SEDAR
Southeast Data, Assessment, and Review

SEDAR 49
Stock Assessment Report

Gulf of Mexico Data-limited Species:

Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, Lesser Amberjack

December 2016

SEDAR
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SECTION I: Introduction

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EXECUTIVE SUMMARY

SEDAR 49 addressed the stock assessments for Gulf of Mexico data-limited species, specifically Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, Lesser Amberjack. The assessment process consisted of two in-person workshops, as well as a series of webinars. The Data Workshop was held May 2-6, 2016 in New Orleans, LA, the Assessment Process was conducted via webinars June - September 2016, and the Review Workshop took place November 1-3, 2016 in Miami, FL.

The Stock Assessment Report is organized into 6 sections. Section I – Introduction contains a brief description of the SEDAR Process, Assessment and Management Histories for the species of interest, and the management specifications requested by the Cooperator. The Data Workshop Report can be found in Section II. It documents the discussions and data recommendations from the Data Workshop Panel. Section III is the Assessment Process report. This section details the assessment model, as well as documents any changes to the data recommendations that may have occurred after the data workshop. Consolidated Research Recommendations from all three stages of the process (data, assessment, and review) can be found in Section IV for easy reference. Section V documents the discussions and findings of the Review Workshop (RW). Finally, Section VI – Addenda and Post-Review Workshop Documentation consists of any analyses conducted during or after the RW to address reviewer concerns or requests. It may also contain documentation of the final RW-recommended base model, should it differ from the model put forward in the Assessment Report for review.

The final Stock Assessment Reports (SAR) for Gulf of Mexico data-limited species was disseminated to the public in December 2016. The Council's Scientific and Statistical Committee (SSC) will review the SAR for its stock. The SSCs are tasked with recommending whether the assessments represent Best Available Science, whether the results presented in the SARs are useful for providing management advice and developing fishing level recommendations for the Council. An SSC may request additional analyses be conducted or may use the information provided in the SAR as the basis for their Fishing Level Recommendations (e.g., Overfishing Limit and Acceptable Biological Catch). The Gulf of Mexico Fishery Management Council's SSC will review the assessment at its January 2017 meeting, followed by the Council receiving that information at its January 2017. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

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. SEDAR seeks improvements in the scientific quality of stock assessments and the relevance of information available 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; a representative from the Highly Migratory Species Division of NOAA Fisheries, and Interstate Commission representatives: Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is normally organized around two workshops and a series of webinars. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. The second stage is the Assessment Process, which is conducted via a workshop and/or a series of webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. The final step 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 stages 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 Cooperator. 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.

2 MANAGEMENT OVERVIEW

2.1 REEF FISH FISHERY MANAGEMENT PLAN AND AMENDMENTS

Original FMP:

The Reef Fish Fishery Management Plan was implemented in November 1984. The regulations, designed to rebuild declining reef fish stocks, included: (1) prohibitions on the use of fish traps, roller trawls, and powerhead-equipped spear guns within an inshore stressed area; and, (2) data reporting requirements.

2.2 Trip Limits

Species Affected	Effective Date	End Date	Sector	Individual Daily Bag Limit	Vessel Daily Bag Limit	Region Affected	FR Reference	Amendment Number or Rule Type
Red Drum	12/19/1986	10/15/1987	Com	0	Incidental catch only	Gulf EEZ	51 FR 46675	Original Red Drum FMP
	12/19/1986	10/15/1987	Rec	1	NA	Gulf EEZ	51 FR 46675	Original Red Drum FMP
	10/16/1987	6/28/1988	Com	0	Incidental catch only	EEZ off LA/MS/AL	52 FR 34918	Red Drum Amendment 1
	10/16/1987	6/28/1988	Rec	1	NA	EEZ off LA/MS/AL	52 FR 34918	Red Drum Amendment 1
Lane Snapper	1/15/1997	Ongoing	Rec	20 reef fish agg limit[1]	NA	Gulf EEZ	61 FR 65983	Reef Fish Amendment 12
Wenchman	1/15/1997	Ongoing	Rec	20 reef fish agg limit[1]	NA	Gulf EEZ	61 FR 65983	Reef Fish Amendment 12
Yellowmouth Grouper	2/21/1990	5/17/2009	Rec	5 grouper agg limit	NA	Gulf EEZ	55 FR 2078	Reef Fish Amendment 1
	3/3/2005	6/8/2005	Com	NA	10,000 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 8037	Emergency Rule
	6/9/2005	8/3/2005	Com	NA	7,500 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 33033	Temporary Rule
	8/4/2005	12/31/2005	Com	NA	5,500 lbs gw; SWG[4]	Gulf EEZ	70 FR 42279	Temporary Rule
	1/1/2006	12/31/2009	Com	NA	6,000 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 77057	Regulatory Amendment
	5/18/2009	Ongoing	Rec	4 grouper agg limit[2]	NA	Gulf EEZ	74 FR 17603	Reef Fish Amendment 30B
	1/1/2010	Ongoing	Com	NA	IFQ	Gulf EEZ	74 FR 44732	Reef Fish Amendment 29
Speckled Hind	2/21/1990	11/23/2009	Rec	5 grouper agg limit	NA	Gulf EEZ	55 FR 2078	Reef Fish Amendment 1
	11/24/1999	5/17/2009	Rec	5 grouper agg limit[2]	1	Gulf EEZ	64 FR 57403	Reef Fish Amendment 16B
	3/3/2005	6/8/2005	Com	NA	10,000 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 8037	Emergency Rule
	6/9/2005	12/31/2005	Com	NA	7,500 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 33033	Temporary Rule
	1/1/2006	12/31/2009	Com	NA	6,000 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 77057	Reef Fish Regulatory Amendment
	5/18/2009	Ongoing	Rec	4 grouper agg limit[2]	1	Gulf EEZ	74 FR 17603	Reef Fish Amendment 30B
	1/1/2010	Ongoing	Com	NA	IFQ	Gulf EEZ	74 FR 44732	Reef Fish Amendment 29

Snowy Grouper	2/21/1990	5/17/2009	Rec	5 grouper agg limit	NA	Gulf EEZ	55 FR 2078	Reef Fish Amendment 1
	3/3/2005	6/8/2005	Com	NA	10,000 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 8037	Emergency Rule
	6/9/2005	12/31/2005	Com	NA	7,500 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 33033	Temporary Rule
	1/1/2006	12/31/2009	Com	NA	6,000 lbs gw; DWG[3]/SWG[4]	Gulf EEZ	70 FR 77057	Regulatory Amendment
	5/18/2009	Ongoing	Rec	4 grouper agg limit[2]	NA	Gulf EEZ	74 FR 17603	Reef Fish Amendment 30B
	1/1/2010	Ongoing	Com	NA	IFQ	Gulf EEZ	74 FR 44732	Reef Fish Amendment 29
Almaco Jack	1/15/1997	Ongoing	Rec	20 reef fish agg limit[1]	NA	Gulf EEZ	61 FR 65983	Reef Fish Amendment 12
Lesser Amberjack	1/15/1997	11/23/1999	Rec	20 reef fish agg limit[1]	NA	Gulf EEZ	61 FR 65983	Reef Fish Amendment 12
	11/24/1999	Ongoing	Rec	5 agg limit + banded rudderfish	NA	Gulf EEZ	64 FR 57403	Reef Fish Amendment 16B

2.3 Size Limits

Species Affected	Effective Date	End Date	Sector	Size Limit	Length Type	Region Affected	FR Reference	Amendment Number or Rule Type
Red Drum					NONE			
Lane Snapper	2/21/1990	Ongoing	Both	8 inches	Total Length	Gulf EEZ	55 FR 2078	Reef Fish Amendment 1
Wenchman					NONE			
Yellowmouth Grouper					NONE			
Speckled Hind					NONE			
Snowy Grouper					NONE			
Almaco Jack					NONE			
Lesser Amberjack	11/24/1999	Ongoing	Both	14 - 22 inches	Fork Length	Gulf EEZ	64 FR 57403	Reef Fish Amendment 16B

2.4 Fishery Closures

Species Affected	Effective Date	End Date	Sector	Closure Type	First Day Closed	Last Day Closed	Region Affected	FR Reference	Amendment Number or Rule Type
Red Drum	6/20/1986	12/22/1986	Com	Quota	20-Jul	22-Dec	Gulf EEZ	51 FR 26554, 51 FR 27413	Closure
	10/16/1987	7/28/1988	Both	Ban	1-Jan	31-Dec	EEZ off FL/TX	52 FR 34918	Red Drum Amendment 1
	7/29/1988	Ongoing	Both	Ban	29-Jun	31-Dec	Gulf EEZ	53 FR 24662	Red Drum Amendment 2
Lane Snapper							NONE		
Wenchman							NONE		
Yellowmouth Grouper	11/15/2004	12/31/2004	Com	Quota	15-Nov	31-Dec	Gulf EEZ	69 FR 65092	Closure
	10/10/2005	12/31/2005	Com	Quota	10-Oct	31-Dec	Gulf EEZ	70 FR 57802	Closure
	4/18/2009	7/4/2013	Rec	Seasonal	1-Feb	31-Mar	Gulf EEZ	74 FR 17603	Reef Fish Amendment 30B
	7/5/2013	Ongoing	Rec	Seasonal	1-Feb	31-Mar	Gulf EEZ > 20 fathoms	78 FR 33259	Reef Fish Framework Action
Speckled Hind	7/15/2004	12/31/2004	Comm	Quota	15-Jul	31-Dec	Gulf EEZ	69 FR 41433	Closure
	6/23/2005	12/31/2005	Comm	Quota	23-Jun	31-Dec	Gulf EEZ	70 FR 34400	Closure
	6/27/2006	12/31/2006	Comm	Quota	27-Jun	31-Dec	Gulf EEZ	71 FR 35198	Closure
	6/2/2007	12/31/2007	Comm	Quota	2-Jun	31-Dec	Gulf EEZ	72 FR 29444	Closure
	4/10/2008	10/31/2008	Comm	Quota	10-Apr	31-Oct	Gulf EEZ	73 FR 24883, 73 FR 58058	Closure, Reopening
	6/27/2009	12/31/2009	Comm	Quota	27-Jun	31-Dec	Gulf EEZ	74 FR 29430	Closure
Snowy Grouper	7/15/2004	12/31/2004	Comm	Quota	15-Jul	31-Dec	Gulf EEZ	69 FR 41433	Closure
	6/23/2005	12/31/2005	Comm	Quota	23-Jun	31-Dec	Gulf EEZ	70 FR 34400	Closure
	6/27/2006	12/31/2006	Comm	Quota	27-Jun	31-Dec	Gulf EEZ	71 FR 35198	Closure
	6/2/2007	12/31/2007	Comm	Quota	2-Jun	31-Dec	Gulf EEZ	72 FR 29444	Closure
	4/10/2008	10/31/2008	Comm	Quota	10-Apr	31-Oct	Gulf EEZ	73 FR 24883, 73 FR 58058	Closure, Reopening
	6/27/2009	12/31/2009	Comm	Quota	27-Jun	31-Dec	Gulf EEZ	74 FR 29430	Closure
Almaco Jack							NONE		
Lesser Amberjack							NONE		

2.5 Spatial Closures

Area	Effective Date	End Date	First Day Closed	Last Day Closed	Restriction During Closure	FR Reference	Amendment Number or Rule Type
Madison-Swanson	4/19/2000	6/2/2004	1-Jan	31-Dec	Fishing prohibited except HMS[1]	65 FR 31827	Reef Fish Regulatory Amendment
	6/3/2004	Ongoing	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532, 74 FR 17603	Reef Fish Amendment 21, Reef Fish Amendment 30B
	6/3/2004	Ongoing	1-Nov	30-Apr	Fishing prohibited	70 FR 24532, 74 FR 17603	Reef Fish Amendment 21, Reef Fish Amendment 30B
Steamboat Lumps	4/19/2000	6/2/2004	1-Jan	31-Dec	Fishing prohibited except HMS[1]	65 FR 31827	Reef Fish Regulatory Amendment
	6/3/2004	Ongoing	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532, 74 FR 17603	Reef Fish Amendment 21, Reef Fish Amendment 30B
	6/3/2004	Ongoing	1-Nov	30-Apr	Fishing prohibited	70 FR 24532, 74 FR 17603	Reef Fish Amendment 21, Reef Fish Amendment 30B
The Edges	7/24/2009	Ongoing	1-Jan	30-Apr	Fishing prohibited	74 FR 30001	Reef Fish Amendment 30B Supplement
20 Fathom Break	7/5/2013	Ongoing	1-Feb	31-Mar	Fishing for SWG prohibited[2]	78 FR 33259	Reef Fish Framework Action
Flower Garden Banks	1/17/1992	Ongoing	1-Jan	31-Dec	Fishing with bottom gears prohibited[3]	56 FR 63634	Sanctuary Designation
Riley's Hump	2/7/1994	8/18/2002	1-May	30-Jun	Fishing prohibited	59 FR 966	Reef Fish Amendment 5
Tortugas Reserves	8/19/2002	Ongoing	1-Jan	31-Dec	Fishing prohibited	67 FR 47467	Tortugas Amendment
Pulley Ridge	1/23/2006	Ongoing	1-Jan	31-Dec	Fishing with bottom gears prohibited[3]	70 FR 76216	EFH Amendment 3

2.6 Gear Restrictions

Gear Type	Effective Date	End Date	Gear/Harvesting Restrictions	Region Affected	Reference
Poison and Drugs		Ongoing	Prohibited for all fish	Gulf EEZ	
Explosives and Powerheads	11/1/1984	Ongoing	Prohibited for reef fish in inshore stressed areas	Gulf EEZ	Original Reef Fish FMP
Pots and Traps	11/1/1984	1/1/1990	Prohibited for reef fish in inshore stressed areas	Gulf EEZ	Original Reef Fish FMP
	1/1/1990	2/1/1994	Established fish trap permit	Gulf EEZ	Reef Fish Amendment 1
	2/1/1994	3/1/1997	Created endorsement for historical captains, prohibited other use	Gulf EEZ	Reef Fish Amendment 5
	3/1/1997	1/1/1998	Phase out of fish traps begins	Gulf EEZ	Reef Fish Amendment 14
	1/1/1998		Prohibited use of non-permitted fish traps	Gulf EEZ	Reef Fish Amendment 15
Slurp gun and Dip Nets		Ongoing	Allow only slurp gun and hand-held dip nets for aquarium trade	Gulf EEZ	
Gillnets		Ongoing	Prohibit gill and trammel net for reef species	Gulf EEZ	
All		Ongoing	Prohibited fileting fish at sea	Gulf EEZ	
Spear		Ongoing	Prohibited for Red Drum	Gulf EEZ	See individual States' rules
Longline	1/1/1990	Ongoing	Gear boundary at approximately the 50 fathom depth contour west of Cape San Blas, Florida and the 20 fathom depth contour east of Cape San Blas, shoreward of which directed harvest of reef fish is prohibited	Gulf EEZ	Reef Fish Amendment 1
Vertical Line		Ongoing	Allowed for all fish	Gulf EEZ	

3 ASSESSMENT HISTORY AND REVIEW

3.1 Red Drum

Since the enactment of Amendment 1 (GMFMC 1987) to the Fishery Management Plan (FMP) for Red Drum (USDOC 1986), multiple federal stock assessments and updates have been conducted on Red Drum in the Gulf of Mexico. Although individual states along the Gulf coast also conduct stock assessments, derived estimates of abundance and fishing mortality therein pertain to local populations and are not directly comparable to the results from Gulf-wide assessments. Below we provide a brief summary of assessments and stock status for Gulf of Mexico Red Drum:

Goodyear (1987):

- Assessed commercial landings trends from 1890-1986;
- Estimated recreational harvest from 1979-1986;
- Summarized average weight of recreationally-caught fish from 1979-1986;
- Performed catch curve analysis on recreational survey data (1986), Texas Parks and Wildlife Department (TPWD) creel survey data (1983-1986), TPWD gillnet survey data (1984-1986), and purse seine samples collected from the offshore fishery by the Coastal Fisheries Institute at Louisiana State University;
- Assessed Spawning Stock Biomass Per Recruit under assumption that the Spawning Stock Ratio (SSR) should be maintained at or above 20%;
- Provided estimates of escapement, which is the minimum escapement level of juveniles to the 'offshore' spawning stock of 20% of the number that would have escaped had there been no inshore fishery; and
- Conducted yield per recruit analysis for F=0.01 to F=1.5 and for minimum size at recruitment to the fishery from 0 to 40 inches total length.

SSR results suggest that any significant increase in F on adults would endanger recruitment inshore. The current level of exploitation greatly exceeds the level permissible with the 20% SSR goal. Additional measures were suggested to either increase escapement above 20% or eliminate fishing on Red Drum which have "escaped" the inshore fishery.

Goodyear (1988b):

- Updated commercial and recreational landings estimates for 1987; and
- Updated average weights of recreationally-caught fish for 1987.

View of the condition of the stock and its sensitivity to fishing mortality unchanged from the conclusions developed in Goodyear (1987).

(Goodyear 1989b):

- Updated commercial and recreational landings estimates for 1988;

- Discussed direct estimates of stock size available from aerial surveys, back calculations of spawning stock size from surveys of egg and larval densities, and estimates from a mark-recapture study (Nichols 1988);
- Performed catch curve analysis on purse seine samples collected in 1987 and 1988; and
- Employed LSIM (length-based fish population simulation model; Goodyear 1989a) to evaluate various aspects of the structure and dynamics of fish populations, including equilibrium analysis of the SSR for F=1.5, estimation of recruitment to the inshore population, and derivation of escapement rates.

Commercial harvest declined after 1986 following the closure of federal waters of the U.S. EEZ to harvesting Red Drum. Simulation analyses revealed declines in recruitment. A decline in SSB was also suggested if mean recruitment to the juvenile population does not change and if fishing rates on juveniles return to levels typical of the early 1980s. Further, if the estimated 1986 fishing mortality rates were maintained and no harvest of adults occurred, SSB/R was estimated at 13%.

Goodyear (1990):

- Updated commercial and recreational landings estimates for 1989; and
- Updated average weights for recreationally-caught fish for 1989.

Reduced landings provided evidence that the conservation actions were reducing fishing mortality on the stock; however, additional analysis was recommended to determine the extent to which management measures increased escapement of juveniles into the adult stock.

Goodyear (1991):

- Updated commercial and recreational landings estimates for 1990; and
- Updated average weights for recreationally-caught fish for 1990.

Reduced landings provided evidence that the conservation actions were reducing fishing mortality on the stock; however, additional analysis was recommended to determine the extent to which management measures increased escapement of juveniles into the adult stock.

Goodyear (1993):

- Updated commercial and recreational landings estimates for 1991;
- Updated average weights for recreationally-caught fish for 1991;
- Performed catch curve analysis on purse seine samples collected off Louisiana between 1985 – 1988, 1986-1991;
- Analyzed mark-recapture data provided by TPWD, Louisiana Department of Wildlife and Fisheries (LDWF), Gulf Coast Conservation Association of Louisiana, Mississippi's Gulf Coast Research Laboratory, Alabama Marine Resources Division, Florida Department of Natural Resources, and Florida Conservation Association;
- Calculated catch per unit effort from TPWD bag seine and gillnet surveys, LDWF bag seine, trammel-net, and gill-net surveys, and the Gulf Coast Research Laboratory gill-net survey; and

- Conducted Virtual Population Analysis (VPA) using TPWD and LDWF gill net data.

Reduced landings provided evidence that the conservation actions were reducing fishing mortality on the stock. Additional analyses presented as appendices revealed increased survival of juvenile Red Drum in inshore waters and reduced fishing mortality from Texas to Florida via mark-recapture programs. Abundance of newly recruited adults increased in samples of the offshore stock. VPA results were consistent with previous findings of high fishing mortality on juveniles prior to 1987, with escapement rates estimated at 10% in the early 1980s, about 1% in 1986 and 1987, and above 40% by 1991. A mismatch between estimated stock size and mark-recapture estimates of the magnitude of the spawning stock was identified but required further investigation.

Goodyear (1996):

- Updated commercial and recreational landings estimates for 1995;
- Estimated incidental catch to the Gulf of Mexico shrimp fishery through 1995;
- Updated average weights of recreationally-caught fish to include 1995;
- Described direct estimates of stock size available from aerial surveys, back calculations of spawning stock size from surveys of egg and larval densities, and estimates from a mark-recapture studies
- Performed catch curve analysis on purse seine samples collected off Louisiana between 1985-1988 and 1986-1992;
- Analyzed mark-recapture data provided by TPWD, LDWF, Gulf Coast Conservation Association of Louisiana, Mississippi's Gulf Coast Research Laboratory, NMFS Cooperative Gamefish Tagging Program, and Florida Department of Environmental Protection;
- Calculated catch per unit effort from Florida Department of Environmental Protection bag seine and gillnet surveys, TPWD bag-seine and gill-net, LDWF bag seine, trammel-net, and gill-net surveys, and the Gulf Coast Research Laboratory gill-net survey;
- Conducted Sequential Population Analysis (SPA) using the ADAPT procedure. Data requirements included age composition of the catch by year, an estimate of natural mortality in the stock, an index of abundance, and the age specific selectivities to fishing mortality in the final year of the analysis; and
- Evaluated and projected spawning potential ratio using LSIM (Goodyear 1989a) with the fishing mortality rates estimated with ADAPT.

Estimates of the escapement rates were more pessimistic than expected based on Goodyear (1993) and SPR did not increase at the rate anticipated. However, an increase in recruitment was identified starting in 1992. The Red Drum stock was recognized as overfished.

(Porch 1999a, b), Version 1.0:

- Updated commercial and recreational landings estimates for 1997;
- Estimated incidental catch to the Gulf of Mexico shrimp fishery through 1998;

- Reviewed studies characterizing the age structure of schooling red drum including the Coastal Fisheries Institute at Louisiana State University, Alabama Sea Grant Extension Service, and Florida Marine Research Institute;
- Described direct estimates of stock size available from aerial surveys, back calculations of spawning stock size from surveys of egg and larval densities, and estimates from a mark-recapture study;
- Calculated catch per unit effort from TPWD bag seine and gill net surveys, LDWF bag seine, trammel net, and gill net surveys, and Florida Department of Environmental Protection bag seine and otter trawl surveys; and
- Conducted Sequential Population Analysis (SPA) using the age-structured population model CATCHEM (Porch and Turner 1997). Data requirements include total removals, age and length composition, and indices of abundance. Length data were aggregated annually and semiannually. CATCHEM is a more statistically rigorous platform compared to ADAPT, treats the recruitment indices as data, and explicitly considers the quality of the fits to the length composition data.

The base-case CATCHEM model where length data were aggregated annually suggested that adult Red Drum had declined greatly since the 1970s, were severely overfished with respect to the 30% SPR criterion, and would continue to decline at the 1997 rate of fishing. Different conclusions regarding stock status were noted between CATCHEM results and Goodyear (1996), however differing modeling platforms and treatment of data prevented comparison of results. It was concluded that unless the fishing mortality rate on juveniles (primarily age 2) was reduced considerably, the Red Drum stock would continue to be overfished.

Porch (2000a), Version 2.0:

- Same as model discussed in (Porch 1999a, b) with the exception of the treatment of length composition. Length data were aggregated quarterly and by state (Texas, Florida, and Louisiana-Mississippi-Alabama).

The base-case CATCHEM quarterly model provided a better fit to the length composition data than did the annual model (Porch 1999b). While the corresponding projections were more optimistic than those of Goodyear (1996), the condition of the stock remained unchanged from the conclusions developed in (Porch 1999a, b).

(Porch 2000b), Version 2.1:

- Same as model discussed in Porch (2000a) with the following modifications:
    1. Assumed that the recreational discards were spread over ages 0 to 4 in proportion to their abundance in the population;
    2. Down-weighted the bycatch of Red Drum in the Gulf of Mexico shrimp fishery;
    3. Included a retrospective analysis;
    4. De-emphasized the offshore age-composition data;
    5. Held selectivity on ages 4 and older constant in the recreational fisheries; and
    6. Implemented area-specific growth curves to account for slower growth off Texas.

The base-case CATCHEM quarterly model provided a much better fit to the length composition data than did the annual model (Porch 1999b). While the corresponding projections were more optimistic than those of (Goodyear 1996), the condition of the stock remained unchanged from the conclusions developed in (Porch 1999a, b, 2000a).

3.2 Lane Snapper

No formal stock assessments have been conducted for Lane Snapper in the Gulf of Mexico. Fisheries statistics were summarized by Goodyear (1988a) and GMFMC (1989) and included:

- Commercial harvest estimates from 1972-1986;
- Recreational harvest estimates from 1979-1986;
- Observed average weights and sampling frequencies from recreational fisheries from 1979-1986; and
- Number and weight caught in the Gulf of Mexico headboat fishery in 1986.

3.3 Wenchman

No formal stock assessments have been conducted for Wenchman in the Gulf of Mexico. Fisheries statistics were summarized by Goodyear (1988a) and included:

- Recreational harvest estimates between 1979-1986; and
- Observed average weights and sampling frequencies from recreational fisheries from 1979-1986.

3.4 Yellowmouth Grouper

No formal stock assessments have been conducted for Yellowmouth Grouper in the Gulf of Mexico. Fisheries statistics were summarized by Goodyear (1988a) and included:

- Commercial harvest estimates of “groupers and scamp” from 1972-1986;
- Recreational harvest estimates from 1979-1986;
- Number and weight caught in the Gulf of Mexico headboat fishery in 1986;
- Observed average weights and sampling frequencies from recreational fisheries from 1979-1986; and
- Length-frequency sampled from fish traps by TIP from 1984-1986.

3.5 Snowy Grouper

No formal stock assessments have been conducted on Snowy Grouper in the Gulf of Mexico. Fisheries statistics were summarized by Goodyear (1988a) and included:

- Commercial harvest estimates of “groupers and scamp” from 1972-1986;
- Recreational harvest estimates from 1979-1986;
- Number and weight caught in the Gulf of Mexico headboat fishery in 1986;
- Observed average weights and sampling frequencies from recreational fisheries from 1979-1986; and
- Length-frequency sampled from fish traps by TIP from 1984-1986.

3.6 Speckled Hind

No formal stock assessments have been conducted on Speckled Hind in the Gulf of Mexico. Fisheries statistics were summarized by Goodyear (1988a) and included:

- Commercial harvest estimates of "groupers and scamp" from 1972-1986;
- Number and weight caught in the Gulf of Mexico headboat fishery in 1986; and
- Length-frequency sampled from fish traps by TIP from 1984-1986.

3.7 Lesser Amberjack

Berry and Burch (1979) provided the first comprehensive estimates of amberjack landings which included Lesser Amberjack in the U.S. from 1950 through 1977. Fisheries statistics were summarized by Goodyear (1988a) and included:

- Commercial harvest estimates of all *Seriola* species from 1972-1986;
- Recreational harvest estimates from 1979-1986;
- Number and weight caught in the Gulf of Mexico headboat fishery in 1986; and
- Observed average weights and sampling frequencies from recreational fisheries from 1979-1986.

In 1993, fisheries statistics were summarized for Lesser Amberjack in the Gulf of Mexico by Cummings-Parrack (1993). Reported statistics included:

- Commercial harvest estimates of all *Seriola* species from 1962-1991 and species-specific landings of Lesser Amberjack in 1991 following the implementation of mandatory logbook reporting program in 1990;
- Recreational harvest estimates from 1979-1990;
- Observed average lengths and sampling frequencies from commercial fisheries from 1990-1991;
- Observed average lengths, weights, and sampling frequencies from recreational fisheries from 1979-1991; and
- Catch per unit effort estimated from recreational fishing trips for the Marine Recreational Fisheries Statistics Survey (MRFSS) (1979, 1980-1991), NMFS Headboat (1986-1990), and TPWD (1983-1986 and 1988-1991); and
- Updated bag limit analyses.

Due to the sporadic catches and small sample sizes for Lesser Amberjack, the statistics presented were deemed unreliable. In 1996, an update to Cummings-Parrack (1993) was completed using data through 1995 (Cummings and McClellan 1996) and included:

- Species-specific commercial landings of Lesser Amberjack between 1992 and 1996 following the implementation of mandatory logbook reporting program in 1990;
- Recreational catch estimates from 1982-1995;
- Observed average lengths, weights, and sampling frequencies from commercial fisheries from 1990-1995;
- Observed average lengths, weights, and sampling frequencies from recreational fisheries from 1982-1995; and

- Catch per unit effort estimated from commercial logbooks from 1992-1996; and
- Catch per unit effort estimated from recreational fishing trips for MRFSS (1982-1990, 1993), NMFS Headboat (1986, 1988-1995), and TPWD (1983-1986, 1988-1991).

3.8 Almaco Jack

Berry and Burch (1979) provided the first comprehensive estimates of amberjack landings which included Almaco Jack in the U.S. from 1950 through 1977. Fisheries statistics were summarized by Goodyear (1988a) and included:

- Commercial harvest estimates of all *Seriola* species from 1972-1986;
- Recreational harvest estimates from 1979-1986;
- Number and weight caught in the Gulf of Mexico headboat fishery in 1986; and
- Observed average weights and sampling frequencies from recreational fisheries from 1979-1986.

In 1993, fisheries statistics were summarized for Almaco Jack in the Gulf of Mexico by Cummings-Parrack (1993) and included:

- Commercial harvest estimates of all *Seriola* species from 1962-1991 and species-specific landings of Almaco Jack from 1990 - 1992 following the implementation of mandatory logbook reporting program in 1990;
- Recreational harvest estimates from 1980-1991;
- Observed average lengths, weights, and sampling frequencies from commercial fisheries from 1983-1991;
- Observed average lengths, weights, and sampling frequencies from recreational fisheries from 1980-1991;
- Catch per unit effort estimated from recreational fishing trips for MRFSS (1980-1982, 1984-1991) NMFS Headboat (1986-1991), and TPWD (1983-1986,1988-1991); and
- Updated recreational bag limit analyses.

Due to the sporadic catches and small sample sizes for Almaco Jack, the statistics presented were deemed unreliable. In 1996, an update to Cummings-Parrack (1993) was completed using data through 1995 (Cummings and McClellan 1996) and included:

- Species-specific commercial landings of Almaco Jack between 1991 and 1996 following the implementation of mandatory logbook reporting program in 1990;
- Recreational harvest estimates from 1981-1996;
- Observed average lengths, weights, and sampling frequencies from commercial fisheries from 1983-1995;
- Observed average lengths, weights, and sampling frequencies from recreational fisheries from 1981-1995; and
- Catch per unit effort estimated from commercial logbooks from 1991-1996;
- Catch per unit effort estimated from recreational fishing trips for MRFSS (1981,1984-1995), NMFS Headboat (1986-1995), and TPWD (1983-1986, 1988-1995); and
- Updated recreational bag limit analyses.

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4 REGIONAL MAPS

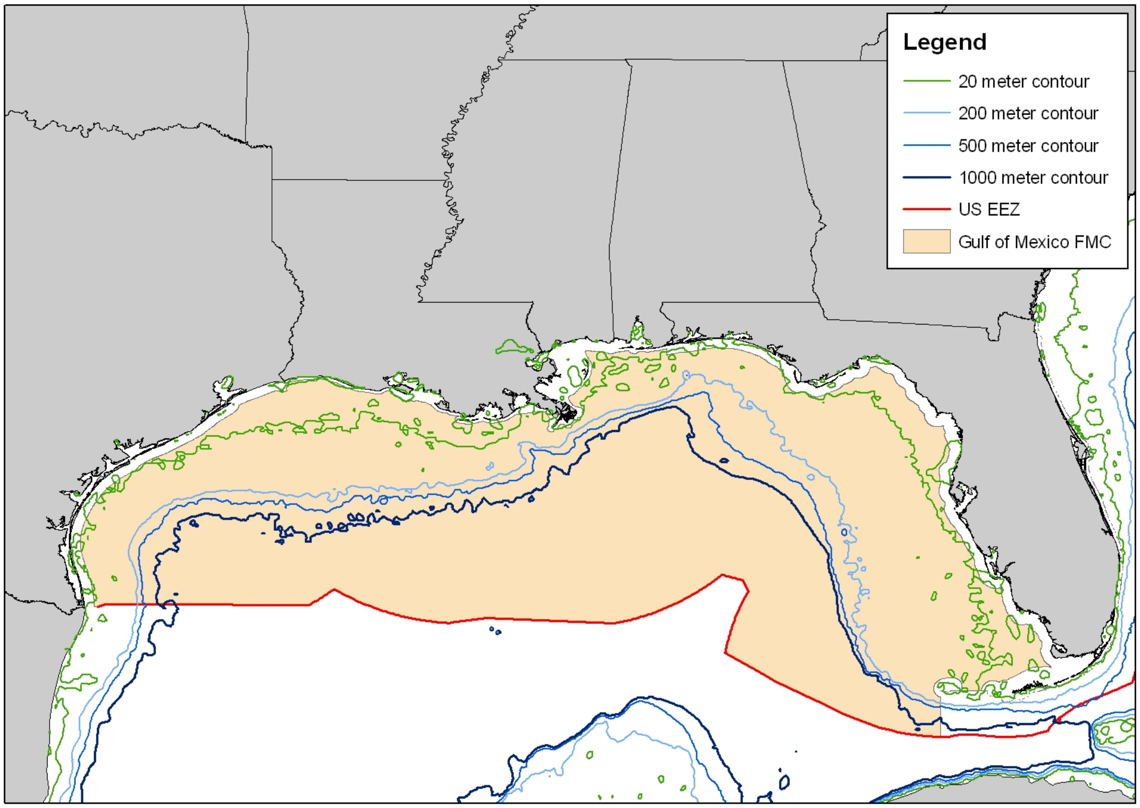

Figure 4.1 Southeast Region including Council and EEZ Boundaries.

5 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
AMRD	Alabama Marine Resources Division
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAM	Beaufort Assessment Model

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 that will result 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
F0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fish 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
HMS	Highly Migratory Species
LDWF	Louisiana Department of Wildlife and Fisheries
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey
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
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment and Review
SEFIS	Southeast Fishery-Independent Survey
SEFSC	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries 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
SS	Stock Synthesis
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
TPWD	Texas Parks and Wildlife Department
Z	total mortality, the sum of M and F

–

SEDAR

Southeast Data, Assessment, and Review

SEDAR 49

Gulf of Mexico Data-limited Species:

Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, Lesser Amberjack

SECTION II: Data Workshop Report

June 2016

This information is distributed solely for the purpose of peer review. It does not represent and should not be construed to represent any agency determination or policy.

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1 INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 49 GULF OF MEXICO data-limited species data workshop was held May 2-6, 2016 in New Orleans, Louisiana. In addition to the workshop, an additional webinar was held to finalize the data recommendations.

1.2 TERMS OF REFERNCE

1. Review stock structure and unit stock definitions.
2. Review, discuss, and tabulate available life history information.
    - Provide estimates of central tendency and variability (CV) of the following, as available. Use proxies if warranted.
        - Natural Mortality
        - Length at 50% and 95% maturity
        - Von Bertalanffy parameters (t0, k, Linf)
        - Von Bertalanffy K parameter
        - Von Bertalanffy Linf parameter
        - Length-weight relationship
        - Maximum age
        - Steepness
    - Evaluate the adequacy of available life history information for conducting stock assessments and recommend life history information for use in population modeling.
    - Evaluate and discuss the sources of uncertainty and error.
3. Consider measures of population abundance that are appropriate for stock assessment.

- Review and develop (as needed) all available nominal abundance indices from relevant fishery-dependent and -independent data sources.
- Discuss the degree to which available indices adequately represent fishery and population conditions.
- Select a single abundance index that reliably represents population abundance for use in assessment modeling. Choose sensitivity indices if needed (i.e. if no single index can reliably represent population abundance due to changes in fishing practices, survey methods etc.).

4. Provide estimates of harvest (in weight) from the following data sources:
    - Commercial landings, by gear (e,g. vertical line, longline, trap, etc.)
    - Recreational landings, by fishing mode (e.g. for-hire, private anglers, etc.)
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest by species.
    - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source.
5. Provide estimates of discards (in weight) from the following data sources:
    - Commercial discards, by gear (e,g. vertical line, longline, trap, etc.)
    - Recreational discards, by fishing mode (e.g. for-hire, private anglers, etc.)
    - Other bycatch as appropriate
    - Review and/or develop release mortality estimates by fleet and gear. As needed, apply release mortality to obtain estimate of dead discards (in pounds).
    - Evaluate and discuss the adequacy of available data for accurately characterizing discards by species.
    - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source.
6. Provide length and/or age distributions for both landings and discards if feasible.
    - Evaluate and discuss the adequacy of available data for accurately characterizing length/age composition, by species.
7. In cooperation with stakeholders and fisheries experts, develop estimates of the central tendency and variability (CV) of the following, as feasible:

- Length at first capture and full selection
- Current stock depletion
- Depletion over time (e.g. as derived from trends in effort).
- Evaluate and discuss the adequacy of available data for accurately characterizing these estimates.
- Evaluate and discuss the sources of uncertainty and error.

8. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section II of the SEDAR assessment report)

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Additional Attendess via Webinars
Harry Blanchet .... LDWF
Ken Brennan .... NMFs Beaufort
Ching-Ping Chih .... NMFS Miami
Nancie Cummings .... NMFS Miami

Bob Gill ....SSC
Chad Hanson ....Pew Charitable Trust
Rich Hart ....NMFS Galveston
Michael Larkin ....NMFS SERO
Sue Lowerre-Barbieri ....FWRI
Refik Orhun .... NMFS Miami
Liz Scott-Denton ....NMFS Galveston
Yuying Zhang .... FIU

1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERNCE DOCUMENTS

Document #	Title	Authors	Date Submitted
Documents Prepared for the Data Workshop			
SEDAR49-DW-01	Shrimp Fishery Bycatch Estimates for Gulf of Mexico Data Limited Species: Wenchman and Lane Snapper, 1972-2014	Jeff Isely	6 April 2016 Updated: 20 June 2016
SEDAR49-DW-02	Catch per unit effort indices and Effort Time-series for SEDAR 49 Data Limited Species captured in the Gulf of Mexico Recreational Headboat Fishery (1986 – 2015)	Matthew S. Smith and Adyan Rios	28 April 2016
SEDAR49-DW-03	Timeseries of effort and nominal abundance indies derived from the Gulf of Mexico recreational private and charter fishery for the species included in the SEDAR 49 data limited stock assessment	Matt Smith	Not Received
SEDAR49-DW-04	Review of bycatch in the Gulf menhaden fishery with implications for the stock assessment of red drum	Skyler R. Sagarese, Matthew A. Nuttall, Joseph E. Serafy and Elizabeth Scott-Denton	27 April 2016
SEDAR49-DW-05	Gulf of Mexico Data-Limited Species Life History Compilation	Molly S. Adams, Skyler R. Sagarese, and Adyan B. Rios	18 April 2016
SEDAR49-DW-06	Lane snapper *Lutjanus synagris* Findings from the NMFS Panama City Laboratory Trap & Camera	D.A. DeVries, C.L. Gardner, P. Raley,	22 April 2016

	Fishery-Independent Survey 2004-2014		
SEDAR49-DW-07	The Red Drum (*Sciaenops ocellatus*) spawning population in the eastern Gulf of Mexico: composition, site fidelity, and size	Susan Lowerre-Barbieri, Mike Tringali, Joel Bickford, Sarah Burnsed, and Mike Murphy	20 April 2016
SEDAR49-DW-08	Summary of length data and length frequency distributions for eight data limited species collected in the Gulf of Mexico from 1981 to 2015	Ching-Ping Chih	27 April 2016
SEDAR49-DW-09	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Almaco Jack	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John Moser, Ryan Caillouet	29 April 2016
SEDAR49-DW-10	SEAMAP Reef Fish Video Survey:Relative Indices of Abundance of Lane Snapper	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John Moser, Ryan Caillouet	29 April 2016
SEDAR49-DW-11	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Lesser Amberjack	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John Moser, Ryan Caillouet	29 April 2016
SEDAR49-DW-12	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Snowy grouper	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John	29 April 2016

		Moser, Ryan Caillouet	
SEDAR49-DW-13	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Speckled Hind	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John Moser, Ryan Caillouet	29 April 2016
SEDAR49-DW-14	Size Composition of Eight SEDAR49 Data Limited Species by Sector and Gear	J.J. Isely, M.W. Smith and C-P Chih	3 May 2016
SEDAR49-DW-15	Almaco jack *Seriola rivoliana* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey 2004-2014	D.A. DeVries, C.L. Gardner, P. Raley, and K. Overly	29 April 2016
SEDAR49-DW-16	Current Status of Adult Red Drum (*Sciaenops ocellatus*) in the North Central Gulf of Mexico: An Update of Abundance, Age Composition, and Mortality Estimates	Crystal L. Hightower, J. Marcus Drymon, and Sean P. Powers	2 May 2016 Updated: 8 May 2016
SEDAR49-DW-17	Lane Snapper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Adam G. Pollack, David S. Hanisko and G. Walter Ingram, Jr.	2 May 2016 Updated: 11 May 2016
SEDAR49-DW-18	Wenchman Abundance Indices from MSLABS Small Pelagics Surveys in the Northern Gulf of Mexico	Adam G. Pollack, David S. Hanisko and G. Walter Ingram, Jr.	2 May 2016 Updated: 11 May 2016
SEDAR49-DW-19	Wenchman Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Adam G. Pollack, David S. Hanisko and G. Walter Ingram, Jr.	2 May 2016 Updated: 11 May 2016
SEDAR49-DW-20	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Wenchman	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John	4 May 2016

		Moser, Ryan Caillouet	
SEDAR49-DW-21	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Yellowmouth grouper	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John Moser, Ryan Caillouet	4 May 2016
SEDAR49-DW-22	Summary of length and weight data for seven data limited species collected during NMFS and SEAMAP fishery-independent surveys in the Gulf of Mexico	David S. Hanisko and Adam Pollack	20 May 2016
Reference Documents			
SEDAR49-RD01	Spatial and size distribution of red drum caught and released in Tampa Bay, Florida, and factors associated with the post-release hooking mortality	Kerry E. Flaherty, Brent L. Winner, Julie L. Vecchio, and Theodore S. Switzer	
SEDAR49-RD02	Evaluating the current status of red drum (*Sciaenops ocellatus*) in offshore waters of the North Central Gulf of Mexico: age and growth, abundance, and mercury concentration	Crystal LouAllen Hightower	

2 LIFE HISTORY

2.1 OVERVIEW

2.1.1 Life History Workgroup (LHW) members

Linda Lombardi (lead)	NMFS/SEFSC, Panama City, FL
Jim Tolan	TPWD, Corpus Christi, TX
Jason Adriance	LADWF, New Orleans, LA
Marcus Drymon	USA/DISL, Dauphin Island, AL
Jennifer Herbig	MDMR, Ocean Springs, MS
Robert Leaf	USM/GCRL, Ocean Springs, MS
Savannah Michaelsen	VIMS, Gloucester Point, VA
Emily Satterfield	MDMR, Ocean Springs, MS

Unofficial members:

Molly Adams	UM/RSMAS, Miami, FL
Bill Harford	UM/RSMAS, Miami, FL
Crystal Hightower	USA/DISL, Dauphin Island, AL

2.1.2 LHW Topics addressed

Peer-reviewed published literature, published and unpublished reports, and raw data were evaluated to understand the life history characteristics of a taxonomically diverse group of commercially and recreationally harvested fish stocks. The LHWG is responsible (as described in Terms of Reference) to:

- Review, discuss, and tabulate available life history information
- Provide estimates of central tendency and variability (CV) of the following, as available (use proxies if warranted):
  - Natural Mortality (based on updated Hoenig in Then et al. 2015)
  - Maximum age
  - Length-weight relationship
  - von Bertalanffy parameters (L_∞, k, t_0)
  - Length and Age at 50% and 95% maturity
  - Steepness

The stocks evaluated include Red Drum (*Sciaenops ocellatus*), Lane Snapper (*Lutjanus synagris*), Wenchman (*Pristipomoides aquilonaris*), Yellowmouth Grouper (*Mycteroperca interstitialis*), Snowy Grouper (*Hyporthodus niveatus*), Speckled Hind (*Epinephelus drummondhayi*), Lesser Amberjack (*Seriola fasciata*), and Almaco Jack (*Seriola rivoliana)*.

