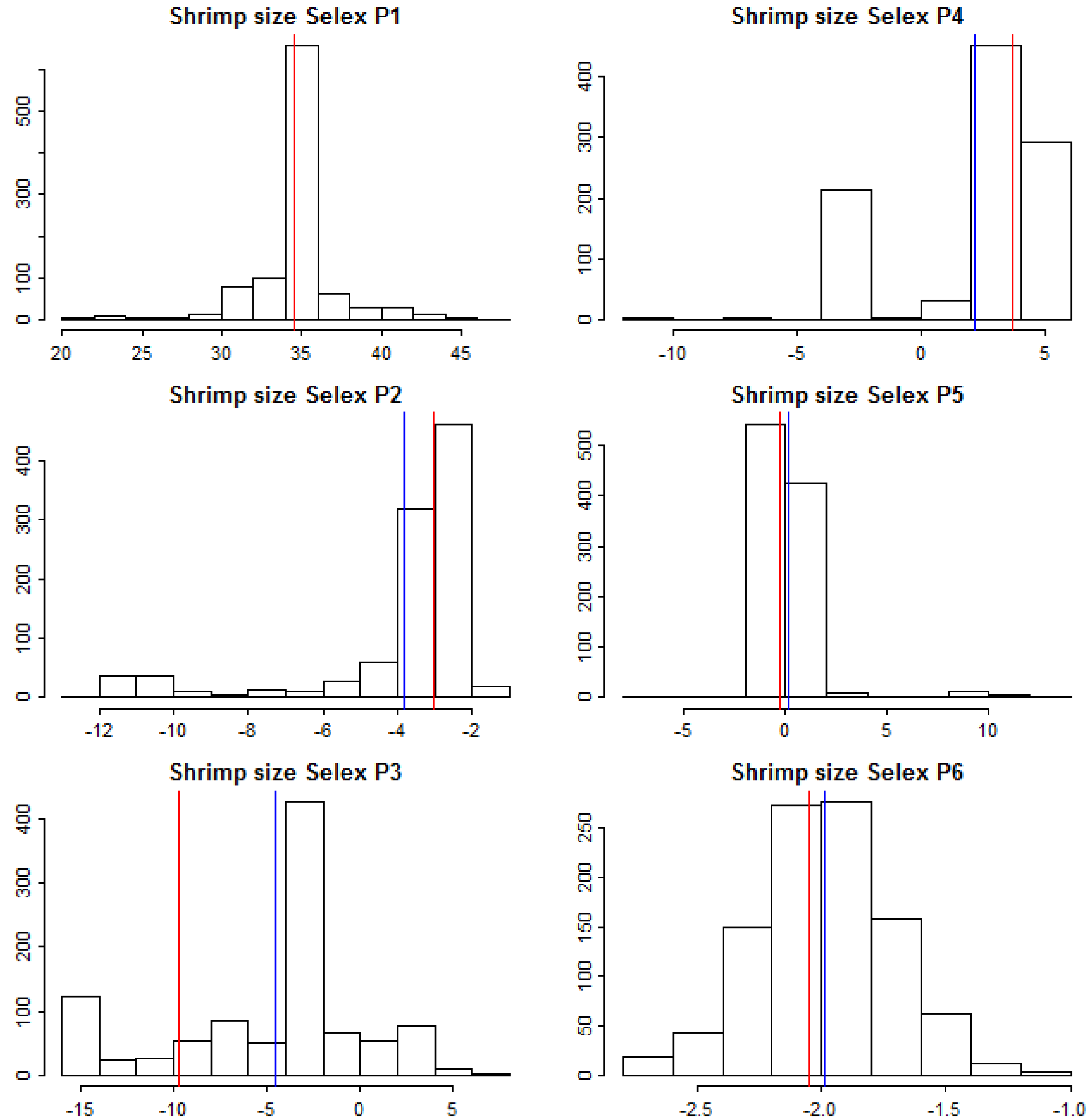


Figure 3.26. Distribution of estimated shrimp selectivity parameters from 1000 bootstrap samples. Blue lines represent mean estimates from the bootstrap samples, red lines represent the point estimate of the parameters from the base model.

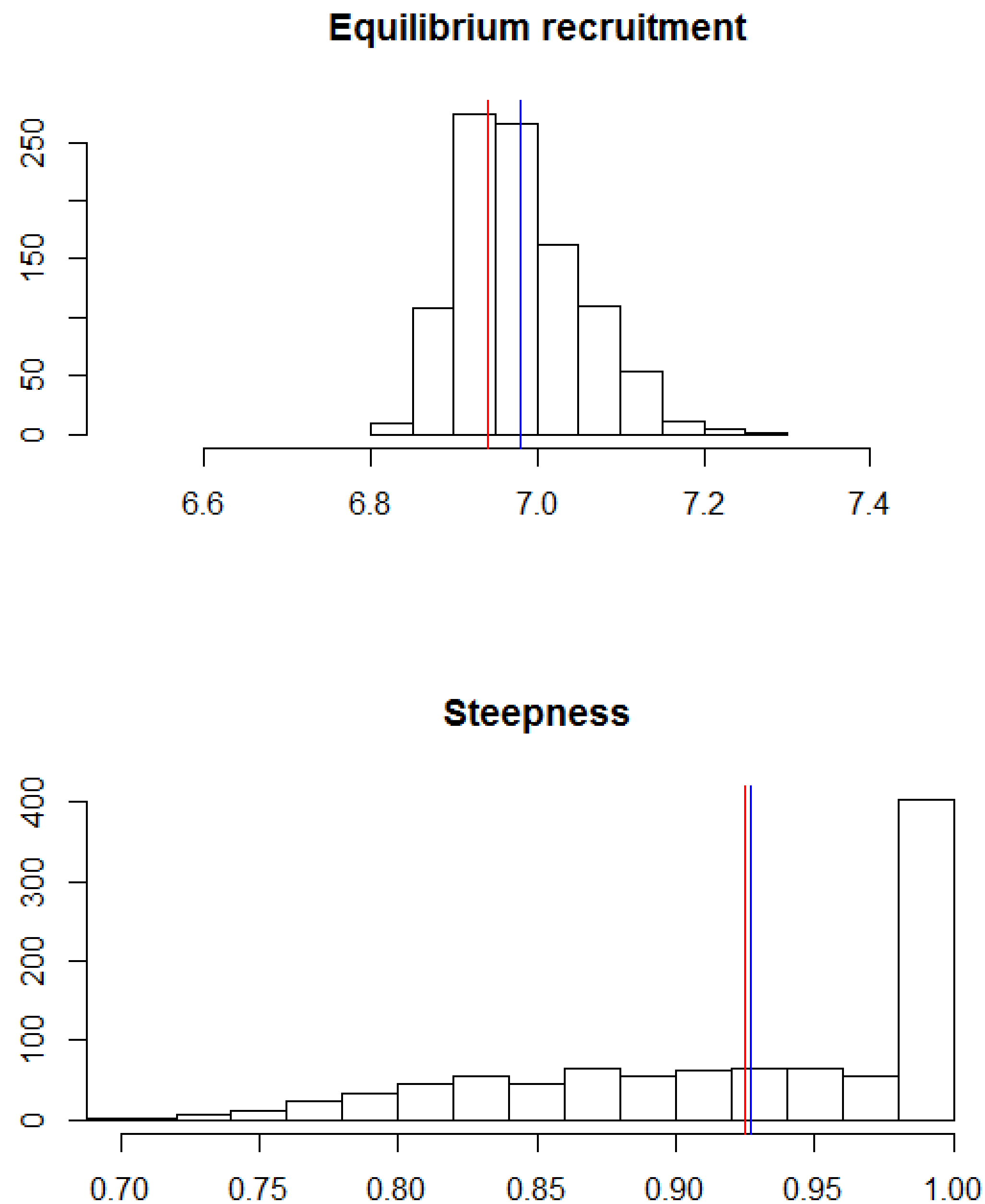


Figure 3.27. Distribution of estimated equilibrium recruitment and steepness from 1000 bootstrap samples. Blue lines represent mean estimates from the bootstrap samples, red lines represent the point estimate of the parameters from the base model.

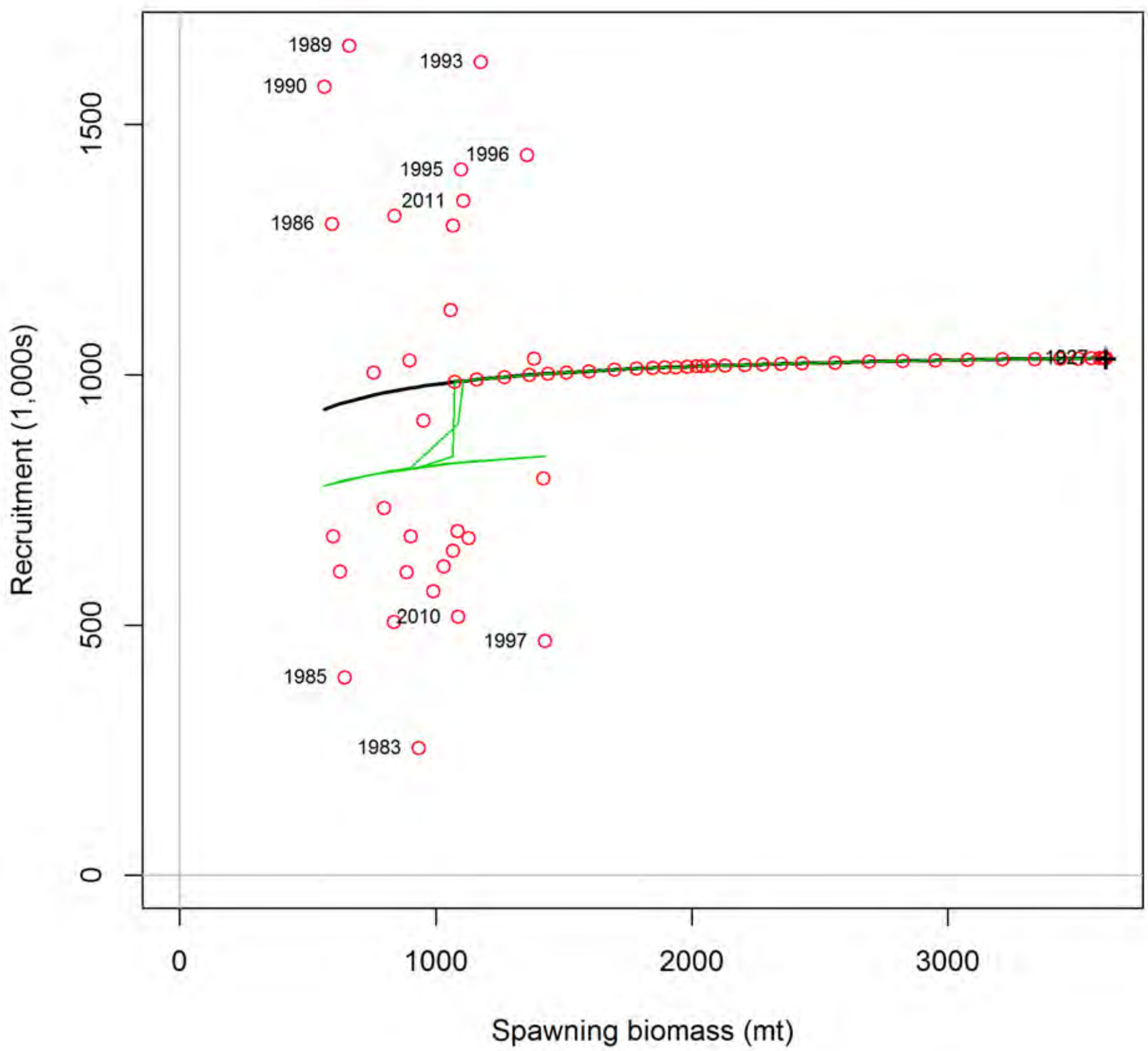


Figure 3.28. Predicted stock-recruitment relationship for Gulf of Mexico cobia for the base model. Plotted are predicted annual recruitments from SS (circles), expected recruitment from the stock-recruit relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (green line).

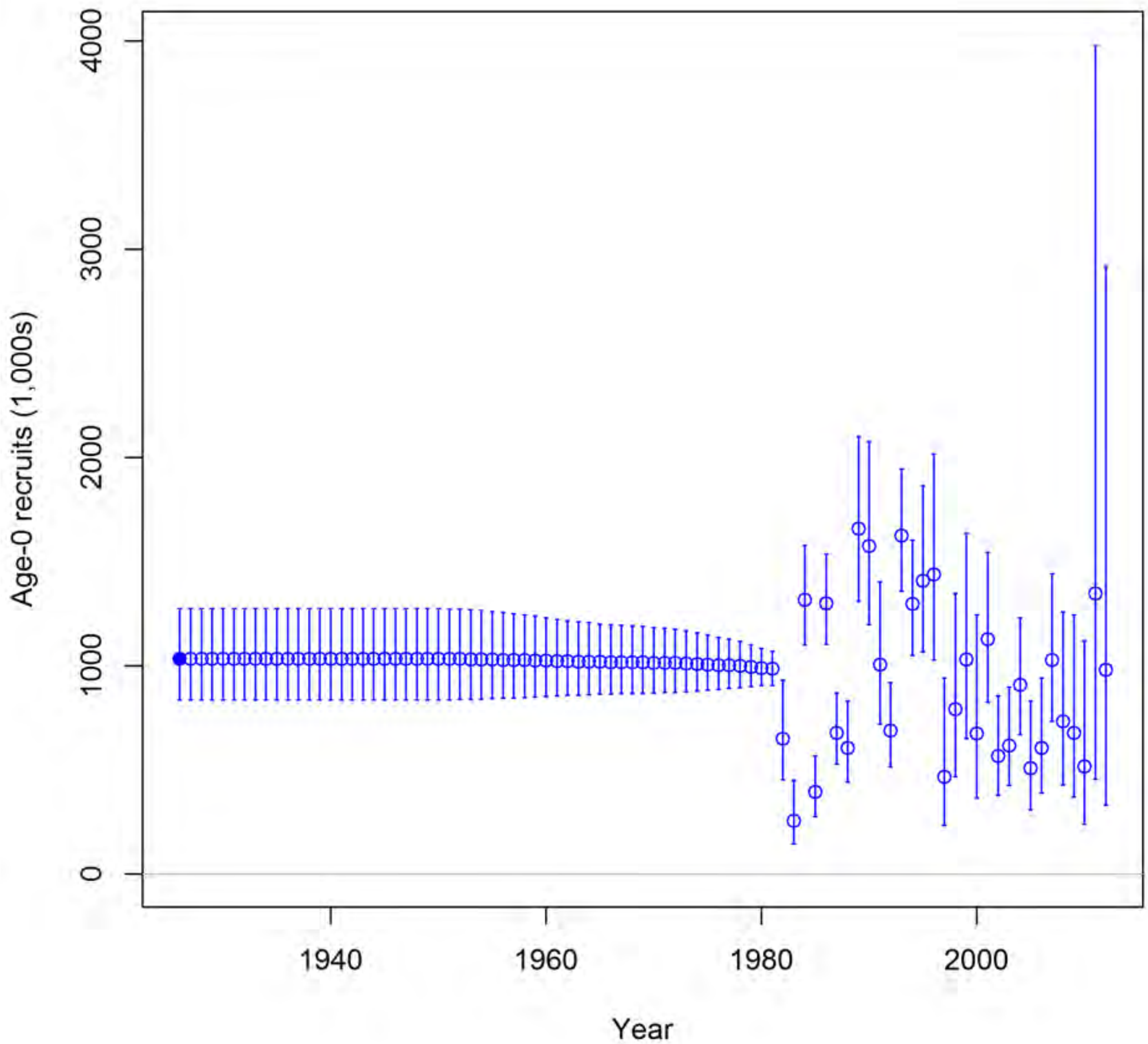


Figure 3.29. Predicted age-0 recruits with associated 95% asymptotic intervals.

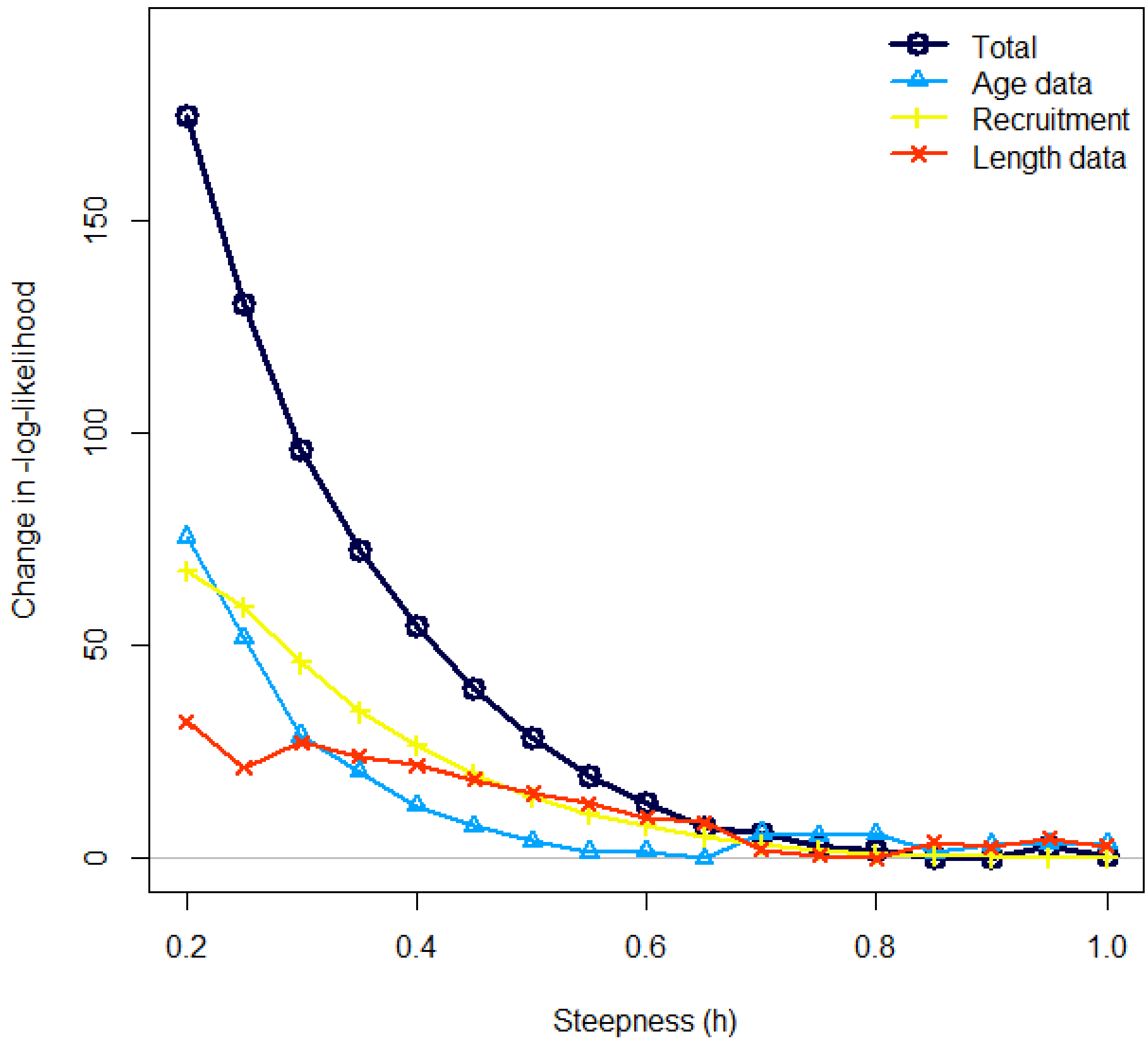


Figure 3.30. Likelihood profile for steepness at intervals of 0.05.

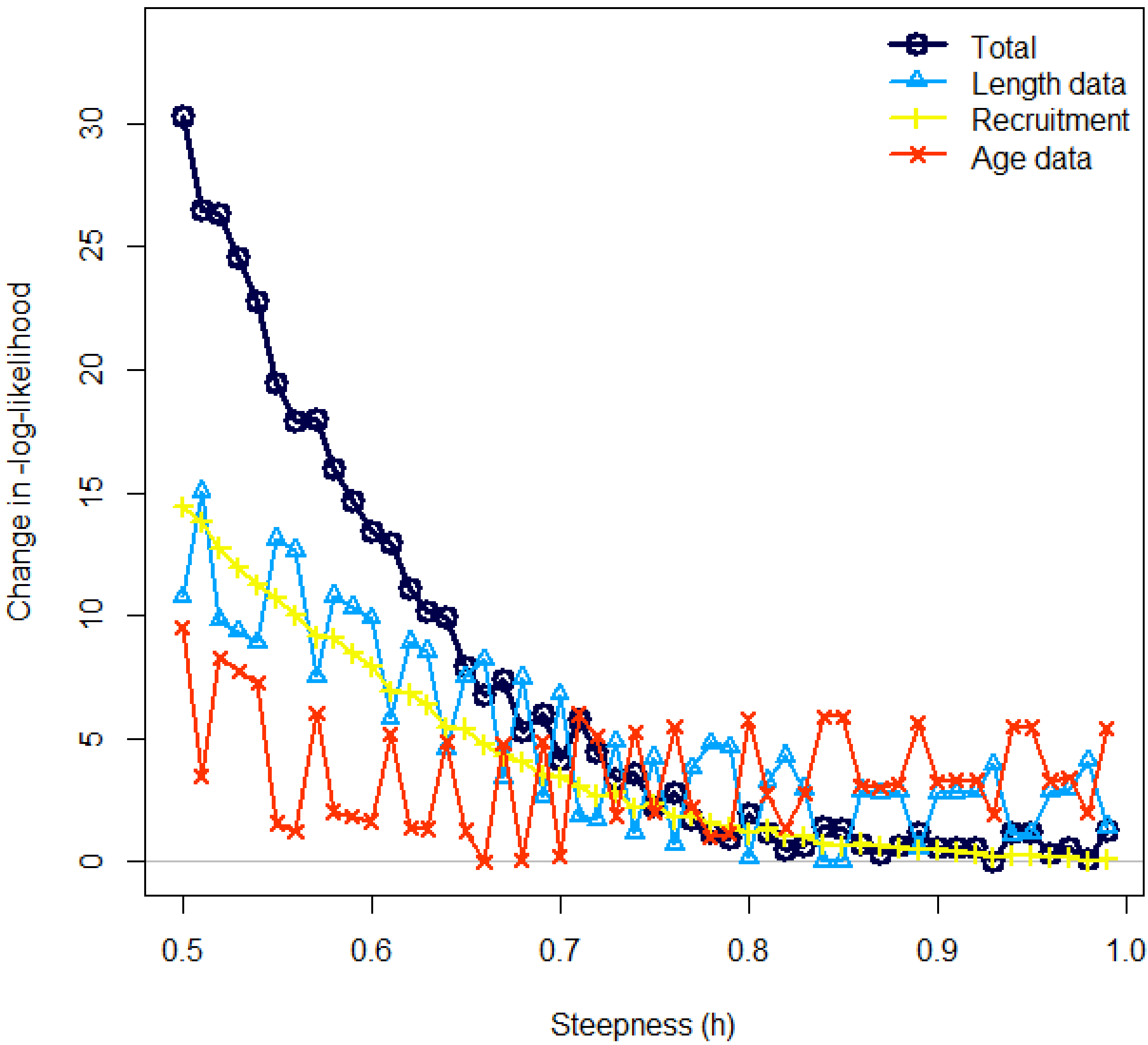


Figure 3.31. Likelihood profile for steepness at intervals of 0.01.

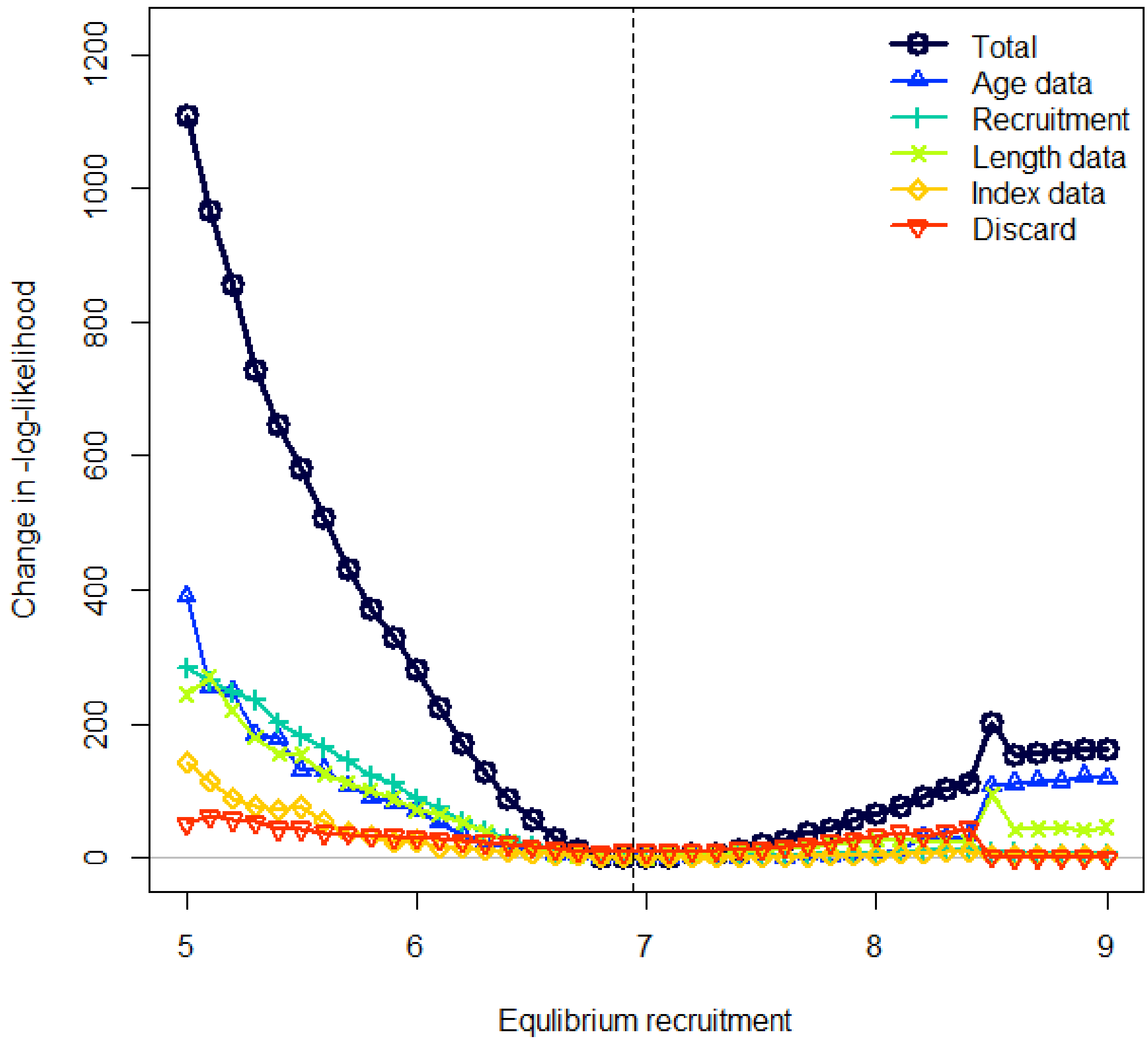


Figure 3.32. Likelihood profile for equilibrium recruitment. The dotted line represents the point estimate from the base model.

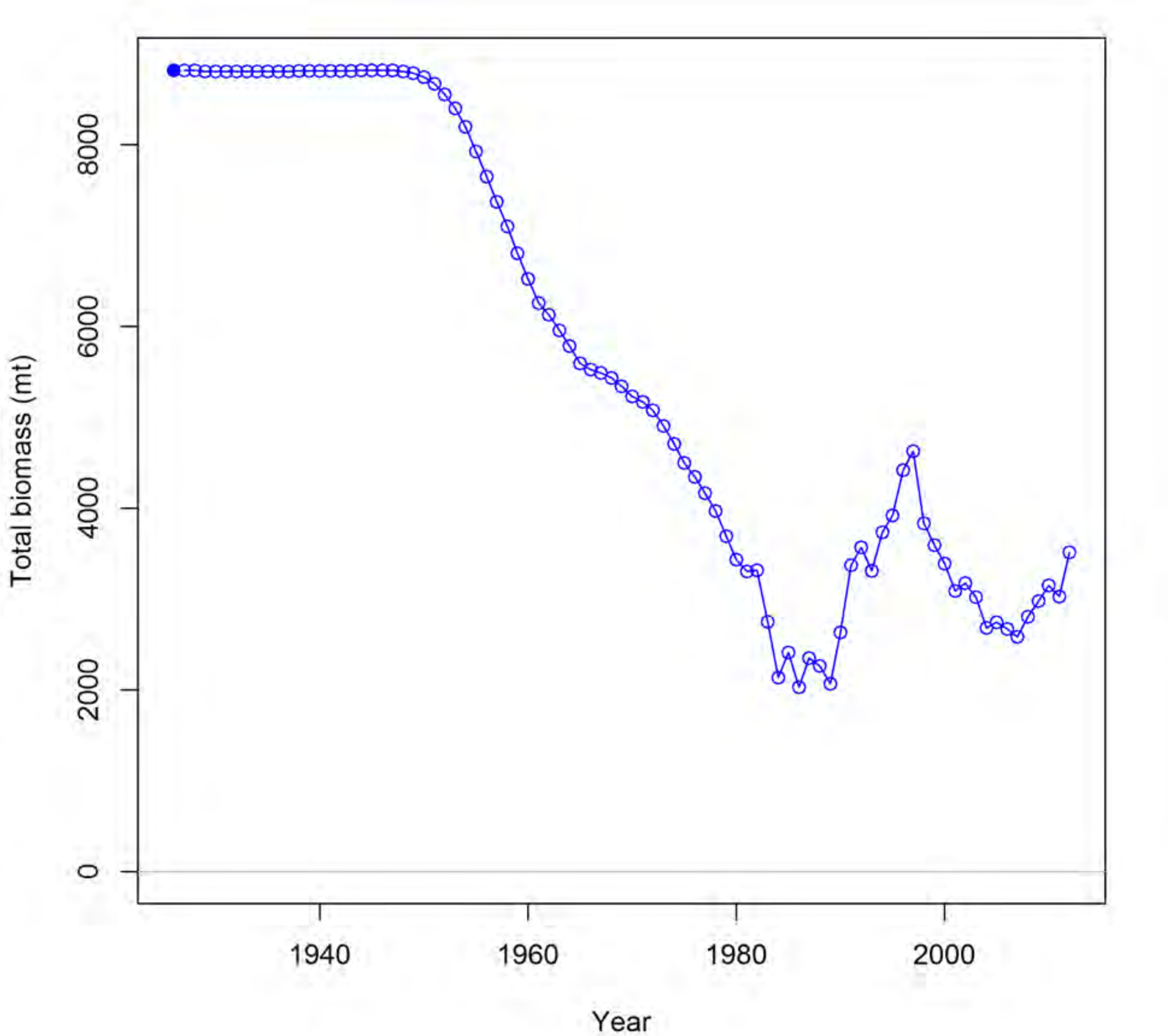


Figure 3.33. Predicted total biomass (mt) of Gulf of Mexico cobia from 1927-2011.

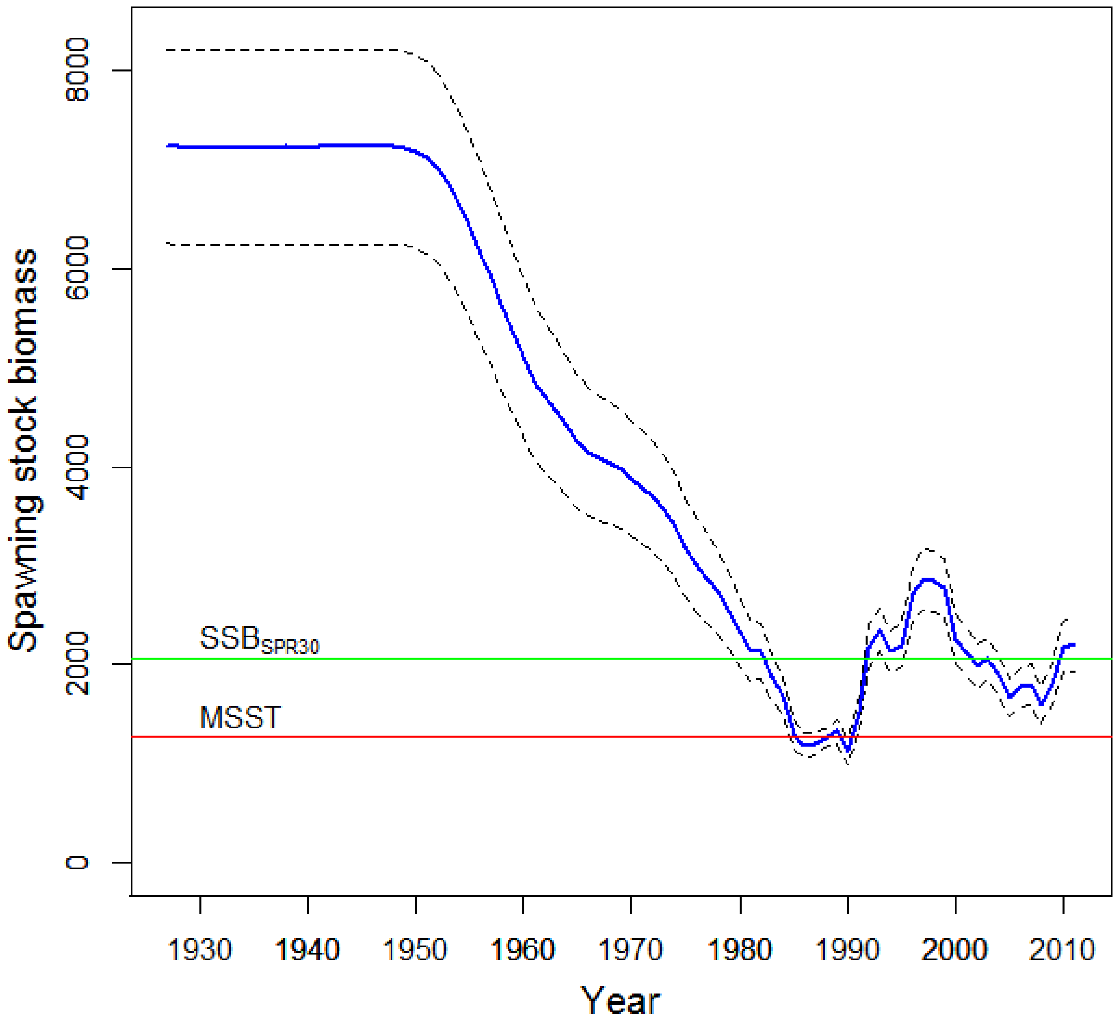


Figure 3.34. Predicted spawning biomass (mt) of Gulf of Mexico cobia (blue line) with associated 80% asymptotic intervals (dashed lines). The green line represents spawning stock biomass at $F_{SPR30\%}$ and the red line represents the minimum stock size threshold.

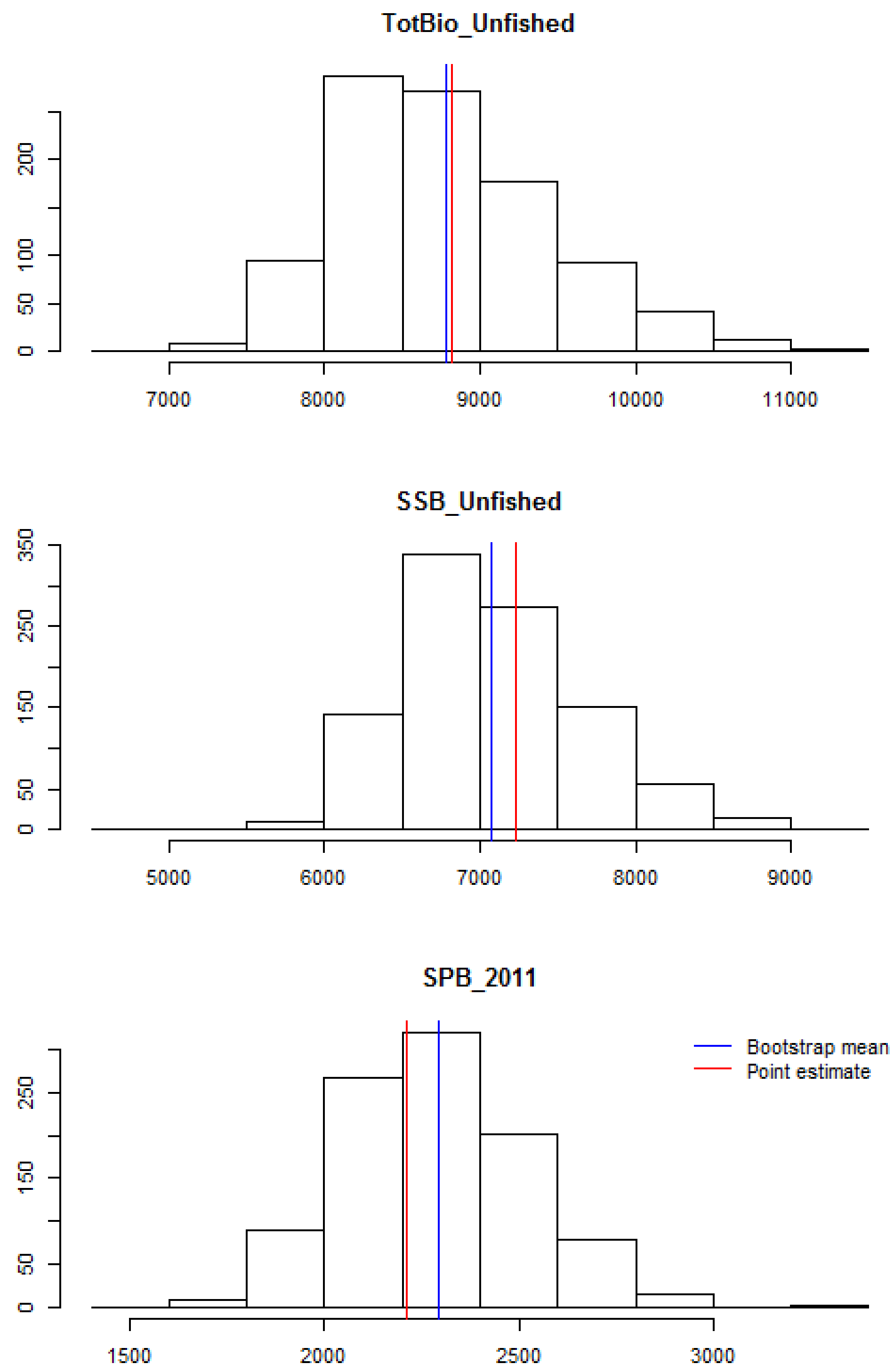

TotBio_Unfished
0
50
100
200
7000
8000
9000
10000
11000
SSB_Unfished
0
50
150
250
350
5000
6000
7000
8000
9000
SPB_2011
Bootstrap mean
Point estimate
0
50
150
250
1500
2000
2500
3000

Figure 3.35. Distribution of estimated unfished total biomass, unfished spawning biomass and current spawning biomass (2011) from 1000 bootstrap samples of the base model. Blue lines represent mean estimates from the bootstrap samples, red lines represent the point estimate of the parameters from the base model.

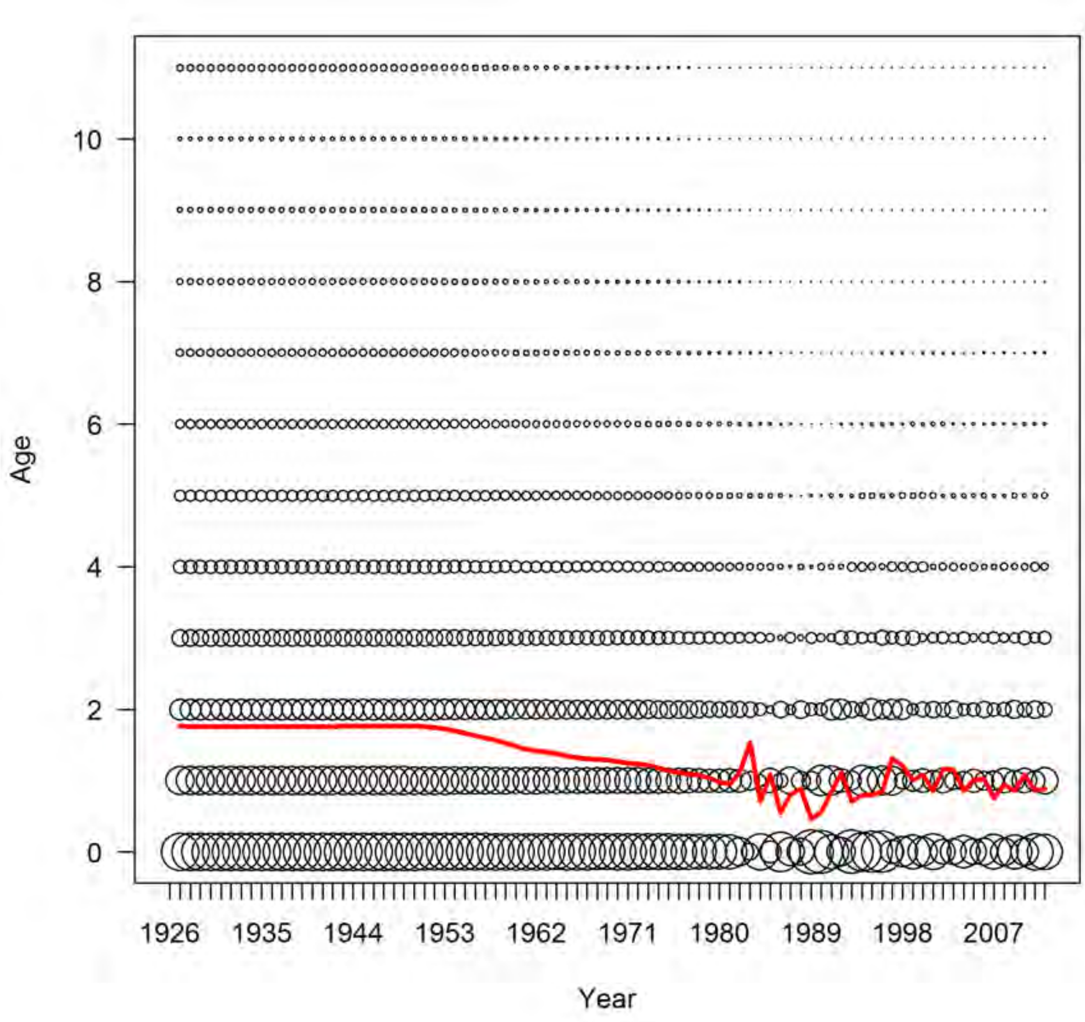


Figure 3.36. Predicted numbers at age (bubbles) and mean age of Gulf of Mexico cobia (red line).

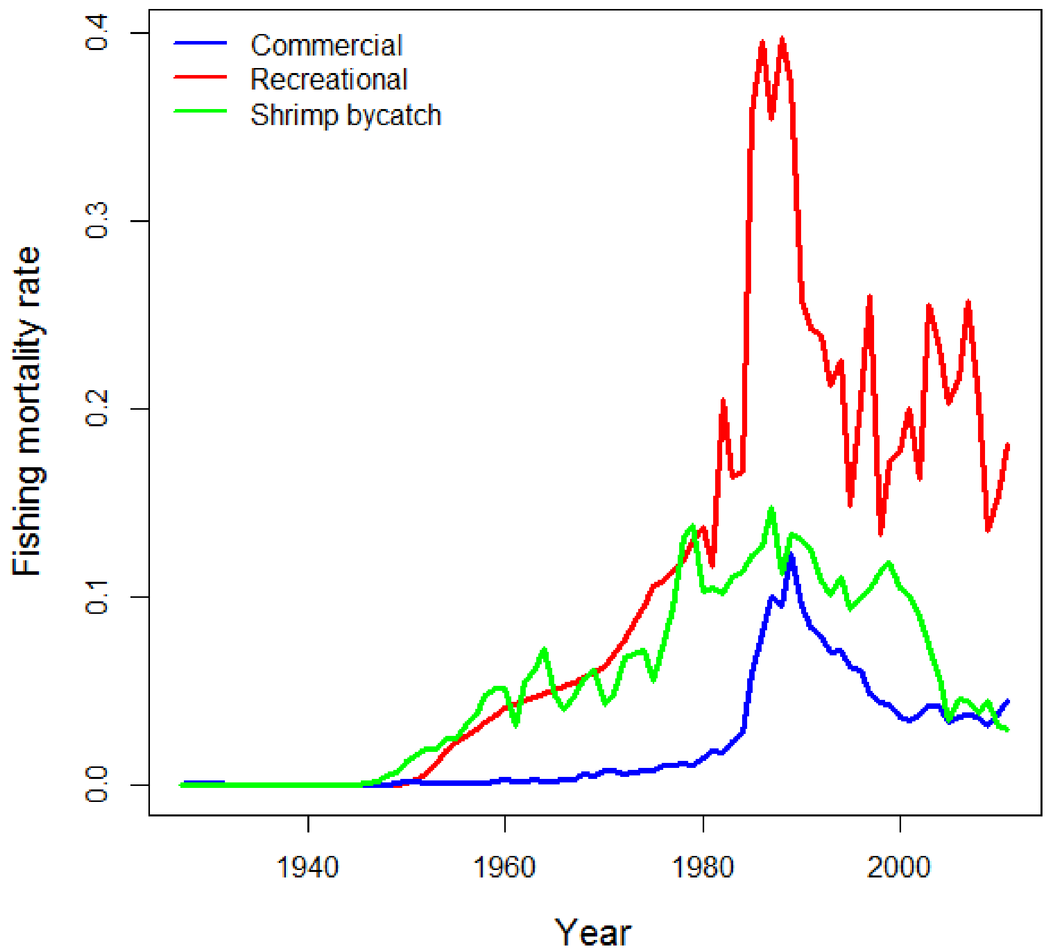


Figure 3.37. Fleet-specific estimates of instantaneous fishing mortality rate in terms of exploitable biomass.

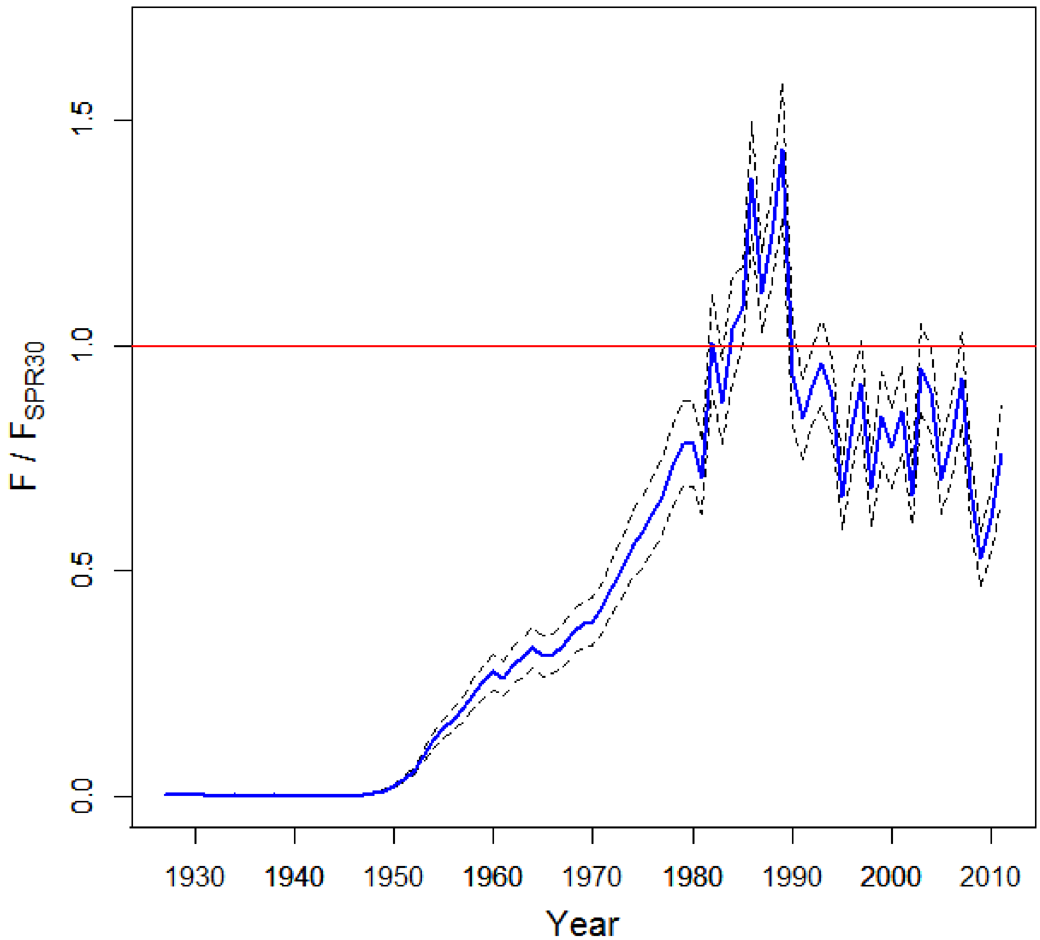


Figure 3.38. Total fishing mortality rate relative to F_{SPR30} for Gulf of Mexico cobia with associated 80% asymptotic confidence limits.

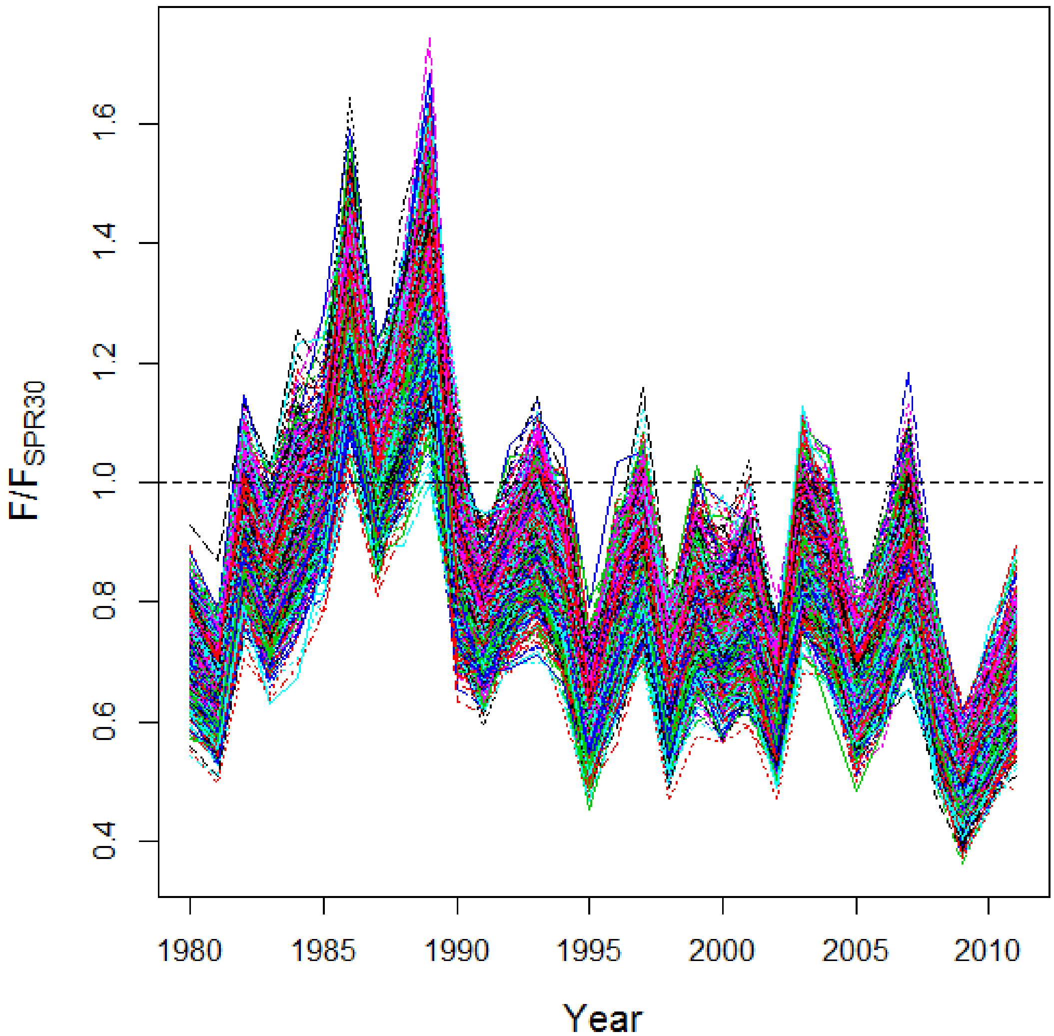


Figure 3.39. 1000 bootstrap estimates of the current fishing mortality (F2009-F2011) relative to F_{SPR30} for Gulf of Mexico cobia from 1980-2011.

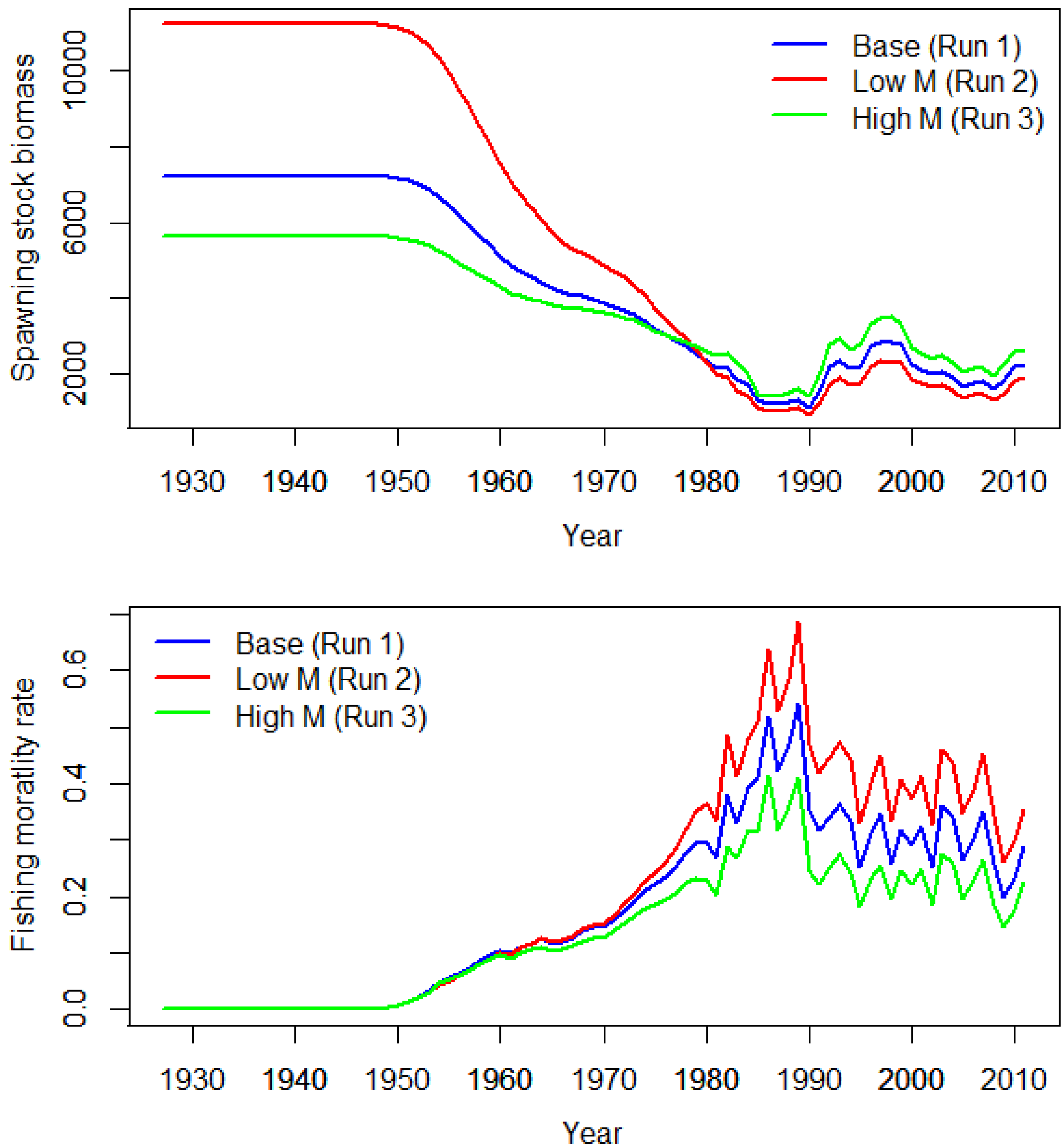


Figure 3.40. Predicted spawning stock biomass (top panel) and fishing mortality rate (bottom panel) over time for Gulf of Mexico cobia for three alternative levels of natural mortality rate (Runs 1-3).

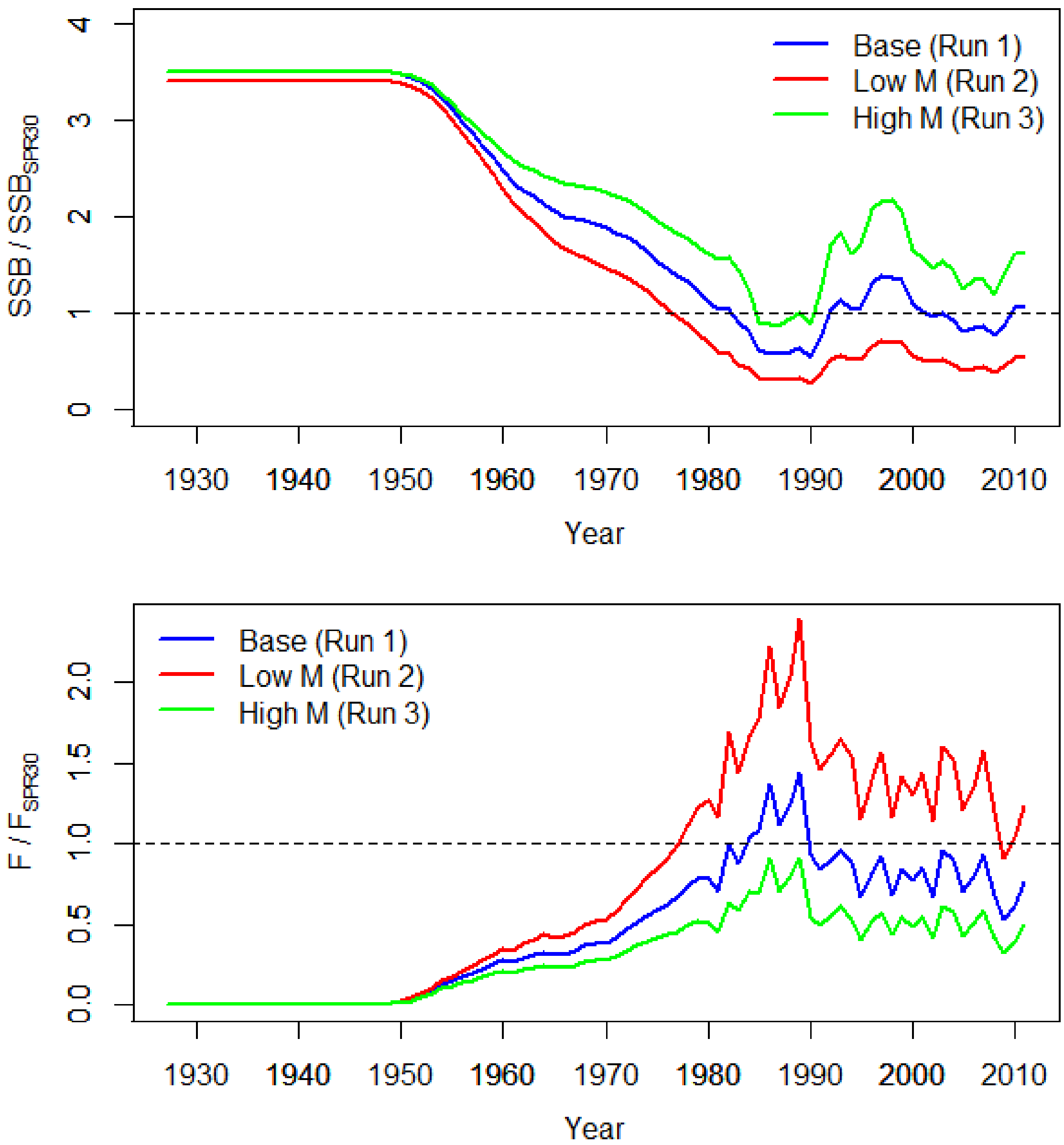


Figure 3.41. Predicted spawning stock biomass relative to $SSB_{SPR30\%}$ (top panel) and fishing mortality rate relative to $F_{SPR30\%}$ (bottom panel) over time for Gulf of Mexico cobia for three alternative levels of natural mortality rate (Runs 1-3).