2.2 REVIEW OF WORKING PAPERS

A variety of peer-reviewed published literature, published and unpublished reports were evaluated in a semi-quantitative method. A scoring reliability rubric was created to judge the overall quality of work for informing one or more life history characteristics of interest (see table per species). Each LHWG member was assigned a specific species or group (snappers, groupers, amberjacks, Red Drum) prior to the Data Workshop, so as to provide ample time to review the literature and strengthen expertise for each assigned species or group. Life history characteristics were discussed for each species (by two to four LHWG members) and were reported as consensus scores that reflected the LHWG's confidence in aspects of sampling (number of samples, temporal duration and frequency, spatial allocation, and method, etc.), the quality of data collection and analysis, and the overall reliability of the paper to inform the mean and variance in the various demographic characteristics of interest. Scores of 0.0, 0.5, and 1.0

reflected the degree of confidence (i.e., low, medium, and high) for each compiled parameter, and the summed score for each work was used to rank the "quality" of each study in describing life history characteristics. In addition, sampling score was multiplied by age-length, length-weight, maturity, mortality, and steepness to obtain scores within each of the main criteria items.

SEDAR49-DW-05 (Adams et al. 2016): This report describes the Life History Database under development at the Southeast Fisheries Science Center and summarizes the pre-Data Workshop meta-analysis conducted for the eight data-limited species. A variety of literature search engines (e.g., ProQuest, Google Scholar) were utilized to organize literature for these eight species, as well as, closely related species of groupers, snappers, and amberjacks.

SEDAR49-DW-07 (Lowerre-Barbieri et al. 2016): This report provides a description of Red Drum caught using purse seines along Florida's west coast. The study used aerial surveys to locate schools of Red Drum. Red Drum were sampled for genetics and ovarian biopsies were taken to collect data on oocyte development. Selected Red Drum were also implanted with acoustic tags to collect data on site fidelity and to inform tag-recapture models.

SEDAR49-DW-08 (Chih 2016): This report summarizes the length frequency data available from multiple state and federal fishery-dependent data sources for the eight species.

SEDAR49-DW-16 (Hightower et al. 2016): This report provides a summary of Red Drum caught during fishery-independent and fishery-dependent sampling along Alabama's coastline. Data from this report were available to the LHWG and were used to model growth and estimate meristic regressions.

2.3 STOCK STRUCTURE

2.3.1 Red Drum (Sciaenops ocellatus)

Red Drum in the Gulf of Mexico (GOM) were considered a single unit stock after review of the stock structure literature. The SEDAR 44 assessment of Red Drum focused solely on the Atlantic stock (SEDAR 2015a). Nuclear gene and mitochondrial DNA data obtained to date indicate that Red Drum are genetically subdivided between the GOM and Atlantic (Gold and Richardson 1994; Gold et al. 1993; Gold et al. 1999). It is suggested that a biological or geographical barrier separates, or perhaps historically separated Red Drum in the GOM from those in the Atlantic (Gold and Richardson 1991). Analysis of otolith chemistry has also provided evidence of a distinction between the GOM and Atlantic based on differences in water chemistry (Patterson et al. 2004). A recent examination of 20 microsatellite markers and a fragment of mitochondrial DNA from both inshore (juvenile, sub-adult) and offshore (adult) Red Drum from the GOM found no population structure along the inshore and offshore northern GOM (Michaelsen 2015).

This analysis also revealed high levels of connectivity among populations (Michaelsen 2015). Conversely, hierarchical analysis of molecular variance has suggested that additional subdivision of the GOM stock between peninsular Florida and the northern and western GOM may be warranted (Seyoum et al. 2000). A modified stepping-stone model of gene flow was developed for Red Drum and revealed consistency with an isolation-by-distance pattern, where the highest probability of gene exchange was between adjacent bays and estuaries (Gold et al. 2001). Although some genetics studies of Red Drum may indicate significant genetic divergence across the northern GOM, the genetic differences do not delimit specific populations or stocks with fixed geographic boundaries (Gold and Turner 2002). Preliminary results from an ongoing study by Dr. David Portnoy, which sampled juvenile Red Drum between 2008 and 2015 from 7 localities throughout the northern GOM, do not support a single genetic unit (Portney, pers. comm.).

2.3.2 Lane Snapper (Lutjanus synagris)

A single unit stock was assumed for Lane Snapper in the GOM in the absence of additional support for two separate stocks. There is evidence of two genetically distinct stocks in the northern GOM based on microsatellites: a western stock which includes individuals from the northwestern and northcentral GOM and an eastern stock that includes individuals from the west coast of FL, the Florida Keys, and the Atlantic coast of FL (Karlsson et al. 2009). However, the authors observed no significant difference in stock structure for two closely related lutjanids, Gulf Red Snapper (*L. campechanus*) (Pruett et al. 2005; Saillant and Gold 2006) and Gray Snapper (*L. griseus*) (Gold et al. 2009). Lane Snapper are capable of hybridizing with Yellowtail Snapper (*Ocyurus chrysurus*), with the hybridized offspring previously considered a valid species (*L. ambiguus*) (Domeier and Clarke 1992).

2.3.3 Wenchman (Pristipomoides aquilonaris)

Currently, no information exists regarding the stock structure of Wenchman in the GOM. Due to a lack of appropriate data and analysis for Wenchman or a similar species, we assumed a single unit stock in the GOM.

2.3.4 Yellowmouth Grouper (Mycteroperca interstitialis)

Currently, no information exists regarding the stock structure of Yellowmouth Grouper in the GOM.

For the closely related Gag Grouper (*Mycteroperca microlepis*), this species has been managed as separate south Atlantic and GOM stock units due to a lack of conclusive understanding regarding the degree of exchange between the GOM and Atlantic (SEDAR 2014a). Similarly, a single unit stock is assumed within the GOM (SEDAR 2014a). A variety of methods including genetics, otolith constituent analysis, larval transport and connectivity, and tagging studies have provided conflicting trends which are detailed in SEDAR (2014a). Due to a lack of appropriate data and analysis for Yellowmouth Grouper, we assumed a single unit stock in the GOM based on the stock structure assumed for Gag Grouper.

2.3.5 Snowy Grouper (Hyporthodus niveatus)

Currently, no information exists regarding the stock structure of Snowy Grouper in the GOM.

For the closely related Yellowedge Grouper (*Hyporthodus flavolimbatus*), a single unit stock was assumed in the GOM due to a lack of information on stock structure (SEDAR 2011a). The South Atlantic stock assessment of Snowy Grouper assumed a single unit stock but recognized a paucity of information concerning movements, migrations and stock structure (SEDAR 2013). Although larval diffusion was suggested between the South Atlantic and the GOM, the assumption of a single unit stock in the South Atlantic was considered reasonable and was based on the broad dispersal of their planktonic larvae and the likelihood of restricted movement of adults in or out of the region (SEDAR 2004). Due to a lack of appropriate data and analysis for Snowy Grouper, we assumed a single unit stock in the GOM based on the stock structure assumed for Yellowedge Grouper.

2.3.6 Speckled Hind (Epinephelus drummondhayi)

Currently, no information exists regarding the stock structure of Speckled Hind in the GOM.

For the closely related Red Grouper (*Epinephelus morio*), a single unit stock was assumed for the GOM in the most recent stock assessment due to a lack of new information regarding mixing of the Atlantic and GOM stock units (SEDAR 2015b). Genetic studies have not revealed any separate stock structure or reproductive isolation among the southeastern U.S. Atlantic, northeastern GOM, and southwestern GOM collections of Red Grouper according to mitochondrial DNA (Richardson and Gold 1997) and microsatellite genetic markers (Zatcoff et al. 2004). However, a longer timescale of generations may be needed to detect genetic differences (Zatcoff et al. 2004). Due to a lack of appropriate data and analysis for Speckled Hind, we assumed a single unit stock in the GOM based on the stock structure assumed for Red Grouper.

2.3.7 Lesser Amberjack (Seriola fasciata)

Currently, no information exists regarding the stock structure of Lesser Amberjack in the GOM.

For the closely related Greater Amberjack (*Seriola dumerili*), Gold and Richardson (1998) found evidence of two stocks off the southeastern U.S.: one in the northern GOM and a second along the western Atlantic coast. Additional research using otolith shape analysis, tagging, and genetics in Greater Amberjack collected from the GOM and Atlantic found evidence of regionalization within the GOM but no significant difference between the GOM and Atlantic stocks (SEDAR 2014b). The authors concluded that the difference in otolith shape was not great enough to consider Greater Amberjack off of Louisiana as a sub-stock (Crandall et al. 2013). Tagging studies have found little mixing between the Florida Keys and GOM fish (McClellan and Cummings 1997; Murie and Parkyn 2013). Lastly, genetic analyses did not support panmixia for the Atlantic and GOM stocks (Murie et al. 2011). Due to a lack of appropriate data and analysis for Lesser Amberjack, we assumed a single unit stock based on the stock structure assumed for Greater Amberjack.

2.3.8 Almaco Jack (Seriola rivoliana)

Currently, no information exists regarding the stock structure of Almaco Jack in the GOM. Due to a lack of appropriate data and analysis for Almaco Jack, we assumed a single unit stock based on the stock structure assumed for Greater Amberjack and described in Section 2.3.7.

2.4 AGE AND GROWTH DATA

2.4.1 Red Drum

A review of literature compiled prior to the SEDAR 49 Data Workshop was conducted to determine the age and growth parameters best suited for the data-limited assessment of Red Drum (Table 2.12.1). Six references, primarily peer-reviewed literature, conducted age and growth studies using sectioned otoliths, where counts were used to generate von Bertalanffy growth model parameters. In addition, several assessments (e.g., Goodyear 1987, SEDAR 2015a, etc.) compiled and reviewed these age data for stock assessment purposes. Additional growth models that may better account for discrete growth phases in this species (e.g., Porch et al. 2002) were reviewed, but these model parameters are not currently accepted in the DLMtool approach to be used. The age and growth studies deemed most complete were Murphy and Taylor (1990), Beckman et al. (1989) and Wilson and Nieland (2000). Growth parameters from these studies are shown in Table 2.12.2.

To re-estimate more recent von Bertalanffy growth model parameters for the GOM, five datasets including over 8,000 age estimates were made available to the LHWG. Red Drum were collected between 1986 and 2014 and across all five GOM states. Fish ranged in size from 202 to 1195 mm maximum total length, and ranged in age from 0 to 42 years (Table 2.12.3). Red Drum were collected using both fishery-independent and fishery-dependent gear types (purse seine, gillnet, handline, bottom longline). Mean growth parameter estimates (95% CI) were calculated using the three parameter von Bertalanffy growth model (Table 2.12.2, Figure 2.13.1).

The recommended von Bertalanffy growth model parameters for Red Drum are (Table 2.12.4):

Asymptotic length (L_∞) = 881 mm (FL) ± 1.123 SE

Growth coefficient (k) = 0.32 ± 0.003 SE

Theoretical age at length zero (t_0) = -1.29 ± 0.033 SE

2.4.2 Lane Snapper

Mean and variance estimates of the von Bertalanffy length-at-age parameters for Lane Snapper were fully or partially reported for adults in five published papers. Two papers (Johnson et al. 1995 and Luckhurst et al. 2000) had similar and high reliability scores in the evaluation rubric (0.94 and 0.69, respectively) (Table 2.12.7). Each of these papers had a wide range of observed ages (1 to 19 y) and large sample sizes (300 to 694). Johnson et al. (1995) collected fish from the recreational fishery throughout the northern GOM. The LHWG thought that this was very desirable, given the contrast in the von Bertalanffy growth function parameter estimates between Johnson et al. (1995) and Luckhurst et al. (2000).

Because of the methodological problems in estimating the von Bertalanffy growth model of Johnson et al. (1995), who fit to back-calculated lengths, and the divergent estimates among the studies in the mean von Bertalanffy growth parameter estimates (Table 2.12.8), available raw data (n = 694) collected by Johnson et al. was used to re-estimate the mean and 95% confidence intervals of the von Bertalanffy growth function parameters using a non-linear curve fitting algorithm (nls in R). In the nonlinear regression a questionable data point was removed, an age 11 y fish measuring 673 mm TL – the removal of this spurious point resulted in a more reasonable mean L_∞ value (449 mm FL) than was previously reported (L_∞ = 479.9 mm TL) by Johnson et al. (1995) and ($L\infty$ = 330.9 mm TL) by Luckhurst et al. (2000) (Figure 2.13.4).

The LHWG recommends the re-estimated von Bertalanffy estimates (Table 2.12.9) as the best regional estimates of growth dynamics for Lane Snapper. These estimates capture uncertainty within the mean parameters and represent the consensus best available data for the species in the northern GOM.

The recommended von Bertalanffy growth model parameters for Lane Snapper are:

Asymptotic length (L_∞) = 449 mm (FL) ± 17.22 SE

Growth coefficient (k) = 0.17 ± 0.03 SE

Theoretical age at length zero (t_0) = -2.59 ± 0.67 SE

2.4.3 Wenchman

A single study (Anderson et al. 2009) described life history parameters for Wenchman (n=115). Using specimens collected from the GOM during the 2007 NMFS Pascagoula fall groundfish survey between October and November, von Bertalanffy growth parameters (L_∞ = 240 mm FL, k = 0.18, t_0 = -4.75) were estimated for Wenchman ranging from 119 to 237 mm FL. Ages were estimated using thin-sectioned otolith sections, however, annual deposition was not validated due to the short period of data collection. The number of increments ranged from 1 to 14. This study had the highest reliability rubric (0.70) (Table 2.12.12).

The LHWG recommends using the available life history parameters from this GOM study (Table 2.12.13). However, the LHWG strongly recommends further research to assess the appropriateness of these estimates given more data (see Section 2.10.3). For comparison, the largest Wenchman specimens collected from the GOM include: a 471 mm FL individual from the NMFS groundfish survey (Pollack et al. 2016) and a 560 mm FL individual from the commercial longline fishery (Isely et al. 2016); however, 99.8% of the length data used for regressions were between 0 – 30 cm FL with a maximum length of 27.8 cm FL. The relatively small L_∞ could suggest either a relatively small asymptotic size for Wenchman or an incomplete picture of age and growth for this species.

For comparison, life history information pertaining to the genus *Pristipomoides* was tabulated (Table 2.12.14).

2.4.4 Yellowmouth Grouper

Four studies investigated the age and growth of Yellowmouth Grouper, with only one study collecting fish from the GOM (South Atlantic, Burton et al. 2014; Trinidad and Tobago, Manickchand-Heileman and Phillip 2000; Florida Keys, Ault et al. 1998; Gulf of Mexico, Bullock and Murphy 1994). Of these studies, Bullock and Murphy (1994) received the highest overall reliability score (0.60 out of 1.0, Table 2.12.16). This study collected Yellowmouth Grouper caught by recreational vessels fishing on the Florida Middle Grounds during opportunistic sampling over the course of 14 years (1978 − 1992, n = 203). A more recent Yellowmouth Grouper age and growth study from the South Atlantic (Burton et al. 2014), also received a similar reliability ranking for sampling, age, length, and growth criteria (0.69) as Bullock and Murphy (1994); however, the LHWG recommend Bullock and Murphy (1994) since this study collected fish from the Florida Middle Grounds and also included data on reproductive traits (Table 2.12.16). Both studies (Burton et al. 2014, Bullock and Murphy 1994) estimated age from thin-sectioned sagittal otoliths and estimated longevity between 28 and 31 years. The estimated growth curves (specifically the shape of the curve) were similar between studies, comparing the Burton et al. (2014) non size limited corrected growth model parameters (Table 2.12.17, Figure 2.13.8). Note that Yellowmouth Grouper in the GOM are not managed under a size limit in federal waters.

The recommended von Bertalanffy growth model parameters (Table 2.12.18) for Yellowmouth Grouper are:

Asymptotic length (L_∞) = 828 mm (TL) ± 45 mm (SE)

Growth coefficient (k) = 0.08 ± 0.02 (SE)

Theoretical age at length zero (t_0) = -7.50 ± 1.61 (SE)

2.4.5 Snowy Grouper

Although eight studies assessed age and growth of Snowy Grouper throughout the Southeast U.S., several studies combined data from earlier references (Wyanski et al. 2013, Wyanski et al. 2000 data were included in SEDAR 2013; Matheson and Huntsman 1984, cited with Potts et al. 1998) (Table 2.12.20). One study reported life history parameters from Snowy Grouper collected from the Gulf of Mexico (Kowal 2010); however, Kowal (2010) only reported on data collected through 2004. Therefore, the LHWG recommended using the age and growth parameters from SEDAR (2013), which included data collected throughout the U.S. South Atlantic and from more recent years (1974 − 2012).

The SEDAR (2013) assessment scored higher in the reliability rubric (age and growth = 0.57; overall = 0.83) but had a lower overall reliability score than the top scoring paper from Kowal (2010) (Table 2.12.20). The LHWG recommended SEDAR (2013) growth parameters for the following reasons:

1. SEDAR (2013) included data through 2012 while Kowal (2010) only included data through 2004.

2. SEDAR (2013) had a larger sample size of otoliths (n= >11,000) than Kowal (2010) (n=774).

3. Data from SEDAR36 (2013) has been reviewed in the SEDAR process.

4. Growth parameters estimated by SEDAR (2013) and Kowal (2010) were comparable (Table 2.12.21; Figure 2.13.10). The parameters estimated between the studies showed similar growth curves; although the studies reported different length types. Snowy Grouper has a fairly straight caudal fin therefore, these length types would be similar.

The recommended von Bertalanffy growth model parameters (Table 2.12.22) for Snowy Grouper are:

Asymptotic length (L_∞) = 1064.62 mm (TL) ± 65.22 (SE)

Growth coefficient (k) = 0.094 ± 0.021 (SE)

Theoretical age at length zero (t_0) = -2.884 ± 0.951 (SE)

2.4.6 Speckled Hind

Age and growth of Speckled Hind has been investigated from fish collected from the U.S. South Atlantic, particularly fish from North and South Carolina (Matheson and Huntsman 1984, Ziskin et al. 2011). Data included in both of these studies were used in a 2004 assessment (SEDAR 2004) and a 1998 assessment of static spawning potential ratios (Potts et al. 1998).

The 2004 assessment of Speckled Hind in the U.S. South Atlantic included Speckled Hind collected by fishery-dependent (commercial and recreational) and fishery-independent data sources using multiple gears (traps, handlines, longlines, etc.). These same data were described in both Ziskin (2008) and Ziskin et al. (2011). Since the same data were reported in three documents, the LHWG used the reliability rubric scores for Ziskin et al. (2011).

Overall, Ziskin et al. (2011) received the highest (0.67) reliability rubric (Table 2.12.25). This study included Speckled Hind collected over a long time period (1977 – 1993, 2004 – 2007), a large sample size (n = 1,365), and an extended range of lengths (164 – 973 mm TL) and ages (1 – 35 y) (Table 2.12.26). The panel recommended using the age and growth parameters from Ziskin et al. (2011).

The recommended von Bertalanffy growth model parameters (Table 2.12.27) for Speckled Hind are:

Asymptotic length (L_∞) = 888 mm (TL) ± 70 (SE)
Growth coefficient (k) = 0.12 ± (0.02)
Theoretical age at length zero (t_0) = -1.80 ± (0.90)

However, interpreting band increments (and estimating age) in thin-sectioned sagittal otoliths of Speckled Hind is a difficult task. A recent validation study by Andrews et al. (2013) provided evidence that Speckled Hind have been underaged in earlier literature (e.g., Ziskin et al. 2011). Andrews et al. (2013) used radiocarbon to validate the timing of band deposition in Speckled Hind and concluded longevities up to 60 − 80 years (Figure 2.13.12). Ziskin et al. (2011) also noted the difficulties in interpreting band increments, ‘In some sections, groups of increments consisting of a number of narrow translucent and opaque zones separated by a larger translucent zone were present instead of single increments. We counted each group of increments as a single increment.'

According to the results of Andrews et al. (2013), each single increment along the dorsal side of the otolith should be counted to be consistent in age estimation (Figure 2.13.12).

2.4.7 Lesser Amberjack

A single study (Oliveira et al. 2015) provided usable life history parameters for Lesser Amberjack collected from the northeastern Atlantic, although analysis was restricted to a length-weight regression. The remaining studies identified during the pre-Data Workshop literature review generally provided taxonomic descriptions and methods for species identification among the four *Seriola* species (Greater Amberjack, Almaco Jack, Lesser Amberjack, and Banded Rudderfish (*S. zonata*); see Szedlmayer, 1991; Cummings and McClellan 1996; Renshaw et al. 2012) (Table 2.12.29). Thompson et al. (1996) attempted aging with sectioned sagittal otoliths, but were unable to provide confident ages. Lesser Amberjack growth model parameters were reported in Farmer et al. (2016), but the parameters could not be verified in the original citations. Therefore, no age or growth parameters are available for the Lesser Amberjack assessment.

Borrowing of parameters from congeneric species such as Greater Amberjack and Yellowtail Amberjack (*Seriola lalandi*) was considered, however, the LHWG decided that it would not be appropriate to recommend these parameters due to the noted differences in maximum sizes between these species. Although not as prominent as with Greater Amberjack, Lesser Amberjack were also noted for sexual dimorphic growth, with females being slightly larger than males (Thompson et al. 1996).

Given the lack of information available for a data-limited assessment for Lesser Amberjack (Table 2.12.30), parameters for an Amberjack operating model are provided and are based on Greater Amberjack (SEDAR 2014b) (Table 2.12.31). These parameters can be used in simulation analysis for a generic Amberjack stock; however, caution should be exercised in applying these results to Lesser Amberjack.

2.4.8 Almaco Jack

Similar to Lesser Amberjack, studies reviewed for Almaco Jack were predominantly taxonomic descriptions that provided identification information and lacked growth and age information for this species (Table 2.12.33). Overall, life history data were especially poor for Almaco Jack, and overall no life history parameters were recommended for assessment (Table 2.12.34). Also, Almaco Jack growth model parameters were reported in Farmer et al. (2016), but the parameters could not be verified in the original citations. As discussed in Section 2.4.7, an Amberjack operating model could be developed using parameters from Greater Amberjack; however, caution should be exercised in applying these results to Almaco Jack.

2.5 NATURAL MORTALITY

During SEDAR Best Practices (SEDAR 2015c), the various empirical methods to calculate point estimates for natural mortality were reviewed. It was concluded that the updated Hoenig equation using longevity (t_max) was the most robust (Then et al. 2015).

$$\text{Natural Mortality (M)} = 4.899 * t\_max^{-0.916}$$

Therefore, estimation of instantaneous annual natural mortality rate for each species is based on maximum longevity as described in Then et al. (2015). The cross-validation prediction error of the updated Hoenig equation from Then et al. (2015) was adopted as the CV for each species.

2.5.1 Red Drum

A range of maximum ages (36 − 42 y) was selected from the reviewed literature considered most reliable (Table 2.12.4). The high value in this range (age 42) was the oldest aged individual (Wilson and Nieland 2000), whereas the low value in this range was the mode of the maximum ages in the literature and the database of ages provided for SEDAR49 (Table 2.12.3). Based on these values, the recommended natural mortality was 0.17 y^{-1} ± 0.32 (SE) with a range from 0.16 y^{-1} to 0.18 y^{-1} (Table 2.12.4).

2.5.2 Lane Snapper

Based on the observed range of maximum aged individuals in all studies (age 17 – 19 y), the recommended natural mortality was 0.33 y^{-1} ± 0.32 (SE) (maximum age 19 y) with a range from 0.33 y^{-1} to 0.37 y^{-1} (Table 2.12.9).

2.5.3 Wenchman

Based on the observed maximum age of 14 y from Anderson et al. (2009), the point estimate of M was 0.44 y^{-1} (Table 2.12.13). No range was available due to limited data.

2.5.4 Yellowmouth Grouper

Each of the four age and growth studies for Yellowmouth Grouper provided estimates of longevity (range: 17 – 41) (South Atlantic, Burton et al. 2014, maximum age = 31 y; Trinidad and Tobago, Manickchand-Heileman and Phillip 2000, maximum age = 41 y; Florida Keys, Ault et al. 1998, maximum age = 17 y (from length); Gulf of Mexico, Bullock and Murphy 1994, maximum age = 28 y).

The LHWG recommended a maximum age of 28 y, which provides a point estimate of M of 0.23 y^{-1}. Burton et al. (2014) and Bullock and Murphy (1994) reported one and two Yellowmouth Grouper of this age, respectively (Table 2.12.18). The LHWG would recommend a range of maximum age of 28 − 31 y, corresponding to a range in M 0.21 y^{-1} to 0.23 y^{-1}. The recommendation excludes the age estimated from length in Ault et al. (1998).

2.5.5 Snowy Grouper

The LHWG recommended a maximum age of 35 (SEDAR 2013), a point estimate of M of 0.19 y^{-1}, and a range of 35 to 44 y corresponding to a range in M of 0.15 y^{-1} to 0.19 y^{-1} (Table 2.12.22).

A maximum age of 35 (SEDAR 2013) was chosen even though Kowal (2010) reported a maximum age of 44 y. Kowal (2010) only reported two fish older than 35 y. Natural mortality calculated using the updated Hoenig equation (Then et al. 2015) decreases slightly between age 35 and 45 years (Table 2.12.23).

2.5.6 Speckled Hind

Due to the difficulties in interpreting band increments in thin-sectioned sagittal otoliths of Speckled Hind and the results of the radiometric dating validation study, the LHWG recommends a maximum age of 45 years (M of 0.15 y^{-1}) and a range of 35 – 45 years (M 0.15 y^{-1} to 0.19 y^{-1}) (Figure 2.13.13) (Table 2.12.27). This age is older than the maximum age of 35 years reported by Ziskin et al. (2011) and 25 years reported by Matheson and Huntsman (1984). However, given the results of radiocarbon, Speckled Hind longevity is at least 45 years with a corresponding point estimate of M of 0.15 y^{-1}.

2.5.7 Lesser Amberjack

While a maximum age of eight years was suggested by Thompson et al. (1996), this age was not confidently estimated. In addition, no natural mortality estimates were encountered in the pre-Data Workshop meta-analysis (Adams et al. 2016). Therefore, no parameters are available to estimate M (Table 2.12.30).

2.5.8 Almaco Jack

No estimates of natural mortality are available for Almaco Jack for the same reasons discussed in Section 2.5.7 (Table 2.12.34).

2.6 REPRODUCTION

2.6.1 Red Drum

The complete library of Red Drum life history literature compiled for SEDAR 49 was reviewed for reproduction and age/length at maturity. Three studies were chosen as the most comprehensive accounts of reproduction for this species. Wilson and Nieland (1994) sampled fish from Texas, Louisiana, Mississippi and Alabama from the period 1986 − 1992 and used histology to document the development of oocyte maturation. Reproductive values from this study were similar to values in both Overstreet (1983) and Murphy and Taylor (1990), both earlier investigations of the reproductive biology of this species. While these values were in agreement, Wilson and Nieland (1994) provided the only sex-specific lengths at 50% maturity derived from a logistic model (Table 2.12.5). Size at 95% maturity was 810 mm FL (Wilson and Nieland 1994; Table 2.12.4).

2.6.2 Lane Snapper

Five published papers addressed reproductive dynamics of Lane Snapper and were evaluated by the LHWG (Table 2.12.7). The LHWG discouraged the use of Rodriguez-Castro et al. (1999) because the mean length-at-maturity from individuals (n = 1,155) was not reported and the sampling and analytical methods were not well described. Of the remaining four papers, Aiken (2001) and Manickchand-Dass (1987) were from the Caribbean, from fishery-dependent data collection, and had limited duration of sample collection (Table 2.12.10).

The remaining two papers included work by Freitas et al. (2014) and Luckhurst et al. (2000) (Table 2.12.10). Each of these studies were conducted outside the northern GOM and were conducted suitably for describing the reproductive dynamics of Lane Snapper. Characteristics for one or both of these studies included large sample sizes, a wide range of lengths (14.7 to 56 cm TL), histological analysis, well described collection and analysis, more recent work, and long temporal duration.

The LHWG decided to adopt the mean estimates of length-at-maturity (240 mm FL, range 235 − 245 mm FL) reported by Luckhurst et al. (2000) but recognize that the work by Freitas et al. (2014) provides slightly smaller mean estimates of the length at 50% maturity (L_{50}) (Table 2.12.10). Though Freitas et al. (2014) use a logistic regression to describe maturity-at-length, they did not provide a variance estimate on the L_{50} value. The LHWG approximated the length of 95% maturity (270 mm FL, range 260 − 280 mm FL) based on the size of age 2 − 3 y fish (Table 2.12.9).

2.6.3 Wenchman

No maturity or reproduction information is available for Wenchman from the Gulf of Mexico and elsewhere in this species geographical distribution. Although estimates of length at maturity could be borrowed from Caribbean and Indo-Pacific congeners including Cardinal Snapper (*P. macrophthalus*), Crimson Jobfish (*P. filamentosus*) and Goldbanded Jobfish (*P. multidens*), there are concerns regarding the interchangeability of parameters for these species (Table 2.12.14). The Caribbean Cardinal Snapper was more similar in length, compared to either the Crimson Jobfish or the Goldbanded Jobfish. The Crimson Jobfish and the Goldbanded Jobfish reach older ages (44 y, Andrews et al. 2012; 30 y, Newman and Dunk 2003) and larger lengths (817 mm FL, Mees 1993; 600 mm FL, Kailola 1993), cautioning the utility of life history parameters derived from these species as a proxy for Wenchman.

2.6.4 Yellowmouth Grouper

A single study reporting reproductive characteristics for Yellowmouth Grouper classified reproductive phases for males, females and transitional fish using histologically prepared gonad tissue (Bullock and Murphy 1994). This study estimated size and age at maturity given the proportion of mature females per size group and age class (L_{50} = 400 − 450 mm TL; A_{50} = 2 − 4 years) (Table 2.12.18). The LHWG recommends the use of these estimates for size and age at maturity. The length of 95% maturity was estimated from the data presented by length bins in Bullock and Murphy (1994) as 475 mm TL (Table 2.12.18).

2.6.5 Snowy Grouper

Four studies estimated age at 50% maturity (A_{50}), with two of the four studies also estimating length at 50% maturity (L_{50}). The LHWG recommended using A_{50} and L_{50} from SEDAR (2013) because it had the highest reliability score (0.71) and a large sample size (n=2,738) (L_{50} – 600 mm TL; L_{95} – 750 mm TL) (Table 2.12.20, Table 2.12.22).

SEDAR (2013) used the updated values from Wyanski et al. (2013) which analyzed histological samples to examine sex and a logistic function to estimate A_{50}. Wyanski et al. (2013) estimated A_{50} for female Snowy Grouper to be 5.6 years (5% CI = 5.3 − 5.9 y). However, neither SEDAR (2013) nor Wyanski et al. (2013) give L_{50}. SEDAR (2013) and Wyanski et al (2013) did report annual proportion of mature females and average body length by age. At six years old, 57% of females were mature and the average total length of six year old fish was 623.8 mm TL. At 10 years old, 96% of females were mature and the average total length of 10 year old fish was 761.9 mm TL.

2.6.6 *Speckled Hind*

A single study investigated reproductive life history for Speckled Hind from the U.S. South Atlantic (Ziskin et al. 2011). Ziskin et al. (2011) used data collected from histologically staged gonads to calculated size and age at 50% maturity using logistic regressions (2004 − 2007; n = 182; L_{50} = 532 mm TL, 95% CI = 522 − 542 mm TL; A_{50} = 6.6 years, 95% CI = 6.1 – 7.6 years). The size and age at 50% maturity for Speckled Hind collected more recently (2004 − 2007) are likely similar to size and age at 50% maturity for Speckled Hind in the Gulf of Mexico. The LHWG recommends a size of 50% of 532 mm TL and a size of 95% maturity of 675 mm TL (Table 2.12.27).

2.6.7 *Lesser Amberjack*

No studies provided any information on maturity parameters for Lesser Amberjack.

2.6.8 *Almaco Jack*

No studies provided any information on maturity parameters for Almaco Jack.

2.7 MERISTIC CONVERSIONS

Meristic data (various length and weight types) from multiple fishery-independent and -dependent data sources were combined to estimate conversion factors. These data source databases were queried for any instance of capture for seven of the eight species (See Section 2.7.1 for additional data sources collected for Red Drum). Linear and non-linear regressions were calculated using R (lm and nls functions, respectively). Regressions were only employed for sample sizes ≥ 50.

Data Source	
Fishery-independent	NMFS/SEFSC Pascagoula surveys (groundfish, small pelagic, bottom longline, reef fish) Gulf States Marine Fisheries Commission SEAMAP
Fishery-dependent	NMFS/SEFSC Trip Interview Program NMFS/SEFSC Southeast Headboat Survey NMFS/SEFSC Reef Fish Observer Program

	NMFS/SEFSC Shark Bottom Longline Observer Program Marine Recreational Fisheries Statistics Survey Marine Recreational Information Program Gulf States Marine Fisheries Commission – Fisheries Information Network Florida Fish and Wildlife Conservation Commission Texas Parks and Wildlife Department

2.7.1 Red Drum

Length-weight conversions were generated from fishery-independent data provided by the National Marine Fisheries Service, Florida Fish and Wildlife Conservation Commission/Fishery Independent Monitoring, University of South Alabama/Dauphin Island Sea Laboratory, Alabama Division of Marine Resources, Mississippi Department of Marine Resources, and Louisiana Department of Wildlife and Fisheries (n >25,000 individuals; Table 2.12.6, Figure 2.13.2, Figure 2.13.3).

2.7.2 Lane Snapper

The panel used available data from fishery-independent and -dependent data sources from the GOM for meristic conversions (Table 2.12.11, Figures 2.13.5 and Figure 2.13.6).

2.7.3 Wenchman

The panel used available data from fishery-independent and -dependent data sources from the GOM for meristic conversions (Table 2.12.15, Figure 2.13.7).

2.7.4 Yellowmouth Grouper

The panel used available data from fishery-independent and -dependent data sources from the GOM for meristic conversions (Table 2.12.19, Figure 2.13.9).

2.7.5 Snowy Grouper

The panel used available data from fishery-independent and -dependent data sources from the GOM for meristic conversions (Table 2.12.24, Figure 2.13.11).

2.7.6 Speckled Hind

The panel used available data from fishery-independent and -dependent data sources from the GOM for meristic conversions (Table 2.12.28, Figure 2.13.14).

2.7.7 Lesser Amberjack

The panel used available data from fishery-independent and -dependent data sources from the GOM for meristic conversions (Table 2.12.32, Figure 2.13.15).

2.7.8 Almaco Jack

The panel used available data from fishery-independent and -dependent data sources from the GOM for meristic conversions (Table 2.12.35, Figure 2.13.16).

2.8 STEEPNESS

2.8.1 Red Drum

Adams et al. (2016) provided a meta-analysis of life history metrics for Red Drum which included estimates of steepness from a previous Atlantic SEDAR and from state of Florida stock assessments.

SEDAR (2015a) provided a range of steepness values for Red Drum between 0.80 − 1.00. In SEDAR (2015a), steepness was not estimable and was fixed at 0.99.

Both Chagaris et al. (2015) and Murphy and Munyandorero (2009) fixed steepness at 0.8 in the Florida assessment.

Porch (2000) did not report values of steepness.

The LHWG recommends using a steepness value of 0.90 (range 0.8 − 1.0) based on reported values from previous Red Drum stock assessments (Table 2.12.4). A plausible range of recruitment variability, or Sigma R, was derived from past assessments for Red Drum (Table 2.12.4).

2.8.2 Lane Snapper

The LHWG recommends the steepness estimate of 0.95 for Lutjanidae derived from the meta-analysis conducted by Myers et al. (1999). However, given the range (0.5 − 0.99) of steepness parameters considered in assessments of other Lutjanid species, there is considerable uncertainty in this input (Table 2.12.9). A plausible range of recruitment variability, or Sigma R, was derived from past assessments of other Lutjanids (Table 2.12.9).

2.8.3 Wenchman

No assessments have been conducted on Wenchman or any congeners in the southeast US. An assessment of the Indo-Pacific congener Goldband Snapper (*Pristipomoides multidens*) assumed a steepness value of 0.7 for a Beverton-Holt stock-recruitment relationship (Prescott and Bentley 2009). This value was considered a reasonable best guess based on the Rose et al. (2001) analysis which included Gulf Red Snapper. Although not necessarily congeners, many snappers have been assessed in the Gulf of Mexico, with steepness values ranging from 0.70 to 1.00 and sensitivity analyses testing values from 0.5 − 0.99, which is also the recommendation by the LHWG for Wenchman (Table 2.12.13). A plausible range of recruitment variability, or Sigma R, was derived from past assessments of other Lutjanids (Table 2.12.13).

2.8.4 Yellowmouth Grouper

Two congeners of the Yellowmouth Grouper have been assessed in both the South Atlantic and Gulf of Mexico using data-rich methods: Gag Grouper (*Mycteroperca microlepis*; SEDAR 2014a) and Black Grouper (*Mycteroperca bonaci*; SEDAR 2010). These most recent assessments estimated steepness values for these species at 0.99 (GOM Gag) and 0.84 (SEDAR 2010, SEDAR 2014c). However, these assessments included a number of different steepness values as sensitivity runs, suggesting a wide range of uncertainty in this parameter for each stock. The LHWG recommends a steepness of 0.84 for Yellowmouth Grouper based on Shertzer and Conn (2012) (Table 2.12.18). A plausible range of recruitment variability, or Sigma R, was derived from past assessments of other groupers (Table 2.12.18).

2.8.5 Snowy Grouper

SEDAR (2004) and SEDAR (2013) provided steepness values for Snowy Grouper. The SEDAR Panel recommended using a fixed steepness value of 0.84 from a meta-analysis, updated since SEDAR4 (2004), conducted by Shertzer and Conn (2012). Both SEDAR (2004) and SEDAR (2013) were unable to estimate a steepness value and instead used fixed values from a meta-analysis. Therefore, the LHW recommends a steepness of 0.84 for Snowy Grouper (Table 2.12.22). A plausible range of recruitment variability, or Sigma R, was derived from past assessment of Snowy Grouper, which fixed Sigma R at 0.55 (Table 2.12.22).

2.8.6 Speckled Hind

Two congeners of Speckled Hind, Goliath Grouper (*Epinephelus itajara*) and Red Grouper (*Epinephelus morio*), have been assessed in both the South Atlantic and GOM (SEDAR 2011b, 2015b). For these species, steepness values have been estimated between 0.9 and 0.91, with alternative values of 0.65 and 0.98 considered for GOM Red Grouper (SEDAR 2015b). The most recent assessment for Yellowedge Grouper (*Hyporthodus flavolimbatus*) estimated steepness at 0.95 but considered three alternative values as sensitivity runs (SEDAR 2011; 0.60, 0.65, 0.70). SEDAR (2004) was unable to estimate a steepness value for Speckled Hind and instead used a fixed value of 0.84 from a meta-analysis. Therefore, the LHWG recommends a steepness of 0.84 for Speckled Hind (Shertzer and Conn 2012) (Table 2.12.27). A plausible range of recruitment variability, or Sigma R, was derived from past assessments of other groupers (Table 2.12.27).

2.8.7 Lesser Amberjack

The LHWG cannot make a recommendation for an estimate of steepness for Lesser Amberjack due to the lack of any assessments nor information on recruitment available in the literature. The only *Seriola* species assessed in the Gulf of Mexico has been the Greater Amberjack (SEDAR 2014b). The LHWG does not recommend the steepness or estimated Sigma R for Greater Amberjack be applied to Lesser Amberjack, given the unknown life history of Lesser Amberjack.

2.8.8 Almaco Jack

The LHWG cannot make a recommendation for an estimate of steepness for Almaco Jack due to the lack of any assessments nor information on recruitment available in the literature. The steepness value for Greater Amberjack was not recommended as discussed in Section 2.8.7.

2.9 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

2.9.1 Red Drum

Parameters suitable for the current assessment were identified from a comprehensive review of the available literature; however, re-estimation of life history parameters is recommended using the most current and comprehensive datasets. The datasets provided to the LHWG were comprehensive (n > 8000 otoliths), were collected during more recent years (1986 − 2015), and span the entire U.S. Gulf of Mexico. While a more appropriate model for adult Red Drum growth may be the two-phase model proposed by Porch et al. (2002), the current version of DLMtool requires inputs from a three parameter growth model (i.e., a traditional von Bertalanffy growth curve). For Red Drum, the 3-parameter von Bertalanffy growth curve does not adequately capture the abrupt change in growth rate. The estimates of maturity from Wilson and Nieland (1994) are greater than 20 years old, however, they are spatially comprehensive and include a large sample size. Furthermore, they are similar to recent estimates generated by Chagaris et al. (2015) from the state of Florida. For these reasons, we propose these estimates as the best available reproductive data for this species.

2.9.2 Lane Snapper

With the exception of values associated with the recruitment dynamics of Lane Snapper, which will be derived from meta-analysis, the published and unpublished papers and reports and fishery-dependent and fishery-independent data provided to the LHWG allowed precise and seemingly accurate estimates of most of the necessary life history parameters for inclusion into the data-limited assessment. The parameters that the LHWG has particular confidence in include the estimated length-at-age, weight-at-length (meristic relationships), and length-at-maturity.

The von Bertalanffy length-at-age estimates were determined from data collected from the northern GOM and subject to quality control to remove the spurious data point that compromised the published and available estimates. The use of the non-linear curve fitting methods allowed the mean and associated confidence intervals to be determined with confidence (Figure 2.13.4). Similarly, the LHWG has confidence in the mean and error estimates of parameters concerning the weight-at-length and variants of length (Table 2.12.6). Each of the estimates of length-at-age and weight-at-length are determined from samples taken throughout the GOM.

2.9.3 Wenchman

For Wenchman, only one study was available to derive parameters from. While the study was comprehensive, the small sample size (n=115) and single year of sampling warrant caution in applying parameter estimates.

2.9.4 Yellowmouth Grouper

The LHWG agrees that there is limited information available for Yellowmouth Grouper. However, the two main references, Bullock and Murphy (1994) and Burton et al. (2014), provide reasonable descriptions of life history for Yellowmouth Grouper in their respective regions (Gulf of Mexico and U.S. South Atlantic) and used similar methods of data collection and age estimation.

Both of these studies scored the same in the reliability rubric for sampling, and age-length data (0.41, 0.40, respectively) (Table 2.12.16). The LHWG recommended the Bullock and Murphy

(1994) study given the capture location of the fish and the inclusion of reproductive parameters. However, the LHWG recognizes that the Bullock and Murphy (1994) study results may be outdated, since it has been over 20 years since sampling and fish were only collected by intercepting recreational vessels.

2.9.5 Snowy Grouper

There were 12 papers reviewed for Snowy Grouper that estimated life history parameters for use in the assessment for this stock (Table 2.12.20).

Of the 12 papers, a single paper (Kowal 2010) assessed life history parameters of Snowy Grouper in the GOM.

> The LHWG did not recommend this study for life history parameters due to its low sample size (otolith sample size n=774, gonad sample size= 90) and because it has been over 10 years since sampling.

The LHWG recommended SEDAR (2013) as a source for age and growth parameters (L_∞, k, and t_0) and maturity parameters (A_{50} and L_{50}). The panel recommended SEDAR (2013) for the following reasons:

SEDAR (2013) had high reliability estimates (Table 2.12.20).

The data were sampled over a long time period and included samples from recent years (1974 − 2012).

Snowy Grouper were collected from multiple sources (commercial, recreational, fishery-independent) and from multiple gears (traps, handline, and longline).

Age and reproduction were assessed thoroughly (n= >11,000 otoliths and n=>2,500 gonads).

Data have already been reviewed by SEDAR.

There are disadvantages to using SEDAR (2013) for age and growth parameters and maturity parameters. The data were collected from the South Atlantic rather than the Gulf of Mexico. Regional differences in fishing pressure, habitat and population structure could affect Snowy Grouper life history parameters.

2.9.6 Speckled Hind

The LHWG agrees that there is limited information for Speckled Hind but do agree that the Ziskin et al. (2011) study provides reasonable descriptions of the life history for Speckled Hind in the U.S. South Atlantic and used sound methods of data collection, age estimation, and reproductive analysis (Table 2.12.25).

There are two disadvantages to using Ziskin et al. (2011) for age and growth parameters and maturity parameters. The data were collected from the South Atlantic rather than the Gulf of Mexico and regional differences in fishing pressure, habitat and population structure could affect Speckled Hind life history parameters. The LHWG cautions the application of longevity estimates provided herein.

2.9.7 Lesser Amberjack

No substantial data are available at this time to determine life history parameters for Lesser Amberjack in the GOM for assessment.

2.9.8 Almaco Jack

No substantial data are available at this time to determine life history parameters for Almaco Jack in the GOM for assessment.