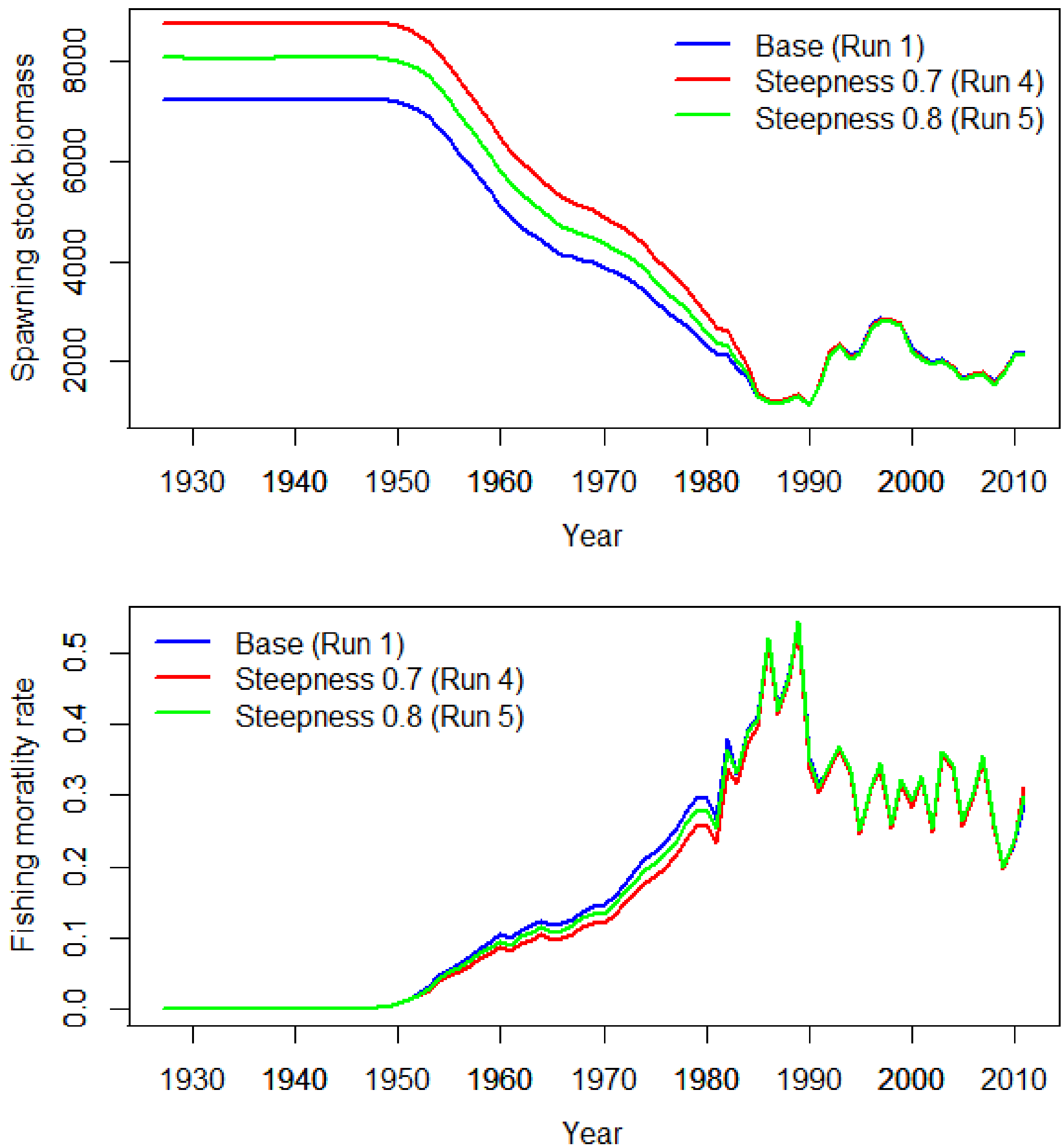


Figure 3.42. Predicted spawning stock biomass (top panel) and fishing mortality rate (bottom panel) over time for Gulf of Mexico cobia for three alternative levels of steepness (Runs 1, 5, 6; Base model steepness is 0.92).

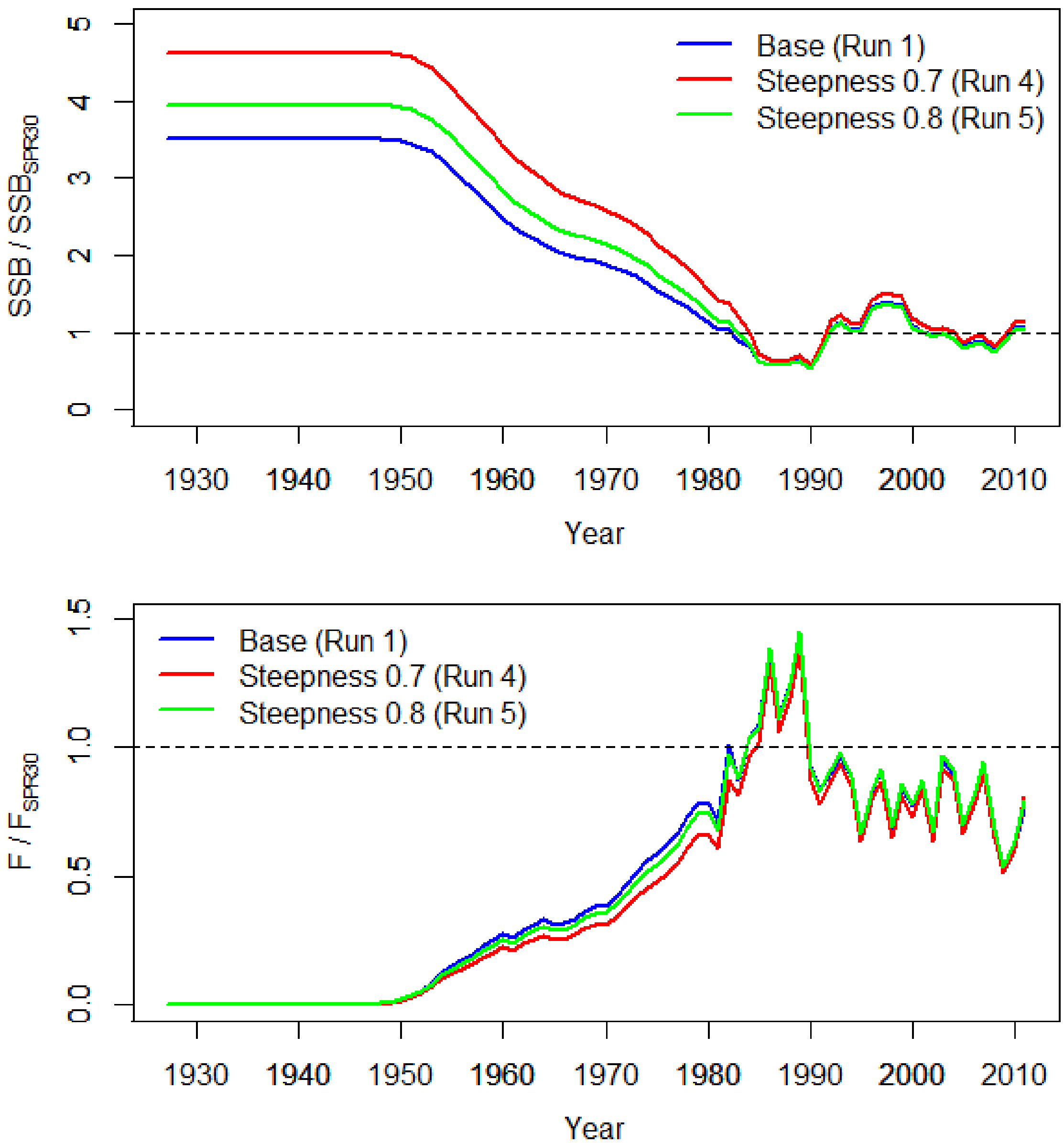


Figure 3.43. Predicted spawning stock biomass relative to $SSB_{SPR30\%}$ (top panel) and fishing mortality rate relative to $F_{SPR30\%}$ (bottom panel) over time for Gulf of Mexico cobia for three alternative levels of steepness (Runs 1, 5, 6; Base model steepness is 0.92).

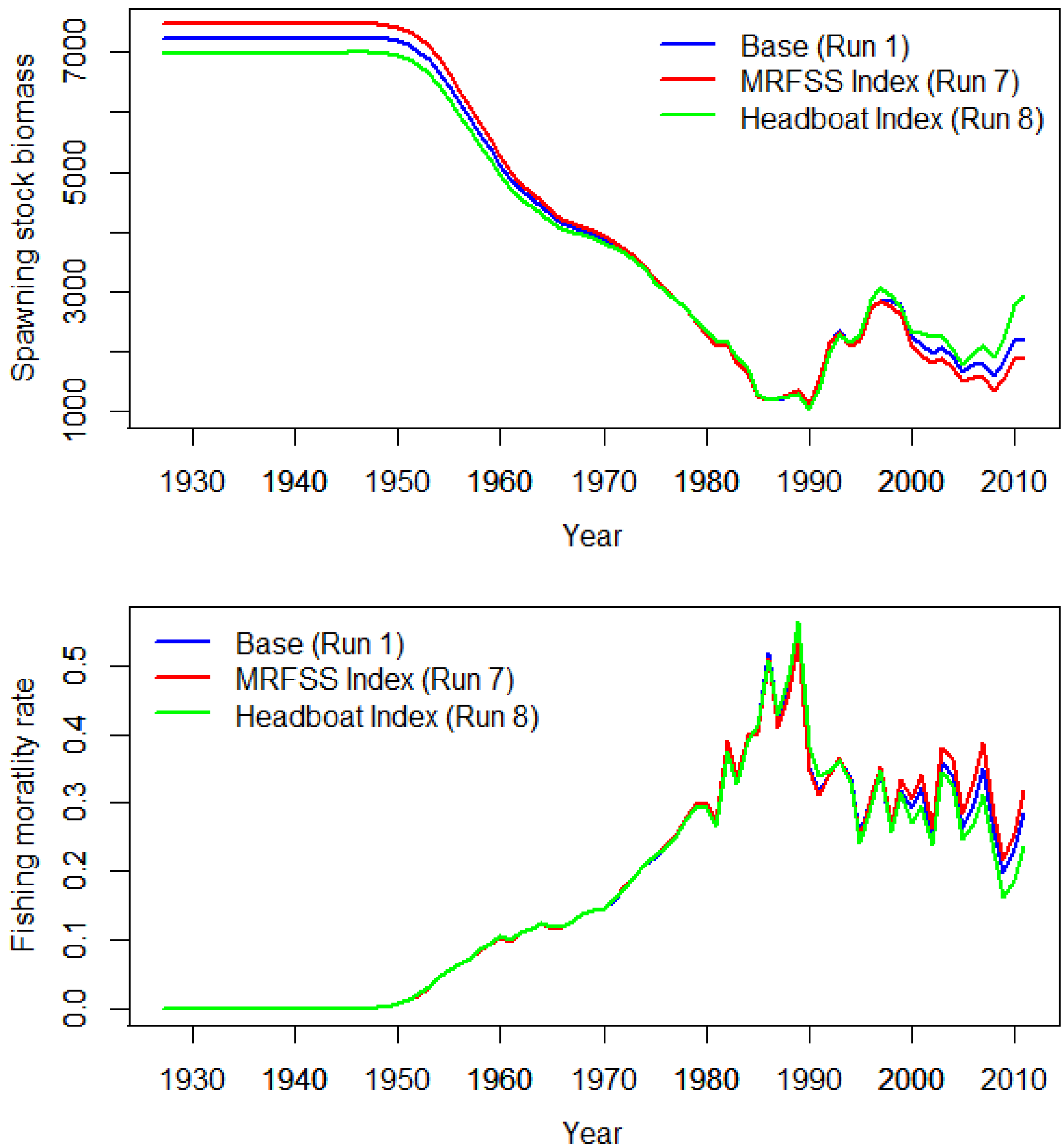


Figure 3.44. Predicted spawning stock biomass (top panel) and fishing mortality rate (bottom panel) over time for Gulf of Mexico cobia under three scenarios; using both indices of abundance, removing the Headboat index, and removing the MRFSS index (Runs 1, 7, 8).

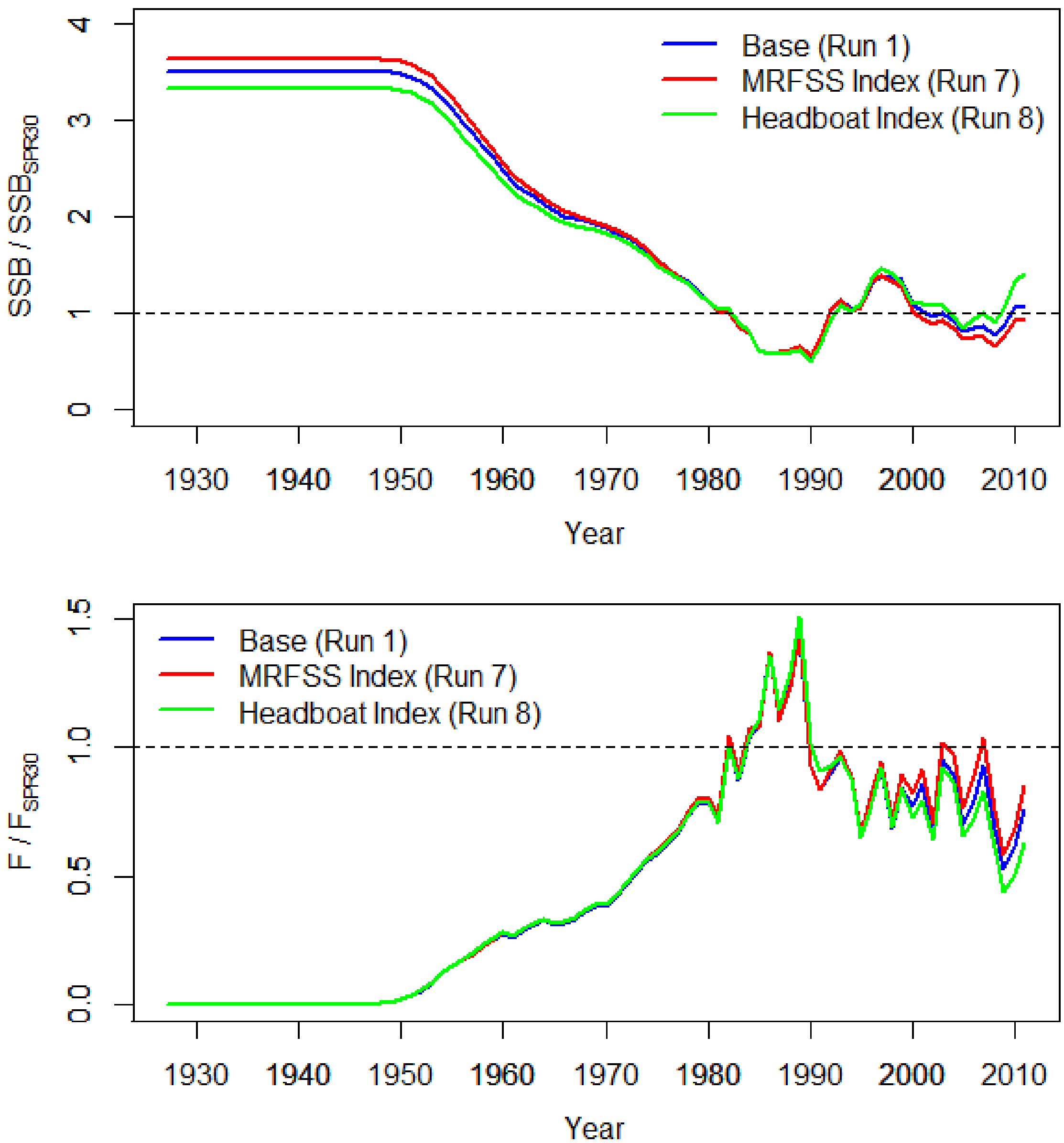


Figure 3.45. Predicted spawning stock biomass relative to $SSB_{SPR30\%}$ (top panel) and fishing mortality rate relative to $F_{SPR30\%}$ (bottom panel) over time for Gulf of Mexico cobia under three scenarios; using both indices of abundance, removing the Headboat index, and removing the MRFSS index (Runs 1, 7, 8).

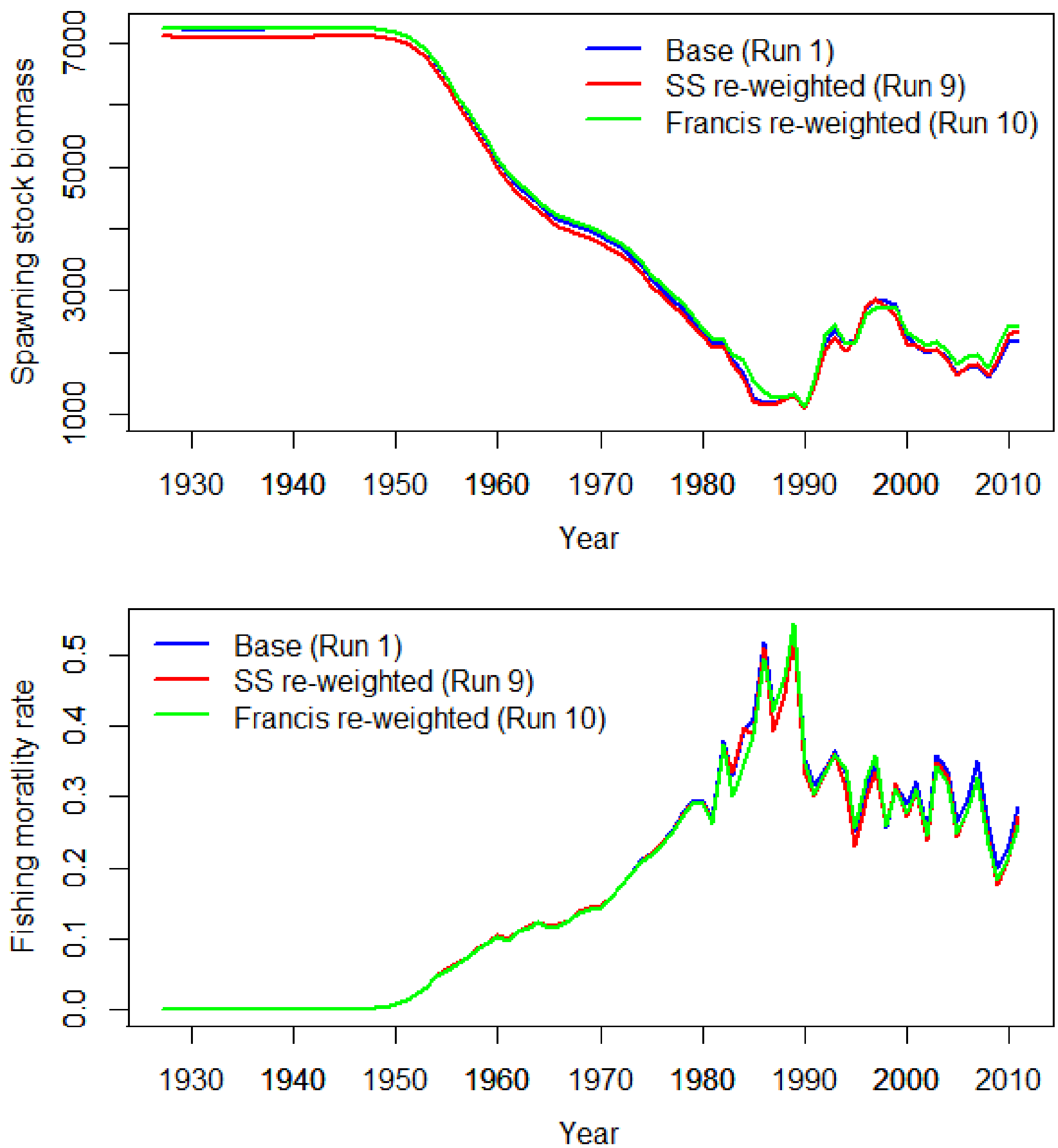
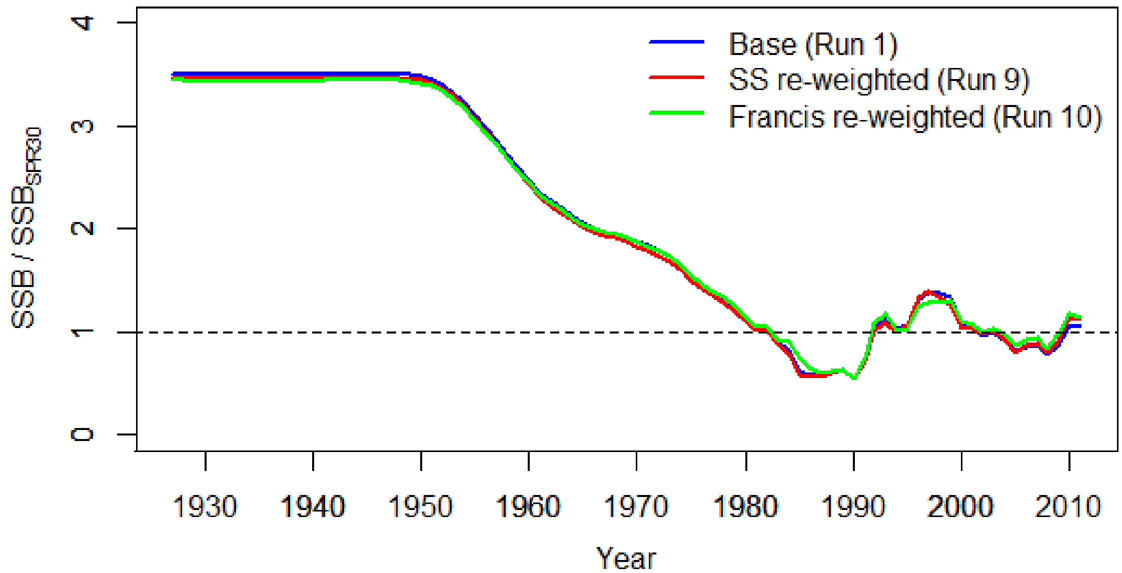


Figure 3.46. Predicted spawning stock biomass (top panel) and fishing mortality rate (bottom panel) over time for Gulf of Mexico cobia using alternative data weighting approaches; the base model does not reweight model components (Run 1), the SS reweighted (Run 9) and Francis (Run 10) scenarios reweight model components relative to the models ability to fit the data.



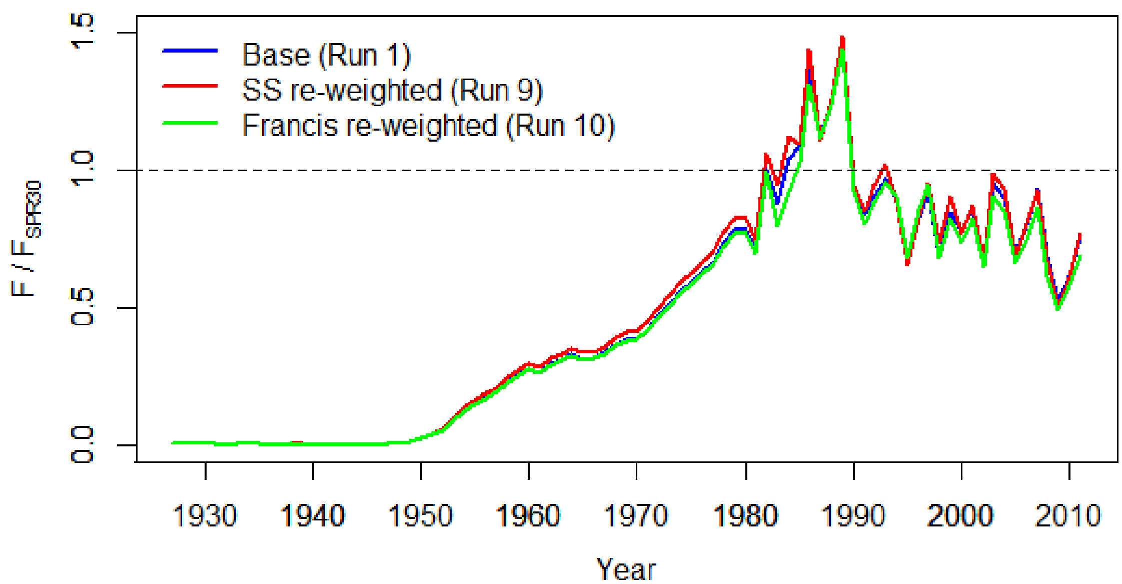


Figure 3.47. Predicted spawning stock biomass relative to $SSB_{SPR30\%}$ (top panel) and fishing mortality rate relative to $F_{SPR30\%}$ (bottom panel) over time for Gulf of Mexico cobia using alternative data weighting approaches; the base model does not reweight model components (Run 1), the SS reweighted (Run 9) and Francis (Run 10) scenarios reweight model components relative to the models ability to fit the data.

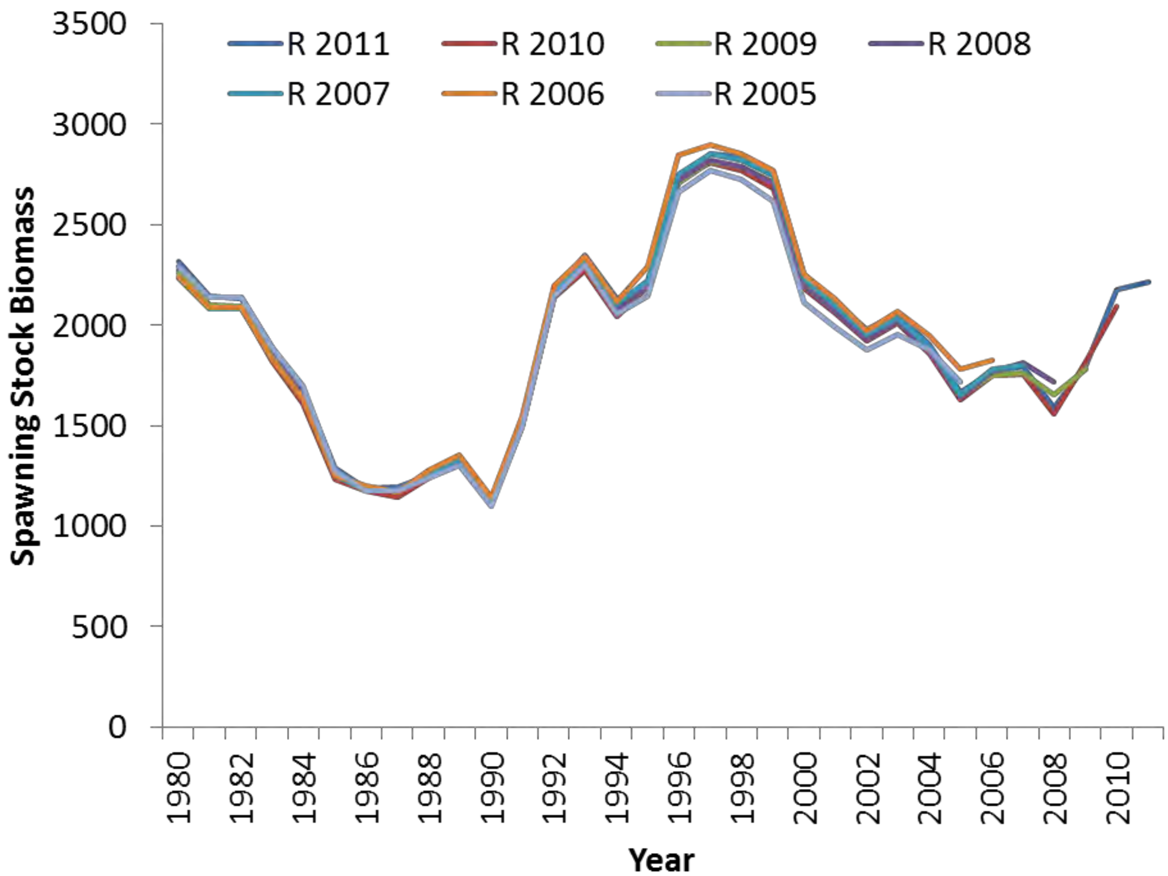


Figure 3.48. Predicted spawning stock biomass over time for Gulf of Mexico cobia from the retrospective analysis.

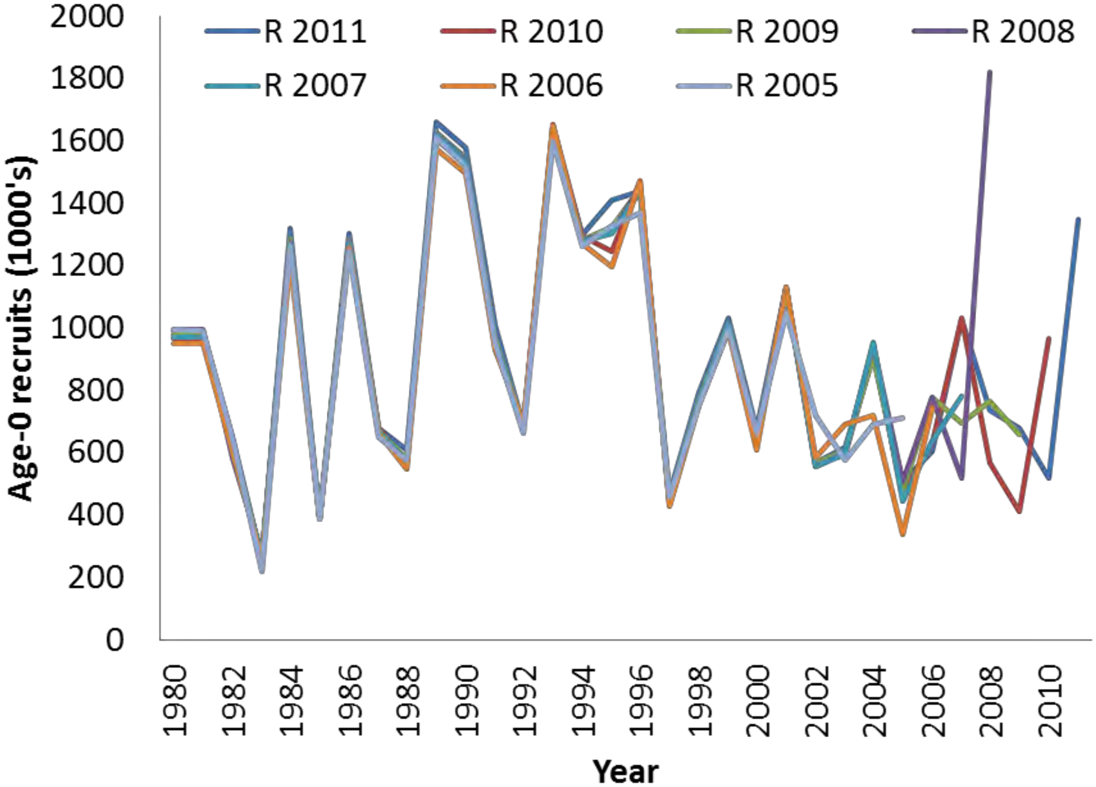


Figure 3.49. Predicted age-0 recruits (1000's) over time for Gulf of Mexico cobia from the retrospective analysis.

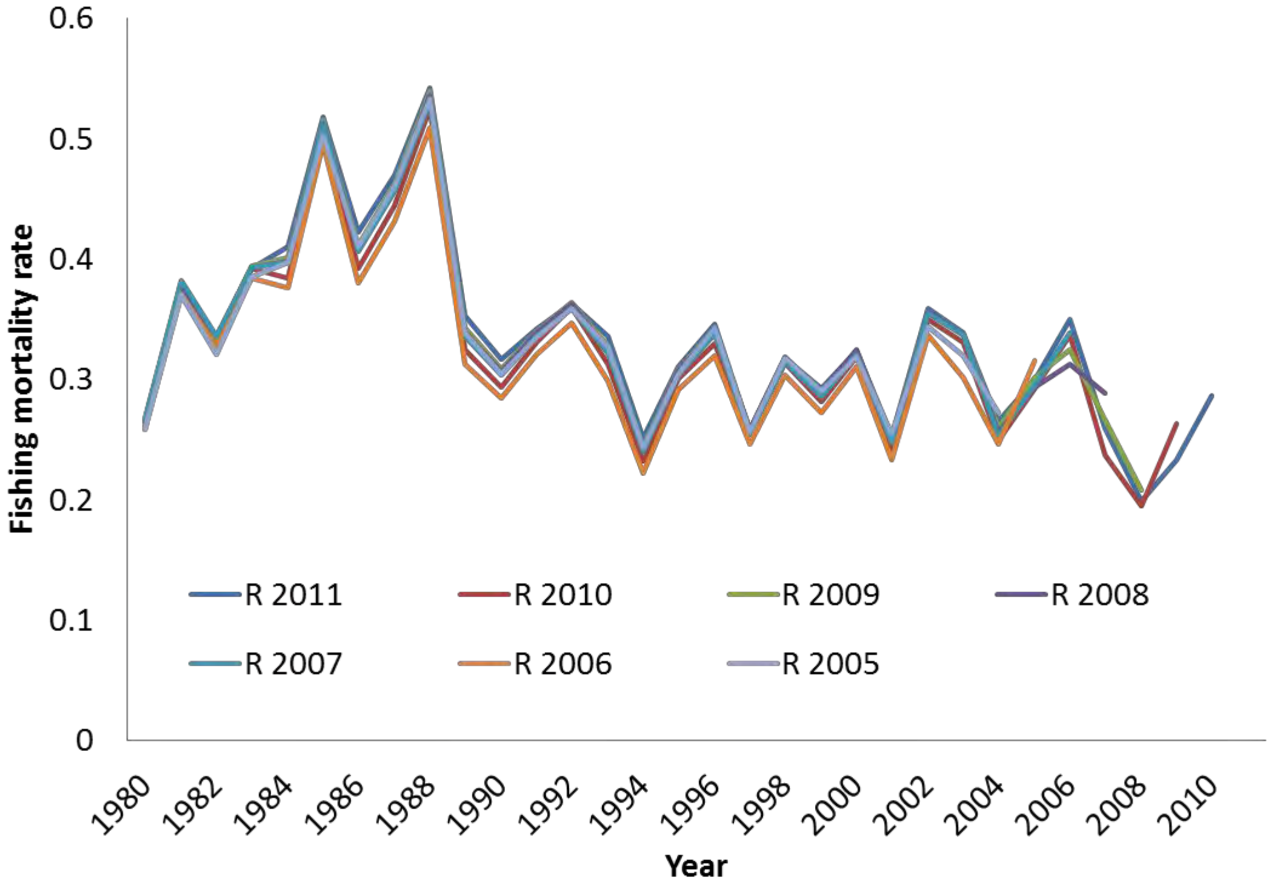


Figure 3.50. Predicted fishing mortality rate for Gulf of Mexico cobia from the retrospective analysis.

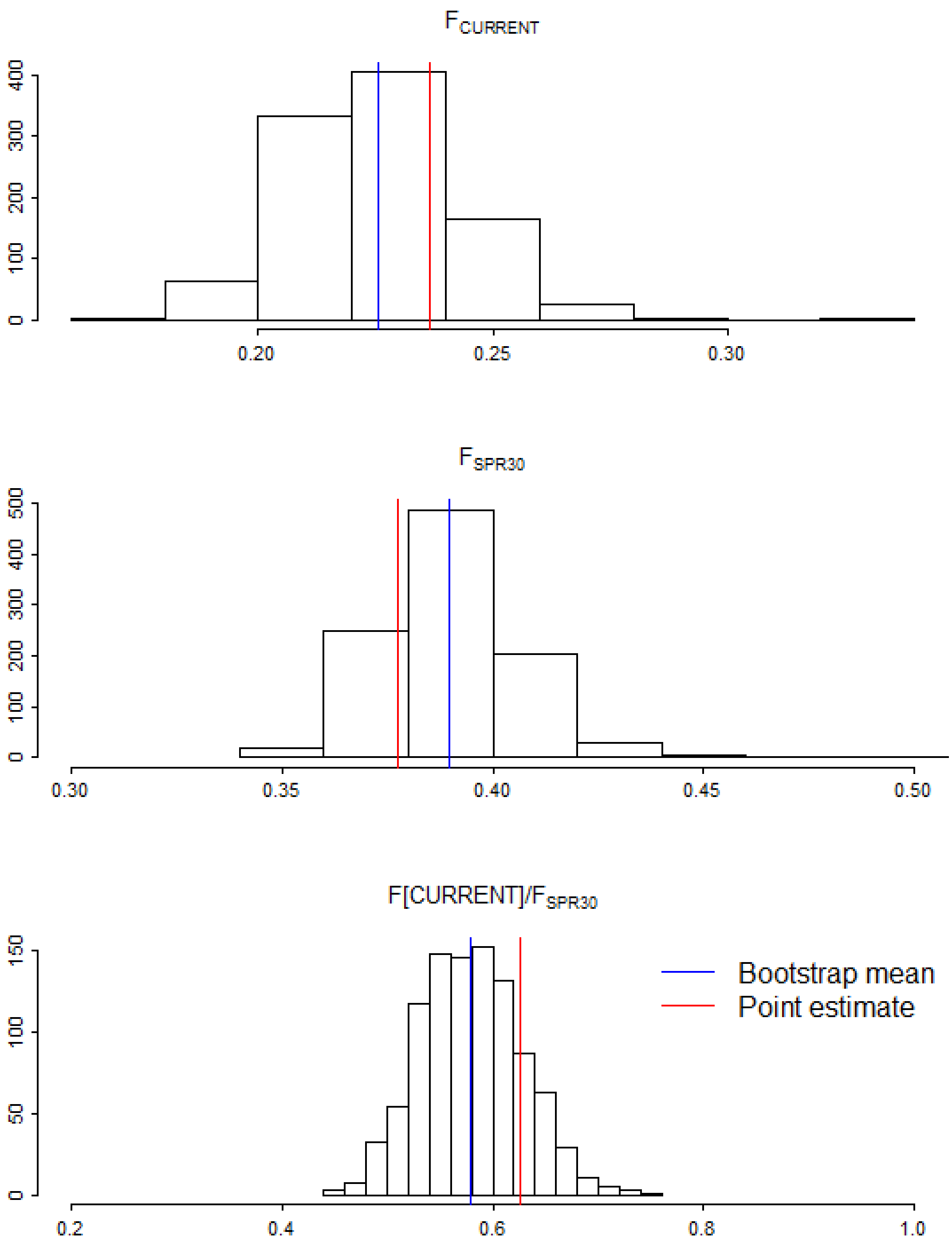


Figure 3.51. Estimates of F(2011) and F(2011)/ $F_{SPR30\%}$ from 1000 bootstrap samples of the base model. Blue lines represent mean estimates from the bootstrap samples, red lines represent the point estimate of the parameters from the base model.

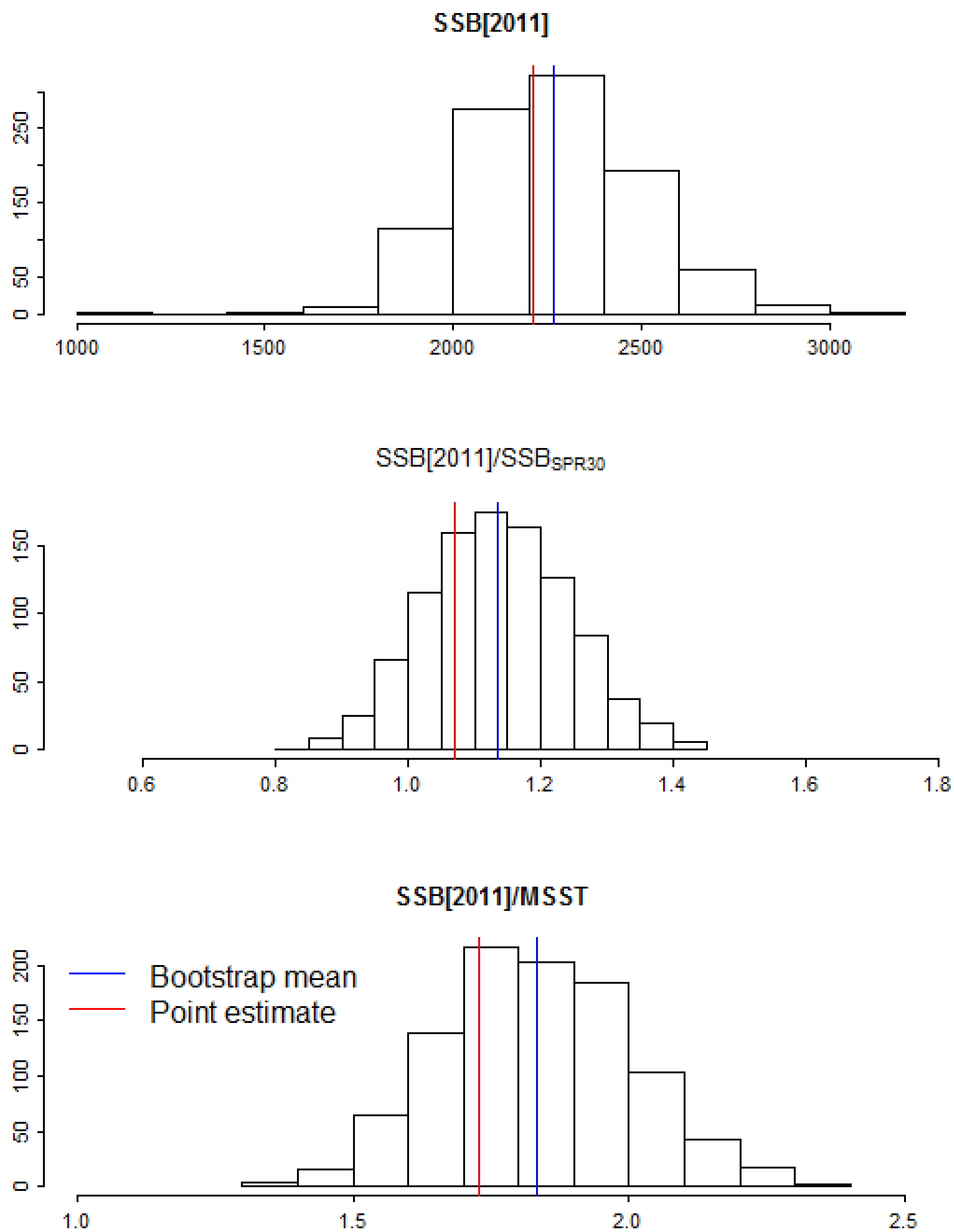


Figure 3.52. Estimates of spawning biomass in 2011, spawning biomass relative to SSB and spawning biomass relative to MSST from 1000 bootstrap samples of the base model. Blue lines represent mean estimates from the bootstrap samples, red lines represent the point estimate of the parameters from the base model.

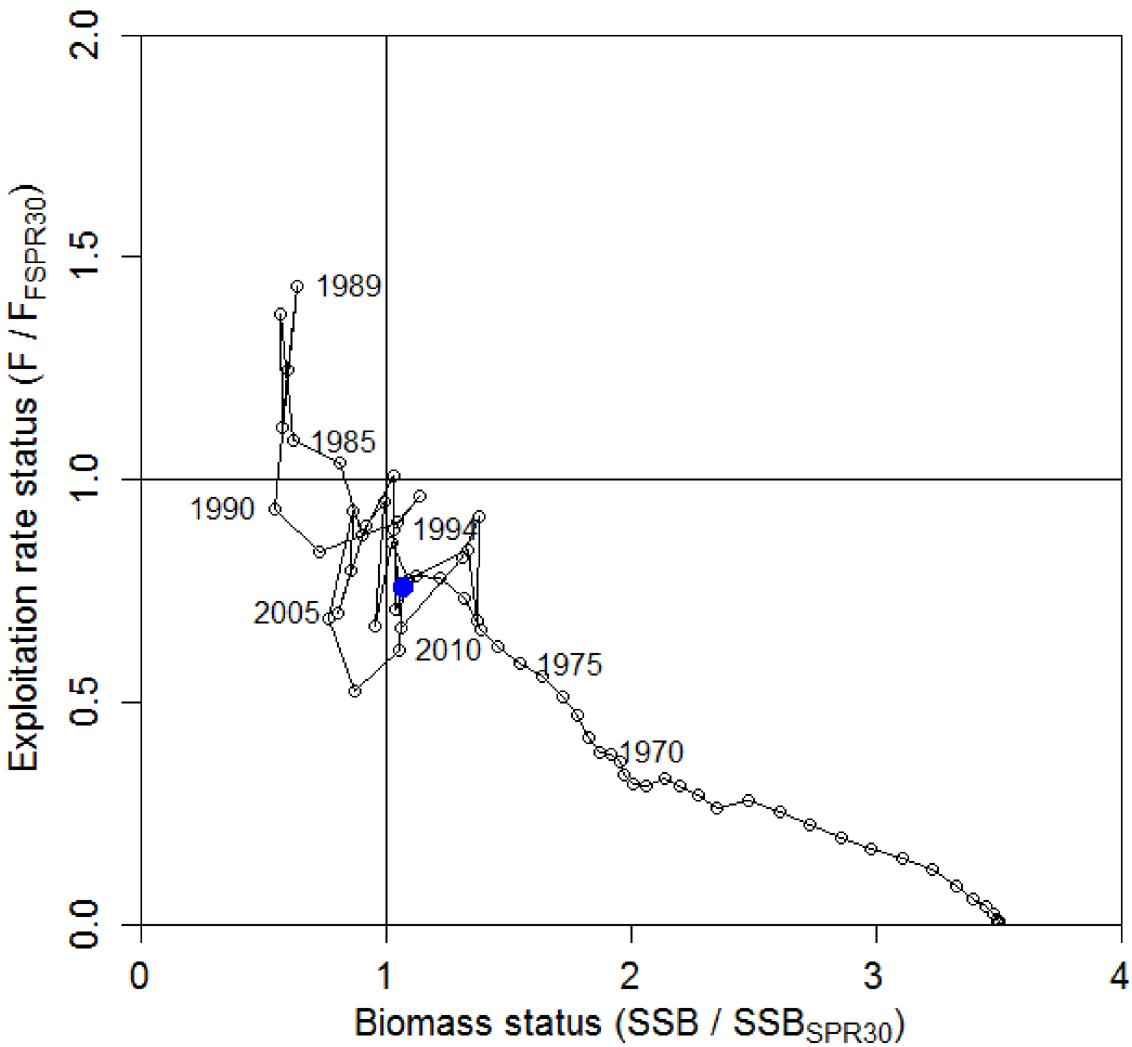


Figure 3.53. Stock status relative to reference targets for fishing mortality rate ($F_{SPR30\%}$) and spawning stock biomass ($SSB_{SPR30\%}$) over time for the base model. The large blue dot represents predicted stock status in 2011.

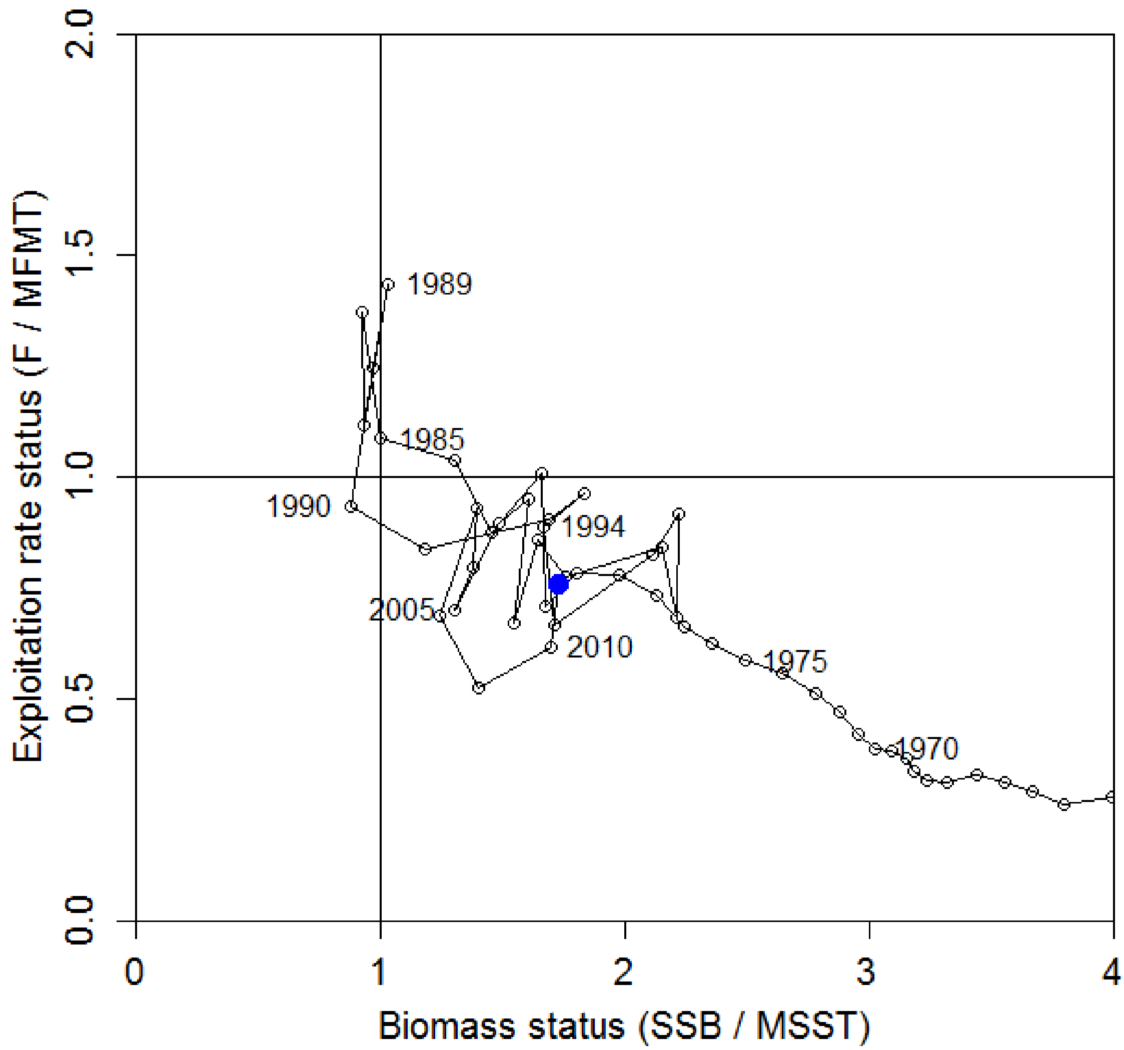


Figure 3.54. Stock status relative to reference targets for fishing mortality rate (MFMT) and spawning stock biomass (MSST) over time for the base model. The large blue dot represents predicted stock status in 2011.

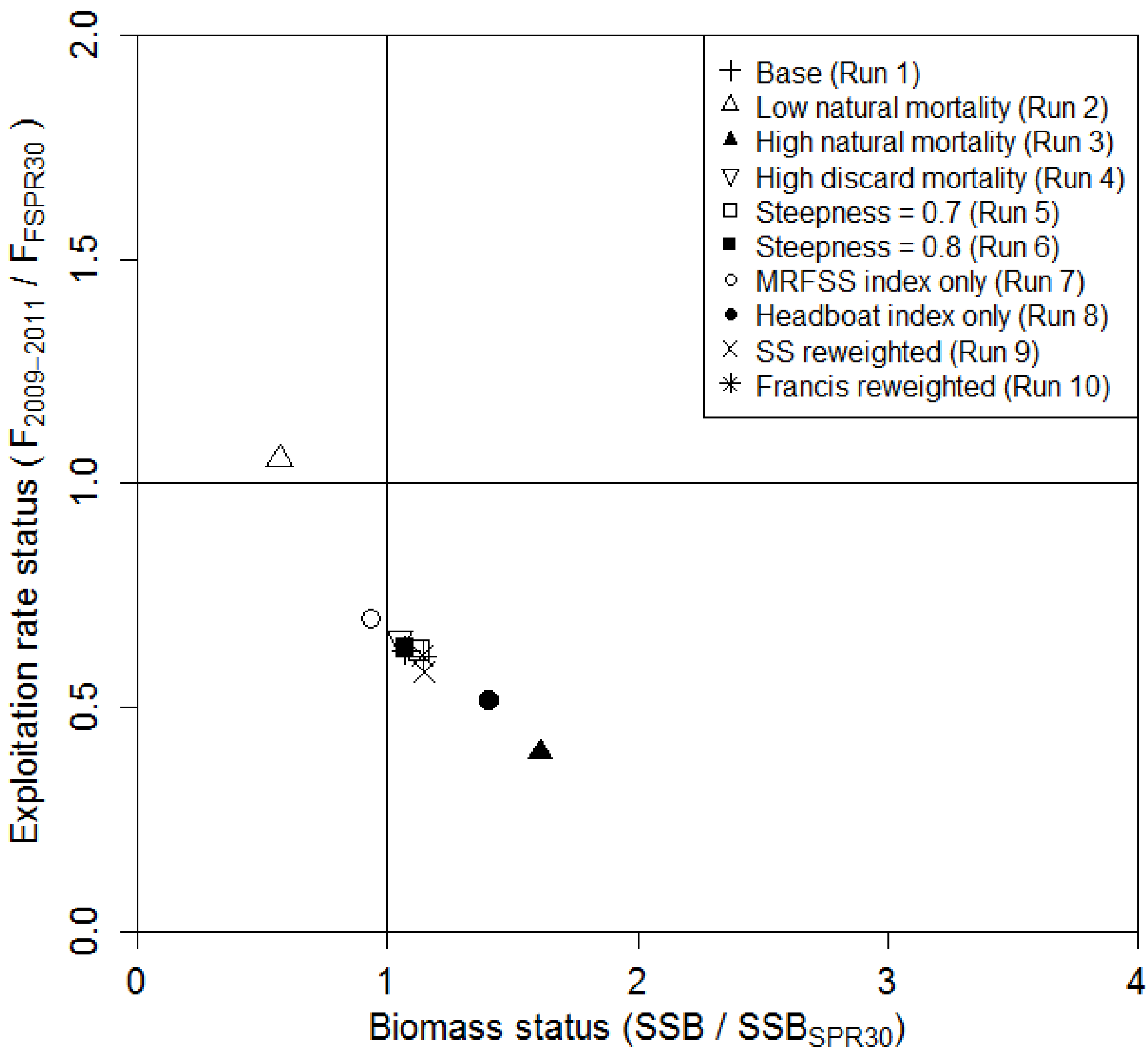


Figure 3.55. Phase plot of terminal status estimates relative to SPR 30% levels for all sensitivity runs.

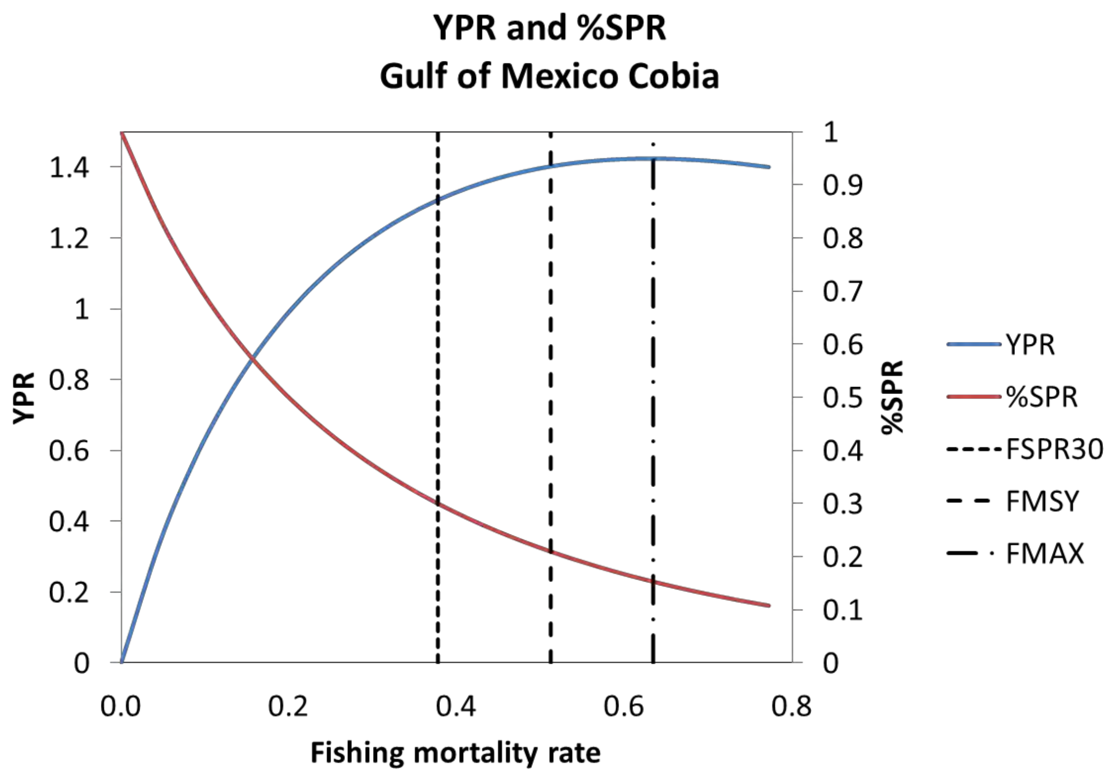


Figure 3.56. Yield per recruit (blue line) and spawning potential ratio (red line) as a function of fishing mortality rate. Vertical lines represent $F_{SPR30\%}$ (F = 0.378), F_{MSY} (F = 0.512), and F_{MAX} (F = 0.634).

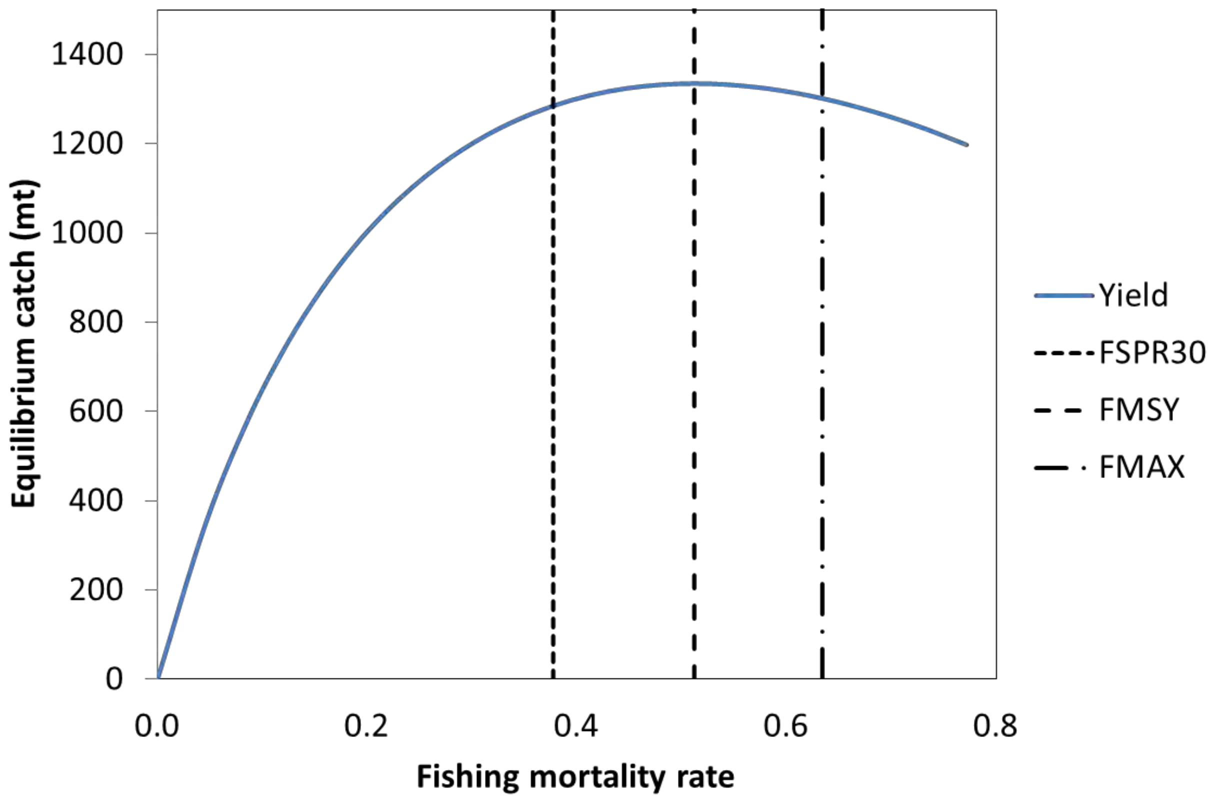


Figure 3.57. Equilibrium catch (retained catch plus dead discards; mt) as a function of fishing mortality rate. The peak occurs where fishing mortality rate is F_{MSY} = 0.512 and equilibrium catch is MSY = 1335 (mt) and equilibrium landings (retained catch) are MSY = 1176 (mt).