2.10 RESEARCH RECOMMENDATIONS

2.10.1 Red Drum

The SEDAR 49 Gulf of Mexico data-limited stock assessment represents the initial attempt at assessing Gulf of Mexico Red Drum since the federal harvest moratorium. A comprehensive review of the literature, as well as inclusion of the most recent datasets available, provided the most up to date life history information possible (Table 2.12.1, 2.12.4). Through this review of the literature, it is apparent that GOM Red Drum remain a data-limited species. Below we provide the following research recommendations:

1. Increase offshore sampling across the entire GOM, especially at the individual school level, for biological samples (e.g., meristics, otoliths, reproductive tissues, fin clips). We recommend purse seine as the least size-selective sampling gear for this species in offshore waters.
2. Consensus and consistency is needed in assigning calendar age, calculating fractional ages and recording edge type across the GOM to ensure the age data collected are comparable between studies.
3. A concerted effort should be made to identify and record reproductive phase for oocyte development, both macroscopically and histologically. This is particularly

true given that the most recent reproductive estimates are greater than 20 years old. Improved quantification (e.g., binary logistic regression) is needed for better point estimates of size and age at 50% and 95% maturity.
4. Collection of tissues (e.g., fin clips) is a low-cost and easy-to-archive means to ensure future studies examining stock delineation, site fidelity, effective population size, etc. for this species are possible.

2.10.2 Lane Snapper

A primary open question in the life history analyses is how the recreational fishery has impacted the stock since the early 1990's. There are no data available to make inferences about how age frequency in the fishery and stock may have changed over the time series.

Primary research needs identified by the team included the following. These are listed below in order of priority based on perceived priority:

1. Increase the precision (by increasing sample size and thorough validation) of estimates of length-at-age and maturity-at-age to provide rigorous estimates. This would require an increase in dockside and at-sea sampling for biostatistical information, especially the collection of otoliths and reproductive tissue.
2. Design random sampling protocol for NMFS Pascagoula's groundfish and small pelagic surveys to collect length- and age-composition of Lane Snapper encountered by these surveys.
3. Perform a survey of the genetic structure of the stock to more precisely understand spatial stock structure, in particular the potential for hybridization with other Lutjanids.

2.10.3 Wenchman

Due to the limited sampling of life history parameters (two months of data in a single year), more research is needed for all life history aspects of Wenchman. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material).
2. An aging study that includes validation with increased sample sizes.
3. Design a random sampling protocol for NMFS Pascagoula groundfish and small pelagic surveys.

4. Collect reproductive maturity estimates.

2.10.4 Yellowmouth Grouper

Additional research is needed to obtain more recent estimates of all life history parameters for Yellowmouth Grouper. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase in dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material) for the GOM.
2. Conduct an updated age and growth study for GOM samples, including a validation study based on radiochemical dating.
3. Conduct an updated reproductive study for the GOM to examine not only maturity but the size and age of transition.

2.10.5 Snowy Grouper

Additional research is needed to obtain more recent estimates of all life history parameters for Snowy Grouper in the GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase in dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material) for the GOM.
2. Conduct an updated age and growth study for GOM samples, which also includes a more extensive validation study based on radiochemical dating (see Harris 2005).
3. An increase in dockside and other sampling programs to complete a more comprehensive and an updated reproductive study for GOM to examine not only maturity but size and age of transition.

2.10.6 Speckled Hind

Additional research is needed to obtain estimates of all life history parameters for Speckled Hind in the northern GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase in dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material) for the GOM.
2. Conduct an updated age and growth study for GOM samples, using the new criteria of counting narrower groups of translucent and opaque band increments on the dorsal side of the otolith (as described in Andrews et al. 2013).
3. An increase in dockside and other sampling programs to complete a more comprehensive and an updated reproductive study for the GOM to examine not only maturity but size and age of transition.

2.10.7 Lesser Amberjack

Additional research is needed to obtain estimates of all life history parameters for Lesser Amberjack in the GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following.

1. Increase in dockside and at-sea sampling for biological samples including age structures, reproductive tissues, and genetic material.
2. While age has been attempted, finding an appropriate aging methodology that includes a way to validate age using multiple hard structures is suggested.
3. Further research is needed for natural mortality estimates.
4. Need for reproductive tissue to examine maturity.

2.10.8 Almaco Jack

Additional research is needed to obtain estimates of all life history parameters for Lesser Amberjack in the GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following.

1. Increase in dockside and at-sea sampling for biological samples including age structures, reproductive tissues, and genetic material.
2. While age has been attempted, finding an appropriate aging methodology that includes a way to validate age using multiple hard structures is suggested.
3. Further research is needed for natural mortality estimates.
4. Need for reproductive tissue to examine maturity.

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2.12 TABLES

Table 2.12.1. Reliability rubric for Red Drum (see section 2.2 for detailed information on the construction of this rubric).

Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Hightower et al. 2016	FWC 2008	Powers et al. 2012	Wilson and Nieland 1994	Bacheler et al. 2009	Doerzbacher et al. 1988	Porch 1999	Porch 2000
SAMPLING		**1.00**	**0.92**	**0.92**	**0.86**	**0.83**	**0.83**	**0.83**	**0.83**
Sampling location	Not reported (0.0)								
	South America (0.5)								
	Caribbean (0.5)								
	Campeche/Yucatan (0.5)								
	U.S. South Atlantic (0.5)		0.5			0.5			
	U.S. Gulf of Mexico (1.0)	1.0		1.0	1.0		1.0	1.0	1.0
Sampling timeframe	Not reported (0.0)								
	< 12 Months (0.0)								
	1-2 years (0.5)								
	3-4 years (0.5)			0.5		0.5			
	5+ years (1.0)	1.0	1.0		1.0		1.0	1.0	1.0
Time since sampling	20+ years (0.0)				0.0		0.0		
	19-11 years (0.5)							0.5	0.5
	10-1 years (1.0)	1.0	1.0	1.0		1.0			
Sampling frequency	Not reported (0.0)								
	Seasonal (0.5)								
	Annual (0.5)							0.5	0.5
	Monthly (1.0)	1.0	1.0	1.0	1.0	1.0	1.0		
	Daily (1.0)								
Sampling method	Not reported (0.0)								
	Fishery independent (0.5)								
	Fishery Dependent (0.5)								
	Combination (FI & FD) (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sampling gear	Not reported (0.0)								
	Active gear (e.g., hook and line) (0.5)								
	Passive gear (e.g., nets) (0.5)				1.0				
	Combo(1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
AGE-LENGTH	**Age-Length Score**	**0.81**	**0.81**	**0.69**	**0.75**	**0.13**	**0.21**	**0.75**	**0.75**
	Age-Length * Sampling Score	**0.81**	**0.74**	**0.63**	**0.64**	**0.1**	**0.18**	**0.63**	**0.63**
Total sample size of age structures	Not reported (0.0)						0.0		
	<200 (0.5)								
	201-500 (0.5)			0.5		0.5			
	>501 (1.0)	1.0	1.0		1.0			1.0	1.0
Length	Not reported (0.0)								
	Narrow range metrics (0.5)			0.5		0.5			
	Wide range metrics (1.0)	1.0	1.0		1.0		1.0	1.0	1.0
Age	Not reported (0.0)					0.0	0.0		
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)	1.0	1.0	1.0	1.0			1.0	1.0

continue Table 2.12.1 page 2

Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Hightower et al. 2016	FWC 2008	Powers et al. 2012	Wilson and Nieland 1994	Bacheler et al. 2009	Doerzbacher et al. 1988	Porch 1999	Porch 2000
Ageing method	Not reported (0.0)					0.0			
	Other hard part (0.5)								
	Age-at-Length Key/tag-recapture (0.5)						0.5		
	Scales (0.5)								
	Otoliths: Whole (0.5), Section (1.0)	1.0	1.0	1.0	1.0			1.0	1.0
Age validated	Not reported (0.0)	0.0		0.0	0.0	0.0	0.0	0.0	0.0
	Captive Rearing (0.5)								
	Marginal increment (0.5)								
	Temporal length frequency (0.5)								
	Tag-recapture with chemical marking (0.5)		0.5						
	Radiochemical Dating (1.0)								
Reader precision	Not reported (0.0)		0.0		0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)								
	Average Percent Error (1.0)	1.0		1.0					
	Estimate of variation (CVs) (1.0)								
Number of samples per age class	Not reported (0.0)					0.0	0.0		
	5 (0.5)			0.5					
	10 (0.5)								
	20+ (1.0)	1.0	1.0		1.0			1.0	1.0
Growth parameters estimation method	Not reported (0.0)					0.0			
	Waldford plot (0.5)								
	Length Frequency (0.5)	0.5							
	Min. least squares (SAS, R, Excel) (1.0)		1.0	1.0	1.0			1.0	1.0
LENGTH-WEIGHT	**Length-Weight Score**	**1.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.7**
	Length-Weight * Sampling Score	**1.00**	**0.92**	**0.00**	**0.00**	**0.0**	**0.00**	**0.83**	**0.56**
Length	Not reported (0.0)								
	Narrow range metrics (0.5)			0.5		0.5			
	Wide range metrics (1.0)	1.0	1.0		1.0		1.0	1.0	1.0
Weight	Not reported (0.0)			0.0		0.0	0.0		0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)	1.0	1.0		1.0			1.0	
Number of samples per length bin	Not reported (0.0)					0.0			
	5 (0.5)			0.5					
	10 (0.5)								
	20+ (1.0)	1.0	1.0		1.0		1.0	1.0	1.0
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0

continue Table 2.12.1 page 3

Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Hightower et al. 2016	FWC 2008	Powers et al. 2012	Wilson and Nieland 1994	Bacheler et al. 2009	Doerzbacher et al. 1988	Porch 1999	Porch 2000
MATURITY	**Maturity Score**	**0.00**	**0.14**	**0.14**	**1.00**	**0.00**	**0.00**	**0.14**	**0.14**
	Maturity * Sampling Score	**0.00**	**0.13**	**0.13**	**0.86**	**0.00**	**0.00**	**0.12**	**0.12**
Number of reproductive samples	Not reported (0.0)	0.0	0.0			0.0	0.0	0.0	0.0
	<200 (0.5)								
	201-500 (0.5)			0.5					
	>501 (1.0)				1.0				
Length	Not reported (0.0)	0.0	0.0	0.0		0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)				1.0				
Weight	Not reported (0.0)	0.0	0.0	0.0		0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)				1.0				
Age	Not reported (0.0)	0.0	0.0	0.0		0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)				1.0				
Sex determination methods	Not reported (0.0)	0.0	0.0			0.0	0.0	0.0	0.0
	Macroscopic examination (0.5)			0.5					
	Histological examination (1.0)				1.0				
Length of maturity estimation method	Not reported (0.0)	0.0		0.0		0.0	0.0		
	Estimated based on observed (0.5)		0.5					0.5	0.5
	Data fit using Logistic Model (1.0)				1.0				
Age of maturity estimation method	Not reported (0.0)	0.0		0.0		0.0	0.0		
	Estimated based on observed (0.5)		0.5					0.5	0.5
	Data fit using Logistic Model (1.0)				1.0				
MORTALITY	**Mortality Score**	**1.00**	**1.00**	**0.00**	**0.00**	**0.50**	**0.00**	**1.00**	**1.00**
	Mortality * Sampling Score	**1.00**	**0.92**	**0.00**	**0.00**	**0.42**	**0.00**	**0.83**	**0.83**
Natural mortality estimation method	Not reported (0.0)			0.0	0.0		0.0		
	Based on VB growth parameters (0.5)								
	Tag-recapture (0.5)					0.5			
	Based on maximum age (1.0)	1.0	1.0					1.0	1.0
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)								
	Previous stock assessment (1.0)								

continue Table 2.12.1 page 4

Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Bacheler et al. 2008	Mercer 1984	Murphy and Taylor 1990	Porch et al. 2002	Goodyear 1987	Goodyear 1989	Goodyear 1996	Winner et al. 2014
SAMPLING		**0.80**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**
Sampling location	Not reported (0.0)								
	South America (0.5)								
	Caribbean (0.5)								
	Campeche/Yucatan (0.5)								
	U.S. South Atlantic (0.5)	0.5	0.5						
	U.S. Gulf of Mexico (1.0)			1.0	1.0	1.0	1.0	1.0	1.0
Sampling timeframe	Not reported (0.0)								
	< 12 Months (0.0)								
	1-2 years (0.5)			0.5					
	3-4 years (0.5)				0.5				0.5
	5+ years (1.0)	1.0	1.0			1.0	1.0	1.0	
Time since sampling	20+ years (0.0)		0.0	0.0		0.0	0.0	0.0	
	19-11 years (0.5)				0.5				
	10-1 years (1.0)								1.0
Sampling frequency	Not reported (0.0)								
	Seasonal (0.5)								
	Annual (0.5)	0.5				0.5	0.5	0.5	
	Monthly (1.0)		1.0	1.0	0.5				1.0
	Daily (1.0)								
Sampling method	Not reported (0.0)								
	Fishery independent (0.5)								0.5
	Fishery Dependent (0.5)								
	Combination (FI & FD) (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Sampling gear	Not reported (0.0)								
	Active gear (e.g., hook and line) (0.5)								0.5
	Passive gear (e.g., nets) (0.5)								
	Combo(1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
AGE-LENGTH	**Age-Length Score**	**0.44**	**0.69**	**0.94**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**
	Age-Length * Sampling Score	**0.4**	**0.52**	**0.70**	**0.56**	**0.56**	**0.56**	**0.56**	**0.56**
Total sample size of age structures	Not reported (0.0)								
	<200 (0.5)								
	201-500 (0.5)								
	>501 (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Length	Not reported (0.0)								
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Age	Not reported (0.0)								
	Narrow range metrics (0.5)	0.5							
	Wide range metrics (1.0)		1.0	1.0	1.0	1.0	1.0	1.0	1.0

continue Table 2.12.1 page 5

Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Bacheler et al. 2008	Mercer 1984	Murphy and Taylor 1990	Porch et al. 2002	Goodyear 1987	Goodyear 1989	Goodyear 1996	Winner et al. 2014
Ageing method	Not reported (0.0)	0.0							
	Other hard part (0.5)								
	Age-at-Length Key/tag-recapture (0.5)	0.5							
	Scales (0.5)								
	Otoliths: Whole (0.5), Section (1.0)		1.0	1.0	1.0	1.0	1.0	1.0	1.0
Age validated	Not reported (0.0)	0.0			0.0	0.0	0.0	0.0	0.0
	Captive Rearing (0.5)								
	Marginal increment (0.5)		0.5						
	Temporal length frequency (0.5)								
	Tag-recapture with chemical marking (0.5)			1.0					
	Radiochemical Dating (1.0)								
Reader precision	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)			0.5					
	Average Percent Error (1.0)								
	Estimate of variation (CVs) (1.0)								
Number of samples per age class	Not reported (0.0)								
	5 (0.5)								
	10 (0.5)		0.5						
	20+ (1.0)	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Growth parameters estimation method	Not reported (0.0)	0.0							
	Waldford plot (0.5)								
	Length Frequency (0.5)		0.5						
	Min. least squares (SAS, R, Excel) (1.0)			1.0	1.0	1.0	1.0	1.0	1.0
LENGTH-WEIGHT	**Length-Weight Score**	**0.0**	**1.0**	**1.0**	**0.0**	**0.7**	**0.7**	**1.0**	**1.0**
	Length-Weight * Sampling Score	**0.0**	**0.75**	**0.75**	**0.00**	**0.50**	**0.50**	**0.75**	**0.75**
Length	Not reported (0.0)								
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Weight	Not reported (0.0)	0.0			0.0	0.0	0.0		
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)		1.0	1.0				1.0	1.0
Number of samples per length bin	Not reported (0.0)								
	5 (0.5)								
	10 (0.5)								
	20+ (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	0.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0

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Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Bacheler et al. 2008	Mercer 1984	Murphy and Taylor 1990	Porch et al. 2002	Goodyear 1987	Goodyear 1989	Goodyear 1996	Winner et al. 2014
MATURITY	**Maturity Score**	**0.00**	**0.64**	**0.79**	**0.00**	**0.14**	**0.57**	**0.71**	**0.64**
	Maturity * Sampling Score	**0.00**	**0.48**	**0.59**	**0.00**	**0.11**	**0.43**	**0.54**	**0.48**
Number of reproductive samples	Not reported (0.0)	0.0			0.0	0.0	0.0	0.0	
	<200 (0.5)		0.5	0.5					
	201-500 (0.5)								
	>501 (1.0)								1.0
Length	Not reported (0.0)	0.0			0.0	0.0			
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)		1.0	1.0			1.0	1.0	1.0
Weight	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0	1.0	
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)			1.0					1.0
Age	Not reported (0.0)	0.0			0.0	0.0	1.0	1.0	
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)		1.0	1.0					1.0
Sex determination methods	Not reported (0.0)	0.0			0.0	0.0			
	Macroscopic examination (0.5)								0.5
	Histological examination (1.0)		1.0	1.0			1.0	1.0	
Length of maturity estimation method	Not reported (0.0)	0.0			0.0				0.0
	Estimated based on observed (0.5)		0.5	0.5		0.5	0.5	0.5	
	Data fit using Logistic Model (1.0)								
Age of maturity estimation method	Not reported (0.0)	0.0			0.0				0.0
	Estimated based on observed (0.5)		0.5	0.5		0.5	0.5	0.5	
	Data fit using Logistic Model (1.0)								
MORTALITY	**Mortality Score**	**0.50**	**0.00**	**1.00**	**0.00**	**0.50**	**0.50**	**0.50**	**0.00**
	Mortality * Sampling Score	**0.40**	**0.00**	**0.75**	**0.00**	**0.38**	**0.38**	**0.38**	**0.00**
Natural mortality estimation method	Not reported (0.0)		0.0		0.0				0.0
	Based on VB growth parameters (0.5)								
	Tag-recapture (0.5)	0.5				0.5	0.5	0.5	
	Based on maximum age (1.0)			1.0					
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.50**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.38**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0		0.0	0.0
	Based on meta-analysis (0.5)						0.5		
	Previous stock assessment (1.0)								

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Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Lowerre-Barbieri et al. 2016	Beckman et al. 1989	Boothby and Avault Jr. 1971	Green et al. 1985	Wilson and Nieland 2000	Bass and Avault 1975	Overstreet 1983	McInerny and Potts unpublished
SAMPLING		**0.67**	**0.58**	**0.58**	**0.58**	**0.58**	**0.50**	**0.50**	**0.50**
Sampling location	Not reported (0.0)								
	South America (0.5)								
	Caribbean (0.5)								
	Campeche/Yucatan (0.5)								
	U.S. South Atlantic (0.5)								
	U.S. Gulf of Mexico (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sampling timeframe	Not reported (0.0)								
	< 12 Months (0.0)						0.0	0.0	0.0
	1-2 years (0.5)	0.5	0.5	0.5		0.5			
	3-4 years (0.5)				0.5				
	5+ years (1.0)								
Time since sampling	20+ years (0.0)		0.0	0.0	0.0		0.0	0.0	
	19-11 years (0.5)					0.5			
	10-1 years (1.0)	1.0							1.0
Sampling frequency	Not reported (0.0)				0.0				0.0
	Seasonal (0.5)		0.5			0.5			
	Annual (0.5)	0.5							
	Monthly (1.0)			1.0			1.0	1.0	
	Daily (1.0)								
Sampling method	Not reported (0.0)								
	Fishery independent (0.5)	0.5	0.5				0.5	0.5	0.5
	Fishery Dependent (0.5)			0.5		0.5			
	Combination (FI & FD) (1.0)				1.0				
Sampling gear	Not reported (0.0)								
	Active gear (e.g., hook and line) (0.5)	0.5				0.5		0.5	0.5
	Passive gear (e.g., nets) (0.5)			0.5			0.5		
	Combo(1.0)		1.0		1.0				
AGE-LENGTH	**Age-Length Score**	**0.13**	**0.88**	**0.00**	**0.31**	**0.63**	**0.19**	**0.25**	**0.88**
	Age-Length * Sampling Score	**0.08**	**0.51**	**0.00**	**0.18**	**0.36**	**0.1**	**0.13**	**0.44**
Total sample size of age structures	Not reported (0.0)	0.0		0.0	0.0				
	<200 (0.5)						0.5		
	201-500 (0.5)							0.5	
	>501 (1.0)		1.0			1.0			1.0
Length	Not reported (0.0)			0.0					
	Narrow range metrics (0.5)					0.5	0.5		
	Wide range metrics (1.0)	1.0	1.0		1.0			1.0	1.0
Age	Not reported (0.0)	0.0		0.0	0.0			0.0	
	Narrow range metrics (0.5)						0.5		
	Wide range metrics (1.0)		1.0			1.0			1.0

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Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Lowerre-Barbieri et al. 2016	Beckman et al. 1989	Boothby and Avault Jr. 1971	Green et al. 1985	Wilson and Nieland 2000	Bass and Avault 1975	Overstreet 1983	McInerny and Potts unpublished
Ageing method	Not reported (0.0)	0.0		0.0			0.0	0.0	
	Other hard part (0.5)								
	Age-at-Length Key/tag-recapture (0.5)				0.5				
	Scales (0.5)								
	Otoliths: Whole (0.5), Section (1.0)		1.0			1.0			1.0
Age validated	Not reported (0.0)	0.0		0.0	0.0	0.0	0.0	0.0	
	Captive Rearing (0.5)								
	Marginal increment (0.5)		0.5						0.5
	Temporal length frequency (0.5)								
	Tag-recapture with chemical marking (0.5)								
	Radiochemical Dating (1.0)								
Reader precision	Not reported (0.0)	0.0		0.0	0.0	0.0	0.0	0.0	
	Percent Frequency (0.5)								
	Average Percent Error (1.0)								
	Estimate of variation (CVs) (1.0)		1.0						1.0
Number of samples per age class	Not reported (0.0)	0.0		0.0			0.0	0.0	
	5 (0.5)								
	10 (0.5)					0.5			0.5
	20+ (1.0)		1.0		1.0				
Growth parameters estimation method	Not reported (0.0)	0.0		0.0	0.0		0.0		
	Waldford plot (0.5)								
	Length Frequency (0.5)		0.5					0.5	
	Min. least squares (SAS, R, Excel) (1.0)					1.0			1.0
LENGTH-WEIGHT	**Length-Weight Score**	**0.0**	**1.0**	**0.0**	**0.0**	**0.7**	**0.7**	**0.8**	**0.8**
	Length-Weight * Sampling Score	**0.00**	**0.58**	**0.00**	**0.00**	**0.39**	**0.3**	**0.38**	**0.42**
Length	Not reported (0.0)			0.0					
	Narrow range metrics (0.5)					0.5	0.5		
	Wide range metrics (1.0)	1.0	1.0		1.0			1.0	1.0
Weight	Not reported (0.0)	0.0		0.0	0.0				
	Narrow range metrics (0.5)						0.5		
	Wide range metrics (1.0)		1.0			1.0		1.0	1.0
Number of samples per length bin	Not reported (0.0)	0.0		0.0				0.0	
	5 (0.5)								
	10 (0.5)					0.5			0.5
	20+ (1.0)		1.0		1.0		1.0	1.0	
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	0.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0

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Red Drum	***Sciaenops ocellatus***								
Criteria	**Description**	Lowerre-Barbieri et al. 2016	Beckman et al. 1989	Boothby and Avault Jr. 1971	Green et al. 1985	Wilson and Nieland 2000	Bass and Avault 1975	Overstreet 1983	McInerny and Potts unpublished
MATURITY	**Maturity Score**	**0.43**	**0.67**	**0.07**	**0.00**	**0.86**	**0.00**	**0.57**	**0.00**
	Maturity * Sampling Score	**0.29**	**0.39**	**0.04**	**0.00**	**0.50**	**0.00**	**0.29**	**0.00**
Number of reproductive samples	Not reported (0.0)			0.0	0.0		0.0		0.0
	<200 (0.5)								
	201-500 (0.5)							0.5	
	>501 (1.0)	1.0	1.0			1.0			
Length	Not reported (0.0)			0.0	0.0		0.0		0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)	1.0	1.0			1.0		1.0	
Weight	Not reported (0.0)	0.0		0.0	0.0		0.0		0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)		1.0			1.0		1.0	
Age	Not reported (0.0)	0.0		0.0	0.0		0.0	0.0	0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)		1.0			1.0			
Sex determination methods	Not reported (0.0)				0.0		0.0		0.0
	Macroscopic examination (0.5)			0.5					
	Histological examination (1.0)	1.0				1.0		1.0	
Length of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0		0.0		0.0
	Estimated based on observed (0.5)					0.5		0.5	
	Data fit using Logistic Model (1.0)								
Age of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0		0.0	0.0	0.0
	Estimated based on observed (0.5)					0.5			
	Data fit using Logistic Model (1.0)								
MORTALITY	**Mortality Score**	**0.00**	**0.00**	**0.00**	**0.50**	**1.00**	**0.00**	**0.00**	**0.00**
	Mortality * Sampling Score	**0.00**	**0.00**	**0.00**	**0.29**	**0.58**	**0.00**	**0.00**	**0.00**
Natural mortality estimation method	Not reported (0.0)	0.0	0.0	0.0			0.0	0.0	0.0
	Based on VB growth parameters (0.5)								
	Tag-recapture (0.5)				0.5				
	Based on maximum age (1.0)					1.0			
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)								
	Previous stock assessment (1.0)								

Table 2.12.2 Summary of Red Drum von Bertalanffy growth model parameters reported in the literature and estimated using 5 datasets provided for SEDAR49. Data were fit using a non-linear least squares regression (R; nls). Reliability rubric reflects age-length * sampling score (0 = low, 0.5 = medium, 1.0 = high).

Reference	Reliability rubric	N	Sampling timeframe	Sampling location	Length range (mm)	Max age (y)	L_∞ (mm)	k	t_0
Murphy and Taylor 1990	0.70	551 (GOM)	1981 – 1983	GOM and ATL	225 – 980 (FL) (GOM)	24 (GOM)	934 (FL)	0.460	0.029
Powers et al. 2012	0.63	403	2008 – 2010	MS AL	660 – 1156 (TL)	38	M 923 (FL) F 965 (FL) C 993 (FL)	M 0.110 F 0.109 C 0.109	M -10.00 F - 10.00 C -10.00
Beckman et al. 1989	0.51	1,726	1985 – 1987	GOM	~560 – 1060 (FL)	M 37 F 36	M 909 (FL) F 1013 (FL)	M 0.137 F 0.088	M -7.74 F -11.29
McInerny and Potts (unpublished)	0.44	1,146	2002	GOM (most LA, MS)	212 – 1187 (FL)	37	962 (FL)	K_1 0.37 K_2 0.12	T_1 0.35 T_2 -7.01
Wilson and Nieland 2000	0.36	929 (1990s) 1,352 (1980s)	1986 – 1988 1997 – 1998	GOM	~600 – ~1100 (FL)	42	$M_{80's}$ 890.3 (FL) $M_{90's}$ 905.8 (FL) $F_{80's}$ 989.0 (FL) $F_{90's}$ 970.8 (FL)	0.17 0.15 0.08 0.14	-7.01 -5.40 -14.29 -5.69
5 datasets combined		7,848	1986 – 2014	GOM	164 – 1128 (FL)	42	881 (FL)	0.32	-1.29

Table 2.12.3 Description of the five Red Drum datasets available for SEDAR49.

Reference	Data provider	N	Sampling timeframe	Sampling location	Gear	Length range (max TL, mm)	Age range (y)
Wilson and Nieland 2000	LSU	2,279	1986 – 1987 1997 – 1998	TX, LA, MS, AL, FL	Purse seine	620 – 1149	2 – 42
McInerny and Potts (unpublished report)	NMFS	1,146	2002	LA, MS, AL, FL	Handline	212 – 1187	1 – 37
Powers et al. 2012 Hightower et al. 2016	USA/DISL	1,540	2008 – 2014	MS, AL	Longline Purse seine Handline	235 – 1195	0 – 40
Winner et al. 2014	FWRI	1,725	1996 – 1998 2006 – 2008	FL	Purse seine	674 – 1085	2 – 35
None	MDMR	1,158	2005 – 2014	MS	Gill net	202 – 1065	0 – 31, majority <4

Table 2.12.4 LHWG summary of recommendations for Red Drum life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – *a* from weight-length regression; beta – *b* from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; *h* – steepness; Sigma *R* – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	42 y	Maximum age observed (Wilson and Nieland 2000)	0.14	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	36 − 42 y	Range of plausible values obtained from reliable studies (Beckman et al. 1989; Wilson and Nieland 2000)
M	0.160 y^{-1}	Then et al. (2015) using maximum age	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2015)	0.160 − 0.184 y^{-1}	Range based on plausible values of maximum age
L ∞	881 mm FL	Recalculated from SEDAR49 analysis for FL	1.123	SE from SEDAR49 analysis for FL (N = 7,763)	878 − 883 mm FL	95% Confidence intervals from SEDAR 49 analysis for FL
k	0.32	Recalculated from SEDAR49 analysis for FL	0.003	SE from SEDAR49 analysis for FL (N = 7,763)	0.314 − 0.325	95% Confidence intervals from SEDAR 49 analysis for FL
t0	-1.29	Recalculated from SEDAR49 analysis for FL	0.033	SE from SEDAR49 analysis for FL (N = 7,763)	-1.33 − -1.25	95% Confidence intervals from SEDAR 49 analysis for FL
alpha	1.43E-05	Value from SEDAR49 data analysis from FL to W Wt	1.14E-06	SE from SEDAR49 data analysis from FL to W Wt (N = 4,669)	-	-
beta	3.15	Value from SEDAR49 data analysis from FL to W Wt	1.78E-02	SE from SEDAR49 data analysis from FL to W Wt (N = 4,669)	-	-
L50	680 mm FL	Mean reported values for sexes (Wilson and Nieland 1994)	0.3	Best guess	665 − 695 mm FL	Range of reported values for sexes in Wilson and Nieland (1994)
L95	810 mm FL	Length at full maturity (Wilson and Nieland 1994)	0.3	Best guess	No data available	No data available
h	0.9	Based on midpoint of range; see Adams et al. (2016), Table 8	0.11	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	0.8 − 1.0	Range considered in SEDAR 2015a and Chagaris et al. (2015); see Adams et al. (2016), Table 8
Sigma *R*	-	-	-	-	0.6 − 0.76	Range considered in SEDAR (2015a); see Adams et al. (2016),

Table 8

Table 2.12.5 Summary of Red Drum reproductive parameters reported in the literature. Reliability rubric reflects maturity * sampling score (0 = low, 0.5 = medium, 1.0 = high).

Reference	Reliability rubric	N	Sampling timeframe	Sampling location	Length range (mm)	Macro/ Histo	A_{50}	L_{50} (mm FL)
Wilson and Nieland 1994	0.86	3,351	1986 – 1992	GOM: TX,LA,MS, AL	399 – 1115 (FL)	Both	3 – 4	M 660 – 670 F 690 – 700
Murphy and Taylor 1990	0.59	M 265 F 260 (GOM)	1981 – 1983	GOM and ATL	225 – 1110 (FL)	Both		825 (GOM) macro
Overstreet 1983	0.29	861	1978 – 1982	MS	143 – 857 (SL)	Both		

Table 2.12.6 Meristic regressions for Red Drum *(*1986 – 2015) from the Gulf of Mexico. Data combined from all fishery-independent data sources. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length, SL – Standard Length; Weight Type: W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively).

Regression	Equation	Parameters ± std. err.	Statistic	N	Data range
Max TL to Nat TL	Nat TL = a + max_TL *b	a = 0.49 ± 0.11 b = 0.97 ± 0.14e-02	r^2 = 0.9976	1,265	Max TL:40.80 – 119.50 Nat TL: 40.20 – 118.00
Max TL to FL	FL = a + max_TL *b	a = 1.95 ± 0.07 b = 0.92 ± 0.91-03	r^2 = 0.9983	1,745	Max TL: 24.30 – 119.50 FL: 23.90 – 112.80
Max TL to SL	SL = a + max_TL *b	a = -0.53 ± 0.06 b = 0.84 ± 0.79e-03	r^2 = 0.9956	5,012	Max TL:19.00 – 119.50 SL: 15.00 – 102.20
Nat TL to FL	FL = a + nat_TL * b	a = 1.97 ± 0.16 b = 0.93 ± 0.20e-02	r^2 = 0.9921	1,726	Nat TL:40.20 – 118.00 FL: 39.20 – 112.80
Nat TL to SL	SL = a + nat_TL * b	a = -1.38 ± 0.15 b = 0.86 ± 0.16e-02	r^2 = 0.9638	10,539	Nat TL: 40.20 – 118.00 SL: 33.40 – 102.20
SL to FL	FL = a + SL * b	a = 3.79 ± 0.14 b = 1.07 ± 0.21e-02	r^2 = 0.9918	2,080	FL:23.90 – 112.80 SL: 20.00 – 102.20
Max TL to W Wt	W WT =a* (max_TL^^{b})	a = 3.19e-05 ± 5.90e-07 b = 2.93 ± 4.12e-03	RSE = 1.024	28,344	Max TL:5.30 – 119.90 W WT: 0.06 – 44.97
Nat TL to W Wt	W WT = a* (nat_TL^^{b})	a = 1.97e-05 ± 2.83e-06 b = 3.05 ± 3.19e-02	RSE = 2.136	1,805	Nat TL: 40.20 – 118.00 W WT: 1.26 – 44.97
FL to W Wt	W WT = a* (FL^^{b})	a = 1.43e-05 ± 1.14e-06 b = 3.15 ± 1.78e-02	RSE = 1.983	4,669	FL: 21.00 – 112.80 W WT: 0.25 – 44.97
SL to W Wt	W WT = a* (SL^^{b})	a = 7.72e-05 ± 4.86e-06 b = 2.84 ± 1.45e-02	RSE = 1.553	5,227	SL: 15.00 – 102.20 W WT: 0.17 – 44.97

Table 2.12.7. Reliability rubric for Lane Snapper (see section 2.2 for detailed information on the construction of this rubric).

Lane Snapper	***Lutjanus synagris***								
Criteria	**Description**	Mikulas and Rooker 2008	Johnson et al. 1995	Manooch and Mason 1984	Manickchand -Dass 1987	Freitas et al. 2014	Luckhurst et al. 2000	Aiken 2001	Acosta and Appeldoorn 1992
SAMPLING		**0.75**	**0.60**	**0.58**	**0.58**	**0.58**	**0.50**	**0.42**	**0.42**
Sampling location	Not reported (0.0)								
	South America (0.5)					0.5			
	Caribbean (0.5)				0.5		0.5	0.5	0.5
	Campeche/Yucatan (0.5)								
	U.S. South Atlantic (0.5)								
	U.S. Gulf of Mexico (1.0)	1.0	1.0	1.0					
Sampling timeframe	Not reported (0.0)								
	< 12 Months (0.0)								0.0
	1-2 years (0.5)	0.5				0.5			
	3-4 years (0.5)		0.5		0.5		0.5	0.5	
	5+ years (1.0)			1.0					
Time since sampling	20+ years (0.0)			0.0	0.0				0.0
	19-11 years (0.5)	0.5				0.5	0.5	0.5	
	10-1 years (1.0)								
Sampling frequency	Not reported (0.0)			0.0					
	Annual (0.5)		0.5				0.5		
	Monthly (1.0)				1.0			0.5	1.0
	Daily (1.0)	1.0				1.0			
Sampling method	Not reported (0.0)								
	Fishery independent (0.5)	0.5			0.5				
	Fishery Dependent (0.5)		0.5			0.5	0.5	0.5	0.5
	Combination (FI & FD) (1.0)			1.0					
Sampling gear	Not reported (0.0)							0.0	
	Active gear (e.g., hook and line) (0.5)		0.5	0.5		0.5	0.5		0.5
	Passive gear (e.g., nets) (1.0)	1.0			1.0				
AGE-LENGTH	**Age-Length Score**	**0.69**	**0.94**	**0.75**	**0.81**	**0.00**	**0.69**	**0.69**	**0.31**
	Age-Length * Sampling Score	**0.52**	**0.56**	**0.44**	**0.47**	**0.00**	**0.34**	**0.29**	**0.13**
Total sample size of age structures	Not reported (0.0)					0.0			0.0
	<200 (0.5)								
	201-500 (0.5)						0.5		
	>501 (1.0)	1.0	1.0	1.0	1.0			1.0	
Length	Not reported (0.0)					0.0			
	Narrow range metrics (0.5)	0.5							
	Wide range metrics (1.0)		1.0	1.0	1.0		1.0	1.0	1.0
Age	Not reported (0.0)					0.0			
	Narrow range metrics (0.5)	0.5							
	Wide range metrics (1.0)		1.0	1.0	1.0		1.0	1.0	1.0
Ageing method	Not reported (0.0)					0.0			0.0
	Other hard part (0.5)								
	Scales (0.5)						0.5		
	Otoliths: Whole (0.5), Section (1.0)	1.0	1.0	1.0	1.0			1.0	

continue Table 2.12.7 page 2

Lane Snapper	***Lutjanus synagris***								
Criteria	**Description**	Mikulas and Rooker 2008	Johnson et al. 1995	Manooch and Mason 1984	Manickchand -Dass 1987	Freitas et al. 2014	Luckhurst et al. 2000	Aiken 2001	Acosta and Appeldoorn 1992
Age validated	Not reported (0.0)			0.0		0.0			0.0
	Captive Rearing (0.5)								
	Marginal increment (0.5)		0.5		0.5		0.5	0.5	
	Temporal length frequency (0.5)								
	Tag-recapture with chemical marking (0.5)	0.5							
	Radiochemical Dating (1.0)								
Reader precision	Not reported (0.0)			0.0	0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)	0.5							
	Average Percent Error (1.0)		1.0						
	Estimate of variation (CVs) (1.0)								
Number of samples per age class	Not reported (0.0)					0.0			0.0
	5 (0.5)								
	10 (0.5)							0.5	
	20+ (1.0)	1.0	1.0	1.0	1.0		1.0		
Growth parameters estimation method	Not reported (0.0)					0.0			
	Waldford plot (0.5)								
	Length Frequency (0.5)	0.5						0.5	0.5
	Min. least squares (SAS, R, Excel) (1.0)		1.0	1.0	1.0		1.0		
LENGTH-WEIGHT	**Length-Weight Score**	**0.00**	**1.00**	**1.00**	**0.00**	**0.00**	**0.00**	**0.83**	**0.50**
	Length-Weight * Sampling Score	**0.00**	**0.60**	**0.58**	**0.00**	**0.00**	**0.00**	**0.35**	**0.21**
Length	Not reported (0.0)					0.0			
	Narrow range metrics (0.5)	0.5							
	Wide range metrics (1.0)		1.0	1.0	1.0		1.0	1.0	1.0
Weight	Not reported (0.0)				0.0	0.0	0.0		0.0
	Narrow range metrics (0.5)	0.5							
	Wide range metrics (1.0)		1.0	1.0				1.0	
Number of samples per length bin	Not reported (0.0)								
	5 (0.5)								
	10 (0.5)				0.5			0.5	
	20+ (1.0)	1.0	1.0	1.0		1.0	1.0		0.5
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	0.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0

continue Table 2.12.7 page 3

Lane Snapper	***Lutjanus synagris***								
Criteria	**Description**	Mikulas and Rooker 2008	Johnson et al. 1995	Manooch and Mason 1984	Manickchand -Dass 1987	Freitas et al. 2014	Luckhurst et al. 2000	Aiken 2001	Acosta and Appeldoorn 1992
MATURITY	**Maturity Score**	**0.14**	**0.00**	**0.00**	**0.71**	**0.57**	**0.29**	**0.29**	**0.00**
	Maturity * Sampling Score	**0.11**	**0.00**	**0.00**	**0.42**	**0.33**	**0.14**	**0.12**	**0.00**
Number of reproductive samples	Not reported (0.0)			0.0					0.0
	<200 (0.5)								
	201-500 (0.5)						0.5	0.5	
	>501 (1.0)	1.0			1.0	1.0			
Length	Not reported (0.0)	0.0	0.0	0.0					0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)				1.0	1.0	1.0	1.0	
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)								
Age	Not reported (0.0)	0.0	0.0	0.0		0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)								
	Wide range metrics (1.0)				1.0				
Sex determination methods	Not reported (0.0)	0.0	0.0	0.0				0.0	0.0
	Macroscopic examination (0.5)						0.5		
	Histological examination (1.0)				1.0	1.0			
Length of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0			0.0	0.0	0.0
	Estimated based on observed (0.5)				0.5				
	Data fit using Logistic Model (1.0)					1.0			
Age of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0		0.0	0.0		0.0
	Estimated based on observed (0.5)				0.5			0.5	
	Data fit using Logistic Model (1.0)								
MORTALITY	**Mortality Score**	**1.00**	**0.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.50**
	Mortality * Sampling Score	**0.75**	**0.30**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.21**
Natural mortality estimation method	Not reported (0.0)			0.0	0.0	0.0	0.0	0.0	
	Based on VB growth parameters (0.5)		0.5						0.5
	Based on maximum age (1.0)	1.0							
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)								
	Previous stock assessment (1.0)								

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Lane Snapper	***Lutjanus synagris***					
Criteria	**Description**	Torres and Chavez 1987	Rodriquez-Castro et al. 1999	Claro and Reshetnikov 1981	Allen 1985	Alegria and de Menezes 1970
SAMPLING		**0.33**	**0.08**	**0.08**	**0.00**	**0.00**
Sampling location	Not reported (0.0)		0.0		0.0	
	South America (0.5)					0.0
	Caribbean (0.5)			0.5		
	Campeche/Yucatan (0.5)	0.5				
	U.S. South Atlantic (0.5)					
	U.S. Gulf of Mexico (1.0)					
Sampling timeframe	Not reported (0.0)		0.0	0.0	0.0	
	< 12 Months (0.0)	0.0				0.0
	1-2 years (0.5)					
	3-4 years (0.5)					
	5+ years (1.0)					
Time since sampling	20+ years (0.0)	0.0		0.0	0.0	0.0
	19-11 years (0.5)		0.5			
	10-1 years (1.0)					
Sampling frequency	Not reported (0.0)		0.0	0.0	0.0	0.0
	Annual (0.5)					
	Monthly (1.0)	1.0				
	Daily (1.0)					
Sampling method	Not reported (0.0)		0.0	0.0	0.0	0.0
	Fishery independent (0.5)					
	Fishery Dependent (0.5)	0.5				
	Combination (FI & FD) (1.0)					
Sampling gear	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Active gear (e.g., hook and line) (0.5)					
	Passive gear (e.g., nets) (1.0)					
AGE-LENGTH	**Age-Length Score**	**0.50**	**0.00**	**0.13**	**0.00**	**0.50**
	Age-Length * Sampling Score	**0.17**	**0.00**	**0.01**	**0.00**	**0.00**
Total sample size of age structures	Not reported (0.0)		0.0		0.0	
	<200 (0.5)			0.5		
	201-500 (0.5)	0.5				
	>501 (1.0)					1.0
Length	Not reported (0.0)		0.0		0.0	
	Narrow range metrics (0.5)	0.5		0.5		0.5
	Wide range metrics (1.0)					
Age	Not reported (0.0)		0.0	0.0	0.0	
	Narrow range metrics (0.5)	0.5				
	Wide range metrics (1.0)					0.5
Ageing method	Not reported (0.0)		0.0	0.0	0.0	0.0
	Other hard part (0.5)					
	Scales (0.5)	0.5				
	Otoliths: Whole (0.5), Section (1.0)					

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Lane Snapper	***Lutjanus synagris***					
Criteria	**Description**	Torres and Chavez 1987	Rodriquez-Castro et al. 1999	Claro and Reshetnikov 1981	Allen 1985	Alegria and de Menezes 1970
Age validated	Not reported (0.0)		0.0	0.0	0.0	
	Captive Rearing (0.5)					
	Marginal increment (0.5)					0.5
	Temporal length frequency (0.5)	0.5				
	Tag-recapture with chemical marking (0.5)					
	Radiochemical Dating (1.0)					
Reader precision	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)					
	Average Percent Error (1.0)					
	Estimate of variation (CVs) (1.0)					
Number of samples per age class	Not reported (0.0)		0.0	0.0	0.0	
	5 (0.5)					
	10 (0.5)					
	20+ (1.0)	1.0				1.0
Growth parameters estimation method	Not reported (0.0)		0.0	0.0	0.0	
	Waldford plot (0.5)	0.5				0.5
	Length Frequency (0.5)					
	Min. least squares (SAS, R, Excel) (1.0)					
LENGTH-WEIGHT	**Length-Weight Score**	**0.50**	**0.00**	**0.00**	**0.00**	**0.00**
	Length-Weight * Sampling Score	**0.17**	**0.00**	**0.00**	**0.00**	**0.00**
Length	Not reported (0.0)		0.0		0.0	
	Narrow range metrics (0.5)	0.5		0.5		0.5
	Wide range metrics (1.0)					
Weight	Not reported (0.0)		0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)	0.5				
	Wide range metrics (1.0)					
Number of samples per length bin	Not reported (0.0)		0.0	0.0	0.0	0.0
	5 (0.5)					
	10 (0.5)	0.5				
	20+ (1.0)					
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	0.0	0.0	0.0	0.0

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Lane Snapper	***Lutjanus synagris***					
Criteria	**Description**	Torres and Chavez 1987	Rodriquez-Castro et al. 1999	Claro and Reshetnikov 1981	Allen 1985	Alegria and de Menezes 1970
MATURITY	**Maturity Score**	**0.14**	**0.21**	**0.00**	**0.00**	**0.00**
	Maturity * Sampling Score	**0.05**	**0.02**	**0.00**	**0.00**	**0.00**
Number of reproductive samples	Not reported (0.0)			0.0	0.0	0.0
	<200 (0.5)	0.5				
	201-500 (0.5)		0.5			
	>501 (1.0)					
Length	Not reported (0.0)	0.0		0.0	0.0	0.0
	Narrow range metrics (0.5)		0.5			
	Wide range metrics (1.0)					
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)					
Age	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)					
Sex determination methods	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Macroscopic examination (0.5)					
	Histological examination (1.0)					
Length of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)					
	Data fit using Logistic Model (1.0)					
Age of maturity estimation method	Not reported (0.0)			0.0	0.0	0.0
	Estimated based on observed (0.5)	0.5	0.5			
	Data fit using Logistic Model (1.0)					
MORTALITY	**Mortality Score**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Mortality * Sampling Score	**0.33**	**0.00**	**0.00**	**0.00**	**0.00**
Natural mortality estimation method	Not reported (0.0)		0.0	0.0	0.0	0.0
	Based on VB growth parameters (0.5)					
	Based on maximum age (1.0)	1.0				
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)					
	Previous stock assessment (1.0)					

Table 2.12.8 Summary of Lane Snapper von Bertalanffy growth model parameters reported in the literature and estimated using a non-linear least squares regression (R; nls) on the raw data from Johnson et al. 1995. Reliability rubric reflects age-length * sampling score (0 = low, 0.5 = medium, 1.0 = high).

Reference	Reliability rubric	N	Sampling timeframe	Sampling location	Length range (mm)	Age range (y)	L_∞ (mm)	k	t_0
Johnson et al. 1995	0.56	694	1991 – 1994	Northern GOM	210 – 673 (TL)	2 – 17	479 (TL)	0.126	-4.25
Manooch and Mason 1984	0.44	931		Florida (East coast)	168 – 512 (TL)	0 – 10	501 (TL)	0.133	-1.49
Luckhurst et al. 2000	0.34	300	1992 – 1996	Bermuda	180 – 370 (FL)	1 – 19	331 (FL)	0.395	-1.95
Torres and Chavez 1987	0.17	143		Yucatan	140 – 360 (unk)	0 – 5	410 (unk)	0.247	-1.84
Acosta and Appledorn 1992	0.13	1,308	1988	Puerto Rico	145 – 415 (TL)	1.5 – 8	450 (FL)	0.23	
Raw data (Johnson)		694			210 – 520 (TL)	1 – 17	449 (FL)	0.17	-2.59

Table 2.12.9 LHWG summary of recommendations for Lane Snapper life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – *a* from weight-length regression; beta – *b* from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; *h* – steepness; Sigma *R* – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	19 y	Maximum age observed in meta-analysis (Luckhurst et al. 2000)	0.11	$max\left\|\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\|$	17 − 19 y	Range of values obtained from reliable studies (Johnson et al. 1995; Luckhurst et al. 2000)
M	0.330 y^{-1}	Calculated from Then et al. (2015) using maximum age	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2015)	0.330 − 0.366 y^{-1}	Range based on plausible values of maximum age
$L\infty$	449 mm FL	Recalculated from SEDAR49 analysis for FL	17.221	SE from SEDAR49 analysis for FL (N =675)	422 − 493 mm FL	95% Confidence intervals from SEDAR 49 analysis for FL
k	0.17	Recalculated from SEDAR49 analysis for FL	0.027	SE from SEDAR49 analysis for FL (N =675)	0.116 − 0.219	95% Confidence intervals from SEDAR 49 analysis for FL
t0	-2.59	Recalculated from SEDAR49 analysis for FL	0.668	SE from SEDAR49 analysis for FL (N =675)	-4.16 − -1.51	95% Confidence intervals from SEDAR 49 analysis for FL
alpha	5.92E-05	Value from SEDAR49 data analysis for FL to W Wt	3.29E-06	SE from SEDAR49 data analysis for FL to W Wt (N = 6,395)	-	-
beta	2.86	Value from SEDAR49 data analysis for FL to W Wt	1.57E-02	SE from SEDAR49 data analysis for FL to W Wt (N = 6,395)	-	-
L50	240 mm FL	Luckhurst et al. (2000)	0.3	Best guess	235 − 245 mm FL	Range of reported values for sexes in Luckhurst et al. (2000)
L95	270 mm FL	Based on size of ages 2 – 3 fish	0.3	Best guess	260 − 280 mm FL	Range of reported values for sexes in Luckhurst et al. (2000)
h	0.95	Estimate for Lutjanidae (Myers et al. 1999); see Adams et al. (2016), Table 8	0.47	$max\left\|\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\|$	0.5 − 0.99	Range considered in past snapper SEDARs; see Adams et al. (2016), Table 8
Sigma *R*	-	-	-	-	0.3 − 0.75	Range considered in past snapper SEDARs; see Adams et al. (2016), Table 8

Table 2.12.10 Summary of Lane Snapper reproductive parameters reported in the literature. Reliability rubric reflects reproduction * sampling score (0 = low, 0.5 = medium, 1.0 = high).

Reliability criteria	Manickchand-Dass 1987	Freitas et al. 2014	Luckhurst et al. 2000	Aiken 2001
Reliability score	0.42	0.33	0.14	0.12
Sampling location	Trinidad	Abrolhos Bank, eastern Brazil	Bermuda reef platform	South Shelf Jamaica
Sampling timeframe	November 1979 to November 1981	May 2005 and October 2007	1992 to 1996	February 1996 to June 1999
Sampling gear	Fish pot and trawl	Monthly surveys of hand line and gillnet landings	Fishery-dependent Hook and Line	Fishery-dependent Monofilament beach seine
Age sample size	143		300	94
Length	15 – 46 cm TL	14.7 – 56.0 cm TL	18 – 37 cm FL	15 – 43 cm FL
Age range	0 – 4 (y)		0 – 19 (y)	0 – 14 (y)
Gonad sample size	992 (macroscopic)	770 (histological)	1,034 (macroscopic)	Unknown subset (macroscopic)
Maturity				
L_{50}	M 25 cm TL F 31 cm TL	M 24 cm TL F 23 cm TL	M 23.5 cm FL F 24.5 cm FL	M 221 mm FL F 268 mm FL
A_{50}	M 1 y F 2 y			

Table 2.12.11 Meristic regressions for Lane Snapper (1982 – 2015) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and -dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length; Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively). Regressions only calculated for sample size ≥ 50.

Regression	Equation	Parameters ± std. err.	Statistic	N	Data range
Max TL to Nat TL	Nat TL = a + max_TL *b	a = 0.28 ± 0.22 b = 0.96 ± 0.01	r^2 = 0.989	273	Max TL:21.9 – 51.9 Nat TL: 21.7 – 50.4
Max TL to FL	FL = a + max_TL *b			0	
Nat TL to FL	FL = a + nat_TL * b	a = -0.05 ± 0.45 b = 0.93 ± 0.01	r^2 = 0.986	58	Nat TL:16.7 – 47.6 FL: 15.5 – 44.0
Max TL to G Wt	G WT = a * (max_TL^b)	a = 2.45e-05 ± 3.73e-06 b = 3.06 ± 4.15e-02	RSE = 0.160	383	Max TL:21.2 – 51.0 G WT: 0.31 – 4.50
Max TL to W Wt	W WT =a* (max_TL^b)	a = 8.46e-05 ± 3.12e-06 b = 2.71 ± 9.89e-03	RSE = 0.119	2,049	Max TL:14.3 – 63.9 W WT: 0.11 – 7.72
Nat TL to G Wt	G WT = a * (nat_TL^b)			8	
Nat TL to W Wt	W WT = a* (nat_TL^b)	a = 2.55e-05 ± 4.48e-07 b = 3.05 ± 4.74e-03	RSE = 0.153	12,668	Nat TL:3.3 – 73.7 W WT: 0.02 – 13.36
FL to G Wt	G WT= a* (FL^b)	a = 2.55e-05 ± 1.15e-05 b = 3.08 ± 1.25e-01	RSE = 0.366	277	FL: 25.2 – 47.3 G WT: 0.33 – 4.10
FL to W Wt	W WT = a* (FL^b)	a = 5.92e-05 ± 3.29e-06 b = 2.86 ± 1.57e-02	RSE = 0.195	6,395	FL: 3.6 – 51.0 W WT: 0.02 – 4.81

Table 2.12.12. Reliability rubric for Wenchman (see section 2.2 for detailed information on the construction of this rubric).

Wenchman	*Pristipomoides aquilonaris*				
Criteria	**Description**	Anderson et al. 2009	Russell et al. 1988	Anderson 1972	Allen 1985
SAMPLING		**0.70**	**0.50**	**0.08**	**0.00**
Sampling location	Not reported (0.0)				0.0
	South America (0.5)				
	Caribbean (0.5)			0.5	
	Campeche/Yucatan (0.5)				
	U.S. South Atlantic (0.5)		0.5		
	U.S. Gulf of Mexico (1.0)	1.0			
Sampling timeframe	Not reported (0.0)				0.0
	< 12 Months (0.0)	0.0		0.0	
	1-2 years (0.5)		0.5		
	3-4 years (0.5)				
	5+ years (1.0)				
Time since sampling	20+ years (0.0)		0.0	0.0	0.0
	19-11 years (0.5)				
	10-1 years (1.0)	1.0			
Sampling frequency	Not reported (0.0)			0.0	0.0
	Annual (0.5)		0.5		
	Monthly (1.0)	1.0			
	Daily (1.0)				
Sampling method	Not reported (0.0)			0.0	0.0
	Fishery independent (0.5)	0.5	0.5		
	Fishery Dependent (0.5)				
	Combination (FI & FD) (1.0)				
Sampling gear	Not reported (0.0)			0.0	0.0
	Active gear (e.g., hook and line) (0.5)				
	Passive gear (e.g., nets) (1.0)		1.0		
AGE-LENGTH	**Age-Length Score**	**0.64**	**0.06**	**0.00**	**0.00**
	Age-Length * Sampling Score	**0.45**	**0.03**	**0.00**	**0.00**
Total sample size of age structures	Not reported (0.0)			0.0	0.0
	<200 (0.5)		0.5		
	201-500 (0.5)				
	>501 (1.0)				
Length	Not reported (0.0)		0.0	0.0	0.0
	Narrow range metrics (0.5)				
	Wide range metrics (1.0)	1.0			
Age	Not reported (0.0)		0.0	0.0	0.0
	Narrow range metrics (0.5)				
	Wide range metrics (1.0)	1.0			
Ageing method	Not reported (0.0)		0.0	0.0	0.0
	Other hard part (0.5)				
	Scales (0.5)				
	Otoliths: Whole (0.5), Section (1.0)	1.0			

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Wenchman	***Pristipomoides aquilonaris***				
Criteria	**Description**	Anderson et al. 2009	Russell et al. 1988	Anderson 1972	Allen 1985
Age validated	Not reported (0.0)	0.0	0.0	0.0	0.0
	Captive Rearing (0.5)				
	Marginal increment (0.5)				
	Temporal length frequency (0.5)				
	Tag-recapture with chemical marking (0.5)				
	Radiochemical Dating (1.0)				
Reader precision	Not reported (0.0)		0.0	0.0	0.0
	Percent Frequency (0.5)				
	Average Percent Error (1.0)	1.0			
	Estimate of variation (CVs) (1.0)				
Number of samples per age class	Not reported (0.0)		0.0	0.0	0.0
	5 (0.5)				
	10 (0.5)	0.5			
	20+ (1.0)				
Growth parameters estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0
	Waldford plot (0.5)				
	Length Frequency (0.5)				
	Min. least squares (SAS, R, Excel) (1.0)				
LENGTH-WEIGHT	**Length-Weight Score**	**0.50**	**0.00**	**0.00**	**0.00**
	Length-Weight * Sampling Score	**0.35**	**0.00**	**0.00**	**0.00**
Length	Not reported (0.0)		0.0	0.0	0.0
	Narrow range metrics (0.5)				
	Wide range metrics (1.0)	1.0			
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)				
	Wide range metrics (1.0)				
Number of samples per length bin	Not reported (0.0)		0.0	0.0	0.0
	5 (0.5)	0.5			
	10 (0.5)				
	20+ (1.0)				
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	0.0	0.0	0.0

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Wenchman	***Pristipomoides aquilonaris***				
Criteria	**Description**	Anderson et al. 2009	Russell et al. 1988	Anderson 1972	Allen 1985
MATURITY	**Maturity Score**	**0.00**	**0.00**	**0.00**	**0.00**
	Maturity * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**
Number of reproductive samples	Not reported (0.0)	0.0	0.0	0.0	0.0
	<200 (0.5)				
	201-500 (0.5)				
	>501 (1.0)				
Length	Not reported (0.0)	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)				
	Wide range metrics (1.0)				
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)				
	Wide range metrics (1.0)				
Age	Not reported (0.0)	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)				
	Wide range metrics (1.0)				
Sex determination methods	Not reported (0.0)	0.0	0.0	0.0	0.0
	Macroscopic examination (0.5)				
	Histological examination (1.0)				
Length of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)				
	Data fit using Logistic Model (1.0)				
Age of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)				
	Data fit using Logistic Model (1.0)				
MORTALITY	**Mortality Score**	**0.00**	**0.00**	**0.00**	**0.00**
	Mortality * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**
Natural mortality estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0
	Based on VB growth parameters (0.5)				
	Based on maximum age (1.0)				
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)				
	Previous stock assessment (1.0)				

Table 2.12.13 LHWG summary of recommendations for Wenchman life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. *Note, the timing of otolith band increments for Wenchman has not been validated. The counts in 'Age' may or may not be annual increments. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – a from weight-length regression; beta – b from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; h – steepness; Sigma R – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	14 y*	Maximum age observed in meta-analysis (Anderson et al. 2009)	No other estimates available	-	No other estimates available	-
M	0.437 y^{-1}	Calculated from Then et al. (2015) using maximum age	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2015)	No other estimates available	-
$L\infty$	240 mm FL	Anderson et al. (2009)	Not provided in reference	No data available	No data available	No data available
k	0.18	Anderson et al. (2009)	Not provided in reference	No data available	No data available	No data available
t0	-4.75	Anderson et al. (2009)	Not provided in reference	No data available	No data available	No data available
alpha	5.30E-05	Value from SEDAR49 data analysis for FL to W Wt	2.09E-06	SE from SEDAR49 data analysis for FL to W Wt (N = 5,424)	-	-
beta	2.90	Value from SEDAR49 data analysis for FL to W Wt	1.29E-02	SE from SEDAR49 data analysis for FL to W Wt (N = 5,424)	-	-
L50	None	No data available	None	No data available	None	No data available
L95	None	No data available	None	No data available	None	No data available
h	0.95	Estimate for Lutjanidae (Myers et al. 1999); see Adams et al. (2016), Table 8	0.47	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	$0.5 - 0.99$	Range considered in past snapper SEDARs; see Adams et al. (2016), Table 8
Sigma R	-	-	-	-	$0.3 - 0.75$	Range considered in past snapper SEDARs; see Adams et al. (2016), Table 8

Table 2.12.14 Summary of life history parameters for other species of the genera, *Pristipomoides* to help inform the assessment model for Wenchman. *Note, the timing of otolith band increments for Wenchman has not been validated. The counts in 'Age' may or may not be annual increments. Parameters: L_∞ - von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient

Common name (Scientific name)	N	Sampling timeframe	Sampling location	Length range (mm FL)	Max age*	L_∞ (mm FL)	k	Length at 50% maturity (mm FL)	Reference
Wenchman *(P. aquilonaris)*	115	2007	Gulf of Mexico	119 – 237	14 y*	240	0.18	NA	Anderson et al. (2009)
Wenchman (*P. macrophthalmus*)	432	2005 – 2006	Caribbean	172 – 457	23 y*	NA	NA	F 170 M 200	Rosario et al. (2006)
Crimson Jobfish (*P. filamentosus*)		1989 – 1990	Indo-Pacific	256 – 798	44 y$^+$	817	0.29	F 360 – 380 M 400 – 420	Andrews et al. (2012)$^+$ Mees (1993)
Goldbanded Jobfish (*P. multidens*)			Indo-Pacific		30 y$^+$	600	0.19	500	Newman and Dunk (2003)$^+$ Kailola et al. (1993)

Table 2.12.15 Meristic regressions for Wenchman (1982 – 2015) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and -dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length; Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively). Regressions only calculated for sample size ≥ 50.

Regression	Equation	Parameters ± std. err.	Statistic	N	Data range
Max TL to Nat TL	Nat TL = a + max_TL *b			0	
Max TL to FL	FL = a + max_TL *b			0	
Nat TL to FL	FL = a + nat_TL * b	a = 2.35 ± 0.85 b = 0.75 ± 0.04	r^2 = 0.853	78	Nat TL: 14.5 – 36.4 FL: 12.0 – 24.6
Max TL to G Wt	G WT = a * (max_TL^^{b})			0	
Max TL to W Wt	W WT =a* (max_TL^^{b})			0	
Nat TL to G Wt	G WT = a * (nat_TL^^{b})			0	
Nat TL to W Wt	W WT = a* (nat_TL^^{b})	a = 6.35e-04 ± 3.60e-04 b = 2.02 ± 0.1762	RSE = 0.099	112	Nat TL: 4.1 – 36.4 W WT: 0.002 – 0.706
FL to G Wt	G WT= a* (FL^^{b})			13	
FL to W Wt	W WT = a* (FL^^{b})	a = 5.30e-05 ± 2.09e-06 b = 2.90 ± 1.29e-02	RSE = 0.05	5,424	FL: 3.1 – 44.2 W WT: 0.002 – 3.638

Table.2.12.16. Reliability rubric for Yellowmouth Grouper (see section 2.2 for detailed information on the construction of this rubric).

Yellowmouth Grouper	***Mycteroperca interstitialis***					
Criteria	**Description**	Bullock and Smith 1991	Bullock and Murphy 1994	Burton et al. 2014	Ault et al. 1998	Manickchand-Heileman and Phillip 2000
SAMPLING		**0.67**	**0.60**	**0.58**	**0.50**	**0.50**
Sampling location	Not reported (0.0)					
	South America (0.5)					0.5
	Caribbean (0.5)					
	Campeche/Yucatan (0.5)					
	U.S. South Atlantic (0.5)			0.5		
	Florida Keys (0.5)				0.5	
	U.S. Gulf of Mexico (1.0)	1.0	1.0			
Sampling timeframe	Not reported (0.0)					0.0
	< 12 Months (0.0)					
	1-2 years (0.5)	0.5				
	3-4 years (0.5)					
	5+ years (1.0)		1.0	1.0	1.0	
Time since sampling	20+ years (0.0)	0.0			0.0	
	19-11 years (0.5)					
	10-1 years (1.0)			1.0		
Sampling frequency	Not reported (0.0)		0.0	0.0	0.0	
	Annual (0.5)					
	Monthly (1.0)	1.0				1.0
	Daily (1.0)					
Sampling method	Not reported (0.0)					
	Fishery independent (0.5)				0.5	
	Fishery Dependent (0.5)		0.5	0.5		0.5
	Combination (FI & FD) (1.0)	1.0				
Sampling gear	Not reported (0.0)					
	Active gear (e.g., hook and line) (0.5)	0.5	0.5	0.5		0.5
	Passive gear (e.g., nets) (1.0)				1.0	
AGE-LENGTH	**Age-Length Score**	**0.13**	**0.69**	**0.69**	**0.06**	**0.63**
	Age-Length * Sampling Score	**0.08**	**0.41**	**0.40**	**0.03**	**0.31**
Total sample size of age structures	Not reported (0.0)	0.0			0.0	
	<200 (0.5)					0.5
	201-500 (0.5)		0.5	0.5		
	>501 (1.0)					
Length	Not reported (0.0)				0.0	
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)	1.0	1.0	1.0		1.0
Age	Not reported (0.0)	0.0			0.0	
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)		1.0	1.0		1.0

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Yellowmouth Grouper	***Mycteroperca interstitialis***					
Criteria	**Description**	Bullock and Smith 1991	Bullock and Murphy 1994	Burton et al. 2014	Ault et al. 1998	Manickchand-Heileman and Phillip 2000
Ageing method	Not reported (0.0)	0.0			0.0	
	Other hard part (0.5)					
	Scales (0.5)					
	Otoliths: Whole (0.5), Section (1.0)		1.0	1.0		1.0
Age validated	Not reported (0.0)	0.0			0.0	
	Captive Rearing (0.5)					
	Marginal increment (0.5)		0.5	0.5		0.5
	Temporal length frequency (0.5)					
	Tag-recapture with chemical marking (0.5)					
	Radiochemical Dating (1.0)					
Reader precision	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)					
	Average Percent Error (1.0)					
	Estimate of variation (CVs) (1.0)					
Number of samples per age class	Not reported (0.0)	0.0			0.0	0.0
	5 (0.5)					
	10 (0.5)		0.5	0.5		
	20+ (1.0)					
Growth parameters estimation method	Not reported (0.0)	0.0				
	Waldford plot (0.5)					
	Length Frequency (0.5)				0.5	
	Min. least squares (SAS, R, Excel) (1.0)		1.0	1.0		1.0
LENGTH-WEIGHT	**Length-Weight Score**	**0.67**	**0.83**	**0.67**	**0.00**	**0.33**
	Length-Weight * Sampling Score	**0.44**	**0.50**	**0.39**	**0.00**	**0.17**
Length	Not reported (0.0)				0.0	
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)	1.0	1.0	1.0		1.0
Weight	Not reported (0.0)				0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)	1.0	1.0	1.0		
Number of samples per length bin	Not reported (0.0)	0.0		0.0	0.0	0.0
	5 (0.5)					
	10 (0.5)		0.5			
	20+ (1.0)					
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	1.0	1.0	1.0	1.0

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Yellowmouth Grouper	***Mycteroperca interstitialis***					
Criteria	**Description**	Bullock and Smith 1991	Bullock and Murphy 1994	Burton et al. 2014	Ault et al. 1998	Manickchand-Heileman and Phillip 2000
MATURITY	**Maturity Score**	**0.00**	**0.64**	**0.00**	**0.00**	**0.00**
	Maturity * Sampling Score	**0.00**	**0.39**	**0.00**	**0.00**	**0.00**
Number of reproductive samples	Not reported (0.0)	0.0		0.0	0.0	0.0
	<200 (0.5)		0.5			
	201-500 (0.5)					
	>501 (1.0)					
Length	Not reported (0.0)	0.0		0.0	0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)		1.0			
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)					
Age	Not reported (0.0)	0.0		0.0	0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)		1.0			
Sex determination methods	Not reported (0.0)	0.0		0.0	0.0	0.0
	Macroscopic examination (0.5)					
	Histological examination (1.0)		1.0			
Length of maturity estimation method	Not reported (0.0)	0.0		0.0	0.0	0.0
	Estimated based on observed (0.5)		0.5			
	Data fit using Logistic Model (1.0)					
Age of maturity estimation method	Not reported (0.0)	0.0		0.0	0.0	0.0
	Estimated based on observed (0.5)		0.5			
	Data fit using Logistic Model (1.0)					
MORTALITY	**Mortality Score**	**0.00**	**0.00**	**0.00**	**0.50**	**0.00**
	Mortality * Sampling Score	**0.00**	**0.00**	**0.00**	**0.25**	**0.00**
Natural mortality estimation method	Not reported (0.0)	0.0	0.0	0.0		0.0
	Based on VB growth parameters (0.5)				0.5	
	Based on maximum age (1.0)					
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)					
	Previous stock assessment (1.0)					

Table 2.12.17 Summary of Yellowmouth Grouper von Bertalanffy growth model parameters reported in the literature. Reliability rubric reflects age-length * sampling score (0 = low, 0.5 = medium, 1.0 = high).

Reference	Reliability rubric	N	Sampling timeframe	Sampling location	Length range (mm)	Age range (y)	L_∞ (mm)	k	t_0
Bullock and Murphy 1994	0.41	203	1978 – 1992	GOM	415 – 793 (TL)	2 – 28	828 (TL)	0.076	-7.50
Burton et al. 2014	0.40	388	1980 – 2012	Southeast U.S	300 – 859 (FL)	3 – 31	772 (FL)	0.11	-4.18

Table 2.12.18 LHWG summary of recommendations for Yellowmouth Grouper life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. Parameters: M – natural mortality; L_{∞} – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – a from weight-length regression; beta – b from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; h – steepness; Sigma R – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	28 y	Maximum age observed in meta-analysis (Bullock and Murphy 1994)	0.11	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	28 − 31 y	Ranged recommended based on plausible maximum ages in reliable literature (Bullock and Murphy 1994; Burton et al. 2014)
M	0.231 y^{-1}	Calculated from Then et al. (2015) using maximum age	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2015)	0.211 − 0.231 y^{-1}	Range based on plausible values of maximum age
L ∞	828 mm TL	Bullock and Murphy (1994)	45	SE (Bullock and Murphy 1994) (N = 224)	772 − 828 mm TL	Ranged based on reliable literature (Bullock and Murphy 1994; Burton et al. 2014)
k	0.076	Bullock and Murphy (1994)	0.0158	SE (Bullock and Murphy 1994) (N = 224)	0.076 − 0.11	Ranged based on reliable literature (Bullock and Murphy 1994; Burton et al. 2014)
t0	-7.50	Bullock and Murphy (1994)	1.61	SE (Bullock and Murphy 1994) (N = 224)	-7.50 − -4.18	Ranged based on reliable literature (Bullock and Murphy 1994; Burton et al. 2014)
alpha	2.77E-05	Value from SEDAR49 data analysis for Nat TL to W Wt	6.82E-06	SE from SEDAR49 data analysis for Nat TL to W Wt (N = 128)	-	-
beta	2.98	Value from SEDAR49 data analysis for Nat TL to W Wt	5.81E-02	SE from SEDAR49 data analysis for Nat TL to W Wt (N = 128)	-	-
L50	425 mm TL	Midpoint of range in Bullock and Murphy (1994)	0.3	Best guess	400 − 450 mm TL	Proportion of mature females (Bullock and Murphy 1994)
L95	475 mm TL	Midpoint of range in Bullock and Murphy (1994)	0.3	Best guess	450 − 500 mm TL	Proportion of mature females (Bullock and Murphy 1994)
h	0.84	Mode of meta-analysis (Shertzer and Conn 2012)	0.29	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	0.6 − 0.99	Range considered in SEDAR (2014a, 2015b); see Adams et al. (2016), Table 8
Sigma R	-	-	-	-	0.6 − 0.97	Range considered in SEDAR (2014a, 2015b); see Adams et al. (2016), Table 8

Table 2.12.19 Meristic regressions for Yellowmouth Grouper (1984 – 2015) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and -dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length; Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively). Regressions only calculated for sample size ≥ 50.

Regression	Equation	Parameters ± std. err.	Statistic	N	Data range
Max TL to Nat TL	Nat TL = a + max_TL *b			0	
Max TL to FL	FL = a + max_TL *b			0	
Nat TL to FL	FL = a + nat_TL * b			37	
Max TL to G Wt	G WT = a * (max_TL^^{b})			23	
Max TL to W Wt	W WT =a* (max_TL^^{b})			16	
Nat TL to G Wt	G WT = a * (nat_TL^^{b})			0	
Nat TL to W Wt	W WT = a* (nat_TL^^{b})	a = 2.77e-05 ± 6.82e-06 b = 2.98 ± 5.81e-02	RSE = 0.633	128	Nat TL: 20.5 – 92.5 W WT: 0.31 – 19.05
FL to G Wt	G WT= a* (FL^^{b})			23	
FL to W Wt	W WT = a* (FL^^{b})	a = 2.60e-05 ± 1.94e-05 b = 3.03 ± 1.82e-01	RSE = 0.789	57	FL: 15.9 – 66.8 W WT: 0.09 – 10.00

Table.2.12.20. Reliability rubric for Snowy Grouper (see section 2.2 for detailed information on the construction of this rubric).

Snowy Grouper	***Epinephelus niveatus***						
Criteria	**Description**	Kowal 2010	SEDAR 2013	Wyanski et al. 2013	SEDAR 2004	Wyanski et al 2000	Costa et al. 2012
SAMPLING		**0.92**	**0.83**	**0.83**	**0.75**	**0.60**	**0.58**
Sampling location	Not reported (0.0)						
	South America (0.5)						0.5
	Caribbean (0.5)						
	Campeche/Yucatan (0.5)						
	U.S. South Atlantic (0.5)		0.5	0.5	0.5	0.5	
	U.S. Gulf of Mexico (1.0)	1.0					
Sampling timeframe	Not reported (0.0)						
	< 12 Months (0.0)						
	1-2 years (0.5)						0.5
	3-4 years (0.5)						
	5+ years (1.0)	1.0	1.0	1.0	1.0		
Time since sampling	20+ years (0.0)					0.0	
	19-11 years (0.5)	0.5			0.5		0.5
	10-1 years (1.0)		1.0	1.0			
Sampling frequency	Not reported (0.0)						
	Annual (0.5)		0.5	0.5	0.5	0.5	0.5
	Monthly (1.0)	1.0					
	Daily (1.0)						
Sampling method	Not reported (0.0)						
	Fishery independent (0.5)						
	Fishery Dependent (0.5)						0.5
	Combination (FI & FD) (1.0)	1.0	1.0	1.0	1.0	1.0	
Sampling gear	Not reported (0.0)						
	Active gear (e.g., hook and line) (0.5)						
	Passive gear (e.g., nets) (1.0)	1.0	1.0	1.0	1.0	1.0	1.0
AGE-LENGTH	**Age-Length Score**	**0.75**	**0.69**	**0.69**	**0.63**	**0.75**	**0.63**
	Age-Length * Sampling Score	**0.69**	**0.57**	**0.57**	**0.47**	**0.45**	**0.36**
Total sample size of age structures	Not reported (0.0)						
	<200 (0.5)						
	201-500 (0.5)						0.5
	>501 (1.0)	1.0	1.0	1.0	1.0	1.0	
Range of metrics for age structures: Length	Not reported (0.0)						
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0	1.0	1.0	1.0	1.0	1.0
Age	Not reported (0.0)						
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0	1.0	1.0	1.0	1.0	1.0
Ageing method	Not reported (0.0)						
	Other hard part (0.5)						
	Scales (0.5)						
	Otoliths: Whole (0.5), Section (1.0)	1.0	1.0	1.0	1.0	1.0	1.0

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Snowy Grouper	***Epinephelus niveatus***						
Criteria	**Description**	Kowal 2010	SEDAR 2013	Wyanski et al. 2013	SEDAR 2004	Wyanski et al 2000	Costa et al. 2012
Age validated	Not reported (0.0)	0.0			0.0		
	Captive Rearing (0.5)						
	Marginal increment (0.5)					0.5	0.5
	Temporal length frequency (0.5)						
	Tag-recapture with chemical marking (0.5)						
	Radiochemical Dating (1.0)		1.0	1.0			
Reader precision	Not reported (0.0)		0.0	0.0	0.0		0.0
	Percent Frequency (0.5)					0.5	
	Average Percent Error (1.0)	1.0					
	Estimate of variation (CVs) (1.0)						
Number of samples per age class	Not reported (0.0)	0.0			0.0		0.0
	5 (0.5)		0.5	0.5		0.5	
	10 (0.5)						
	20+ (1.0)						
Growth parameters estimation method	Not reported (0.0)		0.0	0.0			
	Waldford plot (0.5)						
	Length Frequency (0.5)					0.5	
	Min. least squares (SAS, R, Excel) (1.0)	1.0			1.0		1.0
LENGTH-WEIGHT	**Length-Weight Score**	**0.00**	**0.75**	**0.75**	**0.75**	**0.00**	**0.50**
	Length-Weight * Sampling Score	**0.00**	**0.63**	**0.63**	**0.56**	**0.00**	**0.29**
Range of metrics for age structures: Length	Not reported (0.0)						
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0	1.0	1.0	1.0	1.0	1.0
Weight	Not reported (0.0)					0.0	0.0
	Narrow range metrics (0.5)		0.5	0.5	0.5		
	Wide range metrics (1.0)	1.0					
Number of samples per length bin	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	
	5 (0.5)						
	10 (0.5)						0.5
	20+ (1.0)						
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	0.0	1.0	1.0	1.0	0.0	1.0

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Snowy Grouper	***Epinephelus niveatus***						
Criteria	**Description**	Kowal 2010	SEDAR 2013	Wyanski et al. 2013	SEDAR 2004	Wyanski et al 2000	Costa et al. 2012
MATURITY	**Maturity Score**	**0.64**	**0.86**	**0.86**	**0.29**	**0.79**	**0.29**
	Maturity * Sampling Score	**0.59**	**0.71**	**0.71**	**0.21**	**0.47**	**0.17**
Number of reproductive samples	Not reported (0.0)				0.0		0.0
	<200 (0.5)	0.5					
	201-500 (0.5)						
	>501 (1.0)		1.0	1.0		1.0	
Length	Not reported (0.0)				0.0		
	Narrow range metrics (0.5)					0.5	
	Wide range metrics (1.0)	1.0	1.0	1.0			1.0
Weight	Not reported (0.0)	0.0			0.0	0.0	0.0
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)		1.0	1.0			
Age	Not reported (0.0)				0.0		
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0	1.0	1.0		1.0	1.0
Sex determination methods	Not reported (0.0)				0.0		0.0
	Macroscopic examination (0.5)						
	Histological examination (1.0)	1.0	1.0	1.0		1.0	
Length of maturity estimation method	Not reported (0.0)		0.0	0.0			0.0
	Estimated based on observed (0.5)	0.5					
	Data fit using Logistic Model (1.0)				1.0	1.0	
Age of maturity estimation method	Not reported (0.0)						0.0
	Estimated based on observed (0.5)	0.5					
	Data fit using Logistic Model (1.0)		1.0	1.0	1.0	1.0	
MORTALITY	**Mortality Score**	**0.00**	**1.00**	**0.00**	**0.50**	**0.00**	**0.00**
	Mortality * Sampling Score	**0.00**	**0.83**	**0.00**	**0.38**	**0.00**	**0.00**
Natural mortality estimation method	Not reported (0.0)	0.0		0.0		0.0	0.0
	Based on VB growth parameters (0.5)				0.5		
	Based on maximum age (1.0)		1.0				
STEEPNESS	**Steepness Score**	**0.00**	**0.50**	**0.00**	**0.50**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0		0.0		0.0	0.0
	Based on meta-analysis (0.5)		0.5		0.5		
	Previous stock assessment (1.0)						

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Snowy Grouper	*Epinephelus niveatus*						
Criteria	**Description**	Ault et al 1998	Frota et al 2004	Moore and Labisky 1984	Potts et al. 1998	Matheson and Huntsman 1984	Ximenes-Carvalho et al. 1999
SAMPLING		**0.58**	**0.50**	**0.50**	**0.42**	**0.33**	**0.33**
Sampling location	Not reported (0.0)						
	South America (0.5)		0.5				0.5
	Caribbean (0.5)						
	Campeche/Yucatan (0.5)						
	U.S. South Atlantic (0.5)	0.5		0.5	0.5	0.5	
	U.S. Gulf of Mexico (1.0)						
Sampling timeframe	Not reported (0.0)						
	< 12 Months (0.0)						0.5
	1-2 years (0.5)						
	3-4 years (0.5)			0.5			
	5+ years (1.0)	1.0	1.0		1.0	1.0	
Time since sampling	20+ years (0.0)	0.0		0.0	0.0	0.0	
	19-11 years (0.5)		0.5				0.5
	10-1 years (1.0)						
Sampling frequency	Not reported (0.0)	0.0	0.0			0.0	0.0
	Annual (0.5)			0.5	0.5		
	Monthly (1.0)						
	Daily (1.0)						
Sampling method	Not reported (0.0)		0.0				
	Fishery independent (0.5)						
	Fishery Dependent (0.5)	1.0			0.5	0.5	0.5
	Combination (FI & FD) (1.0)			1.0			
Sampling gear	Not reported (0.0)				0.0	0.0	0.0
	Active gear (e.g., hook and line) (0.5)			0.5			
	Passive gear (e.g., nets) (1.0)	1.0	1.0				
AGE-LENGTH	**Age-Length Score**	**0.06**	**0.00**	**0.56**	**0.00**	**0.50**	**0.44**
	Age-Length * Sampling Score	**0.04**	**0.00**	**0.28**	**0.00**	**0.17**	**0.15**
Total sample size of age structures	Not reported (0.0)	0.0	0.0		0.0		
	<200 (0.5)						
	201-500 (0.5)			0.5			0.5
	>501 (1.0)					1.0	
Range of metrics for age structures: Length	Not reported (0.0)	0.0	0.0		0.0	0.0	
	Narrow range metrics (0.5)						0.5
	Wide range metrics (1.0)			1.0			
Age	Not reported (0.0)	0.0	0.0		0.0	0.0	
	Narrow range metrics (0.5)			0.5			0.5
	Wide range metrics (1.0)						
Ageing method	Not reported (0.0)	0.0	0.0		0.0		
	Other hard part (0.5)						
	Scales (0.5)						0.5
	Otoliths: Whole (0.5), Section (1.0)			1.0		1.0	

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Snowy Grouper	***Epinephelus niveatus***						
Criteria	**Description**	Ault et al 1998	Frota et al 2004	Moore and Labisky 1984	Potts et al. 1998	Matheson and Huntsman 1984	Ximenes-Carvalho et al. 1999
Age validated	Not reported (0.0)	0.0	0.0		0.0		
	Captive Rearing (0.5)						
	Marginal increment (0.5)			0.5		0.5	
	Temporal length frequency (0.5)						0.5
	Tag-recapture with chemical marking (0.5)						
	Radiochemical Dating (1.0)						
Reader precision	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)						
	Average Percent Error (1.0)						
	Estimate of variation (CVs) (1.0)						
Number of samples per age class	Not reported (0.0)	0.0	0.0		0.0		
	5 (0.5)			0.5			
	10 (0.5)						0.5
	20+ (1.0)					1.0	
Growth parameters estimation method	Not reported (0.0)		0.0		0.0		
	Waldford plot (0.5)			0.5			0.5
	Length Frequency (0.5)	0.5				0.5	
	Min. least squares (SAS, R, Excel) (1.0)						
LENGTH-WEIGHT	**Length-Weight Score**	**0.00**	**0.00**	**0.50**	**0.00**	**0.00**	**0.25**
	Length-Weight * Sampling Score	**0.00**	**0.00**	**0.25**	**0.00**	**0.00**	**0.08**
Range of metrics for age structures: Length	Not reported (0.0)	0.0	0.0		0.0	0.0	
	Narrow range metrics (0.5)						0.5
	Wide range metrics (1.0)			1.0			
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)						
Number of samples per length bin	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0
	5 (0.5)			0.5			
	10 (0.5)						
	20+ (1.0)						
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	1.0	1.0	0.0	1.0	1.0

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Snowy Grouper	***Epinephelus niveatus***						
Criteria	**Description**	Ault et al 1998	Frota et al 2004	Moore and Labisky 1984	Potts et al. 1998	Matheson and Huntsman 1984	Ximenes-Carvalho et al. 1999
MATURITY	**Maturity Score**	**0.00**	**0.00**	**0.43**	**0.00**	**0.00**	**0.00**
	Maturity * Sampling Score	**0.00**	**0.00**	**0.21**	**0.00**	**0.00**	**0.00**
Number of reproductive samples	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0
	<200 (0.5)			0.5			
	201-500 (0.5)						
	>501 (1.0)						
Length	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0
	Narrow range metrics (0.5)			0.5			
	Wide range metrics (1.0)						
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)						
Age	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0
	Narrow range metrics (0.5)			0.5			
	Wide range metrics (1.0)						
Sex determination methods	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0
	Macroscopic examination (0.5)						
	Histological examination (1.0)			1.0			
Length of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)						
	Data fit using Logistic Model (1.0)						
Age of maturity estimation method	Not reported (0.0)	0.0	0.0		0.0	0.0	0.0
	Estimated based on observed (0.5)			0.5			
	Data fit using Logistic Model (1.0)						
MORTALITY	**Mortality Score**	**0.50**	**0.00**	**0.00**	**0.50**	**0.50**	**0.50**
	Mortality * Sampling Score	**0.29**	**0.00**	**0.00**	**0.21**	**0.17**	**0.17**
Natural mortality estimation method	Not reported (0.0)		0.0	0.0	0.5		
	Based on VB growth parameters (0.5)	0.5				0.5	0.5
	Based on maximum age (1.0)						
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)						
	Previous stock assessment (1.0)						

Table 2.12.21 Summary of Snowy Grouper von Bertalanffy growth model parameters reported in the literature. Reliability rubric reflects age-length * sampling score (0 = low, 0.5 = medium, 1.0 = high).

Reference	Reliability rubric	N	Sampling timeframe	Sampling location	Length range (mm)	Age range (y)	L_∞ (mm)	k	t_0
Kowal 2010	0.69	774	1984 – 2004	GOM	242 – 1096 FL	1 – 44	1057 (FL)	0.094	-2.538
SEDAR 2013	0.57	>11,000	1974 – 2012	South Atlantic	220 – 1090 TL	1 – 35	1065 (TL)	0.094	-2.884

Table 2.12.22 LHWG summary of recommendations for Snowy Grouper life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – theoretical age at length zero; alpha – *a* from weight-length regression; beta – *b* from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; *h* – steepness; Sigma *R* – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	35 y	Maximum age observed in meta-analysis (SEDAR 2013)	0.26	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	35 − 44 y	Ranged recommended based on plausible maximum ages in reliable literature (SEDAR 2013; Kowal 2010)
M	0.189 y^{-1}	Calculated from Then et al. (2015) using maximum age	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2015)	0.153 − 0.189 y^{-1}	Range based on plausible values of maximum age
$L\infty$	1065 mm TL	SEDAR (2013)	65.22	SE (SEDAR 2013) (N = 4,342)	1065 − 1086	Ranged recommended based on plausible maximum ages in reliable literature (converted Kowal (2010) $L\infty$ from FL to TL using equation therein, likely prone to errors)
k	0.094	SEDAR (2013)	0.021	SE (SEDAR 2013) (N = 4,342)	0.077 − 0.111	95% Confidence interval in other reliable literature (Kowal 2010)
t0	-2.88	SEDAR (2013)	0.951	SE (SEDAR 2013) (N = 4,342)	-1.88 − -3.19	95% Confidence interval in other reliable literature (Kowal 2010)
alpha	3.56E-05	Value from SEDAR49 data analysis for Max TL to W Wt	7.12E-06	SE from SEDAR49 data analysis for Max TL to W Wt (N = 52)	-	-
beta	2.98	Value from SEDAR49 data analysis for Max TL to W Wt	4.68E-02	SE from SEDAR49 data analysis for Max TL to W Wt (N = 52)	-	-
L50	600 mm TL	Table 1, SEDAR (2013)	0.3	Best guess	580 − 620 mm TL	SEDAR (2013) - length where 50% maturity falls
L95	750 mm TL	Table 1, SEDAR (2013)	0.3	Best guess	732 − 768 mm TL	SEDAR (2013) - length where 95% maturity falls
h	0.84	Mode of meta-analysis (Shertzer and Conn 2012)	0.12	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	0.74 − 0.94	Range considered in SEDAR (2013); see Adams et al. (2016), Table 8
Sigma *R*	-	-	-	-	0.55 − 0.55	Fixed in SEDAR (2013); see Adams et al. (2016), Table 8

Table 2.12.23 Estimated values for natural mortality using the updated Hoenig equation (Then et al. 2015) with different maximum ages for Snowy Grouper.

Maximum Age	Natural Mortality (y^{-1})
25	0.26
30	0.22
35	0.19
40	0.17
45	0.15

Table 2.12.24 Meristic regressions for Snowy Grouper (1981 – 2015) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and -dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length; Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively). Regressions only calculated for sample size ≥ 50.