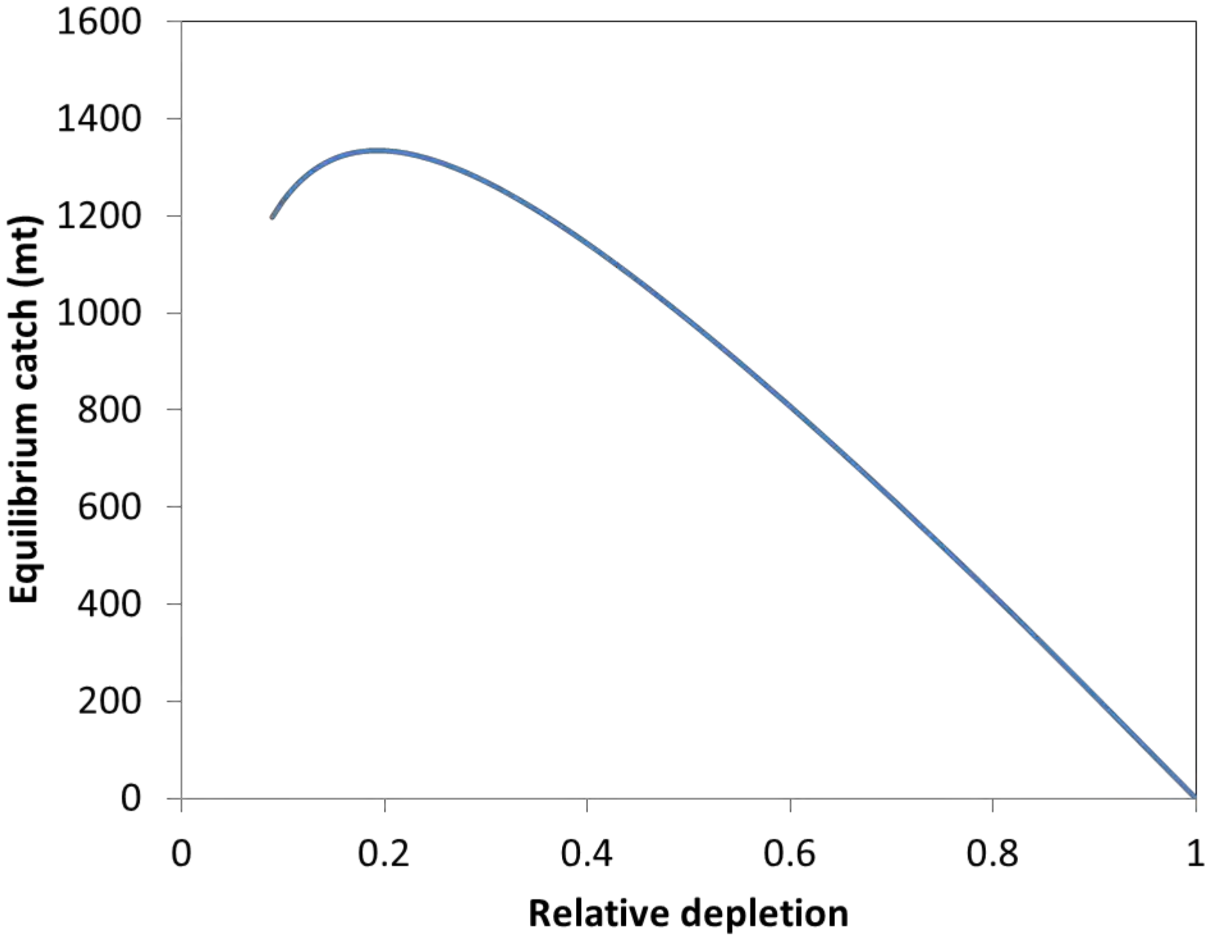


Figure 3.58. Equilibrium catch (retained catch plus dead discards; mt) as a function of relative depletion of the stock, which itself is a function of fishing mortality rate. The peak occurs equilibrium catch is MSY = 1335 (mt) and relative depletion is 0.19.

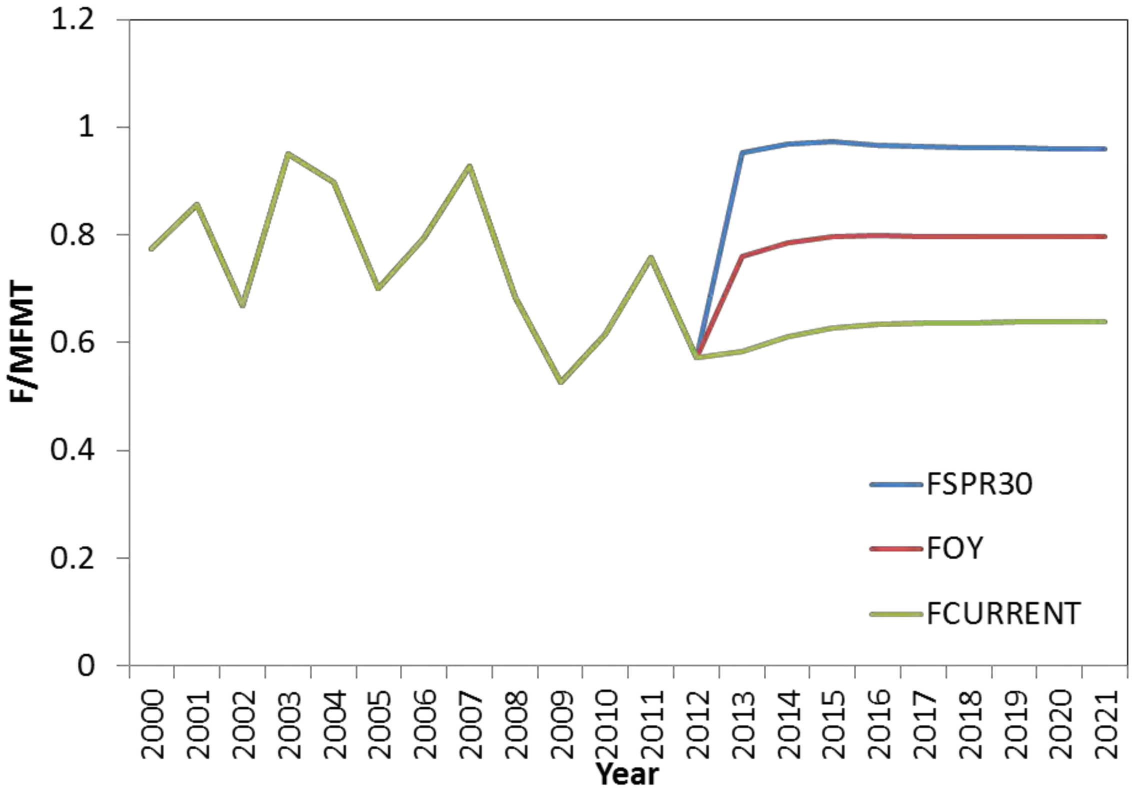


Figure 3.59. Projected fishing mortality rate relative to $F_{SPR30\%}$ for the base model under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

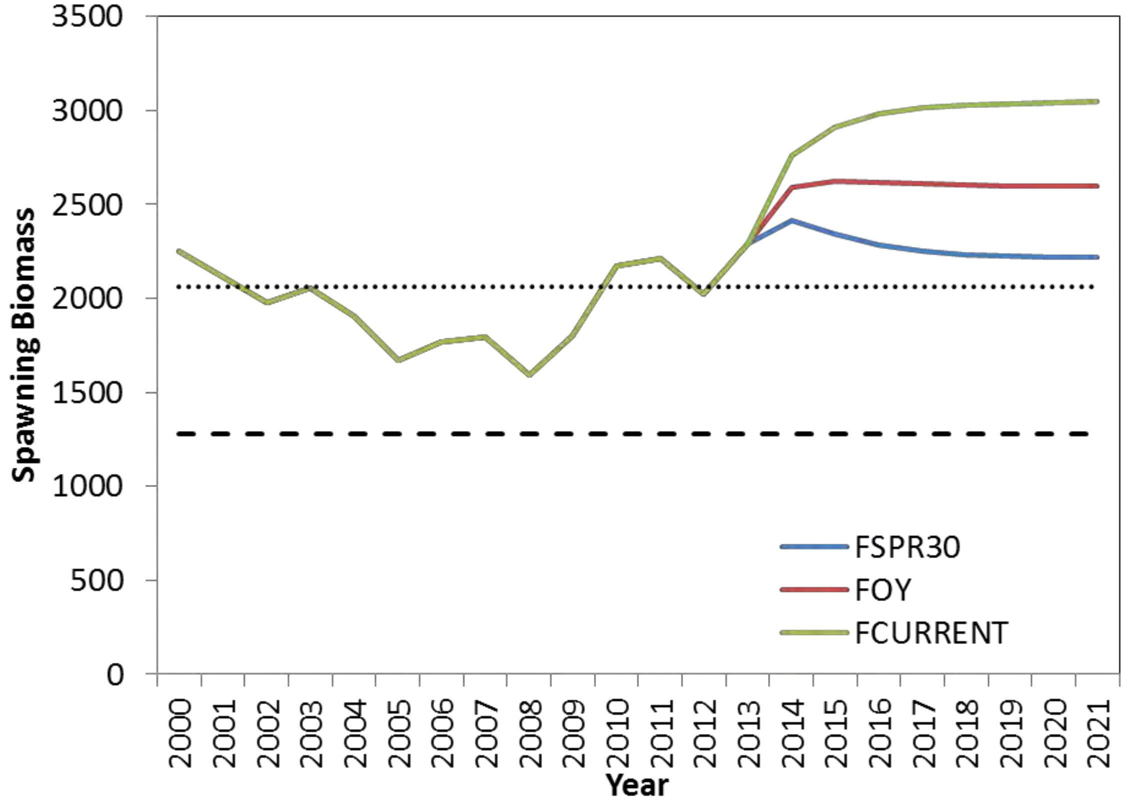


Figure 3.60. Projected spawning biomass for the base model under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}. The black dotted line represents SSB at $F_{SPR30\%}$. The black dashed line represents the minimum stock size threshold (MSST).

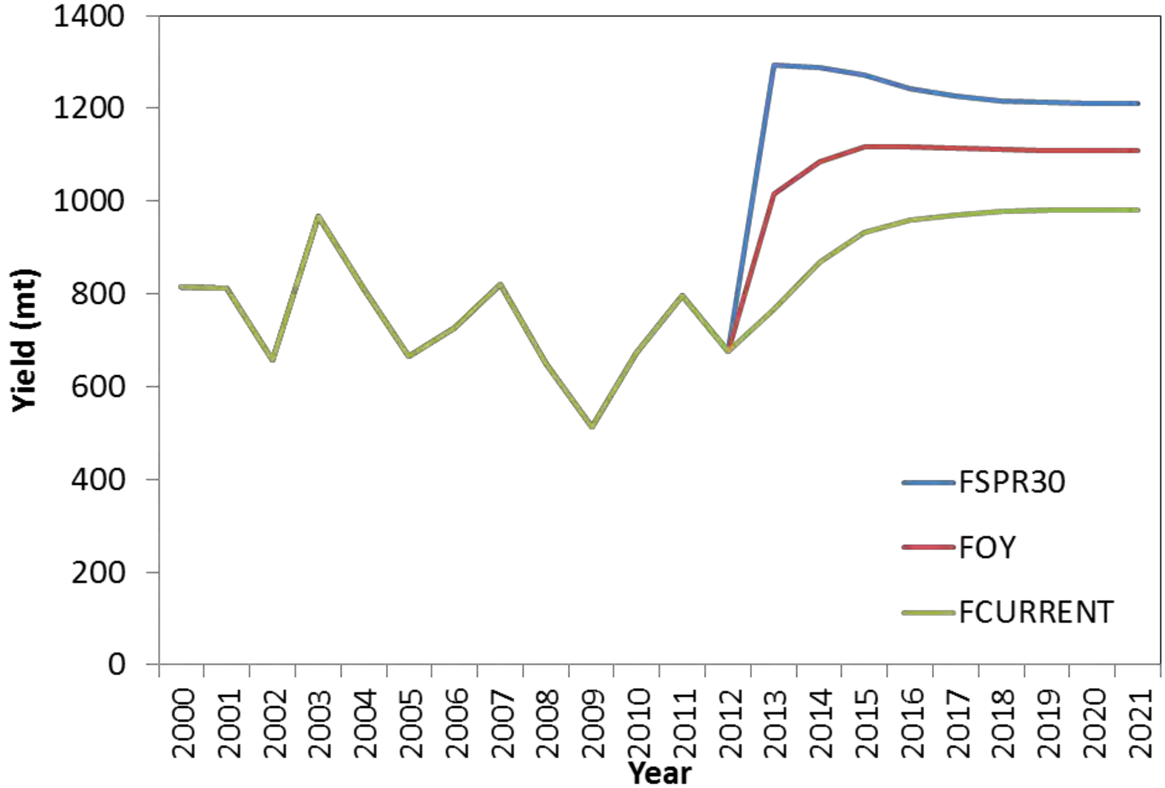


Figure 3.61. Projected yield (mt) for the base model under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

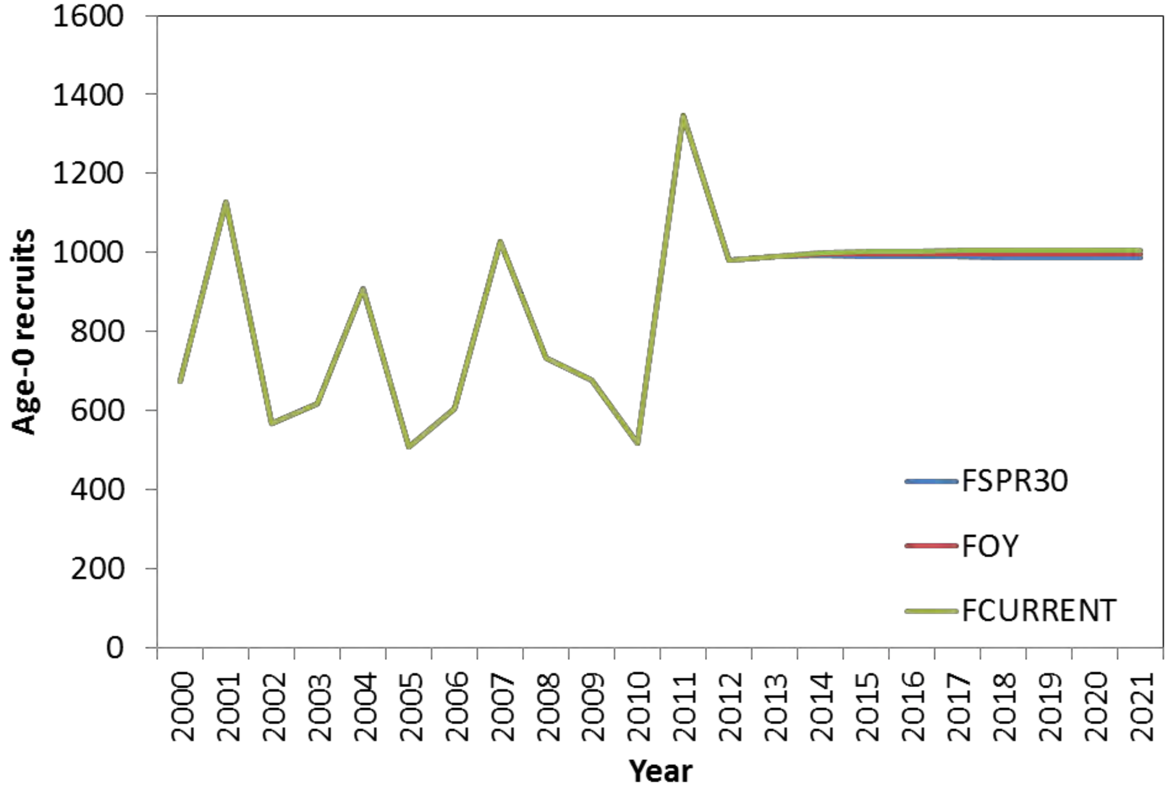


Figure 3.62. Projected age-0 recruits for the base model under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

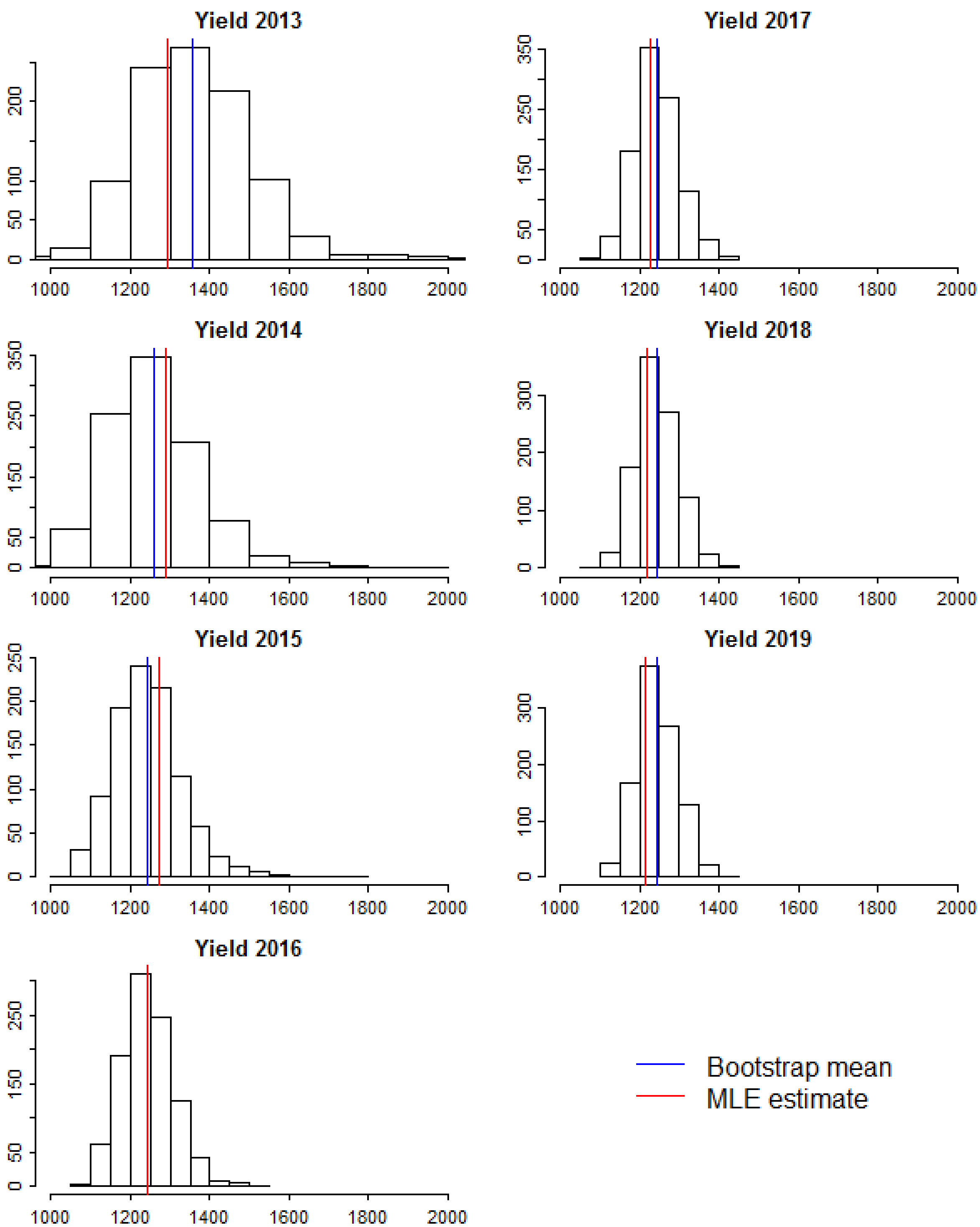


Figure 3.63. Estimates of projected yield (mt) for the base model at $F_{SPR30\%}$ from 1000 bootstrap samples of the base model. Blue lines represent mean estimates from the bootstrap samples, red lines represent the point estimate of the parameters from the base model.

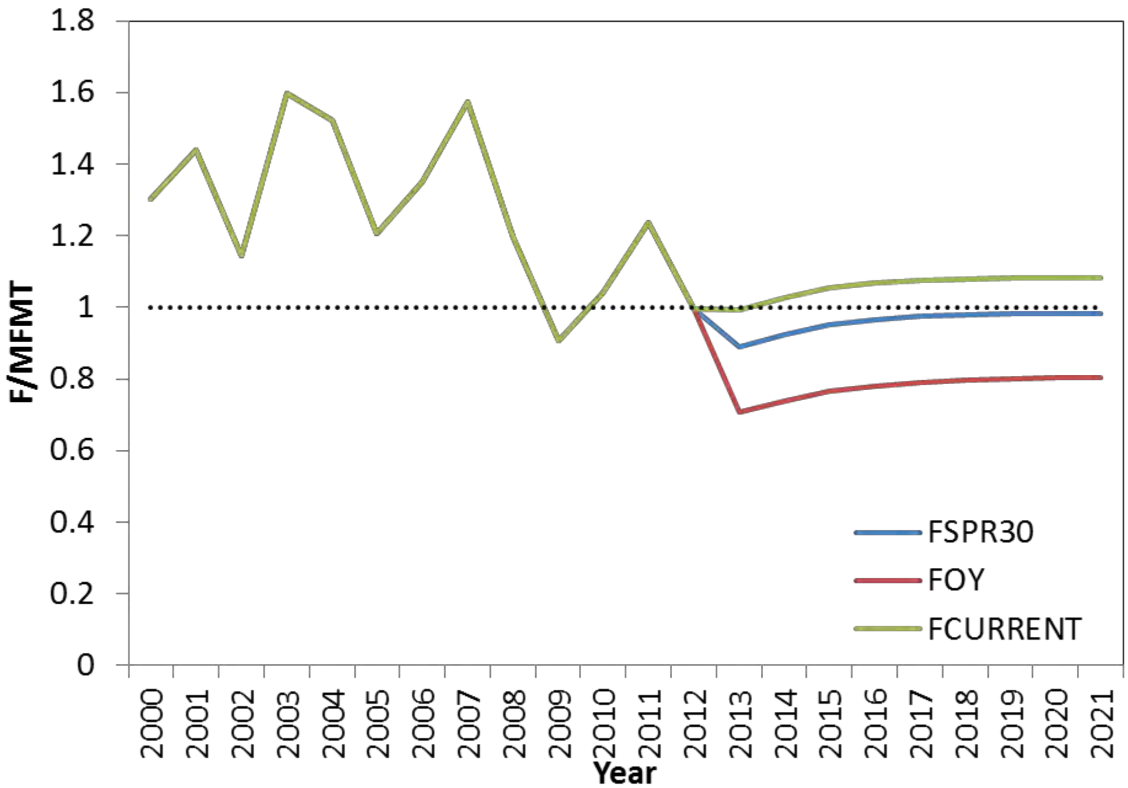


Figure 3.64. Projected fishing mortality rate relative to $F_{SPR30\%}$ for the low natural mortality model (Run 2) under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

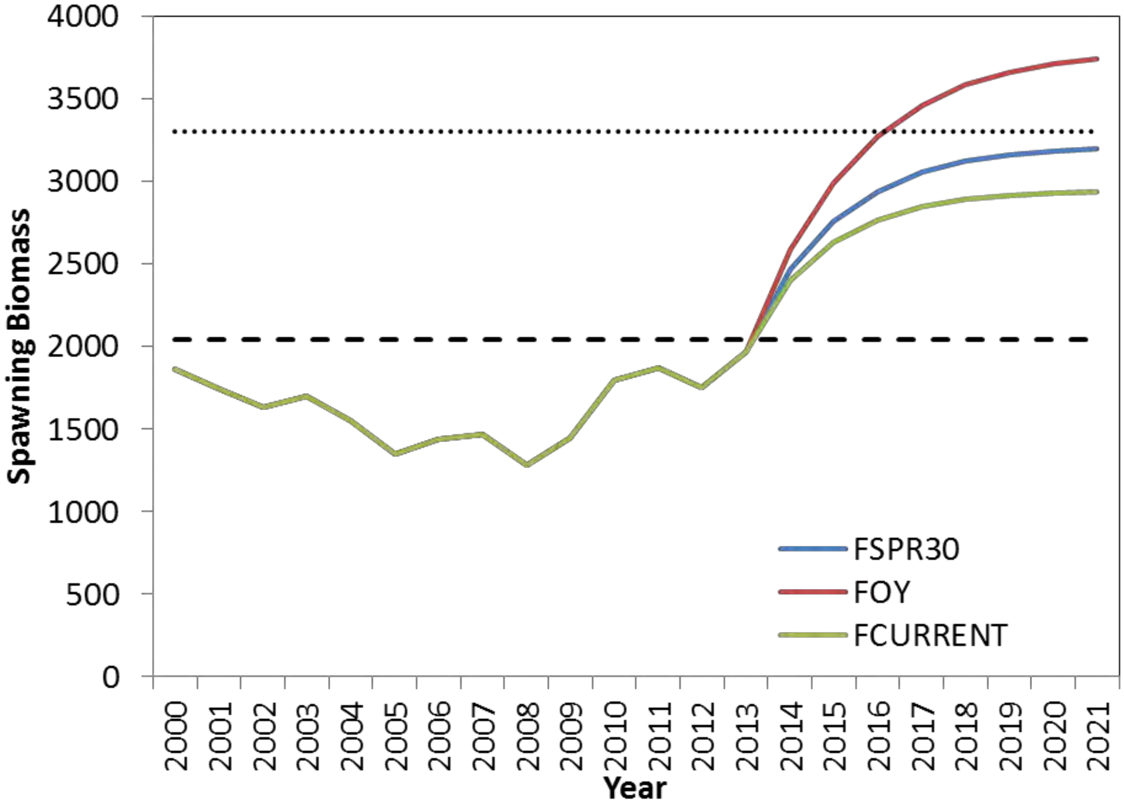


Figure 3.65. Projected spawning biomass for the low natural mortality model (Run 2) under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}. The black dotted line represents SSB at $F_{SPR30\%}$. The black dashed line represents the minimum stock size threshold (MSST).

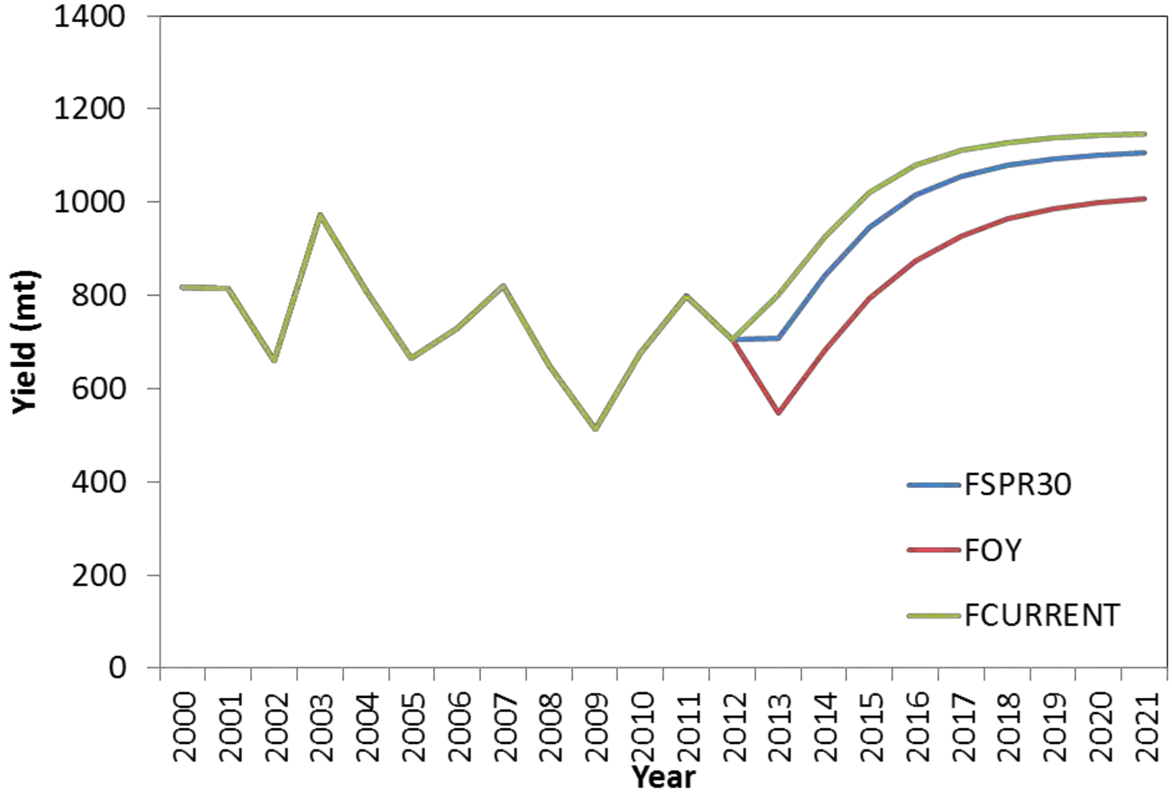


Figure 3.66. Projected yield (mt) for the low natural mortality model (Run 2) under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

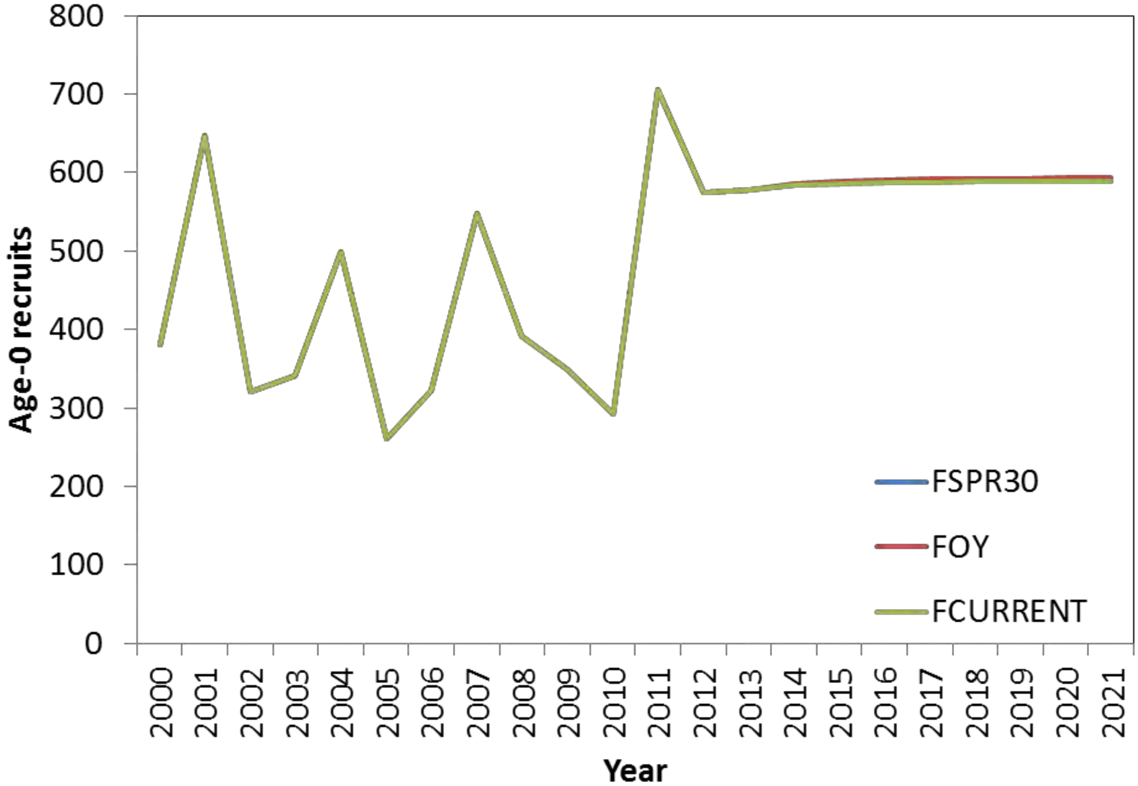


Figure 3.67. Projected age-0 recruits for the low natural mortality model (Run 2) under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

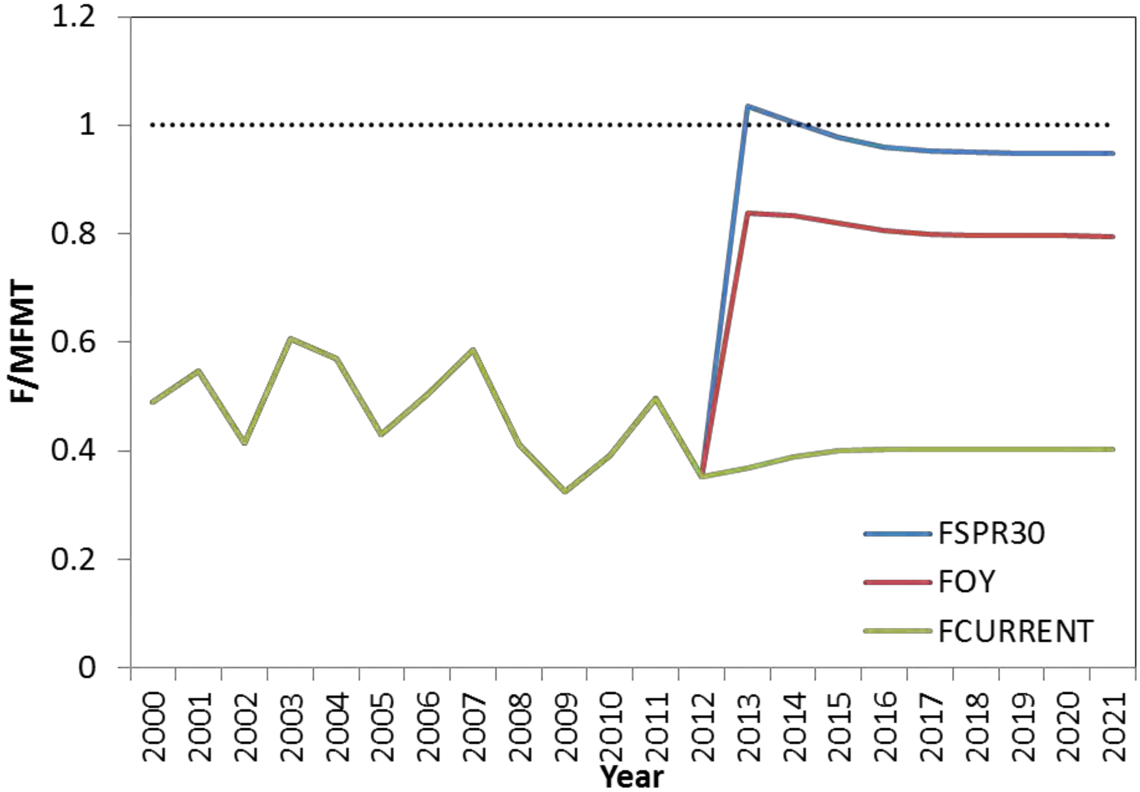


Figure 3.68. Projected fishing mortality rate relative to $F_{SPR30\%}$ for the high natural mortality model (Run 3) under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

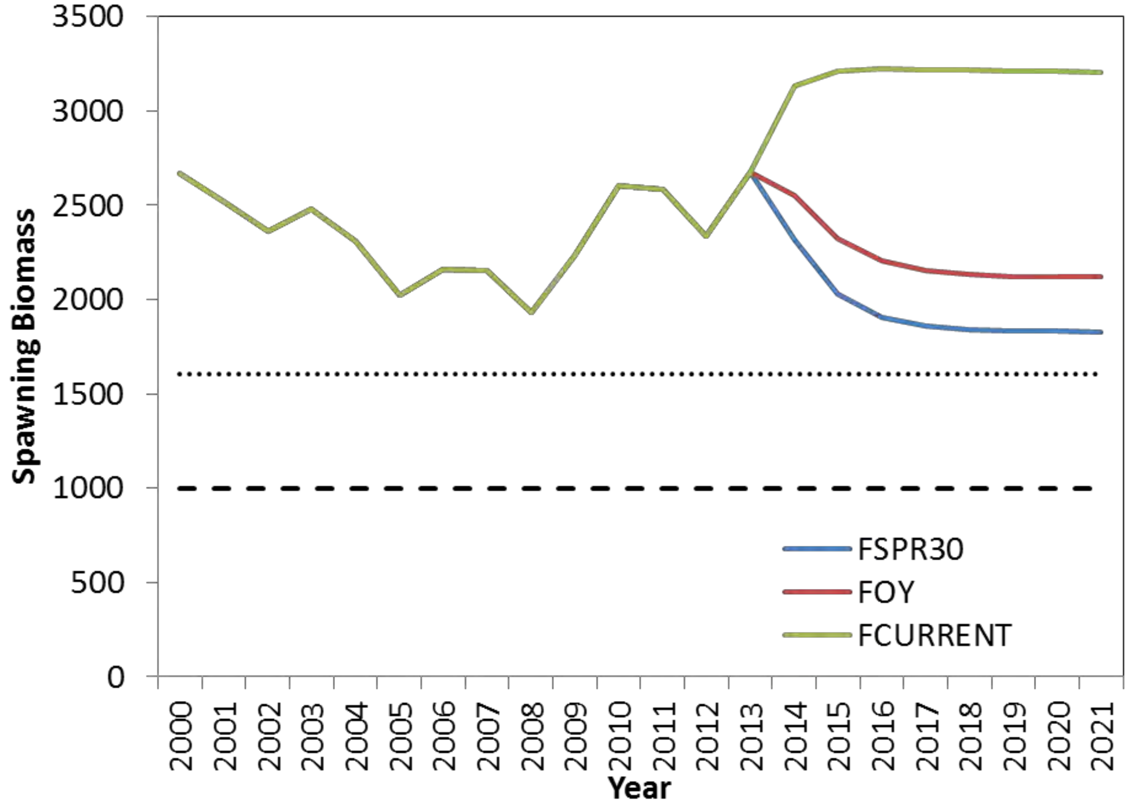


Figure 3.69. Projected spawning biomass for the high natural mortality model (Run 3) under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}. The black dotted line represents SSB at $F_{SPR30\%}$. The black dashed line represents the minimum stock size threshold (MSST).

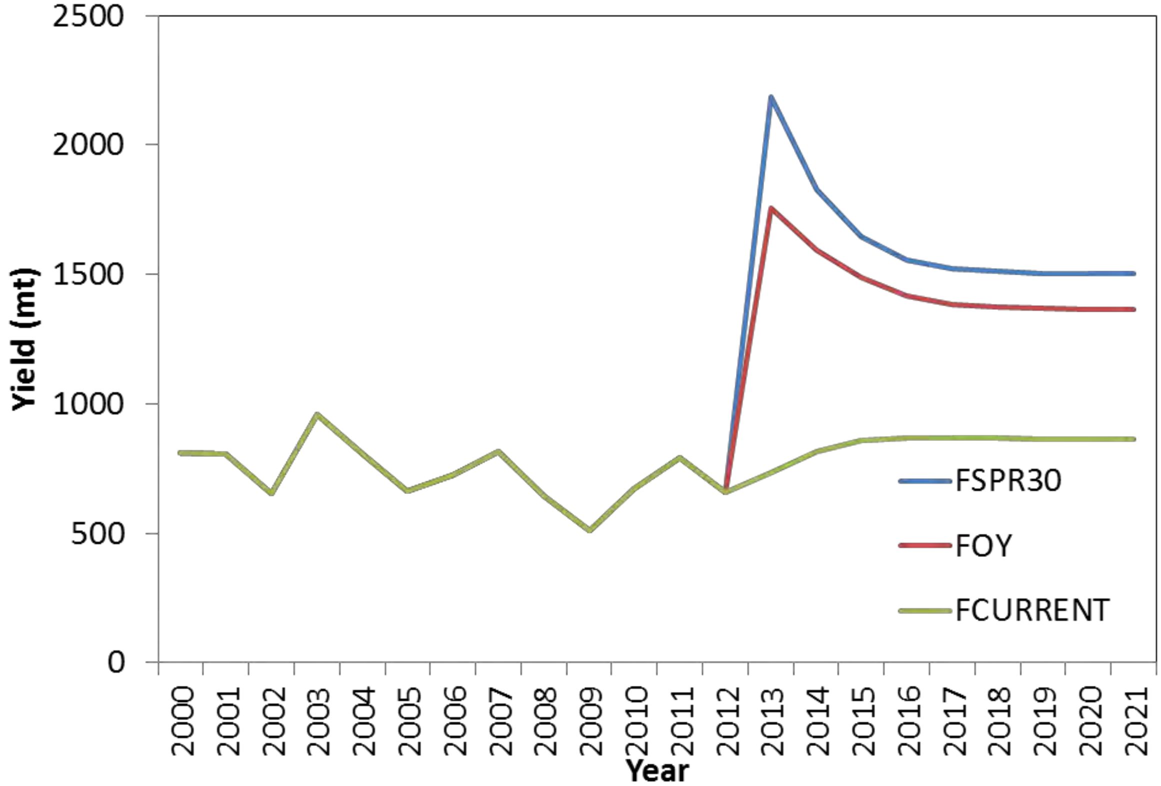


Figure 3.70. Projected yield (mt) for the high natural mortality model (Run 3) under three fishing mortality scenarios: $F_{CURRENT}$, F_{SPR30}, and F_{OY}.

3.8 Appendix A. Cobia.DAT File

#V3.24f
#_SSV3.24fsafe;_08/03/2012;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_10.1
#C Cobia 2011
#_observed data:
1927 #_styr
2011 #_endyr
1 #_nseas
12 #_months/season
1 #_spawn_seas
3 #_Nfleet
1 #_Nsurveys
1 #_N_areas
Com_Combined_1%Recreational_Combined_2%Shrimp_Bycatch_3%MRFSS_4
0.5 0.5 0.5 0.5 #_surveytiming_in_season
1 1 1 1 #_area_assignments_for_each_fishery_and_survey
1 2 2 #_units of catch: 1=bio; 2=num
0.01 0.01 -1 #_se of log(catch) only used for init_eq_catch and for Fmethod 2 and 3; use -1 for discard only fleets
1 #_Ngenders
11 #_Nages
0 0 0 #_init_equil_catch_for_each_fishery
85 #_N_lines_of_catch_to_read
#_catch_biomass(mtons):_columns_are_fisheries,year,season
4.28634 0 0 1927 1
10.3539 0 0 1928 1
6.67988 0 0 1929 1
6.50616 0 0 1930 1
4.73901 0 0 1931 1
2.63304 0 0 1932 1
2.99454 0 0 1933 1
3.3565 0 0 1934 1
3.01631 0 0 1935 1
2.67613 0 0 1936 1
0.907161 0 0 1937 1
3.3565 0 0 1938 1
2.90292 0 0 1939 1
0.635013 0 0 1940 1

0.181432 0 0 1941 1
0.181432 0 0 1942 1
0.181432 0 0 1943 1
0.181432 0 0 1944 1
0.136074 0 0.01 1945 1
0.181432 0 0.01 1946 1
0.181432 0 0.01 1947 1
1.9504 0 0.01 1948 1
12.4281 0 0.01 1949 1
20.0029 1 0.01 1950 1
22.5883 5 0.01 1951 1
17.0546 10 0.01 1952 1
13.1085 20 0.01 1953 1
11.9292 30 0.01 1954 1
13.8796 36.996 0.01 1955 1
6.80371 41.04 0.01 1956 1
11.7024 45.084 0.01 1957 1
11.0674 49.128 0.01 1958 1
18.7329 53.172 0.01 1959 1
25.7634 57.217 0.01 1960 1
15.83 58.244 0.01 1961 1
17.9164 59.271 0.01 1962 1
20.3204 60.299 0.01 1963 1
12.7003 61.326 0.01 1964 1
11.5663 62.354 0.01 1965 1
19.3225 64.819 0.01 1966 1
21.8172 67.284 0.01 1967 1
40.5047 69.749 0.01 1968 1
34.2453 72.215 0.01 1969 1
54.2482 74.68 0.01 1970 1
50.0753 81.468 0.01 1971 1
39.6883 88.257 0.01 1972 1
39.7337 95.045 0.01 1973 1
45.7663 101.833 0.01 1974 1
44.3148 108.622 0.01 1975 1
53.1265 108.813 0.01 1976 1
50.9416 109.003 0.01 1977 1
51.4642 109.194 0.01 1978 1
45.8053 109.385 0.01 1979 1
54.0228 109.576 0.01 1980 1

64.8892 91.665 0.01 1981 1
57.6655 153.543 0.01 1982 1
68.2852 101.89 0.01 1983 1
71.7778 79.79 0.01 1984 1
78.4531 72.75 0.01 1985 1
87.9493 80.022 0.01 1986 1
105.686 73.115 0.01 1987 1
105.773 87.913 0.01 1988 1
137.806 77.311 0.01 1989 1
109.051 58.134 0.01 1990 1
124.218 76.281 0.01 1991 1
157.313 92.24 0.01 1992 1
160.151 81.604 0.01 1993 1
159.576 82.837 0.01 1994 1
150.154 61.643 0.01 1995 1
165.947 95.542 0.01 1996 1
136.901 125.63 0.01 1997 1
130.801 63.632 0.01 1998 1
129.097 72.592 0.01 1999 1
96.1632 65.543 0.01 2000 1
80.6766 68.307 0.01 2001 1
83.2461 54.953 0.01 2002 1
88.372 85.097 0.01 2003 1
81.3225 69.706 0.01 2004 1
62.073 58.589 0.01 2005 1
68.5111 64.71 0.01 2006 1
66.7616 73.074 0.01 2007 1
63.2355 58.197 0.01 2008 1
62.2784 45.264 0.01 2009 1
88.4178 57.214 0.01 2010 1
108.315 64.835 0.01 2011 1
#
124 #_N_cpue_and_surveyabundance_observations
#_Units: 0=numbers; 1=biomass; 2=F
#_Errtype: -1=normal; 0=lognormal; >0=T
#_Fleet Units Errtype
1 1 0 # Com_Combined_1
2 0 0 # Recreational_Combined_2
3 2 0 # Shrimp_Bycatch_3
4 0 0 # MRFSS_4

#_year seas index obs err
1945 1 3 0.001 0.125 # Shrimp_Bycatch_3
1946 1 3 0.00466902 0.125 # Shrimp_Bycatch_3
1947 1 3 0.023812 0.125 # Shrimp_Bycatch_3
1948 1 3 0.0625648 0.125 # Shrimp_Bycatch_3
1949 1 3 0.101084 0.125 # Shrimp_Bycatch_3
1950 1 3 0.180224 0.125 # Shrimp_Bycatch_3
1951 1 3 0.228548 0.125 # Shrimp_Bycatch_3
1952 1 3 0.269869 0.125 # Shrimp_Bycatch_3
1953 1 3 0.278507 0.125 # Shrimp_Bycatch_3
1954 1 3 0.362549 0.125 # Shrimp_Bycatch_3
1955 1 3 0.358814 0.125 # Shrimp_Bycatch_3
1956 1 3 0.460599 0.125 # Shrimp_Bycatch_3
1957 1 3 0.537637 0.125 # Shrimp_Bycatch_3
1958 1 3 0.696151 0.125 # Shrimp_Bycatch_3
1959 1 3 0.748677 0.125 # Shrimp_Bycatch_3
1960 1 3 0.748249 0.125 # Shrimp_Bycatch_3
1961 1 3 0.461965 0.125 # Shrimp_Bycatch_3
1962 1 3 0.796689 0.125 # Shrimp_Bycatch_3
1963 1 3 0.901471 0.125 # Shrimp_Bycatch_3
1964 1 3 1.06238 0.125 # Shrimp_Bycatch_3
1965 1 3 0.688011 0.125 # Shrimp_Bycatch_3
1966 1 3 0.5806 0.125 # Shrimp_Bycatch_3
1967 1 3 0.696735 0.125 # Shrimp_Bycatch_3
1968 1 3 0.816885 0.125 # Shrimp_Bycatch_3
1969 1 3 0.894284 0.125 # Shrimp_Bycatch_3
1970 1 3 0.628212 0.125 # Shrimp_Bycatch_3
1971 1 3 0.711676 0.125 # Shrimp_Bycatch_3
1972 1 3 0.99505 0.125 # Shrimp_Bycatch_3
1973 1 3 1.01257 0.125 # Shrimp_Bycatch_3
1974 1 3 1.04504 0.125 # Shrimp_Bycatch_3
1975 1 3 0.802247 0.125 # Shrimp_Bycatch_3
1976 1 3 1.11513 0.125 # Shrimp_Bycatch_3
1977 1 3 1.38455 0.125 # Shrimp_Bycatch_3
1978 1 3 1.92755 0.125 # Shrimp_Bycatch_3
1979 1 3 2.02914 0.125 # Shrimp_Bycatch_3
1980 1 3 1.49187 0.125 # Shrimp_Bycatch_3
1981 1 3 1.54041 0.125 # Shrimp_Bycatch_3
1982 1 3 1.47356 0.125 # Shrimp_Bycatch_3
1983 1 3 1.59532 0.125 # Shrimp_Bycatch_3

1984 1 3 1.63608 0.125 # Shrimp_Bycatch_3
1985 1 3 1.76228 0.125 # Shrimp_Bycatch_3
1986 1 3 1.85552 0.125 # Shrimp_Bycatch_3
1987 1 3 2.15635 0.125 # Shrimp_Bycatch_3
1988 1 3 1.62936 0.125 # Shrimp_Bycatch_3
1989 1 3 1.94697 0.125 # Shrimp_Bycatch_3
1990 1 3 1.8955 0.125 # Shrimp_Bycatch_3
1991 1 3 1.81257 0.125 # Shrimp_Bycatch_3
1992 1 3 1.57443 0.125 # Shrimp_Bycatch_3
1993 1 3 1.47332 0.125 # Shrimp_Bycatch_3
1994 1 3 1.61289 0.125 # Shrimp_Bycatch_3
1995 1 3 1.38522 0.125 # Shrimp_Bycatch_3
1996 1 3 1.48535 0.125 # Shrimp_Bycatch_3
1997 1 3 1.51771 0.125 # Shrimp_Bycatch_3
1998 1 3 1.64828 0.125 # Shrimp_Bycatch_3
1999 1 3 1.71744 0.125 # Shrimp_Bycatch_3
2000 1 3 1.53573 0.125 # Shrimp_Bycatch_3
2001 1 3 1.49119 0.125 # Shrimp_Bycatch_3
2002 1 3 1.32141 0.125 # Shrimp_Bycatch_3
2003 1 3 1.07636 0.125 # Shrimp_Bycatch_3
2004 1 3 0.829801 0.125 # Shrimp_Bycatch_3
2005 1 3 0.499034 0.125 # Shrimp_Bycatch_3
2006 1 3 0.663099 0.125 # Shrimp_Bycatch_3
2007 1 3 0.649566 0.125 # Shrimp_Bycatch_3
2008 1 3 0.560997 0.125 # Shrimp_Bycatch_3
2009 1 3 0.653462 0.125 # Shrimp_Bycatch_3
2010 1 3 0.46317 0.125 # Shrimp_Bycatch_3
2011 1 3 0.433603 0.125 # Shrimp_Bycatch_3
1981 1 4 0.847337 0.334146 # MRFSS_4
1982 1 4 1.19585 0.216502 # MRFSS_4
1983 1 4 0.871614 0.29782 # MRFSS_4
1984 1 4 0.747462 0.270699 # MRFSS_4
1985 1 4 0.667115 0.306129 # MRFSS_4
1986 1 4 0.551108 0.194988 # MRFSS_4
1987 1 4 0.754596 0.182761 # MRFSS_4
1988 1 4 0.94461 0.192593 # MRFSS_4
1989 1 4 1.02793 0.207095 # MRFSS_4
1990 1 4 1.58666 0.179624 # MRFSS_4
1991 1 4 1.6207 0.152961 # MRFSS_4
1992 1 4 1.08135 0.118142 # MRFSS_4

1993 1 4 1.03541 0.150494 # MRFSS_4
1994 1 4 1.36186 0.131972 # MRFSS_4
1995 1 4 0.666587 0.17157 # MRFSS_4
1996 1 4 1.38528 0.131297 # MRFSS_4
1997 1 4 1.91831 0.110693 # MRFSS_4
1998 1 4 1.18463 0.110908 # MRFSS_4
1999 1 4 1.0917 0.0921619 # MRFSS_4
2000 1 4 0.78377 0.104784 # MRFSS_4
2001 1 4 0.908711 0.097775 # MRFSS_4
2002 1 4 0.930825 0.0924892 # MRFSS_4
2003 1 4 1.0102 0.0957156 # MRFSS_4
2004 1 4 0.841514 0.100863 # MRFSS_4
2005 1 4 0.787023 0.114288 # MRFSS_4
2006 1 4 0.734919 0.112987 # MRFSS_4
2007 1 4 0.808154 0.112244 # MRFSS_4
2008 1 4 0.96015 0.105312 # MRFSS_4
2009 1 4 0.750867 0.123361 # MRFSS_4
2010 1 4 0.900918 0.121558 # MRFSS_4
2011 1 4 1.04283 0.111139 # MRFSS_4
1986 1 2 0.469071 0.277703 # Recreational_Combined_2
1987 1 2 0.401495 0.281573 # Recreational_Combined_2
1988 1 2 0.375526 0.293591 # Recreational_Combined_2
1989 1 2 0.533509 0.269635 # Recreational_Combined_2
1990 1 2 0.709967 0.251059 # Recreational_Combined_2
1991 1 2 0.869174 0.229837 # Recreational_Combined_2
1992 1 2 0.864945 0.228333 # Recreational_Combined_2
1993 1 2 1.13102 0.216958 # Recreational_Combined_2
1994 1 2 1.11466 0.216819 # Recreational_Combined_2
1995 1 2 0.974367 0.231314 # Recreational_Combined_2
1996 1 2 1.04151 0.233091 # Recreational_Combined_2
1997 1 2 1.25721 0.218121 # Recreational_Combined_2
1998 1 2 1.09467 0.225903 # Recreational_Combined_2
1999 1 2 1.68145 0.201552 # Recreational_Combined_2
2000 1 2 0.968132 0.227321 # Recreational_Combined_2
2001 1 2 1.25294 0.219522 # Recreational_Combined_2
2002 1 2 1.00828 0.243063 # Recreational_Combined_2
2003 1 2 1.22685 0.216429 # Recreational_Combined_2
2004 1 2 0.972875 0.245796 # Recreational_Combined_2
2005 1 2 1.02572 0.231821 # Recreational_Combined_2
2006 1 2 0.985744 0.243344 # Recreational_Combined_2

2007 1 2 1.2373 0.213905 # Recreational_Combined_2
2008 1 2 1.19134 0.21467 # Recreational_Combined_2
2009 1 2 1.22684 0.210574 # Recreational_Combined_2
2010 1 2 1.09983 0.225074 # Recreational_Combined_2
2011 1 2 1.28559 0.212042 # Recreational_Combined_2
#
3 #_N_fleets_with_discard
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype: >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for normal with se; -2 for lognormal
#_Fleet units errtype
1 1 -2 # Com_Combined_1
2 1 -2 # Recreational_Combined_2
3 3 -2 # Shrimp_Bycatch_3
90 #_N_discard_obs
#_year seas fleet obs err

1993	1	1	34.45	0.5	#	Com_Combined_1
1994	1	1	41.01	0.5	#	Com_Combined_1
1995	1	1	38.66	0.5	#	Com_Combined_1
1996	1	1	41.88	0.5	#	Com_Combined_1
1997	1	1	46.63	0.5	#	Com_Combined_1
1998	1	1	45.54	0.5	#	Com_Combined_1
1999	1	1	52.00	0.5	#	Com_Combined_1
2000	1	1	48.85	0.5	#	Com_Combined_1
2001	1	1	45.38	0.5	#	Com_Combined_1
2002	1	1	47.77	0.5	#	Com_Combined_1
2003	1	1	50.98	0.5	#	Com_Combined_1
2004	1	1	44.53	0.5	#	Com_Combined_1
2005	1	1	43.31	0.5	#	Com_Combined_1
2006	1	1	43.08	0.5	#	Com_Combined_1
2007	1	1	40.88	0.5	#	Com_Combined_1
2008	1	1	36.21	0.5	#	Com_Combined_1
2009	1	1	44.81	0.5	#	Com_Combined_1
2010	1	1	36.42	0.5	#	Com_Combined_1
2011	1	1	39.99	0.5	#	Com_Combined_1

1981 1 2 11.7264 0.5 # Recreational_Combined_2
1982 1 2 18.9164 0.5 # Recreational_Combined_2
1983 1 2 0.820407 0.5 # Recreational_Combined_2
1984 1 2 43.3077 0.5 # Recreational_Combined_2
1985 1 2 1.66541 0.5 # Recreational_Combined_2

1986 1 2 42.8504 0.5 # Recreational_Combined_2
1987 1 2 24.5445 0.5 # Recreational_Combined_2
1988 1 2 73.4787 0.5 # Recreational_Combined_2
1989 1 2 72.8329 0.5 # Recreational_Combined_2
1990 1 2 92.3444 0.5 # Recreational_Combined_2
1991 1 2 242.742 0.5 # Recreational_Combined_2
1992 1 2 120.366 0.5 # Recreational_Combined_2
1993 1 2 88.4223 0.5 # Recreational_Combined_2
1994 1 2 121.266 0.5 # Recreational_Combined_2
1995 1 2 89.0609 0.5 # Recreational_Combined_2
1996 1 2 114.188 0.5 # Recreational_Combined_2
1997 1 2 134.571 0.5 # Recreational_Combined_2
1998 1 2 115.264 0.5 # Recreational_Combined_2
1999 1 2 114.267 0.5 # Recreational_Combined_2
2000 1 2 125.835 0.5 # Recreational_Combined_2
2001 1 2 145.126 0.5 # Recreational_Combined_2
2002 1 2 139.418 0.5 # Recreational_Combined_2
2003 1 2 88.3938 0.5 # Recreational_Combined_2
2004 1 2 94.211 0.5 # Recreational_Combined_2
2005 1 2 58.681 0.5 # Recreational_Combined_2
2006 1 2 75.825 0.5 # Recreational_Combined_2
2007 1 2 81.802 0.5 # Recreational_Combined_2
2008 1 2 133.537 0.5 # Recreational_Combined_2
2009 1 2 86.264 0.5 # Recreational_Combined_2
2010 1 2 70.6 0.5 # Recreational_Combined_2
2011 1 2 93.617 0.5 # Recreational_Combined_2
1972 -1 3 139.9 0.1 # Shrimp_Bycatch_3
1973 1 -3 41.65 0.5 # Shrimp_Bycatch_3
1974 1 -3 282.1 0.5 # Shrimp_Bycatch_3
1975 1 -3 128.9 0.5 # Shrimp_Bycatch_3
1976 1 -3 105.8 0.5 # Shrimp_Bycatch_3
1977 1 -3 44.2 0.5 # Shrimp_Bycatch_3
1978 1 -3 42.45 0.5 # Shrimp_Bycatch_3
1979 1 -3 445.3 0.5 # Shrimp_Bycatch_3
1980 1 -3 285.2 0.5 # Shrimp_Bycatch_3
1981 1 -3 56.63 0.5 # Shrimp_Bycatch_3
1982 1 -3 165.4 0.5 # Shrimp_Bycatch_3
1983 1 -3 203 0.5 # Shrimp_Bycatch_3
1984 1 -3 143.1 0.5 # Shrimp_Bycatch_3
1985 1 -3 161.8 0.5 # Shrimp_Bycatch_3

1986 1 -3 149.6 0.5 # Shrimp_Bycatch_3
1987 1 -3 221.2 0.5 # Shrimp_Bycatch_3
1988 1 -3 100.8 0.5 # Shrimp_Bycatch_3
1989 1 -3 195.5 0.5 # Shrimp_Bycatch_3
1990 1 -3 173.5 0.5 # Shrimp_Bycatch_3
1991 1 -3 189.1 0.5 # Shrimp_Bycatch_3
1992 1 -3 586.1 0.5 # Shrimp_Bycatch_3
1993 1 -3 166.9 0.5 # Shrimp_Bycatch_3
1994 1 -3 164.7 0.5 # Shrimp_Bycatch_3
1995 1 -3 119.8 0.5 # Shrimp_Bycatch_3
1996 1 -3 411.8 0.5 # Shrimp_Bycatch_3
1997 1 -3 494.9 0.5 # Shrimp_Bycatch_3
1998 1 -3 376 0.5 # Shrimp_Bycatch_3
1999 1 -3 491.1 0.5 # Shrimp_Bycatch_3
2000 1 -3 151.1 0.5 # Shrimp_Bycatch_3
2001 1 -3 455.6 0.5 # Shrimp_Bycatch_3
2002 1 -3 209.4 0.5 # Shrimp_Bycatch_3
2003 1 -3 98.59 0.5 # Shrimp_Bycatch_3
2004 1 -3 44.57 0.5 # Shrimp_Bycatch_3
2005 1 -3 87.34 0.5 # Shrimp_Bycatch_3
2006 1 -3 176.8 0.5 # Shrimp_Bycatch_3
2007 1 -3 47.03 0.5 # Shrimp_Bycatch_3
2008 1 -3 13.34 0.5 # Shrimp_Bycatch_3
2009 1 -3 18.98 0.5 # Shrimp_Bycatch_3
2010 1 -3 5.759 0.5 # Shrimp_Bycatch_3
2011 -1 -3 41.26 0.5 # Shrimp_Bycatch_3
#
0 #_N_meanbodywt_obs
30 #_DF_for_meanbodywt_T-distribution_like
2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
3 # binwidth for population size comp
6 # minimum size in the population (lower edge of first bin and size at age 0.00)
165 # maximum size in the population (lower edge of last bin)
0 #_comp_tail_compression
1e-007 #_add_to_comp
0 #_combine males into females at or below this bin number
54 #_N_LengthBins
6 9 12 15 18 21 24 27 30 33 36 39 42 45 48
51 54 57 60 63 66 69 72 75 78 81 84
87 90 93 96 99 102 105 108 111 114 117 120

123 126 129 132 135 138 141 144 147 150 153 156
159 162 165
85 #_N_Length_obs
#Yr Seas Flt/Svy Gender Part Nsamp datavector(female-male)
1983 1 1 0 2 7 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 2 1 0 0 0 1 0 1
0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0
1984 1 1 0 2 42 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 1 3 3 1 2 4 4 2 3 2 4
4 1 2 2 0 3 0 0 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0
1985 1 1 0 2 36 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 2 0 0 2 0 1 0 1 1 1
2 5 4 3 0 1 0 4 0 0 2 3
0 0 1 1 0 1 1 0 0 0 0
1986 1 1 0 2 32 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 1 0 2 3 2 1 0 5 4 2 1
3 4 1 0 0 2 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
1987 1 1 0 2 9 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 1 1 0 0 2 0 0
1 0 1 1 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
1988 1 1 0 2 7 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 0 0 1 0
0 0 2 0 0 1 0 0 0 2 0 0
0 0 0 0 0 0 0 0 0 0 0
1989 1 1 0 2 3 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0 1 0
0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0

1990	1	1	0	2	47	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	4	9	3	7	9	4
	4	2	0	0	0	1	0	0	1	0	1	0
	0	0	0	0	0	0	0	0	0	0	0	
1991	1	1	0	2	96	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	2	6	12	16	9	8	8
	5	4	7	9	3	0	2	0	2	0	2	0
	0	0	0	0	0	0	0	0	0	0	0	
1992	1	1	0	2	99	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	1	2	2	11	6	15	14	7
	8	7	4	4	8	3	3	2	1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1993	1	1	0	2	83	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	6	6	10	13	17	9
	6	1	3	0	3	1	1	2	0	1	0	0
	0	0	1	0	1	0	0	0	0	0	0	
1994	1	1	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	3	11	8	10	11	7
	11	7	8	9	7	2	1	0	2	1	1	1
	0	0	0	0	0	0	0	0	0	0	0	
1995	1	1	0	2	60	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	3	7	3	4	5	5
	5	5	4	5	4	2	0	2	3	0	2	0
	0	1	0	0	0	0	0	0	0	0	0	
1996	1	1	0	2	47	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	3	5	3	1	7	3
	2	4	2	2	3	5	0	0	3	0	0	2
	2	0	0	0	0	0	0	0	0	0	0	
1997	1	1	0	2	40	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	1	5	2	2	4	3
	2	3	3	1	4	2	2	2	3	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	

1998	1	1	0	2	29	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	1	0	0	1	1	2
	3	0	1	2	2	2	2	1	4	2	2	2
	0	1	0	0	0	0	0	0	0	0	0	
1999	1	1	0	2	30	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	1	0	1	0	1	2
	3	0	6	2	2	2	1	2	1	1	3	1
	0	1	0	0	0	0	0	0	0	0	0	
2000	1	1	0	2	37	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	0	0	0	2	1	1	2	2	3
	3	5	4	2	3	1	0	1	0	0	0	2
	1	1	0	1	1	0	0	0	0	0	0	
2001	1	1	0	2	65	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	1	3	2	0	0	6	3
	4	2	7	4	9	4	2	4	4	2	6	1
	0	0	0	0	0	0	0	0	0	0	0	
2002	1	1	0	2	33	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	1	2	0	3	2	3	3
	4	1	1	0	2	1	4	0	1	1	2	1
	0	0	0	0	0	0	0	0	0	0	0	
2003	1	1	0	2	50	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	1	0	1	2	4	4
	4	4	5	9	5	2	3	3	1	0	0	0
	0	1	0	1	0	0	0	0	0	0	0	
2004	1	1	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	4	5	8	5	9	6
	12	13	11	11	6	8	8	3	8	4	3	1
	0	1	1	0	0	0	0	0	0	0	0	
2005	1	1	0	2	86	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	3	3	6	6	6	1	6
	9	8	10	5	8	1	2	5	1	0	1	0
	2	1	0	0	1	0	0	0	0	0	0	

2006	1	1	0	2	49	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	1	4	7	6	8
	7	2	1	3	3	1	5	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	
2007	1	1	0	2	66	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	1	5	4	10	7	10	5
	9	4	1	1	2	3	0	2	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	
2008	1	1	0	2	38	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	1	0	1	6	3	2	3
	3	2	2	2	3	2	3	1	1	1	0	0
	0	2	0	0	0	0	0	0	0	0	0	
2009	1	1	0	2	48	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	4	4	7	7	4	1
	3	6	2	1	2	2	1	0	0	1	0	0
	0	0	0	0	0	1	0	0	0	0	0	
2010	1	1	0	2	73	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	2	1	7	5	7	7	7	6
	5	8	2	2	2	3	3	3	0	1	0	1
	1	0	0	0	0	0	0	0	0	0	0	
2011	1	1	0	2	80	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	4	20	6	9	12	7
	4	6	5	1	1	1	0	0	0	1	1	0
	0	0	0	0	0	0	0	0	0	0	0	
2006	1	1	0	0	10	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	2	1	1	0	0	0	1	0	0	0	2
	1	1	0	0	0	0	0	0	0	0	0	0
	0	0	1	0	0	0	0	0	0	0	0	
2007	1	1	0	0	15	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	1	2	0	1	0	0	1	3	1	1	0
	4	1	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

2008	1	1	0	0	22	0	0	0	0	0	0	0
	0	0	0	0	0	0	2	0	0	0	1	1
	0	0	2	1	1	2	2	2	1	3	0	1
	1	1	0	0	0	0	1	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	1	0	0	33	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	1	0	0
	1	2	4	0	3	1	0	3	2	3	3	0
	4	2	2	0	0	0	1	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	1	0	0	25	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	1	0	0	0	0
	1	1	2	0	1	2	1	2	1	2	1	2
	1	2	2	0	0	0	1	0	0	0	1	1
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	1	0	0	57	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	3	1
	2	0	2	3	1	2	3	1	10	5	2	3
	3	2	4	3	0	2	0	2	0	0	1	1
	0	0	0	0	0	0	0	0	0	0	0	
1979	1	2	0	2	16	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	0
	0	1	2	0	2	1	0	1	1	0	2	0
	0	0	1	1	1	1	0	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1980	1	2	0	2	11	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	1	3	2	1	1	0	0	0
	0	0	0	1	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1981	1	2	0	2	36	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	1
	0	0	2	5	2	4	2	4	1	7	1	2
	0	1	1	0	1	0	0	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1982	1	2	0	2	65	0	0	0	0	0	0	0
	0	1	0	0	0	1	1	3	1	1	2	6
	4	4	5	3	8	5	2	2	4	2	2	3
	1	1	1	0	0	0	1	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

1983	1	2	0	2	63	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	1	1	0	0	1
	1	4	4	4	3	3	3	2	5	4	3	8
	2	0	0	4	2	3	2	1	1	0	1	0
	0	0	0	0	0	0	0	0	0	0	0	
1984	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	1	4	1	2	3	1	1	5	1
	2	3	4	5	5	6	2	5	7	5	10	8
	6	5	1	1	3	5	1	1	0	0	1	0
	0	0	0	0	0	0	0	0	0	0	0	
1985	1	2	0	2	69	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	2	1	1	2
	2	0	3	2	6	3	7	6	10	5	3	3
	2	6	1	1	1	1	0	0	1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1986	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	2	2
	2	4	2	5	6	15	10	14	17	16	9	8
	10	7	4	3	2	1	3	1	1	0	0	0
	0	1	0	0	0	0	0	0	0	0	0	
1987	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	2	1	4	6
	4	9	1	1	5	6	5	9	17	11	10	16
	14	7	6	1	2	4	0	1	0	0	0	0
	0	0	1	0	0	0	0	0	0	0	0	
1988	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	1
	1	0	1	5	5	12	9	13	11	6	12	3
	6	4	3	2	3	3	1	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1989	1	2	0	2	95	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	2	2	1
	0	0	1	2	3	2	9	9	10	6	10	7
	15	3	4	4	0	2	0	1	0	0	0	1
	1	0	0	0	0	0	0	0	0	0	0	
1990	1	2	0	2	73	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	1	3	5	10	7	7	3	3
	5	6	2	9	3	1	3	0	1	1	0	2
	0	0	0	0	0	0	0	0	0	0	0	

1991	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	3
	1	0	3	1	1	5	9	14	17	14	10	6
	2	3	8	2	1	3	0	0	1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1992	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	1	2	0
	0	1	1	1	3	11	21	19	29	19	16	14
	10	6	4	5	7	3	1	7	4	1	0	1
	0	1	0	0	0	0	0	0	0	0	0	
1993	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	5	12	18	28	27	23	21	18
	13	7	2	8	1	1	1	0	0	2	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1994	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	2	1	2
	0	0	2	3	1	4	26	23	43	30	26	21
	12	10	11	5	3	2	0	1	0	0	2	0
	0	0	0	0	0	0	0	0	0	0	0	
1995	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	0
	1	0	1	2	4	9	22	27	38	26	14	28
	12	14	6	7	4	4	2	1	2	1	0	0
	0	0	1	0	0	0	0	0	0	0	0	
1996	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	1
	0	0	0	1	3	7	31	34	35	29	40	23
	17	6	7	8	10	8	3	4	1	2	0	0
	1	1	0	0	0	0	0	0	0	0	0	
1997	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	2
	0	0	0	3	3	6	33	36	39	30	30	25
	11	9	9	12	9	7	7	6	1	0	3	2
	0	0	0	0	0	0	0	0	0	0	0	
1998	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	1	1	1	2	4	10	23	57	40	37	36	28
	29	38	22	21	14	4	10	8	2	1	3	1
	0	0	0	0	1	0	0	0	0	0	0	

1999	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	0
	1	1	1	5	8	9	23	21	47	23	37	51
	40	43	17	27	16	10	8	5	2	2	1	3
	0	0	0	1	0	0	0	0	0	0	0	
2000	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	0	0	1
	0	0	2	2	6	8	16	27	25	22	9	19
	17	14	14	12	5	10	3	6	3	1	1	1
	0	0	0	0	0	0	0	0	0	0	0	
2001	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	6	5	27	35	31	28	41	25
	25	13	17	8	10	6	1	1	4	2	1	1
	0	0	0	0	1	0	0	0	0	0	0	
2002	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	1
	0	3	2	1	3	3	15	25	32	32	22	25
	20	7	9	10	8	5	4	3	2	0	1	1
	0	0	0	0	0	0	0	0	0	0	0	
2003	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	2	6	6	16	31	32	49	35	23	38
	32	13	14	9	10	10	5	4	3	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	
2004	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	1	2	11	22	26	18	29	30	23
	25	18	14	8	15	8	5	1	2	2	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2005	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	2	1
	0	2	1	2	5	5	17	21	20	20	22	16
	10	11	5	7	10	5	2	2	1	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	
2006	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	2
	0	0	2	4	7	8	17	33	27	28	24	19
	20	16	15	6	8	6	4	1	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	

2007	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	1
	0	2	0	3	6	12	33	30	34	32	13	18
	29	12	7	4	5	6	6	2	4	1	1	0
	0	0	0	0	0	0	0	0	0	0	0	
2008	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	1	0	4	18	34	17	27	24	21
	17	12	7	10	4	2	4	3	2	0	1	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	0	1	4
	1	1	0	1	4	9	17	29	25	19	12	12
	14	6	10	7	7	8	4	2	2	1	1	1
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	2	0	5	18	21	36	25	29	16
	21	16	5	6	7	6	4	3	2	2	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	2	0	2	100	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	3	7	15	12	27	20	19
	10	7	9	8	6	4	2	2	2	0	1	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	-1	3	0	0	294	0	0	0	7	6	9	15
	10	27	43	43	38	38	15	9	5	1	1	1
	2	4	4	1	3	2	2	0	0	0	3	0
	0	0	0	1	0	1	2	0	0	1	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1989	1	-3	0	0	5	0	0	0	0	0	0	0
	0	0	1	0	2	1	0	0	1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1990	1	-3	0	0	9	0	0	0	0	0	0	0
	1	0	2	0	2	3	0	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

1991	1	-3	0	0	5	0	0	0	0	0	0	0
	0	1	0	1	1	2	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1992	1	-3	0	0	9	0	0	0	0	0	0	0
	3	1	0	2	1	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	1	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1993	1	-3	0	0	28	0	0	0	1	0	0	1
	0	2	5	11	5	0	0	2	0	0	0	0
	0	0	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1994	1	-3	0	0	17	0	0	0	0	0	0	1
	0	0	1	3	4	5	1	2	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1995	1	-3	0	0	13	0	0	0	0	1	0	2
	1	0	0	0	1	2	0	0	0	0	0	0
	1	2	1	0	0	0	1	0	0	0	1	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1996	1	-3	0	0	16	0	0	0	0	0	1	1
	0	3	6	2	1	1	0	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1997	1	-3	0	0	28	0	0	0	0	0	0	1
	0	6	6	6	5	2	1	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1998	1	-3	0	0	8	0	0	0	0	0	0	0
	0	1	0	0	1	0	0	0	0	0	0	1
	0	0	1	0	2	1	1	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

1999	1	-3	0	0	15	0	0	0	1	0	0	0
	0	2	1	1	3	5	2	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2000	1	-3	0	0	2	0	0	0	0	0	0	0
	0	0	0	1	0	1	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2001	1	-3	0	0	16	0	0	0	0	0	0	1
	0	3	7	2	1	1	1	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2002	1	-3	0	0	6	0	0	0	0	0	0	0
	0	1	1	0	0	1	1	0	0	0	0	0
	0	1	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2003	1	-3	0	0	9	0	0	0	0	1	1	1
	0	0	2	0	3	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2004	1	-3	0	0	16	0	0	0	0	0	1	0
	0	2	3	4	2	2	1	0	1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2005	1	-3	0	0	22	0	0	0	4	2	1	1
	1	3	1	1	2	3	0	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	2	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2006	1	-3	0	0	13	0	0	0	0	0	1	0
	0	1	1	2	2	0	4	0	1	0	0	0
	0	0	0	0	0	1	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

2007 1 -3 0 0 9 0 0 0 0 0 2 2
1 0 1 1 0 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2008 1 -3 0 0 19 0 0 0 0 0 0 0
1 0 2 3 1 4 1 1 0 0 1 0
0 1 0 1 0 0 0 0 0 0 1 0
0 0 0 0 0 1 0 0 0 1 0 0
0 0 0 0 0 0 0 0 0 0 0
2009 1 -3 0 0 12 0 0 0 1 0 0 1
1 0 0 1 0 2 2 1 2 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2010 -1 -3 0 0 17 0 0 0 0 2 2 3
1 1 3 2 1 2 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
11 #_N_age_bins
0 1 2 3 4 5 6 7 8 9 10
2 #_N_ageerror_definitions
0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5
0.01 0.05 0.15 0.15 0.2 0.3 0.5 0.5 0.75 0.75 1 1
279 #_N_Agecomp_obs
2 #_Lbin_method: 1=poplenbins; 2=datalenbins; 3=lengths
1 #_combine males into females at or below this bin number
#Yr Seas Flt/Svy Gender Part Ageerr Lbin_lo Lbin_hi Nsamp datavector(female-male)
1987 1 2 0 2 2 20 20 1 0 1 0 0
0 0 0 0 0 0 0
1987 1 2 0 2 2 26 26 1 0 0 1 0
0 0 0 0 0 0 0
1987 1 2 0 2 2 29 29 1 0 0 0 1
0 0 0 0 0 0 0
1987 1 2 0 2 2 30 30 3 0 0 1 2
0 0 0 0 0 0 0

1987	1	2	0	2	2	31	31	2	0	0	0	2
	0	0	0	0	0	0	0					
1987	1	2	0	2	2	32	32	1	0	0	1	0
	0	0	0	0	0	0	0					
1987	1	2	0	2	2	33	33	4	0	0	0	2
	0	2	0	0	0	0	0					
1987	1	2	0	2	2	34	34	1	0	0	0	1
	0	0	0	0	0	0	0					
1987	1	2	0	2	2	36	36	2	0	0	1	1
	0	0	0	0	0	0	0					
1987	1	2	0	2	2	37	37	4	0	0	0	4
	0	0	0	0	0	0	0					
1987	1	2	0	2	2	38	38	1	0	0	0	1
	0	0	0	0	0	0	0					
1987	1	2	0	2	2	39	39	1	0	0	0	0
	1	0	0	0	0	0	0					
1987	1	2	0	2	2	40	40	1	0	0	0	0
	0	1	0	0	0	0	0					
1987	1	2	0	2	2	43	43	1	0	0	0	0
	0	1	0	0	0	0	0					
1987	1	2	0	2	2	46	46	2	0	0	0	0
	0	1	1	0	0	0	0					
1987	1	2	0	2	2	47	47	1	0	0	0	0
	0	0	0	1	0	0	0					
1988	1	2	0	2	2	25	25	1	0	0	1	0
	0	0	0	0	0	0	0					
1988	1	2	0	2	2	26	26	1	0	0	1	0
	0	0	0	0	0	0	0					
1988	1	2	0	2	2	27	27	3	0	0	3	0
	0	0	0	0	0	0	0					
1988	1	2	0	2	2	28	28	1	0	0	0	0
	1	0	0	0	0	0	0					
1988	1	2	0	2	2	29	29	3	0	0	2	1
	0	0	0	0	0	0	0					
1988	1	2	0	2	2	30	30	4	0	0	3	1
	0	0	0	0	0	0	0					
1988	1	2	0	2	2	31	31	2	0	0	0	1
	1	0	0	0	0	0	0					
1988	1	2	0	2	2	32	32	6	0	0	0	4
	2	0	0	0	0	0	0					

1988	1	2	0	2	2	33	33	5	0	0	0	2
	3	0	0	0	0	0	0					
1988	1	2	0	2	2	34	34	5	0	0	0	3
	2	0	0	0	0	0	0					
1988	1	2	0	2	2	35	35	5	0	0	0	1
	3	1	0	0	0	0	0					
1988	1	2	0	2	2	36	36	2	0	0	0	1
	1	0	0	0	0	0	0					
1988	1	2	0	2	2	37	37	2	0	0	0	0
	2	0	0	0	0	0	0					
1988	1	2	0	2	2	38	38	2	0	0	0	0
	0	2	0	0	0	0	0					
1988	1	2	0	2	2	39	39	2	0	0	0	0
	2	0	0	0	0	0	0					
1988	1	2	0	2	2	42	42	2	0	0	0	0
	0	1	0	0	1	0	0					
1988	1	2	0	2	2	47	47	1	0	0	0	0
	0	0	1	0	0	0	0					
1988	1	2	0	2	2	50	50	1	0	0	0	0
	0	0	0	0	1	0	0					
1989	1	2	0	2	2	20	20	1	0	1	0	0
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	21	21	2	0	2	0	0
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	25	25	1	0	0	0	1
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	26	26	5	0	0	5	0
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	27	27	14	0	0	13	1
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	28	28	9	0	0	5	4
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	29	29	7	0	0	3	4
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	30	30	22	0	0	4	17
	0	1	0	0	0	0	0					
1989	1	2	0	2	2	31	31	26	0	0	7	19
	0	0	0	0	0	0	0					
1989	1	2	0	2	2	32	32	20	0	0	0	19
	0	1	0	0	0	0	0					

1989	1	2	0	2	2	33	33	23	0	0	2	19
	1	1	0	0	0	0	0					
1989	1	2	0	2	2	34	34	11	0	0	1	7
	1	2	0	0	0	0	0					
1989	1	2	0	2	2	35	35	16	0	0	2	12
	0	2	0	0	0	0	0					
1989	1	2	0	2	2	36	36	7	0	0	0	3
	3	1	0	0	0	0	0					
1989	1	2	0	2	2	37	37	9	0	0	0	6
	2	1	0	0	0	0	0					
1989	1	2	0	2	2	38	38	5	0	0	0	1
	1	2	1	0	0	0	0					
1989	1	2	0	2	2	39	39	8	0	0	0	2
	3	2	0	1	0	0	0					
1989	1	2	0	2	2	40	40	4	0	0	0	1
	1	1	0	0	0	1	0					
1989	1	2	0	2	2	41	41	1	0	0	0	0
	0	1	0	0	0	0	0					
1989	1	2	0	2	2	42	42	1	0	0	0	0
	0	0	0	1	0	0	0					
1989	1	2	0	2	2	43	43	2	0	0	0	0
	0	2	0	0	0	0	0					
1989	1	2	0	2	2	44	44	1	0	0	0	0
	0	0	0	1	0	0	0					
1989	1	2	0	2	2	45	45	2	0	0	0	0
	0	1	1	0	0	0	0					
1989	1	2	0	2	2	49	49	1	0	0	0	0
	0	0	0	0	0	1	0					
1990	1	2	0	2	2	13	13	1	1	0	0	0
	0	0	0	0	0	0	0					
1990	1	2	0	2	2	16	16	1	0	1	0	0
	0	0	0	0	0	0	0					
1990	1	2	0	2	2	18	18	1	0	1	0	0
	0	0	0	0	0	0	0					
1990	1	2	0	2	2	19	19	2	0	1	1	0
	0	0	0	0	0	0	0					
1990	1	2	0	2	2	20	20	6	0	5	1	0
	0	0	0	0	0	0	0					
1990	1	2	0	2	2	21	21	2	0	2	0	0
	0	0	0	0	0	0	0					

1990	1	2	0	2	2	22	22	6	0	6	0	0	0	0	0	0	0	0	0
1990	1	2	0	2	2	23	23	2	0	2	0	0	0	0	0	0	0	0	0
1990	1	2	0	2	2	24	24	3	0	3	0	0	0	0	0	0	0	0	0
1990	1	2	0	2	2	26	26	1	0	1	0	0	0	0	0	0	0	0	0
1990	1	2	0	2	2	27	27	14	0	1	12	1	0	0	0	0	0	0	0
1990	1	2	0	2	2	28	28	5	0	4	0	1	0	0	0	0	0	0	0
1990	1	2	0	2	2	29	29	6	0	0	4	1	1	0	0	0	0	0	0
1990	1	2	0	2	2	30	30	11	0	0	4	5	2	0	0	0	0	0	0
1990	1	2	0	2	2	31	31	13	0	0	3	4	6	0	0	0	0	0	0
1990	1	2	0	2	2	32	32	14	0	0	3	6	3	2	0	0	0	0	0
1990	1	2	0	2	2	33	33	11	0	0	4	2	3	1	0	1	0	0	0
1990	1	2	0	2	2	34	34	21	0	0	2	8	7	3	0	1	0	0	0
1990	1	2	0	2	2	35	35	13	0	0	0	3	10	0	0	0	0	0	0
1990	1	2	0	2	2	36	36	12	0	0	1	5	6	0	0	0	0	0	0
1990	1	2	0	2	2	37	37	12	0	0	0	5	6	0	1	0	0	0	0
1990	1	2	0	2	2	38	38	3	0	0	0	0	2	1	0	0	0	0	0
1990	1	2	0	2	2	39	39	3	0	0	0	0	2	1	0	0	0	0	0
1990	1	2	0	2	2	40	40	5	0	0	0	1	1	2	1	0	0	0	0
1990	1	2	0	2	2	41	41	2	0	0	0	0	1	0	0	0	0	1	0
1990	1	2	0	2	2	42	42	3	0	0	0	0	2	1	0	0	0	0	0

1990	1	2	0	2	2	43	43	4	0	0	0	0
	1	2	0	1	0	0	0					
1990	1	2	0	2	2	44	44	2	0	0	0	0
	0	1	0	0	0	1	0					
1990	1	2	0	2	2	49	49	1	0	0	0	0
	0	0	0	0	1	0	0					
1991	1	2	0	2	2	15	15	1	0	1	0	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	16	16	1	0	1	0	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	17	17	1	0	1	0	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	19	19	1	0	1	0	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	25	25	2	0	0	2	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	26	26	3	0	0	3	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	27	27	11	0	0	11	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	28	28	2	0	0	2	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	29	29	7	0	0	7	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	30	30	4	0	0	4	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	31	31	5	0	0	3	2
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	32	32	3	0	0	1	1
	0	1	0	0	0	0	0					
1991	1	2	0	2	2	33	33	2	0	0	0	1
	0	1	0	0	0	0	0					
1991	1	2	0	2	2	34	34	1	0	0	1	0
	0	0	0	0	0	0	0					
1991	1	2	0	2	2	35	35	4	0	0	1	1
	2	0	0	0	0	0	0					
1991	1	2	0	2	2	36	36	1	0	0	0	0
	1	0	0	0	0	0	0					
1991	1	2	0	2	2	38	38	5	0	0	0	1
	1	3	0	0	0	0	0					

1991	1	2	0	2	2	39	39	2	0	0	0	0
	0	2	0	0	0	0	0					
1991	1	2	0	2	2	40	40	2	0	0	0	0
	1	1	0	0	0	0	0					
1991	1	2	0	2	2	41	41	3	0	0	0	0
	0	2	1	0	0	0	0					
1991	1	2	0	2	2	42	42	1	0	0	0	0
	1	0	0	0	0	0	0					
1991	1	2	0	2	2	43	43	2	0	0	0	0
	1	0	1	0	0	0	0					
1991	1	2	0	2	2	44	44	1	0	0	0	0
	0	1	0	0	0	0	0					
1991	1	2	0	2	2	46	46	2	0	0	0	0
	0	1	1	0	0	0	0					
1992	1	2	0	2	2	27	27	2	0	0	2	0
	0	0	0	0	0	0	0					
1992	1	2	0	2	2	28	28	2	0	0	2	0
	0	0	0	0	0	0	0					
1992	1	2	0	2	2	30	30	1	0	0	1	0
	0	0	0	0	0	0	0					
1992	1	2	0	2	2	31	31	1	0	0	1	0
	0	0	0	0	0	0	0					
1992	1	2	0	2	2	32	32	1	0	0	1	0
	0	0	0	0	0	0	0					
1992	1	2	0	2	2	36	36	1	0	0	0	0
	0	0	1	0	0	0	0					
1992	1	2	0	2	2	39	39	1	0	0	0	1
	0	0	0	0	0	0	0					
1993	1	2	0	2	2	31	31	1	0	0	0	1
	0	0	0	0	0	0	0					
1993	1	2	0	2	2	32	32	1	0	0	0	0
	1	0	0	0	0	0	0					
1994	1	2	0	2	2	23	23	1	0	1	0	0
	0	0	0	0	0	0	0					
1994	1	2	0	2	2	27	27	1	0	0	1	0
	0	0	0	0	0	0	0					
1994	1	2	0	2	2	28	28	1	0	0	0	1
	0	0	0	0	0	0	0					
1994	1	2	0	2	2	31	31	1	0	0	0	1
	0	0	0	0	0	0	0					

1994	1	2	0	2	2	33	33	1	0	0	0	0
	0	1	0	0	0	0	0					
1994	1	2	0	2	2	34	34	1	0	0	0	0
	1	0	0	0	0	0	0					
1995	1	2	0	2	2	11	11	3	3	0	0	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	12	12	2	2	0	0	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	13	13	1	1	0	0	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	18	18	3	0	3	0	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	26	26	2	0	1	1	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	27	27	6	0	1	5	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	28	28	5	0	0	4	1
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	29	29	1	0	0	0	1
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	30	30	1	0	0	0	1
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	31	31	1	0	0	1	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	32	32	1	0	0	1	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	33	33	1	0	0	1	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	34	34	1	0	0	1	0
	0	0	0	0	0	0	0					
1995	1	2	0	2	2	35	35	1	0	0	0	0
	0	1	0	0	0	0	0					
1995	1	2	0	2	2	37	37	1	0	0	0	0
	1	0	0	0	0	0	0					
1995	1	2	0	2	2	39	39	1	0	0	0	0
	0	1	0	0	0	0	0					
1995	1	2	0	2	2	41	41	1	0	0	0	0
	1	0	0	0	0	0	0					
1995	1	2	0	2	2	46	46	1	0	0	0	0
	0	0	0	0	1	0	0					

1996	1	2	0	2	2	12	12	2	2	0	0	0
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	13	13	1	1	0	0	0
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	19	19	2	0	2	0	0
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	20	20	1	0	1	0	0
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	21	21	2	0	1	1	0
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	22	22	6	0	0	3	3
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	23	23	4	0	0	3	1
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	24	24	2	0	0	1	1
	0	0	0	0	0	0	0					
1996	1	2	0	2	2	25	25	7	0	2	2	2
	1	0	0	0	0	0	0					
1996	1	2	0	2	2	26	26	19	0	1	11	5
	2	0	0	0	0	0	0					
1996	1	2	0	2	2	27	27	27	0	0	9	12
	3	3	0	0	0	0	0					
1996	1	2	0	2	2	28	28	35	0	1	15	14
	5	0	0	0	0	0	0					
1996	1	2	0	2	2	29	29	32	0	0	10	16
	5	1	0	0	0	0	0					
1996	1	2	0	2	2	30	30	33	0	0	12	14
	2	3	1	1	0	0	0					
1996	1	2	0	2	2	31	31	22	0	0	7	11
	3	0	1	0	0	0	0					
1996	1	2	0	2	2	32	32	25	0	0	7	11
	5	1	1	0	0	0	0					
1996	1	2	0	2	2	33	33	23	0	1	1	15
	2	3	1	0	0	0	0					
1996	1	2	0	2	2	34	34	13	0	0	3	5
	2	1	1	1	0	0	0					
1996	1	2	0	2	2	35	35	13	0	0	1	7
	1	1	2	1	0	0	0					
1996	1	2	0	2	2	36	36	7	0	0	0	1
	3	0	2	0	1	0	0					

1996	1	2	0	2	2	37	37	8	0	0	2	2
	2	1	1	0	0	0	0					
1996	1	2	0	2	2	38	38	6	0	0	0	1
	1	2	2	0	0	0	0					
1996	1	2	0	2	2	39	39	11	0	0	0	2
	4	1	3	1	0	0	0					
1996	1	2	0	2	2	40	40	7	0	0	0	0
	1	2	3	1	0	0	0					
1996	1	2	0	2	2	41	41	4	0	0	0	0
	0	1	2	0	0	1	0					
1996	1	2	0	2	2	42	42	4	0	0	0	0
	1	1	1	0	1	0	0					
1996	1	2	0	2	2	43	43	1	0	0	0	0
	0	0	0	1	0	0	0					
1996	1	2	0	2	2	44	44	1	0	0	0	0
	0	0	1	0	0	0	0					
1996	1	2	0	2	2	45	45	1	0	0	0	0
	0	0	1	0	0	0	0					
1996	1	2	0	2	2	47	47	1	0	0	0	0
	0	0	1	0	0	0	0					
1996	1	2	0	2	2	51	51	1	0	0	0	0
	0	1	0	0	0	0	0					
1997	1	2	0	2	2	10	10	1	0	1	0	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	14	14	1	0	1	0	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	16	16	1	0	1	0	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	17	17	1	0	1	0	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	20	20	1	0	0	1	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	21	21	1	0	0	1	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	22	22	3	0	1	1	1
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	24	24	1	0	1	0	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	25	25	2	0	0	1	1
	0	0	0	0	0	0	0					

1997	1	2	0	2	2	26	26	3	0	0	3	0
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	27	27	7	0	0	4	2
	1	0	0	0	0	0	0					
1997	1	2	0	2	2	28	28	11	0	0	6	4
	1	0	0	0	0	0	0					
1997	1	2	0	2	2	29	29	9	0	1	4	4
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	30	30	11	0	1	6	3
	1	0	0	0	0	0	0					
1997	1	2	0	2	2	31	31	21	0	0	9	7
	4	0	1	0	0	0	0					
1997	1	2	0	2	2	32	32	12	0	0	2	6
	4	0	0	0	0	0	0					
1997	1	2	0	2	2	33	33	15	0	1	2	5
	6	0	0	0	1	0	0					
1997	1	2	0	2	2	34	34	14	0	0	2	6
	5	0	1	0	0	0	0					
1997	1	2	0	2	2	35	35	18	0	0	3	6
	6	1	0	1	1	0	0					
1997	1	2	0	2	2	36	36	9	0	0	0	3
	6	0	0	0	0	0	0					
1997	1	2	0	2	2	37	37	16	0	0	0	6
	7	2	0	1	0	0	0					
1997	1	2	0	2	2	38	38	8	0	0	0	1
	6	0	1	0	0	0	0					
1997	1	2	0	2	2	39	39	13	0	0	1	4
	6	1	1	0	0	0	0					
1997	1	2	0	2	2	40	40	6	0	0	1	1
	3	0	1	0	0	0	0					
1997	1	2	0	2	2	41	41	2	0	0	0	2
	0	0	0	0	0	0	0					
1997	1	2	0	2	2	42	42	1	0	0	0	0
	1	0	0	0	0	0	0					
1997	1	2	0	2	2	43	43	1	0	0	0	0
	0	0	1	0	0	0	0					
1997	1	2	0	2	2	44	44	1	0	0	0	0
	0	0	1	0	0	0	0					
1997	1	2	0	2	2	45	45	1	0	0	0	1
	0	0	0	0	0	0	0					

1997	1	2	0	2	2	53	53	1	0	0	0	0
	0	0	1	0	0	0	0					
1998	1	2	0	2	2	30	30	1	0	0	0	1
	0	0	0	0	0	0	0					
1998	1	2	0	2	2	31	31	1	0	0	1	0
	0	0	0	0	0	0	0					
1998	1	2	0	2	2	32	32	1	0	0	0	1
	0	0	0	0	0	0	0					
1999	1	2	0	2	2	27	27	1	0	0	1	0
	0	0	0	0	0	0	0					
1999	1	2	0	2	2	31	31	1	0	0	0	1
	0	0	0	0	0	0	0					
1999	1	2	0	2	2	36	36	1	0	0	0	1
	0	0	0	0	0	0	0					
2000	1	2	0	2	2	26	26	1	0	0	1	0
	0	0	0	0	0	0	0					
2000	1	2	0	2	2	27	27	1	0	0	1	0
	0	0	0	0	0	0	0					
2000	1	2	0	2	2	28	28	1	0	1	0	0
	0	0	0	0	0	0	0					
2001	1	2	0	2	2	28	28	1	0	0	0	0
	1	0	0	0	0	0	0					
2001	1	2	0	2	2	41	41	1	0	0	0	0
	0	0	0	0	1	0	0					
2002	1	2	0	2	2	24	24	1	0	0	1	0
	0	0	0	0	0	0	0					
2002	1	2	0	2	2	28	28	1	0	0	0	1
	0	0	0	0	0	0	0					
2004	1	2	0	2	2	25	25	1	0	0	1	0
	0	0	0	0	0	0	0					
2004	1	2	0	2	2	27	27	1	0	0	1	0
	0	0	0	0	0	0	0					
2004	1	2	0	2	2	28	28	1	0	0	1	0
	0	0	0	0	0	0	0					
2004	1	2	0	2	2	29	29	2	0	0	0	2
	0	0	0	0	0	0	0					
2004	1	2	0	2	2	30	30	7	0	0	2	4
	0	1	0	0	0	0	0					
2004	1	2	0	2	2	31	31	2	0	0	0	2
	0	0	0	0	0	0	0					

2004	1	2	0	2	2	32	32	1	0	0	0	1
	0	0	0	0	0	0	0					
2004	1	2	0	2	2	41	41	1	0	0	0	0
	0	0	1	0	0	0	0					
2005	1	2	0	2	2	26	26	1	0	0	0	1
	0	0	0	0	0	0	0					
2005	1	2	0	2	2	27	27	2	0	0	2	0
	0	0	0	0	0	0	0					
2005	1	2	0	2	2	28	28	2	0	0	1	1
	0	0	0	0	0	0	0					
2005	1	2	0	2	2	31	31	1	0	0	0	1
	0	0	0	0	0	0	0					
2005	1	2	0	2	2	32	32	1	0	0	0	1
	0	0	0	0	0	0	0					
2005	1	2	0	2	2	33	33	2	0	0	0	0
	0	1	1	0	0	0	0					
2005	1	2	0	2	2	35	35	1	0	0	0	0
	1	0	0	0	0	0	0					
2005	1	2	0	2	2	36	36	1	0	0	0	1
	0	0	0	0	0	0	0					
2005	1	2	0	2	2	39	39	1	0	0	0	0
	0	0	1	0	0	0	0					
2006	1	2	0	2	2	25	25	1	0	0	1	0
	0	0	0	0	0	0	0					
2006	1	2	0	2	2	26	26	2	0	0	2	0
	0	0	0	0	0	0	0					
2006	1	2	0	2	2	27	27	2	0	0	1	1
	0	0	0	0	0	0	0					
2006	1	2	0	2	2	28	28	8	0	0	5	3
	0	0	0	0	0	0	0					
2006	1	2	0	2	2	29	29	6	0	0	2	3
	1	0	0	0	0	0	0					
2006	1	2	0	2	2	30	30	8	0	0	1	5
	1	1	0	0	0	0	0					
2006	1	2	0	2	2	31	31	6	0	0	0	3
	1	2	0	0	0	0	0					
2006	1	2	0	2	2	32	32	4	0	0	0	3
	0	1	0	0	0	0	0					
2006	1	2	0	2	2	33	33	4	0	0	0	3
	1	0	0	0	0	0	0					

2006	1	2	0	2	2	34	34	2	0	0	1	0
	0	1	0	0	0	0	0					
2006	1	2	0	2	2	35	35	1	0	0	0	0
	1	0	0	0	0	0	0					
2006	1	2	0	2	2	36	36	2	0	0	0	1
	1	0	0	0	0	0	0					
2006	1	2	0	2	2	37	37	2	0	0	0	0
	0	2	0	0	0	0	0					
2006	1	2	0	2	2	38	38	1	0	0	0	0
	0	1	0	0	0	0	0					
2007	1	2	0	2	2	27	27	1	0	0	0	1
	0	0	0	0	0	0	0					
2007	1	2	0	2	2	28	28	3	0	0	1	2
	0	0	0	0	0	0	0					
2007	1	2	0	2	2	29	29	1	0	0	0	1
	0	0	0	0	0	0	0					
2007	1	2	0	2	2	30	30	1	0	0	0	1
	0	0	0	0	0	0	0					
2007	1	2	0	2	2	32	32	3	0	0	0	3
	0	0	0	0	0	0	0					
2007	1	2	0	2	2	33	33	1	0	0	0	1
	0	0	0	0	0	0	0					
2008	1	2	0	2	2	27	27	2	0	0	2	0
	0	0	0	0	0	0	0					
2008	1	2	0	2	2	28	28	2	0	0	1	1
	0	0	0	0	0	0	0					
2008	1	2	0	2	2	29	29	2	0	0	1	1
	0	0	0	0	0	0	0					
2008	1	2	0	2	2	30	30	1	0	0	0	0
	1	0	0	0	0	0	0					
2008	1	2	0	2	2	31	31	1	0	0	0	0
	1	0	0	0	0	0	0					
2008	1	2	0	2	2	36	36	3	0	0	0	2
	1	0	0	0	0	0	0					
2008	1	2	0	2	2	37	37	1	0	0	0	1
	0	0	0	0	0	0	0					
2008	1	2	0	2	2	38	38	2	0	0	0	0
	0	1	1	0	0	0	0					
2008	1	2	0	2	2	40	40	1	0	0	0	0
	0	1	0	0	0	0	0					

2008	1	2	0	2	2	45	45	1	0	0	0	0
	0	0	0	0	1	0	0					
2009	1	2	0	2	2	26	26	1	0	0	1	0
	0	0	0	0	0	0	0					
2009	1	2	0	2	2	28	28	2	0	0	2	0
	0	0	0	0	0	0	0					
2009	1	2	0	2	2	29	29	2	0	0	0	2
	0	0	0	0	0	0	0					
2009	1	2	0	2	2	31	31	1	0	0	0	1
	0	0	0	0	0	0	0					
2009	1	2	0	2	2	32	32	1	0	0	0	0
	1	0	0	0	0	0	0					
2009	1	2	0	2	2	33	33	1	0	0	0	1
	0	0	0	0	0	0	0					
2009	1	2	0	2	2	49	49	1	0	0	0	0
	0	0	0	1	0	0	0					
2010	1	2	0	2	2	26	26	2	0	0	0	2
	0	0	0	0	0	0	0					
2010	1	2	0	2	2	27	27	2	0	0	0	2
	0	0	0	0	0	0	0					
2010	1	2	0	2	2	28	28	4	0	0	0	4
	0	0	0	0	0	0	0					
2010	1	2	0	2	2	29	29	2	0	0	1	1
	0	0	0	0	0	0	0					
2010	1	2	0	2	2	30	30	3	0	0	0	2
	1	0	0	0	0	0	0					
2010	1	2	0	2	2	32	32	1	0	0	0	1
	0	0	0	0	0	0	0					
2010	1	2	0	2	2	35	35	1	0	0	0	1
	0	0	0	0	0	0	0					

0 #_N_MeanSize-at-Age_obs
#Yr Seas Flt/Svy Gender Part Ageerr Ignore datavector(female-male)
samplesize(female-male)
0 #_N_environ_variables
0 #_N_environ_obs
0 # N sizefreq methods to read
0 # no tag data
0 # no morphcomp data
999
ENDDATA

3.9 Appendix B. Cobia.CTL File

```
#V3.24f
#_data_and_control_files: cobia_dat.ss // cobia_ctl.ss
#_SS-V3.24f-
safe;_08/03/2012;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_10.1
1  #_N_Growth_Patterns
1 #_N_Morphs_Within_GrowthPattern
#_Cond 1 #_Morph_between/within_stdev_ratio (no read if N_morphs=1)
#_Cond  1 #vector_Morphdist_(-1_in_first_val_gives_normal_approx)
#_Cond 0  #  N recruitment designs goes here if N_GP*nseas*area>1
#_Cond 0  #  placeholder for recruitment interaction request
#_Cond 1 1 1  # example recruitment design element for GP=1, seas=1, area=1
#_Cond 0 # N_movement_definitions goes here if N_areas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on
do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2, age1=4,
age2=10
1 #_Nblock_Patterns
2 #_blocks_per_pattern
# begin and end years of blocks
1927 1984 1985 2011
0.6 #_fracfemale
3 #_natM_type:_0=1Parm;
1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate
#3 #_reference age for Lorenzen function
#_Age_natmort_by gender x growthpattern
0.54636 0.599 0.485   0.432   0.404   0.387   0.376   0.370   0.366   0.363   0.361   0.360
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_speciific_K; 4=not
implemented
0.75 #_Growth_Age_for_L1
999 #_Growth_Age_for_L2 (999 to use as Linf)
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4
logSD=F(A)
3 #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by
growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss
0.0 0.0 0.5 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 #_placeholder for empirical age-maturity by growth
pattern
2 #_First_Mature_Age
```

3 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L; (5)eggs=a+b*W
0 #_hermaphroditism option: 0=none; 1=age-specific fxn
1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)
2 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)
Prior types (-1 = none, 0=normal, 1=symmetric beta, 2=full beta, 3=lognormal)
#_growth_parms
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
0.2 0.5 0.38 0.4 0 1 -3 0 0 0 0 0 0 0 # NatM_p_1_Fem_GP_1
30 60 41 41 -1 10 3 0 0 0 0 0.5 0 0 # L_at_Amin_Fem_GP_1
100 150 128.1 128.1 -1 10 3 0 0 0 0 0.5 0 0 # L_at_Amax_Fem_GP_1
0.05 0.8 0.3 0.42 -1 0.8 3 0 0 0 0 0.5 0 0 # VonBert_K_Fem_GP_1
0.01 0.5 0.1 0.1 0 -1 5 0 0 0 0 0.5 0 0 # CV_young_Fem_GP_1
0.01 0.5 0.1 0.1 0 -1 5 0 0 0 0 0.5 0 0 # CV_old_Fem_GP_1
0 1 0.00000964367 0.00000964367 0 0.1 -3 0 0 0 0 0.5 0 0 # Wtlen_1_Fem
0 4 3.03 3.03 0 0.8 -3 0 0 0 0 0.5 0 0 # Wtlen_2_Fem
50 100 70 70 -1 0.8 -3 0 0 0 0 0 0 0 # Mat50%_Fem
-1 0 -0.065 -0.065 -1 0.8 -3 0 0 0 0 0 0 0 # Mat_slope_Fem
0 3 1 1 -1 0.8 -3 0 0 0 0 0 0 0 # Eggs/kg_inter_Fem
0 3 1 1 -1 0.8 -3 0 0 0 0 0 0 0 # Eggs/kg_slope_wt_Fem
0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # RecrDist_GP_1
0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # RecrDist_Area_1
0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # RecrDist_Seas_1
0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # CohortGrowDev
#_Cond 0 #custom_MG-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-environ parameters
#_Cond 0 #custom_MG-block_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-block parameters
#_Cond No MG parm trends
#_seasonal_effects_on_biology_parms
0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#_Cond -4 #_MGparm_Dev_Phase
#
#_Spawner-Recruitment
3 #_SR_function: 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm

#_LO HI INIT PRIOR PR_type SD PHASE
 1 20 7.05864 7.05 -1 10 1 # SR_LN(R0)
 0.2 1 0.8 0.8 -1 0.05 4 # SR_BH_steep
 0 2 0.6 0.6 -1 0.8 -4 # SR_sigmaR
 -5 5 0.1 0 -1 1 -3 # SR_envlink
 -5 5 0 0 -1 1 -4 # SR_R1_offset
 0 0 0 0 -1 0 -99 # SR_autocorr
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
1 #do_recdev: 0=none; 1=devvector; 2=simple deviations
1982 # first year of main recr_devs; early devs can preceed this era
2010 # last year of main recr_devs; forecast devs start in following year
2 #_recdev phase
1 # (0/1) to read 13 advanced options
0 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
-4 #_recdev_early_phase
0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
1 #_lambda for Fcast_recr_like occurring before endyr+1
1972 #_last_early_yr_nobias_adj_in_MPD
1983 #_first_yr_fullbias_adj_in_MPD
2009 #_last_yr_fullbias_adj_in_MPD
2011 #_first_recent_yr_nobias_adj_in_MPD
1 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
0 #_period of cycles in recruitment (N parms read below)
-5 #min rec_dev
5 #max rec_dev
0 #_read_recdevs
#_end of advanced SR options
#
#Fishing Mortality info
0.3 # F ballpark for tuning early phases
-2010 # F ballpark year (neg value to disable)
2 # F_Method: 1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
2.9 # max F or harvest rate, depends on F_Method
no additional F input needed for Fmethod 1
if Fmethod=2; read overall start F value; overall phase; N detailed inputs to read
if Fmethod=3; read N iterations for tuning for Fmethod 3
0.05 1 3 # overall start F value; overall phase; N detailed inputs to read
#Fleet Year Seas F_value se phase (for detailed setup of F_Method=2)
1 1927 1 0.01 0.05 1

```
2 1950 1 0.01 0.05 1
3 1945 1 0.01 0.05 1
#
#_initial_F_parms
#_LO HI INIT PRIOR PR_type SD PHASE
 0 1 0 0.01 0 99 -1 # InitF_1Com_Combined_1
 0 1 0 0.01 0 99 -1 # InitF_2Recreational_Combined_2
 0 1 0 0.01 0 99 -1 # InitF_3Shrimp_Bycatch_3
#
#_Q_setup
 # Q_type options:  <0=mirror, 0=float_nobiasadj, 1=float_biasadj, 2=parm_nobiasadj,
3=parm_w_random_dev, 4=parm_w_randwalk, 5=mean_unbiased_float_assign_to_parm
#_for_env-var:_enter_index_of_the_env-var_to_be_linked
#_Den-dep  env-var  extra_se  Q_type
 0 0 0 0 # 1 Com_Combined_1
 0 0 0 0 # 2 Recreational_Combined_2
 0 0 0 2 # 3 Shrimp_Bycatch_3
 0 0 0 0 # 4 MRFSS_4
#
#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q;
1=read a parm for each year of index
#_Q_parms(if_any)
# LO HI INIT PRIOR PR_type SD PHASE
 -10 20 1 1 -1 1 1 # Q_base_3_Shrimp_Bycatch_3
#
#_size_selex_types
#discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_dead
#_Pattern Discard Male Special
 1 2 0 0 # 1 Com_Combined_1
 1 2 0 0 # 2 Recreational_Combined_2
 24 3 0 0 # 3 Shrimp_Bycatch_3
 5 0 0 2 # 4 MRFSS_4
#
#_age_selex_types
#_Pattern ___ Male Special
 11 0 0 0 # 1 Com_Combined_1
 15 0 0 1 # 2 Recreational_Combined_2
 11 0 0 0 # 3 Shrimp_Bycatch_3
 15 0 0 1 # 4 MRFSS_4
```

#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
Commercial selectivity (2), retention (4), discard mortality (4)
40 150 80 80 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_2P_1_Com_Combined_2
1 60 15 20 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_2P_2_Com_Combined_2
30 100 83 83 -1 99 -3 0 0 0 0 0.5 1 2 # Retain_1P_1_Com_Combined_1
-1 20 1 1 -1 99 -3 0 0 0 0 0.5 1 2 # Retain_1P_2_Com_Combined_1
0 1 1 1 -1 99 -2 0 0 0 0 0.5 0 0 # Retain_1P_3_Com_Combined_1
-1 2 0 0 -1 99 -4 0 0 0 0 0.5 0 0 # Retain_1P_4_Com_Combined_1
-10 10 -5 -5 -1 99 -2 0 0 0 0 0.5 0 0 # DiscMort_1P_1_Com_Combined_1
-1 2 1 1 -1 99 -4 0 0 0 0 0.5 0 0 # DiscMort_1P_2_Com_Combined_1
-1 2 0.05 0.05 -1 99 -2 0 0 0 0 0.5 0 0 # DiscMort_1P_3_Com_Combined_1
-1 2 0 0 -1 99 -4 0 0 0 0 0.5 0 0 # DiscMort_1P_4_Com_Combined_1
Recreational selectivity (2), retention (4), discard mortality (4)
40 150 70 70 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_2P_1_Recreational_Combined_2
1 60 10 10 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_2P_2_Recreational_Combined_2
30 100 83 83 -1 99 -3 0 0 0 0 0.5 1 2 # Retain_2P_1_Recreational_Combined_2
-1 20 1 1 -1 99 -3 0 0 0 0 0.5 1 2 # Retain_2P_2_Recreational_Combined_2
0 1 1 1 -1 99 -2 0 0 0 0 0.5 0 0 # Retain_2P_3_Recreational_Combined_2
-1 2 0 0 -1 99 -4 0 0 0 0 0.5 0 0 # Retain_2P_4_Recreational_Combined_2
-10 10 -5 -5 -1 99 -2 0 0 0 0 0.5 0 0 # DiscMort_2P_1_Recreational_Combined_2
-1 1 1 1 -1 99 -4 0 0 0 0 0.5 0 0 # DiscMort_2P_2_Recreational_Combined_2
-1 2 0.05 0.05 -1 99 -2 0 0 0 0 0.5 0 0 # DiscMort_2P_3_Recreational_Combined_2
-1 2 0 0 -1 99 -4 0 0 0 0 0.5 0 0 # DiscMort_2P_4_Recreational_Combined_2
Shrimp fishery selectivity (6)
20 60 35 35 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_3P_1_Shrimp_Bycatch_3
-15 5 -3 -3.4 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_3P_2_Shrimp_Bycatch_3
-15 10 -2 -5 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_3P_3_Shrimp_Bycatch_3
-12 6 5 5 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_3P_4_Shrimp_Bycatch_3
-15 15 -10 -2 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_3P_5_Shrimp_Bycatch_3
-15 15 -10 -2 -1 99 5 0 0 0 0 0.5 0 0 # SizeSel_3P_6_Shrimp_Bycatch_3
MRFSS selectivity bins (2)
1 57 1 1 -1 99 -1 0 0 0 0 0 0 0 # SizeSel_4P_1_MRFSS_4
1 57 57 53 -1 99 -1 0 0 0 0 0 0 0 # SizeSel_4P_2_MRFSS_4
Age selectivity
0 15 0 0 -1 99 -1 0 0 0 0 0 0 0 # AgeSel_1P_1_Com_Combined_1
0 15 15 15 -1 99 -1 0 0 0 0 0 0 0 # AgeSel_1P_2_Com_Combined_1
0 15 0 0 -1 99 -1 0 0 0 0 0 0 0 # AgeSel_3P_1_Shrimp_Bycatch_3
0 15 15 15 -1 99 -1 0 0 0 0 0 0 0 # AgeSel_3P_2_Shrimp_Bycatch_3
#_Cond 0 #_custom_sel-env_setup (0/1)

#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no enviro fxns
1 #_custom_sel-blk_setup (0/1)
Retention time block setup
30 85 40 52.4316 -1 1 -6 # Retain_1P_1_Com_Combined_1_BLK1repl_1927
70 100 83.8 83 -1 1 6 # Retain_1P_1_Com_Combined_1_BLK1repl_1988
0 20 2 10 -1 1 -4 # Retain_1P_2_Com_Combined_1_BLK1repl_1927
0 20 2 5 -1 1 6 # Retain_1P_2_Com_Combined_1_BLK1repl_1988
30 85 40 60 -1 1 -6 # Retain_2P_1_Recreational_Combined_2_BLK1repl_1927
70 100 83.8 83 -1 1 6 # Retain_2P_1_Recreational_Combined_2_BLK1repl_1988
0 20 2 10 -1 99 6 # Retain_2P_2_Recreational_Combined_2_BLK1repl_1927
0 20 2 5 -1 99 6 # Retain_2P_2_Recreational_Combined_2_BLK1repl_1988
#_Cond No selex parm trends
#_Cond -4 # placeholder for selparm_Dev_Phase
1 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)
#
Tag loss and Tag reporting parameters go next
0 # TG_custom: 0=no read; 1=read if tags exist
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0 #_placeholder if no parameters
#
1 #_Variance_adjustments_to_input_values
#_fleet: 1 2 3 4
0 0 0 0 #_add_to_survey_CV
0 0 0 0 #_add_to_discard_stddev
0 0 0 0 #_add_to_bodywt_CV
1 1 1 1 #_mult_by_lencomp_N
1 1 1 1 #_mult_by_agecomp_N
1 1 1 1 #_mult_by_size-at-age_N
#
7 #_maxlambdaphase
1 #_sd_offset
#
0 # number of changes to make to default Lambdas (default value is 1.0)
Like_comp codes: 1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;
9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin
#like_comp fleet/survey phase value sizefreq_method
#
lambdas (for info only; columns are phases)

0 #_CPUE/survey:_1
1 #_CPUE/survey:_2
1 #_CPUE/survey:_3
1 #_CPUE/survey:_4
1 #_discard:_1
1 #_discard:_2
1 #_discard:_3
0 #_discard:_4
1 #_lencomp:_1
1 #_lencomp:_2
1 #_lencomp:_3
0 #_lencomp:_4
0 #_agecomp:_1
1 #_agecomp:_2
0 #_agecomp:_3
0 #_agecomp:_4
1 #_init_equ_catch
1 #_recruitments
1 #_parameter-priors
1 #_parameter-dev-vectors
1 #_crashPenLambda
0 # (0/1) read specs for more stddev reporting
 # 0 1 -1 5 1 5 1 -1 5 # placeholder for selex type, len/age, year, N selex bins, Growth pattern, N growth ages, NatAge_area(-1 for all), NatAge_yr, N Natages
 # placeholder for vector of selex bins to be reported
 # placeholder for vector of growth ages to be reported
 # placeholder for vector of NatAges ages to be reported
999

3.10 Appendix C. Starter.SS File

```
#Starter file for cobia full SS3 model
#Stock Synthesis Version 3.24
cobia_dat.ss
cobia_ctl.ss
0 # 0=use init values in control file; 1=use ss3.par
1 # run display detail (0,1,2)
1 # detailed age-structured reports in REPORT.SSO (0,1)
0 # write detailed checkup.sso file (0,1)
4 # write parm values to ParmTrace.sso
2 # report level in CUMREPORT.SSO (0,1,2)
1 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence
0 # Number of bootstrap datafiles to produce
7 # Turn off estimation for parameters entering after this phase
1000 # MCMC burn interval
100  # MCMC thin interval
0.2  # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr)
-2 # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0 # N individual STD years
0.0001 # final convergence criteria
0 # retrospective year relative to end year
1 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator
4 # (1-SPR)_reporting:  0=skip; 1=rel(1-SPR); 2=rel(1-SPR_MSY); 3=rel(1-SPR_Btarget);
4=notrel
1 # F_std reporting: 0=skip; 1=exploit(Bio); 2=exploit(Num); 3=sum(frates)
1 # F_report_basis: 0=raw; 1=rel Fspr; 2=rel Fmsy ; 3=rel Fbtgt
999
```

3.11 Appendix D. Forecast.SS File

#C generic forecast file
#V3.20b
for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for rel.endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
1 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.3 # SPR target (e.g. 0.40)
0.3 # Biomass target (e.g. 0.40)
0 0 -5 0 0 0 #_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
1 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
10 # N forecast years
0.2 # F scalar (only used for Do_Forecast==5)
-5 0 -2 0 #_Fcast_years: beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel.endyr)
2 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB))
0.01 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40)
0.001 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
1.0 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1-3) (fixed at 3 for now)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)
2013 #FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
2013 # Rebuilder: first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2014 # Rebuilder: year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F: 1=use first-last alloc year; 2=read seas(row) x fleet(col) below
Note that fleet allocation is used directly as average F if Do_Forecast=4
2 # basis for fcast catch tuning and for fcast catch caps and allocation (2=deadbio; 3=retainbio; 5=deadnum;6=retainnum)
Conditional input if relative F choice = 2
Fleet relative F: rows are seasons, columns are fleets
#_Fleet: FISHERY1
1
max totalcatch by fleet (-1 to have no max)
-1 -1 -1
max totalcatch by area (-1 to have no max)
-1

fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
0 0 0
#_Conditional on >1 allocation group
allocation fraction for each of: 0 allocation groups
no allocation groups
12 # Number of forecast catch levels to input (else calc catch from forecast F)
99 # basis for input Fcast catch: 2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
Input fixed catch values
#Year Seas Fleet Catch(or_F)

2012	1	1	0.0993
2012	1	2	0.4123
2012	1	3	0.0919
2013	1	3	0.0919
2014	1	3	0.0919
2015	1	3	0.0919
2016	1	3	0.0919
2017	1	3	0.0919
2018	1	3	0.0919
2019	1	3	0.0919
2020	1	3	0.0919
2021	1	3	0.0919

999 # verify end of input

SEDAR

Southeast Data, Assessment, and Review

SEDAR 28
Gulf of Mexico Cobia

SECTION IV: Research Recommendations
April 2013

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

Section IV: Research Recommendations

Contents

Data Workshop Research Recommendations:
Gulf of Mexico Cobia

Life History

- Implement a tagging study along the entire east coast of Florida and evaluate genetic samples from the same to determine more precise stock boundaries.
- Explore the feasibility of satellite tags for Cobia movement studies.
- Provide genetic sampling kits to interested groups to better understand the stock division line between the Gulf and Atlantic Cobia stocks. Possible collectors of genetic samples could include Charter operators, fishing clubs and state fisheries personnel.
- Recommend developing a tagging program for inshore and offshore South Atlantic Cobia populations. The goal would be to deploy tags inshore during the spring migration and offshore during the fall and winter to get a clearer picture of fall and spring migrations and to better identify spawning areas and aggregations.
- Conduct research on cobia release mortality.
- To increase overall amount of data available, have port samplers do complete workups when sampling, including otolith removal for aging, length, weight, sex, genetic sampling and record a catch location.