Regression	Equation	Parameters ± std. err.	Statistic	N	Data range
Max TL to Nat TL	Nat TL = a + max_TL *b			31	
Max TL to FL	FL = a + max_TL *b			0	
Nat TL to FL	FL = a + nat_TL * b			16	
Max TL to G Wt	G WT = a * (max_TL^b)	a = 3.56e-05 ± 3.79e-06 b = 2.98 ± 2.37e-02	RSE = 1.437	506	Max TL: 17.10 – 130.30 G WT: 0.50 – 71.00
Max TL to W Wt	W WT =a* (max_TL^b)	a = 3.56e-05± 7.12e-06 b = 2.98 ± 4.68e-02	RSE = 0.468	52	Max TL: 17.10 – 130.30 W WT: 0.002 – 61.299
Nat TL to G Wt	G WT = a * (nat_TL^b)			0	
Nat TL to W Wt	W WT = a* (nat_TL^b)	a = 1.86e-05 ± 2.73e-06 b = 3.13 ± 3.32e-02	RSE = 1.009	230	Nat TL: 3.10 – 109.60 W WT: 0.002 – 61.299
FL to G Wt	G WT= a* (FL^b)	a = 1.859e-05 ± 8.25-07 b = 3.11 ± 1.02e-02	RSE = 1.193	3,411	FL: 14.10 – 129.20 G WT: 0.50 – 71.00
FL to W Wt	W WT = a* (FL^b)	a = 3.16e-05 ± 2.08e-06 b = 2.99 ± 1.49e-02	RSE = 1.292	1,329	FL: 14.10 – 129.20 W WT: 0.002 – 61.299

Table.2.12.25. Reliability rubric for Speckled Hind (see section 2.2 for detailed information on the construction of this rubric).

Speckled Hind	***Epinephelus drummondhayi***						
Criteria	Description	Ziskin et al. 2011	Bullock and Smith 1991	Ault et al. 1998	Andrews et al. 2013	Matheson and Huntsman 1984	Brule et al. 2000
SAMPLING		**0.67**	**0.67**	**0.50**	**0.50**	**0.42**	**0.42**
Sampling location	Not reported (0.0)						
	South America (0.5)						
	Caribbean (0.5)						
	Campeche/Yucatan (0.5)						0.5
	U.S. South Atlantic (0.5)	0.5				0.5	
	Florida Keys (0.5)			0.5			
	U.S. Gulf of Mexico (1.0)		1.0		1.0		
Sampling timeframe	Not reported (0.0)						
	< 12 Months (0.0)						
	1-2 years (0.5)		0.5				
	3-4 years (0.5)						0.5
	5+ years (1.0)	1.0		1.0	1.0	1.0	
Time since sampling	20+ years (0.0)		0.0	0.0		0.0	
	19-11 years (0.5)	0.5					0.5
	10-1 years (1.0)						
Sampling frequency	Not reported (0.0)			0.0	0.0	0.0	0.0
	Annual (0.5)	0.5					
	Monthly (1.0)		1.0				
	Daily (1.0)						
Sampling method	Not reported (0.0)						
	Fishery independent (0.5)			0.5	0.5		
	Fishery Dependent (0.5)					0.5	0.5
	Combination (FI & FD) (1.0)	1.0	1.0				
Sampling gear	Not reported (0.0)				0.0		
	Active gear (e.g., hook and line) (0.5)	0.5	0.5			0.5	0.5
	Passive gear (e.g., nets) (1.0)			1.0			
AGE-LENGTH	**Age-Length Score**	**0.88**	**0.13**	**0.06**	**0.56**	**0.56**	**0.00**
	Age-Length * Sampling Score	**0.58**	**0.08**	**0.03**	**0.28**	**0.23**	**0.00**
Total sample size of age structures	Not reported (0.0)		0.0	0.0			0.0
	<200 (0.5)				0.5		
	201-500 (0.5)					0.5	
	>501 (1.0)	1.0					
Length	Not reported (0.0)			0.0			0.0
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0	1.0		1.0	1.0	
Age	Not reported (0.0)		0.0	0.0			0.0
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0			1.0	1.0	
Ageing method	Not reported (0.0)		0.0	0.0			0.0
	Other hard part (0.5)						
	Scales (0.5)						
	Otoliths: Whole (0.5), Section (1.0)	1.0			1.0	1.0	

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Speckled Hind	***Epinephelus drummondhayi***						
Criteria	Description	Ziskin et al. 2011	Bullock and Smith 1991	Ault et al. 1998	Andrews et al. 2013	Matheson and Huntsman 1984	Brule et al. 2000
Age validated	Not reported (0.0)		0.0	0.0			0.0
	Captive Rearing (0.5)						
	Marginal increment (0.5)	0.5				0.5	
	Temporal length frequency (0.5)						
	Tag-recapture with chemical marking (0.5)						
	Radiochemical Dating (1.0)				1.0		
Reader precision	Not reported (0.0)		0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)						
	Average Percent Error (1.0)	1.0					
	Estimate of variation (CVs) (1.0)						
Number of samples per age class	Not reported (0.0)		0.0	0.0	0.0		0.0
	5 (0.5)						
	10 (0.5)	0.5				0.5	
	20+ (1.0)						
Growth parameters estimation method	Not reported (0.0)		0.0		0.0	0.0	0.0
	Waldford plot (0.5)						
	Length Frequency (0.5)			0.5			
	Min. least squares (SAS, R, Excel) (1.0)	1.0					
LENGTH-WEIGHT	**Length-Weight Score**	**0.67**	**0.67**	**0.00**	**0.00**	**0.33**	**0.00**
	Length-Weight * Sampling Score	**0.44**	**0.44**	**0.00**	**0.00**	**0.14**	**0.00**
Length	Not reported (0.0)			0.0			0.0
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0	1.0		1.0	1.0	
Weight	Not reported (0.0)			0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0	1.0				
Number of samples per length bin	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
	5 (0.5)						
	10 (0.5)						
	20+ (1.0)						
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	1.0	1.0	0.0	1.0	0.0

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Speckled Hind	***Epinephelus drummondhayi***						
Criteria	Description	Ziskin et al. 2011	Bullock and Smith 1991	Ault et al. 1998	Andrews et al. 2013	Matheson and Huntsman 1984	Brule et al. 2000
MATURITY	**Maturity Score**	**0.79**	**0.00**	**0.00**	**0.00**	**0.00**	**0.50**
	Maturity * Sampling Score	**0.52**	**0.00**	**0.00**	**0.00**	**0.00**	**0.21**
Number of reproductive samples	Not reported (0.0)		0.0	0.0	0.0	0.0	
	<200 (0.5)						
	201-500 (0.5)						
	>501 (1.0)	1.0					
Length	Not reported (0.0)		0.0	0.0	0.0	0.0	
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)	1.0					1.0
Weight	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	
	Narrow range metrics (0.5)						
	Wide range metrics (1.0)						1.0
Age	Not reported (0.0)		0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)	0.5					
	Wide range metrics (1.0)						
Sex determination methods	Not reported (0.0)		0.0	0.0	0.0	0.0	
	Macroscopic examination (0.5)						
	Histological examination (1.0)	1.0					1.0
Length of maturity estimation method	Not reported (0.0)		0.0	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)						
	Data fit using Logistic Model (1.0)	1.0					
Age of maturity estimation method	Not reported (0.0)		0.0	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)						
	Data fit using Logistic Model (1.0)	1.0					
MORTALITY	**Mortality Score**	**1.00**	**0.00**	**0.50**	**0.00**	**0.50**	**0.00**
	Mortality * Sampling Score	**0.67**	**0.00**	**0.25**	**0.00**	**0.21**	**0.00**
Natural mortality estimation method	Not reported (0.0)		0.0		0.0		0.0
	Based on VB growth parameters (0.5)			0.5		0.5	
	Based on maximum age (1.0)	1.0					
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)						
	Previous stock assessment (1.0)						

Table 2.12.26 Summary of Speckled Hind von Bertalanffy growth model parameters reported in the literature. Reliability rubric reflects age-length * sampling score (0 = low, 0.5 = medium, 1.0 = high).

Reference	Reliability rubric	N	Sampling timeframe	Sampling location	Length range (mm TL)	Age range (y)	L_∞ (mm TL)	k	t_0
Ziskin et al. 2011*	0.58	1,365	1977 – 2007	Southeast U.S.	164 – 973	1 – 35	888	0.12	-1.80
Matheson and Huntsman 1984	0.23	463	1975 – 1979	Southeast U.S.	240 – 1096	1 – 25	967	0.13	-1.01

*The same data were reported in SEDAR (2004) and Ziskin (2008).

Table 2.12.27 LHWG summary of recommendations for Speckled Hind life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – a from weight-length regression; beta – b from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; h – steepness; Sigma R – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	45 y	Minimum maximum age observed in radiocarbon study (Andrews et al. 2013)	0.22	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	35 − 45 y	Ranged recommended based on plausible maximum ages in reliable literature (Ziskin et al. 2011; Andrews et al. 2013)
M	0.150 y^{-1}	Calculated from Then et al. (2015) using maximum age	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2015)	0.150 − 0.189 y^{-1}	Ranged recommended based on plausible maximum ages
L ∞	888 mm TL	Ziskin et al. (2011)	70	SE, expert opinion best estimate based on other large serranids	888 − 967 mm TL	Ranged recommended based on reliable literature (Ziskin et al. 2011; Matheson and Huntsman 1984)
k	0.12	Ziskin et al. (2011)	0.02	SE, expert opinion best estimate based on other large serranids	0.12 − 0.13	Ranged recommended based on reliable literature (Ziskin et al. 2011; Matheson and Huntsman 1984)
t0	-1.80	Ziskin et al. (2011)	0.9	SE, expert opinion best estimate based on other large serranids	-1.80 − -1.01	Ranged recommended based on reliable literature (Ziskin et al. 2011; Matheson and Huntsman 1984)
alpha	4.42E-05	Value from SEDAR49 data analysis for Nat TL to W Wt	1.44E-05	SE from SEDAR49 data analysis for Nat TL to W Wt (N = 109)	-	-
beta	2.97	Value from SEDAR49 data analysis for Nat TL to W Wt	7.29E-02	SE from SEDAR49 data analysis for Nat TL to W Wt (N = 109)	-	-
L50	532 mm TL	Ziskin et al. (2011)	0.3	Best guess	522 − 542 mm TL	95% confidence interval from Ziskin et al. (2011)
L95	675 mm TL	Ziskin et al. (2011)	0.3	Best guess	651 − 700 mm TL	Ziskin et al. (2011), where 95% maturity occurs for females
h	0.84	Mode of meta-analysis (Shertzer and Conn 2012)	0.23	$max\left\lvert\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\rvert$	0.65 − 0.98	Range considered in SEDAR (2011a, 2011b, 2015b); see Adams et al. (2016), Table 8
Sigma R	-	-	-	-	0.2 − 1.0	Range considered in SEDAR (2011a, 2011b, 2015b); see Adams et al. (2016), Table 8

Table 2.12.28 Meristic regressions for Speckled Hind (1981 – 2015) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and -dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length; Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively). Regressions only calculated for sample size ≥ 50.

Regression	Equation	Parameters ± std. err.	Statistic	N	Data range
Max TL to Nat TL	Nat TL = a + max_TL *b			3	
Max TL to FL	FL = a + max_TL *b			0	
Nat TL to FL	FL = a + nat_TL * b			22	
Max TL to G Wt	G WT = a * (max_TL^b)	a = 5.17e-05 ± 8.12e-06 b = 2.93 ± 3.58e-02	RSE = 1.195	207	Max TL: 27.5 – 100.3 G WT: 0.65 – 38.00
Max TL to W Wt	W WT =a* (max_TL^b)			5	
Nat TL to G Wt	G WT = a * (nat_TL^b)			0	
Nat TL to W Wt	W WT = a* (nat_TL^b)	a = 4.42e-05 ± 1.44e-05 b = 2.97 ± 7.29e-02	RSE = 1.497	109	Nat TL: 12.5 – 97.9 W WT: 0.05 – 38.59
FL to G Wt	G WT= a* (FL^b)	a = 3.52e-05 ± 3.90e-06 b = 3.02 ± 2.54e-02	RSE = 1.585	786	FL: 27.0 – 107.6 G WT: 0.60 – 45.18
FL to W Wt	W WT = a* (FL^b)	a = 3.45e-05 ± 4.03e-06 b = 3.05 ± 2.70e-02	RSE = 1.883	1,031	FL: 24.1 – 109.2 W WT: 0.22 – 56.00

Table.2.12.29. Reliability rubric for Lesser Amberjack (see section 2.2 for detailed information on the construction of this rubric).

Lesser Amberjack	***Seriola fasciata***			
Criteria	**Description**	Oliveira et al. 2015	Thompson et al. 1996	Szedlmayer 1991
SAMPLING		**0.79**	**0.33**	**0.25**
Sampling location	Not reported (0.0)			
	South America (0.5)			
	Caribbean (0.5)			
	Campeche/Yucatan (0.5)			
	U.S. South Atlantic (0.5)	0.5		
	U.S. Gulf of Mexico (1.0)		1.0	1.0
Sampling timeframe	Not reported (0.0)		0.0	
	< 12 Months (0.0)			
	1-2 years (0.5)			0.5
	3-4 years (0.5)			
	5+ years (1.0)	1.0		
Time since sampling	20+ years (0.0)		0.0	0.0
	19-11 years (0.5)			
	10-1 years (1.0)	1.0		
Sampling frequency	Not reported (0.0)		0.0	0.0
	Annual (0.5)			
	Monthly (1.0)	1.0		
	Weekly (1.0)			
	Daily (1.0)			
Sampling method	Not reported (0.0)			0.0
	Fishery independent (0.5)			
	Fishery Dependent (0.5)	0.5	0.5	
	Combination (FI & FD) (1.0)			
Sampling gear	Not reported (0.0)			0.0
	Active gear (e.g., hook and line) (0.5)	0.5	0.5	
	Passive gear (e.g., nets) (1.0)	1.0		
AGE-LENGTH	**Age-Length Score**	**0.13**	**0.44**	**0.06**
	Age-Length * Sampling Score	**0.10**	**0.15**	**0.02**
Total sample size of age structures	Not reported (0.0)			
	<200 (0.5)	0.5		0.5
	201-500 (0.5)		0.5	
	>501 (1.0)			
Length	Not reported (0.0)			0.0
	Narrow range metrics (0.5)	0.5		
	Wide range metrics (1.0)		1.0	
Age	Not reported (0.0)	0.0		0.0
	Narrow range metrics (0.5)		0.5	
	Wide range metrics (1.0)			

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Lesser Amberjack	***Seriola fasciata***			
Criteria	**Description**	Oliveira et al. 2015	Thompson et al. 1996	Szedlmayer 1991
Ageing method	Not reported (0.0)	0.0		0.0
	Other hard part (0.5)			
	Scales (0.5)			
	Otoliths: Whole (0.5), Section (1.0)		1.0	
Age validated	Not reported (0.0)	0.0		0.0
	Captive Rearing (0.5)			
	Marginal increment (0.5)		0.5	
	Temporal length frequency (0.5)			
	Tag-recapture with chemical marking (0.5)			
	Radiochemical Dating (1.0)			
Reader precision	Not reported (0.0)	0.0	0.0	0.0
	Percent Frequency (0.5)			
	Average Percent Error (1.0)			
	Estimate of variation (CVs) (1.0)			
Number of samples per age class	Not reported (0.0)	0.0	0.0	0.0
	5 (0.5)			
	10 (0.5)			
	20+ (1.0)			
Growth parameters estimation method	Not reported (0.0)	0.0	0.0	0.0
	Waldford plot (0.5)			
	Length Frequency (0.5)			
	Min. least squares (SAS, R, Excel) (1.0)			
LENGTH-WEIGHT	**Length-Weight Score**	**0.33**	**0.00**	**0.00**
	Length-Weight * Sampling Score	**0.26**	**0.00**	**0.00**
Length	Not reported (0.0)			0.0
	Narrow range metrics (0.5)	0.5		
	Wide range metrics (1.0)		1.0	
Weight	Not reported (0.0)			0.0
	Narrow range metrics (0.5)	0.5		
	Wide range metrics (1.0)		1.0	
Number of samples per length bin	Not reported (0.0)	0.0	0.0	0.0
	5 (0.5)			
	10 (0.5)			
	20+ (1.0)			
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	0.0	0.0

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Lesser Amberjack	*Seriola fasciata*			
Criteria	**Description**	Oliveira et al. 2015	Thompson et al. 1996	Szedlmayer 1991
MATURITY	**Maturity Score**	**0.00**	**0.29**	**0.00**
	Maturity * Sampling Score	**0.00**	**0.10**	**0.00**
Number of	Not reported (0.0)	0.0		0.0
reproductive samples	<200 (0.5)		0.5	
	201-500 (0.5)			
	>501 (1.0)			
Length	Not reported (0.0)	0.0	0.0	0.0
	Narrow range metrics (0.5)			
	Wide range metrics (1.0)			
Weight	Not reported (0.0)	0.0	0.0	0.0
	Narrow range metrics (0.5)			
	Wide range metrics (1.0)			
Age	Not reported (0.0)	0.0	0.0	0.0
	Narrow range metrics (0.5)			
	Wide range metrics (1.0)			
Sex determination	Not reported (0.0)	0.0		0.0
methods	Macroscopic examination (0.5)		0.5	
	Histological examination (1.0)			
Length of maturity	Not reported (0.0)	0.0		0.0
estimation method	Estimated based on observed (0.5)		0.5	
	Data fit using Logistic Model (1.0)			
Age of maturity	Not reported (0.0)	0.0		0.0
estimation method	Estimated based on observed (0.5)		0.5	
	Data fit using Logistic Model (1.0)			
MORTALITY	**Mortality Score**	**0.00**	**0.00**	**0.00**
	Mortality * Sampling Score	**0.00**	**0.00**	**0.00**
Natural mortality	Not reported (0.0)	0.0	0.0	0.0
estimation method	Based onVB growth parameters (0.5)			
	Based on maximum age (1.0)			
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0
	Based on meta-analysis (0.5)			
	Previous stock assessment (1.0)			

Table 2.12.30 LHWG summary of recommendations for Lesser Amberjack life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – *a* from weight-length regression; beta – *b* from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; *h* – steepness; Sigma *R* – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	None	No data available	None	No data available	None	No data available
M	None	No data available	None	No data available	None	No data available
L_∞	None	No data available	None	No data available	None	No data available
k	None	No data available	None	No data available	None	No data available
t_0	None	No data available	None	No data available	None	No data available
alpha	1.68E-05	Value from SEDAR49 data analysis for FL to W Wt	1.74E-05	SE from SEDAR49 data analysis for FL to W Wt (N = 250)	-	-
beta	2.60	Value from SEDAR49 data analysis for FL to W Wt	2.51E-02	SE from SEDAR49 data analysis for FL to W Wt (N = 250)	-	-
L50	None	No data available	None	No data available	None	No data available
L95	None	No data available	None	No data available	None	No data available
h	None	No data available	None	No data available	None	No data available
Sigma *R*	None	No data available	None	No data available	None	No data available

Table 2.12.31 LHWG summary of recommendations for Greater Amberjack life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented for use in a 'Jack' operational assessment model. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – a from weight-length regression; beta – b from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; h – steepness; Sigma R – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	15 y	SEDAR (2014b)	0.6	SD from SEDAR (2014b)	15 − 17 y	page 14 in SEDAR (2014b)
M	0.410 y^{-1}	SEDAR (2014b)	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2015)	0.366 − 0.410 y^{-1}	Range recommended for testing by LHWG, SEDAR (2014b)
L_∞	1436 mm FL	SEDAR (2014b), Table 2	37.58	SD from SEDAR (2014b)	1398 − 1474 mm FL	SEDAR (2014b) value ± SD
k	0.175	SEDAR (2014b), Table 2	1.00E-02	SD from SEDAR (2014b)	0.165 − 0.185	SEDAR (2014b) value ± SD
t_0	-0.954	SEDAR (2014b), Table 2	8.40E-02	SD from SEDAR (2014b)	-1.038 − -0.87	SEDAR (2014b) value ± SD
alpha	7.05E-05	Value from SEDAR (2014b)	3.90E-06	SE from SEDAR (2014b) (N = 1,865)	-	-
beta	2.633	Value from SEDAR (2014b)	1.20E-02	SE from SEDAR (2014b) (N = 1,865)	-	-
L50	825 mm FL	Midpoint of range in SEDAR (2014b)	0.3	Best guess	820 − 830 mm FL	SEDAR (2014b)
L95	950 mm FL	SEDAR (2014b)	0.3	Best guess	No data available	No data available
h	0.84	Estimated, SEDAR (2014b)	0.18	$max\left\|\frac{Range\ estimate - Point\ estimate}{Point\ estimate}\right\|$	0.7 − 0.99	SEDAR (2014b) range
Sigma R	None	No data available	None	No data available	0.6 − 0.6	Fixed in SEDAR (2014b); see Adams et al. (2016), Table 8

Table 2.12.32 Meristic regressions for Lesser Amberjack (1982 – 2015) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and -dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length; Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively). Regressions only calculated for sample size ≥ 50.

Regression	Equation	Parameters ± std. err.	Statistic	N	Data range
Max TL to Nat TL	Nat TL = a + max_TL *b			3	
Max TL to FL	FL = a + max_TL *b			0	
Nat TL to FL	FL = a + nat_TL * b			4	
Max TL to G Wt	G WT = a * (max_TL^b)			16	
Max TL to W Wt	W WT =a* (max_TL^b)			22	
Nat TL to G Wt	G WT = a * (nat_TL^b)			0	
Nat TL to W Wt	W WT = a* (nat_TL^b)	a = 5.97e-05 ± 7.35e-06 b = 2.78 ± 2.97e-02	RSE = 0.4768	250	Nat TL: 24.5 – 92.0 W WT: 0.34 – 17.42
FL to G Wt	G WT= a* (FL^b)			0	
FL to W Wt	W WT = a* (FL^b)	a = 1.68e-05 ± 1.74e-05 b = 2.60 ± 2.51e-02	RSE = 0.5525	293	FL: 15.4 – 95.0 W WT: 0.13 – 24.74

Table.2.12.33. Reliability rubric for Almaco Jack (see section 2.2 for detailed information on the construction of this rubric).

Almaco Jack	***Seriola rivoliana***					
Criteria	Description	Frota et al. 2004	Abdussamad et al. 2008	Morato et al. 2001	Burch 1979	Thompson et al. 1996
SAMPLING		**0.67**	**0.58**	**0.50**	**0.50**	**0.33**
Sampling location	Not reported (0.0)					
	Indian Ocean (0.0)		0.0			
	South America (0.5)	0.5				
	Caribbean (0.5)			0.5		
	Campeche/Yucatan (0.5)					
	U.S. South Atlantic (0.5)				0.5	
	U.S. Gulf of Mexico (1.0)					1.0
Sampling timeframe	Not reported (0.0)					0.0
	< 12 Months (0.0)					
	1-2 years (0.5)			0.5	0.5	
	3-4 years (0.5)		0.5			
	5+ years (1.0)	1.0				
Time since sampling	20+ years (0.0)				0.0	0.0
	19-11 years (0.5)	0.5		0.5		
	10-1 years (1.0)		1.0			
Sampling frequency	Not reported (0.0)	0.0		0.0		0.0
	Annual (0.5)					
	Monthly (1.0)					
	Weekly (1.0)		1.0			
	Daily (1.0)				1.0	
Sampling method	Not reported (0.0)					
	Fishery independent (0.5)			0.5		0.5
	Fishery Dependent (0.5)		0.5		0.5	
	Combination (FI & FD) (1.0)	1.0				
Sampling gear	Not reported (0.0)					
	Active gear (e.g., hook and line) (0.5)		0.5		0.5	0.5
	Passive gear (e.g., nets) (1.0)	1.0		1.0		
AGE-LENGTH	**Age-Length Score**	**0.19**	**0.06**	**0.31**	**0.00**	**0.44**
	Age-length * Sampling Score	**0.13**	**0.04**	**0.16**	**0.00**	**0.15**
Total sample size of age structures	Not reported (0.0)				0.0	
	<200 (0.5)	0.5	0.5	0.5		0.5
	201-500 (0.5)					
	>501 (1.0)					
Length	Not reported (0.0)		0.0		0.0	
	Narrow range metrics (0.5)	0.5				
	Wide range metrics (1.0)			1.0		1.0
Age	Not reported (0.0)	0.0	0.0	0.0	0.0	
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)					1.0

continue Table.2.12.33. page 2

Almaco Jack	*Seriola rivoliana*					
Criteria	Description	Frota et al. 2004	Abdussamad et al. 2008	Morato et al. 2001	Burch 1979	Thompson et al. 1996
Ageing method	Not reported (0.0)	0.0	0.0	0.0	0.0	
	Other hard part (0.5)					
	Scales (0.5)					
	Otoliths: Whole (0.5), Section (1.0)					1.0
Age validated	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Captive Rearing (0.5)					
	Marginal increment (0.5)					
	Temporal length frequency (0.5)					
	Tag-recapture with chemical marking (0.5)					
	Radiochemical Dating (1.0)					
Reader precision	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Percent Frequency (0.5)					
	Average Percent Error (1.0)					
	Estimate of variation (CVs) (1.0)					
Number of samples per age class	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	5 (0.5)					
	10 (0.5)					
	20+ (1.0)					
Growth parameters estimation method	Not reported (0.0)		0.0		0.0	0.0
	Waldford plot (0.5)					
	Length Frequency (0.5)	0.5				
	Min. least squares (SAS, R, Excel) (1.0)			1.0		
LENGTH-WEIGHT	**Length-Weight Score**	**0.17**	**0.00**	**0.67**	**0.00**	**0.00**
	Length-Weight * Sampling Score	**0.11**	**0.00**	**0.33**	**0.00**	**0.00**
Length	Not reported (0.0)		0.0		0.0	
	Narrow range metrics (0.5)	0.5				
	Wide range metrics (1.0)			1.0		1.0
Weight	Not reported (0.0)	0.0	0.0		0.0	
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)			1.0		1.0
Number of samples per length bin	Not reported (0.0)	0.0	0.0	0.0	0.0	
	5 (0.5)					
	10 (0.5)					
	20+ (1.0)					1.0
Length-Weight regression	Reported (1.0) ; Not Reported (0.0)	1.0	0.0	1.0	1.0	0.0

continue Table.2.12.33. page 3

Almaco Jack	***Seriola rivoliana***					
Criteria	Description	Frota et al. 2004	Abdussamad et al. 2008	Morato et al. 2001	Burch 1979	Thompson et al. 1996
MATURITY	**Maturity Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.21**
	Maturity * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.07**
Number of reproductive samples	Not reported (0.0)	0.0	0.0	0.0	0.0	
	<200 (0.5)					0.5
	201-500 (0.5)					
	>501 (1.0)					
Length	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)					
Weight	Not reported (0.0)		0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)	0.0				
	Wide range metrics (1.0)					
Age	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Narrow range metrics (0.5)					
	Wide range metrics (1.0)					
Sex determination methods	Not reported (0.0)	0.0	0.0	0.0	0.0	
	Macroscopic examination (0.5)					
	Histological examination (1.0)					1.0
Length of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)					
	Data fit using Logistic Model (1.0)					
Age of maturity estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Estimated based on observed (0.5)					
	Data fit using Logistic Model (1.0)					
MORTALITY	**Mortality Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Mortality * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Natural mortality estimation method	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Based VB growth parameters (0.5)					
	Based on maximum age (1.0)					
STEEPNESS	**Steepness Score**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Steepness * Sampling Score	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Steepness estimation	Not reported (0.0)	0.0	0.0	0.0	0.0	0.0
	Based on meta-analysis (0.5)					
	Previous stock assessment (1.0)					

Table 2.12.34 LHWG summary of recommendations for Almaco Jack life history parameters (1) a point estimate, (2) an estimate of variability (SD,SE,CV), and (3) a range of plausible values with sources documented. Parameters: M – natural mortality; L_∞ – von Bertalanffy asymptotic length; k – von Bertalanffy growth coefficient; t_0 – von Bertalanffy theoretical age at length zero; alpha – *a* from weight-length regression; beta – *b* from weight-length regression; L50 – size at 50% maturity; L95 – size at 95% maturity; *h* – steepness; Sigma *R* – process error in recruitment deviations; SD – standard deviation; SE – standard error; CV – coefficient of variation

Parameter	Point estimate	Source	Variability (SD, SE, or CV)	Source	Range	Source
Maximum Age	None	No data available	None	No data available	None	No data available
M	None	No data available	None	No data available	None	No data available
L_∞	None	No data available	None	No data available	None	No data available
k	None	No data available	None	No data available	None	No data available
t_0	None	No data available	None	No data available	None	No data available
alpha	9.09E-05	Value from SEDAR49 data analysis for FL to W Wt	8.71E-06	SE from SEDAR49 data analysis for FL to W Wt (N = 1,867)	-	-
beta	2.76	Value from SEDAR49 data analysis for FL to W Wt	2.20E-02	SE from SEDAR49 data analysis for FL to W Wt (N = 1,867)	-	-
L50	None	No data available	None	No data available	None	No data available
L95	None	No data available	None	No data available	None	No data available
h	None	No data available	None	No data available	None	No data available
Sigma *R*	None	No data available	None	No data available	None	No data available

Table 2.12.35 Meristic regressions for Almaco Jack (1982 – 2015) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and -dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length; Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (cm) and weight (lbs). Linear and non-linear regressions calculated using R (lm and nls functions, respectively). Regressions only calculated for sample size ≥ 50.

Regression	Equation	Parameters ± std. err.	statistic	N	Data Range
Max TL to Nat TL	Nat TL = a + max_TL *b			18	
Max TL to FL	FL = a + max_TL *b			0	
Nat TL to FL	FL = a + nat_TL * b	a = -0.68 ± 0.63 b = 0.90 ± 0.01	r^2 = 0.9939	54	Nat TL: 23.9 – 110.5 FL: 20.2 – 102.0
Max TL to G Wt	G WT = a * (max_TL^b)			23	
Max TL to W Wt	W WT =a* (max_TL^b)	a = 1.22e-05 ± 3.86e-06 b = 3.25 ± 7.25e-02	RSE = 1.353	150	Max TL: 22.7 – 98.0 W WT: 0.45 – 38.92
Nat TL to G Wt	G WT = a * (nat_TL^b)			0	
Nat TL to W Wt	W WT = a* (nat_TL^b)	a = 3.84e-05 ± 1.41e-06 b = 2.89 ± 8.52e-03	RSE = 0.5736	2,409	Nat TL: 22.7 – 119.4 W WT: 0.34 – 38.25
FL to G Wt	G WT= a* (FL^b)	a = 2.14e-05 ± 4.04e-05 b = 2.54 ± 4.24e-02	RSE = 1.326	224	FL: 32.0 – 104.4 G WT: 1.10 – 28.22
FL to W Wt	W WT = a* (FL^b)	a = 9.09e-05 ± 8.71e-06 b = 2.76 ± 2.20e-02	RSE = 1.755	1867	FL: 14.7 – 102.0 W WT: 0.14 – 55.57

2.13 FIGURES

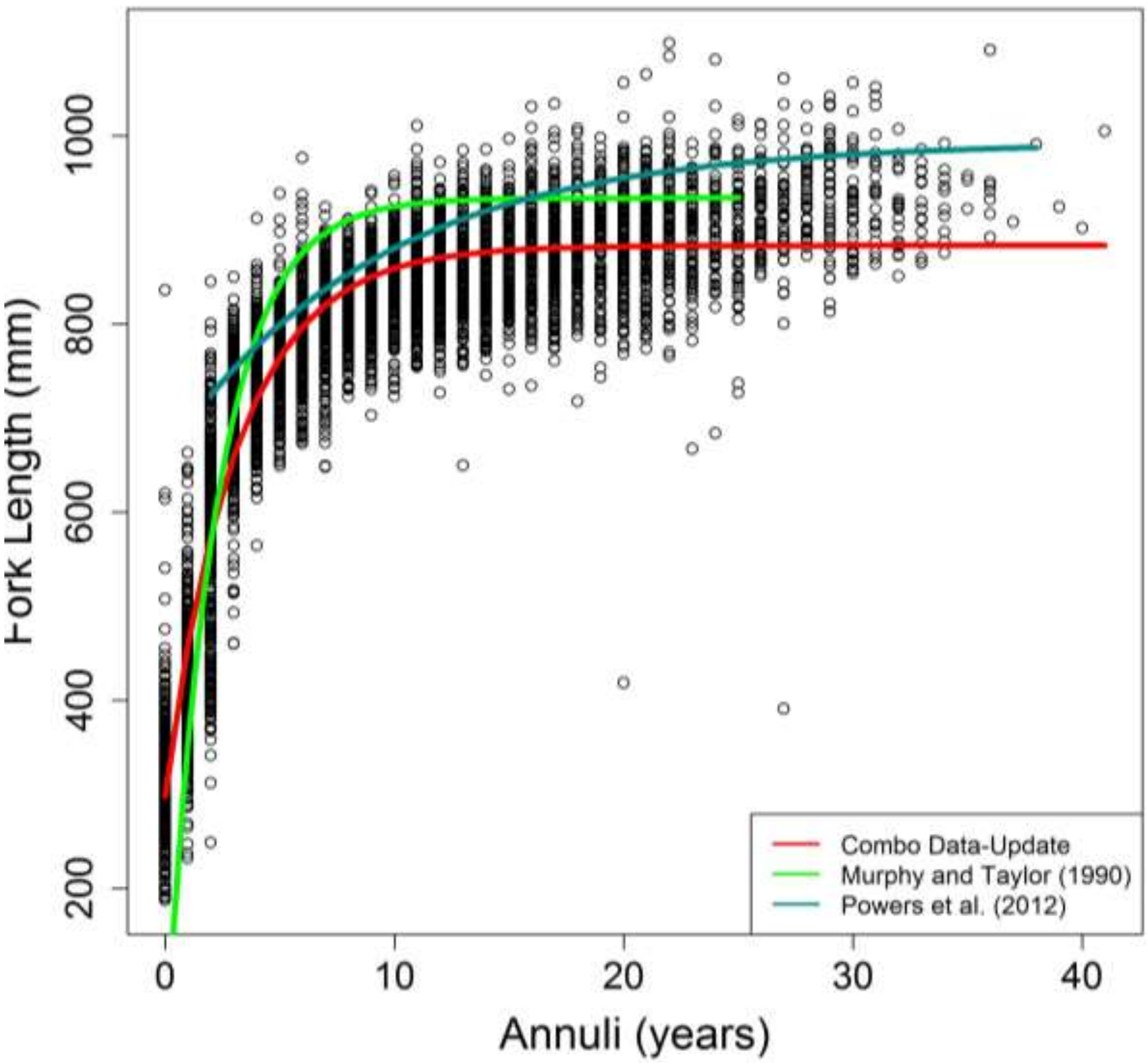

Figure 2.13.1 A comparison among the Red Drum growth parameters estimated by Murphy and Taylor (1990), Powers et al. (2012), and re-estimated growth parameters given five original datasets provided for SEDAR49 and fit using a non-linear regression (R; nls). The LHWG recommended using the re-estimated growth parameters. Note: the combo data-update curve was fit to the data plotted (open circles). The other two curves were calculated given a vector of ages, corresponding growth parameters and plotted for comparison.

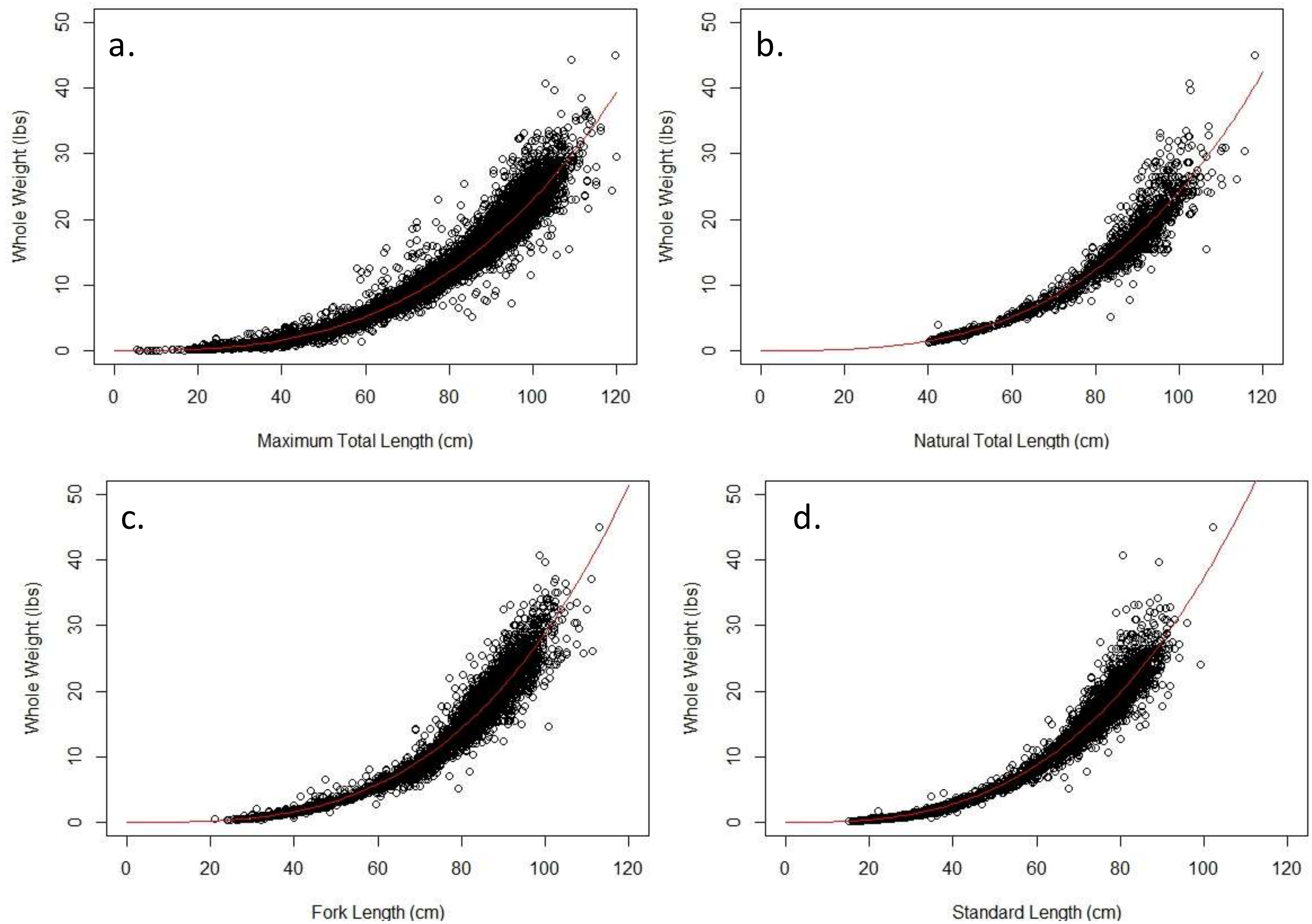

Figure 2.13.2 Red Drum meristic regression predicting (a) whole weight from maximum total length, (b) whole weight from natural total length, (c) whole weight from fork length, and (d) whole weight from standard length using all fishery-independent data from the Gulf of Mexico (see Table 2.12.6 for regression results and sample sizes).

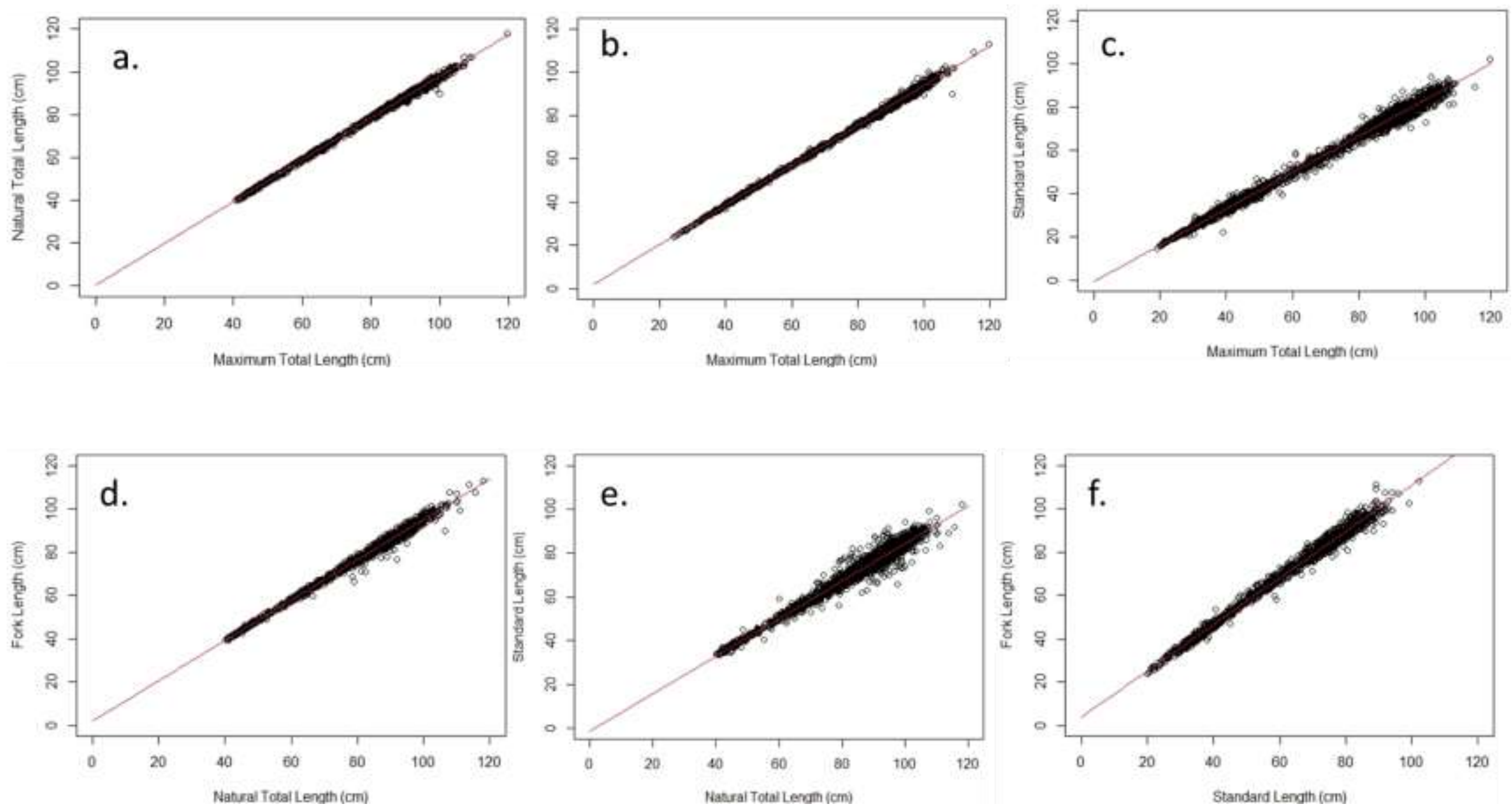

Figure 2.13.3 Red Drum meristic regression predicting (a) natural total length from maximum total length, (b) fork length from maximum total length, (c) standard length from maximum total length, (d) fork length from natural total length, (e) standard length from natural total length, and (f) fork length from standard length using all fishery-independent data from the Gulf of Mexico (see Table 2.12.6 for regression results and sample sizes).