Commercial Statistics
The WG determined the following recommendations be added to any pending recommendations issued in SEDAR 17 that have not been addressed:

- Need expanded observer coverage for the fisheries encountering cobia
    - 5-10% allocated by strata within states
    - get maximum information from fish
- Need research methods that capture cobia in large enough numbers to create a reasonable index for young (age 0) cobia
- Expand TIP sampling to better cover all statistical strata
    - Predominantly from Florida and by hand line
    - Greater emphasis on collecting unbiased samples
- Establish a mechanism for identifying age samples that were collected by length or market categories, so as to better address any potential bias in age compositions.
- Need better information on migration patterns
- Need to address issue of fish retained for bait (undersized) or used for food by crew (how to capture in landings)
- Compiling commercial data is surprisingly complex. As this is the 28th SEDAR, one might expect that many of the complications would have been resolved by now through better coordination among NMFS, ACCSP, and the states. Increased attention should be given toward the goal of "one-stop shopping" for commercial data.

Recreational Statistics

- Increase proportion of fish with biological data within MRFSS sampling.
- Continue to develop methods to collect a higher degree of information on released fish (length, condition, etc.) in the recreational fishery.
- Require mandatory reporting for all charter boats state and federal.
- Continue development of electronic mandatory reporting for for-hire sector.
- Continued research efforts to incorporate/require logbook reporting from recreational anglers.
- Establish a review panel to evaluate methods for reconstructing historical landings (SWAS, FWS, etc.).
- Quantify historical fishing photos for use in reconstructing recreational historical landings.
- Narrow down the sampling universe. Identify angler preference and effort. Require a reef fish stamp for anglers targeting reef fish, pelagic stamp for migratory species, and deepwater complex stamp for deep-water species. The program would be similar to the federal duck stamp required of hunters. This would allow the managers to identify what anglers were fishing for.
- Continue and expand fishery dependent at-sea-observer surveys to collect discard information, which would provide for a more accurate index of abundance.

Indices

None provided.

Assessment Workshop Research Recommendations:
Gulf of Mexico Cobia

Gulf of Mexico cobia suffers some of the same problems that make assessments of data poor species so difficult. There is not a large targeted fishery for cobia and they tend to occur mostly as an opportunistic catch. For this reason, many sources of data lacked sufficient sample sizes to be included in the assessment. Given the low frequency of positive catches per trip, both of the fishery dependent indices of abundance and the annual estimates of recreational discards were sensitive to individual positive catches.

The majority of the length composition data, all of the age-composition data, and both indices of abundance came from the recreational fishery which is the primary fishery. The landings data are dominated by the recreational fishery; however, catches prior to 1981 are likely highly uncertain. Uncertainty in the hindcast estimates of recreational landings was not incorporated into the model and should be evaluated in future assessments.
Data on the size of discarded fish was lacking for the recreational fishery. The reef fish observer program provided some information on the size composition of released fish for the commercial fishery in recent years. This information helped in estimating the selectivity and retention parameters of the commercial fishery. Length composition data of discarded fish for the recreational fishery would have improved the assessment model.

Lack of age composition data restricted the assessment from being able to track cohorts through time or identify strong year classes. A systematic age sampling program for the recreational fishing sector would improve future assessments.

The parameters describing early growth of cobia and the selectivity pattern of the shrimp fishery had the greatest uncertainty and required extensive model diagnostics to reconcile. Additional information on the size selectivity patterns for the shrimp fishery would have improved the assessment model.

Review Workshop Research Recommendations:
Gulf of Mexico Cobia

Reviewer #1:
I support the Research Recommendations presented by the Data Workshop. In particular and given the lack of information on cobia recruitment, the development of a recruitment (age 0) index for this important stock is recommended.

A tagging study to identify spawning areas and aggregations would be valuable if additional conservation measures were to be required. The development of a fishery-independent index of abundance is recommended.

Reviewer #2:
A number of research needs, which are listed below in order of priority, were identified in the course of the desk review. As expected, these were highly consistent with, and thus overlap, many of the research needs that had been identified by the Data and Assessment workshops.

1. Review or establish programs to collect data on the length composition and age-at-length compositions of landings and discards from each commercial gear and from each recreational fishing mode, and of bycatch of cobia from the shrimp fishery. Ensure that the statistical design and spatial coverage of survey or sampling programs are appropriate and that survey or sampling intensity is sufficient to produce estimates of the required precision for Gulf of Mexico cobia. Set goals for performance and establish and monitor performance criteria to assess the quality and completeness of data collection programs. This item is of the highest priority as it will provide information required by Stock Synthesis to determine the selectivity and retention curves for cobia for the commercial, recreational, and shrimp fisheries, the lack of which is a key source of uncertainty in the model.

2. Undertake research to determine reliable relationships between the proportion of females that are mature and both length and age for the Gulf of Mexico stock of cobia. This item is also of high priority, as the maturity information that is currently used is imprecise. The calculation of spawning stock biomass, a crucial parameter in the calculation of benchmarks and assessment of stock status, should be based on reliable data.

3. Review programs that are used to collect discard data for cobia (and data on the bycatch of cobia by the shrimp fishery), and refine these programs to ensure that accurate and complete data estimates of the discards (and bycatch) are collected. Ensure that the statistical design and spatial coverage of survey or sampling programs are appropriate and that survey or sampling intensity is sufficient to produce estimates for Gulf of Mexico cobia that are of the required precision. Set goals for performance and establish and monitor performance criteria to assess the quality and completeness of data collection programs and provide feedback regarding performance to those programs. While this research item will not provide immediate improvement in the quality of the

1. assessment, it is important that action is taken as soon as possible to improve the accuracy and precision of the data relating to the quantities of fish that are discarded from each of the fisheries, such that, in the future, the time series of discards become more reliable.

4. A comprehensive genetic study of cobia should be undertaken, with the following objectives:
    a. To confirm the preliminary genetic findings of Darden for cobia in the Gulf of Mexico and US Atlantic Coast, using samples with sample sizes greater than 100 at all sites, thereby addressing the issue in that earlier study that sizes of samples from the north of the Gulf of Mexico and from waters off the west coast of Florida had been small;
    b. To increase the spatial resolution of the genetic sampling in the region of overlap of the two stocks, such that the boundary between the stocks or extent of overlap can be determined;
    c. To extend sampling into Mexican waters and thereby determine the southern boundary of the Gulf of Mexico stock;
    d. To reconcile the differences in the findings reported in SEDAR28-DW01 and those reported in SEDAR28---RD09, where the former advises that collections from offshore in the Gulf of Mexico were genetically distinct from those offshore in the South Atlantic region while the latter reports that the results of the study "suggest the offshore groups are genetically homogenous, even between the SA and GOM";
    e. To extend sampling beyond the spawning season and ascertain whether catches of fish may be assigned reliably to either the Gulf of Mexico or South Atlantic stock on the basis of the area in which they are caught. Some of the objectives of this study, *e.g*., identification of the southern boundary of the stock, would also benefit from tagging or other studies.

    As this study will take some time before completion, it has been assigned a lower priority than the previous items. Determination of the southern stock boundary, however, is important to ensure that other removals from the stock are not occurring in Mexican waters, as such removals are not taken into account in the current assessment.

5. Undertake research to determine the discard mortality of Gulf of Mexico cobia that are discarded from the catches of each commercial fishing gear or each recreational fishing mode, recognizing that such mortality is likely to differ among different categories into which the discarded fish are classified, *e.g*., "alive", "mostly alive", and "mostly dead".

6. In future stock assessments for the Gulf of Mexico stock of cobia, explore whether the use of an age-dependent rather than constant *M* results in a significant improvement in fit, considering the Lorenzen and alternative functional forms of the relationship with age and the alternative of estimating the value of the age-dependent *M* at each age (or range of ages).

7. In future stock assessments, explore the sensitivity of the model to the uncertainty of the landings data.

8. Develop an ageing error matrix for Gulf of Mexico cobia.

9. A research study should be undertaken to determine an approach (or approaches) by which an appropriate range (or ranges) of feasible values of *M* for a species might be selected for use in stock assessment as alternate plausible states of nature. The need to determine an appropriate range for sensitivity runs arose in both the cobia and Spanish mackerel assessments, but the final decisions on the range to use were rather arbitrary and subjective. The issue arises in almost all assessments and it would be useful to establish an objective protocol to determine an appropriate range of values of *M* to be explored.

10. Develop a fishery-independent survey for Gulf of Mexico cobia, or investigate what changes would be required to make data from an existing fishery-independent survey appropriate for use as an index of abundance.

11. As a low research priority, assess whether, in future refinement of the Stock Synthesis model, sexually dimorphic growth should be introduced. Note that the benefit of this might only be realized if appropriate sex composition data for landings and discards are available for input, and length and age-at-length compositions are sexually disaggregated.

Reviewer #3:

In the short-term, a new assessment is needed. There are no defensible abundance indices and it will hard to produce any quickly. Therefore, an assessment which looks at worst case scenarios should be considered. If the stock is in reasonable shape even at biomass levels that would only just allow the estimated catch to have been taken, then there is no rush to produce a full assessment.

Of course, a reliable assessment generally requires a defensible abundance time series. The development of such a series should be the top priority. Pursuit of such an index should also provide some answers on what other data need to be collected to provide defensible indices for cobia.

A workshop should be held to train people in the analysis and post-stratification of composition data.

My main recommendations are:

- Top priority should be given to the construction of defensible abundance indices for both cobia and Spanish mackerel from the commercial and recreational data. I suggest the following approach:
  - Discussion with some of the participants in the fisheries to get some understanding of how, when, and where, they target cobia and Spanish mackerel.

  - A full descriptive/exploratory analysis of the data to understand the temporal and spatial variation in the catches and all of the available explanatory variables.
  - Identification of regional and seasonal fisheries for which fishing effort is likely to catch the species of interest (cobia or Spanish mackerel). This is likely to involve the identification of vessels in each year which fish at the times and places of interest and catch the species on some of their trips. It does not require that individual vessels be tracked across years (although that would be ideal).
  - An analysis to determine if fishing regulations have impacted on the ability of the data to track abundance (time series may have to be split to account for different fishing behavior caused by regulation changes)
  - Production of standardized CPUE indices for each identified regional/seasonal fishery
  - Comparison of the trends across the different fisheries
  - Decide which if any of the CPUE indices are defensible as relative abundance indices (the length of the time series is not relevant to this decision).
- If defensible abundance indices can be constructed then assessments can be done as before except:
  - Composition data should be appropriately post-stratified and scaled; sample sizes should be based on the number of trips/landings sampled (not the number of fish measured or aged). This will require an analysis of the variability in length frequencies and proportion-at-age for given length across the various strata.
  - Recruitment deviates should only be estimated for cohorts which are well represented in the composition data (e.g., appear at least three times in the age data).
  - Steepness should be fixed or estimated with an informed prior.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 28

Gulf of Mexico Cobia

SECTION V: Review Report
April 2013

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

Table of Contents

1. Review Proceedings

1.1 Introduction

1.1.1 Method of Review

The SEDAR 28 Review for Gulf of Mexico Spanish Mackerel (*Scomberomorus maculatus*) and Cobia (*Rachycentron canadum*) was conducted as a Center for Independent Experts (CIE) desk review. Three reviewers were provided with all information generated throughout the Data and Assessment Workshops and webinars, and each reviewer then provided an independent analysis of the stock.

1.1.2 Terms of Reference

1. Evaluate the quality and applicability of data used in the assessment.
2. Evaluate the quality and applicability of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.
5. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.
6. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.
    - Provide measures of uncertainty for estimated parameters
    - Ensure that the implications of uncertainty in technical conclusions are clearly stated
    - If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.
        - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments
        - Provide justification for the weightings used in producing the combinations of models
7. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.
8. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.
9. Make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring needs that could improve the reliability of future assessments

10. Prepare a Review Summary Report summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Review Summary Report no later than the date set by the Review Panel Chair at the conclusion of the workshop.

The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the SEDAR Guidelines and the SEDAR Review Panel Overview and Instructions.

The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made, alternate model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.

1.1.3 List of Participants

Reviewers

Beatriz Roel	Reviewer	CIE
Patrick Cordue	Reviewer	CIE
Norm Hall	Reviewer	CIE

1.1.4 List of Review Working Papers

Documents Prepared for the Review		
SEDAR28-GRW01	CIE Desk Review: SEDAR 28: Gulf of Mexico Spanish Mackerel and Cobia	Roel
SEDAR28-GRW02	CIE Desk Review: SEDAR 28: Gulf of Mexico Spanish Mackerel and Cobia	Cordue
SEDAR28-GRW03	CIE Desk Review: SEDAR 28: Gulf of Mexico Spanish Mackerel and Cobia	Hall

2. CIE Reviewer Summary Reports

The following CIE reviewer summary reports are the findings and opinions of the individual author of each report. Reviewers were not influenced by the findings and/or determinations of other reviewers involved in the SEDAR 28 review process for cobia.

Independent Peer Review Report on the SEDAR 28 Desk Review of the Gulf of Mexico Spanish Mackerel and Cobia Assessments

Dr. Beatriz A. Roel

Prepared for

Center for Independent Experts (CIE)

The Centre for Fisheries and Aquaculture Science
Lowestoft Laboratory
Pakefield Road
Lowestoft
Suffolk NR33 0HT
UK

Executive Summary

The assessments of Spanish mackerel and cobia in the Gulf of Mexico were reviewed independently for the Center for Independent Experts (CIE) without consultation with other reviewers or those who produced the assessments. The process extended from 9 January to 4 February 2013. The main conclusions are given separately by species.

The Gulf of Mexico Spanish mackerel stock assessment presented to the SEDAR 28 Assessment Workshop provided output and analysis of results from Stock Synthesis (SS), an integrated statistical catch-at-age model. The model was considered appropriate because it can make best use of the data available including a data-poor historical period. However, data limitations (a recruitment index and data that would inform the model on the stock's response to exploitation) have enforced the requirement for strong assumptions to be made on key parameters.

SS was used to estimate the stock status of Spanish mackerel in the Gulf of Mexico in relation to SPR30% reference points for the Base Run and each alternative model examined. The current stock status was estimated in the Base Run as SSB_{2011} / MSST = 2.96, and exploitation status as $F_{2009\text{-}2011}$ / $F_{SPR30\%}$ = 0.5. Sensitivity tests carried out resulted in estimates of key parameters for management that suggest that the stock is above MSST and exploited below MFMT. The results suggest that the Gulf of Mexico Spanish mackerel stock is not overfished under any of the model scenarios examined and that it is not undergoing overfishing under any of the scenarios examined.

The Spanish mackerel assessment would benefit from the development of an enhanced biological sampling programme. For instance, the development of a research recruitment index would inform the model on the process and possibly preclude the introduction of such strong assumptions.

The Gulf of Mexico cobia assessment was based on results from SS. The assessment used data through 2011 and the time period of the assessment is 1926–2011. Model projections were run from 2013 to 2019. The estimated biomass trajectories showed a sharp decline as the fisheries developed, reaching levels below the minimum stock threshold (MSST) in the late 1980s and early 1990s. Since then the stock appears to have fluctuated above and below the target spawning stock biomass.

Benchmark and reference points for fishing mortality and stock biomass were estimated relative to SPR 30% which were presented for the base case and for each of the sensitivity runs. For cobia, SPR30% reference points are considered valid proxies for MSY. For the base model $F_{current\ (2009–2011)}$ / $F_{SPR30\%}$ was 0.63, whereas the current spawning biomass (2011) relative to MSST was 1.73; on that basis the stock is not considered to be overfished nor undergoing overfishing.

The stock was considered neither overfished nor undergoing overfishing in most of the sensitivity scenarios explored. In the case of low natural mortality, the more pessimistic scenario, both the F_{SPR30} and F_{OY} scenarios led to future stock conditions where the stock was no longer overfished nor undergoing overfishing by 2014. However, fishing under current F predicted a stock undergoing overfishing throughout the projection period.

The lack of information on recruits of age 0 in the data increased the uncertainty of the assessment and the evaluation of the stock relative to reference points. The development of a fishery-independent recruitment index is recommended.

Background

SEDAR 28 consisted of a compilation of data, an assessment of the stocks, and an assessment review conducted for Gulf of Mexico Spanish mackerel and cobia. The Center for Independent Experts (CIE) review for SEDAR 28 was scheduled from 9–24 January 2013, with the deadline for submission of the Peer Review Report on 4 February 2013. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 28 are within the jurisdiction of the Gulf of Mexico Fisheries Management Council and states in the Gulf of Mexico region.

Three CIE reviewers with the requisite qualifications to complete an impartial and independent peer review in accordance with the statement of work (SoW) tasks and terms of reference (ToRs) specified herein participated in the process. They were selected on the basis of their expertise in stock assessment, statistics, fisheries science and marine biology being deemed sufficient to complete the tasks of the peer review described herein. Each CIE reviewer participated and conducted an independent peer review as a desk review, so travel was not required.

Description of the Individual Reviewer's Role in the Review Activities

I participated in all aspects of the review. In particular, I conducted the necessary pre-review preparations, including reviewing background material and reports provided by the NMFS Project Contact in advance of the peer review. I then conducted an impartial and independent (of anyone else) peer review in accordance with the tasks and ToRs specified herein, focusing on the data analyses, parameter estimation and associated uncertainties and the implications for management advice.

SPANISH MACKEREL

Findings by ToR

1. Evaluate the quality and applicability of data used in the assessment

A wide range of commercial, recreational and research data was made available for the stock assessment. The data were explored extensively at the Data Workshop (DW).

Life history: The available life history information was reviewed and the main issues were considered carefully. The information does seem to be adequate to conduct a stock assessment. The DW followed the Life History Group recommendation to model the natural mortality rate (M) as a declining Lorenzen function of size consistent with previous SEDAR recommendations.

Discard mortality depends on the conditions of the catching process, including the type of gear utilised. Gillnets had few discards because of its selectivity patterns, but discard mortality does appear to be very high. The shrimp trawl fishery results in very high discard mortality (virtually 100%). There is in fact limited information available on discard mortality for Spanish mackerel, so the values for the gillnet, shrimp trawl and handline fisheries were agreed on the basis of fisher experience and "common sense" and recommended to the Assessment Workshop (AW). Testing the sensitivity to these assumptions would be appropriate here.

The growth models considered seemed to be appropriate, and the decision to combine sexes given practical considerations (the fishery does not distinguish them) is sensible. The scarcity of small fish in the samples did result in growth parameters being rather unrealistic, but the output was adjusted to more biologically reasonable values.

Based on different data sources, it appears that insufficient gonad samples are being collected for histological analyses.

<u>Commercial fishery statistics</u>: Commercial landings data have been developed by gear for the period 1890–2010 and appear to be adequate to support the assessment, although the landings prior to 1950 are considered to be highly uncertain. Landings were aggregated by gillnet, handline and miscellaneous gears, but for assessment purposes, the category miscellaneous is assigned proportionally into gillnet and handline categories.

<u>Shrimp fishery discards</u>: A median value was assumed over the entire period 1945–2011. Initially, this seemed a somewhat questionable decision given that annual shrimp fishery effort was available and a catchability parameter estimated, allowing annual estimates of Spanish mackerel bycatch to be computed. However, bycatch in the shrimp fishery appeared difficult to determine given the low encounter rate between shrimp trawls and Spanish mackerel, and because of irregular observer coverage. As a consequence, the annual variability in shrimp bycatch appeared to be poorly estimated. The decision to impose a super-period based on an estimated mean bycatch seemed therefore to be appropriate.

<u>Commercial discards</u>: These were computed for the period 1998–2010 based on a gear-specific discard rate and effort data. The method seemed to be appropriate but cannot be applied prior to 1998. Discard estimates are, of course, more uncertain than the landings. A weakness here is that the calculated discards may only represent the minimum number of discards made by the commercial fisheries.

<u>Biological sampling</u>: Sample sizes for developing length compositions were inadequate for a considerable number of years and gear strata. This may jeopardise the use of length compositions to correct for potential biases in age compositions in those years.

<u>Recreational fishery statistics</u>: Landings appear to be adequately recorded or estimated for the period covered. For historical recreational landings, a period is defined as pre-1981, with removals for the years 1955–1981 based on a hindcast. It is difficult to assess

the strengths and weaknesses of this data series based on the report of the Data Workshop.

Discards: Sample sizes for Spanish mackerel in the observer data are very small. Some extrapolations were applied and proxies used to calculate the discarded quanta from the different fisheries. There seem to be uncertainties here that need to be reconciled.

Biological sampling: The number of fish sampled is listed, but it is not possible to characterise the sample sizes because the sampling strategy and the targets are not shown. Size data appear to represent the landed catch for the charter and headboat sector adequately. Based on examination of the length composition histograms shown in Fig 4.12.21, sample sizes may have been rather small in recent years.

2. Evaluate the quality and applicability of methods used to assess the stock.

The assessment is carried out using Stock Synthesis (SS), a methodology widely used for stock assessment in the United States and elsewhere, including in Europe, where it is used to assess quite a few ICES stocks (ICES, 2012). Interaction with the model developer has contributed to correct implementation of the methodology, and it focused on the handling of discards, which were estimated according to “super periods”; however, the reasons and advantages of using this approach need to be stated more clearly. There is reference to a small CV associated with discards, but it is not clear how that was estimated.

Discard release mortality was incorporated in the model, but the rate seems to be based on rather few data.

A tool to conduct parametric bootstrap analyses was used to characterise uncertainty. This seems to have been a correct decision, because SS provides asymptotic standard errors only, which constitute a minimum estimate.

The model configuration seems to have been appropriate; it includes removals from three directed fisheries:

1. Commercial gillnet (COM-GN)
2. Commercial vertical line gears (Com_RR)
3. Recreational charter, private, headboat and shore anglers (REC)

Of these, the miscellaneous commercial category was apportioned into 1 and 2.

The model fits three indices of abundance (there is some confusion regarding the labelling of the fishery cpue indices on section 3.1.2 of the Assessment Workshop report):

1. Recreational (MRFSS),
2. Commercial line fishery (FWC Vertical line fishery),
3. SEAMAP fishery independent trawl survey.

The indices seem, however, to be very noisy generally, and varying without a trend.

Natural mortality is based on a declining Lorenzen function, and sensitivity to the various assumptions is explored throughout the stock assessment. This is an appropriate procedure because assumptions on the level of M are anticipated to be very influential.

Several parameters were fixed, namely steepness (h) and recruitment variability, but it is not that obvious that the sensitivity to such assumptions was explored sufficiently in the assessment process.

In terms of shrimp fishery discards, a median value was assumed over the entire period 1945–2011. It is not clear why this is done given that annual shrimp fishery effort was available and a catchability parameter estimated, allowing annual estimates of Spanish mackerel bycatch to have been computed.

Model configuration and equations: The shrimp effort index seems to be fitted well by the SS. The index is said to be used to derive annual estimates of F for the shrimp bycatch fleet. This seems to have been done by estimating the catchability Q parameter. However, F is then used to estimate the mackerel bycatch. Figure 3.3c shows the fit (straight line) to the "observed" discards. That procedure is not explained clearly, and specifying the equations would help understanding.

I believe that presentation of the likelihood function would go a long way towards interpreting the model fit to the data.

The fact that the model resulted in an unrealistic estimate for steepness needs further investigation. A plot of the time-series of total landings may provide some insight on the response of the stock to exploitation. Landings between the 1950s and the late 1990s were large, but abundance indices are only available from the 1980s on and do not seem to capture the response of the stock to the decrease in exploitation during recent years. In light of this, fixing steepness to a more realistic value would seem to be appropriate. The value assumed for steepness is the same as that assumed for South Atlantic Spanish mackerel, which would be expected to have similar dynamics.

There are obviously some poor fits to the length composition data, perhaps at least partly related to the model trying to fit the noisy data resulting from small sample sizes. The assessment team chose an assessment model that can make use of all data available, but it is a complex model that requires many assumptions, and the sensitivities to these were not always explored fully. Simpler age-structured production models (Restrepo and Legault 1998; De Oliveira *et al.*, 2007) run from 1981 on would require fewer assumptions, would be less labour-intensive, and may well perform adequately.

3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

A number of datasets were examined by the Data Workshop. Those considered appropriate for use in the assessment model were ranked according to their utility as indices of abundance.

1. SEAMAP Groundfish Survey (1987–2011). Recommended for use because it is a long time-series with good geographic coverage.
2. Florida Trip Ticket index (1986–2011) is recommended because it provides good spatial coverage. All indices are based on positive trips only, which is a limitation, and including zero trips would enhance the index's performance as

an indicator of abundance. The handline/trolling index is good because it covers a long period and samples the entire fishery, both inshore and offshore.

3. Recreational MRFSS Index (1981– 2011). This is a Cpue standardised index based on all trips.

The indices proposed are appropriate as indicators of abundance, representing both the commercial and the recreational fisheries as well as providing fishery-independent information. The recreational Headboat Index, based on all trips and standardised by means of a generalized linear model, was not used in the assessment. The reasons behind this decision are not clearly stated in the report.

A shrimp effort index was used to estimate Spanish mackerel mortality in the shrimp fishery.

4. *Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.*

The methods used to estimate population benchmarks and management parameters are based on MSY criteria and yield per recruit. MSY reference points are also supported by ICES, based on international agreements to achieve MSY for exploited stocks by 2015. MSY reference points are based on assumptions about the stock and recruitment functional form that may not be justified by the data. SPR reference points are well accepted proxies for MSY. For precautionary considerations, short-lived species and pelagic stocks should be kept above 30% virgin SPR (Caddy and Agnew, 2004).

The SS estimates of F_REF and SSB_REF (based on 30% SPR) from 1000 bootstrap samples (Figs 3.48-3.49) show that the probability of the stock being outside precautionary levels is very low. Results for the more pessimistic Run 1 also identify the stock as not overfished and not undergoing overfishing. Tables 3.7 and 3.8 provide the necessary values to assess the state of the stock relative to management benchmarks for all configurations presented for review.

5. *Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.*

Deterministic future population status were projected in terms of SSB and SSB and F relative to 30%SPR reference points for two values of steepness (0.8; 0.9) and three levels of exploitation. The projections are not sensitive to the steepness assumed. The results suggest that the stock is projected to remain within safe biological limits given the selected F, and will remain exploited below optimal levels. Note that the top and the bottom panels in Figure 3.52 are the same and that Figure 3.53 was not discussed in the Assessment Workshop report.

Figure 3.53 illustrates future yields for stochastic projections. Yields appear to be stabilising at levels above estimated MSY (Table 3.9).

6. *Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.*
    - *Verify that appropriate measures were provided*
    - *Verify that the implications of uncertainty in technical conclusions are clearly and acceptably stated*
    - *If there are significant changes to the base model, or to the choice of alternate states of nature, then verify that a probability distribution function for the base model, or a combination of models that represent alternate states of nature were provided.*

Asymptotic standard errors were computed for all the parameters estimated. As these tend to underestimate associated uncertainties, the results from a parametric bootstrap procedure (mean and standard error) are presented for key parameters. Mean and standard deviations resulting from bootstrapping were presented. Showing the median as a measure of central tendency and the CVs for comparison between parameters would probably have been a better choice of statistics.

Model estimates are highly sensitive to the value of steepness, which the model estimates poorly. Comparison of the distributions in Figures 3.34 and 3.35 shows that fixing steepness results in more sensible distributions for virgin biomass, SSB ref and R0.

Sensitivity tests were carried out to explore the impact of uncertainties in model parameters such as natural mortality (M) and steepness, data exclusion, data weighting and discard mortality, on parameters that have implications for management. The results from the analyses did not change the perception of the stock relative to reference points because none of the configurations explored suggested that the stock was outside safe biological limits. Interesting to note here is that the alternative exclusion of the abundance indices made little difference to the estimates of key parameters relative to the base run.

7. *If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.*

The stock assessment results are clearly stated in the Stock Assessment report. Table 3.9 addressed the MSRA evaluations requirements. Mortality rate and biomass criteria were estimated for steepness values of 0.8 and 0.9. Annual yields (2013–2022) are provided for F_{MFMT}, F_{OY} and $F_{current}$.

In terms of the requirements for projections, these were all met, although only total yields were provided. Projections were made under three scenarios for fishing mortality: $F_{current}$, F_{SPR30} (F_{msy}) and F_{OY}. Projections under $F_{rebuild}$ or F_0 were not necessary.

8. *Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.*

The SEDAR process results in a rigorous and in-depth review of the data made available and of the assessment. As this is a desk-based review, it lacks any possibility to include interaction with other reviewers of the same material or with the analysts, in my opinion undermining the quality of the review process. Succinctly, questions arising during the review cannot be addressed to those who conducted the analyses, nor was it possible for reviewers of varying skills to complement each others' skills in coming to an overall evaluation of the appropriateness of the methodology or outputs.

9. *Make any additional recommendations or prioritizations warranted.*

    - *Clearly denote research and monitoring needs that could improve the reliability of future assessments*

Increasing sample sizes for the length composition data in both extractions and surveys is recommended if this information is to be used in the assessment. Further, an expanded observer coverage in all Spanish mackerel fisheries would enhance data quality overall.

The sensitivity to uncertainties in the catch data do need to be explored in future.

I agree with the Data Workshop recommendation that there is need of research-based data where Spanish mackerel are caught in sufficiently large numbers to provide a reasonable index of young fish (age 0) abundance. There is currently very little signal of recruitment strength to inform the assessment.

Errata
Assessment Workshop Report
Figure 3.6 caption 2nd line: mackerel commercial **vertical line** gear fishery.
Figure 3.42 upper panel the y-axis needs to be expanded to include all exploitation rate values.
Figure 3.47 define FWC in the figure caption.
Figure 3.49 MFMP definition repeated.

Gulf of Mexico Cobia

Findings by ToR

1. *Evaluate the quality and applicability of data used in the assessment.*

Life history data used in the assessment included natural mortality, growth, maturity and fecundity. There is some uncertainty regarding life history characteristics for this stock because of a general paucity of data, so some common sense decisions were made by the Data Workshop and the Assessment Workshop, such as assuming 50% maturity at age 2 despite recognizing that maturity is better correlated with size. Despite the differential growth of males and females the decision to conduct the stock assessment on the basis of both sexes combined seemed appropriate.

<u>Landings</u>
In terms of commercial landings, the Data Workshop apportioned commercial landings into handline, longline and miscellaneous. For the assessment, commercial landings data (1927– 2011) were aggregated across gears; handline landings represent ~67% of the total commercial landings since 1981. The reason for aggregation is not clearly stated in the workshop reports but presumably is related to inadequate samples sizes for developing length compositions for sufficient year and gear strata, along with inadequate age composition data for all years. Landings data before 1950 are considered to be very uncertain.

Discard estimates have greater uncertainty than the landings and they are likely to be underestimated. The year-specific age structure of cobia could not always be estimated.

The bycatch of cobia in the shrimp fishery was estimated from observer data and SEAMAP trawl data, then scaled using shrimp effort.

Recreational landings data (1950–2011) were aggregated across modes and regions for the assessment. Landings data were collected from 1981 but were hindcast to 1950. Uncertainties in the historical period were estimated, but it is not clear whether those were taken into account in the assessment.

Discard information from recreational fisheries is limited; in other words the discard information reported by anglers cannot be verified, as some surveys simply do not estimate discard levels. Discarded fish size is unknown for all modes covered by MRFSS.

Biological data

Length composition data were collected in both commercial and recreational fisheries with reasonable sample sizes for the recreational fishery. However, given the minimum size limit in operation and the variable growth patterns of cobia, length frequency data did not provide sufficient information on historical recruitment patterns. Age composition data were collected, but there was too little information to be able to track cohorts through time.

Having reviewed the information presented by the Data Workshop and the Assessment Workshop, it was concluded that, despite certain limitations such as those mentioned above, the data provided for assessment were the best available. Every effort had clearly been made to eliminate potential biases and to make the best possible decisions in cases where data were missing. Those decisions and assumptions are fully documented in the report of the Data Workshop.

2. Evaluate the quality and applicability of methods used to assess the stock.

The stock was assessed by means of Stock Synthesis (SS), Methot 2011. Model configurations of increasing complexity were explored, showing that trends in estimated stock biomass remained similar as model complexity increased. The selected model seems to have been appropriate because it allows the assessors to make best use of the information that was available.

The assessment used data through 2011 and the time period of the assessment is 1926–2011. Model projections were run from 2013 to 2019. The assessment was set up to include three fishing fleets and two indices of abundance. The stock was assumed to be at equilibrium at the start of the modelled period in 1926. Removals of cobia were not substantial until after World War II for any of the fisheries.

A single Beverton & Holt stock–recruitment function was estimated in SS, although the reason for selecting this function was not stated. The model was configured to estimate steepness and equilibrium recruitment; however, steepness is very poorly estimated. Variability in recruitment was constrained by fixing sigma R to 0.6. The reality is that there were few data to inform the Beverton & Holt function parameters, and there is concern that the assumptions on steepness may be driving model results. However, the perception of the stock relative to reference points did not change for the range of steepness explored in the sensitivity tests, rendering the assumption at least credible. Estimated parameter standard deviations were generally small and the convergence test results suggested that the model converged with high probability.

Patterns in the residuals from the fit to length frequency data suggest that the model underestimated the numbers of small and large fish in the early period of the commercial data. This is probably related to small sample sizes in which fish at the extremes of the distribution would have been generally under-represented, resulting in selectivity curves that would have driven model predictions for the entire period. Given the paucity of length data, the assumption of time-invariant selection for all fisheries was appropriate. The model seemed to have underestimated small, undersize fish in the recreational fishery, which was hardly surprising.

3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

Estimates of SSB, total biomass and fishing mortality were provided by SS. The model predicted the trends in the two indices of catch per unit effort (CPUE) reasonably well, but the uncertainty associated with point estimates appeared to be large. The SSB trajectories show a sharp decline as the fisheries developed, reaching levels below MSST in the late 1980s and early 1990s. Model-predicted SSB is shown with associated 80% asymptotic intervals rather than 90% or 95% confidence intervals, which might be slightly deceiving. Fishing mortality was estimated to have decreased in the early 1990s, and varying with a slightly declining trend thereafter. Whereas F in the recreational fishery has fluctuated quite widely since the late 1990s, fishing mortality in both the commercial fishery and the shrimp fishery declined during the same period. Results from bootstrap analysis show greater uncertainties around the estimated trajectory of F than reflected by 80% asymptotic intervals.

4. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.

The state of the stock is primarily evaluated relative to 30% spawner-per-recruit population benchmarks. Those seem more appropriate in the case of Gulf of Mexico cobia than MSY reference points, which may be driven by assumptions about the stock–recruit relationship.

Stock status and benchmarks relative to SPR 30% were presented for the base case and each of the sensitivity runs. For the base model $F_{current\ (2009–2011)}$ / $F_{SPR30\%}$ was 0.63, whereas the current spawning biomass (2011) relative to MSST was 1.73; on that basis the stock is not considered to be overfished nor undergoing overfishing. Based on results from the bootstrap analysis for the base case, the $F_{current}$ /$F_{SPR30\%}$ ratio was estimated to be <1, with a high probability, and current SSB /MSST was estimated to be >1, also with a high probability.

The stock was considered neither overfished nor undergoing overfishing in most of the sensitivity scenarios explored. The exceptions were the low M scenario where the stock was considered both overfished and undergoing overfishing, and Run 7; for the latter, only the MRFSS index fitted, which suggested that the stock was overfished.

5. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.

Model projections carried out with SS were run from 2013 to 2019. The stock was projected under constant fishing mortalities: $F_{current}$, $F_{30\%SPR}$ and F_{OY}. Recruitment was projected by the fitted stock and recruit function. All scenarios explored show an increase in SSB and yields over the projection period as a result of predicting recruitment at a higher level than the recent average. A more pessimistic scenario of future recruitment, e.g., randomly selecting from the estimated recruitment between 2000 and 2009 (omitting 2010 and2011 as highly uncertain), would have been informative.

Fishing at $F_{current}$, $F_{30\%SPR}$ and F_{OY}, the stock is predicted to be within safe biological limits for the base case. For the most pessimistic scenario, low M, the stock is predicted to undergo overfishing under $F_{current}$ but not under $F_{30\%SPR}$ or $F_{OY.}$

For the base model, under the assumptions made in the projections, fishing the stock at $F_{30\%SPR}$ (F = 0.378) seems to lead to a long-term equilibrium yield below the estimated MSY. Yield per recruit F_{max} is estimated as well above F_{msy}.

6. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.

- *Verify that appropriate measures were provided*
- *Verify that the implications of uncertainty in technical conclusions are clearly and acceptably stated*
- *If there are significant changes to the base model, or to the choice of alternate states of nature, then verify that a probability distribution function for the base model, or a combination of models that represent alternate states of nature were provided.*

Asymptotic standard errors were computed for all the parameters estimated. As these tend to underestimate associated uncertainties, the results from a parametric bootstrap procedure (mean and standard error) were presented for key parameters. In general, estimates of uncertainty were similar between the two methods. The distributions of F and SSB relative to benchmark parameters from bootstrap samples were shown for the base model, suggesting that there is a high probability that the stock is neither overfished nor undergoing overfishing.

A number of alternative model configurations and states of nature were investigated in sensitivity tests. Iteratively re-weighting the different components did not reveal any conflicting information among alternative data sources. However, this sensitivity run favoured the Headboat index, leading to a conclusion of a slightly more productive stock and experiencing lower fishing mortalities.

The model was only fit assuming a Beverton & Holt stock–recruit relationship but fitting it to an alternative such as a smooth hockey stick would have been informative as a sensitivity test. As a general point, exploring alternative assessment models that do not require strong assumptions on the stock and recruitment functional form would provide clues on the sensitivity of the assessment results to structural assumptions.

Results from the retrospective analysis suggest a stable assessment and show no indication of substantial bias in the assessment. The analysis for age 0 recruits illustrates the uncertainty associated with recruit estimates for the final few years in a given assessment. This is to be expected given the lack of information on recruitment strength for year classes that have not passed through the fishery.

7. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.

Stock assessment results are accurately presented in the Stock Assessment Report and are consistent with the Panel recommendations.

8. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.

This review was conducted as a desk review which, in the opinion of this reviewer, might have been undermined by the lack of direct interactions with other members of the Panel and the analysts. The data analyses and stock assessment presented for review were of high standard and state of the art. Terms of Reference were addressed appropriately during the assessment process.

9. Make any additional recommendations or prioritizations warranted.

- *Clearly denote research and monitoring needs that could improve the reliability of future assessments.*

I support the Research Recommendations presented by the Data Workshop. In particular and given the lack of information on cobia recruitment, the development of a recruitment (age 0) index for this important stock is recommended.

A tagging study to identify spawning areas and aggregations would be valuable if additional conservation measures were to be required.

The development of a fishery-independent index of abundance is recommended.

References

Caddy, J. F. and Agnew, D. J. 2004. An overview of recent global experience with recovery plans for depleted marine resources and suggested guidelines for recovery planning. *Reviews in Fish Biology and Fisheries* **14**: 43–112.

De Oliveira, J. A. A., Boyer, H. J, and Kirchner, C. H. 2007. Developing age-structured production models as a basis for management procedure evaluations for Namibian sardine. *Fisheries Research* **85**: 148–158.

ICES. 2012. Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim. ICES Document CM 2012/ACOM: 11.

Restrepo, V. R. and C. M. Legault 1998. A Stochastic Implementation of an Age-Structured Production Model. Alaska Sea Grant College Program • AK-SG-98-01. *Fishery Stock Assessment Models* pp 435 – 450.

Appendix 1: **Bibliography of materials provided for review**

SEDAR 28 Gulf of Mexico Cobia Data Workshop Report, May 2012

SEDAR 28 Gulf of Mexico Spanish mackerel Data Workshop Report, May 2012

SEDAR 28 Gulf of Mexico Cobia, Assessment Workshop Report, Dec 2012

SEDAR 28 Gulf of Mexico Spanish Mackerel, Assessment Workshop Report, Dec 2012

Working Papers

SEDAR28-AW01 Florida Trip Tickets

SEDAR28-AW02 Spanish mackerel bycatch estimates from US Atlantic coast shrimp trawls

Appendix 2: **Statement of Work**

Statement of Work

External Independent Peer Review by the Center for Independent Experts

SEDAR 28: Gulf of Mexico Cobia and Spanish Mackerel Assessment Desk Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description SEDAR 28 will be a compilation of data, an assessment of the stocks, and an assessment review conducted for Gulf of Mexico Spanish mackerel and cobia. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 28 are within the jurisdiction of the Gulf of Mexico Fisheries Management Councils and states in the Gulf of Mexico region. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the statement of work (SoW) tasks and terms of reference (ToRs) specified herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall participate and conduct an independent peer review as a desk review, therefore travel will not be required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer contact information to the COR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the assessment and other pertinent background documents for the peer review. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an impartial and independent peer review in accordance with the tasks and ToRs specified herein, and each ToRs must be addressed (**Annex 2**).
3) No later than January 25, 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to

shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

21 December 2012	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
2 January 2013	NMFS Project Contact sends the CIE Reviewers the assessment report and background documents
9-24 January 2013	Each reviewer conducts an independent peer review as a desk review
25 January 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
8 February 2013	CIE submits CIE independent peer review reports to the COR
15 February 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Program Manager, COR
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

Roger W. Peretti, Executive Vice President
Northern Taiga Ventures, Inc. (NTVI)
22375 Broderick Drive, Suite 215, Sterling, VA 20166
RPerretti@ntvifederal.com Phone: 571-223-7717

Key Personnel:

NMFS Project Contact:

Ryan Rindone, SEDAR Coordinator
2203 N. Lois Avenue, Suite 1100
Tampa, FL 33607
Ryan.Rindone@gulfcouncil.org Phone: 813-348-1630

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

   The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2a – Terms of Reference for

SEDAR 28: Gulf of Mexico Cobia Assessment Desk Review

1. Evaluate the quality and applicability of data used in the assessment.
2. Evaluate the quality and applicability of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.
5. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.
6. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.
    - Provide measures of uncertainty for estimated parameters
    - Ensure that the implications of uncertainty in technical conclusions are clearly stated
    - If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.
        - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments
        - Provide justification for the weightings used in producing the combinations of models
7. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.
8. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.
9. Make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring needs that could improve the reliability of future assessments

SEDAR 28:

Gulf of Mexico

Cobia and Spanish Mackerel

Stock Assessment Review

P.L. Cordue

Fisheries Consultant

New Zealand

***For* CIE Independent System for Peer Review**

19 February 2013

Executive summary

A desktop review of Gulf of Mexico cobia and Spanish mackerel stock assessments was conducted by three independent CIE reviewers, in January 2013, as part of SEDAR 28. This document presents my findings and recommendations, with regard to the assessments, based on a detailed review of the assessments as described in the Data and Assessment Workshop reports and supporting documents.

The cobia and Spanish mackerel stocks in the Gulf of Mexico were both assessed using the Stock Synthesis package SS3. This is a well-tested package which enables fully-integrated age-structured stock assessments using landings, discards, length, and age data from multiple fisheries.

Both assessments used very similar data sources: landings and discard data from recreational fisheries (the bulk of the landings) and some commercial fisheries; discard estimates from the shrimp fishery (substantial in some years); length and age data as available for each fishery; and standardized CPUE indices.

A simple and typical model structure was used in both assessments. Population in age-structured equilibrium before the start of the fisheries. Year-round fisheries with constant selectivity patterns (with some time-blocking). Constant age-specific natural mortality over time. A single von Bertalanffy growth curve estimated in the model and a Beverton Holt stock-recruitment relationship. Year class strengths (recruitment deviations) estimated for about 20 cohorts.

The assessments have common problems: the CPUE time series used in the assessment runs are not defensible as relative abundance indices; and the length and age data were not appropriately post-stratified or scaled. Primarily because of the lack of defensible abundance indices it would be unsafe to use the assessments to provide management advice.

My main conclusions are:

- Stock structure and fixed life history parameters were adequately considered.
- Landings history, discards, and discard mortalities were adequately determined and considered.
- Composition data were poorly treated at both the Data and Assessment Workshops. There was an absence of appropriate analysis and discussion with regard to post-stratification of the data to deal with inadequate sample sizes within some strata.
- The Index Working Group made very poor recommendations with regard to the time series to use in the stock assessments as relative abundance indices:
    - For cobia, two recreational CPUE time series were recommended but these both had very low proportions of successful trips and spanned a period when fishing regulations had become more restrictive.
    - For Spanish mackerel: a SEAMAP survey was recommended as a recruitment time series, but it caught very few Spanish mackerel each year; a recreational time series was recommended but it had a very low proportion of successful trips; and a commercial index based on catch-per-trip was recommended but it had not been standardized for trip duration or time fished.
- None of the abundance indices used in the stock assessment runs are defensible.

- The model structure used, the choice of runs, and the methods of projection and describing of uncertainty were adequate but could not overcome the flawed data inputs.
- None of the model runs should be used to determine biomass estimates or recommend stock status.

My main recommendations are:

- Top priority should be given to the construction of defensible abundance indices for both cobia and Spanish mackerel from the commercial and recreational data:
  - Talk to some of the participants in the fisheries to get an understanding of how, when, and where, they target cobia and Spanish mackerel (if at all).
  - Perform a full descriptive/exploratory analysis of the data to understand the temporal and spatial variation in the catches and the potential explanatory variables.
  - Identify regional and seasonal fisheries for which fishing effort is "likely" to catch cobia or Spanish mackerel.
  - Perform an analysis to determine if fishing regulations have impacted on the ability of the data to track abundance (time series may have to be split to account for different fishing behaviour caused by regulation changes)
  - Produce standardized CPUE indices for each identified regional/seasonal fishery and consider which if any can defensibly be used as abundance indices.

- If defensible abundance indices can be constructed then assessments can be done as before except:
  - Composition data should be appropriately post-stratified and scaled; sample sizes should be based on the number of trips/landings sampled (not the number of fish measured or aged).
  - Recruitment deviates should only be estimated for cohorts which are well-represented in the composition data (e.g., appear at least three times in the age data).

Background

The South-East, Data, Assessment, Review (SEDAR) process was initiated in 2002 to improve the reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. This review is part of SEDAR 28 and covers the Gulf of Mexico Spanish mackerel and cobia stock assessments.

I am one of three CIE reviewers who performed a desktop review during January 2013. The three reviews are meant to be independent and I have had no contact or discussion with the other two reviewers. This report presents my findings and recommendations in accordance with the Terms of Reference (ToRs) for the review (Appendix 2, annex 2).

Review Activities

The main documents provided for the review were made available in a timely manner through an ftp site. Also, a link was provided to the SEDAR website which contained many workshop, background, and reference documents (Appendix 1).

I noted, that in the original ToRs, it was assumed that a normal review was being conducted and that the reviewers would jointly write a Summary Report. I contacted CIE and they supplied me with amended ToRs which were specific to a desktop review (Appendix 2, annex 2).

The main documents for the review were the Data Workshop and Assessment Workshop reports (Appendix 1). I read these four reports in detail, a number of times, over the period of the review and consulted specific workshop or reference documents as needed. I also searched the Web to obtain information on current and past federal and state recreational fishing regulations for cobia (in particular).

Summary of findings

Cobia and Spanish mackerel were both assessed using the Stock Synthesis package SS3. This is a well-tested package that allows data from a range of sources to be fitted to obtain estimates of population parameters and management quantities. Estimates of uncertainty were obtained by performing sensitivity runs and bootstrapping the main runs.

The two assessments use very similar methods and data sources (estimated catch histories for commercial and recreational fisheries, abundance indices, and length and age data). For this reason they share a number of strengths and weaknesses.

Before considering the specific ToRs for each assessment I will discuss some problems which are common to both assessments.

Obtaining abundance indices from recreational CPUE data

For both assessments standardized CPUE indices were calculated for the headboat survey and for the MRFSS data (although the headboat time series was not used in the mackerel assessment). In each case a delta-lognormal model was used (binomial for success/failure and lognormal for positive catches). This approach was applied to the whole of each dataset with limited or no filtering of records to remove irrelevant effort. As a consequence, the proportions of successful trips (those that caught the species of interest) were very low (mackerel: MRFSS 5%, headboat <5%; cobia: MRFSS <1%, headboat 7%).

These success rates are so low that one would think that it was very unlikely that the CPUE indices could be tracking abundance. The Index Working Groups (IWG) had attempted to filter the data to obtain relevant effort using Stephens and MacCall (2004) and a number of ad hoc approaches. However, they were unable to find a satisfactory subset of the data to use and defaulted to the full data set. (The failure of Stephens and MacCall (2004) is interesting and bears further investigation at a later date – why did the method fail so completely?)

I have no faith in any of these CPUE time series as indices of *relative abundance* because the very low success rates show that most of the effort is irrelevant to cobia and Spanish mackerel. This means that the basic assumption of catch being proportional to effort is violated. The standardization of the indices does not help. To get a defensible abundance index from these data requires that relevant effort is identified – e.g., so that a doubling of effort (in a given "stratum") will result in a doubling of catch – or a doubling of biomass for a given amount of effort will double the catch.

In order to subset these data and identify relevant effort it is necessary to obtain an understanding of the different recreational fisheries that are operating on cobia and Spanish mackerel. This will not be an easy process. It will probably require that additional information on the operation of the fisheries be obtained by interviewing the participants (e.g. headboat skippers). Cobia and Spanish mackerel are probably targeted by recreational fishers in some places at some times during the year (e.g., cobia during a known migration wave). It may be possible to identify vessels which fish in certain areas at certain times and to use their data (positive catches and success/failure in the given areas and times) to obtain defensible abundance indices. Alternatively, it may be that additional information needs to be routinely collected from recreational fishers before any reliable abundance indices can be produced from the recreational fisheries for these species.

Using the positive catches is a possibility, which was explored by the IWG. The concern is that such indices will be hyperstable. However, with sufficient descriptive analysis it may be possible to justify the use of just the positive trips (e.g., showing that there is no shrinkage in the area and the season from which successful trips occur over time).

Changes in recreational fishing regulations

Changes in fishing regulations have to be considered when recreational CPUE data are being analysed for abundance indices.

For cobia, the Data Workshop report contains no information on changes in regulations or the variation in regulations between state and federal waters. This is a serious omission because the federal daily bag limit of 2 per person did not come into effect until August 1990 and in Florida state waters the limit was reduced to 1 per person (with no more than 6 per vessel) on 22 March 2001. The only abundance indices used in the cobia assessment are the headboat and MRFSS time series which both span the period of regulation changes (headboat: 1986-2010; MRFSS: 1981-2010). The implementation of a minimum legal size for cobia in 1984 is mentioned in the Data Workshop report and the potential change in selectivity is modelled in the assessment. In the Assessment Workshop report the imposition of the federal bag limit in 1990 is noted, but only in the discussion of the fit to discard rates. The Florida state regulation is not mentioned in the Assessment Workshop report.

For Spanish mackerel there were numerous changes in bag limits over the period covered by the MRFSS CPUE indices. The fact that there were changes is noted in the reports but no analysis or discussion of the potential effect on catch rates is given. The changes were generally increases in the daily bag limit, so it may be that they are not particularly important in terms of affecting catch rates. However, there should have been an analysis of the data to see if there were effects such as a limiting of catch before the bag limits were increased.

Modelling of year interactions as random effects

The standard approach taken by the Index Working Group when standardizing the commercial and recreational CPUE data was to fit two-way interactions involving year as a random effect. The software will let this be done, but it is inappropriate because year interactions are probably not random (in the sense of random effects, where the values can be considered as random samples from a particular distribution). For example, consider a year-area interaction. If there are very different trends in different areas then this is a sign that there are groups of fish associated with each area which have different abundance trajectories – not a random effect at all (the changes in abundance are correlated within each area and perhaps across areas). Also, it is a sign of a fundamental problem with the CPUE analysis. A valid abundance index can only be obtained in this case if the number of records in each area is a good approximation to the relative abundance across areas (so that the different trends are appropriately weighted). Fitting the year-area interactions as a random effect does not change the mean effects (Venables and Dichmont, 2004) and merely hides the potential problem. This is not to say that mixed models should not be used – there are factors which can be appropriately modelled as random effects (e.g., individual vessel effects).

Scaling of length and age (composition) data

It is important to try to make of the most of whatever composition data are available. These are the data that provide information on growth, selectivity, and year class strength. If they are not properly stratified and scaled then legitimate signals in the data will be obscured.

There should be little debate about how length and age data are scaled. If there was an appropriate sampling design, then this includes the stratification and how to scale the data. For length samples, normally, there is a two-stage scaling procedure: sample scaled to catch or landing; and then the combined samples within a stratum are scaled to the stratum catch (and then combined across strata without any further weighting). For age data, sampled at random, the same scaling procedure applies. For age data, collected to construct an age-length key, the length frequency is first constructed (by appropriate scaling) and then the age-length key(s) is applied to produce the age frequency.

The recommendation of the Data Working Group, for both cobia and mackerel, to scale the age data “using the length frequency” is very worrying. I first heard of this method when reviewing SEDAR 17 and on investigation I found that it was invalid. Simple examples were enough to show that the method did not achieve its stated intent (Cordue 2008). That the same method is still being recommended is very disappointing. They cite a paper which apparently uses the method when estimating growth curves (Chih 2009). It may have some utility in the situation the author considered but the method should not be used to produce age frequencies.

When composition data are sampled in an ad hoc basis (or there are inadequate sample sizes in the original stratification) it is important to post-stratify in such a way that the full (spatial and temporal) extent of the fishery is covered with adequate sample sizes in each stratum (for the years, or groups of years, in which there are adequate data). It is also important to exclude data in years when the coverage is inadequate – it should not just be "thrown in" in the hope that the model can account for non-representative samples (because it cannot).

Using age data as conditional age-at-length

This appears to have become the norm for assessments using SS3. It has advantages and disadvantages. It stops the worry about the double-use of age and length data, where the age data came from a subset of the fish that were measured. Also, it allows non-randomly collected age samples to be used in the assessment in a natural fashion and facilitates the estimation of growth parameters. However, it does not preclude the necessity for a careful analysis of the age data in terms of where samples came from, when they were collected, and how they were collected.

One problem is the timing of the sampling. It is important to consider how fast the fish grow and at what size they are recruited to each fishery. If fish are growing rapidly during the year in which they were sampled then there is the problem that the age proportions at given length change during the year (e.g., sample for age at 20 cms: on 1 February the proportions at age are 70% 1 year old and 30% 2 year old; but on 1 November the expected proportions are 100% 1 year old).

Another issue is that age-proportions at given length can also vary spatially. For example, a recreational fishery in one area may be catching spawning fish, while in another area the same "fishery" (in the model at least) is capturing non-spawning fish. The age-proportions at length will be very different between the two areas. A similar effect could occur because of spatial variation in growth. Yet another issue is the variation in growth between cohorts. At a given time of year, the age-proportions at a given length could be dramatically different for fast and slow growing cohorts. If there is only patchy conditional age-at-length data in the model then fast growing cohorts could be estimated as strong cohorts and slow-growing cohorts as weak cohorts.

Because of all of these issues it is by no means certain that it is best to incorporate age data into SS3 as conditional age-at-length and to estimate growth in the model. Certainly, it is always important to analyse the age data with regard to these potential issues and to make sure that the data are appropriately stratified and scaled.

None of the issues relating to the problems of using conditional age-at-length data appear to have been considered in the cobia and Spanish mackerel assessments. The paucity of data is not an excuse for ignoring these issues – it does, in some ways, make it more important that they are considered.

Data weighting

There are various methods for obtaining relative weights (CVs and effective sample sizes) for the different data sets fitted in a stock assessment model. In both assessments, fairly arbitrary weights are used in the base models and iterative re-weighting methods (Francis 2011, SS3 re-weighting) are only considered in sensitivity runs. This is the wrong way round. The base runs should be using a formal weighting scheme and alternative schemes investigated in sensitivity runs. As it happens, it appears that the results are not particularly sensitive to the relative weights.

Effective sample sizes for composition data

This is partly covered under the data weighting heading (the method of Francis will give much lower sample sizes for composition data than SS3 re-weighting). However, in the cobia and mackerel assessments, the effective sample sizes that are used are based on the number of fish measured or aged (with a cap for sample size on length frequencies). This is not good practice. Best practice is to bootstrap the data to determine an effective sample size for each year based on how many fish were sampled in each trip and hence the within and between trip variability (and to use these sample sizes as initial values in iterative reweighting). Alternatively, if a rule-of-thumb is used, then the initial sample sizes should be based on the number of trips sampled rather than the total number of fish measured/aged. For example, if 100 fish were measured from 1 trip, the effective sample size should be closer to 1 than to 100 (e.g., Pennington et al. 2002). For age data the scaling down shouldn't be as extreme as for length data. For example, 100 fish aged from 10 trips could be worth 3-5 fish per trip, but almost certainly not 10 per trip.

That covers the joint problems.

Each of the ToRs are specifically considered below.

Cobia

1. *Evaluate the quality and applicability of data used in the assessment.*

Life history
The Life History Working Group covered the definition of stock boundaries and the estimation of fixed biological parameters. They considered appropriate data and made sensible recommendations with the exception of recommending 60% females at birth. They based this on the skewed sex ratios observed in the fisheries. However, the sex ratio in the population is hopelessly confounded with the fishing selectivities. It will make little difference, but the fishery dependent data considered do not give a reasonable basis to move from a 50-50 sex ratio at birth.

Catch history
The catch history was estimated for the commercial fishery starting in 1926 for three gear types (hand-line, long-line, and other). Recreational landings (which are much larger than the commercial landings) were calculated by mode and region (to some extent). Modes included charter-boat, headboat, private/rental boat, and shore based. Landings for Texas were calculated separately from the Gulf. Discard data for commercial and recreational fisheries were also compiled. The bycatch from the shrimp fishery, which was very substantial in some years, was also estimated (SEDAR28-DW6).

It is usually a difficult and tedious job to reconstruct full catch histories for stock assessment purposes and I think that a good job was done in this case. However, it would have been useful to provide the assessment team with an envelope of potential landings and discards so that they could have easily performed sensitivity runs with "low" and "high" levels of landings and discards.

Composition data
Available length and age data from the recreational and commercial fisheries were compiled by the Data Workshop (DW).