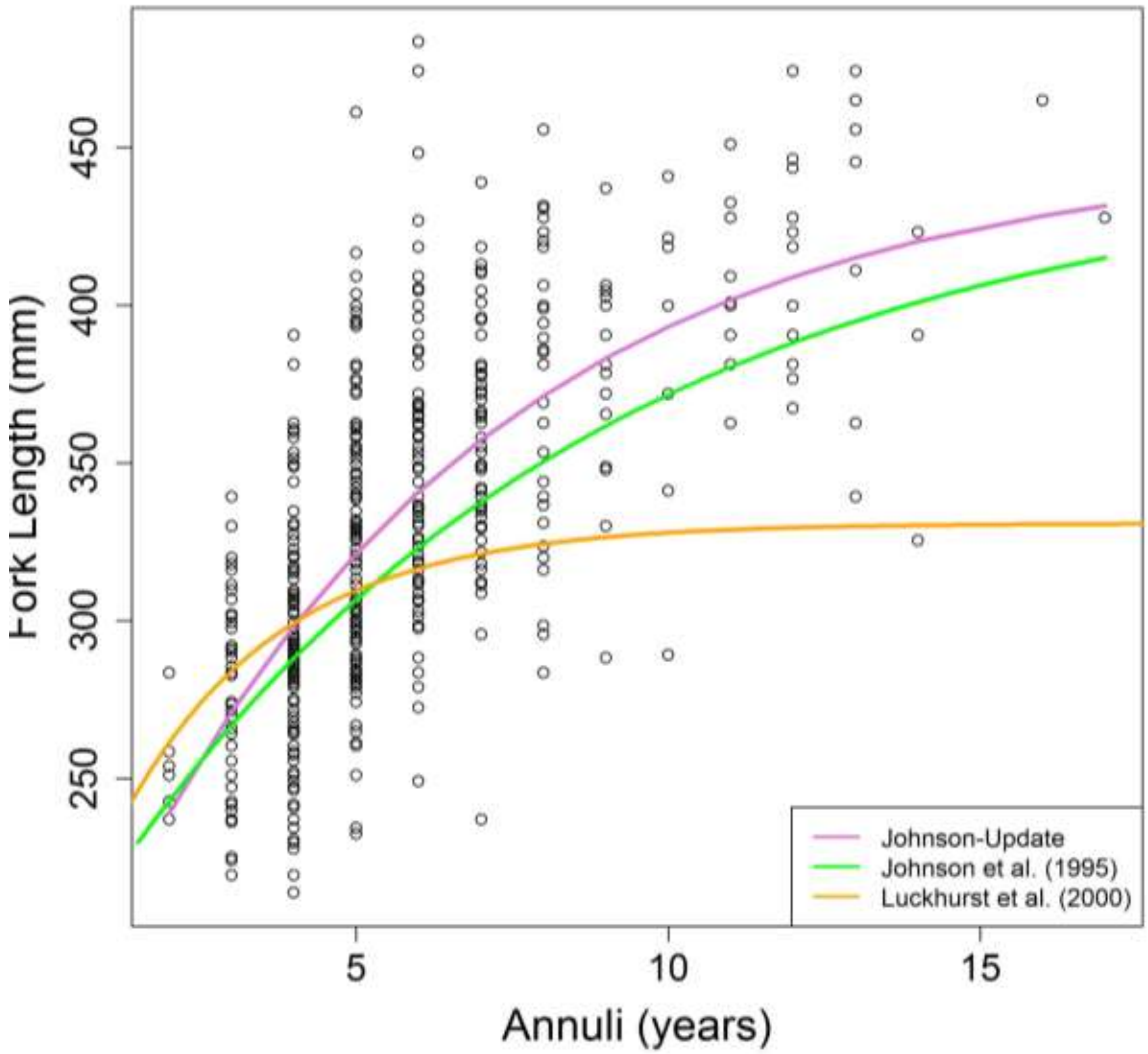

Figure 2.13.4 A comparison among the Lane Snapper growth parameters estimated by Johnson et al. (1995), Luckhurst et al. (2000), and re-estimated growth parameters given age and length data from Johnson et al. and fit using a non-linear regression (R; nls). The LHWG recommended using the re-estimated growth parameters. Note: the Johnson-Update curve was fit to the data plotted. The other two curves were calculated given a vector of ages, corresponding growth parameters and plotted for comparison.

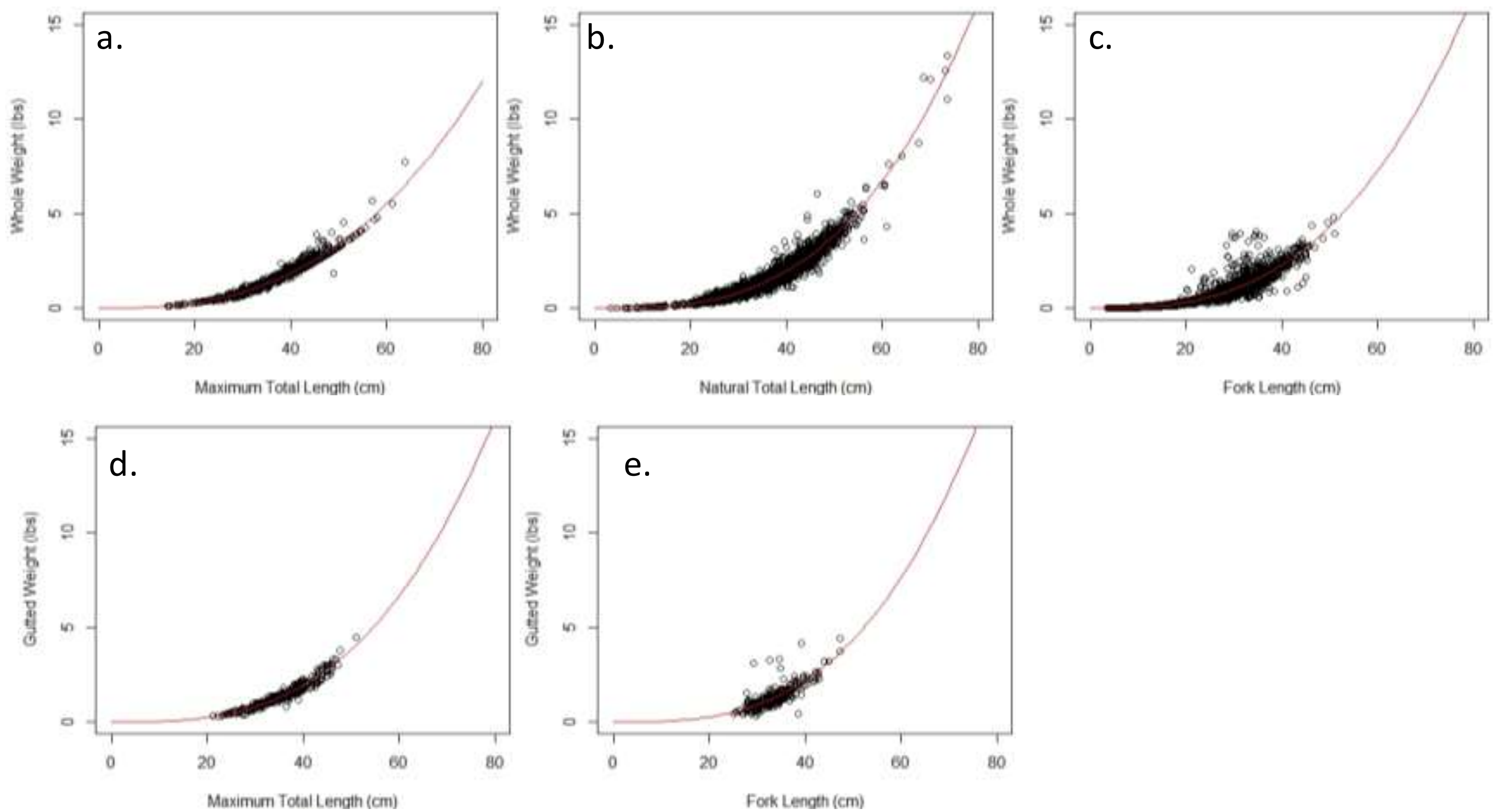

Figure 2.13.5 Lane Snapper meristic regression predicting (a) whole weight from maximum total length, (b) whole weight from natural total length, (c) whole weight from fork length, (d) gutted weight from maximum total length, and (e) gutted weight from fork length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.11 for regression results and sample sizes).

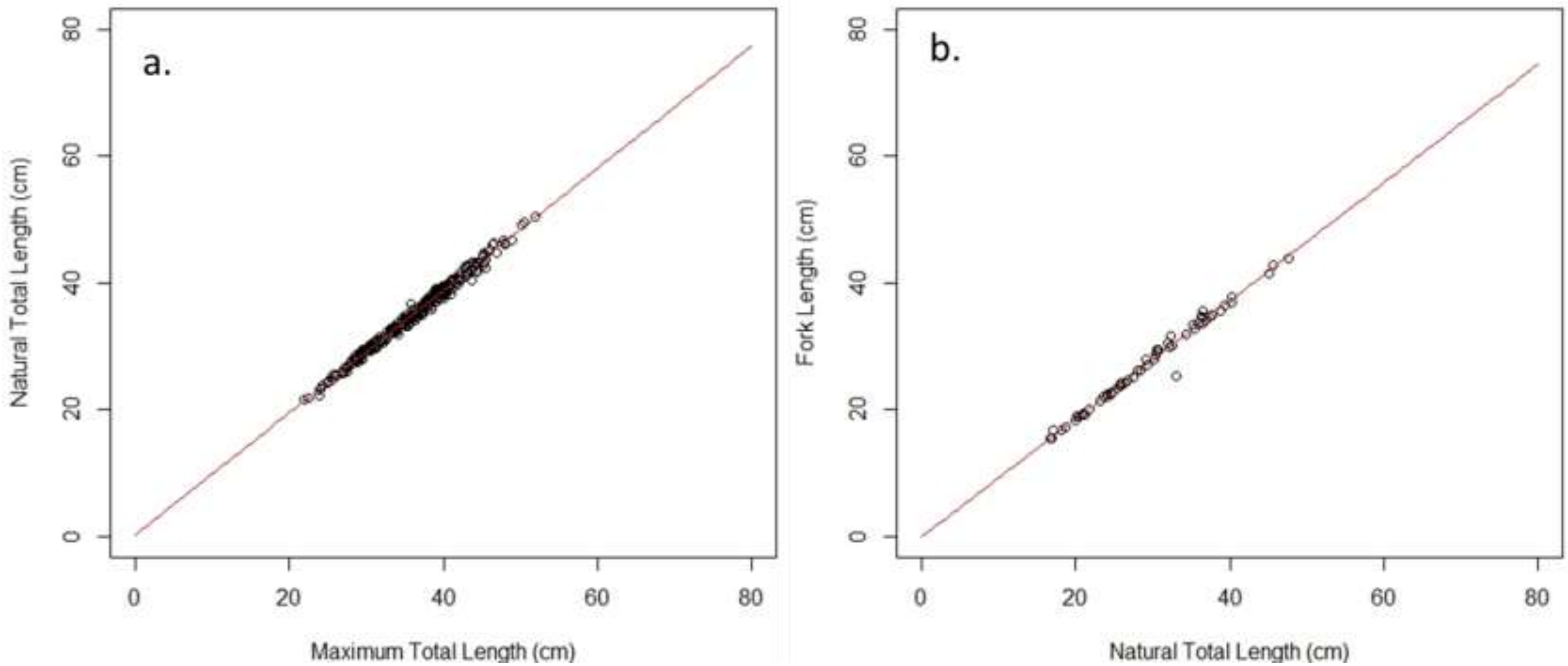

Figure 2.13.6 Lane Snapper meristic regression predicting (a) natural total length from maximum total length, and (b) fork length from natural total length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.11 for regression results and sample sizes).

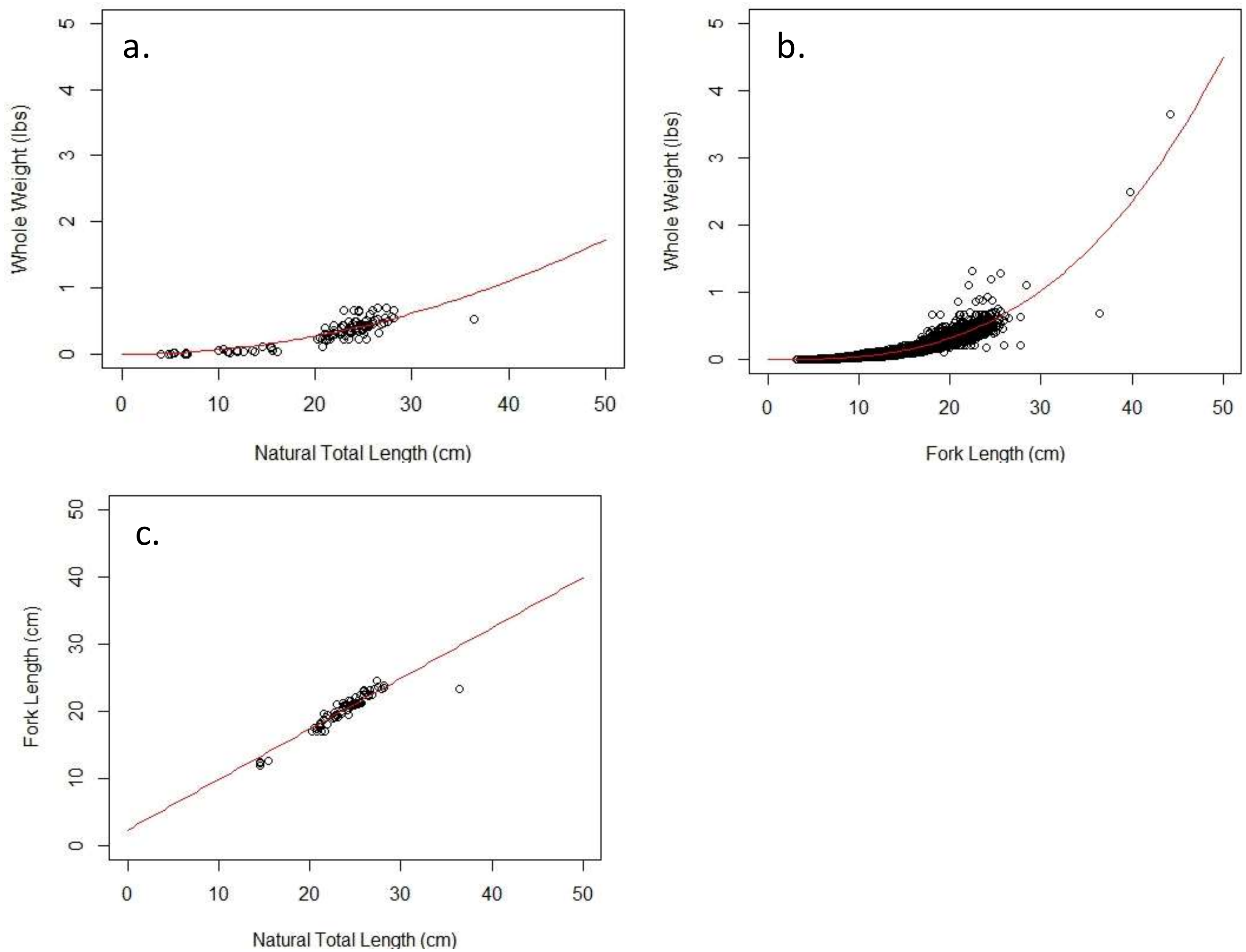

Figure 2.13.7 Wenchman meristic regressions predicting (a) whole weight from natural total length, (b) whole weight from fork length, and (c) fork length from natural total length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.15 for regression results and sample sizes).

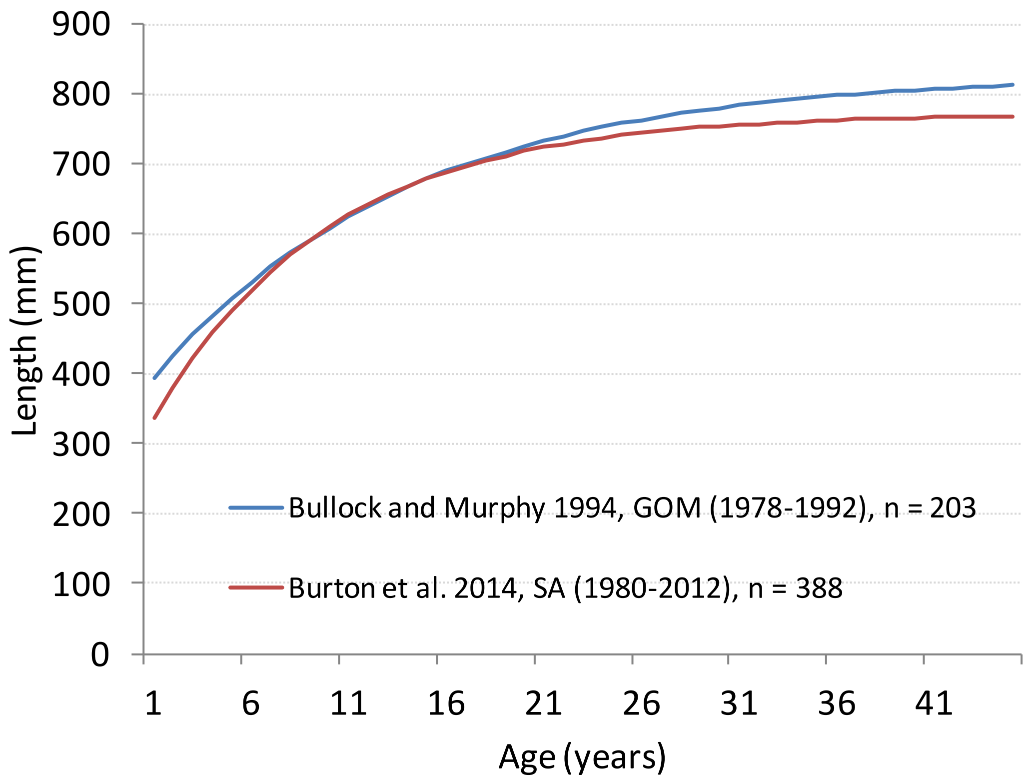

Figure 2.13.8 A comparison between the Yellowmouth Grouper growth parameters estimated by Bullock and Murphy (1994) and Burton et al. (2014). The growth parameters predict similar growth curves. Note – citations reported different lengths (TL and FL, respectively).

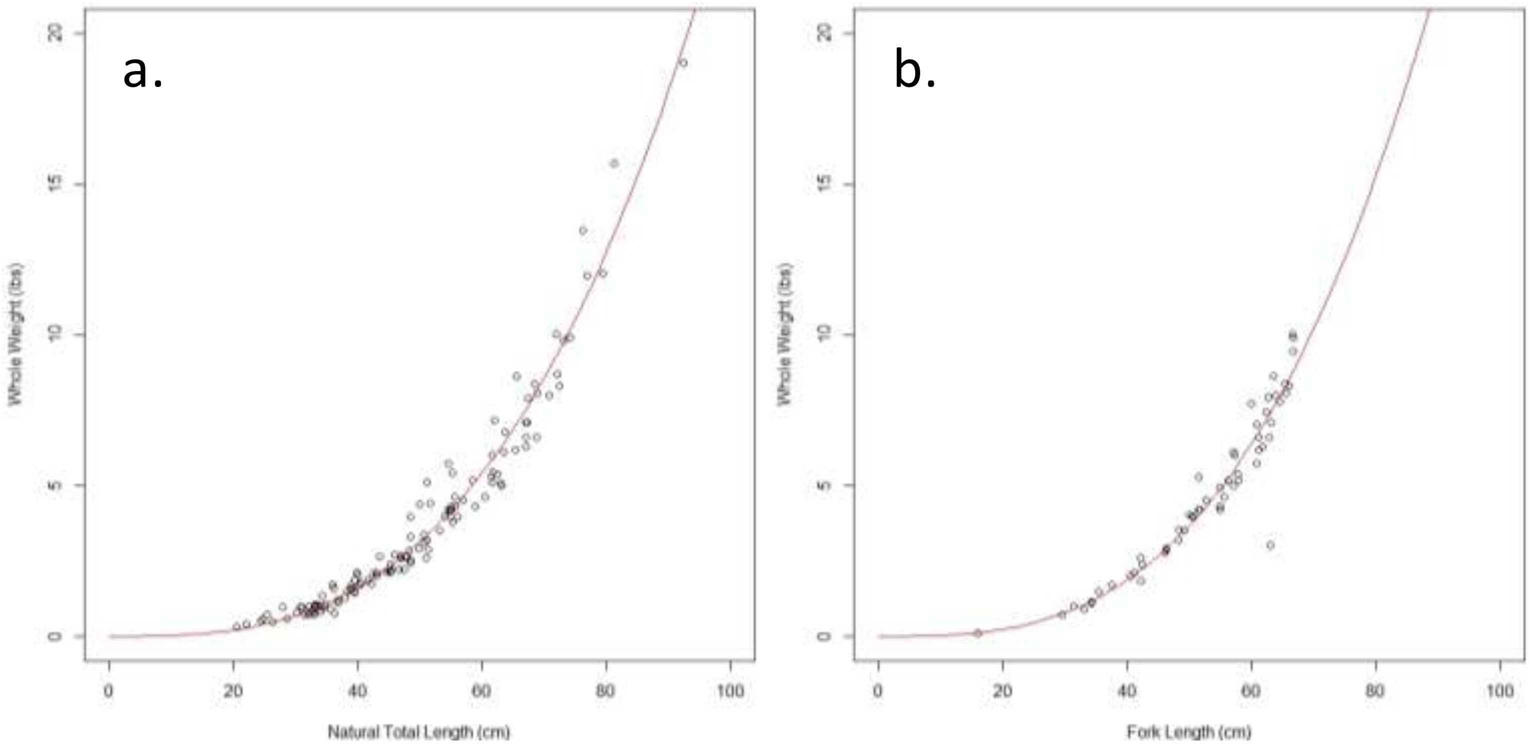

Figure 2.13.9 Yellowmouth Grouper meristic regression predicting (a) whole weight from natural total length and (b) whole weight from fork length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.19 for regression results and sample sizes).

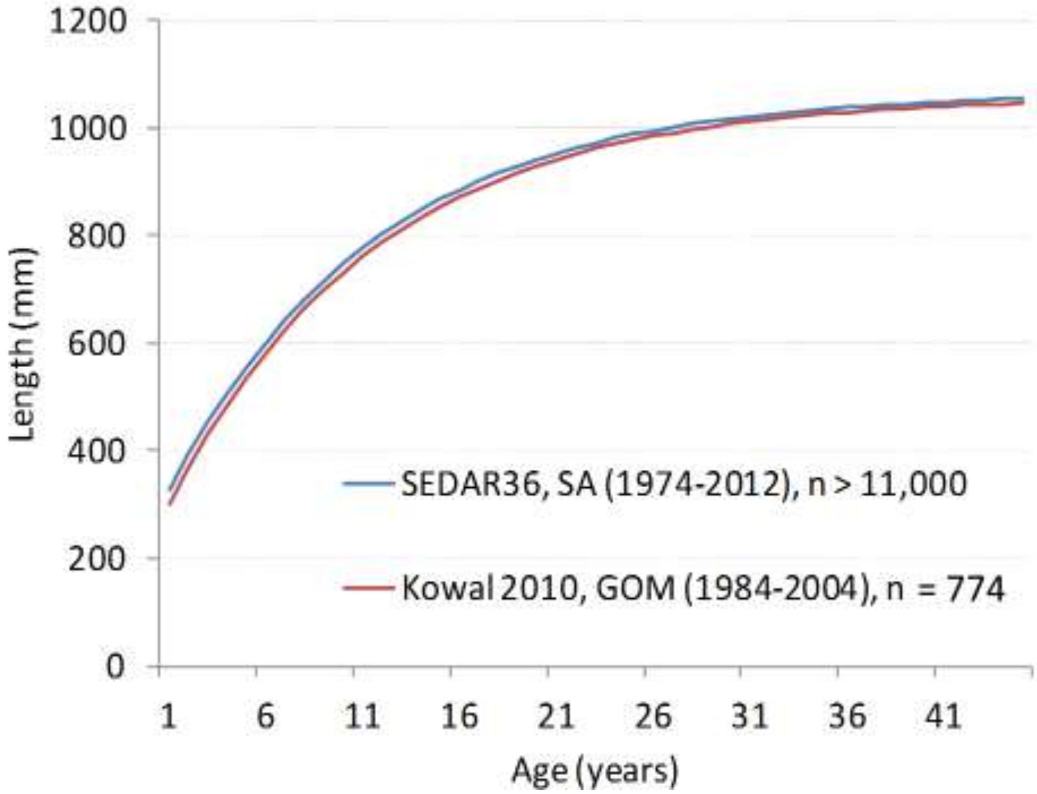

Figure 2.13.10 A comparison between Snowy Grouper growth parameters estimated by SEDAR (2013) and Kowal (2010). The growth parameters yield similar growth curves. Note – citations reported different lengths (TL and FL, respectively).

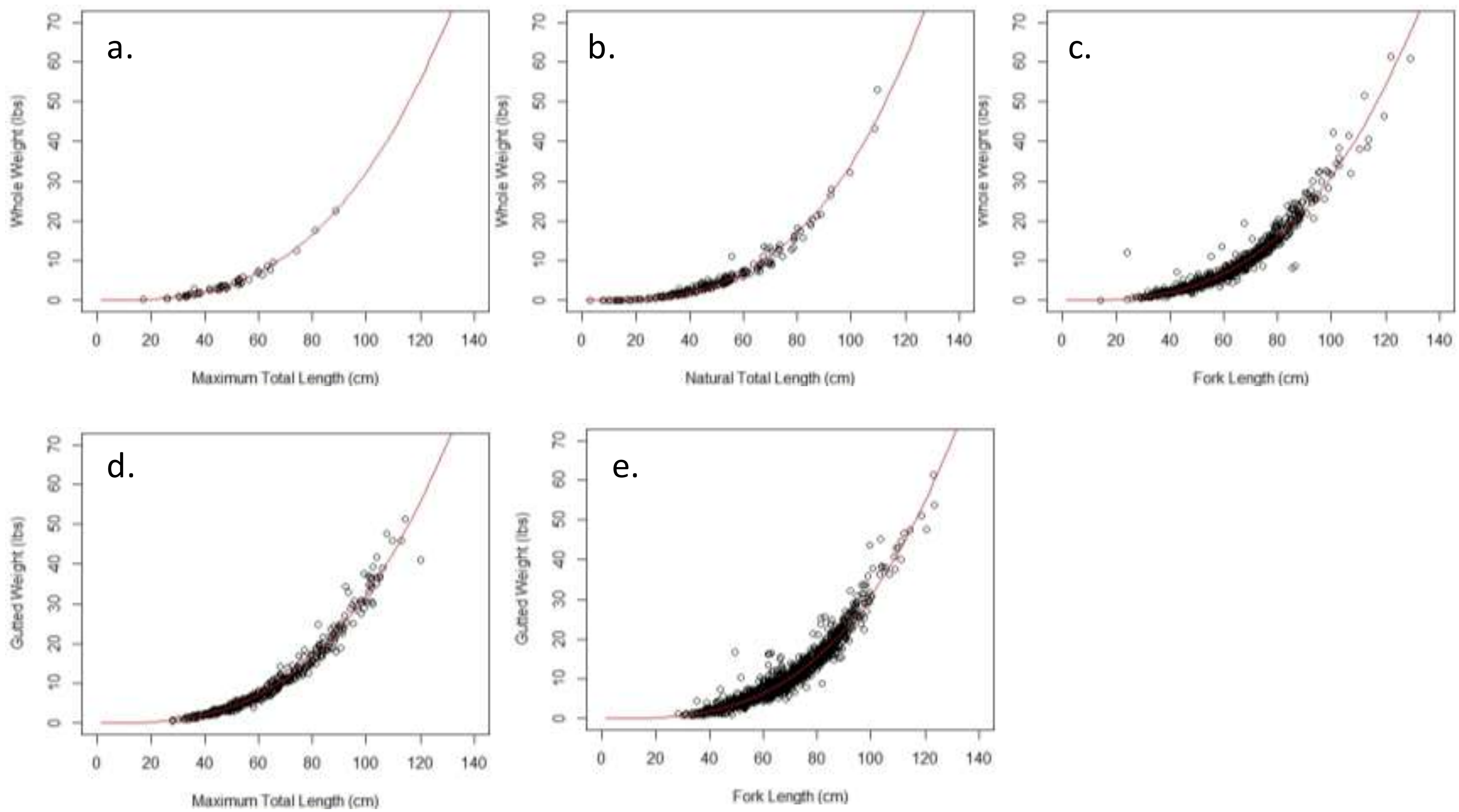

Figure 2.13.11 Snowy Grouper meristic regression predicting (a) whole weight from maximum total length, (b) whole weight from natural total length, (c) whole weight from fork length, (d) gutted weight from maximum total length, and (e) gutted weight from fork length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.24 for regression results and sample sizes).

Andrews et al. 2013
''Fig. 1. Two images of the same transverse otolith section from specimen SPH-13 (*E. drummondhayi*) viewed with (A) reflected light on a black background and (B) off-axis transmitted light (Leica TL4000 Rotterman Contrast). Precise core extraction is visible as the grooved notch on the topside (distal margin) of the otolith section images. The delta ^{14}C value measured for this sample indicated that the age of this fish was at least 44 years. Note the complexity of the growth zone structure that can lead to a wide range of age estimate interpretations. The right side of the sulcus (ventral) reveals broad zone groupings quantifiable to approximately 25 years (A, B). The left side of the sulcus (dorsal) reveals a finer structure that can be quantified to more than 50 years and is more apparent with Rotterman Contrast transmitted light (B), which is consistent with bomb radiocarbon dating. Scale bar = 1 mm.''

Figure 2.13.12 Image of a thin-sectioned Speckled Hind (Figure 1. Andrews et al. 2013).

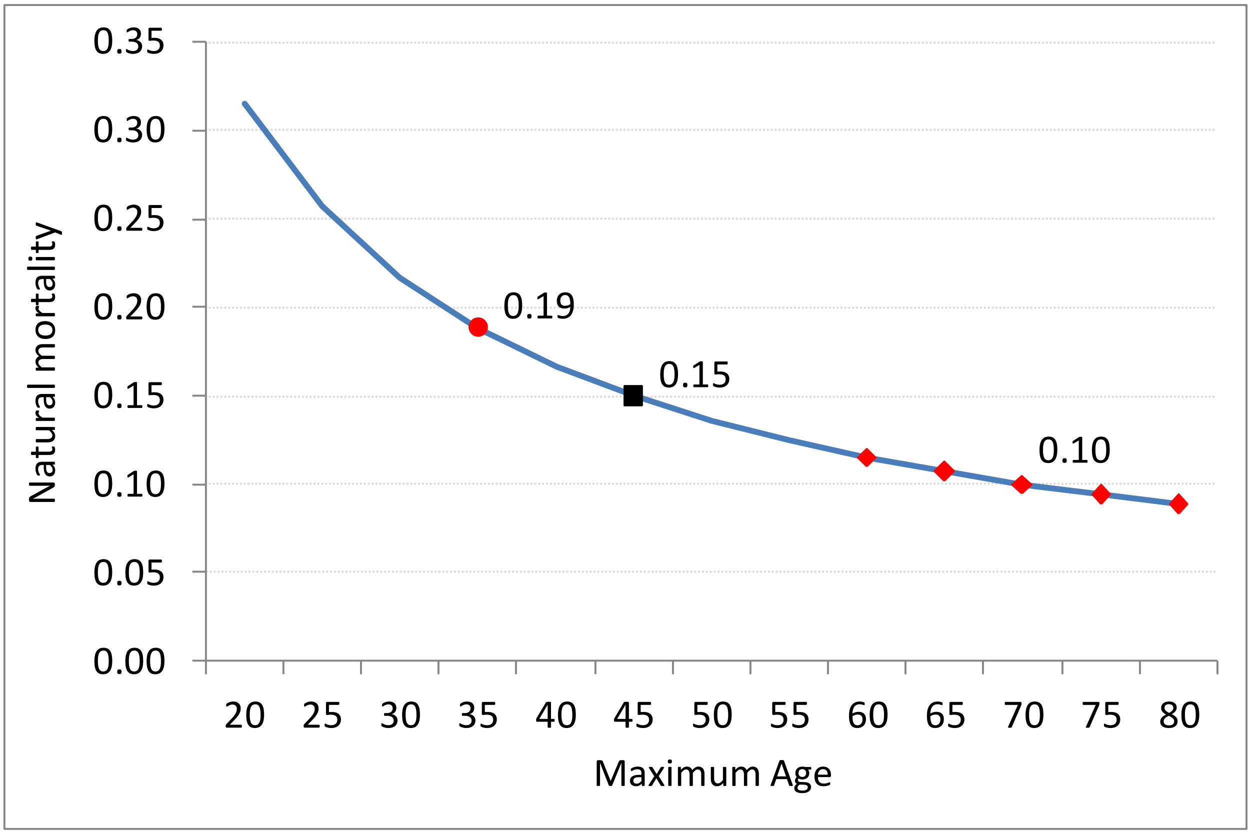

Figure 2.13.13 Speckled Hind natural mortality estimates using the updated Hoenig regression (Then et al. 2015) for a wide range of longevities (20 – 80 years). Ziskin et al. (2011) reported longevity of 35 years (red circle), whereas Andrews et al. (2013) reported longevity of 60 – 80 years (red diamonds). The LHWG recommends a maximum age of 45 years (black square).

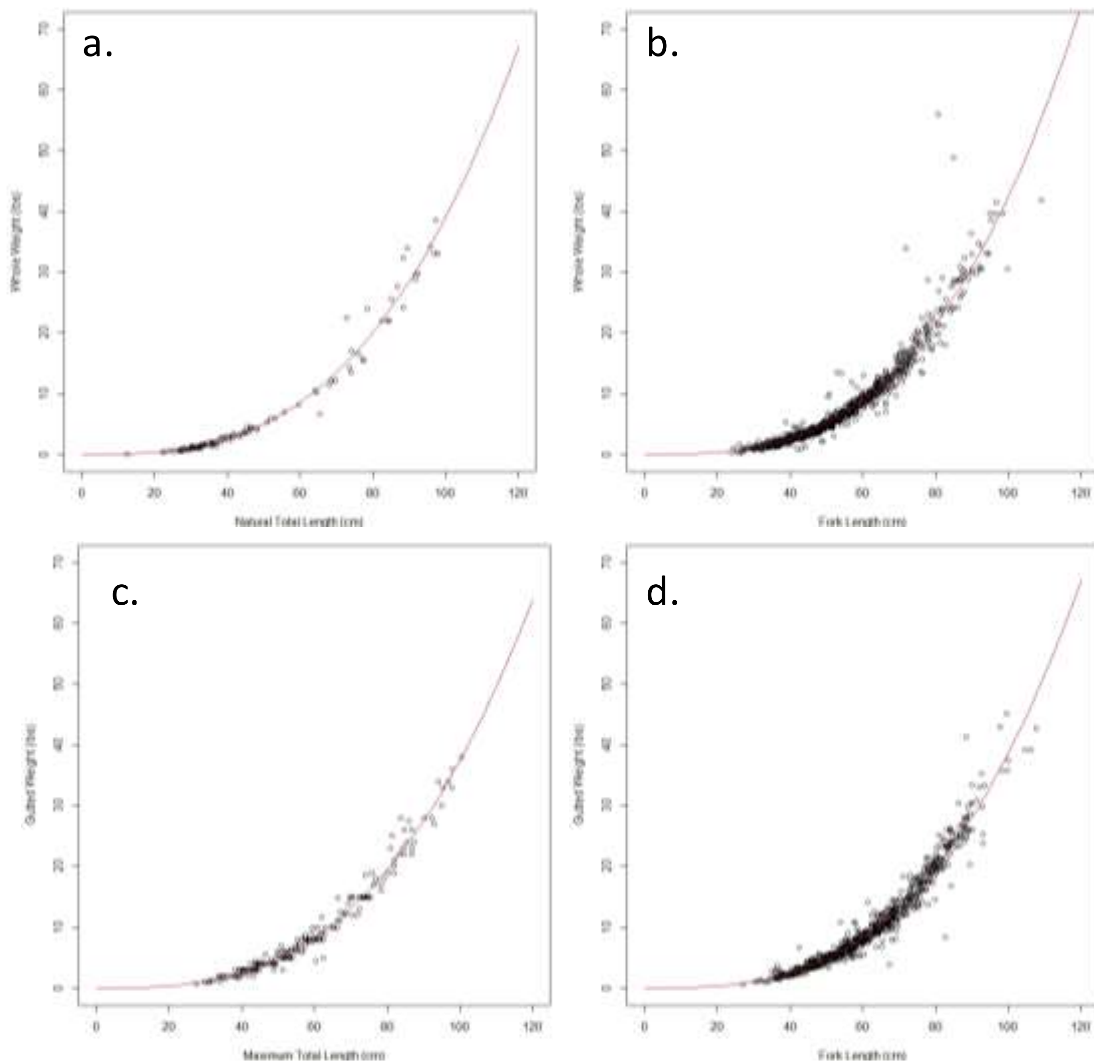

Figure 2.13.14 Speckled Hind meristic regression predicting (a) whole weight from natural total length, (b) whole weight from fork length, (c) gutted weight from maximum total length, and (d) gutted weight from fork length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.28 for regression results and sample sizes).

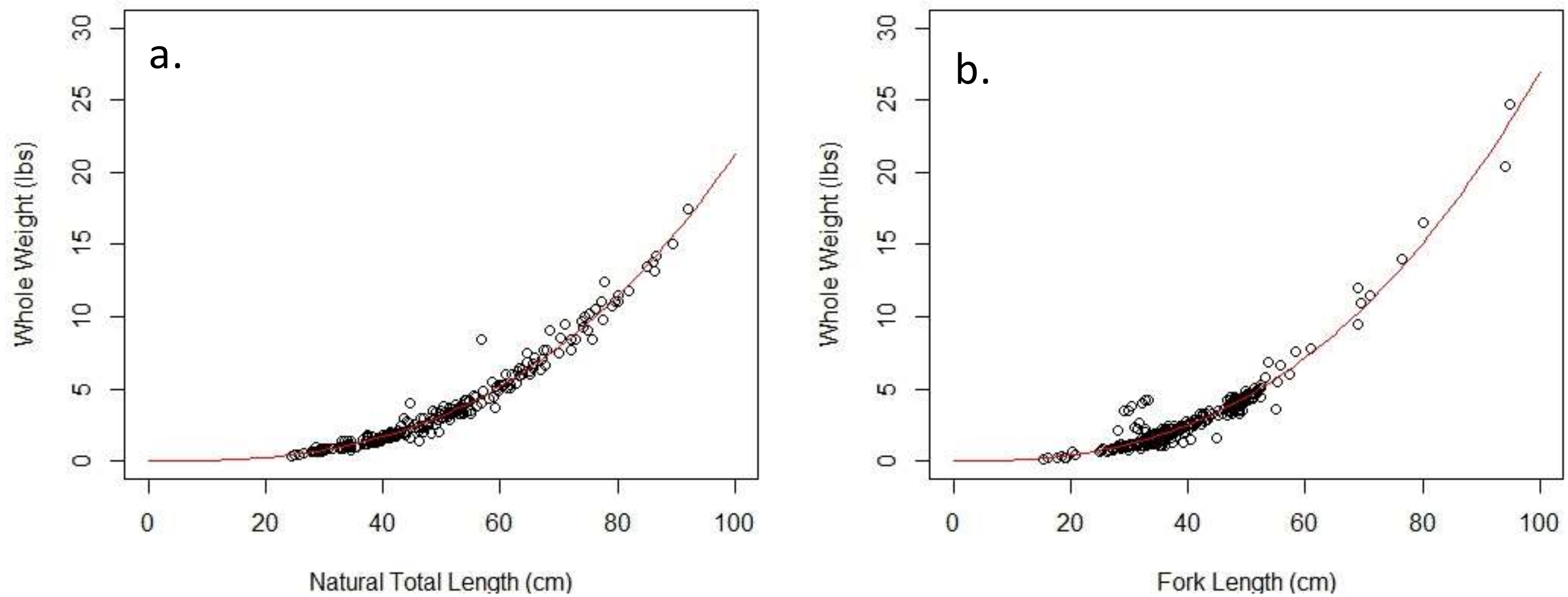

Figure 2.13.15 Lesser Amberjack meristic regression predicting (a) whole weight from natural total length and (b) whole weight from fork length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.32 for regression results and sample sizes).

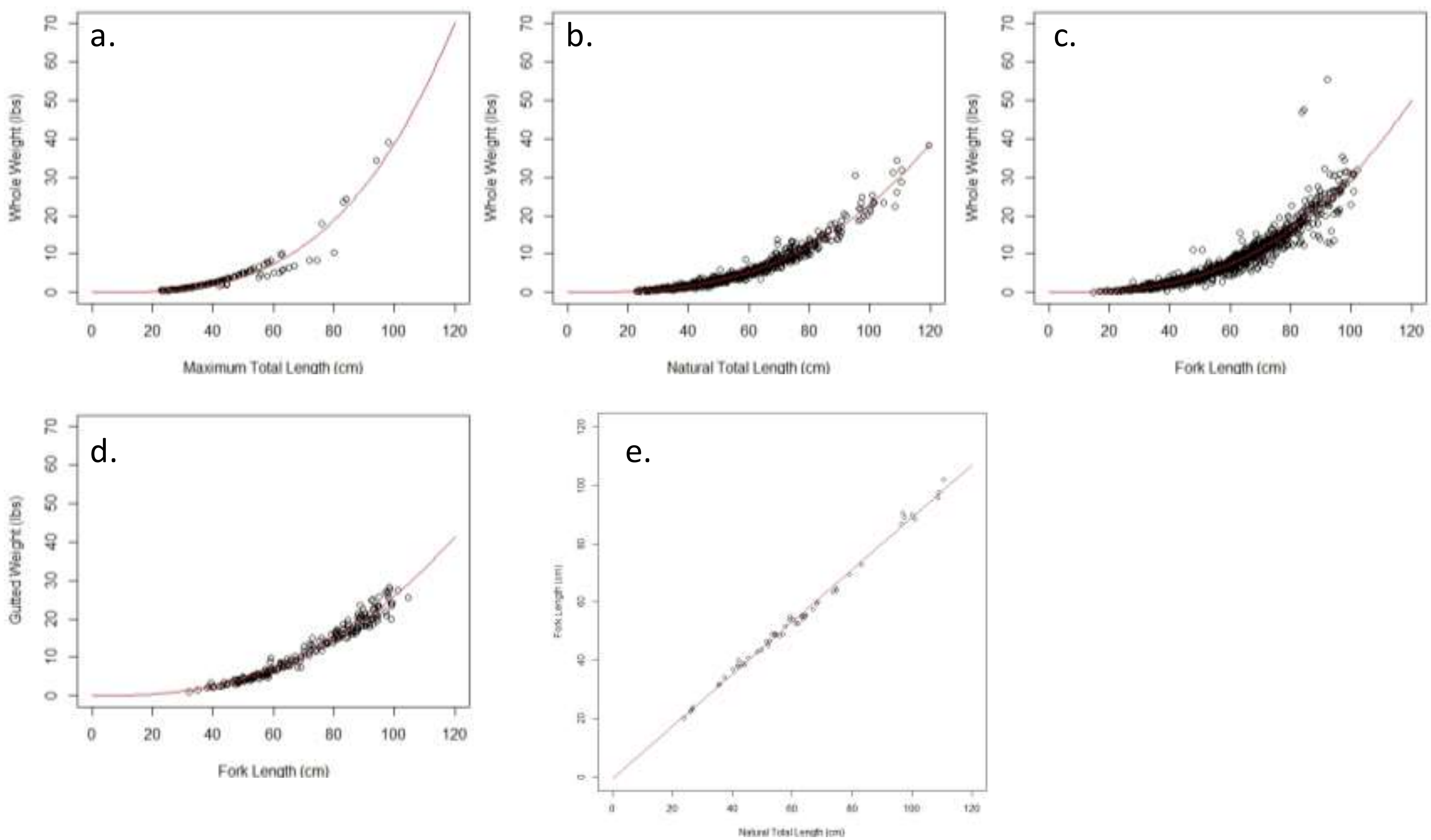

Figure 2.13.16 Almaco Jack meristic regressions predicting (a) whole weight from maximum total length, (b) whole weight from natural total length, (c) whole weight from fork length, (d) gutted weight from fork length, and (e) fork length from natural total length using all fishery-dependent and -independent data from the Gulf of Mexico (see Table 2.12.35 for regression results and sample sizes).

3 COMMERCIAL FISHERY STATISTICS

3.1 OVERVIEW

Commercial landings of the eight SEDAR 49 data-limited species in the U.S. Gulf of Mexico were constructed using data housed in the NOAA's Southeast Fisheries Science Center's Accumulated Landings System (ALS). The ALS includes landings data beginning in 1962. The terminal year for SEDAR 49 was 2014.

3.1.1 Commercial Workgroup Participants

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3.1.2 Issues Discussed at the Data Workshop

Issues discussed in the commercial workgroup included determining the initial year of the landings time series for each species, possible species identification problems, assignment of unclassified fish (e.g., groupers) to species, and estimating uncertainty of landings and discards.

3.2 REVIEW OF WORKING PAPERS

Methods used to estimate the number of SEDAR 49 species taken as bycatch in Gulf of Mexico shrimp fisheries are described in document SEDAR49-DW-01. A literature review of Red Drum bycatch in the Gulf menhaden reduction purse seine fishery is described in SEDAR49-DW-04. No other documents describing commercial fisheries landings or non-shrimp commercial fisheries discards of the SEDAR 49 species were available at the Data Workshop.

3.3 COMMERCIAL LANDINGS

The commercial landings were compiled from the Accumulated Landings System (ALS) from 1962-2014 when available. The data series for Red Drum began in 1962 and in 1965 for Lane Snapper. For the groupers, (Snowy Grouper, Yellowmouth Grouper, and Speckled Hind) the data series began in 1986.

Starting in 1986, groupers began to be classified according to their own individual NMFS codes, rather than being reported as unclassified groupers (NMFS species code 1410). Yearly total non-confidential commercial landings in pounds whole weight are provided by species in Table 3.8.1. In some cases, landings data were available for years prior to those shown. The data series were truncated if reporting was incomplete (e.g., Lane Snapper, Red Drum) or if misidentification or reporting by species group was common (e.g., Lesser Amberjack, Speckled Hind).

3.3.1 Red Drum

Non-confidential Red Drum commercial landings are provided by year and gear in Table 3.8.2 in pounds whole weight. Although commercial Red Drum landings data were available beginning in 1962, the time series for Red Drum provided for SEDAR 49 includes the years 1981-2014, as recommended by the workgroup. The data-limited approach employed for SEDAR 49 requires total removals (i.e., commercial landings, recreational landings, discards, and bycatch from other fisheries) over the entire time period used in the assessment models; therefore, the commercial landings time series was truncated to match the recreational fishery time series of landings. In Table 3.8.2, some year/gear combinations included confidential data that cannot be shown (as indicated with an *).

3.3.2 Lane Snapper

Non-confidential Lane Snapper commercial landings are provided by year and gear in Table 3.8.3 in pounds whole weight. The time series for Lane Snapper includes the years 1986-2014 as recommended by the workgroup. Some year/gear combinations included confidential data that cannot be shown (as indicated with an *). Lane Snapper commercial landings were available beginning in 1965; however, it was uncertain if those data prior to 1986 (beginning of Florida trip ticket program) were complete. Prior to state trip ticket programs, landings data were collected through dealer surveys that may have been incomplete.

3.3.3 Wenchman

Wenchman landings were extracted from the ALS at the Southeast Fisheries Science Center in Miami (Table 3.8.4, non-confidential landings). A review of the landings information by gear indicated that 98 percent of the Wenchman landings from 1986-2014 came from “net” gear. A more in-depth review of the underlying FL trip ticket data indicated that “net” gear was actually from the fish trawl fishery. The primary species associated with trips in which Wenchman is caught, are Butterfish (Stromateidae) and an unclassified fish category. These two “species” categories make up 76 percent of the landings from trips with Wenchman landings. The consensus of the group is that Wenchman is primarily a bycatch species in the Butterfish trawl fishery, with some other infrequent catches by other gear.

The workgroup was also tasked with deciding the year in which to start the time series. A review of the landings seemed to indicate low Wenchman landings during the years of 1986-1996 with an abrupt increase in landings in 1997. The group felt that fishermen could have been using Wenchman for bait until they found they could sell them and so started landing more of the species. Alternatively, it is possible that they were more reliably identified in landings from 1997 on. As a large increase was noted in 1997, it was decided to use 1997 as the start year for the landings time series.

3.3.4 Yellowmouth Grouper

Non-confidential Yellowmouth Grouper commercial landings are provided by year and gear in Table 3.8.5 in pounds whole weight. The time series for Yellowmouth Grouper includes the years 1991-2014, as recommended by the workgroup. Almost all year/gear combinations included confidential data that cannot be shown (as indicated with an *).

3.3.5 Snowy Grouper

Non-confidential Snowy Grouper commercial landings are provided by year and gear in Table 3.8.6 in pounds whole weight. The time series for Snowy Grouper includes the years 1990-2014, as recommended by the workgroup. Some year/gear combinations included confidential data that cannot be shown (as indicated with an *). As with Lane Snapper landings, Snowy Grouper landings data appeared to be incomplete prior to 1986. Prior to 1990, 600,000 - 12,000,000 pounds whole weight of unclassified grouper were landed each year. Species-specific reporting improved beginning in 1990 when less than 300,000 pounds of unclassified grouper were landed. Due to that improvement in species-specific reporting, the workgroup recommended beginning the landings time series at 1990.

3.3.6 Speckled Hind

Non-confidential Speckled Hind commercial landings are provided by year and gear in Table 3.8.7 in pounds whole weight. The time series for Speckled Hind includes the years 1997-2014, as recommended by the workgroup. Some year/gear combinations included confidential data that cannot be shown (as indicated with an *).

3.3.7 Lesser Amberjack

Non-confidential Lesser Amberjack commercial landings are provided by year and gear in Table 3.8.8 in pounds whole weight. The time series for Lesser Amberjack includes the years 1991-2014, as recommended by the workgroup. Some year/gear combinations included confidential data that cannot be shown (as indicated with an *).

3.3.8 Almaco Jack

Non-confidential Almaco Jack commercial landings are provided by year and gear in Table 3.8.9 in pounds whole weight. The time series for Almaco Jack includes the years 1991-2014, as recommended by the workgroup. Some year/gear combinations included confidential data that cannot be shown (as indicated with an *).

3.4 DISCARDS AND BYCATCH

Discards were calculated for the commercial vertical line, bottom longline, and shrimp trawl fisheries. The Gulf of Mexico menhaden reduction purse seine fishery was also examined for bycatch of Red Drum. Due to the paucity of Red Drum bycatch in the fishery, no analyses were conducted.

Shrimp bycatch estimates for Gulf of Mexico data limited species were generated using the approach developed by Nichols and used in SEDAR 7 Gulf of Mexico Red Snapper assessment (Nichols 2004a, 2004b). A detailed description of the data and methods used to produce shrimp bycatch estimates can be found in Linton (2012) and Isely (2016). Estimates of shrimping effort were provided by SEFSC Galveston Laboratory (Figure 3.9.1). Although length and weigh were determined from fishery-independent bycatch samples, sampling was not representative. Therefore, bycatch in weight could not be calculated.

Discard data were also available from the reef fish and shark bottom longline observer programs and the reef fish vertical line observer program. Discards from commercial logbooks were available from 2002-2014, but underreporting of fisherman-reported discards has been noted in prior SEDAR assessments (McCarthy, 2011).

Observer program data from 2007 to 2014 were examined for their utility in estimating total discards by species. Table 3.8.10 provides a summary of the percent frequency of occurrence, by set, of each SEDAR 49 species in the reef fish and shark observer data sets. Calculation of discards of Speckled Hind and Snowy Grouper was recommended by the workgroup because those species were observed in more than 2.5 percent of sets of one or more gears. Although Almaco Jack were also observed in 2.5 percent of bandit rig sets, calculation of discards for that species was not recommended due to the presumed low discard mortality of jacks. Similarly, Lane Snapper were observed in more than 2.5 percent of sets but discard calculation of Lane Snapper using reef fish or shark observer data was not recommended primarily due to fisher expert testimony. Lane Snapper were believed to be caught at shallow depths, including those caught on bottom longline gear (assumed caught as the gear was retrieved), and therefore had low discard mortality.

Speckled Hind and Snowy Grouper discards were calculated, following the methods of SEDARs 42 and 43 (Gulf of Mexico Red Grouper and Gray Triggerfish), as:

(observer reported discard rate/observer reported kept rate)*commercial landings

Data were stratified by: gear (bottom longline, vertical line = handline + bandit rig), year, subregion (east = shrimp grids 1-8, west = 9-21; i.e., east and west of Cape San Blas, Florida), and season (open or closed). Discards were calculated for each gear/year/subregion/season stratum. Bottom longline data were available from both the reef fish and shark observer programs. Those bottom longline data were further stratified so that all bottom longline data from vessels with shark permits were combined and data from bottom longline vessels without shark permits formed a second stratum. Bottom longline stratification was: gear (bottom longline)/shark permit (yes, no)/year/subregion (as defined above)/season (as above). All vertical line data were from the reef fish observer data set.

For the calculation of discards prior to 2007 (first full year of observer data), weighted mean discard and kept rates over years within each gear/subregion/season stratum were used in the calculation of discards for the years 1993-2006. The time series began in 1993, the beginning of full reporting to the coastal logbook program. The coastal logbook data were used to properly apportion landings to each stratum.

3.4.1 Red Drum

Red Drum were not common in shrimp bycatch. A total of 401 Red Drum were present in only 226 hauls (Table 3.8.11). Consequently, Red Drum discards as bycatch were consider negligible.

Red Drum discards were not calculated for the vertical line and bottom longline fisheries due to the low frequency of occurrence in the observer data (Table 3.8.10).

3.4.2 Lane Snapper

Lane snapper were common in shrimp bycatch (Table 3.8.11). A total of 45,641 lane snapper were present in only 4239 hauls. Consequently, lane snapper discards as bycatch were consider significant. Shrimp bycatch estimates of lane snapper were calculated using observer data and estimated shrimping effort.
The DLM requires all landings in weight. However, representative length-weight data from fishery-dependent trawl samples were not available. Consequently, total annual bycatch weight

was not calculated. For assessment purposes, all bycatch was assumed to be age-0. Annual estimates of shrimp bycatch (numbers) are presented in Figure 3.9.2 and Table 3.8.12.

Discards of Lane Snapper were not calculated for the vertical line and bottom longline fisheries due to the workgroup's assumption of low discard mortality of Lane Snapper in those fisheries (see Section 3.4).

3.4.3 Wenchman

Wenchman were common in shrimp bycatch (Table 3.8.11). A total of 156,357 Wenchman were present in only 6507 hauls. Consequently, Wenchman discards as bycatch were consider significant. Discards were calculated as described for lane snapper. Similarly, representative length-weight data for Wenchman were unavailable and weights were not calculated. Annual estimates of shrimp bycatch (numbers) are presented in Figure 3.9.3 and Table 3.8.13.

Wenchman discards were not calculated for the vertical line and bottom longline fisheries due to the low frequency of occurrence in the observer data (Table 3.8.10).

3.4.4 Yellowmouth Grouper

Yellowmouth Grouper were not common in shrimp bycatch. Only four Yellowmouth Grouper were present in only two hauls (Table 3.8.11). Consequently, Yellowmouth Grouper discards as bycatch were considered negligible.

Yellowmouth Grouper discards were not calculated for the vertical line and bottom longline fisheries due to the low frequency of occurrence in the observer data (Table 3.8.10).

3.4.5 Snowy Grouper

Snowy Grouper were not common in shrimp bycatch. Only 109 Snowy Grouper were present in 57 hauls (Table 3.8.11). Consequently, Snowy Grouper discards as bycatch were considered negligible.

Yearly Snowy Grouper discards calculated using observer reported bottom longline data are provided in Table 3.8.14. Snowy Grouper discards calculated using reef fish observer vertical line data are also shown in Table 3.8.14. Discard calculation methods are briefly described in Section 3.4. The workgroup recommended that discard mortality of Snowy Grouper in the bottom longline and vertical line commercial fisheries be assumed to be 100 percent.

3.4.6 Speckled Hind

Speckled Hind were not common in shrimp bycatch. Only four Speckled Hind were present in a single haul (Table 3.8.11). Consequently, Speckled Hind discards as bycatch were considered negligible.

Yearly Speckled Hind discards calculated using observer reported bottom longline data are provided in Table 3.8.15. Speckled Hind discards calculated using reef fish observer vertical line data are shown in Table 3.8.15. Discard calculation methods are briefly described in Section 3.4. The workgroup recommended that discard mortality of Speckled Hind in the bottom longline and vertical line commercial fisheries be assumed to be 100 percent.

3.4.7 Lesser Amberjack

Lesser Amberjack were not common in shrimp bycatch. Only 69 Lesser Amberjack were present in only 28 hauls (Table 3.8.11). Consequently, Lesser Amberjack discards as bycatch were considered negligible.

Lesser Amberjack discards were not calculated for the vertical line and bottom longline fisheries due to the workgroup's assumption of low discard mortality of that species in those fisheries.

3.4.8 Almaco Jack

Almaco Jack were not common in shrimp bycatch. Only 56 Almaco Jack were present in 19 hauls (Table 3.8.11). Consequently, Almaco Jack discards as bycatch were considered negligible.

Almaco Jack discards were not calculated for the vertical line and bottom longline fisheries due to the low frequency of occurrence in the observer data (Table 3.8.10).

3.5 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

For most species, the commercial landings data were considered adequate for assessment analyses. Uncertainty estimates were provided for the landings of each species and accounted for species misidentification, landings reported by species group, and differences among states in the implementation of trip ticket programs. The workgroup used expert opinion to estimate landings uncertainty for each species. For each species, one uncertainty estimate was provided for the entire time series because the SEDAR 49 data-limited approach requires a single uncertainty estimate. Uncertainties in commercial landings are provided for each species as a percentage of the yearly landings; e.g., 50 percent uncertainty of 100,000 pounds of landings results in an upper bound of 150,000 pounds and a lower bound of 50,000 pounds.

3.5.1 Red Drum

Red Drum commercial landings in federal waters were prohibited beginning on October 16, 1987. There have been no landings reported from Florida since 1988 and no Texas landings reported since 1981. Landings prior to the fishery closure in federal waters may have been underreported due to the survey methods used during those years; e.g., minor (small landings volume) dealers were often not surveyed. Landings since the federal closure rely on state surveys or trip tickets. Trip ticket systems have not been in place in all states over all years since 1987. Those potential reporting problems are reflected in the workgroup recommended landings uncertainty of 75 percent.

3.5.2 Lane Snapper

Lane Snapper commercial landings data were considered adequate for assessment analyses by the workgroup. During the initial years of the time series (late 1980's), some landings were reported by species group; however, misidentification of Lane Snapper was unlikely. The commercial workgroup recommended landings uncertainty of 20 percent.

3.5.3 Wenchman

Wenchman commercial landings data were considered adequate for assessment analyses by the workgroup. The time series was truncated to include only the years 1997-2014. This was done to reduce or eliminate the problems of reporting landings to species group and species misidentification. The recommended landings uncertainty was 35 percent. Nearly all of the total removals of Wenchman were as bycatch from the shrimp fishery with a calculated CV over the entire time series of 0.31 (31 percent) (i.e., SD / median, SEDAR49-DW-01).

3.5.4 Yellowmouth Grouper

Commercial Yellowmouth Grouper landings were low (less than 10,000 pounds for all years of available data combined). The workgroup was concerned that this species may have been misidentified as scamp throughout the time series. That concern resulted in high uncertainty (100 percent) around the reported landings.

3.5.5 Snowy Grouper

Snowy Grouper commercial landings data were considered adequate for assessment analyses by the workgroup. The time series was truncated to include only the years 1990-2014. This was done to reduce problems of reporting landings by species group. Species misidentification was not considered to be a concern. The recommended landings uncertainty was 12 percent.

3.5.6 Speckled Hind

Speckled Hind commercial landings data were considered adequate for assessment analyses by the workgroup. The time series was truncated to include only the years 1997-2014. This was done to reduce problems or eliminate the problems of reporting landings to species group and species misidentification. The recommended landings uncertainty was 30 percent.

3.5.7 Lesser Amberjack

Lesser Amberjack commercial landings data were considered adequate for assessment analyses by the workgroup. The time series was truncated to include only the years 1991-2014 (note that the base recommendation is to end in 2009 due to concerns over changes in fisher behavior after the implementation of IFQs). This was done to reduce or eliminate the problems of reporting landings to species group and species misidentification. The recommended landings uncertainty was 50 percent.

3.5.8 Almaco Jack

Almaco Jack commercial landings data were considered adequate for assessment analyses by the workgroup. The time series was truncated to include only the years 1991-2014. As with Lesser Amberjack, truncating the time series was done to reduce or eliminate the problems of reporting landings to species group and species misidentification. The recommended landings uncertainty was 50 percent.

3.6 RESEARCH RECOMMENDATIONS

Further development of methods for calculating overall uncertainty when summing total removals from commercial, recreational, and other fisheries (e.g., shrimp and other trawl fisheries). Methods should account for differences in programs; e.g., some programs provide CVs while others produce ranges of uncertainty based upon expert opinion.

Develop more robust estimates of discard mortality for all SEDAR 49 species from each sector of the commercial fishery.

Develop methods to more appropriately estimate uncertainty of discard estimates from each sector of the commercial fishery.

3.6.1 Red Drum

Develop data collection methods to enable investigation of the magnitude of bycatch in the Gulf of Mexico menhaden fishery for Red Drum. Investigate the impact of menhaden fishery bycatch on stock assessments.

3.6.2 Lane Snapper

Develop appropriate sampling methods to determine the size composition of Lane Snapper caught as bycatch in Gulf of Mexico shrimp fisheries.

3.6.3 Wenchman

During the Data Workshop, a northern Gulf of Mexico finfish trawl fishery (likely targeting Butterfish) was identified as being the primary commercial fishery for Wenchman. That fishery was recommended as the representative fleet for Wenchman. Further investigation of that finfish trawl fishery is recommended. Data sources useful for accurately determining targeting, effort, and landings of the fishery should be identified.

Develop appropriate sampling methods to determine the size composition of Wenchman caught as bycatch in Gulf of Mexico shrimp fisheries.

3.6.4 Yellowmouth Grouper

Develop genetic markers for species identification and determine the frequency of misidentification of Yellowmouth Grouper.

Use port samplers to determine the frequency of Yellowmouth Grouper misidentification or misreporting.

3.6.5 Snowy Grouper

No research recommendations were suggested for Snowy Grouper.

3.6.6 Speckled Hind

No research recommendations were suggested for Speckled Hind.

3.6.7 Lesser Amberjack

Use port samplers to determine the frequency of Lesser Amberjack misidentification or misreporting.

3.6.8 Almaco Jack

Use port samplers to determine the frequency of Almaco Jack misidentification or misreporting.

3.7 LITERATURE CITED

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3.8 TABLES

Table 3.8.1 Summarized annual total Gulf of Mexico commercial landings (whole weight, pounds) for all eight species evaluated in the Data-Limited Species SEDAR 49.

Year	Almaco Jack	Red Drum	Snowy Grouper	Yellowmouth Grouper	Speckled Hind	Lesser Amberjack	Lane Snapper	Wenchman
1981		2,747,934						
1982		2,425,176						
1983		3,127,031						
1984		4,334,193						
1985		6,342,733						
1986		14,127,803					60,174	
1987		4,890,774					51,972	
1988		291,842					57,659	
1989		166,446					93,596	
1990		7,572	138,452				81,358	
1991	17,605	22,162	142,584	*		23,055	119,289	
1992	29,715	62,551	202,437			16,712	99,127	
1993	24,143	85,588	137,158			27,792	107,136	
1994	45,737	43,203	108,796	*		32,535	91,729	
1995	45,882	24,110	103,960			60,781	71,294	
1996	31,803	32,493	76,652			68,697	54,581	
1997	45,070	25,831	124,638		49,596	42,453	61,251	6,492
1998	31,999	35,567	94,902	*	39,432	26,043	31,753	*
1999	43,452	40,202	118,060	837	45,967	29,035	49,233	17,391
2000	43,616	38,084	175,354	*	64,262	42,300	47,684	46,640
2001	57,024	22,695	176,905	127	63,672	46,950	48,858	103,827
2002	46,939	19,997	130,689	951	48,753	110,257	53,056	66,210

Table 3.8.1 cont'd.

Year	Almaco Jack	Red Drum	Snowy Grouper	Yellowmouth Grouper	Speckled Hind	Lesser Amberjack	Lane Snapper	Wenchman
2004	28,254	32,318	182,008	523	98,296	67,850	50,829	64,318
2006	15,148	32,324	193,040	*	77,789	41,190	49,356	40,137
2007	30,696	26,440	177,683	*	86,612	26,996	29,234	40,958
2008	24,480	31,260	208,402	*	49,250	24,359	25,475	44,427
2009	37,351	35,290	183,424	*	68,884	46,475	35,848	30,447
2010	27,964	46,002	99,902	*	18,393	26,993	17,262	31,621
2011	36,800	35,223	158,905	*	28,935	6,414	14,365	34,549
2012	47,366	43,620	199,989	233	51,090	5,490	28,928	31,761
2013	32,110	44,907	127,727	759	41,316	20,577	23,189	23,949
2014	39,732	66,365	177,196	1,478	74,903	2,262	29,948	20,784

*Confidential data

Table 3.8.2. Red Drum annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1981-2014.

Year	Vertical Line	Long Line	Net	Trap	Other	Grand Total
1981	78,869		2,669,065			2,747,934
1982	*	*	2,356,267			2,425,176
1983	*		3,048,811		*	3,127,031
1984	109,968		4,224,225			4,334,193
1985	63,695		6,279,038			6,342,733
1986	214,398	*	13,909,053		*	14,127,803
1987	102,427	*	4,787,934		*	4,890,774
1988	*	*	283,535			291,842
1989	10,997		155,449			166,446
1990	1,767		*		*	7,572
1991	516	*	21,466	*		22,162
1992	612		61,939			62,551
1993	38		83,666		1,884	85,588
1994	1,699		38,547		2,957	43,203
1995	3,834		20,276			24,110
1996	3,825		26,743		1,925	32,493
1997	*		15,878		*	25,831
1998	9,887	*	20,121		*	35,567
1999	13,498	*	26,572		*	40,202
2000	*	*	23,406			38,084
2001	10,482		12,213			22,695
2002	8,942		11,055			19,997
2003	*		17,980		*	26,646
2004	*		17,951		*	32,318
2005	11,097	*	15,299		*	52,898
2006	16,825	*	*		*	32,324
2007	21,085	*	*		*	26,440
2008	19,536	*	*		*	31,260
2009	32,108		3,182			35,290
2010	43,498		*		*	46,002
2011	31,998	*	3,103		*	35,223
2012	37,740	*	3,469		*	43,620
2013	34,722	*	6,006		*	44,907
2014	39,881	*	19,838		*	66,365

*Confidential data

Table 3.8.3 Lane Snapper annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1986-2014.

Year	Vertical Line	Long Line	Net	Trap	Other	Grand Total
1986	28,537	*	*	*	*	60,174
1987	*	*	*	*	*	51,972
1988	28,768	*	*	*	*	57,659
1989	*	*	*	*	*	93,596
1990	*	*	*	*	13,064	81,358
1991	*	*	*	*	11,345	119,289
1992	*	*	*	*	3,183	99,127
1993	*	*	*	*	4,548	107,136
1994	*	*	*	*	5,307	91,729
1995	*	*	*	*	3,988	71,294
1996	*	*	*	*	6,109	54,581
1997	15,236	735	252	39,105	5,923	61,251
1998	10,081	342	279	14,021	7,027	31,750
1999	11,134	934	*	18,347	18,777	49,233
2000	28,162	1,223	*	17,282	1,009	47,684
2001	24,153	1,748	1,640	20,964	277	48,782
2002	31,545	1,998	324	17,967	1,136	52,970
2003	40,424	678	1,485	7,174	823	50,584
2004	43,885	1,363	282	3,183	2,042	50,755
2005	28,432	567	*	4,995	5,529	39,951
2006	29,211	1,052		9,496	9,581	49,340
2007	16,450	1,278		*	11,446	29,222
2008	17,850	1,947			5,678	25,475
2009	31,433	1,081		*	3,320	35,848
2010	15,360	1,166		*	698	17,262
2011	12,484	1,416		*	461	14,365
2012	26,307	1,114		*	1,501	28,928
2013	21,355	1,117		*	706	23,189
2014	26,090	3,303		*	299	29,948

*Confidential data

Table 3.8.4 Wenchman annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1997-2014.

Year	Vertical Line	Long Line	Net	Other	Grand Total
1997	*	*	*	*	6,492
1998	*		*		*
1999	*		*	3,624	17,391
2000	1,105	*	*		46,640
2001	861	*	*		103,827
2002	400	*	*		66,210
2003	*	673	*		53,106
2004	147	*	*		64,318
2005	1,191	*	*		63,301
2006	*	*	*		40,137
2007			40,431		40,431
2008	*	*	*		44,427
2009		*	*		30,447
2010	*		*		31,621
2011	*	*	34,421		34,549
2012	*		*		31,761
2013	*		*		23,949
2014	*		*		20,784

*Confidential data

Table 3.8.5 Yellowmouth Grouper annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1991-2014. Due to confidentiality restrictions, the commercial landings data had to be summed across all years.

Year	Vertical Line	Long Line	Other	Grand Total
1991-2014	5,041	475	3,903	9,419

Table 3.8.6. Snowy Grouper annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1990-2014.

Year	Vertical Line	Long Line	Net	Trap	Other	Grand Total
1990	55,819	66,665			15,968	138,452
1991	38,973	*		*	14,108	142,584
1992	26,162	143,218		1,262	31,795	202,437
1993	*	*			22,279	137,158
1994	*	*			11,290	108,796
1995	*	*	*		11,324	103,960
1996	*	*			6,913	76,652
1997	30,071	86,271			8,296	124,638
1998	35,688	52,380	*	*	6,801	94,893
1999	37,655	67,158		*	*	118,060
2000	*	139,607			*	175,354
2001	38,580	138,013		*	*	176,850
2002	34,707	95,681	*		*	130,689
2003	*	139,899			*	217,020
2004	*	129,377	*			181,982
2005	*	135,534			*	184,364
2006	*	139,108			*	193,040
2007	51,235	123,372			3,076	177,683
2008	38,918	162,143			7,334	208,395
2009	42,196	135,674			5,554	183,424
2010	30,134	63,428			6,340	99,902
2011	42,682	91,854			24,369	158,905
2012	67,394	120,468			12,127	199,989
2013	36,017	83,057			8,653	127,727
2014	39,980	132,093			5,123	177,196

*Confidential data

Table 3.8.7 Speckled Hind annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1997-2014.

Year	Vertical Line	Long Line	Trap	Other	Grand Total
1997	8,262	41,165	*	*	49,596
1998	5,047	34,276	*	*	39,432
1999	6,575	38,710		682	45,967
2000	4,821	59,441			64,262
2001	*	57,350		*	63,672
2002	3,720	44,555		478	48,753
2003	8,287	73,518	*	*	82,192
2004	6,664	91,600	*	*	98,296
2005	6,040	82,981			89,021
2006	*	65,523		*	77,789
2007	8,657	76,449		1,506	86,612
2008	*	44,562		*	49,250
2009	7,174	60,325		1,385	68,884
2010	3,937	13,912		544	18,393
2011	7,911	20,753		271	28,935
2012	22,864	27,616		610	51,090
2013	11,600	29,275		441	41,316
2014	15,484	58,797		622	74,903

*Confidential data

Table 3.8.8 Lesser Amberjack annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1991-2014.

Year	Vertical Line	Long Line	Net	Trap	Other	Grand Total
1991-1996	143,380	9,008	5,125	524	5,339	229,572
1997	37,624	3,418	*	*	*	42,453
1998	23,508	1,705	*	*	656	23,508
1999	16,831	*		*	10,909	29,035
2000	33,455	8,530		*	*	42,300
2001	43,644	3,084		*	*	46,843
2002	91,992	18,024	*	*	*	110,257
2003		9,623	*		*	72,953
2004		3,090	*		*	67,850
2005		*			*	43,785
2006	33,470	6,060	1,040		620	41,190
2007	21,986	4,484			526	26,996
2008	17,065	*			*	24,359
2009	44,111	*			*	46,475
2010	25,972	*			*	26,993
2011	4,973	1,441				6,414
2012	*	*				5,490
2013	18,624	*			*	20,577
2014	1,323	*			*	2,262

*Confidential data

Table 3.8.9 Almaco Jack annual total Gulf of Mexico commercial landings (whole weight, pounds) by year and gear 1991-2014.

Year	Vertical Line	Long Line	Net	Trap	Other	Grand Total
1991-1996	33,080		*		161,270	194,885
1997	10,098	*	*		*	44,976
1998	10,525	1,671			19,803	31,999
1999	11,983	1,061	*	*	30,116	43,452
2000	42,034	*			*	43,616
2001	53,083	*			*	56,827
2002	45,517	693			671	46,881
2003	34,758	580	378		171	35,887
2004	26,293	1,594	*		*	28,254
2005	17,575	443	*		*	18,724
2006	14,162	*			*	15,148
2007	29,596	467	*		*	30,601
2008	22,922	*			*	24,406
2009	31,839	*	*		3,954	37,351
2010	23,334	*	*		4,005	27,964
2011	30,036	*	*		5,525	36,800
2012	36,643	*	*		9,980	47,366
2013	23,457	*	*		7,610	32,110
2014	26,916	984	131		11,701	39,732

*Confidential data

Table 3.8.10. Percent frequency of occurrence, by set, of SEDAR 49 species as reported in each of the available reef fish and shark observer data sets. For vertical line (bandit and handline), a set is a fishing activity at a particular site of any duration. For longline gear, a set includes all fishing effort and catch from the time fishing gear is deployed until all the fishing gear is onboard and the vessel moves to a new location.

Species	Reef - Bandit		Reef - Handline		Reef - Longline		Shark - Longline	
	Mean (%)	Range (%)	Mean (%)	Range (%)	Mean (%)	Range (%)	Mean (%)	Range (%)
Speckled Hind	0.7	0.2 - 1.7	0.1	0.0 - 0.9	8.6	2.8 - 17.1	-	-
Snowy Grouper	0.7	0.4 - 1.7	0.1	0.0 - 0.6	10.8	0.0 - 23.5	-	-
Lane Snapper	2.9	1.2 - 5.1	5.3	1.4 - 9.1	5.9	3.7 - 11.0	-	-
Yellowmouth Grouper	0.1	0.0 - 0.6	0.0	0.0 - 0.0	0.4	0.0 - 3.0	-	-
Wenchman	0.2	0.0 - 0.5	0.0	0.0 - 0.2	1.0	0.0 - 4.6	-	-
Red Drum	0.2	0.0 - 0.7	1.7	0.1 - 8.8	0.1	0.0 - 0.6	0.8	0.0 - 3.4
Lesser Amberjack	0.6	0.0 - 2.7	0.1	0.0 - 0.6	0.8	0.0 - 4.0	-	-
Almaco Jack	2.5	0.4 - 4.3	1.1	0.0 - 4.4	2.2	0.0 - 4.9	0.6	0.0 - 4.9

Table 3.8.11. Total number landed (Catch) and total number of positive tows (Tows) for the eight SEDAR49 data-limited species.

Species	Catch	Tows
Wenchman	156,357	6,507
Lane Snapper	45,641	4,239
Red Drum	401	226
Snowy Grouper	109	57
Lesser Amberjack	69	28
Almaco Jack	56	19
Yellowmouth Grouper	4	2
Speckled Hind	4	1

Table 3.8.12. Summary statistics of marginal posterior densities of annual estimates Lane Snapper as bycatch (millions of fish) in the Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	54.02	139.9	1.2920	5.051	27.890	256.1
1973	5.28	14.18	0.1131	0.514	2.597	25.4
1974	12.20	35.35	0.2775	1.428	6.218	56.1
1975	19.56	48.23	0.3523	2.596	10.030	91.4
1976	8.38	15.66	0.0991	2.581	5.767	29.0
1977	6.45	10.56	0.0692	1.677	4.489	22.6
1978	6.70	12.38	0.0973	1.898	4.624	23.1
1979	8.05	18.23	0.2447	0.592	3.958	40.3
1980	5.83	5.438	0.0448	2.281	4.566	17.0
1981	21.96	46.05	0.3946	3.729	12.640	94.4
1982	17.44	37.22	0.3206	2.024	9.571	78.9
1983	6.38	13.03	0.1281	0.707	3.530	28.6
1984	8.42	16.86	0.1768	0.917	4.668	38.2
1985	5.99	12.73	0.1158	0.629	3.262	27.4
1986	19.09	41.62	0.3209	1.980	10.600	86.1
1987	28.44	62.35	0.5165	2.902	15.740	127.0
1988	17.50	39.97	0.3217	1.909	9.822	78.5
1989	22.76	43.28	0.3839	2.570	13.030	101.0
1990	25.54	54.77	0.4599	2.791	14.150	113.0
1991	67.65	131.80	1.1660	7.743	38.380	299.3
1992	15.98	25.16	0.1544	6.248	11.440	51.7
1993	11.32	22.63	0.1173	4.389	7.339	43.0
1994	14.04	13.79	0.0866	7.270	11.480	35.7
1995	21.17	16.74	0.1164	10.44	17.990	50.2
1996	23.26	42.03	0.3167	4.233	14.430	94.3
1997	34.85	74.57	0.4918	5.497	19.840	147.9
1998	27.07	59.83	0.4316	2.986	14.310	126.9
1999	115.60	238.8	2.0260	13.370	64.880	516.1
2000	175.40	327.5	3.1880	19.930	99.500	768.1
2001	158.50	299.5	2.8170	16.600	88.900	714.4
2002	113.20	218.5	2.0230	12.470	63.690	508.4
2003	105.80	273.2	2.0280	11.420	58.720	467.7
2004	75.60	172.5	1.4470	7.242	39.590	355.1
2005	88.79	214.8	1.7280	7.554	43.710	433.5
2006	53.64	120.2	0.9298	5.997	30.170	234.9
2007	39.25	68.4	0.6431	4.814	23.380	167.6
2008	21.06	51.45	0.4045	2.423	11.880	92.4
2009	36.91	84..00	0.7050	3.950	19.700	171.2
2010	13.09	26.93	0.2247	1.469	7.448	57.5
2011	21.40	47.74	0.3612	2.086	11.490	98.1
2012	29.22	75.28	0.5665	3.053	15.750	132.5
2013	22.72	49.79	0.4122	2.049	11.930	106.9
2014	46.27	96.16	0.7254	4.761	24.990	210.5

Table 3.8.13. Summary statistics of marginal posterior densities of annual estimates of Wenchman as bycatch (millions of fish) in the Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	15.75	26.84	0.437	1.56	8.85	72.16
1973	1.48	2.98	0.032	0.17	0.83	6.59
1974	19.18	24.33	0.285	5.61	13.96	63.74
1975	8.11	14.82	0.161	1.09	4.72	34.82
1976	18.49	16.02	0.165	8.20	15.36	47.33
1977	3.96	7.61	0.063	0.61	2.36	16.86
1978	7.83	14.77	0.144	1.21	4.61	32.89
1979	9.00	18.64	0.299	0.75	4.77	42.03
1980	1.29	4.40	0.028	0.13	0.63	6.23
1981	7.68	17.86	0.159	0.87	4.21	34.86
1982	9.48	16.58	0.185	1.22	5.67	40.55
1983	5.67	9.43	0.112	0.75	3.45	23.85
1984	21.41	33.05	0.400	2.97	13.28	89.41
1985	20.10	33.57	0.367	2.52	11.94	86.08
1986	19.69	35.84	0.361	2.45	11.75	82.73
1987	21.63	43.79	0.411	2.57	12.44	94.87
1988	13.21	32.00	0.270	1.50	7.62	58.30
1989	15.59	29.44	0.301	1.76	9.00	68.39
1990	20.03	49.88	0.459	1.92	10.20	95.54
1991	7.78	14.44	0.140	0.91	4.52	33.69
1992	11.12	7.61	0.054	5.79	9.86	23.12
1993	10.21	2.20	0.019	7.30	9.88	15.04
1994	13.38	8.14	0.064	6.22	11.79	29.56
1995	0.95	1.55	0.014	0.21	0.61	3.71
1996	2.77	6.69	0.051	0.30	1.43	12.82
1997	1.32	2.06	0.023	0.24	0.87	5.06
1998	2.45	6.63	0.046	0.30	1.40	10.73
1999	17.72	44.14	0.388	2.03	10.01	77.12
2000	14.58	28.10	0.285	1.70	8.42	63.24
2001	14.41	26.60	0.265	1.61	8.52	61.68
2002	18.48	33.87	0.360	2.23	11.01	79.90
2003	21.86	36.94	0.380	2.68	13.36	91.64
2004	19.78	47.71	0.414	1.65	10.00	94.99
2005	31.29	75.42	0.616	2.47	15.70	153.60
2006	6.49	14.65	0.145	0.66	3.56	29.63
2007	9.24	19.59	0.190	0.89	5.06	41.86
2008	4.71	16.67	0.124	0.47	2.52	21.49
2009	5.00	9.71	0.103	0.53	2.81	22.43
2010	10.87	20.76	0.203	1.07	6.02	49.36
2011	6.28	11.69	0.117	0.69	3.59	27.76
2012	5.48	23.13	0.128	0.53	2.89	24.56
2013	14.26	29.50	0.252	1.42	7.83	65.28
2014	5.31	10.61	0.098	0.53	2.95	24.02

Table 3.8.14. Snowy Grouper total discards (pounds whole weight) calculated using reef fish and shark bottom longline observer data. Discards calculated using reef fish vertical line observer data also provided.

Year	Bottom longline discards whole weight	Vertical line discards whole weight
1993	3,789	701
1994	4,730	363
1995	5,156	585
1996	3,297	554
1997	4,713	832
1998	3,111	856
1999	3,405	868
2000	7,904	755
2001	6,934	1,031
2002	4,861	841
2003	6,834	2,192
2004	5,084	3,641
2005	4,184	1,539
2006	5,227	1,576
2007	26	145
2008	1,290	0
2009	6,711	0
2010	8,192	10,322
2011	3,379	148
2012	470	1,463
2013	1,949	1,453
2014	862	1,837
Total	92,108	31,701

Table 3.8.15. Speckled Hind total discards (pounds whole weight) calculated using reef fish and shark bottom longline observer data. Discards calculated using reef fish vertical line observer data also provided.

Year	Bottom longline discards whole weight	Vertical line discards whole weight
1997	12,348	3,837
1998	10,265	2,403
1999	11,258	3,162
2000	16,520	2,818
2001	16,718	3,760
2002	12,675	2,414
2003	20,415	5,034
2004	24,978	3,772
2005	23,112	3,018
2006	16,737	6,752
2007	166	880
2008	0	643
2009	1,167	2
2010	7,380	12,981
2011	8,349	1,439
2012	4,270	5,069
2013	13,278	7,094
2014	21,862	4,052
Total	221,499	69,129

3.9 FIGURES

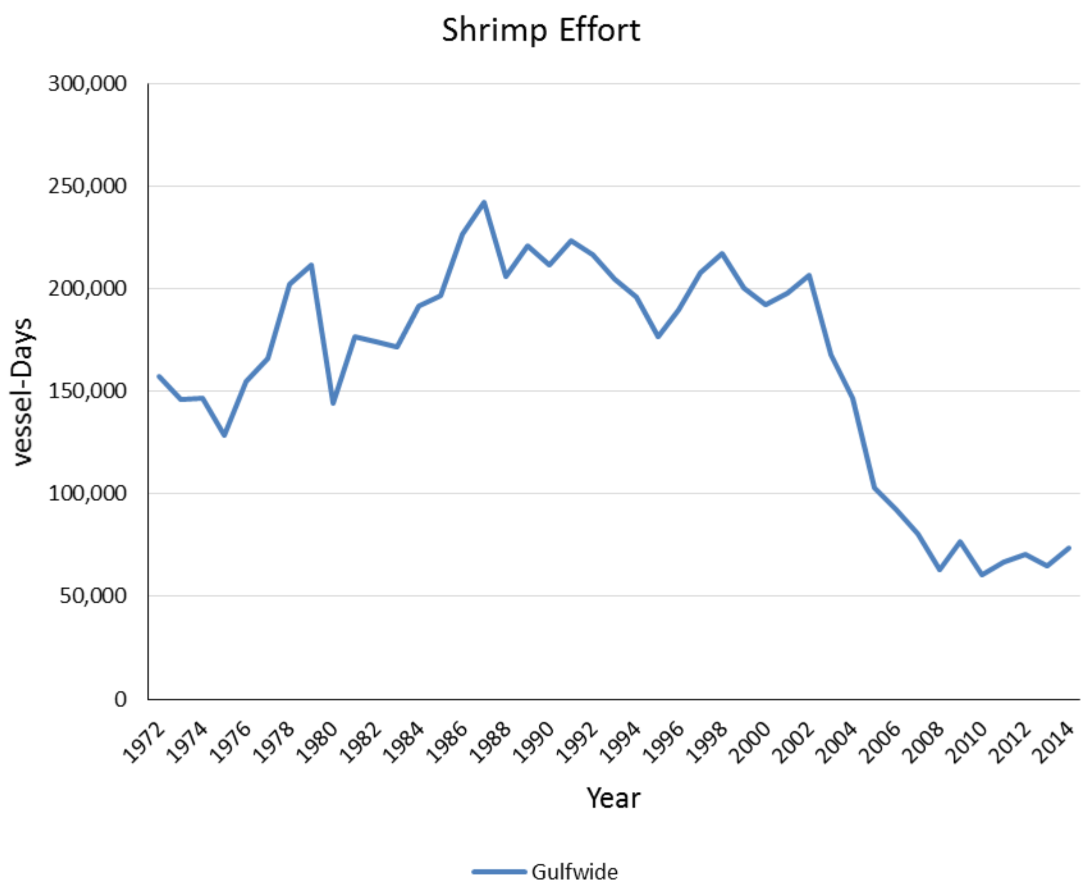

Figure 3.9.1. Gulf of Mexico shrimp fishery effort (thousands of vessel-days) provided by the NMFS Galveston Lab. The reported effort does not include the average effort values used to fill empty cells.

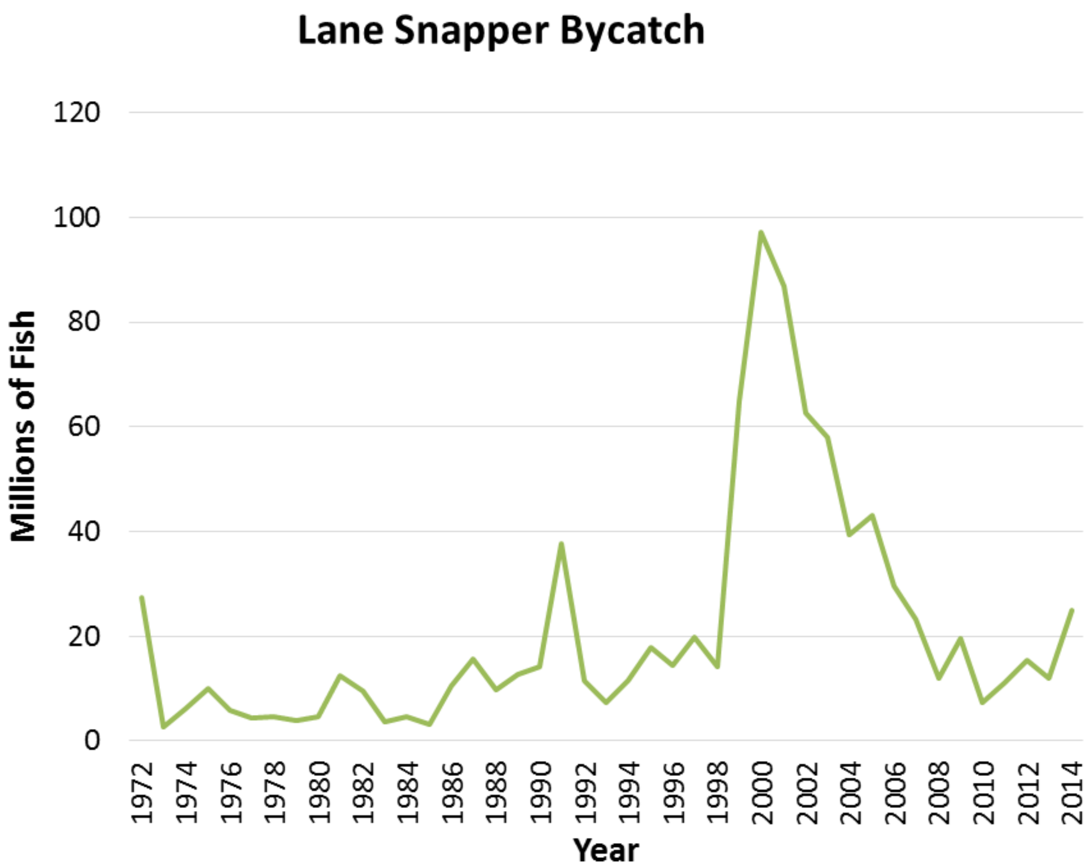

Figure 3.9.2. Median annual bycatch (millions of fish) of Lane Snapper in the Gulf of Mexico shrimp fishery.