There was very little commercial length data and almost no commercial age data. The DW report says that the length data were “weighted by the landings in numbers by strata (state, year, gear)”. This is not appropriate as many of the strata contained no samples. In order to get sensible length frequencies for the assessment there needed to have been an attempt to identify period of years which could be combined to provide adequate samples across a sensible post-stratification (e.g., combining some states). To determine an appropriate post-stratification requires an analysis of the variability of length frequencies across the various strata (e.g., it may be that some gear types could be combined). With so few samples the best that can probably be done is to construct a combined-year length frequency for each fishery.

The recreational sample sizes are also very low with many strata having zero or close to zero fish measured. Again it raises the issue of having to conduct a detailed analysis of the length data to determine how strata should be combined before scaling and production of annual or combined-year length frequencies. This is not discussed in the DW report at all so I must assume that no such analysis was done and that strata with low sample sizes (including zero) were just mechanically scaled.

Abundance indices

The Index Working Group (IWG) considered five potential abundance time series and recommended two of them for use in the assessment.

The SEAMAP data were not recommended because of the very low occurrence of cobia in the catch. A time series was developed from a delta-lognormal model. There is no mention in the DW report or the document they cite for details (SEDAR28-DW03) of why the indices were not constructed in the normal way for a trawl survey. Certainly, the original design was a random stratified trawl survey – so it makes no sense to use a delta-lognormal model which only measures density when abundance/biomass could have been measured. However, given the index was not used, my point is academic.

The Texas Parks and Wildlife Survey (TPWS) was analyzed using a delta-lognormal model where the data were restricted to an area that had relatively high cobia catches (SEDAR28-DW10). However, even for this area the proportion of positive trips was only 3.1% and the IWG did not recommend its use. The very low success rate does mean it is very unlikely to be tracking abundance.

A commercial vertical line index was constructed using the usual delta-lognormal model and no descriptive analysis at all (SEDAR28-DW16). The IWG did not recommend the time series because of the restrictive trip limit of two fish per person per day. The proportion of successful trips was also very low (2-4% each year). Certainly the derived indices could not be recommended. However, this dataset deserves more analysis. There may be a subset of trips which could provide some useful qualitative information on abundance from the proportion of positive trips.

The headboat and MRFSS datasets were analyzed to produce recreational CPUE indices (SEDAR28-DW28). Different filtering methods were considered and implemented but none were successful in identifying a subset of relevant cobia effort. Indices were calculated from just positive trips and also, using the delta-lognormal model, from all trips. Eventually the decision was made to base the index on all trips: “The working group also noted that there was little difference in the indices that were estimated for the entire dataset and the indices estimated for the subset of only positive trips. Therefore, it was reluctantly decided at the data workshop, that fishing effort for cobia and Spanish mackerel would be based on all trips”.

I assume that the IWG felt that they had to recommend at least one time series for use as a relative abundance index in the stock assessment. However, the low level of successful trips for the headboat (7%) and MRFSS (<1%) datasets should have led to the same conclusion as for the TPWS. Additionally, there is the issue of the change in regulations in the period spanned by the time series and the different regulations in Florida state waters. These data may be able to provide useful abundance indices. However, an analysis based on an understanding of the various fisheries which occur over the region, will be needed to deliver defensible indices.

The two time series recommended by the IWG are not defensible in my opinion.

2. *Evaluate the quality and applicability of methods used to assess the stock.*

The stock assessment modeling was adequate but the assessment overall cannot recover from the poor data inputs. In the Data Workshop, there was inadequate attention to detail in regard to the composition data, and the recommended CPUE indices were not defensible as relative abundance indices.

Stock Synthesis 3

The Data Working Group recommended that the assessment be updated using ASPIC because of the paucity of composition data. This was a poor recommendation because the important fisheries for the stock have very different size/age based selectivities. It is not clear how the bycatch in the shrimp fishery could have been modeled satisfactorily in ASPIC or how a minimum legal size would have been implemented.

Perhaps an assessment could have been done in ASPIC, but then an equivalent assessment could also be done in SS3 – which can be run as an “age-based production model”. The advantage of using SS3 is that there are numerous options for exploring the effect of fitting the available composition data and estimating or not estimating selectivity patterns and year class strengths.

Model structure

A simple and typical model structure was used. Population in age-structured equilibrium before the start of the fisheries. Year-round fisheries with constant selectivity patterns (with some time-blocking). Constant age-specific natural mortality over time. A single von Bertalanffy growth curve estimated in the model and a Beverton Holt stock-recruitment relationship. Year class strengths (recruitment deviations) were estimated from 1982-2010 (which is probably far too many given the paucity of composition data).

The shrimp fishery was modeled as a bycatch fishery with the catch driven by an effort time series and fitted to the median estimate of cobia bycatch from 1972-2011 using the “super-year” feature of SS3. Modeling the shrimp fishery in this way is a good approach.

Only a single commercial and a single recreational fishery were modeled despite the Data Working group providing landings histories for a number of fisheries. I assume the lumping of these data was because of the paucity of composition data but no explanation was provided in the Assessment Report. I have not considered whether it was justified or not – it would depend on whether the fisheries had similar selectivity patterns and whether their landings histories varied in a similar way over time.

Treatment of the data
The catch/landings histories were combined into single commercial and recreational fisheries which may or may not have been justified. The raw composition data, assembled by the Data Working group, seems to have been used in the assessment without any stratification or scaling (e.g., see Table 2.11 in the Assessment report – the number of fish measured is given in each year and then the number of fish in each 3cm bin is given; it looks like raw un-scaled data).

To get the most out of the limited composition data requires that it is very carefully post-stratified and scaled. The data are just there to help with estimation of growth, selectivities, and year class strength so it is unlikely to be fatal if they are not properly prepared; rather there is just a loss of information. Of course, if they are over-weighted relative to the abundance indices, then properly prepared or not they can severely distort an assessment.

The likelihood profile on virgin recruitment in the Assessment report (Figure 3.32) suggests that the age and length data are dominating the abundance indices in terms of a biomass signal (although it is a bit hard to tell – a “zoom in” would have been useful). The sample sizes, based on the number of fish measured or aged are too large. However, the abundance time series appear to be consistent with the biomass signal from the composition data so re-weighting of the data is unlikely to change the result.

Model runs
The base model used all of the available data and estimated steepness as well as numerous recruitment deviations. Given the paucity of composition data (and the fact it was not prepared properly) it is unlikely that there is good information on year class strength. The model will have no trouble coming up with estimates and will even provide good precision for those estimates because of the relatively high effective sample sizes assumed – but, in reality, the model is over-parameterized (and year class strengths are not well estimated).

Estimating steepness in these models is almost always the wrong thing to do. To get a good estimate requires excellent information on year class strengths over a wide range of relative spawning biomass. A glance at the available data tells us that steepness should not be estimated in this model.

A good range of sensitivity runs were performed, including low and high natural mortality and using one or other of the abundance time series. The only runs missing were those exploring the effects of different catch histories and discard rates. Certainly, the early catch history is very uncertain as are the discards from the shrimp fishery.

3. *Recommend appropriate estimates of stock abundance, biomass, and exploitation.*

I cannot recommend any of the model runs for this assessment. The abundance indices are not defensible. The composition data were not properly prepared (and are over-weighted). The model was over-parameterized.

4. *Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.*

The methods used to estimate the SPR-based benchmarks are standard and done within SS3 which has been thoroughly tested. However, I cannot recommend any of the model runs and therefore do not provide any declarations of stock status.

5. *Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.*

   The base run and the low and high natural mortality runs were projected forward under three levels of fishing mortality ($F_{CURRENT}$, $FSPR_{30}$, and F_{OY}) using 1000 bootstrap replicates. The method is appropriate but I cannot recommend any of the runs.

6. *Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.*

   Uncertainty in the assessment was characterized by sensitivity runs and a parametric bootstrap on the base run. A good range of sensitivities were performed. The use of the bootstrap would not be my preferred choice but it is an acceptable approach. Calculation of Bayesian posteriors is generally preferable (even with uninformed priors). Also, uncertainty is badly under-estimated because of all the structural assumptions in the model (which is always the case) and the relatively large sample sizes used for the composition data (which does not have to be the case).

   - *Provide measures of uncertainty for estimated parameters*

     Confidence intervals from the bootstrap are provided in the Assessment report.

   - *Ensure that the implications of uncertainty in technical conclusions are clearly stated*

     The Assessment Report does not conclude that the assessment is highly uncertain and should be treated with extreme caution. This is my conclusion, mainly because of the lack of defensible abundance indices, but also because of the poor treatment of the composition data and the over-parameterization in the model.

   - *If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.*
     - *Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments*
     - *Provide justification for the weightings used in producing the combinations of models*

     Not applicable for this desktop review.

7. *If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.*

   Not applicable for this desktop review.

8. *Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.*

   In general, the SEDAR process is a useful process for developing good quality stock assessments. However, the Data and Assessment Workshops in this case have not delivered good assessments.

   Problems with the cobia assessment should have been identified at the Data Workshop – someone should have had the courage to say “we don’t have a defensible abundance index” and they should have been listened to. The changes in fishing regulations and the variation between state and federal rules should have been noted by somebody.

   The ToRs of the Data Workshop were each addressed. Of course, some were done better than others as I have already noted. The preparation of the composition data was very poor. The recommendation to scale the age data using the length frequencies was unfortunate.

   ToR 5 for the Data Workshop requires them to recommend the assessment method. I don’t think this is the role of a data workshop. They should get all the data together, in a form that provides options for the stock assessment (e.g., finer scale than that which might eventually be used in the stock assessment) but they shouldn’t be telling the scientists who have to do the stock assessment modeling how to do it. Of course, ideally the person who has to do the modeling should be closely involved in all aspects of the Data Workshop.

   The ToRs of the Assessment Workshop were each addressed. They used SS3 instead of ASPIC, which was a good choice. They didn’t adequately document their reasons for some choices, such as using only a single commercial fishery and a single recreational fishery. They also appear to have used completely un-stratified and un-scaled composition data – certainly there is no explanation of how the data were scaled.

   The review process normally involves a meeting where questions can be asked and answered and additional analyses used to explore issues. A desktop review, where the reviewers are not able to ask questions or discuss issues with the assessment scientists and each other, is not as good. Desktop reviewers only comment on the issues that they notice. In a meeting, issues that are noticed by each reviewer (and other meeting participants) come to the attention of all reviewers.

9. *Make any additional recommendations or prioritizations warranted.*
   - *Clearly denote research and monitoring needs that could improve the reliability of future assessments*

   In the short-term, a new assessment is needed. There are no defensible abundance indices and it will hard to produce any quickly. Therefore, an assessment which looks at worst case scenarios should be considered. If the stock is in reasonable shape even at biomass levels that would only just allow the estimated catch to have been taken, then there is no rush to produce a full assessment.

   Of course, a reliable assessment generally requires a defensible abundance time series. The development of such a series should be the top priority. Pursuit of such an index should also provide some answers on what other data need to be collected to provide defensible indices for cobia.

A workshop should be held to train people in the analysis and post-stratification of composition data.

Spanish Mackerel

10. *Evaluate the quality and applicability of data used in the assessment.*

Life history
The Life History Working Group covered the definition of stock boundaries and the estimation of fixed biological parameters. They considered appropriate data and made sensible recommendations with the exception of a strange recommendation on sex ratio: "Over all ages and gears, weighted percent females 66%". This was derived from their analysis of sex ratio data from fisheries. The Assessment Workshop took this as a recommendation for 50-50 at birth in 1886 (apparently): "Sex ratio at the start time of the population analysis (1886) was assumed to be 1:1 as recommended by the SEDAR 28 DW". It is strangely worded as 50-50 at birth in 1886 means 50-50 every year at birth.

Catch history
The catch history was estimated for the commercial fishery starting in 1880 for three gear types (gill nets, hand-line, and other). Recreational landings (which are much larger than the commercial landings) were calculated by mode and region (to some extent): MRFSS/MRIP estimates of landings from charter, private angler; Texas Parks and Wildlife (charter, private and headboat); and the for-hire headboat fishery. Discard data for commercial and recreational fisheries were also compiled. The bycatch from the shrimp fishery, which was very substantial in some years, was also estimated (SEDAR28-DW6).

It is usually a difficult and tedious job to reconstruct full catch histories for stock assessment purposes and I think that a good job was done in this case (no doubt building on the work done in previous assessments). However, it would have been useful to provide the assessment team with an envelope of potential landings and discards so that they could have easily performed sensitivity runs with "low" and "high" levels of landings and discards.

Composition data
Available length and age data from the recreational and commercial fisheries were compiled by the Data Workshop.

There were few commercial length and age data. The DW report says that the length data "were weighted by the trip landings in numbers and the landings in numbers by strata (state, year, gear).". This is not appropriate when many of the strata contained no samples. In order to get sensible length frequencies for the assessment there needed to have been an attempt to identify period of years which could be combined to provide adequate samples across a sensible post-stratification (e.g., combining some states). To determine an appropriate post-stratification requires an analysis of the variability of length frequencies across the various strata.

The recreational sample sizes are much higher but there are still a number of strata having zero or close to zero fish measured. Again it raises the issue of having to conduct a detailed analysis of the length data to determine how strata should be combined before scaling and production of annual or combined-year length frequencies. This is not discussed in the DW report at all so I must assume that no such analysis was done and that strata with low sample sizes (including zero) were just mechanically scaled. This is not a big issue for the MRFSS data, but for the headboat survey the sampling is very patchy and the data need to be carefully post-stratified.

Abundance indices
The Index Working Group (IWG) considered nine potential abundance time series and recommended three of them for use in the assessment.

The SEAMAP data were analyzed to produce an abundance time series for 0-1 year old Spanish mackerel (SEDAR28-DW03). The IWG recommended the time series for use because “ it is a fisheries independent survey across a long time series (1987-2010), with very good spatial converge (TX/Mexico border to Mobile Bay)”. Their statement is true but does not provide sufficient justification to include this time series in a stock assessment. In total, the two surveys each year caught between 32 and 487 fish. Typically, about 50-200 fish are caught each year. The proportion of positive stations was about 4% in summer and 8% in fall (SEDAR28-DW03). Basically, the survey doesn’t catch much Spanish mackerel and the variability in the index is probably unrelated to the abundance of Spanish mackerel.

The three recreational surveys (Texas sport-boat angler survey, headboat, and MRFSS) all have very few successful trips. The IWG rejected the Texas and headboat surveys on this basis but recommended the use of the MRFSS time series although they didn’t give any reasons other than: “This index was particularly favored because it presents a long time series.” With less than 5% positive trips it is not reasonable to accept the unfiltered delta-lognormal time series as an abundance index.

Of the commercial data sets considered the IWG preferred the Florida State ticket data to the commercial logbook data for vertical lines and gillnets. I agree that the “run-around” gillnet method is likely to produce hyper-stable indices. Also, if Florida covers most of the fishery and has a longer time series then it is probably to be preferred to the shorter time series from the vertical line index (though, perhaps not in this case – see below).

The Florida trip-ticket data were used to construct cast net, hand-line/trolling, and gillnet indices split into time periods when trip limits were (assumed to be) not too restrictive. The IWG identified various problems with the “interpretation of data from trips using gill nets (e.g., deployment methods, mesh sizes, configuration of panels, and changes in state/federal waters restrictions) and cast nets (e.g., configuration, depth, bottom types)”. I agree with their recommendation not to use these time series in stock assessment.

The IWG did recommend the Florida trip-ticket hand-line/trolling index (which shows an increasing trend over time) for use in stock assessment. This is a standardized index of catch-per-trip for trips that caught some Spanish mackerel (SEDAR28-AW01). The standardization approach is unusual as 8 of 11 explanatory variables are dummy variables which indicate whether a species-group was caught on the trip or not (this is slightly problematic as these are random variables and, strictly speaking, should not be used as explanatory variables). The remaining variables are year, month, and Florida sub-region. The documentation for this analysis does not mention using any measure of trip duration or “actual time fished” (which is a field on the Trip Ticket). They also do not make use of “number of crew” another field on the trip ticket (available since 2000). The response variable is given as “catch per trip” and not as "catch per trip per hour". Perhaps this is just a documentation error? It is very hard to tell because there is no descriptive analysis to give a context to the standardization analysis. There is some discussion of outliers in the response variable: "those with landings greater than 1,223 pounds were excluded". This tends to support "catch per trip", but also it seems odd to exclude data on this basis – again the length of trip and the size of the vessel/number of crew, are important because longer trips and bigger vessels may catch more fish.

If "actual time fished" was not used in the standardization, and/or it is not properly reported on the form, then it is wrong to use this time series in stock assessment. The increasing trend could simply be the result of longer trips over time. It could also be the result of a change in the fleet with vessels that used to make short trips and/or not catch many fish, dropping out of the fishery over time. In a proper standardization these effects would be accounted for. It is also important when doing a standardization to first fully understand the data by doing a descriptive/exploratory analysis – it is very bad practice, as appears to have been done here, to simply "throw the data into the machine and turn the handle". Not using "actual time fished" in the analysis is very hard to understand.

Unfortunately, I have found fatal faults with each of the three abundance times series used in the Spanish mackerel stock assessment.

11. *Evaluate the quality and applicability of methods used to assess the stock.*

The stock assessment modeling was adequate but the assessment overall cannot recover from the poor data inputs. In the Data Workshop, there was inadequate attention to detail in regard to the composition data, and the recommended CPUE indices were not defensible as relative abundance indices.

Stock Synthesis 3
The use of this package was appropriate given the available data.

Model structure
A simple and typical model structure was used. Population in age-structured equilibrium before the start of the fisheries. Year-round fisheries with constant selectivity patterns (with some time-blocking). Constant age-specific natural mortality over time. A single von Bertalanffy growth curve estimated in the model and a Beverton Holt stock-recruitment relationship. Year class strengths (recruitment deviations) were estimated from 1985-2010.

The shrimp fishery was modeled as a bycatch fishery with the catch driven by an effort time series and fitted to the median estimate of Spanish mackerel bycatch from 1972-2011 using the "super-year" feature of SS3. Modeling the shrimp fishery in this way is a good approach.

Two commercial fisheries were modeled but only a single recreational fishery was used despite the Data Working group providing landings histories for a number of fisheries. No explanation for this was provided in the Assessment Report. I have not considered whether it was justified or not – it would depend on whether the fisheries had similar selectivity patterns and whether their landings histories varied in a similar way over time.

Treatment of the data
The catch/landings histories were combined into two commercial fisheries and a single recreational fishery which may or may not have been justified. The raw length data, assembled by the Data Working group, seems to have been used in the assessment without

state in the stratification: “Length data were stratified by calendar year, fishery/survey (commercial gillnet fleet (COM_GN), commercial line gears (COM_RR), and recreational all fisheries combined (headboat, private angler, charter, shore = REC)”. There should have been scaling from sample to trip and stratification needed to include state (unless there was an analysis showing that length frequencies were similar across states).

To get the most out of the limited composition data requires that it is very carefully post-stratified and scaled. The data are just there to help with estimation of growth, selectivities, and year class strength so it is unlikely to be fatal if they are not properly prepared; rather there is just a loss of information. Of course, if they are over-weighted relative to the abundance indices, then properly prepared or not they can severely distort an assessment.

The likelihood profile on virgin recruitment in the Assessment report (Figure 3.32) suggests that the age and length data are dominating the abundance indices in terms of a biomass signal (though it is a bit hard to tell – a “zoom in” would have been useful). The sample sizes, based on the number of fish measured or aged are too large. However, the abundance time series appear to be consistent with the biomass signal from the composition data so re-weighting of the data is unlikely to change the result.

Model runs

The base model (Run 3) used all of the available data and sensibly fixed steepness (0.8). Estimating steepness in these models is almost always the wrong thing to do. To get a good estimate requires excellent information on year class strengths over a wide range of relative spawning biomass.

A good range of sensitivity runs were performed, including low and high natural mortality and alternative values of steepness. The only runs missing were those exploring the effects of different catch histories and discard rates. Certainly, the early catch history is very uncertain as are the discards from the shrimp fishery.

12. *Recommend appropriate estimates of stock abundance, biomass, and exploitation.*

I cannot recommend any of the model runs for this assessment. The abundance indices are not defensible. The composition data were not properly prepared (and are over-weighted).

13. *Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.*

The methods used to estimate the SPR-based benchmarks are standard and done within SS3 which has been thoroughly tested. However, I cannot recommend any of the model runs and therefore do not provide any declarations of stock status.

14. *Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.*

The base run and a sensitivity run on steepness were projected forward deterministically under three levels of fishing mortality (FCURRENT, FSPR30, and F_{OY}). Stochastic projections using 1000 bootstrap replicates were also done for the base model. The method is adequate but I cannot recommend any of the runs.

15. *Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.*

    Uncertainty in the assessment was characterized by sensitivity runs and a parametric bootstrap on the base run. A good range of sensitivities were performed. The use of the bootstrap would not be my preferred choice but it is an acceptable approach. Calculation of Bayesian posteriors is generally preferable (even with uninformed priors). Also, uncertainty is badly under-estimated because of all the structural assumptions in the model (which is always the case) and the relatively large assumed sample sizes for the composition data (which does not have to be the case).

    - *Provide measures of uncertainty for estimated parameters*

      Confidence intervals from the bootstrap are provided in the Assessment report.

    - *Ensure that the implications of uncertainty in technical conclusions are clearly stated*

      The Assessment Report does not conclude that the assessment is highly uncertain and should be treated with extreme caution. This is my conclusion, mainly because of the lack of defensible abundance indices, but also because of the poor treatment of the composition data.

    - *If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.*
      - *Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments*
      - *Provide justification for the weightings used in producing the combinations of models*

      Not applicable for this desktop review.

16. *If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.*

    Not applicable for this desktop review.

17. *Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.*

    In general, the SEDAR process is a useful process for developing good quality stock assessments.

    The ToRs of the Data Workshop were each addressed. Of course, some were done better than others as I have already noted. The preparation of the composition data was poor. The recommendation to scale the age data using the length frequencies was very poor.

    ToR 5 for the Data Workshop requires them to recommend the assessment method. I don't think this is the role of a data workshop. They should get all the data together, in a form that provides options for the stock assessment (e.g., finer scale than that which might eventually be used in the stock assessment) but they shouldn't be telling the scientists who have to do the stock assessment modeling how to do it. Of course, ideally the person who has to do the modeling should be closely involved in all aspects of the Data Workshop.

The ToRs of the Assessment Workshop were each addressed. They didn't adequately document their reasons for some choices, such as using only a single recreational fishery. The stratification of the length data was very poor (state should have been included or a full justification given for ignoring it).

The review process normally involves a meeting where questions can be asked and answered and additional analyses used to explore issues. A desktop review, where the reviewers are not able to ask questions or discuss issues with the assessment scientists and each other, is not as good. Desktop reviewers only comment on the issues that they notice. In a meeting, issues that are noticed by each reviewer (and other meeting participants) come to the attention of all reviewers.

18. *Make any additional recommendations or prioritizations warranted.*
    - *Clearly denote research and monitoring needs that could improve the reliability of future assessments*

In the short-term, a new assessment is needed. There are data that may provide defensible abundance indices if analyzed properly (e.g., commercial logbook, vertical line data; Florida trip-ticket, hand-line/trolling data). It may also be possible to get something useful from the recreational data with appropriate filtering.

A workshop should be held to train people in the analysis and post-stratification of composition data.

Conclusions and Recommendations

The reviewed cobia and Spanish mackerel assessments are not suitable to be used to provide management advice because of the flawed data inputs used in the models.

My main conclusions are:

- Stock structure and fixed life history parameters were adequately considered.
- Landings history, discards, and discard mortalities were adequately determined and considered.
- Composition data were poorly treated at both the Data and Assessment Workshops. There was an absence of appropriate analysis and discussion with regard to post-stratification of the data to deal with inadequate sample sizes within some strata.
- The Index Working Group made very poor recommendations with regard to time series to use in the stock assessments as relative abundance indices:
    - For cobia, two recreational CPUE time series were recommended but these both had very low proportions of successful trips and spanned a period when fishing regulations had become more restrictive.
    - For Spanish mackerel: a SEAMAP survey was recommended as a recruitment time series, but it caught very few Spanish mackerel each year; a recreational time series was recommended but it had a very low proportion of successful trips; and a commercial index based on catch-per-trip was recommended but it had not been standardized for trip duration or time fished.
- None of the abundance indices used in the stock assessment runs were defensible.
- The model structure used, the choice of runs, and the methods of projection and capturing of uncertainty were adequate but could not overcome the flawed data inputs.
- None of the model runs should be used to determine biomass estimates or recommend stock status.

My main recommendations are:

- Top priority should be given to the construction of defensible abundance indices for both cobia and Spanish mackerel from the commercial and recreational data. I suggest the following approach:
    - Discussion with some of the participants in the fisheries to get some understanding of how, when, and where, they target cobia and Spanish mackerel.
    - A full descriptive/exploratory analysis of the data to understand the temporal and spatial variation in the catches and all of the available explanatory variables.
    - Identification of regional and seasonal fisheries for which fishing effort is likely to catch the species of interest (cobia or Spanish mackerel). This is likely to involve the identification of vessels in each year which fish at the times and places of interest and catch the species on some of their trips. It does not require that individual vessels be tracked across years (although that would be ideal).
    - An analysis to determine if fishing regulations have impacted on the ability of the data to track abundance (time series may have to be split to account for different fishing behaviour caused by regulation changes)
    - Production of standardized CPUE indices for each identified regional/seasonal fishery
    - Comparison of the trends across the different fisheries

    - Decide which if any of the CPUE indices are defensible as relative abundance indices (the length of the time series is not relevant to this decision).

- If defensible abundance indices can be constructed then assessments can be done as before except:
    - Composition data should be appropriately post-stratified and scaled; sample sizes should be based on the number of trips/landings sampled (not the number of fish measured or aged). This will require an analysis of the variability in length frequencies and proportion-at-age for given length across the various strata.
    - Recruitment deviates should only be estimated for cohorts which are well-represented in the composition data (e.g., appear at least three times in the age data).
    - Steepness should be fixed or estimated with an informed prior.

References

Chih, C. 2009. The effects of otolith sampling methods on the precision of growth curves. *North American Journal of Fisheries Management 29*: 1519-1528.

Cordue, P.L. 2008: Report on SEDAR 17, Stock Assessment Review, South Atlantic Vermilion Snapper and Spanish Mackerel, October 20 - 24, 2008, Savannah, Georgia. *For* CIE Independent System for Peer Review. 36 p.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. *Can. J. Fish. Aquat. Sci. 68*: 1124–1138.

Pennington, M.; Burmeister, L.; Hjellvik V. 2002. Assessing the precision of frequency distributions estimated from trawl-survey samples. *Fish. Bull. 100*: 74–80.

Stephens, A.; MacCall, A. 2004. A multispecies approach to sub-setting logbook data for the purposes of estimating CPUE. *Fisheries Research 70*: 299–310.

Venables, W.N.; Dichmont, C.M. 2004. GLMs, GAMs and GLMMs: an overview of theory for applications in fisheries research. *Fisheries Research 70*: 319–337.

Appendix 1: Bibliography of supplied material

The following data and assessment workshop reports were supplied for the desktop review.

SEDAR 28: Gulf of Mexico cobia, SECTION II: Data Workshop Report, May 2012. 239 p.
SEDAR 28: Gulf of Mexico Spanish mackerel, SECTION II: Data Workshop Report, May 2012. 268 p.
SEDAR 28: Gulf of Mexico cobia, SECTION III: Assessment Process Report, December 2012. 208 p.
SEDAR 28: Gulf of Mexico Spanish mackerel, SECTION III: Assessment Workshop Report, December 2012. 274 p.

The numerous workshop, background, and reference documents listed below were made available through the SEDAR website and were consulted as needed.

Document	**Title**	**Authors**
SEDAR28-DW01	Cobia preliminary data analyses – US Atlantic and GOM genetic population structure	Darden 2012
SEDAR28-DW02	South Carolina experimental stocking of cobia *Rachycentron canadum*	Denson 2012
SEDAR28-DW03	Spanish Mackerel and Cobia Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Pollack and Ingram, 2012
SEDAR28-DW04	Calculated discards of Spanish mackerel and cobia from commercial fishing vessels in the Gulf of Mexico and US South Atlantic	K. McCarthy
SEDAR28-DW05	Evaluation of cobia movement and distribution using tagging data from the Gulf of Mexico and South Atlantic coast of the United States	M. Perkinson and M. Denson 2012
SEDAR28-DW06	Methods for Estimating Shrimp Bycatch of Gulf of Mexico Spanish Mackerel and Cobia	B. Linton 2012
SEDAR28-DW07	Size Frequency Distribution of Spanish Mackerel from Dockside	N.Cummings, J. Isely

	Sampling of Recreational and Commercial Landings in the Gulf of Mexico 1981-2011	
SEDAR28-DW08	Size Frequency Distribution of Cobia from Dockside Sampling of Recreational and Commercial Landings in the Gulf of Mexico 1986-2011	J. Isely and N. Cummings
SEDAR28-DW09	Texas Parks and Wildlife Catch Per unit of Effort Abundance Information for Spanish mackerel	N. Cummings, J. Isely
SEDAR28-DW10	Texas Parks and Wildlife Catch Per unit of Effort Abundance Information for cobia	J. Isely, N. Cummings
SEDAR28-DW11	Size Frequency Distribution of Cobia and Spanish Mackerel from the Galveston, Texas, Reef Fish Observer Program 2006-2011	J Isely and N Cummings
SEDAR28-DW12	Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the South Atlantic and Gulf of Mexico in 1981-1985 with For Hire Survey estimates with application to Spanish mackerel and cobia landings	V. Matter, N Cummings, J Isely, K Brennen, and K Fitzpatrick
SEDAR28-DW13	Constituent based tagging of cobia in the Atlantic and Gulf of Mexico waters	E. Orbesen

SEDAR28-DW14	Recreational Survey Data for Spanish Mackerel and Cobia in the Atlantic and the Gulf of Mexico from the MRFSS and TPWD Surveys	V. Matter
SEDAR28-DW15	Commercial Vertical Line and Gillnet Vessel Standardized Catch Rates of Spanish Mackerel in the US Gulf of Mexico, 1998-2010	N. Baertlein, K. McCarthy
SEDAR28-DW16	Commercial Vertical Line Vessel Standardized Catch Rates of Cobia in the US Gulf of Mexico, 1993-2010	K. McCarthy
SEDAR28-DW17	Standardized Catch Rates of Spanish Mackerel from Commercial Handline, Trolling and Gillnet Fishing Vessels in the US South Atlantic, 1998-2010	K. McCarthy
SEDAR28-DW18	Standardized catch rates of cobia from commercial handline and trolling fishing vessels in the US South Atlantic, 1993-2010	K. McCarthy
SEDAR28-DW19	MRFSS Index for Atlantic Spanish mackerel and cobia	Drew et al.
SEDAR28-DW20	Preliminary standardized catch rates of Southeast US Atlantic cobia (*Rachycentron canadum*) from headboat data.	NMFS Beaufort
SEDAR28-DW21	Spanish mackerel preliminary data summary: SEAMAP-SA Coastal Survey	Boylan and Webster
SEDAR28-DW22	Recreational indices for cobia and Spanish mackerel in the Gulf of Mexico	Bryan and Saul
SEDAR28-DW23	A review of Gulf of Mexico and Atlantic Spanish mackerel (*Scomberomorus*	Palmer, DeVries, and Fioramonti

	maculatus) age data, 1987-2011, from the Panama City Laboratory, Southeast Fisheries Science Center, NOAA Fisheries Service	
SEDAR28-DW24	SCDNR Charterboat Logbook Program Data, 1993 - 2010	Errigo, Hiltz, and Byrd
SEDAR28-DW25	South Carolina Department of Natural Resources State Finfish Survey (SFS)	Hiltz and Byrd
SEDAR28-DW26	Cobia bycatch on the VIMS elasmobranch longline survey:1989-2011	Parsons et al.
SEDAR28-RW01	The Beaufort Assessment Model (BAM) with application to cobia: mathematical description, implementation details, and computer code	Craig
SEDAR28-RW02	Development and diagnostics of the Beaufort assessment model applied to Cobia	Craig
SEDAR28-RW03	The Beaufort Assessment Model (BAM) with application to Spanish mackerel: mathematical description, implementation details, and computer code	Andrews
SEDAR28-RW04	Development and diagnostics of the Beaufort assessment model applied to Spanish mackerel	Andrews
SEDAR28-RD01	List of documents and working papers for SEDAR 17 (South Atlantic Spanish mackerel) – all documents available on the SEDAR website	SEDAR 17
SEDAR28-RD02	2003 Report of the mackerel Stock Assessment Panel	GMFMC and SAFMC, 2003
SEDAR28-RD03	Assessment of cobia, Rachycentron canadum, in the waters of the U.S. Gulf of Mexico	Williams, 2001

SEDAR28-RD04	Biological-statistical census of the species entering fisheries in the Cape Canaveral area	Anderson and Gehringer, 1965
SEDAR28-RD05	A survey of offshore fishing in Florida	Moe 1963
SEDAR28-RD06	Age, growth, maturity, and spawning of Spanish mackerel, Scomberomorus maculates (Mitchill), from the Atlantic Coast of the southeastern United States	Schmidt et al. 1993
SEDAR28-RD07	Omnibus amendment to the Interstate Fishery Management Plans for Spanish mackerel, spot, and spotted seatrout	ASMFC 2011
SEDAR28-RD08	Life history of Cobia, Rachycentron canadum (Osteichthyes: Rachycentridae), in North Carolina waters	Smith 1995
SEDAR28-RD09	Population genetics of cobia Rachycentron canadum: Management implications along the Southeastern US coast	Darden et al, 2012
SEDAR28-RD10	Inshore spawning of cobia (Rachycentron canadum) in South Carolina	Lefebvre and Denson, 2012
SEDAR28-RD11	A review of age, growth, and reproduction of cobia Rachycentron canadum, from US water of the Gulf of Mexico and Atlantic ocean	Franks and Brown-Peterson, 2002
SEDAR28-RD12	An assessment of cobia in Southeast US waters	Thompson 1995
SEDAR28-RD13	Reproductive biology of cobia, Rachycentron canadum, from coastal waters of the southern United States	Brown-Peterson et al. 2001
SEDAR28-RD14	Larval development, distribution, and ecology of cobia Rachycentron canadum (Family: Rachycentridae) in the northern Gulf of Mexico	Ditty and Shaw 1992

SEDAR28-RD15	Age and growth of cobia, Rachycentron canadum, from the northeastern Gulf of Mexico	Franks et al 1999
SEDAR28-RD16	Age and growth of Spanish mackerel, Scomberomorus maculates, in the Chesapeake Bay region	Gaichas, 1997
SEDAR28-RD17	Status of the South Carolina fisheries for cobia	Hammond, 2001
SEDAR28-RD18	Age, growth and fecundity of the cobia, Rachycentron canadum, from Chesapeake Bay and adjacent Mid-Atlantic waters	Richards 1967
SEDAR28-RD19	Cobia (Rachycentron canadum) tagging within Cheasapeake Bay and updating of growth equations	Richards 1977
SEDAR28-RD20	Synopsis of biological data on the cobia Rachycentron canadum (Pisces: Rachycentridae)	Shaffer and Nakamura 1989
SEDAR28-RD21	South Carolina marine game fish tagging program 1978-2009	Wiggers, 2010
SEDAR28-RD22	Cobia (Rachycentron canadum), amberjack (Seriola dumerili), and dolphin (Coryphaena hipurus) migration and life history study off the southwest coast of Florida	MARFIN 1992
SEDAR28-RD23	Sport fish tag and release in Mississippi coastal water and the adjacent Gulf of Mexico	Hendon and Franks 2010
SEDAR28-RD24	VMRC Cobia otolith preparation protocol	VMRC
SEDAR28-RD25	VMRC Cobia otolith ageing protocol	VMRC
SEDAR28-RD26	Age, growth, and reproductive biology of greater amberjack and cobia from Louisiana waters	Thompson et al. 1991

SEDAR28-RD27	Gonadal maturation in the cobia, Rachycentron canadum, from the northcentral Gulf of Mexico	Lotz et al. 1996
SEDAR28-RD28	Cobia (Rachycentron canadum) stock assessment study in the Gulf of Mexico and in the South Atlantic	Burns et al. 1998
SEDAR28-RD29	Total mortality estimates for Spanish mackerel captured in the Gulf of Mexico commercial and recreational fisheries 1983 to 2011	Bryan 2012

SEDAR28-AW01	Florida Trip Tickets	S. Brown
SEDAR28-AW02	SEDAR 28 Spanish mackerel bycatch estimates	NMFS Beaufort

Appendix 2: Statement of Work for Patrick Cordue

Amended Statement of Work

External Independent Peer Review by the Center for Independent Experts

SEDAR 28: Gulf of Mexico Cobia and Spanish Mackerel Assessment Desk Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description SEDAR 28 will be a compilation of data, an assessment of the stocks, and an assessment review conducted for Gulf of Mexico Spanish mackerel and cobia. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 28 are within the jurisdiction of the Gulf of Mexico Fisheries Management Councils and states in the Gulf of Mexico region. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the statement of work (SoW) tasks and terms of reference (ToRs) specified herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall participate and conduct an independent peer review as a desk review, therefore travel will not be required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer contact information to the COR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the assessment and other pertinent background documents for the peer review. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an impartial and independent peer review in accordance with the tasks and ToRs specified herein, and each ToRs must be addressed (**Annex 2**).
3) No later than January 25, 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

21 December 2012	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
2 January 2013	NMFS Project Contact sends the CIE Reviewers the assessment report and background documents
9-24 January 2013	Each reviewer conducts an independent peer review as a desk review
25 January 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
8 February 2013	CIE submits CIE independent peer review reports to the COR
15 February 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Program Manager, COR
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

Roger W. Peretti, Executive Vice President
Northern Taiga Ventures, Inc. (NTVI)
22375 Broderick Drive, Suite 215, Sterling, VA 20166
RPerretti@ntvifederal.com Phone: 571-223-7717

Key Personnel:

NMFS Project Contact:

Ryan Rindone, SEDAR Coordinator
2203 N. Lois Avenue, Suite 1100
Tampa, FL 33607
Ryan.Rindone@gulfcouncil.org Phone: 813-348-1630

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

   The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2a – Terms of Reference for

SEDAR 28: Gulf of Mexico Cobia Assessment Desk Review

1. Evaluate the quality and applicability of data used in the assessment.
2. Evaluate the quality and applicability of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.
5. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.
6. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.
    - Provide measures of uncertainty for estimated parameters
    - Ensure that the implications of uncertainty in technical conclusions are clearly stated
    - If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.
        - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments
        - Provide justification for the weightings used in producing the combinations of models
7. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.
8. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.
9. Make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring needs that could improve the reliability of future assessments

Table 1. Required MSRA Evaluations for cobia assessment:

Criteria	Definition* (2001)	Current Value* (2001)
Mortality Rate Criteria		
F_{MSY}	F_{MSY}	0.34
MFMT	F_{MSY}	0.34
F_{OY}	75% of F_{MSY}	0.26
$F_{CURRENT}$	F_{2000}	0.30
$F_{CURRENT}$/ F_{MSY}	Percentage of $F_{Current}/F_{MSY}$ > MFMT	0.40
Base M		0.30
Biomass Criteria		
SSB_{MSY}	Equilibrium SSB_{MSY} @ F_{MSY}	3.02 mp
MSST	(1-M)*SSB_{MSY}: M=0.30	2.11 mp
$SSB_{CURRENT}$	SSB_{2000}	
$SSB_{CURRENT}$/ SSB_{MSY}	Percentage of $SSB_{Current}/SSB_{MSY}$ < MSST	0.30
Equilibrium MSY	Equilibrium Yield @ F_{MSY}	1.50 mp
Equilibrium OY	Equilibrium Yield @ F_{OY}	1.45 mp
OFL	Annual Yield @ MFMT	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	
Annual OY**	Annual Yield @ F_{OY}	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	

*Definitions and values are subject to change as per guidance from this assessment.

**Based upon current definitions of OY, where OY = 75% of F_{MSY}

Table 2. Projection Scenario Details for cobia assessment

2.1 Initial Assumptions:

OPTION	Value
2012 base TAC	TBD
2012 Recruits	TBD by Panel
2012 Selectivity	TBD by Panel
Projection Period	6 yrs (2013-2018)
1st year of change F, Yield	2013

2.2 Scenarios to Evaluate (preliminary, to be modified as appropriate)

1. Landings fixed at 2013 target
2. F_{OY}= 65%, 75%, 85% F_{MSY} (project when OY will be achieved)
3. F_{MSY}
4. $F_{REBUILD}$ (if necessary)
5. F=0 (if necessary)

2.3 Output values

1. Landings
2. Discards (including dead discards)
3. Exploitation
4. F/F_{MSY}
5. B/B_{MSY}

10. Evaluate the quality and applicability of data used in the assessment.
11. Evaluate the quality and applicability of methods used to assess the stock.
12. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
13. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.
14. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.
15. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.
    - Provide measures of uncertainty for estimated parameters
    - Ensure that the implications of uncertainty in technical conclusions are clearly stated
    - If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.
        - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments
        - Provide justification for the weightings used in producing the combinations of models
16. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.
17. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.
18. Make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring needs that could improve the reliability of future assessments

Table 1. Required MSRA Evaluations for Spanish mackerel assessment:

Note: te = trillion eggs

Criteria	Definition* (as of 2002/2003)	Current Value* (2002/03)
Mortality Rate Criteria		
F_{MSY}	$F_{30\%SPR}$	
MFMT	$F_{30\%SPR}$	
F_{OY}	75% of $F_{30\%SPR}$	0.40
$F_{CURRENT}$	$F_{2002/03}$	
$F_{CURRENT}$/MFMT		0.53
Base M		0.30
Biomass Criteria		
SSB_{MSY}	Equilibrium SSB_{MSY} @ $F_{30\%SPR}$	19.10 te
MSST	(1-M)*SSB_{MSY}: M=0.30	13.40 te
$SSB_{CURRENT}$	SSB_{2003}	17.96 te
$SSB_{CURRENT}$/ MSST		1.34
Equilibrium MSY	Equilibrium Yield @ $F_{30\%SPR}$	8.7 mp
Equilibrium OY	Equil. Yield @ 75% of $F_{30\%SPR}$	8.3 mp
OFL	Annual Yield @ MFMT	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	
Annual OY**	Annual Yield @ F_{OY}	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	

*Definitions and values are subject to change as per guidance from this assessment.

**Based upon current definitions of OY, where OY = 75% of F_{MSY}

Table 2. Projection Scenario Details for Spanish mackerel assessment

2.1 Initial Assumptions:

OPTION	Value
2012 base TAC	TBD
2012 Recruits	TBD by Panel
2012 Selectivity	TBD by Panel
Projection Period	6 yrs (2013-2018)
1st year of change F, Yield	2013

2.2 Scenarios to Evaluate (preliminary, to be modified as appropriate)

1. Landings fixed at 2013 target
2. F_{OY}= 65%, 75%, 85% F_{MSY} (project when OY will be achieved)
3. F_{MSY}
4. $F_{REBUILD}$ (if necessary)
5. F=0 (if necessary)

2.3 Output values

1. Landings
2. Discards (including dead discards)
3. Exploitation
4. F/F_{MSY}
5. B/B_{MSY}

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Report on the SEDAR 28 Desk Review of the Stock Assessments for Gulf of Mexico Cobia and Spanish Mackerel

N. G. Hall

Unit 2
2 Wexford Street
Subiaco
Western Australia 6008
Australia
Phone: +61 8 9401 6891
Email: nghall@iinet.net.au

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Contents

1. Executive Summary

Between 9 and 24 January 2013, a Center for Independent Experts (CIE) desk review of the SEDAR 28 Gulf of Mexico cobia (*Rachycentron canadum*) and Spanish mackerel (*Scomberomorus maculates*) stock assessments was undertaken. The key findings of that review are summarised below.

Prior to the development of assessment models by the Assessment Workshops, the Data Workshops had collated the biological data for the Gulf of Mexico stocks of cobia and Spanish mackerel and constructed time series of reliable data for the landings made by the commercial and recreational fisheries. Despite some deficiencies of the data collection programs, the Workshops had developed time series of discards from these fisheries and of the bycatch of the two species from the shrimp fishery. Although imprecise, these time series, together with the time series of landings data, had been considered appropriate for use in the assessments. Length composition data sufficient to characterize the landings data, and, in the case of the Spanish mackerel stock, one of the survey indices, had been collated, together with those age-at-length data that were available. The Data Workshop for cobia had also recommended two fishery-dependent survey indices, while that for Spanish mackerel had recommended one fishery-independent index of abundance and two fishery-dependent indices. Each of the survey indices had been standardized using an appropriate statistical approach.

Although both maturity at age and the various time series of discard data for both species were imprecise, and there was a lack of length and age-at-length composition data for those fish that had been discarded from the commercial and recreational fisheries, the data that the Data Workshops had collated for the Gulf of Mexico stocks of both cobia and Spanish mackerel represented the best data that were available and were considered adequate for use in stock assessment. It should be noted, however, that the imprecision of the input data and limited age composition data are reflected in uncertainty in the results of each assessment. In the case of cobia, the lack of a fishery-independent index of abundance is also likely to have influenced the results that were obtained from the assessment.

Assessments for both cobia and Spanish mackerel had been undertaken by the Assessment Workshops using Stock Synthesis 3, a versatile and well-tested program that has been employed in numerous stock assessments both in the U.S. and elsewhere. The methods employed by this program are of high quality and the software provides tools that facilitate exploration of uncertainty, calculation of benchmarks, projection of yields with specified fishing rates to assess future stock status, and, through bootstrapping, either within Stock Synthesis (in the case of cobia) or using auxiliary software (in the case of Spanish mackerel), generation of probability distributions of parameters, benchmarks, and other variables. The ease with which alternative values of parameters can be set up within Stock Synthesis had facilitated (1) the exploration by the Assessment Workshops of the sensitivity of the results produced by the cobia and Spanish mackerel models to a number of alternative assumptions regarding values of natural mortality, steepness, and discard mortality, (2) the conducting of retrospective analyses, and (3) investigation of alternative data weighting options.

For both cobia and Spanish mackerel, estimates of the steepness of the stock-recruitment relationship had been found to be imprecise. The key uncertainty reflected in the choice by the Assessment Workshop for Gulf of Mexico cobia of a set of models to represent alternative states of nature was the value of steepness. For Spanish mackerel, the Assessment Workshop chose to explore the effects of a range of values for the base level of natural mortality M when proposing alternative states of nature. Sensitivity analysis had also indicated that the results of the assessment for cobia were sensitive to this parameter.

The base model for the Gulf of Mexico stock of cobia assumed a base level of natural mortality of 0.38 y^{-1}, which, when fitted, resulted in an estimated steepness of 0.925. Based on the sensitivity analyses and explorations of uncertainty that had been carried out by the Assessment Workshop, this model and two alternative models were accepted as suitable for use as alternative states of nature when assessing the condition of the cobia stock. The alternative models assumed base levels of natural mortality of 0.26 and 0.5 y^{-1}, and, when fitted, resulted in steepness estimates of 0.96 and 0.92, respectively. On fitting the base model for the Gulf of Mexico stock of cobia, it was estimated that $SSB_{2011}/MSST=1.73$ and that $F_{current}/$ MFMT = 0.63, where the benchmarks MSST and MFMT had been calculated as MFMT = $F_{30\%SPR}$ and MSST = $(1 - M)$ $SSB_{30\%SPR}$. Based on this result and the examination of the results of the various sensitivity runs for Gulf of Mexico cobia, it is highly likely that the stock of cobia is not overfished and is not experiencing overfishing.

Exploration of parameter estimates, sensitivity runs, likelihood profiles, and results from bootstrapping led the Assessment Workshop for the Gulf of Mexico stock of Spanish mackerel to accept an alternative to the initial model as the new base model for this species. While this new model had an identical structure to that of the original base model, the value of steepness was fixed at 0.8, rather than estimated. An alternative model with similar structure to that of the new base model, but with steepness fixed at 0.9, was chosen by the Assessment Workshop to represent an alternative state of nature. Estimates obtained from the fitted base model indicated that $SSB_{2011}/MSST=3.06$ and that $F_{current}/$ MFMT = 0.38, where the benchmarks MSST and MFMT had been calculated as MFMT = $F_{30\%SPR}$ and MSST = $(1 - M)$ $SSB_{30\%SPR}$. Based on this result and examination of the results of the various sensitivity runs, it is highly likely that the Gulf of Mexico stock of Spanish mackerel is not overfished and is not experiencing overfishing.

The assessments produced by the Assessment Workshops for the Gulf of Mexico stocks of cobia and Spanish mackerel are based on the best data that are available, and the models that have been developed in Stock Synthesis are appropriate given the input data that are available for each stock. The results of these assessments provide the best scientific advice regarding the status of these two stocks that is currently available. While the limitations of the data and the uncertainty reflected in the sensitivity analyses and in the values calculated by the assessment models should be recognized when considering future management options, the explorations described in the Assessment Workshop Reports suggest that the conclusions regarding current stock status and levels of fishing mortality are likely to be robust despite the uncertainty associated with the assessments. Future stock assessments would benefit from improvement in the programs used (1) to collect discard data from the commercial and recreational fisheries and bycatch data from the shrimp fishery, and (2) to collect length and age-at-length data from landings and discards from both the commercial and recreational fisheries and from the bycatch of cobia and Spanish mackerel by the shrimp fishery.

The individuals involved in collating the input data and in developing the stock assessments are commended for their efforts.

2. Background

2.1. Overview

Between 9 and 24 January, 2013, a Center for Independent Experts (CIE) desk review was undertaken of the SEDAR 28 Gulf of Mexico cobia and Spanish mackerel stock assessments.

The Statement of Work provided to Dr Norm Hall by the CIE is attached as Appendix 2. This CIE report, which is prepared in accordance with the Statement of Work, describes his evaluation of the assessments and the review process.

Prior to the Review, stock assessment documents and other background documentation were made available to CIE Reviewers. A list of these documents is presented in Appendix 1. Note that, in the text of this review report, the "Gulf of Mexico – Cobia – Assessment Process Report" is referred to as the "Workshop Assessment Report" for the Gulf of Mexico stock of cobia.

2.2. Terms of Reference

The terms of reference for the desk review of the stock assessments of the Gulf of Mexico stocks of cobia and Spanish mackerel are presented in the Statement of Work (Appendix 2).

3. Description of Reviewer's role in review activities

Prior to undertaking the desk review, the Reviewer familiarised himself with the background documentation and the assessment reports for the two species that were the subject of the review (Appendix 1). Subsequently, he examined the Data Workshop and Assessment Workshop Reports for each species in greater detail, focussing on the preparation of this document, *i.e.*, the CIE report describing his evaluation of the two stock assessments and the SEDAR process.

4. Summary of findings relevant to the SEDAR 28 stock assessments for Gulf of Mexico cobia and Spanish mackerel

Because of the similarity of the models and many aspects of the data for the Gulf of Mexico stocks of cobia and Spanish mackerel, common issues in both assessments were often identified. There is thus some duplication of the text used when discussing those issues under the Terms of Reference for the separate stocks.

*4.1 Gulf of Mexico Cobia (***Rachycentron canadum***).*

ToR 1. Evaluate the quality and applicability of data used in the assessment.

Conclusions

The data that the Data Workshop has compiled for the Gulf of Mexico stock of cobia are the best that are available. Although limited, and imprecise in some aspects, the data are of a quality that allows a broad assessment of the likely condition of the stock.

Strengths

- The collation of life history data for the Gulf of Mexico stock of cobia.
- The collation of commercial landings data to produce time series of landings by handline, longline, and other gears from 1927, and, particularly, more precise data from 1950.
- The collation of a time series of estimates of bycatch of cobia by the shrimp fishery from 1972, using a Bayesian model to estimate catch per unit of effort.
- The collation of recreational fisheries data from different sources to produce sound time series of landings by fishing mode from 1955, and, particularly, more precise data from 1981.
- The collation of data to produce time series of discards from the commercial gears and recreational fishing modes.
- The collation of length composition data to characterize the landings by the commercial and recreational fisheries.
- The collation of two fishery-dependent indices of abundance, and the use of appropriate statistical analyses to standardize those indices of abundance.

Weaknesses

- Lack of definition of the southern boundary of the Gulf of Mexico stock of cobia.
- Paucity of data on the relationship of the proportion mature with age.
- The unreliable nature of the discard data due to low reporting, low intercept rates, and inadequate data collection programs.
- Inadequate sampling of length and age composition data from commercial landings and from bycatch of cobia from the shrimp fishery.

- Lack of length and age composition sampling from commercial and recreational discards.

Specific comments

Stock structure

The decision that, during the spawning season, mature individuals of cobia in the Gulf of Mexico are genetically distinct from those on the Atlantic coast north of Florida appears sound given the genetic and tagging data that are available. While the number of cobia in the sample collected in waters off Texas for the genetic study appears adequate, samples from the north of the Gulf of Mexico and from waters off the west coast of Florida are small. Further research to collect additional data from within the Gulf and to confirm the preliminary genetic findings would be valuable.

Despite the overall conclusion that the Gulf of Mexico stock is distinct from the South Atlantic stock of cobia, the genetic and tagging data indicate that there is some gene flow and a small amount of movement between the stock in the Gulf and those stocks in the stock complex off the South Atlantic coast, the latter complex being considered as the South Atlantic "stock" of cobia. There is also an inconsistency between the findings reported in SEDAR28-DW01 and those reported in SEDAR28-RD09, which needs to be reconciled. The former report advises that the collections from offshore in the Gulf of Mexico were genetically distinct from those offshore in the South Atlantic region, while the latter reports that "Based on our U.S. collections of *R. canadum* encountered along the SA and GOM coasts, tests of both genotypic distributions and pairwise hierarchical RST statistics suggest the offshore groups are genetically homogenous, even between the SA and GOM" and that "information gathered from the offshore collections … shows high levels of movement between the SA and GOM".

From the Data Workshop Report, it appears that the majority of tag recoveries have been made in locations that are consistent with the location of release of the tagged fish and the results of genetic studies of fish collected during the spawning season. Although not stated in this Report, the temporal distribution of recaptures of tagged fish presumably reflects the temporal distribution of catches in both spawning and non-spawning periods. The tag recovery data thus suggest that, despite the migrations that cobia undertake, regardless of the time of year and with the exception of fish caught in the waters off Brevard County, catches of fish may be assigned reliably to one or other of the two stocks on the basis of the area in which they are caught. Genetic studies should be undertaken to confirm this hypothesis, however.

As concluded in the Data Workshop Report, the genetic and tagging data indicate that Gulf of Mexico and South Atlantic stocks of cobia overlap in the waters to the east of Florida, and there is thus no distinct boundary that separates the stocks. For assessment and management, and for allocation of catches to one or other of the two stocks, the boundary between Florida and Georgia was selected (for convenience and because it was consistent with genetic, tagging and life history data) as the line separating the two stocks. Consideration should be given to whether catches within the area of overlap are of sufficient magnitude that assessment results could be sensitive to this decision, *i.e.*, whether an assessment based on an alternative line of separation at, say, the southern edge of the zone of overlap of the two stocks would be likely to yield results that differ greatly from those reported for the current assessment.

Unfortunately, maps of the distribution of the species and stocks of cobia, which were requested in the terms of reference for the Data Workshop, were not prepared. FishBase (Froese and Pauly, 2012) advises, however, that cobia has a worldwide distribution, which extends south of U.S. waters into waters off South America. The genetic study provides no information to suggest that the Gulf of Mexico stock does not extend into waters off Mexico, where it may also experience the effects of fishing. Further genetic research to determine the southern extent of the Gulf of Mexico stock of cobia appears necessary.

Biological data

The Life History Working Group's recommendation to base its estimate of the average value of the instantaneous rate of natural mortality M for fully-selected fish (ages 3-11) on the value determined from the Hoenig (1983) equation for fish using a maximum age of 11 years, *i.e*., 0.38 y^{-1}, is endorsed. The range of estimates of M ultimately used to explore the sensitivity of the assessment model to imprecision in the estimate of natural mortality, *i.e*., 0.26 to 0.5 y^{-1}, was broader than that initially proposed by the Life History Working Group (LHWG), *i.e*., 0.26 to 0.42 y^{-1}. While the LHWG also recommended that a range of values of M based on a CV of 0.54 (MacCall, 2011), or other CVs, should also be explored, such exploration does not appear to have been undertaken by the Assessment Workshop. The basis for the use of 0.5 y^{-1} as a high value of M is not explained in the Assessment Workshop Report, but it is noted that the difference between this high value and the base level of 0.38 y^{-1} is equal to the difference between that latter value and the low value of 0.26 y^{-1}. Research is needed to determine methods by which an appropriate range of feasible values of M for a species might be selected for use in stock assessment as alternate plausible states of nature.

For Gulf of Mexico cobia, estimates of M from the Lorenzen equation were scaled such that the average value of M over the fully-selected ages 3 to 11 years was equal to the estimate from Hoenig's (1983) equation for fish, *i.e*., 0.38 y^{-1}. It is unclear, however, whether the same approach as used for Run 1 was applied in sensitivity runs 2 and 3 when, as advised in the Assessment Workshop Report, the Lorenzen-based age dependent mortalities were scaled to achieve the same cumulative survivals over all ages as that expected for constant mortalities equal to the low and high values of M, respectively. It is likely that the cumulative survival was calculated over only ages 3-11, rather than all ages, to ensure consistency with the approach used in Run 1 when average M was set to 0.38 y^{-1}.

Use of the Lorenzen (1996) equation to derive age-dependent estimates of natural mortality M is not endorsed. In his report to the CIE on the stock assessments conducted for yellowtail flounder and Atlantic herring at Woods Hole in 2012, Francis (2012) advised that prediction of M, and, through body weight, its variation with age for an individual species, using Lorenzen's (1996) equation was likely to be highly imprecise, as was evident in the wide scatter about the regression line in Lorenzen's Figure 1. Francis observed that, for about one-third of Lorenzen's data points, predicted and observed Ms appeared to differ by a factor of more than 2. Furthermore, in the case of both herring and yellowtail, the values of M estimated by Lorenzen's (1996) equation differed markedly from the values estimated using Hoenig's (1983) equation and had to be scaled substantially for use in the yellowtail flounder and Atlantic herring assessments. If it is assumed that the length measure used for Gulf of Mexico cobia in the growth equation, the parameters of which are presented in Table 2.7.1 of the Data Workshop Report, is fork length rather than total length (not advised in the text or table but inferred from Fig. 2.7.2), the value of *M* at age 3 is estimated by the Lorenzen (1996) equation to be 0.21 y^{-1}. This suggests that the estimates for the Gulf of Mexico stock of cobia calculated using Lorenzen's (1996) method were scaled up by a factor of at least 1.8 to produce the estimates of age-dependent natural mortality used in the assessment. Francis (2012) raised the valid point that, if the estimates produced for a species by Lorenzen's (1996) equation provide such unreliable estimates that the mean *M* differs from the estimate calculated using Hoenig's (1983) equation by a factor that differs markedly from 1, can it be considered sufficiently reliable to estimate how *M* varies with age within these species?

There has been no test to assess whether the introduction of the additional complexity associated with age-dependent natural mortality was justified by the resultant improvement in fit that was obtained for the Gulf of Mexico cobia model. It is recommended that a model employing a constant value of *M* is fitted to the cobia data. If this model fits just as well as the model that employs an age-dependent *M*, then the simpler model should be used. If the age-dependent model produces a significantly better fit, it would probably be better to estimate age-dependent *M* within the assessment model rather than assuming that it is of the form predicted by the Lorenzen (1996) equation.

The Data Workshop's decision, that cobia are hardy and unlikely to suffer barotrauma-associated post-release mortality, is subjective. Further research on discard mortality would be useful.

The Data Workshop correctly identified that, because of bias introduced into biological samples by the 33 inch minimum legal size, an allowance would need to be made when fitting von Bertalanffy growth curves to length-at-age data. By fitting the growth curves in Stock Synthesis, the influence of the selection curves on the observed length-at-age data is automatically taken into account and uncertainty associated with fitting the growth curves is carried through to the estimates of parameters and benchmarks that are produced by Stock Synthesis.

Because of the paucity of the youngest ages of fish in samples, the advice relating to maturity at age, which was reported in the Data Workshop Report, was subjective. Research based on fishery-independent samples is needed to provide more reliable estimates of the parameters of the maturity-length relationship and the proportion mature at age.

Although the Data Workshop noted that cobia exhibit sexually dimorphic growth, the Stock Synthesis model used in the assessment employed only the growth curve for the pooled sexes. In future refinement of the assessment model, consideration should be given to including sexually dimorphic growth, noting that the benefit of this might only be realised if appropriate sex composition data for landings and discards become available for input, and length and age-at-length compositions are sexually disaggregated.

Commercial landings

The decision by the Data Workshop to extend the historical time series of commercial landings of Gulf of Mexico cobia as far as possible into the past is endorsed, as catches from that earlier time period are likely to have influenced current stock status. It was noted that the Data Workshop reported that "Landings prior to 1950 are considered highly uncertain" and that the precision of landings improved following the introduction of the trip ticket system in each state. The tables that are presented provide no estimates of the precision likely to be associated with the annual landings data, nor is any information provided as to whether the commercial landings for cobia, which were reported by the Data Workshop, were likely to be biased, and, if so, the magnitude and direction of such bias.

Without an alternative time series, such as fishing effort, to provide information on fishing mortality, Stock Synthesis assumes that the catches are known sufficiently well to estimate the fishing mortalities required to take those catches (Methot and Wetzel, 2012), and thus estimated catches match the values that were input. In the current assessment, there has been no evaluation of the implications of the greater imprecision of the commercial landings data prior to 1950. Such evaluation may have required a sensitivity run with an alternative time series of commercial landings encompassing the imprecision of the landings data.

The Data Workshop has reported that, because few trips with cobia discards were observed by the Reeffish Observer Program and the NMFS logbook does not provide coverage of the entire fishery, discards of cobia by the commercial fishery have greater uncertainty than commercial landings and are likely to underestimate the true quantities of discarded fish. No estimate is provided of the likely magnitude of such underestimation.

The Working group advised that discards reported as "kept, not sold" should be added to the landings, and not included in the discards. This recommendation does not appear to have been accepted by the Assessment Workshop as Table 3.6 of the Data Workshop Report includes these fish within the discards, and the same values are carried over and used in the assessment (Table 2.5 and Appendix A, Assessment Workshop Report). The value for 2011 in Table 2.5 differs from that reported in Appendix A in the Assessment Workshop Report.

The estimates of the annual bycatch of cobia in the Gulf of Mexico by the shrimp fishery, which are reported in Table 2.7 of the Assessment Workshop Report, differ from the values in Table 3.10 of the Data Workshop Report. The latter values match those reported in SEDAR-DW06. There is no explanation in the Assessment Workshop Report to explain this inconsistency. Although the Assessment Workshop Report refers to a data workshop report for SEDAR 22 for details of the methods employed to obtain these bycatch estimates, frequent other references to SEDAR 22 in the Assessment Workshop Report suggest that the references to SEDAR 22 are erroneous and that the correct citation should have been the Data Workshop Report for SEDAR 28. This last report provides no explanation for the inconsistency between the values presented in the two reports.

The Assessment Workshop Report presents a table (Table 2.8) of annual standardized estimates of effort for 1945-2011 by the shrimp fishery. These effort values are inconsistent with the effort (days fished) for 1981-2010, which are reported in Table 3 of SEDAR-DW06. While this could possibly have been explained by the fact that the values in Table 2.8 of the Assessment Workshop Report have been standardized, there is no explanation as to how the data for these estimates were collected, nor the method employed to standardize the values. As a further complication, the Assessment Workshop Report advises that the values of effort for the shrimp fishery were input as an index of fishing mortality for the shrimp fishery and. while it would therefore have been expected that the effort values used in the Stock Synthesis model would have been those values reported in Table 2.8 of the Assessment Workshop Report, this is not the case. While there is a broad degree of similarity, the values that are actually input into Stock Synthesis 3, as shown in the data file listed in Appendix A of the Assessment Workshop Report, differ considerably from those presented in Table 2.8. No explanation for this inconsistency is to be found in the cobia Assessment Workshop Report, however the time series of values of effort used in the Stock Synthesis data file for cobia appears to match the time series of scaled effort for the shrimp fishery presented in Table 2.8 of the Assessment Workshop Report for Spanish mackerel. Although this inconsistency thus appears to have a possible explanation, it is important that the results of the stock synthesis runs, estimates of benchmarks, and determinations of current stock status, which have been reported for cobia in the cobia Assessment Workshop Report, are based on the input data for Stock Synthesis that were described in the appendices of that assessment report. Inconsistencies between the data inputs for cobia that have been described and the Stock Synthesis data files for that species need to be reconciled.

The Data Workshop noted that the CVs of the estimates of bycatch of cobia by the shrimp fishery ranged from 66 to 208%, with only 4 of the 39 years having CVs less than 100%. An issue that may have been resolved after the Data Workshop was that a number of the estimates of bycatch calculated by the Bayesian model became stuck on bounds, although the Data Workshop Report does not identify which of the 39 years encountered such problems. As a consequence of these issues, bycatch estimates for the shrimp fishery were recognised by the Assessment Workshop as being very imprecise. For this reason, shrimp fishery effort was used as a proxy for the trends present in the point estimates of bycatch by the shrimp fishery. The median of the 1972 to 2011 estimates of bycatch was used, however, to provide an estimate of the magnitude of the bycatch. An estimate of the catchability coefficient relating shrimp effort to fishing mortality was then calculated within Stock Synthesis using 1972 to 2011 as a super period. A similar super period approach was employed in Stock Synthesis to accommodate the small sample sizes of the length composition data from the SEAMAP program, which were considered to be representative of the length compositions of cobia caught by the shrimp fishery. Use of such a super period to deal with the imprecision of the bycatch estimates of cobia from the shrimp fishery is an appropriate modelling approach. It would have been preferable, however, to have used a reliable time series of precise estimates of discards of the bycatch of cobia from the shrimp fishery in the Stock Synthesis model if such a time series had been available, rather than having to “work around” the problem. Consideration therefore should be given to establishing a well-designed program to monitor the bycatch of cobia by the shrimp fishery such that reliable estimates can be collected in the future.

Very few samples of landed fish were available from catches taken by commercial miscellaneous gears, and thus reliable characterization of the length composition of these landings is not possible, The Data Workshop advised that sample sizes for developing length compositions of commercial landings were inadequate for a considerable number of gears and years. It is reasonable to conclude that length composition data collected from the commercial landings are imprecise. Low sample sizes may also affect the extent to which the resultant length compositions are representative of total annual landings. After filtering, too few measurements of discarded cobia were available from the Reeffish Observer Program to characterize the length composition of discarded fish. The Data Workshop Report advised that age compositions of commercial catches were inadequate for all years and that no aging error matrix could be generated for these ageing data because 86% of the age readings were from a period 15-20 years earlier and thus reader comparisons were not possible. Well-designed monitoring programmes to collect length and age composition data from the landings and discards by each of the principal gear types used by commercial fishers should be established.

Recreational landings

When combining the time series of data collected by different approaches for the same fishing mode, calibration factors were calculated using the data collected during a period of overlap. No comment is made in the Data Workshop Report, but it should be recognised that imprecision of the calculated calibration factor adds to the imprecision of the data that are adjusted and should be carried through into the resulting time series.

While CVs of the estimates of the recreational landings for a fishing mode are calculated and reported in summaries for a number of the data collection programs, estimates of the uncertainty of the values in the resulting time series of the total recreational landings are not provided (Table 2.4, Assessment Workshop Report), and thus are not considered in the assessment.

The collection of age data from the landings of the recreational fishery appears opportunistic, judging from the description provided in the Data Workshop Report. A well-designed program to collect length and age composition data for Gulf of Mexico cobia from the landings and discards of the recreational fishery should be established.

Survey indices

The decisions made by the Data Workshop when selecting indices of abundance appear sound. Despite the fact that both were derived from fishery-dependent data, the time series of headboat and MRFSS catch-per-unit-of-effort (cpue) data were endorsed by the Data Workshop as acceptable indices of abundance for Gulf of Mexico cobia. The time series of data for these indices were standardized using the delta lognormal model.

Adjustment by Assessment Workshop

Although the Data Workshop produced time series of commercial landings by gear type, the Assessment Workshop pooled these data to create a single time series, which was input to Stock Synthesis. Similarly, the Assessment Workshop combined the recreational landings, which had been tabulated by mode, into a single time series of recreational landings. Such pooling obviously suited the incremental approach that was used when developing the assessment model, *i.e.*, first developing a simple production model, then an age-structured production model, and finally a length-structured catch-at-age model. By pooling the data into the two time series, the number of parameters to be estimated was reduced but, as a common selection curve is applied to each time series of combined data within Stock Synthesis, it is assumed that annual length and age-at-length data for the pooled data were representative of those combined data.

ToR 2. Evaluate the quality and applicability of methods used to assess the stock.

Conclusions

Stock Synthesis 3, the software within which the model for the Gulf of Mexico stock of cobia was developed, has gained international recognition for its quality and the applicability of the methods it uses to assess the condition of fish stocks. The model for cobia was of an appropriate structure given the data that were available. Values predicted by the model, including those of benchmarks, were imprecise, however, due to the nature of the input data. Further imprecision of model outputs due to alternative values of key parameters, such as natural mortality and steepness of the stock-recruitment relationship, was explored. Recognising the types of data that were available for input and the uncertainty of model outputs that arose as a consequence of the nature of those input data, the Stock Synthesis model for cobia is of a quality consistent with that which would be considered "best practice", and is able to provide a valuable assessment of the likely condition of the stock in 2011, and, when projected, the likely trajectory of yields and stock condition over the next five to six years.

Strengths

- The decision to use Stock Synthesis 3 as the modelling framework.
- The structure of the model for cobia, which was developed within the Stock Synthesis framework, was appropriate given the data that were available.
- The enhancement of Stock Synthesis to allow modelling of a fishery for which the only source of mortality is that associated with discarding of bycatch.
- The assessment of the uncertainty of parameter estimates was thorough.
- Selectivity runs explored key uncertainties and demonstrated appropriateness of conclusions regarding the current condition of the stock.
- Benchmarks were appropriately calculated.
- Projections were undertaken using two states of nature.

Weaknesses

- Subjective decision to set effective sample size to actual sample size capped at a maximum of 100 rather than to use iterative reweighting, such as proposed by Francis (2011).
- Lack of exploration of sensitivity to the assumption of logistic selectivity for the recreational and commercial fisheries.
- Lack of length and age composition data to provide information on the length compositions of discards and the shape of the retention curves
- Failure of model to match the trends in discards from the commercial and recreational fisheries
- Imprecision in the estimate of steepness of the stock-recruitment relationship.
- Lack of exploration of uncertainty associated with time series of commercial and recreational landings.
- Errors in Stock Synthesis files in the Appendices.

Both the decision by the Assessment Workshop to employ Stock Synthesis 3 as the modelling framework and the structure of the model for the Gulf of Mexico stock of cobia that was developed within this framework are appropriate. Stock Synthesis has been extensively tested, and has the flexibility to be applied to fisheries with data qualities ranging from poor to rich. The software has been equipped with tools to explore uncertainty, to estimate benchmarks, and to undertake projections using alternative harvest policies. Because of its versatility, Stock Synthesis is well suited to explorations of the sensitivities of model outputs to a broad range of alternative model structures or use of alternative sets of data inputs. The enhancement of Stock Synthesis to allow modelling of a fishery for which the only source of mortality is that associated with discarding of bycatch is a particular strength of the assessment that was developed for the Gulf of Mexico stock of cobia. While some deficiencies were identified in the fit of the base model, the overall fit was regarded as adequate.

The Stock Synthesis model for the Gulf of Mexico stock of cobia included three fishing fleets, *i.e.*, commercial, recreational and discards of bycatch from the shrimp trawl fishery, and two fishery-dependent abundance indices, *i.e.*, cpue data from the MRFSS survey and from the headboat survey. Time series of discards from the commercial, recreational, and shrimp fisheries were input, together with length composition data of cobia from the commercial and recreational fisheries, and, combining the data into a super period, from the bycatch from the shrimp fishery. Age composition data were input for the recreational fishery and considered within the model as age compositions that were conditional on length.

The model employed 3-cm bins for the length composition of cobia, and the lower bounds of the length intervals within these bins ranged from 6 to 165 cm. It was pleasing to note that the Assessment Workshop had reported exploration of the effect of bin size on estimation of selectivity parameters, at least to a limited extent, and concluded that use of a bin width of 3 cm was preferable to use of one that was 5 cm. Methot (2011) notes that, on occasion, wide bin widths can cause problems when the slope of a selectivity or retention curve becomes so steep that all change occurs within a single length class.

Although the Assessment Workshop reported that, as its value is typically unable to be estimated within the assessment model, the standard deviation of recruitment was fixed at 0.6, no justification for the choice of this particular value is provided in the Assessment Workshop Report. It might be useful to note that the use of this value has been proposed in a number of studies (*e.g.*, Smith and Punt 1998; Maunder and Deriso, 2003), which typically advise that the value 0.6 is supported by the results of the meta-analyses undertaken by Beddington and Cooke (1983), and later by Mertz and Myers (1996).

When developing the base model for cobia, a subjective decision was made to employ an effective sample size for the length composition data of cobia, which was set equal to annual sample size but capped at a maximum of 100 when the number of fish in the annual sample exceeded this number. Rather than using this subjective approach, the iterative re-weighting approach that was explored in sensitivity run 10, *i.e.*, the method proposed by Francis (2011), is recommended.

The decisions by the Assessment Panel to use asymptotic, logistic, size-based selectivity curves for the recreational and commercial fisheries and a double-normal selectivity curve to represent the selectivity of cobia by the shrimp fishery, and to keep these selectivity curves constant over time, are endorsed. It would have been expected, however, that sensitivity to this choice of selectivity patterns would have been explored. As was appropriate, to accommodate the introduction in 1984 of a minimum size limit of 33 inches, separate retention curves were assumed for the time blocks 1927-1984 and 1985-2011. Because of the lack of data prior to 1993, however, it was necessary to assume the shape and parameters of the retention curve for the earlier time block. This represents a source of uncertainty, and it would therefore be appropriate to consider whether assessment results are likely to be sensitive to the assumptions made regarding the form and values of parameters of this retention curve.

The base model was fitted to the data for Gulf of Mexico stock of cobia and reported as Run 1. All estimated parameters were assumed to have uniform, non-informative priors, with wide bounds. The results of the jitter test, with 48 of 50 trials converging to within 2 likelihood units of the minimum, suggested that the model was not particularly sensitive to the initial values of the parameters that were estimated.

While model predictions were broadly consistent with the commercial and recreational discards, the trends of the predictions did not match those of the observed data, suggesting some structural deficiency of the model or, if the model structure was correct, inadequacy of the discard data or overriding influence of other data. In the case of discards by the commercial fishery, the possibility that the discard data were inadequate cannot be discounted as the Data Workshop had identified that these estimates were likely to be both imprecise, as few trips with cobia discards had been recorded in the Reeffish Observer Program, and erroneously low, as the NMFS logbooks do not provide coverage of the entire fishery. In the case of the recreational fishery, however, it is likely that the failure to fit the trend in recreational discards was due to the competing influence of other datasets on model predictions.

It would be useful to advise in the captions of Figures 3.7 and 3.8 of the Assessment Workshop Report that these are plots of the MRFSS and headboat cpue data, respectively. As noted in the Report, the fits to these indices and to the effort data for the shrimp fishery are quite good, although runs of positive and negative deviations were present in the headboat cpue data. Some structure also appeared present in the Pearson residual plots for the commercial (Fig. 3.11) and recreational (Fig. 3.13) length composition data.

In the base model represented by Run 1, estimates of both the log of unexploited equilibrium recruitment (1,033,130 fish) and the steepness of the stock recruitment curve, *i.e.*, 0.925, were calculated by Stock Synthesis when the model was fitted to the input data. The Assessment Workshop provided a well-considered evaluation of the reliability of the estimate of steepness, noting that a large proportion of bootstrap estimates of steepness approached the upper bound of 1, and that, although probably greater than 0.8, the distribution of estimates between 0.85 and 1 was relatively uniform. The likelihood profile for steepness was relatively flat between 0.8 and 1, but suggested a minimum between 0.85 and 0.95. Tension was exhibited in the values of steepness that were most consistent with recruitment data (favouring a value of ~1), length and discard data (favouring a value of ~0.8), and age composition (favouring a value of ~0.65), with little information relating to steepness evident in the abundance indices. The fact that the input data were more consistent with lower values of steepness, while the assumption regarding recruitment deviations appeared to be providing the support for higher values of steepness, is interesting as it raises the question of whether, in the case of Gulf of Mexico cobia, the influence of recruitment deviations on the resultant parameter estimates was excessive. The assessment Workshop Report advised that steepness may not be well estimated by the Stock Synthesis model, a conclusion that appears sound. The recent study by Lee *et al.* (2012), which demonstrated the difficulty that is typically encountered when attempting to estimate steepness, concluded that "steepness is reliably estimable inside the stock assessment model only when the model is correctly specified for relatively low productive stocks with good contrast in spawning biomass". This conclusion is relevant to the cobia assessment, for which the results of fitting the base model to cobia, a species that, on the basis of its natural mortality, would be considered of medium productivity, indicated that biomass had been relatively stable over the last 30 years, the period covered by the abundance indices and much of the more reliable input data.

The question of how to respond when the steepness of the stock-recruitment relationship is imprecise or cannot be estimated reliably should be considered. Francis (2012) has suggested that, in such circumstances, he considers it better to fix steepness at a value, such as 0.75, *i.e*., the default value recommended in Francis (1993), and which is frequently used in Australia and New Zealand, or the average of published values for the same or similar species. Francis (2012) advises that the uncertainty associated with this parameter should then be explored using sensitivity runs with lower and higher values of steepness.

There would have been value in assessing whether the value of steepness estimated from the base model, *i.e*., 0.925, is consistent with published values for cobia or similar species. The fact that this value of steepness for the base model, and the values of steepness estimated when fitting the models using the low and high values of the base level of natural mortality, which were subsequently used as alternative states of nature, ranged from 0.92 to 0.96 (Table 3.7, Assessment Workshop Report) was initially of concern to the Reviewer, as such values of steepness reflect a robust stock that is able to maintain recruitment despite considerable decline in stock size. It was noted subsequently, however, that the Assessment Workshop had explored sensitivity runs with lower steepness, *i.e*., 0.7 and 0.8, and that these runs had produced very similar conclusions regarding the condition of the stock with respect to benchmark levels as were determined using the base model (Table 3.8, Stock Assessment Report). Accordingly, after considering the results of the other sensitivity runs, it is concluded that, despite imprecision in the estimate of steepness, the base model accepted by the Assessment Workshop, *i.e*., the model associated with Run 1, is appropriate for determination of the current condition of the Gulf of Mexico stock of cobia and for use in projecting the fishery over a short time period to assess the likely outcomes of fishing with specified levels of fishing mortality.

There are errors in the stock synthesis files listed in the appendices. For example, there are actually 91 length observations in the data file, not 85, where this inconsistency would cause Stock Synthesis to abort when it attempted to read the data. Also, the number of length bins is specified as 54 in the data file, but the specification of the selectivity for MRFSS data attempts to use 57, which would cause Stock Synthesis to abort when it attempted to run following data input. The listings should be those associated with the base model, but appear to be those of a model that was still under development.

ToR 3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

Conclusions

Estimates of stock abundance, biomass, and exploitation are produced when the Stock Synthesis model is fitted. The values of total biomass and annual exploitation in 2011, which were estimated when the base model for the Gulf of Mexico stock of cobia was fitted, were 3,030 mt and 0.29, respectively.

Strengths

Stock Synthesis 3 is able to calculate time series of abundance, total biomass, and annual exploitation.

Stock abundance:

The report file that is produced by Stock Synthesis, report.sso, contains a time series section, in which the time series of abundance, recruitment and catch for each of the areas are reported. Output quantities include summary biomass and summary numbers for each gender and growth pattern. The Assessment Workshop Report for the Gulf of Mexico cobia stock has not reported these abundance estimates, but they will be available in the output file for Run 1.

Biomass:

Stock Synthesis produces an estimate of total annual biomass (Table 3.4, Fig. 3.33). The estimate (for Run 1) of total biomass for 2011 was 3,030 mt.

Exploitation:

Although not reported in the text of the Assessment Workshop Report, the code within the Starter.SS file presented in Appendix C of this report specifies that, for the Gulf of Mexico stock of cobia, Stock synthesis is to set the value of fishing mortality, *F*, to the value of annual exploitation, calculated as the ratio of the weight of the total catch (including discards) to the total biomass. The estimate (for Run 1) of the annual exploitation rate for 2011 was 0.29 (Table 3.6, Assessment Workshop Report).

ToR 4. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.

Conclusion

Stock Synthesis calculates a range of population benchmarks and management parameters. Benchmarks calculated for cobia were MFMT = $F_{30\%\text{SPR}}$ and MSST = (1 – M) $\text{SSB}_{30\%\text{SPR}}$. The estimates of F_{current} and $\text{SSB}_{\text{current}}$, which were calculated for 2011 using the base model for cobia, were 0.24 and 2,213 mt, respectively. The ratios $F_{\text{current}}/\text{MFMT}$ and $\text{SSB}_{\text{current}}/\text{MSST}$, which were calculated using the base model, were 0.63 and 1.73, respectively. These results, which were consistent with those produced by all but one (the model with natural mortality set to 0.26 y^{-1}) of the models used in the various sensitivity runs, imply that, in 2011, the Gulf of Mexico stock of cobia was not experiencing overfishing and was not overfished.

Strengths

Stock Synthesis possesses well-tested procedures to calculate and output a range of population benchmarks and management parameters.

Summary

Stock Synthesis provides estimates of population benchmarks and management parameters. In particular, it is able to produce estimates for indicator variables and reference points based on maximum sustainable yield (MSY), spawning potential ratio (SPR), and spawning stock biomass (SSB), and taking the stock-recruitment relationship into account. SPR is calculated as the equilibrium spawning biomass per recruit that would result from a given year's pattern and the levels of *F*'s and selectivities for that year. For MSY-based reference points, Stock Synthesis searches for a fishing mortality that would maximise the equilibrium yield. For SPR-based reference points, the computer program searches for an *F* that would produce the specified level of SPR. For spawning biomass-based reference points, the software searches for an *F* that would produce the specified level of spawning biomass relative to the unfished value.

The management benchmarks, *i.e.*, the Maximum Fishing Mortality Threshold (MFMT) and Minimum Stock Size Threshold (MSST), which were proposed for the Gulf of Mexico stock of cobia by the Assessment Workshop, are appropriate for use in determining the status of that stock. These benchmarks, which were based on the level of fishing mortality and equilibrium spawning stock biomass associated with a spawning potential ratio of 30%, are

$$\text{MFMT} = F_{30\%\text{SPR}} \quad \text{and} \quad \text{MSST} = (1 - M)\ \text{SSB}_{30\%\text{SPR}},$$

where it was concluded that overfishing was occurring if F_{current} > MFMT, *i.e.*, $F_{\text{current}}/\text{MFMT} > 1$, and the stock was considered to be overfished if $\text{SSB}_{\text{current}}$ < MSST, *i.e.*, $\text{SSB}_{\text{current}}/\text{MSST} < 1$.These benchmarks are approximations for

$$\text{MFMT} = F_{\text{MSY}} \quad \text{and} \quad \text{MSST} = (1 - M)\ \text{SSB}_{\text{MSY}},$$

where F_{MSY} is the fishing mortality that produces the maximum sustainable yield MSY, M is the point estimate of natural mortality for fully recruited ages, and SSB_{MSY} is the equilibrium spawning stock biomass that produces MSY. The benchmarks for the Gulf of Mexico stock of cobia use proxies, where these proxies were based on a spawning potential ratio SPR of 30%. Thus, the proxy that was used for F_{MSY} was the fishing mortality, $F_{30\%\text{SPR}}$, which produces a spawning stock biomass per recruit that is 30% of the spawning stock biomass per recruit produced when the stock is not fished, *i.e.* an SPR of 30%. The proxy that was used for SSB_{MSY} was the corresponding value of equilibrium spawning stock biomass, *i.e.* the spawning stock biomass $\text{SSB}_{30\%\text{SPR}}$ that is produced with a fishing mortality of $F_{30\%\text{SPR}}$.

Although Stock Synthesis is able to estimate MSY-based rather than SPR-based reference points, the Assessment Panel chose to use the proxies $F_{30\%\text{SPR}}$ and $\text{SSB}_{30\%\text{SPR}}$ rather than F_{MSY} and SSB_{MSY}. The latter two reference points are likely to be more appropriate if assessing “the capacity of a fishery to produce the maximum sustainable yield on a continuing basis” (Magnuson-Stevens Fishery Conservation and Management Act, May 2007).

F_{current} was calculated as the geometric mean of the estimates of the three most recent annual fishing mortalities, *i.e.*, the fishing mortalities for 2009-2011, where annual fishing mortality was estimated by its proxy, exploitation rate, calculated as the ratio of the total catch (including discards) to estimated total biomass. $\text{SSB}_{\text{current}}$ was the estimate of spawning stock biomass for 2011.

Table 3.8 of the Assessment Workshop Report, a subset of which is reproduced below, contains the values of the current (2011) fishing mortality and spawning stock biomass for Gulf of Mexico cobia, the values of the MFMT and MSST benchmarks for this stock, and the results of the stock determination for each of the models that were explored in the assessment. The only one of these models, for which the current fishing mortality exceeded MFMT (*i.e.*, overfishing was occurring) or the current SSB was less than MSST (*i.e.*, the stock was overfished), was the sensitivity trial in which a low value of natural mortality was employed as the base level when scaling the Lorenzen (1996) estimates to determine age-dependent estimates of natural mortality.

Quoted from Assessment Workshop Report: "Table 3.8, Assessment Workshop Report. Reference points and benchmarks from sensitivity runs for Gulf of Mexico cobia from SS. Benchmarks are reported for SPR 30%. Current refers to the geometric mean of 2009-2011 for F. MSST = (1-M)*SSBSPR30% with M = 0.38 y^{-1} for all models except runs 2 (M = 0.26 y^{-1}) and 3 (M = 0.50 y^{-1})".

Run	Model	Fcurrent	SSB2011	MFMT	MSST	F/MFMT	SSB/MSST	Overfishing occurring?	Overfished?
1	Base model	0.24	2213	0.38	1280	0.63	1.73	No	No
2	M_Low	0.3	1872	0.29	2443	**1.05**	**0.77**	**Yes**	**Yes**
3	M_High	0.18	2587	0.45	804	0.4	3.22	No	No
4	D_High	0.24	2197	0.37	1302	0.65	1.69	No	No
5	Steepness=0.7	0.24	2121	0.39	1174	0.63	1.81	No	No
6	Steepness=0.8	0.24	2168	0.38	1257	0.64	1.73	No	No
7	MRFSS only	0.26	1921	0.37	1277	0.7	1.5	No	No
8	HB only	0.19	2940	0.37	1301	0.52	2.26	No	No
9	Stock synthesis weighted	0.22	2340	0.35	1273	0.58	1.85	No	No
10	Francis (2011) weighting	0.22	2415	0.38	1305	0.61	1.84	No	No

ToR 5. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.

Conclusions

Stock Synthesis provides a well-tested procedure to project the model through a range of future years, using a fishing rate based on MSY, SPR, a specified target biomass, or a multiple of the recent average fishing rate, and producing estimates of yield and key management parameters, thereby allowing assessment of future stock condition. The methods used, which are recognised as being of high quality, are designed to produce the estimates of future population status that are needed by managers. For the base model, fishing mortality would be increased from F_{current} if adjusted to F_{OY} or $F_{30\%\text{SPR}}$. Projections from 2013 to 2019 suggest that spawning stock biomass would increase from $\text{SSB}_{\text{current}}$ if fishing mortality was maintained at F_{current}, increase to a lesser extent if fishing mortality was increased to F_{OY}, and decline very slightly if fishing mortality was increased to $F_{30\%\text{SPR}}$. Yield would be expected to increase under each of these three fishing mortalities. The condition of the stock would be expected to continue to be classified as "not overfished, with overfishing not occurring".

Strengths

Projections are undertaken using the well-tested procedures within Stock Synthesis.

Weaknesses

It would have been useful to have undertaken a projection using a model with a lower steepness, such as 0.8.

Summary

Stock Synthesis includes a well-tested procedure to project the future stock status that would be expected to result when using a fishing rate based on MSY, SPR, a specified target biomass, or a multiple of the recent average fishing rate. Use of this procedure ensures consistency of model predictions with the assumptions, with the parameter estimates obtained by fitting the model, and with the length and age structure predicted as the current state of the stock. It is thus highly applicable for use with the Gulf of Mexico stock of cobia.

Deterministic projections for 2013 to 2019 were run for the Gulf of Mexico stock of cobia using three models, *i.e.*, the base model (Run 1), and the low and high mortality models (Runs 2 and 3, respectively), which the Assessment Panel considered representative of possible alternative states of nature. The projections were made using fishing rates set to MFMT (*i.e.*, the proxy $F_{30\%SPR}$ for F_{MSY}), F_{OY} (*i.e.*, 75% of $F_{30\%SPR}$), and $F_{current}$, where this last value was calculated as the geometric mean of the annual values of F for the last three years, *i.e.*, 2009-2011. The fishing mortality of the shrimp fishery during the projection period was assumed to remain constant, and was set to the geometric mean of the annual fishing mortalities for this fishery over the last three years, *i.e.*, 2009-2011. Selectivity, discarding, and retention patterns were assumed to be the same as those experienced in the five most recent years, *i.e.*, 2007-2011, while the distribution of catches among the fishing fleets, *i.e.*, fisheries, reflected the distribution of average fishing intensities among those fleets in 2009-2011. Recruitment during the projection period was calculated as the value predicted by the stock-recruitment relationship. The base model was also projected using a fishing mortality of $F_{30\%SPR}$ for 1000 samples generated using the bootstrap facility within Stock Synthesis to produce distributions of the estimated yields predicted by the model for each year between 2012 and 2019 (Fig. 3.63, Assessment Workshop Report).

The final year of the time series of data used in the assessment for the Gulf of Mexico stock of cobia was 2011. In order to carry out projections, it was therefore necessary to estimate the removals that were likely to have occurred in 2012. Accordingly, removals of cobia for each of the fisheries in 2012 were estimated using a fixed fishing mortality set to the geometric average of the annual fishing mortalities in 2009-2011.

The methods used in Stock Synthesis to predict the outcomes expected between 2013 and 2019 were considered to be of a high quality. The quality of the resulting projections depends, however, on the extent to which the alternative states of nature represented by the different models used in the projection are likely to be representative of the true state of nature, and the extent to which each of those alternative models provides a reliable representation of the dynamics of the stock. The results of the projections should thus be considered in the context of the accuracy and precision of the predictions made by the model with respect to the input data they were intended to represent.

Although the three models used in the projections bracket the range of estimates of natural mortality for cobia, the estimates of steepness for these models range only between 0.92 and 0.96, *i.e.*, there will be little reduction in recruitment as spawning stock biomass declines, until the depletion in spawning stock biomass becomes severe. There would have been value in considering a model with a considerably lower value of steepness, *e.g.*, 0.8, to represent an alternative state of nature, which, given the nature of the input data and the uncertainty of the estimate of steepness, appears feasible.

The results obtained from the projections are presented in Table 3.9 and Figures 3.59-3.70 of the Assessment Workshop Report. Estimates of stock condition depend on which of the states of nature explored in the assessment is most likely to reflect the true state of nature. Of the three scenarios considered in the assessment, that represented by the base model (Run 1) would be considered to provide the best description of the data that were available, given the assumptions that were made regarding those data, the biology of the cobia stock, and the fisheries exploiting this stock. For the base model, fishing mortality would be increased from F_{current} if adjusted to F_{OY} or $F_{\text{30\%SPR}}$. The base model predicts that spawning stock biomass would be expected to increase from $\text{SSB}_{\text{current}}$ if fishing mortality was maintained at F_{current}, increase to a lesser extent if fishing mortality was increased to F_{OY}, and decline very slightly if fishing mortality was increased to $F_{\text{30\%SPR}}$. Yield would increase under each of these three fishing mortalities. If the model with the lower natural mortality, *i.e.*, Run 2, represented the true state of nature, continued fishing with a fishing mortality of F_{current} is predicted to allow the spawning biomass to increase beyond the MSST by 2014, *i.e.*, become no longer overfished, despite the fact that overfishing was continuing. The reduction in fishing mortality associated with F_{OY} or $F_{\text{30\%SPR}}$ would result in overfishing no longer occurring and would produce an increase in spawning stock biomass such that, by 2014, the stock would no longer be classified as being overfished. If natural mortality was greater, *i.e.*, Run 3, spawning stock biomass would increase if fishing mortality was maintained at F_{current} but would decline if it was set to F_{OY}, and would decline to an even greater extent if fishing mortality was set to $F_{\text{30\%SPR}}$.

It would have been informative to explore the consequences (for each pair of putative states of nature) of incorrectly assuming that one of these alternative states of nature was true, and setting allowable catches accordingly, when in fact one of the alternative states of nature was the “true” state. Such an analysis allows an assessment of the robustness of an incorrect decision relating to which of the alternative models is considered most likely to represent the true state of nature.

ToR 6. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.

- **Provide measures of uncertainty for estimated parameters**
- **Ensure that the implications of uncertainty in technical conclusions are clearly stated**
- **If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.**
- **Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments**
- **Provide justification for the weightings used in producing the combinations of models**

Conclusions

The methods within Stock Synthesis that may be used to explore uncertainty include calculation of estimates of asymptotic standard errors, calculation of likelihood profiles, MCMC analyses, and bootstrapping. These tools are complemented by auxiliary routines that allow production of diagnostic plots, which also assist in communicating the uncertainty of estimates. The software encourages exploration of alternative model structures and sensitivity to alternative values of parameters or functional forms. The model that was developed for the Gulf of Mexico stock of cobia employed an appropriate set of these methods. Probability distributions were produced for initial equilibrium biomass and steepness, unfished total and spawning biomass, and spawning biomass in 2011. As the iterative approach required to calculate P^* cannot be implemented in Stock Synthesis, Stock Synthesis "calculates the expected time series of probabilities that the F resulting from a specified harvest policy would exceed a specified level" (Methot and Wetzel, 2012).

Strengths

- Stock Synthesis provides an extensive suite of methods that may be used to explore uncertainty.
- The retrospective analysis revealed no strong systematic patterns.
- Bootstrapping was used to produce probability distributions

Summary

Stock Synthesis provides a number of methods that may be used to characterize the uncertainty associated with the estimates of parameters, benchmark estimates, and predicted values of parameters. These include options to generate likelihood profiles and to run a bootstrapping or Markov Chain Monte Carlo (MCMC) analysis. The software is well suited for use in exploring the uncertainty associated with the models that were fitted to the Gulf of Mexico stock of cobia. Thus, for each run of the Stock Synthesis model for this stock, estimates of asymptotic standard errors would have been calculated for each of the parameters that were estimated (see Table 3.1, Assessment Workshop Report, for parameter estimates and estimates of asymptotic standard errors for the base model, Run 1, for which the average value of natural mortality for fully-selected cobia was M = 0.38 y^{-1} and estimated steepness = 0.925). These standard errors may be considered to represent minimum values for the uncertainty of the estimated parameters. The uncertainty of selected parameter estimates for the Gulf of Mexico cobia stock was also characterized using the results from bootstrapping (Table 3.2, Figs 3.26 and 3.27). Additional uncertainties (sensitivities) arising from differences in model structure or data input for the cobia model were also assessed by re-running Stock Synthesis using those alternative model structures or data sets.

The initial run (Run 1) was carried out using the model structure that had been proposed for the Gulf of Mexico stock of cobia and estimating the steepness parameter of the Beverton and Holt stock-recruitment relationship. Bootstrapping of this model demonstrated that, given the data that were available, the steepness of the stock recruitment relationship was estimated imprecisely, a result which was confirmed by constructing likelihood profiles for this parameter. A number of sensitivity runs of Stock Synthesis were then run to explore the effect of varying this and other parameters, or the methods employed in the analysis.

As is typical in stock assessment, exploratory runs for the Gulf of Mexico stock of cobia were first employed to determine a base model for the assessment, *i.e.*, a model that is considered the most likely of the alternative model configurations that have been proposed. Despite the imprecision of the estimate of steepness, the decision was made at the Assessment Workshop to retain Run 1 as the base model as parameter estimates and patterns of stock dynamics were similar for the models using alterative estimates of steepness.

The Assessment Workshop selected the models with low M (Run 2) and high M (Run 3) as representative of alternative states of nature. Projections using these models were explored.

While the iterative approach required to calculate P^* cannot be implemented in Stock Synthesis, a complementary approach has been developed to produce estimates of the probability that F, the fishing rate based on MSY, SPR, a specified target biomass, or a multiple of the recent average fishing rate that is employed in the projection, exceeds the OFL (Methot and Wetzel, 2012). These authors advise that, whereas the P^* approach calculates the future stream of annual catches that would have a specified annual probability of $F >$ OFL, Stock Synthesis "calculates the expected time series of probabilities that the F resulting from a specified harvest policy would exceed a specified level".

The models were not combined, but presented as alternatives for consideration by the Review Panel.

ToR 7. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.

The Review was undertaken as a desktop review, rather than a review within a workshop setting. Accordingly, it was not possible for the recommendations made in review reports to be acted upon, nor to ensure that the results were incorporated accurately in the resultant Stock Assessment Report.

ToR 8. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.

The SEDAR Process provides a very sound basis for stock assessment. It has ensured that all aspects of the assessment process for the Gulf of Mexico cobia, from collation of data through to model development, exploration, and production of management advice, have been documented in detail, including the underlying reasons for decisions that were made concerning data to be used and model structure to be employed. For the reviewer, it has thus provided a thorough understanding of the details of the assessment and assisted in identifying opportunities for improvement and in detecting errors or inadequacies.

The Terms of Reference for the Assessment Process, which are presented below, are now examined and comment is made on the degree to which these were addressed.

1. Review and provide justifications for any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model.

   Accomplished.

2. Recommend a model configuration which is deemed most reliable for providing management advice using available compatible data. Document all input data, assumptions, and equations.

   The configuration of the model for cobia that was set up within the Stock Synthesis framework was described. The equations used within Stock Synthesis were not described in the Assessment Workshop Report. This is understandable as, to some extent, the rate of development of this software has outpaced the development of the technical descriptions relating to the features within the Stock Synthesis software. Methot and Wetzel (2012) have recently addressed this issue, however, and their recent paper should be cited in the Assessment Workshop Report.

3. Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.

   No environmental covariates were identified by the Data or Assessment Workshops.

4. Provide estimates of stock population parameters.
   - Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as appropriate given data availability and modeling approaches
   - Include appropriate and representative measures of precision for parameter estimates

   Accomplished.

5. Characterize uncertainty in the assessment and estimated values.
   - Consider components such as input data, modeling approach, and model configuration
   - Provide appropriate measures of model performance, reliability, and 'goodness of fit'

   Accomplished.

6. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.

   Accomplished.

7. Provide estimates of stock status relative to management criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards for each model run presented for review.

   Accomplished.

8. Project future stock conditions and develop rebuilding schedules if warranted, including estimated generation time. Develop stock projections in accordance with the following:
   A) If stock is overfished:
      F=0, FCurrent, FMSY, FOY
      F=FRebuild (max that permits rebuild in allowed time)
   B) If stock is undergoing overfishing:
      F= FCurrent, FMSY, FOY
   C) If stock is neither overfished nor undergoing overfishing:
      F= FCurrent, FMSY, FOY
   D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice

   Accomplished.

9. Provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.
   - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments for use with the Tier 1 ABC control rule
   - Provide justification for the weightings used in producing combinations of models

   The Assessment Workshop Report noted that three of the sensitivity runs had been considered as alternate states of nature, and projections had been run for each of these The Assessment Workshop Report advised that probability distribution functions had been developed for the subset of three runs and would "be made available to the Scientific and Statistical Committee (SSC) for the development of management advice, including OFL and ABC". No information relating to these probability distribution functions was presented in the Report.

10. Provide recommendations for future research and data collection. Be as specific as possible in describing sampling design and intensity, and emphasize items which will improve assessment capabilities and reliability. Recommend the interval and type for the next assessment.

    Attention was directed to the research recommendations that were made in the Data Workshop Report. The Workshop Assessment Report identified gaps in data, which, if addressed, would improve the assessment capabilities and reliability. Specific sampling design and intensity were not discussed. No recommendations relating to the interval and type for the next assessment were made by the Assessment Workshop.

11. Prepare a spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.

    A spreadsheet was not provided in the documentation that was circulated to the Review Panel. The Assessment Workshop addressed this Term of Reference in its Report by providing a table listing the estimates for all parameters used in the model and presenting a listing of each of the input files required to run the Stock Synthesis model for Gulf of Mexico cobia.

12. Complete the Assessment Workshop Report (Section III: SEDAR Stock Assessment Report).

    Accomplished.

ToR 9. Make any additional recommendations or prioritizations warranted.

- **Clearly denote research and monitoring needs that could improve the reliability of future assessments**

A number of research needs, which are listed below in order of priority, were identified in the course of the desk review. As expected, these were highly consistent with, and thus overlap, many of the research needs that had been identified by the Data and Assessment workshops.

1. Review or establish programs to collect data on the length composition and age-at-length compositions of landings and discards from each commercial gear and from each recreational fishing mode, and of bycatch of cobia from the shrimp fishery. Ensure that the statistical design and spatial coverage of survey or sampling programs are appropriate and that survey or sampling intensity is sufficient to produce estimates of the required precision for Gulf of Mexico cobia. Set goals for performance and establish and monitor performance criteria to assess the quality and completeness of data collection programs. This item is of the highest priority as it will provide information required by Stock Synthesis to determine the selectivity and retention curves for cobia for the commercial, recreational, and shrimp fisheries, the lack of which is a key source of uncertainty in the model.
2. Undertake research to determine reliable relationships between the proportion of females that are mature and both length and age for the Gulf of Mexico stock of cobia. This item is also of high priority, as the maturity information that is currently used is imprecise. The calculation of spawning stock biomass, a crucial parameter in the calculation of benchmarks and assessment of stock status, should be based on reliable data.
3. Review programs that are used to collect discard data for cobia (and data on the bycatch of cobia by the shrimp fishery), and refine these programs to ensure that accurate and complete data estimates of the discards (and bycatch) are collected. Ensure that the statistical design and spatial coverage of survey or sampling programs are appropriate

and that survey or sampling intensity is sufficient to produce estimates for Gulf of Mexico cobia that are of the required precision. Set goals for performance and establish and monitor performance criteria to assess the quality and completeness of data collection programs and provide feedback regarding performance to those programs. While this research item will not provide immediate improvement in the quality of the assessment, it is important that action is taken as soon as possible to improve the accuracy and precision of the data relating to the quantities of fish that are discarded from each of the fisheries, such that, in the future, the time series of discards become more reliable.

4. A comprehensive genetic study of cobia should be undertaken, with the following objectives:
    a. to confirm the preliminary genetic findings of Darden for cobia in the Gulf of Mexico and US Atlantic Coast, using samples with sample sizes greater than 100 at all sites, thereby addressing the issue in that earlier study that sizes of samples from the north of the Gulf of Mexico and from waters off the west coast of Florida had been small;
    b. to increase the spatial resolution of the genetic sampling in the region of overlap of the two stocks, such that the boundary between the stocks or extent of overlap can be determined;
    c. to extend sampling into Mexican waters and thereby determine the southern boundary of the Gulf of Mexico stock;
    d. to reconcile the differences in the findings reported in SEDAR28-DW01 and those reported in SEDAR28-RD09, where the former advises that collections from offshore in the Gulf of Mexico were genetically distinct from those offshore in the South Atlantic region while the latter reports that the results of the study "suggest the offshore groups are genetically homogenous, even between the SA and GOM";
    e. to extend sampling beyond the spawning season and ascertain whether catches of fish may be assigned reliably to either the Gulf of Mexico or South Atlantic stock on the basis of the area in which they are caught.

    Some of the objectives of this study, *e.g.*, identification of the southern boundary of the stock, would also benefit from tagging or other studies. As this study will take some time before completion, it has been assigned a lower priority than the previous items. Determination of the southern stock boundary, however, is important to ensure that other removals from the stock are not occurring in Mexican waters, as such removals are not taken into account in the current assessment.
5. Undertake research to determine the discard mortality of Gulf of Mexico cobia that are discarded from the catches of each commercial fishing gear or each recreational fishing mode, recognising that such mortality is likely to differ among different categories into which the discarded fish are classified, *e.g.*, "alive", "mostly alive", and "mostly dead".
6. In future stock assessments for the Gulf of Mexico stock of cobia, explore whether the use of an age-dependent rather than constant *M* results in a significant improvement in fit, considering the Lorenzen and alternative functional forms of the relationship with age and the alternative of estimating the value of the age-dependent *M* at each age (or range of ages).

7. In future stock assessments, explore the sensitivity of the model to the uncertainty of the landings data.
8. Develop an ageing error matrix for Gulf of Mexico cobia.
9. A research study should be undertaken to determine an approach (or approaches) by which an appropriate range (or ranges) of feasible values of *M* for a species might be selected for use in stock assessment as alternate plausible states of nature. The need to determine an appropriate range for sensitivity runs arose in both the cobia and Spanish mackerel assessments, but the final decisions on the range to use were rather arbitrary and subjective. The issue arises in almost all assessments and it would be useful to establish an objective protocol to determine an appropriate range of values of *M* to be explored.
10. Develop a fishery-independent survey for Gulf of Mexico cobia, or investigate what changes would be required to make data from an existing fishery-independent survey appropriate for use as an index of abundance.
11. As a low research priority, assess whether, in future refinement of the Stock Synthesis model, sexually dimorphic growth should be introduced. Note that the benefit of this might only be realised if appropriate sex composition data for landings and discards are available for input, and length and age-at-length compositions are sexually disaggregated.

*4.2 Gulf of Mexico Spanish Mackerel (***Scomberomorus maculates***)*

ToR 10. Evaluate the quality and applicability of data used in the assessment.

Conclusions

The data compiled for the Gulf of Mexico stock of Spanish mackerel by the Data Workshop are the best that are available. Certainly, some aspects of the data are imprecise, *e.g.*, discards from commercial catches, and there are data gaps, such as the lack of length and age-at-length composition data for discards. Nevertheless, the data that are available are of a quality that would allow a broad assessment of the likely condition of the stock, which, although uncertain, would be useful to fisheries managers.

Strengths

- The collation of life history data for the Gulf of Mexico stock of Spanish mackerel.
- The collation of commercial landings data to produce time series of landings by gillnet, handline, and other gears from 1887, and, particularly, more precise data from 1950.
- The collation of a time series of estimates of bycatch of Spanish mackerel by the shrimp fishery from 1972, using a Bayesian model.
- The collation of recreational fisheries data from different sources to produce sound time series of landings by fishing mode from 1955, and, particularly, more precise data from 1981.
- The collation of data to produce time series of discards from the commercial gears and recreational fishing modes.

- The collation of length composition data to characterize the landings by the commercial and recreational fisheries.
- The collation of a fishery-independent and two fishery-dependent indices of abundance, and the use of appropriate statistical analyses to standardize those indices of abundance.

Weaknesses

- Lack of definition of the southern boundary of the Gulf of Mexico stock of Spanish mackerel.
- Uncertainty of the age at which 50% of Spanish mackerel are mature.
- The unreliable nature of the discard data due to low reporting, low intercept rates, and inadequate data collection programs.
- Inadequate sampling of length and age composition data from commercial landings and from bycatch of Spanish mackerel from the shrimp fishery.
- Lack of length and age composition sampling from commercial and recreational discards.

Specific comments

Stock structure

Spanish mackerel from US waters within the Gulf of Mexico and to the north of Highway 1 in Monroe County, Florida, which have been designated the "Gulf of Mexico stock", were the subject of the stock assessment. The Data Workshop Report acknowledged that studies of stock structure for Spanish mackerel in the Gulf of Mexico and off the US South Atlantic coast have produced conflicting results. The Report advised that, while early morphometric, meristic, allozyme, and electrophoresis studies and a more recent study of otolith shape and chemistry identify differences between fish from the Gulf of Mexico and those from the South Atlantic coast, a recent mitochondrial and nuclear DNA study did not detect a difference, which suggests at least a small amount of genetic flow between the two regions sufficient to homogenize allele frequencies. Based on results of the earlier studies, and taking into account spawning locations, stock distribution patterns, and catch history, the two groups of fish were recognized as separate management units, with a boundary at US Highway 1 in Monroe County, Florida, which has served as the boundary for data collection from the commercial and recreational fisheries. The evidence supporting the proposed stock structure and, in particular, the boundary separating the two putative stocks is not strong. Further studies to improve understanding of stock composition, *e.g.*, genetic, otolith microchemistry, species composition of parasites, tagging studies, should be initiated.

In the review of data relating to stock structure for Spanish mackerel, the Data Workshop Report makes no mention of the southern boundary of the putative Gulf of Mexico stock, and whether this stock extends into Mexican waters. If such extension is the case, failure to take into account Mexican catches of Spanish mackerel would result in bias in assessment results. The stock assessment that has been undertaken implicitly assumes that the Gulf of Mexico stock of Spanish mackerel is confined to US waters, and thus conclusions from the assessment must be considered conditional on the validity of this assumption.

Biological data

The use of Hoenig's (1983) equation for fish and maximum age to produce an estimate of natural mortality *M* for a fish stock is accepted practice when no data are available from the stock to allow direct estimation of this parameter. Thus, noting also that other methods of estimating *M* from life history data were investigated, its use of Hoenig's (1983) equation to estimate the base value of *M* for Gulf of Mexico Spanish mackerel is endorsed. The Data and Assessment Workshops also correctly recognized that this estimate of *M* was imprecise, and that the results of stock assessment were likely to be sensitive to this uncertainty.

For the reasons noted earlier when discussing the assessment for Gulf of Mexico cobia, use of the Lorenzen (1996) equation to derive age-dependent estimates of natural mortality *M* for Gulf of Mexico Spanish mackerel is not endorsed. In his report to the CIE on the stock assessments conducted for yellowtail flounder and Atlantic herring at Woods Hole in 2012, Francis (2012) advised that prediction of *M*, and, through body weight, its variation with age for an individual species, using Lorenzen's (1996) equation was likely to be highly imprecise, as was evident in the wide scatter about the regression line in Lorenzen's Figure 1. Francis observed that, for about one-third of Lorenzen's data points, predicted and observed *M*s appeared to differ by a factor of more than 2. Furthermore, in the case of both herring and yellowtail, the values of *M* estimated by Lorenzen's equation differed markedly from the values estimated using Hoenig's (1983) equation and had to be scaled substantially for use in the yellowtail flounder and Atlantic herring assessments. Francis (2012) raised the very valid point that, if the estimates produced for a species by Lorenzen's equation provide such unreliable estimates that the mean *M* differs from the estimate calculated using Hoenig's (1983) equation by a factor that differs markedly from 1, can it be considered sufficiently reliable to estimate how *M* varies with age within these species?

There has been no test to assess whether the introduction of the additional complexity associated with age-dependent natural mortality to the model for Gulf of Mexico Spanish mackerel is justified by the resultant improvement in fit that was obtained. It is recommended that a model employing a constant value of *M* is fitted to the Spanish mackerel data. If this model fits just as well as the model that employs an age-dependent *M*, then the simpler model should be used. If the age-dependent model produces a better fit, it would be better to estimate age-dependent *M* within the assessment model rather than assuming that it is of the form predicted by the Lorenzen (1996) equation.

Data on the rate of mortality for discarded hook and line caught Spanish mackerel are limited, and thus the estimates of discard mortality are imprecise. It was pleasing to note that the Assessment Workshop investigated the implications of uncertainty in the estimate of discard mortality by conducting a sensitivity run. Further research is required to produce a more reliable estimate.

Although only the parameter estimates of the von Bertalanffy growth curve fitted to the length at age data using the Diaz *et al.* (2004) model are input to Stock Synthesis to provide the initial values of the growth curve fitted within the assessment model, the growth curve developed for the Data Workshop is of value as a basis of comparison with the growth curve fitted by Stock Synthesis. Fitting the growth curve within Stock Synthesis ensures that the assumptions regarding selectivity are consistent with those employed in other parts of the model and that uncertainty in the estimates of growth is reflected in the estimates of the spawning stock biomass, fishing mortality and benchmarks.

Spanish mackerel exhibit dimorphic growth, yet the Stock Synthesis model considers only pooled data. In future refinement of the model, consideration should be given to modelling both females and males rather than combined sexes, noting that the benefit of this might only be realised if appropriate sex composition data for landings and discards are available for input, and length and age-at-length compositions are sexually disaggregated.

The Data Workshop Report advises that, due to a paucity of age data, percentage maturity was related to size class rather than age. It is not clear whether the data reported in Tables 2.3 and 2.4 represent only fish collected during the spawning season, *i.e.*, when mature fish can be distinguished readily from immature fish on the basis of macroscopic examination of their gonads. It is unclear how the age at 50% maturity for females was estimated, *i.e.*, was this obtained by transforming from length to age using the fitted growth curve. Further details are required. The value of 0.2 y seems surprisingly low for the age at 50% maturity of females. This low value drew comment from the Data Workshop, which suggested that it might have been due to identification of mature fish using macroscopic examination and recommended the use of the age at 50% maturity that was determined for the Atlantic stock of Spanish mackerel, *i.e.*, 0.7 y. Using the relationship between age at maturity and maximum age determined by Froese and Binohlan (2000), a species with an age at maturity of 0.2 y would be expected to have a maximum age of 0.8 y, a value far lower than the 11 years that the Data Workshop employed when estimating *M*. Further research to determine the relationship between percentage mature and age appears to be necessary given this unusually low value and the statement in Section 2.8 of the Data Workshop Report that there is a paucity of age data for Gulf of Mexico Spanish mackerel.

Commercial landings

The decision to extend the time series of landings data as far back in time as possible was endorsed, although it is noted that (1) the data in Table 3.2 of the Data Workshop Report were very sparse until 1927, and (2) the reliability of commercial data improved substantially in 1950. Note that it would be useful to state in the heading of Table 3.2 whether the gaps in data prior to 1927 represent missing years, or, as reported in Table 3.4, represent zero landings. As an alternative to using data extending back to 1887, it might be interesting to compare the results obtained from the model by using a shorter time series ranging from 1927 to 2011, noting that the imprecision associated with imputing the missing landings between 1887 and 1926 should also be considered.

The decision made by the Data Workshop to combine landings from commercial fishing gears other than gillnets and handlines was not explained. Was it to reduce the number of time series of landings considered in Stock Synthesis, and thereby reduce complexity, or was the decision made in recognition of a lack of data to characterize the length composition of each of the miscellaneous gears? A decision made because of the latter reason would indicate an inadequacy of the data collection programs, which might need to be addressed.

Until 1996, the annual landings of the combined commercial gears, other than gillnets and handlines, were typically of a greater magnitude than the landings made by handlines, and subsequently were of similar magnitude. As recommended by the Data Workshop, the Assessment Workshop apportioned these combined landings of the miscellaneous commercial gears to the landings of the two primary gears in proportion to the annual landings of those last two gears. The length composition of the resultant time series of landings thus reflect a weighted combination of the length compositions of the catches from the different fishing gears, each of which would have reflected the selectivity curve of that gear. Length composition data collected from the landings taken using gillnets or those taken using handlines will therefore fail to reflect the length compositions of the mixtures of landings of those primary gears and the contribution from the landings of the miscellaneous gears, particularly in the case of the length composition data for the handline landings.

Comment is made in Section 3.3.5 of the Data Workshop Report that there was a precipitous decrease in landings in 1977 and subsequent years following cold weather in Florida in 1976-77. This environmental event was not explored by the Assessment Workshop, but it might be interesting to consider whether the cold weather caused increased mortality or reduced growth, and whether this could explain the reduced landings that followed the 1977 event.

The Data Workshop is commended for its collation of the commercial landings data from the various sources and development of a time series of commercial landings suitable for use in the stock assessment process for the Gulf of Mexico stock of Spanish mackerel. It would be useful to assess and report the imprecision of the annual estimates.

Although the Data Workshop Report advised that the decision was made that discarded fish, which were designated as “kept”, should be removed from the amount of discards and added to landings, it is unclear whether this was done when preparing the landings and discard data for the Assessment Workshop.

Discards recorded for the commercial fisheries are highly uncertain due to low reporting rates and are likely to represent minimum values. Programs to collect discard data from commercial fishers need to be reviewed to identify ways in which more reliable discard data might be obtained.

The Bayesian model, which assumed that counts within cells had a negative binomial distribution, appeared an appropriate approach to estimating the bycatch of Spanish mackerel by the shrimp fishery. The Data Workshop advised, however, that, as a consequence of low encounter rate of Spanish mackerel by the shrimp fishery and irregular observer coverage, estimates of bycatch of Spanish mackerel are imprecise, although the mean is likely to be of the appropriate scale.

The Data Workshop Report advised that “sample sizes for developing length compositions were inadequate for a considerable number of year and gear strata”. Sampling to determine the age compositions of commercial landings has also been sparse, particularly for gillnet landings in recent years. There appear to be no data that could be used to characterize the length or age compositions of discards from the commercial fisheries. Data collection programs should be reviewed to identify how they could be improved to collect representative samples of length and age compositions from the landings and discards of the commercial fisheries.

Recreational landings

As with the commercial landings data, the Data Workshop is commended for its collation of the recreational landings of Gulf of Mexico Spanish mackerel from the various data sources, and, in particular, the extension of this time series of data back to 1955.

The Assessment Workshop reported that the estimates of discards of Spanish mackerel from the recreational fishery were highly uncertain, due to low intercept rates and the changes in quality control and assurance that had occurred between 1981 and 2011.

Age samples for the recreational fishery were collected by the Southeast Region Headboat Survey (SRHS), as lengths but not ages are typically collected within the MRFSS. No samples were available to characterize the length and age compositions of discards of Spanish mackerel by recreational fishers. Consideration should be given to developing a program to collect representative length and age data from Spanish mackerel that are discarded by the recreational fishery.

Survey indices

The recommendation reported in the Data Workshop Report that the fishery-independent SEAMAP survey and the fishery-dependent MRFSS, and FL trip ticket handline/trolling indices, are appropriate for use in the assessment, and that other putative indices should not be used, appears sound. Both the SEAMAP and MRFSS surveys used a delta lognormal model to standardize the data and thereby determine annual indices of abundance. The trip ticket data were standardized using a general linear model with forward stepwise selection.

In Section 5.4.4.6 of the Data Workshop Report, the Working Group advised that the index of abundance based on data from headboats was adequate for use in the assessment, yet the report card for the index advises that, because of the small proportion of observations that reported catches of Spanish mackerel, the Working Group did not endorse the use of the index in the assessment. Table 5.4.4.1 in the Data Workshop Report incorrectly divides total trips by total positive trips and reports the result, 38.89, as the overall percentage of positive trips instead of 2.6%. The incorrect value is then taken from the table and reported as 38.89% in Section 5.4.4.2 of the Data Workshop Report. The overall summary in section 5.1 correctly advises that the headboat index was not recommended for use. Accordingly, the Assessment Workshop did not include this as a survey to be used by Stock Synthesis.

ToR 11. Evaluate the quality and applicability of methods used to assess the stock.

Conclusions

Stock Synthesis 3, the software within which the model for the Gulf of Mexico stock of Spanish mackerel was developed, has gained international recognition for its quality and the applicability of the methods it uses to assess the condition of fish stocks. The model for Spanish mackerel was of an appropriate structure given the data that were available. Values predicted by the model for Spanish mackerel, including those of benchmarks, were imprecise, however, due to the nature of the input data. Further imprecision of model outputs due to alternative values of key parameters, such as natural mortality and steepness of the stock-recruitment relationship, was explored. Recognising the types of data that were available for input and the uncertainty of model outputs that arose as a consequence of the nature of those input data, the Stock Synthesis base model for Spanish mackerel is of a quality consistent with that which would be considered “best practice”, and is able to provide a valuable assessment of the likely condition of the stock in 2011, and, when projected, the likely trajectory of yields and stock condition over the next five to six years.

Strengths

- The decision to use Stock Synthesis 3 as the modelling framework and to complement this with the Fishery Simulation Graphics User Interface (Lee *et al*., 2012).
- The structure of the model developed within the Stock Synthesis framework was appropriate given the data that were available.
- The enhancement of Stock Synthesis to allow modelling of a fishery for which the only source of mortality is that associated with discarding of bycatch.
- Use of super periods when data are too imprecise to fit individual values but the median value is considered to be informative.
- The assessment of the uncertainty of parameter estimates was thorough.
- Selectivity runs explored key uncertainties and demonstrated appropriateness of conclusions regarding the current condition of the stock.
- Benchmarks were appropriately calculated.
- Projections were undertaken using two states of nature.

Weaknesses

- Subjective decision to set effective sample size to actual sample size capped at a maximum of 100 rather than to use iterative reweighting, such as proposed by Francis (2011).
- Lack of information in abundance indices, and shortness of history of length and age-at-length data.
- Lack of length and age composition data to provide information on the length and age compositions of discards and the shape of the retention curves.
- The assumption that natural mortality is age-dependent and has a form that is proportional to the values predicted by the Lorenzen (1996) has not been tested against the simpler assumption of constant natural mortality over age.
- Imprecision in the estimate of steepness of the stock-recruitment relationship.
- Lack of exploration of uncertainty associated with the time series of commercial and recreational landings.

The assessment was undertaken using Stock Synthesis 3, a fully integrated model that allowed use of all available data for Spanish mackerel in the Gulf of Mexico, including life history data, removals, discards, length compositions of catches, conditional age-at length compositions, and survey indices. Other software packages, which were used in the assessment of the Gulf of Mexico Spanish mackerel stock, were r4SS, which produces graphic displays and explores output from Stock Synthesis, and the “Fishery Simulation” Graphics User Interface (GUI) software (Lee *et al*., 2012), which adds bootstrapping analysis support to Stock Synthesis. Stock Synthesis, supported by these software packages, provides a very flexible assessment framework that produces estimates of key population parameters and their uncertainty. The software allowed exploration of the sensitivity of parameters, stock status indicators, and reference points to changes in the structure of the Spanish mackerel model and its assumptions, and to the exclusion of various survey indices when fitting. It also allowed investigation of yield per recruit, spawner per recruit, and stock-recruitment relationships for Spanish mackerel, and produced estimates of reference points to be used when determining stock status. The Stock Synthesis model was also employed to project the effect of different levels of fishing mortality on future catches and condition of the Gulf of Mexico Spanish mackerel stock. Through bootstrapping, Stock Synthesis was used to develop probability distributions for various variables of interest.

The Assessment Workshop Report advised that, apart from the FWC trip ticket vertical line index, which showed a slight increase in abundance after 2003, predicted values of the abundance indices, which exhibited considerable imprecision, were relatively constant over the periods for which abundance indices were available. As noted by the Assessment Workshop, this implies that the survey indices carry little information regarding trends in abundance. The Assessment Workshop also noted that length and conditional length-at-age data cover only a limited recent period, and thus provide limited information on recruitment to inform the model.

Concern that the estimate of steepness produced when fitting the initial model, *i.e*., 0.52, was too low, led the Assessment Panel to profile log-likelihood over a range of values of steepness (Fig. 3.31, Assessment Workshop Report), thereby to assess whether the data were sufficiently informative to allow reliable estimation of this parameter. After examining the results of this and other sensitivity runs, retrospective analyses, profiling, and bootstrap runs, the Assessment Panel concluded that a value of 0.8 for steepness "was more reasonable for this species than that estimated by the model (0.52)" (see further comment regarding this decision below), and adopted this configuration (Run 3) as the base model for the assessment. That is, Run 3 was recommended by the Assessment Panel for final projections and status determinations.

The use within Stock Synthesis of super periods when fitting discards of Spanish mackerel from the commercial line gear fishery, the recreational fishery, and the shrimp fishery, is very appropriate given the high uncertainty associated with the estimates of the annual discards for these three fisheries. By fitting estimates of discards to the average value of discards over these super periods, the model "accepts" the overall level but "ignores" inter-annual variability within the discard time series.

The assumption that was made in the assessment that age data were conditional on length is very appropriate. If it had been assumed that the length and age composition data were independent, the fact that some fish were included in both the length and age composition data would introduce bias. Such potential bias is removed by considering ages to be conditional on length.

The decision that, because of a lack of strong evidence that selectivity was dome-shaped and the fact that little improvement in fit was obtained when using such a selectivity pattern, selectivity functions for the commercial line gears and recreational fisheries would be constrained to those with an asymptotic pattern is endorsed. It was good to note that some exploration had been undertaken before coming to this conclusion, but it would have been useful if the results of that exploration had been presented in the Assessment Workshop Report. The representation of the retention curves using two time blocks, *i.e.* the period before 1993 and the period from 1993 onward, to reflect the change in size limit in 1993, is appropriate.

It would have been appropriate to explore whether the improvement in likelihood of the fitted model justified the additional complexity of considering mortality to be age dependent rather than constant. If not justified, the simpler model would be preferred. If use of an age-dependent model was justified, it would be better to estimate the values of the age-dependent mortalities directly, rather than assuming that the relationship has a form that is a scaled version of the values of mortality at age calculated using Lorenzen's (1996) equation.

The use of a maximum effective sample size of 100 fish is arbitrary, however, it is noted that Sensitivity Run 12 explored the effect of reweighting using the MacAllister and Ianelli (1997) approach. It is recommended that, in future analyses, consideration should be given to the methods described by Francis (2011), such that, for example, effective sample sizes for length compositions are calculated using iterative reweighting based on mean length, and possibly reflecting the relative magnitudes of initial sample sizes.

No length or age composition data were available to characterize the discards from the commercial or recreational catches, thus little information was available to estimate the parameters of the logistic retention curves for these fisheries.

The use of a Beverton and Holt stock-recruitment curve is endorsed, but the choice of the value of 0.7 as the value of the standard deviation in recruitment appears arbitrary. The Assessment Workshop Report advised that the profile of likelihoods over a range of values "did not indicate disparity" with the value chosen (Fig. 3.33). It might be pertinent to note, however, that both Smith and Punt (1998) and Maunder and Deriso set $\sigma^2_{\log_e R} = 0.6$. Beddington and Cooke (1983) are cited as reporting from a meta-analysis over many fish species that recruitment is typically log-normally distributed with the average of $\sigma^2_{\log_e R}$ being around 0.6. Mertz and Myers (1996) are reported to have conducted a further meta-analysis and again found that the average value of $\sigma^2_{\log_e R}$ was around 0.6. Interestingly, the likelihood profile (Fig 3.33) suggests that 0.6 might be slightly more appropriate than 0.7.

As advised in the Assessment Workshop Report, Stock Synthesis effectively treats landings as being known without error and thus fits them precisely. Imprecision associated with the early values within the time series of commercial or recreational landings is thus not assessed unless explored through sensitivity runs using alternative scenarios of landings data. It is not apparent from the Assessment Workshop Report that such sensitivity runs were made and thus the implications of the uncertainty associated with the landings data have not been assessed.

In describing Fig. 3.35, it is unclear whether the 14 of the 1000 bootstrap runs, which produced "large convergence values and illogical estimates of virgin biomass" were not simply the results of poor choices of initial values for the parameters used in Stock Synthesis, given that the jitter analysis produced four out of 100 results that failed to converge to the expected values.

The vertical scale used in the profile of change in log-likelihood over the range of values of steepness (Fig. 3.31, Assessment Workshop Report) compresses the range of values of log-likelihood change for values of steepness ranging from (say) 0.4 to 0.9, which is the region of interest. A maximum value on the y-axis of (say) 100, would have more clearly revealed the trend in log-likelihood change.

The conclusion by the Assessment Workshop that the estimate of steepness is imprecise is valid, however, although the range of values that, given the model structure and data, might be considered to fall within a 95% confidence region would probably extend from about 0.4 to about 0.8. The basis for the decision by the Assessment Panel that a value of steepness of 0.8 is "more reasonable" than the estimated value of 0.52 for the Gulf of Mexico stock of Spanish mackerel is not stated. In this context, it is possibly pertinent to note that Francis (2012) has suggested that, when the steepness of the stock-recruitment relationship is imprecise or cannot be estimated reliably, he considers it better to fix the value of steepness at a value, such as 0.75, *i.e.*, the default value recommended in Francis (1993), and which is frequently used in Australia and New Zealand, or the average of published values for the same or similar species. Francis (2012) advises that the uncertainty associated with this parameter should then be explored using sensitivity runs with lower and higher values of steepness. The value of steepness selected by the Assessment Workshop, *i.e.*, 0.8, is of similar magnitude to the value suggested by Francis (2012), *i.e.*, 0.75. Thus, the decision by the Workshop to use a model with a structure similar to that of the original base model but with a fixed value of steepness of 0.8, *i.e.*, the model of Run 3, as the new base model for the Spanish mackerel stock, and to explore the uncertainty associated with this steepness using sensitivity runs with alternative values of steepness, is consistent with best practice, and is therefore endorsed.

The use of the base model, and of a model with similar structure but with steepness fixed at 0.9, as alternative states of nature is endorsed. Given the results of the sensitivity runs, however, it might also have been useful to include a low natural mortality version of the base model as a third state of nature.

ToR 12. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

Conclusions

Estimates of stock abundance, biomass, and exploitation are produced when the Stock Synthesis model is fitted. The estimates of total biomass and annual exploitation in 2011, which were estimated when the base model for the Gulf of Mexico stock of Spanish mackerel was fitted, were 28,367 mt and 0.1197, respectively.

Strengths

Stock Synthesis 3 calculates time series of abundance, total biomass, and annual exploitation.

Stock abundance:

The report file that is produced by Stock Synthesis, report.sso, contains a time series section, in which the time series of abundance, recruitment and catch for each of the areas are reported. Output quantities include summary biomass and summary numbers for each gender and growth pattern. The Assessment Workshop Report for the Gulf of Mexico Spanish Mackerel stock has not reported these abundance estimates, but they will be available in the output file for the base model, *i.e.*, Run 3.

Biomass:

Stock Synthesis produces an estimate of total annual biomass (Table 3.5, Fig. 3.41). The estimate (for the base model, *i.e.*, Run 3) of total biomass for 2011 was 28,367 mt.

Exploitation:

Stock synthesis calculates the value of annual exploitation rate as the ratio of the weight of the total catch (including discards) to the total biomass (Section 3.26, Assessment Workshop Report; Table 3.6, Fig. 3.42). The calculated value of the annual exploitation rate is used as a proxy for the annual value of fishing mortality, F. The estimate (for the base model, *i.e.*, Run 3) of the annual exploitation rate for 2011 was 0.1197.

ToR 13. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.

Conclusions

Stock Synthesis calculates a range of population benchmarks and management parameters. Benchmarks calculated for Spanish mackerel were MFMT = $F_{30\%SPR}$ and MSST = (1 – M) $SSB_{30\%SPR}$. The estimates of F_{current} and $\text{SSB}_{\text{current}}$, which were calculated for 2011 using the base model, were 0.14 and 19,645 mt, respectively. The ratios $F_{\text{current}}/\text{MFMT}$ and $\text{SSB}_{\text{current}}/\text{MSST}$, which were calculated using the base model, were 0.38 and 3.06, respectively. These results, which were consistent with those produced by all but one (the model with natural mortality set to 0.27 y^{-1}) of the models used in the various sensitivity runs, imply that, in 2011, the Gulf of Mexico stock of Spanish mackerel was not experiencing overfishing and was not overfished.

Strengths

Stock Synthesis possesses well-tested procedures to calculate and output a range of population benchmarks and management parameters.

Weaknesses

Inconsistencies in the values recorded in one of the columns in Table 3.8 made it difficult to assess, with full confidence, whether or not the stock was experiencing overfishing.

Summary

The methods used by Stock Synthesis to estimate population benchmarks and management parameters are sound. Stock Synthesis is able to produce estimates for indicator variables and reference points based on maximum sustainable yield (MSY), spawning potential ratio (SPR), and spawning stock biomass (SSB), and taking the stock-recruitment relationship into account. SPR is calculated as the equilibrium spawning biomass per recruit that would result from a given year's pattern and the levels of F's and selectivities for that year. For MSY-based reference points, Stock Synthesis searches for a fishing mortality that would maximise the equilibrium yield. For SPR-based reference points, the computer program searches for an F that would produce the specified level of SPR. For spawning biomass-based reference points, the software searches for an F that would produce the specified level of spawning biomass relative to the unfished value.

The management benchmarks, *i.e.*, the Maximum Fishing Mortality Threshold (MFMT) and Minimum Stock Size Threshold (MSST), which were proposed for the fishery by the Assessment Workshop, are appropriate for use in determining the status of the Gulf of Mexico stock of Spanish mackerel. These two benchmarks were

$$\mathrm{MFMT} = F_{\mathrm{MSY}} \quad \text{and} \quad \mathrm{MSST} = (1 - M)\ \mathrm{SSB}_{\mathrm{MSY}},$$

where F_{MSY} is the fishing mortality that produces the maximum sustainable yield MSY, M is the point estimate of natural mortality for fully recruited ages calculated using Hoenig's (1983) equation, *i.e.* 0.38 y^{-1}, and $\mathrm{SSB}_{\mathrm{MSY}}$ is the equilibrium spawning stock biomass that produces MSY. The Assessment Workshop Report advises that proxies were used when calculating the above benchmarks, where these proxies were based on a spawning potential ratio (SPR) of 30%. Thus, the proxy that was used for F_{MSY} was the fishing mortality, $F_{30\%\mathrm{SPR}}$, which produces a spawning stock biomass per recruit that is 30% of the spawning stock biomass per recruit produced when the stock is not fished, *i.e.* an SPR of 30%. The proxy that was used for $\mathrm{SSB}_{\mathrm{MSY}}$ was the corresponding value of equilibrium spawning stock biomass, *i.e.* the spawning stock biomass $\mathrm{SSB}_{30\%\mathrm{SPR}}$ that is produced with a fishing mortality of $F_{30\%\mathrm{SPR}}$.

It is surprising to note that, although Stock Synthesis was able to estimate MSY-based rather than SPR-based reference points, the Assessment Panel chose to use the proxies $F_{30\%\mathrm{SPR}}$ and $\mathrm{SSB}_{30\%\mathrm{SPR}}$ rather than F_{MSY} and $\mathrm{SSB}_{\mathrm{MSY}}$. The latter two benchmarks are possibly more appropriate.

For the Gulf of Mexico stock of Spanish mackerel, the benchmarks that were used in determining stock status by the Assessment Workshop were

$$\mathrm{MFMT} = F_{30\%\mathrm{SPR}} \quad \text{and} \quad \mathrm{MSST} = (1 - M)\ \mathrm{SSB}_{30\%\mathrm{SPR}},$$

where it was concluded that overfishing was occurring if $F_{\mathrm{current}} > \mathrm{MFMT}$, *i.e.*, $F_{\mathrm{current}}/\mathrm{MFMT} > 1$, and the stock was considered to be overfished if $\mathrm{SSB}_{\mathrm{current}} < \mathrm{MSST}$, *i.e.*, $\mathrm{SSB}_{\mathrm{current}}/\mathrm{MSST} < 1$. F_{current} was calculated as the geometric mean of the estimates of the three most recent annual fishing mortalities, *i.e.*, the fishing mortalities for 2009-2011, where annual fishing mortality was estimated by its proxy, exploitation rate, calculated as the ratio of the total catch (including discards) to estimated total biomass. $\mathrm{SSB}_{\mathrm{current}}$ was the estimate of spawning stock biomass for 2011.

Note that the specification of the reference points in Section 3.1.9 of the Assessment Workshop Report could be improved, *e.g.* overfished is currently defined as the value of the ratio of $\mathrm{SSB}_{\mathrm{current}}$ to MSST rather than a logical expression.

Table 3.8 of the Assessment Workshop Report, which is reproduced below, contains the values of the current (2011) fishing mortality and spawning stock biomass of the Gulf of Mexico stock of Spanish mackerel, and purports to contain the values of the MFMT and MSST benchmarks, and the results of stock determination for each of the models that were explored in the assessment. According to the caption for this table in the Assessment Workshop Report, F_{ref} represents $F_{30\%\mathrm{SPR}}$, and thus, as MFMT has been set to $F_{30\%\mathrm{SPR}}$, the values of MFMT should be equal to those of F_{ref}. As is evident in Table 3.8, this is clearly not the case. There are inconsistencies between the values of F_{ref} and MFMT for all but three of the 17 runs presented in the Table, Quite frequently, however, the values of F_{ref} and the ratio of F_{current} to MFMT in the rows of this Table are equal. The caption to Figure 3.9 advises that, for this figure, the value of F_{ref} represents the ratio of F_{current} to MFMT, and it appears likely that this inconsistency between definitions of F_{ref} has led to the inconsistent values presented in Table 3.8. The fact that there is such inconsistency makes it difficult to accept the accuracy of the estimates of the ratio of F_{current} to MFMT for any of the runs. Accordingly, while it is not possible from the reported data to assess with complete confidence whether or not the stock is experiencing overfishing, if the values in the column headed "F/MFMT" are correct, then $F_{\mathrm{current}}/\mathrm{MFMT} = 0.38$. From this, and noting the values for this ratio for other selectivity runs, it is very likely that the Gulf of Mexico stock of Spanish mackerel is not currently being subjected to overfishing.

Quoted from Assessment Workshop Report: "Table 3.8. Reference points and benchmarks from sensitivity runs for Gulf of Mexico Spanish mackerel from SS. Benchmarks are reported for SPR 30%. Current refers to geometric mean of 2009-2011 values. MSST is (1-M)*SSBref with M = 0.38, or M=0.27, or M=0.49 representing the M value from the Hoenig maximum age mortality estimator for fully recruited ages from the SEDAR DW corresponding to the Base Model M or the M_LO or M-HI scenario. Ref refers to reference metric, either F30% SPR or SSB 30% SPR. Fratio is Fcurrent / Fref. SSBratio is SSBcurrent / MSST. Spawning biomass units are weight in mtons, and yield units are mtons whole weight".

Name	Fcurrent	SSBcurrent	Yref	Fref	SSBref	MFMT	MSST	F/MFMT	SSB/MSST
Run 1 Configuration	0.19	11,195	3,563	0.37	6,626	0.37	4,108	0.51	2.73
Run 1 Configuration, Steepness=0.9	0.14	18998	3090	0.39	10701	0.35	6634	0.39	2.86
Run 1 Configuration, Steepness=0.8	0.14	19,645	3,053	0.39	10,339	0.36	6,410	0.38	3.06
Run 1 Configuration, Steepness=0.7	0.14	18,235	3,056	0.41	10,264	0.35	6,363	0.41	2.87
Run 3 Configuration, M HI	0.1	23,551	3,682	0.2	8,746	0.5	4,461	0.2	5.28
Run 3 Configuration, M LO	0.2	13,150	4,040	0.83	18,283	0.24	13,347	0.83	**0.99**
Run 3 Configuration, M REF Age 3	0.15	18,140	3,138	0.47	11,862	0.32	7,354	0.47	2.47
Run 3 Configuration, Discard Mortality	0.14	18,995	3,029	0.41	10,730	0.35	6,653	0.41	2.86
Run 3 Configuration, NO MRFSS	0.14	19,886	3,054	0.39	10,637	0.35	6,595	0.39	3.02
Run 3 Configuration, NO FWC	0.12	25,700	2,821	0.34	11,132	0.34	6,902	0.34	3.72
Run 3 Configuration, NO SEAMAP Survey	0.13	20,364	3,053	0.38	10,715	0.35	6,643	0.38	3.07
Run 1 Configuration, SS Reweighting	0.19	11,050	3,743	0.37	7,011	0.37	4,347	0.5	2.54
Run 3 Configuration, RETROSPECITVE_2010	0.15	18,383	3,163	0.43	10,882	0.35	6,747	0.43	2.72
Run 3 Configuration, RETROSPECTIVE_2009	0.16	17,503	2,991	0.46	11,022	0.34	6,834	0.46	2.56
Run 3 Configuration, RETROSPECTIVE_2008	0.15	18,121	2,968	0.44	11,182	0.35	6,933	0.44	2.61
Run 3 Configuration, RETROSPECTIVE_2007	0.15	16,832	3,072	0.46	11,362	0.33	7,044	0.46	2.39
Run 3 Configuration, RETROSPECTIVE_2006	0.16	19,528	3,040	0.48	10,986	0.34	6,811	0.48	2.87

The point estimates of the ratio of $\mathrm{SSB}_{\mathrm{current}}/\mathrm{MSST}$ exceed 1 in all but one case of Table 3.8 of the Assessment Workshop Report, *i.e.*, that for the run in which *M* was set at the lower value, MLO = 0.27 y^{-1}, when this ratio became 0.99, *i.e.*, the SSB was only just below MSST. Apart from this run, the results of the model runs that were undertaken indicate that that it is highly likely that the stock of Spanish mackerel is currently not overfished.

The value of F_{current} for the model with steepness set to 0.8 is reported as 0.14 in Table 3.8 and 0.13 in Table 3.9 of the Assessment Workshop Report. The ratio of F_{current} to MFMT is reported in Tables 3.8 and 3.9 as 0.38 and, 0.50, respectively for this model, and, for the model with steepness of 0.9, as 0.39 and 0.52, respectively. The values of $\text{SSB}_{\text{current}}$ reported in Table 3.8 for the models with steepness values of 0.8 and 0.9 are transposed in Table 3.9. The values of the ratio of $\text{SSB}_{\text{current}}/\text{MSST}$ in Table 3.9 do not match the values reported in Table 3.8 for either model. These inconsistencies should be resolved.

ToR 14. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.

Conclusions

Stock Synthesis provides a well-tested procedure to project the model through a range of future years, using a fishing rate based on MSY, SPR, a specified target biomass, or a multiple of the recent average fishing rate and producing estimates of yield and key management parameters, thereby allowing assessment of future stock condition. The methods used, which are recognised as being of high quality, are designed to produce the estimates of future population status that are needed by managers. If the current fishing rate is maintained over the next 10 years, the projections produced for the base model for the Gulf of Mexico Spanish mackerel stock suggest that there will be little change in spawning stock biomass. If, however, fishing mortality is increased to the level that is estimated as required to produce OY, or further increased to that which would produce a spawning potential ratio of 30%, the spawning stock biomass would be expected to be reduced by approximately 20%. The condition of the stock would be expected to continue to be classified as “not overfished, with overfishing not occurring”.

Strengths

Projections are undertaken using the well-tested procedures provided within Stock Synthesis.

Summary

Stock Synthesis includes a well-tested procedure to project the future stock status that would result when using a fishing rate based on MSY, SPR, a specified target biomass, or a multiple of the recent average fishing rate. Use of this procedure ensures consistency of model predictions with assumptions and parameter estimates used in fitting the model and the age structure predicted as the current state of the stock from which the projection commences. It is thus highly applicable for use with the Gulf of Mexico stock of Spanish mackerel.

For the Gulf of Mexico stock of Spanish mackerel, deterministic projections were run by the Assessment Panel for the models with steepness of 0.8 and 0.9 and using fishing rates set to MFMT (*i.e.*, the proxy $F_{30\%\text{SPR}}$ for F_{MSY}), F_{OY} (*i.e.*, 75% of $F_{30\%\text{SPR}}$), and F_{current}. Using the bootstrapping facility provided by the Fishery Simulation GUI software, stochastic projections were also run for the two models with the fishing rate set to MFMT (the Assessment Workshop report only presents the results for the model with steepness set to 0.8).

The final year of the time series of data used in the assessment for the Gulf of Mexico stock of Spanish mackerel was 2011. In order to carry out projections for 20 years from 2013 (only results from 2013 to 2022 being reported), the 2012 landings "were characterized as the landings [of the different fisheries] from the most recent three years (2009-2011)" (Assessment Workshop Report). Stock Synthesis was used to estimate the fishing mortality for 2012 required to achieve these landings, and used the 2012 estimate of SSB to calculate an estimate of age 0 recruitment from the fitted stock-recruitment relationship.

If the current fishing rate is maintained over the next 10 years, the projections produced for the models with steepness set to 0.8 and 0.9 suggest that there will be little change in spawning stock biomass. If, however, fishing mortality is increased to the level that is estimated as required to produce OY, or further increased to that which would produce a spawning potential ratio of 30%, the spawning stock biomass would be expected to be reduced by approximately 20 or 30%, respectively.

ToR 15. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.

- **Provide measures of uncertainty for estimated parameters**
- **Ensure that the implications of uncertainty in technical conclusions are clearly stated**
- **If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.**
- **Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments**
- **Provide justification for the weightings used in producing the combinations of models**

Conclusions

The methods within Stock Synthesis that may be used to explore uncertainty include calculation of estimates of asymptotic standard errors, calculation of likelihood profiles, MCMC analyses, and bootstrapping. These tools are complemented by auxiliary software that allows production of diagnostic plots, which also assist in communicating the uncertainty of estimates. The software encourages exploration of alternative model structures and sensitivity to alternative values of parameters of functional forms. The model that was developed for the Gulf of Mexico stock of Spanish mackerel employed an appropriate set of these methods. As a result of the exploration of the uncertainty of the estimate of steepness, the base model was modified by fixing steepness to 0.8. Probability distributions were produced for a set of key parameters using both the original and new base models. As the iterative approach required to calculate P^* cannot be implemented in Stock Synthesis, Stock Synthesis "calculates the expected time series of probabilities that the *F* resulting from a specified harvest policy would exceed a specified level" (Methot and Wetzel, 2012).

Strengths

- Stock Synthesis provides an extensive suite of methods that may be used to explore uncertainty.
- Bootstrapping was used to produce probability distributions

Summary

Stock Synthesis provides a number of methods that may be used to characterize the uncertainty associated with the estimates of parameters, benchmark estimates, and predicted values of parameters. These are supplemented by the bootstrapping tools provided by the Fishery Simulation GUI. Together, the software is well suited for use in exploring the uncertainty associated with the models that were fitted to the Gulf Of Mexico Spanish mackerel stock. Thus, for each run of the Stock Synthesis model for the Gulf of Mexico Spanish mackerel, asymptotic standard errors were calculated for each of the parameters that were estimated (see Table 3.1, Assessment Workshop Report, for parameter estimates and estimates of asymptotic standard errors for the base model, with $M = 0.38$ y^{-1} and steepness = 0.8). These estimates of asymptotic standard errors may be considered to represent minimum values for the uncertainty of the estimated parameters. The uncertainty of selected parameter estimates for the Gulf of Mexico Spanish mackerel stock was also characterized using the results from bootstrapping.

The initial run (Run 1) was carried out using the model structure that had been proposed for the Gulf of Mexico stock of Spanish mackerel and estimating the steepness parameter of the Beverton and Holt stock-recruitment relationship. This demonstrated that, given the data that were available, the steepness of the stock recruitment relationship was estimated very imprecisely. A number of sensitivity runs of Stock Synthesis were then run to explore the effect of varying the configuration or methods employed in the analysis.

As is typical in stock assessment, exploratory runs for the Gulf of Mexico Spanish mackerel stock were first employed to determine a base model for the assessment, *i.e.*, a model that is considered the most likely of the alternative model configurations that have been proposed. The decision was made at the Assessment Workshop to reject Run 1 and use Run 3 as the base model. As noted above, a justification for this decision, *i.e.*, to use the initial model structure, *i.e.*, that for Run 1, and to fix the value of steepness at 0.8, was not reported in the Assessment Workshop Report other than to state that the Assessment Workshop found the low estimate of steepness produced when fitting the model in Run 1 to be unacceptable. Probability distributions of the key parameters estimated for the initial model, Run 1, and the new base model, Run 3, were produced and plotted (Figs 3.34 and 3.35 of the Assessment Workshop Report).

The level to which the initial spawning stock biomass had been depleted by 2011 was far less for Run 1, *i.e.*, 0.16 SSB_{B0} than for Run 3, *i.e.*, 0.51 SSB_{B0} (Table 3.7, Assessment Workshop Report). A similar level of depletion, *i.e.*, 0.18 SSB_{B0} as that of Run 1 was estimated to have resulted when the value of natural mortality used in the Run 3 configuration was lowered to 0.27 y^{-1}. When Run 1 was re-fitted, estimating steepness (with a resulting value of 0.53) and iteratively adjusting the weights of the survey indices and the length and age compositions to match the estimated variances of the input data with those of the fitted model, the level of depletion was again low, *i.e*., 0.16 SSB_{B0}. The level of depletion of spawning stock biomass appears sensitive to reduced values of steepness and/or natural mortality. Given the estimated level of depletion of spawning stock biomass for these runs, it is interesting to note that SPR had been reduced in these three model configurations to only 0.51, 0.41, and 0.53, respectively (Table 3.7, Assessment Workshop Report). Again, these results suggest that, when MSY-based reference points are available, these should be used in preference to SPR-based proxies.

While the Assessment Workshop Report provided a comparison of the key parameters, benchmarks, and projections for the base model that was adopted at the workshop, *i.e*., Run 3, with steepness of 0.8, and an alternative model, which had an identical configuration but used a steepness of 0.9, the relative probabilities of the two models was not assessed. The base model was subjected to a bootstrapping analysis, however, and distributions of the resulting estimates of the benchmark estimates are provided in Figures 3.48 and 3.49 of the Assessment Workshop Report, while distributions of projected yields for 2013-2022 are plotted in Fig. 3.53.

The caption of Table 3.9 advises that the table provides results of the required SFA and MSRA evaluations using a SPR 30% reference point for "4 states of nature of steepness at 3 levels of natural mortality". The table, however, only presents results for models representing two values of steepness for one value of natural mortality.

While the iterative approach required to calculate *P** cannot be implemented in Stock Synthesis, a complementary approach has been developed to produce estimates of the probability that *F*, the fishing rate based on MSY, SPR, a specified target biomass, or a multiple of the recent average fishing rate that is employed in the projection, exceeds the OFL (Methot and Wetzel, 2012). These authors advise that, whereas the *P** approach calculates the future stream of annual catches that would have a specified annual probability of *F* > OFL, Stock Synthesis "calculates the expected time series of probabilities that the *F* resulting from a specified harvest policy would exceed a specified level".

ToR 16. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.

The Review was undertaken as a desktop review, rather than in a Workshop setting. Accordingly, it was not possible for the recommendations made in review reports to be acted upon, nor to ensure that the results were incorporated accurately in the resultant Stock Assessment Report.

ToR 17. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.

The SEDAR Process has ensured that all aspects of the assessment process for the Gulf of Mexico stock of Spanish mackerel, from collation of data through to model development, exploration, and production of management advice, have been documented in detail, including the underlying reasons for the decisions that were made concerning data to be used and model structure to be employed. The structure imposed on the Data and Assessment Workshops by their Terms of Reference has assisted by providing a logical framework for the process, and thereby ensuring that key aspects of the assessment were not overlooked. For the reviewer, the documentation of the Spanish mackerel assessment, which was produced through the SEDAR process, proved invaluable in gaining an understanding of the details of the assessment and assisted in identifying opportunities for improvement and in detecting errors or inadequacies.

The Terms of Reference for the Assessment Process, which are presented below, are now examined and comment is made on the degree to which these were addressed.

1. Review and provide justification for any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model.

   Accomplished.

2. Recommend a model configuration which is deemed most reliable for providing management advice using available compatible data. Document all input data, assumptions, and equations.

   Accomplished.

3. Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.

   No environmental covariates were identified by either the Data or Assessment Workshops.

4. Provide estimates of stock population parameters.
   - Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as appropriate given data availability and modeling approaches
   - Include appropriate and representative measures of precision for parameter estimates

   Accomplished.

5. Characterize uncertainty in the assessment and estimated values.
   - Considering components such as input data, modeling approach, and model configuration
   - Provide appropriate measures of model performance, reliability, and 'goodness of fit'

   Accomplished.

6. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.

   Accomplished.

7. Provide estimates of stock status relative to management criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards for each model run presented for review.

   Accomplished.

8. Project future stock conditions and develop rebuilding schedules if warranted, including estimated generation time. Develop stock yield projections in both biomass and numbers of fish in accordance with the following:
   A) If stock is overfished:
      F=0, FCurrent, FMSY, FOY
      F=FRebuild (max that permits rebuild in allowed time)
   B) If stock is undergoing overfishing:
      F= FCurrent, FMSY, FOY
   C) If stock is neither overfished nor undergoing overfishing:
      F= FCurrent, FMSY, FOY
   D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice

   Accomplished.

9. Provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.
   - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments for use with the Tier 1 ABC control rule
   - Provide justification for the weightings used in producing combinations of models

   The Assessment Workshop Report noted that ten sensitivity runs had been considered, one of which had been subjected to stochastic projection. The Assessment Workshop Report advised that “probability distribution functions will be developed for the subset of model recommended by the SEDAR AP for projections … and made available to the Scientific and Statistical Committee (SSC) for the development of management advice, including OFL and ABC”. No information relating to these probability distribution functions was presented in the Report.

10. Provide recommendations for future research and data collection. Be as specific as possible in describing sampling design and intensity, and emphasize items which will improve assessment capabilities and reliability. Recommend the interval and type for the next assessment.

Attention was directed to the research recommendations that were made in the Data Workshop Report. The Workshop Assessment Report identified gaps in data, which, if addressed, would improve the assessment capabilities and reliability. Specific sampling design and intensity were not discussed. No recommendations relating to the interval and type for the next Assessment were made by the Assessment Workshop

11. Prepare a spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.

    A spreadsheet was not provided in the documentation that was circulated to the Review Panel. The Assessment Workshop addressed this Term of Reference in its Report by providing a table listing the estimates for all parameters used in the model and presenting a listing of each of the input files required to run the Stock Synthesis model for Gulf of Mexico Spanish mackerel.

12. Complete the Assessment Workshop Report (Section III: SEDAR Stock Assessment Report).

    Accomplished.

ToR 18. Make any additional recommendations or prioritizations warranted.

- **Clearly denote research and monitoring needs that could improve the reliability of future assessments**

A number of research needs, which are listed below in priority order, were identified in the course of the desk review. As expected, these were highly consistent with, and thus overlap, a number of the research needs that had been identified by the Data and Assessment workshops.

1. Review or establish programs to collect data on the length composition and age-at-length compositions of landings and discards from each commercial gear and from each recreational fishing mode, and of bycatch of Spanish mackerel from the shrimp fishery. Ensure that the statistical design and spatial coverage of survey or sampling programs are appropriate and that survey or sampling intensity is sufficient to produce estimates of the required precision for the Gulf of Mexico stock of Spanish mackerel. Set goals for performance and establish and monitor performance criteria to assess the quality and completeness of data collection programs. This research need is of the highest priority as it will provide information required by Stock Synthesis to determine the selectivity and retention curves for Spanish mackerel for the commercial, recreational, and shrimp fisheries, the lack of which is a key source of uncertainty in the model.
2. Undertake research to determine reliable relationships between the proportion of females that are mature and both length and age for the Gulf of Mexico stock of Spanish mackerel. This is also of high priority, as the maturity information that is currently used is imprecise. The calculation of spawning stock biomass, a crucial

parameter in the calculation of benchmarks and assessment of stock status, should be based on reliable data.

3. Review programs that are used to collect discard data for Spanish mackerel (and data on the bycatch of Spanish mackerel by the shrimp fishery), and refine these programs to ensure that accurate and complete data estimates of the discards (and bycatch) are collected. Ensure that the statistical design and spatial coverage of survey or sampling programs are appropriate and that survey or sampling intensity is sufficient to produce estimates of the required precision. Set goals for performance and establish and monitor performance criteria to assess the quality and completeness of data collection programs. While this research will not produce immediate improvement in the quality of the assessment, it is important that action is taken as soon as possible to improve the accuracy and precision of the data relating to the quantities of fish that are discarded from each of the fisheries, such that, in the future, the time series of discards become more reliable.
4. A comprehensive study of the stock structure of Spanish mackerel should be undertaken, with the following objectives:
    a. to determine stock structure and the areas occupied by each stock;

    and, assuming that the current view that there are two stocks, *i.e.*, a Gulf of Mexico and a South Atlantic stock, is substantiated,

    b. to determine more reliably the boundary between the Gulf of Mexico and South Atlantic stocks or the extent of overlap;
    c. to extend sampling into Mexican waters and thereby determine the southern boundary of the Gulf of Mexico stock;
    d. to ascertain whether, regardless of the time of year, catches of fish may be assigned reliably to either the Gulf of Mexico or South Atlantic stock on the basis of the area in which they are caught.

    As this study will take some time before completion, it has been assigned a lower priority than the previous items. Determination of the southern stock boundary, however, is important to ensure that other removals from the stock are not occurring in Mexican waters, as such removals are not taken into account in the current assessment.
5. Undertake research to determine the discard mortality of Gulf of Mexico Spanish mackerel that are discarded from the catches of each commercial fishing gear or each recreational fishing mode, recognising that such mortality is likely to differ among different categories into which the discarded fish are classified, *e.g.*, “alive”, “mostly alive”, and “mostly dead”.
6. In future stock assessments for the Gulf of Mexico stock of Spanish mackerel, explore whether the use of an age-dependent rather than constant M results in a significant improvement in fit, considering the Lorenzen and alternative functional forms of the relationship with age and the alternative of estimating the value of the age-dependent M at each age (or range of ages).
7. In future stock assessments, explore the sensitivity of the model to the uncertainty of the landings data.
8. As a low research priority, assess whether, in future refinement of the Stock Synthesis model, sexually dimorphic growth should be introduced. Note that the benefit of this might only be realised if appropriate sex composition data for landings and discards are

available for input, and length and age-at-length compositions are sexually disaggregated.

5. Conclusions and recommendations

After considering the information relating to stock structure, the data that were available for the Gulf of Mexico stocks of cobia and Spanish mackerel, and the details of the assessment for each species, the base model that had been proposed by the Assessment Workshop for each assessment was accepted for use in assessing stock status and in projecting the potential yield and likely stock status over the next six years. The results of the accepted base models, which had been developed using the Stock Synthesis 3 framework, suggested that both stocks were currently (in 2011) not overfished and that overfishing was not currently occurring. While the results of the assessment were imprecise, reflecting the quality and nature of the input data, the results of sensitivity runs for each model suggested that the conclusions drawn regarding stock status were likely to be robust to the uncertainty of the base model results.

Although some of the components of the data for the Gulf of Mexico stocks of cobia and Spanish mackerel were limited and/or uncertain, the datasets that had been collated by the Data Workshops represented the best data currently available for those stocks and appeared adequate for use in assessing, albeit imprecisely, the condition of the two stocks. The models that were developed within Stock Synthesis using these datasets were of appropriate structure and were of a standard that would be considered "best practice" given the types and quality of the data that were available. The explorations of uncertainty and decisions made in the assessments were appropriate. The advice regarding the condition of each stock, *i.e.*, that it is not overfished and overfishing is not occurring, appears sound.

Improvement of the assessments will require the collection of adequate and appropriate data sufficient to characterize the length and age-at-length compositions of catches and discards from both the commercial and recreational fisheries and of bycatches of cobia and Spanish mackerel by the shrimp fishery. These data are essential if selectivity and retention curves are to be accurately determined within the assessment models. Reliable data on maturity are also essential if reliable estimates of spawning stock biomass are to be calculated by the models. Further improvement of the models will require the collection of discard and bycatch data of higher quality from the commercial and recreational fisheries and from the shrimp fishery, and determination of the southern boundaries of both the Gulf of Mexico stocks of cobia and Spanish mackerel.

6. References

Beddington, J. R., and Cooke, J. G. 1983. The potential yield of fish stocks. *FAO Fish. Tech. Pap.*, 242: 1–47.

Diaz, G. A., Porch, C. E., and Ortiz, M. 2004. Growth models for red snapper in US Gulf of Mexico Waters estimated from landings with minimum size limit restrictions. NMFS/SFD Contribution SFD-2004-038. SEDAR7-AW1.

Francis, R. I. C. C. (1993). Monte Carlo evaluation of risks for biological reference points used in New Zealand fishery assessments. *Canadian Special Publication of Fisheries and Aquatic Sciences* **120**: 221-230.

Francis, R. I. C. C. 2011. Data weighting in statistical fisheries stock assessment models. *Canadian Journal of Fisheries and Aquatic Sciences*, **68**: 1124-1138.

Francis, R. I. C. C. 2012. Report on the 2012 assessments of yellowtail flounder and herring at Woods Hole. National Institute of Water & Atmospheric Research Ltd., Wellington, New Zealand.

Froese, R. and Binohlan, C. 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. *Journal of Fish Biology* **56**:758-773.

Froese, R., and Pauly, D. (Editors). 2012. FishBase. World Wide Web electronic publication. www.fishbase.org, version (12/2012).

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin*, **82**: 898-903.

Lee, H-H., Maunder, M. N., Piner, K. R., and Methot, R. D. (2012). Can steepness of the stock–recruitment relationship be estimated in fishery stock assessment models? *Fisheries Research*, **125–126**: 254– 261.

Lee, Hua-hui, Cheng-Yu Yang, R., and Taylor, I. 2012. User manual for Fishery Simulation Tool. Joint Institute for Marine and Atmospheric Research, University of Hawaii, Pacific Islands Fisheries Science Center, NOAA Fisheries Honolulu, HI USA, 7pp.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. *Journal of Fish Biology*, **49**: 627-642.

MacCall, A. 2011. What is the precision of *M*? Abstract *In*: Brodziak, J., J. Ianelli, K. Lorenzen, and R.D. Methot Jr. (eds). 2011. Estimating natural mortality in stock assessment applications. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-119, 38 p.

Maunder, M. N. and Deriso, R. B. 2003. Estimation of recruitment in catch-at-age models. *Can. J. Fish. Aquat. Sci*., **60**: 1204-1216.

Mertz, G., and Myers, R. A. 1996. Influence of fecundity on recruitment variability of marine fish. *Can. J. Fish. Aquat. Sci.*, **53**: 1618 - 1625.

Methot, R.D. 2011. User manual for Stock Synthesis: model version 3.23b. Nov 7, 2011. NOAA Fisheries Service, Seattle, WA.

Methot Jr., R. D., and Wetzel, C. R., 2012. Stock Synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fish. Res.* (in press).

Smith, A. D. M., and Punt, A. E. 1998. Stock assessment of gemfish (*Rexea solandri*) in eastern Australia using maximum likelihood and Bayesian methods. *In* Fisheries stock assessment models. Edited by T. J. Quinn II, F. Funk, J. Heifetz, J. N. Ianelli, J. E. Powers, J. F. Schweigert, P. J. Sullivan, and C-I. Zhang. Alaska Sea Grant College Program, AK-SG-98-01. pp. 245–286.

Appendix 1: Bibliography of all material provided

SEDAR 28 - Gulf and South Atlantic -- Spanish Mackerel and Cobia
Workshop Document List

Document #	Title	Authors
	Data and Assessment Workshop Reports considered in CIE Desktop Review	
	SEDAR 28 – Gulf of Mexico Cobia – Data Workshop Report – May 2012	
	SEDAR 28 – Gulf of Mexico Spanish Mackerel – Data Workshop Report – May 2012	
	SEDAR 28 – Gulf of Mexico Cobia – Assessment Process Report – December 2012	
	SEDAR 28 – Gulf of Mexico Spanish – Mackerel Assessment Workshop Report – December 2012	
	Documents Prepared for the Data Workshop	
SEDAR28-DW01	Cobia preliminary data analyses – US Atlantic and GOM genetic population structure	Darden 2012
SEDAR28-DW02	South Carolina experimental stocking of cobia *Rachycentron canadum*	Denson 2012
SEDAR28-DW03	Spanish Mackerel and Cobia Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Pollack and Ingram, 2012
SEDAR28-DW04	Calculated discards of Spanish mackerel and cobia from commercial fishing vessels in the Gulf of Mexico and US South Atlantic	K. McCarthy
SEDAR28-DW05	Evaluation of cobia movement and distribution using tagging data from the Gulf of Mexico and South Atlantic coast of the United States	M. Perkinson and M. Denson 2012
SEDAR28-DW06	Methods for Estimating Shrimp Bycatch of Gulf of Mexico Spanish Mackerel and Cobia	B. Linton 2012
SEDAR28-DW07	Size Frequency Distribution of Spanish Mackerel from Dockside Sampling of Recreational and Commercial Landings in the Gulf of Mexico 1981-2011	N.Cummings, J. Isely
SEDAR28-DW08	Size Frequency Distribution of Cobia from Dockside Sampling of Recreational and Commercial Landings in the Gulf of Mexico 1986-2011	J. Isely and N. Cummings
SEDAR28-DW09	Texas Parks and Wildlife Catch Per unit of Effort Abundance Information for Spanish mackerel	N. Cummings, J. Isely

Document #	Title	Authors
SEDAR28-DW10	Texas Parks and Wildlife Catch Per unit of Effort Abundance Information for cobia	J. Isely, N. Cummings
SEDAR28-DW11	Size Frequency Distribution of Cobia and Spanish Mackerel from the Galveston, Texas, Reef Fish Observer Program 2006-2011	J Isely and N Cummings
SEDAR28-DW12	Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the South Atlantic and Gulf of Mexico in 1981-1985 with For Hire Survey estimates with application to Spanish mackerel and cobia landings	V. Matter, N Cummings, J Isely, K Brennen, and K Fitzpatrick
SEDAR28-DW13	Constituent based tagging of cobia in the Atlantic and Gulf of Mexico waters	E. Orbesen
SEDAR28-DW14	Recreational Survey Data for Spanish Mackerel and Cobia in the Atlantic and the Gulf of Mexico from the MRFSS and TPWD Surveys	V. Matter
SEDAR28-DW15	Commercial Vertical Line and Gillnet Vessel Standardized Catch Rates of Spanish Mackerel in the US Gulf of Mexico, 1998-2010	N. Baertlein, K. McCarthy
SEDAR28-DW16	Commercial Vertical Line Vessel Standardized Catch Rates of Cobia in the US Gulf of Mexico, 1993-2010	K. McCarthy
SEDAR28-DW17	Standardized Catch Rates of Spanish Mackerel from Commercial Handline, Trolling and Gillnet Fishing Vessels in the US South Atlantic, 1998-2010	K. McCarthy
SEDAR28-DW18	Standardized catch rates of cobia from commercial handline and trolling fishing vessels in the US South Atlantic, 1993-2010	K. McCarthy
SEDAR28-DW19	MRFSS Index for Atlantic Spanish mackerel and cobia	Drew et al.
SEDAR28-DW20	Preliminary standardized catch rates of Southeast US Atlantic cobia (*Rachycentron canadum*) from headboat data	NMFS Beaufort
SEDAR28-DW21	Spanish mackerel preliminary data summary: SEAMAP-SA Coastal Survey	Boylan and Webster
SEDAR28-DW22	Recreational indices for cobia and Spanish mackerel in the Gulf of Mexico	Bryan and Saul
SEDAR28-DW23	A review of Gulf of Mexico and Atlantic Spanish mackerel (*Scomberomorus maculatus*) age data, 1987-2011, from the Panama City Laboratory, Southeast Fisheries Science Center, NOAA Fisheries Service	Palmer, DeVries, and Fioramonti

Document #	Title	Authors
SEDAR28-DW24	SCDNR Charterboat Logbook Program Data, 1993 - 2010	Errigo, Hiltz, and Byrd
SEDAR28-DW25	South Carolina Department of Natural Resources State Finfish Survey (SFS)	Hiltz and Byrd
SEDAR28-DW26	Cobia bycatch on the VIMS elasmobranch longline survey:1989-2011	Parsons et al.
	Documents Prepared for the Assessment Workshop	
SEDAR28-AW01	Florida Trip Tickets	S. Brown
SEDAR28-AW02	SEDAR 28 Spanish mackerel bycatch estimates from US Atlantic coast shrimp trawls	NMFS Beaufort
	Documents Prepared for the Review Workshop	
SEDAR28-RW01	The Beaufort Assessment Model (BAM) with application to cobia: mathematical description, implementation details, and computer code	Craig
SEDAR28-RW02	Development and diagnostics of the Beaufort assessment model applied to Cobia	Craig
SEDAR28-RW03	The Beaufort Assessment Model (BAM) with application to Spanish mackerel: mathematical description, implementation details, and computer code	Andrews
SEDAR28-RW04	Development and diagnostics of the Beaufort assessment model applied to Spanish mackerel	Andrews
	Final Assessment Reports (Not available at time of desktop review)	
SEDAR28-SAR1	Assessment of Spanish mackerel in the US South Atlantic	To be prepared by SEDAR 28
SEDAR28-SAR2	Assessment of Spanish mackerel in the US Gulf of Mexico	To be prepared by SEDAR 28
SEDAR28-SAR3	Assessment of cobia in the US South Atlantic	To be prepared by SEDAR 28
SEDAR28-SAR4	Assessment of cobia in the US Gulf of Mexico	To be prepared by SEDAR 28
	Reference Documents	
SEDAR28-RD01	List of documents and working papers for SEDAR17 (South Atlantic Spanish mackerel) – all documents available on the SEDAR website	SEDAR 17
SEDAR28-RD02	2003 Report of the mackerel Stock Assessment Panel	GMFMC and SAFMC, 2003
SEDAR28-RD03	Assessment of cobia, *Rachycentron canadum*, in the waters of the U.S. Gulf of Mexico	Williams, 2001
SEDAR28-RD04	Biological-statistical census of the species entering fisheries in the Cape Canaveral area	Anderson and Gehringer, 1965

Document #	Title	Authors
SEDAR28-RD05	A survey of offshore fishing in Florida	Moe 1963
SEDAR28-RD06	Age, growth, maturity, and spawning of Spanish mackerel, *Scomberomorus maculates* (Mitchill), from the Atlantic Coast of the southeastern United States	Schmidt et al. 1993
SEDAR28-RD07	Omnibus amendment to the Interstate Fishery Management Plans for Spanish mackerel, spot, and spotted seatrout	ASMFC 2011
SEDAR28-RD08	Life history of Cobia, *Rachycentron canadum* (Osteichthyes: Rachycentridae), in North Carolina waters	Smith 1995
SEDAR28-RD09	Population genetics of cobia *Rachycentron canadum*: Management implications along the Southeastern US coast	Darden et al, 2012
SEDAR28-RD10	Inshore spawning of cobia (*Rachycentron canadum*) in South Carolina	Lefebvre and Denson, 2012
SEDAR28-RD11	A review of age, growth, and reproduction of cobia *Rachycentron canadum*, from US water of the Gulf of Mexico and Atlantic ocean	Franks and Brown-Peterson, 2002
SEDAR28-RD12	An assessment of cobia in Southeast US waters	Thompson 1995
SEDAR28-RD13	Reproductive biology of cobia, *Rachycentron canadum*, from coastal waters of the southern United States	Brown-Peterson et al. 2001
SEDAR28-RD14	Larval development, distribution, and ecology of cobia *Rachycentron canadum* (Family: Rachycentridae) in the northern Gulf of Mexico	Ditty and Shaw 1992
SEDAR28-RD15	Age and growth of cobia, *Rachycentron canadum*, from the northeastern Gulf of Mexico	Franks et al 1999
SEDAR28-RD16	Age and growth of Spanish mackerel, *Scomberomorus maculates*, in the Chesapeake Bay region	Gaichas, 1997
SEDAR28-RD17	Status of the South Carolina fisheries for cobia	Hammond, 2001
SEDAR28-RD18	Age, growth and fecundity of the cobia, *Rachycentron canadum*, from Chesapeake Bay and adjacent Mid-Atlantic waters	Richards 1967
SEDAR28-RD19	Cobia (*Rachycentron canadum*) tagging within Cheasapeake Bay and updating of growth equations	Richards 1977
SEDAR28-RD20	Synopsis of biological data on the cobia *Rachycentron canadum* (Pisces: Rachycentridae)	Shaffer and Nakamura 1989
SEDAR28-RD21	South Carolina marine game fish tagging program 1978-2009	Wiggers, 2010

Document #	Title	Authors
SEDAR28-RD22	Cobia (*Rachycentron canadum*), amberjack (*Seriola dumerili*), and dolphin (*Coryphaena hipurus*) migration and life history study off the southwest coast of Florida	MARFIN 1992
SEDAR28-RD23	Sport fish tag and release in Mississippi coastal water and the adjacent Gulf of Mexico	Hendon and Franks 2010
SEDAR28-RD24	VMRC Cobia otolith preparation protocol	VMRC
SEDAR28-RD25	VMRC Cobia otolith ageing protocol	VMRC
SEDAR28-RD26	Age, growth, and reproductive biology of greater amberjack and cobia from Louisiana waters	Thompson et al. 1991
SEDAR28-RD27	Gonadal maturation in the cobia, *Rachycentron canadum*, from the northcentral Gulf of Mexico	Lotz et al. 1996
SEDAR28-RD28	Cobia (*Rachycentron canadum*) stock assessment study in the Gulf of Mexico and in the South Atlantic	Burns et al. 1998
SEDAR28-RD29	Total mortality estimates for Spanish mackerel captured in the Gulf of Mexico commercial and recreational fisheries 1983 to 2011	Bryan 2012

Appendix 2: Copy of the CIE Statement of Work

Attachment A: Statement of Work for Dr. Norm Hall

Amended Statement of Work

External Independent Peer Review by the Center for Independent Experts

SEDAR 28: Gulf of Mexico Cobia and Spanish Mackerel Assessment Desk Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description SEDAR 28 will be a compilation of data, an assessment of the stocks, and an assessment review conducted for Gulf of Mexico Spanish mackerel and cobia. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 28 are within the jurisdiction of the Gulf of Mexico Fisheries Management Councils and states in the Gulf of Mexico region. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the statement of work (SoW) tasks and terms of reference (ToRs) specified herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall participate and conduct an independent peer review as a desk review, therefore travel will not be required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer contact information to the COR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The

NMFS Project Contact is responsible for providing the CIE reviewers with the assessment and other pertinent background documents for the peer review. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an impartial and independent peer review in accordance with the tasks and ToRs specified herein, and each ToRs must be addressed (**Annex 2**).
3) No later than January 25, 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

21 December 2012	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
2 January 2013	NMFS Project Contact sends the CIE Reviewers the assessment report and background documents
9-24 January 2013	Each reviewer conducts an independent peer review as a desk review
25 January 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
8 February 2013	CIE submits CIE independent peer review reports to the COR
15 February 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Program Manager, COR
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

Roger W. Peretti, Executive Vice President
Northern Taiga Ventures, Inc. (NTVI)
22375 Broderick Drive, Suite 215, Sterling, VA 20166
RPerretti@ntvifederal.com Phone: 571-223-7717

Key Personnel:

NMFS Project Contact:

Ryan Rindone, SEDAR Coordinator
2203 N. Lois Avenue, Suite 1100
Tampa, FL 33607
Ryan.Rindone@gulfcouncil.org Phone: 813-348-1630

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

   The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2a – Terms of Reference for

SEDAR 28: Gulf of Mexico Cobia Assessment Desk Review

1. Evaluate the quality and applicability of data used in the assessment.
2. Evaluate the quality and applicability of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.
5. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.
6. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.
    - Provide measures of uncertainty for estimated parameters
    - Ensure that the implications of uncertainty in technical conclusions are clearly stated
    - If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternative states of nature, presented for review.
        - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments
        - Provide justification for the weightings used in producing the combinations of models
7. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.
8. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.
9. Make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring needs that could improve the reliability of future assessments

Table 1. Required MSRA Evaluations for cobia assessment:

Criteria	Definition* (2001)	Current Value* (2001)
Mortality Rate Criteria		
F_{MSY}	F_{MSY}	0.34
MFMT	F_{MSY}	0.34
F_{OY}	75% of F_{MSY}	0.26
$F_{CURRENT}$	F_{2000}	0.30
$F_{CURRENT}$/ F_{MSY}	Percentage of $F_{Current}/F_{MSY}$ > MFMT	0.40
Base M		0.30
Biomass Criteria		
SSB_{MSY}	Equilibrium SSB_{MSY} @ F_{MSY}	3.02 mp
MSST	(1-M)*SSB_{MSY}: M=0.30	2.11 mp
$SSB_{CURRENT}$	SSB_{2000}	
$SSB_{CURRENT}$/ SSB_{MSY}	Percentage of $SSB_{Current}/SSB_{MSY}$ < MSST	0.30
Equilibrium MSY	Equilibrium Yield @ F_{MSY}	1.50 mp
Equilibrium OY	Equilibrium Yield @ F_{OY}	1.45 mp
OFL	Annual Yield @ MFMT	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	
Annual OY**	Annual Yield @ F_{OY}	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	

*Definitions and values are subject to change as per guidance from this assessment.

**Based upon current definitions of OY, where OY = 75% of F_{MSY}

Table 2. Projection Scenario Details for cobia assessment

2.1 Initial Assumptions:

OPTION	Value
2012 base TAC	TBD
2012 Recruits	TBD by Panel
2012 Selectivity	TBD by Panel
Projection Period	6 yrs (2013-2018)
1st year of change F, Yield	2013

2.2 Scenarios to Evaluate (preliminary, to be modified as appropriate)

1. Landings fixed at 2013 target
2. F_{OY}= 65%, 75%, 85% F_{MSY} (project when OY will be achieved)
3. F_{MSY}
4. $F_{REBUILD}$ (if necessary)
5. F=0 (if necessary)

2.3 Output values

1. Landings
2. Discards (including dead discards)
3. Exploitation
4. F/F_{MSY}
5. B/B_{MSY}

10. Evaluate the quality and applicability of data used in the assessment.
11. Evaluate the quality and applicability of methods used to assess the stock.
12. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
13. Evaluate the methods used to estimate population benchmarks and management parameters. Recommend and provide estimated values for appropriate management benchmarks and declarations of stock status for each model run presented for review.
14. Evaluate the quality and applicability of the methods used to project future population status. Recommend appropriate estimates of future stock condition.
15. Evaluate the quality and applicability of methods used to characterize uncertainty in estimated parameters.
    - Provide measures of uncertainty for estimated parameters
    - Ensure that the implications of uncertainty in technical conclusions are clearly stated
    - If there are significant changes to the base model, or to the choice of alternate states of nature, then provide a probability distribution function for the base model, or a combination of models that represent alternate states of nature, presented for review.
        - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments
        - Provide justification for the weightings used in producing the combinations of models
16. If available, ensure that stock assessment results are accurately presented in the Stock Assessment Report and that stated results are consistent with Review Panel recommendations.
17. Evaluate the quality and applicability of the SEDAR Process as applied to the reviewed assessment and identify the degree to which Terms of Reference were addressed during the assessment process.
18. Make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring needs that could improve the reliability of future assessments

Table 1. Required MSRA Evaluations for Spanish mackerel assessment:

Note: te = trillion eggs

Criteria	Definition* (as of 2002/2003)	Current Value* (2002/03)
Mortality Rate Criteria		
F_{MSY}	$F_{30\%SPR}$	
MFMT	$F_{30\%SPR}$	
F_{OY}	75% of $F_{30\%SPR}$	0.40
$F_{CURRENT}$	$F_{2002/03}$	
$F_{CURRENT}$/MFMT		0.53
Base M		0.30
Biomass Criteria		
SSB_{MSY}	Equilibrium SSB_{MSY} @ $F_{30\%SPR}$	19.10 te
MSST	(1-M)*SSB_{MSY}: M=0.30	13.40 te
$SSB_{CURRENT}$	SSB_{2003}	17.96 te
$SSB_{CURRENT}$/ MSST		1.34
Equilibrium MSY	Equilibrium Yield @ $F_{30\%SPR}$	8.7 mp
Equilibrium OY	Equil. Yield @ 75% of $F_{30\%SPR}$	8.3 mp
OFL	Annual Yield @ MFMT	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	
Annual OY**	Annual Yield @ F_{OY}	
	2013	
	2014	
	2015	
	2016	
	2017	
	2018	

*Definitions and values are subject to change as per guidance from this assessment.

**Based upon current definitions of OY, where OY = 75% of F_{MSY}

Table 2. Projection Scenario Details for Spanish mackerel assessment

2.1 Initial Assumptions:

OPTION	Value
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2012 Recruits	TBD by Panel
2012 Selectivity	TBD by Panel
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2.3 Output values

1. Landings
2. Discards (including dead discards)
3. Exploitation
4. F/F_{MSY}
5. B/B_{MSY}