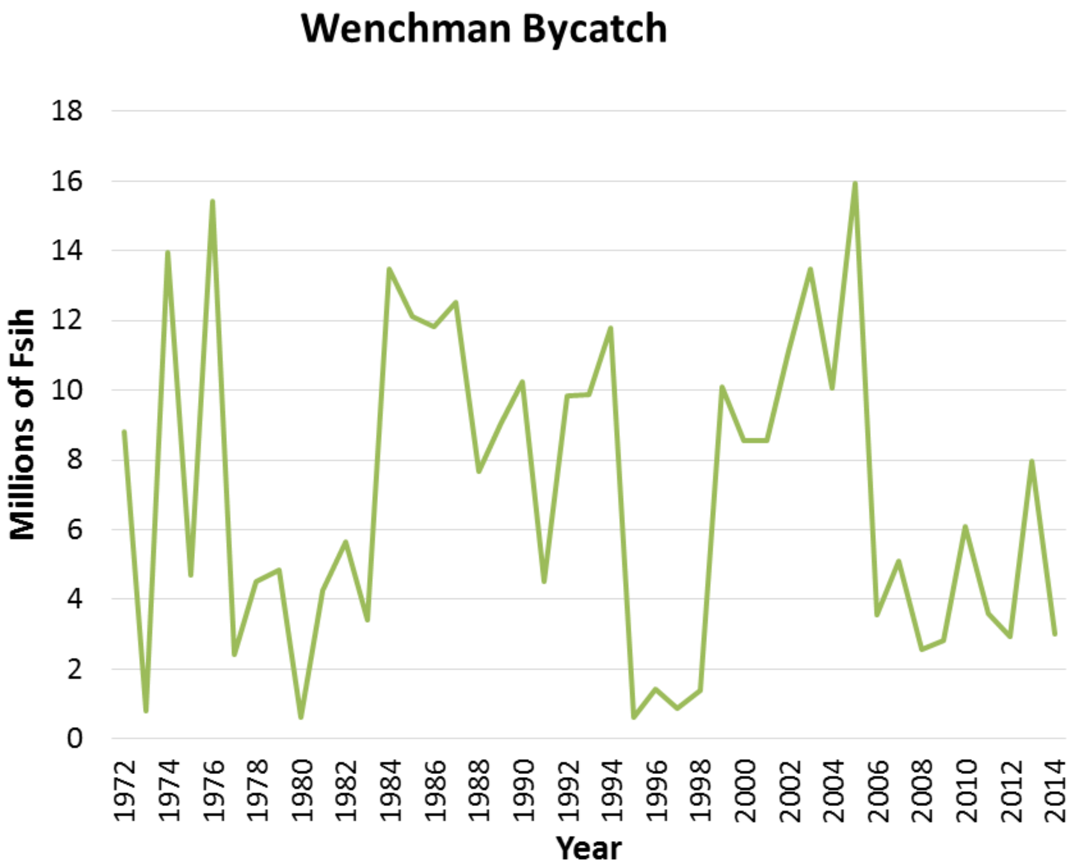

Figure 3.9.3. Median annual bycatch (millions of fish) of Wenchman in the Gulf of Mexico shrimp fishery.

4 RECREATIONAL FISHERY STATISTICS

4.1 OVERVIEW

4.1.1 Recreational Workgroup (RWG) Members

Members-Shane Cantrell (AP/Industry rep TX), FJ Eicke (AP/Industry rep MS), Kelly Fitzpatrick (NMFS SEFSC Beaufort), Jay Gardner (AP/Industry rep TX), Vivian Matter (Leader, NMFS SEFSC Miami), and Adyan Rios (NMFS SEFSC Miami).

4.1.2 Issues Discussed at the Data Workshop

1) MRIP APAIS adjustment: change in survey protocols starting in 2013.
2) Recreational data sources for landings and discards

3) Estimating uncertainty in the landings and discards
4) Recreational effort estimates in angler trips

4.2 REVIEW OF WORKING PAPERS

There were no working papers submitted related to the recreational catch statistics.

4.3 RECREATIONAL LANDINGS

The recreational landings were obtained from the following separate sampling programs:
1) Marine Recreational Fisheries Statistics Survey (MRFSS) and the Marine Recreational Information Program (MRIP)
2) Southeast Region Headboat Survey (SRHS)
3) Texas Parks and Wildlife Department (TPWD)
4) LA Creel Survey

MRFSS/MRIP provided a long time series of estimated catch-per-unit effort, total effort, landings, and discards for six two-month periods (waves) each year. MRFSS/MRIP provided estimates for three recreational fishing modes: shore-based fishing (SH), private and rental boat fishing (PR), and for-hire charter and guide fishing (CH). When the survey first began in Wave 2 (Mar/Apr), 1981, headboats were included in the for-hire mode, but were excluded after 1985 in the South Atlantic and Gulf of Mexico to avoid overlap with the Southeast Region Headboat Survey (SRHS) conducted by the NMFS Beaufort, NC lab. The MRFSS/MRIP survey covers coastal Gulf of Mexico states from Florida to Louisiana. The state of Texas was included in the survey from 1981-1985, although not all modes and waves were covered.

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

The TPWD Sport-boat Angling Survey was implemented in May 1983 and samples fishing trips made by sport-boat anglers fishing in Texas marine waters. All sampling takes place at recreational boat access sites. The raw data include information on catch, effort, and length composition of the catch for sampled boat-trips. These data are used by TPWD to generate recreational catch and effort estimates. The survey is designed to estimate landings and effort by high-use (May 15-November 20) and low-use seasons (November 21-May 14). In SEDAR 16 TPWD seasonal data were disaggregated into months. Since then, SEFSC personnel have disaggregated the TPWD seasonal estimates into waves (2 month periods) using the TPWD intercept data to ensure the TPWD time series is compatible with the MRFSS/MRIP time series. TPWD surveys private and charterboat fishing trips. While TPWD samples all trips (private, charterboat, ocean, bay/pass), most of the sampled trips are associated with private boats fishing in bay/pass, as these trips represent most of the fishing effort. Charterboat trips in ocean waters are the least encountered in the survey.

The Louisiana Department of Wildlife and Fisheries (LDWF) began conducting the Louisiana Creel (LA Creel) survey program for monitoring marine recreational fishery catch and effort on January 1, 2014. Private and charter modes of fishing are sampled. The program is comprised of three separate surveys: a shoreside intercept survey, a private telephone survey, and a for-hire telephone survey. The shoreside survey is used to collect data needed to estimate the mean numbers of fish landed by species for each of five different inshore basins and one offshore area. The private telephone survey sampled from a list of people who possess either a LA fishing license or a LA offshore fishing permit (and provided a valid telephone number). The for-hire telephone survey samples from a list of Louisiana's registered for-hire captains who provided a valid telephone number. Both telephone surveys are conducted weekly. No information is collected on released fish.

A number of adjustments and modifications have been made to the various surveys over the last two decades in attempts to improve sampling and produce more reliable estimates of landings and bycatch. The most important changes in survey protocols and estimation techniques include:

- The For-Hire Telephone Survey (FHS) was developed to estimate effort in the for-hire mode. Conversion factors have been estimated to calibrate the traditional MRFSS charterboat estimates with the FHS for 1986-1997 in the Gulf of Mexico (SEDAR7-AW-03).
- The Marine Recreational Information Program (MRIP) was developed to generate more accurate recreational catch rates by re-designing the MRFSS sampling protocol to address potential biases including port activity and time of day. Starting in 2013, wave 2, the MRIP Access Point Angler Intercept Survey (APAIS) implemented a revised sampling design. As new MRIP APAIS estimates are available for a portion of the recreational time series that MRFSS covers, conversion factors between the MRFSS estimates and the MRIP APAIS estimates were developed in order to maintain one consistent time series for the recreational catch estimates. The MRFSS to MRIP APAIS calibration process is the same as the original MRFSS to MRIP adjustment that has been used since 2012, which is detailed in SEDAR31-DW-25 and SEDAR32-DW-02. Ratio estimators used in SEDAR 49 to Hind-cast catch and variance estimates by fishing mode and species are shown in Table 4.8.1. In order to apply the charterboat ratio estimator

back in time to 1981, charterboat landings were isolated from the combined charterboat/headboat mode for 1981-1985.

- Monroe County MRIP landings are included in the Gulf of Mexico for all SEDAR 49 species' estimates. In order to separate Monroe County estimates from the official West Florida estimate, post-stratification and domain estimation are required. The recreational workgroup determined that this would not be attempted for eight data-limited species in SEDAR 49.

- The MRFSS and the MRIP surveys use different methodologies to estimate landings in weight. To apply a consistent methodology over the entire recreational time series, the Southeast Fisheries Science Center (SEFSC) implemented a method for calculating average weights for the MRIP (and MRIP adjusted) landings. The SEFSC method obtains average weights by aggregating MRFSS/MRIP data according to the following hierarchy: species, region, year, state, mode, wave, and area. The minimum number of weights required at each hierarchy level is 30 fish, except at the final species level, where the minimum is 1 fish. Average weights are multiplied by the landings estimates in number to obtain estimates of landings in weight (SEDAR32-DW-02). This method was used to calculate landings estimates in weight from the MRIP, TPWD, and LA Creel programs.

- Variances are provided by MRFSS/MRIP for their recreational catch estimates. Variances were adjusted to take into account the variance of conversion factors when adjustments to the estimates were made (FHS and MRIP conversions). However, the variance estimates of the charter and headboat modes in 1981-1985 are missing. This is because the combined charter/headboat mode had to be split in order to apply the MRIP adjustment to the charter mode back to 1981. In addition, there are no variance estimates for weight estimates generated through the SEFSC method described above.

- LA Creel landings estimates were used for LA 2014 when MRIP estimates were missing for the following species: Red Drum, Lane Snapper, Wenchman, Snowy Grouper, Lesser Amberjack, and Almaco Jack. Landings estimates for Speckled Hind or Yellowmouth Grouper were either not available or not generated by the survey.

4.3.1 Red Drum

Recreational landings of Red Drum from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.1.

4.3.2 Lane Snapper

Recreational landings of Lane Snapper from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.2a.

4.3.3 Wenchman

Recreational landings of Wenchman from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.3a.

4.3.4 Yellowmouth Grouper

Recreational landings of Yellowmouth Grouper from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.4.

4.3.5 Snowy Grouper

Recreational landings of Snowy Grouper from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.5.

4.3.6 Speckled Hind

Recreational landings of Speckled Hind from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.6.

4.3.7 Lesser Amberjack

Recreational landings of Lesser Amberjack from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.7.

4.3.8 Almaco Jack

Recreational landings of Almaco Jack from all sources are shown in Table 4.8.2 in numbers of fish, Table 4.8.3 in whole weight pounds, and in Figure 5.5.8.

4.4 RECREATIONAL DISCARDS

Annual removals associated with fish discarded by recreational anglers are provided in Table 4.8.4. The estimates of dead discards in weight were obtained by multiplying annual numbers of discarded live fish with recommended discard mortality rates and average weights of discarded fish.

Numbers of Discarded Live Fish

Annual numbers of self-reported discards were available from MRIP/MRFSS and SRHS data (Table 4.8.5).

- Since 1981, anglers interviewed by the MRIP/MRFSS have reported the numbers of fish released alive. MRFSS/MRIP estimates of live released fish (b2 fish) were adjusted in the same manner as the landings (i.e., using charterboat calibration factors, MRIP/APAIS adjustment, etc...; see Section 4.3).
- In 2004, the SRHS logbook form was modified to collect self-reported discards for each reported trip. From 2004-2012 this was described on the form as the number of fish by species released alive and the number released dead. In 2013, the SRHS ceased recording the condition of released fish (live versus dead) and started recording only the total number of fish released regardless of condition.
- TPWD and LA Creel surveys do not estimate discards.
- No discard estimation methods were employed to account for spatial or temporal gaps in the time series.
- Although the identity and quantities of the self-reported discards are not verified, the annual discards by mode for each data-limited species were individually evaluated and deemed reasonable estimates. Additional considerations related to the reliability of the data are discussed in Section 4.5.

Discard Mortality Rates

Discard mortality rates were determined by consensus agreement among the recreational workgroup attendees (Table 4.8.6). The recommended values were based on direct fisher input (see Section 10.5) and review of relevant studies. Additional topics considered included the depth at capture and gear selectivity. For most of the species, field estimates of discard mortality were unavailable and discard rates associated with similar species were discussed as proxies.

Average Weights of Discarded Fish

Average weights of discarded fish were based on assumed average lengths of discarded fish (Table 4.8.7). The workgroup's recommendations, described below, were developed after reflecting on fisher commentary, federal regulations, and visual inspection of histograms of the lengths of landed fish for each species.

- For half of the species, discarded fish were assumed to be the same size as the landed fish. Individual weights by fishing mode from corresponding years of the Trip Interview Program (TIP; see Section 8 for a description) were used to obtain an average weight associated with discarded fish. This method was used for Red Drum, Snowy Grouper, Speckled Hind, and Yellowmouth Grouper.

- Discards for Almaco Jack, Lane Snapper and Lesser Amberjack were attributed to smaller-sized fish. Average sizes for Lane Snapper and Lesser Amberjack were assumed to be half an inch below their respective size limits. The average size for Almaco Jack was assumed to be half an inch below its reported average minimum size retained (20 inches TL). The assumed average lengths were converted to an average weight using length-weight relationships provided by the life history work group (see Section 2.7).
- Average weights for Wenchman discards were not needed since recreational anglers reported no discards of Wenchman from 1997 to 2014.

4.4.1 Red Drum

From 1981 to 2014, the average number of Red Drum discarded annually by recreational anglers was 5,985,321. The recreational discards were 62 percent of recreational catch.

The range of recommended discard mortality rates for Red Drum was 0.05 to 0.08. The workgroup's decision reflected low mortality reported by Flaherty et al. (2013) and considered federal and state regulations, depth at capture, and fish resilience.

The average weight of a released Red Drum was assumed to be the same as the average weight of landed Red Drum. Because of the large number of weight measurements in the TIP data (n = 321,030), mode-specific average weights were used to convert numbers of dead discards by mode into weights of dead discards by mode.

4.4.2 Lane Snapper

From 1986 to 2014, the average number of Lane Snapper discarded annually by recreational anglers was 285,154. The recreational discards were 45 percent of recreational catch.

The range of recommended discard mortality rates for Lane Snapper was 0.05 to 0.15. The workgroup's discussion on discard mortality for Lane Snapper included reviewing discard mortality rates of related species such as Red Snapper and Vermilion Snapper from SEDAR 31 and SEDAR 45, respectively.

Since 1990, the federal minimum size limit for Lane Snapper has been set at 8 inches TL. The average size of a released Lane Snapper was assumed to be 7.5 inches TL (19 cm). This length was converted to weight using a length-weight relationship provided by the life history workgroup (see Section 2.7).

4.4.3 Wenchman

From 1997 to 2014, no discards of Wenchman were reported by recreational anglers. Thus, estimates of discard mortality rates and average weights for Wenchman discards in SEDAR 49 were not needed.

4.4.4 Yellowmouth Grouper

From 1990 to 2014, the average number of Yellowmouth Grouper discarded annually by recreational anglers was 195. The recreational discards were 19 percent of recreational catch.

The range of recommended discard mortality rates for Yellowmouth Grouper was 0.10 to 0.15. The workgroup's discussion on discard mortality for Yellowmouth Grouper included reviewing discard mortality rates of related species such as Gag Grouper and Red Grouper from SEDAR 33 and SEDAR 42, respectively.

The average weight of a released Yellowmouth Grouper was assumed to be the same as the average weight of landed Yellowmouth Grouper. Due to the small number of weight measurements in the TIP data (n = 93), the mean weights by mode were weighted by the proportion of landings in each mode to obtain an overall mean weight.

4.4.5 Snowy Grouper

From 1990 to 2014, the average number of Snowy Grouper discarded annually by recreational anglers was 911. The recreational discards were 22 percent of recreational catch.

The range of recommended discard mortality rates for Snowy Grouper was 0.80 to 1.00. The workgroup's discussion on discard mortality rates for Snowy Grouper reflected primarily on the species' relatively deep depth at capture.

The average weight of a released Snowy Grouper was assumed to be the same as the average weight of landed Snowy Grouper. Due to the small number of weight measurements in the TIP data (n = 359), the mean weights by mode were weighted by the proportion of landings in each mode to obtain an overall mean weight.

4.4.6 Speckled Hind

From 1997 to 2014, the average number of Speckled Hind discarded annually by recreational anglers was 11,163. The recreational discards were 85 percent of recreational catch.

The range of recommended discard mortality rates for Speckled Hind was 0.80 to 1.00. The workgroup's discussion on discard mortality rates for Speckled Hind reflected primarily on the species' relatively deep depth at capture.

The average weight of a released Speckled Hind was assumed to be the same as the average weight of landed Speckled Hind. Due to the small number of weight measurements in the TIP data (n = 92), the mean weights by mode were weighted by the proportion of landings in each mode to obtain an overall mean weight.

4.4.7 Lesser Amberjack

From 1991 to 2009, the average number of Lesser Amberjack discarded annually by recreational anglers was 332. The recreational discards were 6 percent of recreational catch.

From 1991 to 2014, the average number of Lesser Amberjack discarded annually by recreational anglers was 392. The recreational discards were 8 percent of recreational catch.

The range of recommended discard mortality rates for Lesser Amberjack was 0.20 to 0.40. The workgroup's discussion on discard mortality rates for Lesser Amberjack reflected on gear selectivity and depth at capture.

Since 1999, the lower end of the federal slot limit for Lesser Amberjack has been set at 14 inches FL. The average size of a released Lesser Amberjack was assumed to be 13.5 inches FL (34 cm). This length was converted to weight using a length-weight relationship provided by the life history workgroup (see Section 2.7).

4.4.8 Almaco Jack

From 1991 to 2014, the average number of Almaco Jack discarded annually by recreational anglers was 7,309. The recreational discards were 34 percent of recreational catch.

The range of recommended discard mortality rates for Almaco Jack was 0.00 to 0.10. The workgroup's discussion on discard mortality rates for Almaco Jack reflected on gear selectivity and the species' relatively shallow depth at capture.

The average size for Almaco Jack was assumed to be 19.5 inches TL (50cm), half an inch below its reported average size retained. This length was converted to weight using a length-weight relationship provided by the life history workgroup (see Section 2.7).

4.5 COMMENTS ON ADEQUACY OF DATA FOR ASSSESSMENT ANALYSES

Most of the recreational data were considered adequate for assessment analyses. The only data that were not considered adequate were estimates of catch associated with commonly misidentified species prior to when MRFSS implemented enhanced identification training. Relevant caveats to keep in mind when using the recreational data are provided below.

Extreme annual fluctuations in catch
High inter-annual fluctuations in catch estimates from the MRFSS/MRIP survey are common for rare species. The fluctuations are attributed to a reduced likelihood that a rare species is encountered by, or reported to, port samplers along with the survey's design involving the expansion of catch estimates from dock-side interviews using regional estimates of effort. After examining the MRFSS/MRIP time series and the associated CVs, the workgroup considered that fluctuations across years were reasonable.

Spatial and temporal gaps in the collection of discards
The data collection programs that provide estimates of discards have gaps associated with states and fishing modes where no discard data were collected. Specifically, TPWD does not collect any information on discards and SRHS has only collected self-reported discards since 2004. The recreational workgroup determined that developing hole-filling techniques for eight data-limited species would not be attempted at SEDAR 49. Additional research should be conducted to identify and apply proxy values and to determine the relative implications of the gaps in the discard data.

Unknown accuracy of self-reported of discards
Although the species identity and quantities of the self-reported discards are not verified, they were assumed to be accurate. Additional research is necessary to determine if there is bias or misidentification in the data.

Discard mortality rates and average size of discards based on expert opinion
Lacking data that could be used to develop empirical estimates, the values developed by consensus agreement among the recreational workgroup attendees were considered reasonable. Uncertainty associated with these values was neither estimated nor accounted for in the conversion of discards in numbers to dead discards in weight. Thus, uncertainty associated with total removals may be underestimated, particularly for species whose removals are largely recreational dead discards.

Species misidentification
Yellowmouth Grouper, Snowy Grouper, Lesser Amberjack and Wenchman were considered to be species with potential misidentification issues. Yellowmouth Grouper can be confused with

scamp, Snowy Grouper can be confused with Warsaw Grouper, and Lesser Amberjack can be confused with both banded rudderfish and greater Amberjack. Lastly, Wenchman were considered rare and not commonly known by recreational anglers. For SEDAR 49, no efforts were made to account for potential species misidentification in the recreational data.

4.6 RESEARCH RECOMMENDATIONS

4.6.1 Red Drum

- Improve discard length and age data collection in the recreational fishery.
- Develop directed effort estimates.
- Investigate self-reported discards to determine if there is bias or misidentification in the data.
- Determine implications of gaps in the available recreational discard data.

4.6.2 Lane Snapper

- Improve discard length and age data collection in the recreational fishery.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

4.6.3 Wenchman

- Improve discard length and age data collection in the recreational fishery.
- Determine whether species identification issues (not commonly known in the recreational fishery) affect reported landings/discards.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

4.6.4 Yellowmouth Grouper

- Improve discard length and age data collection in the recreational fishery.
- Determine whether species is underreported and the percentage of landings/discards underreported due to species misidentification as Scamp or Black Grouper.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.
    - Species that are not typically targeted (ex: Yellowmouth Grouper) may benefit from a higher-level directed effort estimate (ex: shallow water grouper effort), as they are frequently caught in conjunction with associated species.

4.6.5 Snowy Grouper

- Improve discard length and age data collection in the recreational fishery.
- Determine whether species is underreported and the percentage of landings/discards underreported due to species misidentification as Black Grouper or Warsaw Grouper.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

4.6.6 Speckled Hind

- Improve discard length and age data collection in the recreational fishery.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.
- Investigate self-reported discards to determine if there is bias or misidentification in the data.
- Determine implications of gaps in the available recreational discard data.

4.6.7 Lesser Amberjack

- Improve discard length and age data collection in the recreational fishery.
- Determine effect of misreporting due to species misidentification as Banded Rudderfish or Greater Amberjack.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

4.6.8 Almaco Jack

- Improve discard length and age data collection in the recreational fishery.
- Determine whether dead discards are underestimated in TX due to targeted bait fishery.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.
    - In Texas there is a unique bait fishery which targets Almaco Jack. It was noted that b1 may be underestimated in Texas. It may be worth investigating the directed effort from this fishery.
- Investigate self-reported discards to determine if there is bias or misidentification in the data.
- Determine implications of gaps in the available recreational discard data

4.7 LITERATURE CITED

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4.8 TABLES

Table 4.8.1. Gulf of Mexico ratio estimators for adjusting MRFSS numbers and variance estimates (AB1 and B2) to MRIP APAIS numbers and variances for 1981-2003. The variances of the numbers ratio estimators are also shown.

		Numbers Ratio Estimator		Variance Ratio Estimator		Variance of Numbers Ratio Estimator	
SPECIES	**MODE**	**AB1**	**B2**	**AB1**	**B2**	**AB1**	**B2**
Almaco Jack	**Charterboat**	1.045178	0.859269	2.114181	1.390403	0.010888	0.014478
Almaco Jack	**Private**	1.442523	4.950309	3.435101	71.255760	0.149233	4.888592
Almaco Jack	**Shore**	0.893531	1.511353	0.800767	2.284189		
Almaco Jack	**All**	1.145383	3.041387				
Lane Snapper	**Charterboat**	1.216912	1.126692	10.814293	4.188168	0.007408	0.009021
Lane Snapper	**Private**	1.405661	1.052390	8.425135	4.231274	0.010307	0.070800
Lane Snapper	**Shore**	1.997743	0.750962	12.642442	1.530758	0.094713	0.008033
Lane Snapper	**All**	1.368142	0.976004				
Lesser Amberjack	**Charterboat**	0.444454		0.212652		0.006471	
Lesser Amberjack	**Private**	1.414072	2.892076	2.008957	8.364103	0.000051	
Lesser Amberjack	**Shore**						
Lesser Amberjack	**All**	1.001975	2.892076				
Red Drum	**Charterboat**	1.477175	1.127834	8.506282	6.016530	0.002821	0.004358
Red Drum	**Private**	1.501154	1.502454	6.671765	8.557669	0.002241	0.001797
Red Drum	**Shore**	1.082490	1.146123	2.808509	3.483734	0.010388	0.018466
Red Drum	**All**	1.472617	1.446682				
Snowy Grouper	**Charterboat**	1.356087	0.562722	15.960606	0.543819	0.048740	0.008435
Snowy Grouper	**Private**	3.431165	1.518439	33.667526	3.622516	1.996043	0.004012
Snowy Grouper	**Shore**						
Snowy Grouper	**All**	2.566799	1.370504				
Speckled Hind	**Charterboat**	1.233042	1.710130	5.845358	9.066262	0.070365	0.092474
Speckled Hind	**Private**	2.352338	3.089250	8.123196	27.717786	0.129542	1.079183
Speckled Hind	**Shore**						
Speckled Hind	**All**	2.102017	2.951623				
Wenchman	**Charterboat**	0.694174		0.486409		0.000143	
Wenchman	**Private**						
Wenchman	**Shore**						
Wenchman	**All**	0.694174					

Table 4.8.1 (cont.). Gulf of Mexico ratio estimators for adjusting MRFSS numbers and variance estimates (AB1 and B2) to MRIP APAIS numbers and variances for 1981-2003. The variances of the numbers ratio estimators are also shown.

		Numbers Ratio Estimator		Variance Ratio Estimator		Variance of Numbers Ratio Estimator	
SPECIES	**MODE**	**AB1**	**B2**	**AB1**	**B2**	**AB1**	**B2**
Yellowmouth Grouper	**Charterboat**	1.495748		4.804467		0.160112	
Yellowmouth Grouper	**Private**		0.859098		0.624208		0.133398
Yellowmouth Grouper	**Shore**						
Yellowmouth Grouper	**All**	1.495748	0.859098				

Table 4.8.2 Estimated annual landings (numbers of fish) for SEDAR 49 species from all data sources. Estimates in the gray area are not part of the recommended timeframe.

Year	Almaco Jack	Lane Snapper	Lesser Amberjack	Red Drum	Snowy Grouper	Speckled Hind	Wenchman	Yellowmouth Grouper
1981	2,877	557,614	0	2,351,008	238,307	0	0	0
1982	2,447	313,158	24,787	3,549,765	2,585	0	4,777	0
1983	0	482,784	28,458	5,491,583	68	0	0	0
1984	931	1,443,918	33,425	4,577,954	0	0	0	2,018
1985	4,216	252,330	33,104	3,044,457	62	0	0	874
1986	6,245	207,394	22,453	3,659,150	1,185	564	44	3,625
1987	1,268	490,552	3,837	2,753,438	183	511	425	2,627
1988	7,759	493,923	4,980	1,513,501	131	4,775	418	2,739
1989	14,326	808,540	162,380	2,157,238	257	217	0	1,241
1990	4,680	208,994	206	1,300,519	6,355	847	4	112
1991	7,993	774,992	328	1,859,052	1,564	2,775	75	269
1992	3,493	583,897	1,383	3,474,013	13	1,984	0	5,467
1993	53,734	507,985	90,418	3,492,385	232	187	0	8,038
1994	24,781	665,292	912	2,808,866	696	41	618	4,582
1995	21,493	411,061	6	4,758,063	65	32	0	36
1996	2,990	236,433	35	4,218,262	511	57	0	10
1997	7,243	503,424	59	3,894,111	296	24	19	29
1998	1,911	248,975	714	2,981,001	1,869	4,099	0	261
1999	8,188	217,045	2,773	3,435,713	1,960	11,360	0	90
2000	14,591	149,740	279	5,055,407	716	248	0	714
2001	24,019	401,603	249	4,834,345	1,532	2,104	0	18
2002	15,443	229,650	874	3,856,184	1,207	511	0	5
2003	14,317	284,069	1,813	4,235,911	463	2,472	0	42
2004	12,694	334,293	3,516	4,538,192	4,298	4,038	146	620
2005	4,663	483,987	258	3,572,226	830	102	0	304
2006	10,686	233,639	82	3,640,445	316	4,547	24	79
2007	19,180	184,486	140	4,391,756	2,754	1,187	0	36
2008	17,697	217,464	189	4,961,826	1,254	260	35	172
2009	22,455	319,240	1,333	4,049,193	7,909	282	0	21
2010	4,689	96,589	189	5,202,811	4,725	2,310	0	28
2011	5,151	105,627	284	5,740,112	1,511	736	0	11
2012	12,771	210,323	870	4,368,239	29,248	702	0	72
2013	18,118	321,154	742	4,128,518	7,446	117	0	214
2014	19,061	338,033	1,004	2,105,649	4,838	162	26	196

Table 4.8.3 Estimated annual landings (whole weight in pounds) for SEDAR 49 species from all data sources. Estimates in the gray area are not part of the recommended timeframe.

Year	Almaco Jack	Lane Snapper	Lesser Amberjack	Red Drum	Snowy Grouper	Speckled Hind	Wenchman	Yellowmouth Grouper
1981	14,268	157,995	0	6,251,413	1,299,110	0	0	0
1982	12,136	144,979	62,918	8,533,283	14,091	0	5,339	0
1983	0	333,757	72,236	11,161,319	365	0	0	0
1984	4,615	1,318,251	84,845	11,035,273	0	0	0	11,745
1985	20,930	293,447	84,030	8,299,627	333	0	0	5,088
1986	26,042	336,131	56,943	9,798,826	6,372	1,712	49	20,176
1987	4,798	502,056	9,740	7,459,428	709	1,741	475	15,221
1988	36,906	386,803	12,631	6,303,439	274	19,788	467	15,702
1989	34,765	722,596	409,884	9,984,463	1,483	1,076	0	7,635
1990	18,304	198,216	536	7,316,426	34,514	3,308	4	1,256
1991	33,037	674,031	794	7,817,956	8,544	11,646	37	1,558
1992	10,848	493,230	4,238	13,917,850	53	8,409	0	31,933
1993	263,344	406,980	48,816	15,137,837	1,162	441	0	46,749
1994	85,139	417,652	3,249	13,796,652	3,734	118	691	26,731
1995	102,382	453,172	22	22,970,212	142	158	0	239
1996	13,212	202,538	86	21,565,918	2,597	224	0	59
1997	44,317	443,230	223	21,761,113	1,803	43	14	146
1998	9,616	280,810	1,963	13,466,112	10,339	17,431	0	1,530
1999	54,512	193,570	10,153	15,592,345	9,129	48,287	0	610
2000	37,363	144,029	1,305	23,793,539	3,818	944	0	4,240
2001	114,342	342,576	697	21,357,130	8,151	8,728	0	126
2002	60,413	206,380	3,050	18,696,233	6,460	2,086	0	50
2003	56,445	312,097	5,785	21,128,871	2,514	10,571	0	248
2004	59,785	305,294	8,943	23,135,486	23,198	16,858	163	3,667
2005	32,443	363,554	920	17,970,315	4,649	170	0	1,806
2006	52,499	295,007	165	19,983,113	1,846	19,346	27	923
2007	63,017	219,537	1,465	20,846,926	14,738	5,047	0	307
2008	105,689	227,689	366	22,414,238	6,542	1,023	39	990
2009	207,641	285,426	3,545	19,457,069	42,777	981	0	117
2010	23,493	99,125	440	22,296,423	25,476	9,730	0	167
2011	36,342	108,201	756	25,941,508	7,718	2,754	0	53
2012	89,391	214,281	3,002	20,975,884	159,095	2,752	0	548
2013	109,493	262,068	2,801	20,506,929	41,457	212	0	1,259
2014	131,227	285,875	3,184	11,315,736	30,644	357	29	1,152

Table 4.8.4 Estimated annual removals (whole weight) associated with fish discarded by recreational anglers. Estimates in the gray area are not part of the recommended timeframe.

Year	Almaco Jack	Lane Snapper	Lesser Amberjack	Red Drum	Snowy Grouper	Speckled Hind	Wenchman	Yellowmouth Grouper
1981	0	0	0	254,398	0	0	0	0
1982	0	501	0	289,599	0	0	0	0
1983	0	1,938	0	507,477	0	0	0	0
1984	1,334	261	0	489,085	0	0	0	0
1985	0	0	783	302,770	0	0	0	0
1986	0	1,610	22,189	547,036	0	0	0	68,349
1987	104	1,467	11,054	1,632,164	0	0	0	0
1988	0	2,302	0	1,858,662	0	4,466	0	0
1989	0	4,314	0	1,238,770	0	0	0	0
1990	0	787	0	810,295	858	11,093	0	0
1991	666	15,141	0	2,832,862	471	98,346	0	0
1992	91	8,259	0	2,922,611	5,934	15,985	0	0
1993	11,163	12,709	750	2,189,065	2,441	15,732	0	104,248
1994	11,416	11,324	0	2,292,646	0	5,739	0	163,902
1995	16,658	9,786	0	2,347,506	0	0	0	0
1996	14,750	8,241	0	2,135,483	0	4,739	0	0
1997	598	7,388	128	2,807,360	0	173,101	0	0
1998	0	3,695	1,090	2,436,747	0	63,609	0	0
1999	1,164	3,454	0	2,125,584	577	89,691	0	0
2000	1,432	5,585	43	2,818,101	0	0	0	0
2001	5,834	4,349	94	2,671,181	57	556	0	0
2002	71,987	6,884	106	2,579,954	6,355	719	0	14,600
2003	1,388	3,411	778	3,130,154	0	29,575	0	0
2004	40,089	4,478	5	2,933,602	14,139	16,563	0	0
2005	17,017	4,810	3	2,803,494	1,123	351	0	58,431
2006	7,699	2,848	2	3,019,574	31,323	21,189	0	171
2007	12,619	6,838	52	3,047,809	2,010	108	0	85
2008	7,358	7,242	6	3,449,455	5,988	28,305	0	0
2009	9,800	7,143	23	2,881,729	38,242	426	0	74,402
2010	14,204	1,817	979	3,445,357	14,647	1,663	0	85
2011	1,690	1,873	28	3,228,199	11,321	30	0	256
2012	6,195	1,530	102	3,391,667	9,963	4,536	0	0
2013	15,869	7,456	13	2,748,212	6,475	2,686	0	171
2014	1,319	8,646	400	1,256,785	1,974	894	0	0

Table 4.8.5 Annual numbers of self-reported live discards (B2s) from MRFSS and SHRS. Estimates in the gray area are not part of the recommended timeframe.

Year	Almaco Jack	Lane Snapper	Lesser Amberjack	Red Drum	Snowy Grouper	Speckled Hind	Wenchman	Yellowmouth Grouper
1981	0	0	0	719,251	0	0	0	0
1982	0	25,027	0	893,853	0	0	0	0
1983	0	96,905	0	1,575,090	0	0	0	0
1984	863	13,043	0	1,433,868	0	0	0	0
1985	0	0	1,600	883,171	0	0	0	0
1986	0	80,511	45,376	1,567,399	0	0	0	802
1987	67	73,345	22,605	4,536,384	0	0	0	0
1988	0	115,077	0	5,205,544	0	2,068	0	0
1989	0	215,704	0	3,416,053	0	0	0	0
1990	0	39,349	0	2,276,842	127	5,136	0	0
1991	431	757,067	0	7,912,252	70	45,531	0	0
1992	59	412,962	0	8,156,912	878	7,401	0	0
1993	7,225	635,460	1,533	6,080,950	361	7,283	0	1,223
1994	7,389	566,219	0	6,327,388	0	2,657	0	1,923
1995	10,782	489,318	0	6,425,072	0	0	0	0
1996	9,547	412,074	0	5,745,895	0	2,194	0	0
1997	387	369,381	262	7,713,095	0	80,139	0	0
1998	0	184,740	2,229	6,774,709	0	29,449	0	0
1999	753	172,713	0	5,872,697	85	41,524	0	0
2000	927	279,263	87	7,860,033	0	0	0	0
2001	3,776	217,444	192	7,412,289	8	258	0	0
2002	46,593	344,184	216	7,102,396	940	333	0	171
2003	898	170,574	1,590	8,650,605	0	13,692	0	0
2004	25,948	223,908	11	8,071,299	2,092	7,668	0	0
2005	11,014	240,521	6	7,920,866	166	162	0	685
2006	4,983	142,403	5	8,366,327	4,634	9,810	0	2
2007	8,167	341,883	107	8,346,199	297	50	0	1
2008	4,762	362,121	13	9,450,488	886	13,104	0	0
2009	6,343	357,158	48	7,869,430	5,658	197	0	873
2010	9,194	90,870	2,002	9,493,251	2,167	770	0	1
2011	1,094	93,627	57	8,856,694	1,675	14	0	3
2012	4,010	76,483	209	9,403,329	1,474	2,100	0	0
2013	10,271	372,788	27	7,701,081	958	1,244	0	2
2014	854	432,313	817	3,480,215	292	414	0	0

Table 4.8.6 Discard mortality rates

Species	Discard Mortality Rates for Recreational Fleet	Midpoint Estimate
Almaco Jack	0.00 to 0.10	0.5
Lane Snapper	0.05 to 0.15	0.1
Lesser Amberjack	0.20 to 0.40	0.3
Red Drum	0.05 to 0.08	0.075
Snowy Grouper	0.80 to 1.00	0.9
Speckled Hind	0.80 to 1.00	0.9
Wenchman	none	none
Yellowmouth Grouper	0.10 to 0.15	12.5

Table 4.8.7 Assumed average weights of discarded fish.

Species	Years	Mode	Assumed Weight of Discarded Fish (number of TIP samples)	Source
Almaco Jack	1991-2014	All	**3.09**	Assumed length of discarded fish 19.5 inches TL
Lane Snapper	1986-2014	All	**0.20**	Assumed length of discarded fish 7.5 inches TL
Lesser Amberjack	1991-2009	All	**1.63**	Assumed length of discarded fish 13.5 inches FL
	1991-2014			
Red Drum	1981-2014	CBT	**5.96 (62,558)**	TIP Average Weights by Mode
		HBT	**8.49 (4,023)**	
		PRI	**4.87 (248,246)**	
		SHO	**3.82 (6,203)**	
Snowy Grouper	1990-2014	All	**7.51 (359)**	TIP Average Weights (Reweighted using proportions of recreational landings by mode)
Speckled Hind	1997-2014	All	**2.40 (92)**	
Wenchman	1997-2014	All	**NA**	
Yellowmouth Grouper	1990-2014	All	**6.82 (93)**	

5 TOTAL REMOVALS

5.1 OVERVIEW

Total removals include, as available, the sum of (in pounds whole weight):

commercial landings + commercial dead discards + recreational landings + recreational dead discards

Discard mortality rates for the recreational sector were determined by consensus agreement as described in Section 4.4 and shown in Table 4.8.6. Snowy Grouper and Speckled Hind discard mortality for the commercial sector was assumed to be 100 percent for bottom longline and vertical line fisheries; as per the workgroup's recommendation.

Coefficients of variation (CVs) were calculated for the recreational landings and discard estimates using the variance estimates provided by MRIP. Although the CVs for the landings estimates apply to MRIP landings in number of fish, they are used to characterize the uncertainty around the total recreational landings in weight and are considered the best available information. Similarly, the CVs for the discard estimates apply to MRIP live discards in number of fish (B2s), but are used to characterize the uncertainty around the total recreational dead discards in weight and are considered the best available information.

Uncertainty estimates for commercial landings were based upon expert opinion. Considered in those estimates were misreporting/misidentification problems and landings reporting by species groups (e.g., grouper) rather than as species-specific landings. The misidentification issue was considered particularly important for Lesser Amberjack, Almaco Jack, and Yellowmouth Grouper. Reporting by species group was considered potentially problematic for the groupers, snappers, and jacks. The landings time series were truncated to include only those years when reporting by species group, misreporting/misidentification, and incomplete reporting were assumed by the workgroup to be minimal (i.e., represented a small percentage of the total landings of the species).

The CVs of the calculated commercial discard rates from observer reported data were used as the estimate of uncertainty of the commercial discards. For each gear (vertical line and bottom longline), the discard rate CVs were calculated for each year (CV of the mean discard rate across all strata, see section 3.4). For each year, the higher of the two CVs (vertical line or bottom longline) was used for the estimate of commercial discard uncertainty. This method of using discard rate CVs to approximate uncertainty in commercial discard estimates has been used in prior SEDARs (e.g., SEDARs 42, 43, 45).

A single estimate of uncertainty of the total removals (i.e., the sum of recreational landings, commercial landings, dead recreational discards, and dead commercial discards) was needed for use in the Data Limited Methods assessment approach. That uncertainty estimate was calculated as:

Variance of total removals Var(T) =

$$(CV_{rec}*T_{Rec})^2 + (CV_{Disc\ Rec}*T_{Disc\ Rec})^2 + (CV_{Com}*T_{Com})^2 + ((T_{Com}*CV_{Discards\ Com}*d_{com})^2 + (d_{com}*CV_{Com}*T_{Com})^2 - (CV_{Discards\ Com}*d_{com})^2\ (CV_{Com}*T_{com})^2)$$

Coefficient of variation CV(T) =

$$\sqrt{(Var(T))}/T$$

Where: T = total removals
T_{Rec} = recreational landings
T_{Com} = commercial landings
$T_{Disc\ Rec}$ = recreational dead discards
CV_{rec} = recreational landings coefficient of variation
$CV_{Disc\ Rec}$ = recreational dead discards CV
CV_{Com} = commercial landings CV
$CV_{Discards\ Com}$ = commercial discard rate CV
d_{com} = commercial discard rate

5.2 TOTAL REMOVALS

5.2.1 Red Drum

Total removals in pounds whole weight of Red Drum are provided in Table 5.4.1 and Figure 5.5.1. Total removals were calculated as the sum of Red Drum commercial landings, recreational landings, and dead discards. Dead discards were not estimated from the commercial fishery due to insufficient data. The CV for total removals of Red Drum was 0.049.

5.2.2 Lane Snapper

Total removals in pounds whole weight of Lane Snapper are provided in Table 5.4.2 and Figure 5.5.2. Total removals were calculated as the sum of Lane Snapper commercial landings, recreational landings, and dead discards. Dead discards were not estimated from the commercial longline or vertical line fisheries due to insufficient data. Estimates of dead Lane Snapper caught as bycatch in the shrimp fishery are not included in total removals. The CV for total removals of Lane Snapper was 0.103.

5.2.3 Wenchman

Total removals in pounds whole weight of Wenchman are provided in Table 5.4.3 and Figure 5.5.3. Total removals were calculated as the sum of Wenchman commercial landings, recreational landings, and dead discards. Dead discards were not estimated from the commercial fishery due to insufficient data. The CV for total removals of Wenchman was 0.35.

5.2.4 Yellowmouth Grouper

Total removals in pounds whole weight of Yellowmouth Grouper are provided in Table 5.4.4 and Figure 5.5.4. Total removals were calculated as the sum of Yellowmouth Grouper commercial landings, recreational landings, and dead discards. Dead discards were not estimated from the commercial fishery due to insufficient data. The CV for total removals of Yellowmouth Grouper was 0.439.

5.2.5 Snowy Grouper

Total removals in pounds whole weight of Snowy Grouper are provided in Table 5.4.5 and Figure 5.5.5. Total removals were calculated as the sum of Snowy Grouper commercial landings, recreational landings, and dead discards. The CV for total removal of Snowy Grouper was 0.11.

5.2.6 Speckled Hind

Total removals in pounds whole weight of Speckled Hind are provided in Table 5.4.6 and Figure 5.5.6. Total removals were calculated as the sum of Speckled Hind commercial landings, recreational landings, and dead discards. The CV for total removal of Speckled Hind was 0.282.

5.2.7 Lesser Amberjack

Total removals in pounds whole weight of Lesser Amberjack are provided in Table 5.4.7 and Figure 5.5.7. Total removals were calculated as the sum of Lesser Amberjack commercial landings, recreational landings, and dead discards. Dead discards were not estimated from the commercial fishery due to insufficient data. The CV for total removals of Lesser Amberjack was 0.45 for the period 1991-2009 and 0.448 for the period 1991-2014. Two time series were requested due to workgroup's concern that the implementation of individual fishing quotas (IFQ) for commercial shallow and deep water groupers and tilefish may have changed fisher behavior. Commercial fishers have been more likely to target species other than Lesser Amberjack since

2010 according to fisher testimony at the Data Workshop. The time series 1991-2009 is recommended for a base model with the period 1991-2014 recommended for use in a sensitivity run of the model(s).

5.2.8 Almaco Jack

Total removals in pounds whole weight of Almaco Jack are provided in Table 5.4.8 and Figure 5.5.8. Total removals were calculated as the sum of Almaco Jack commercial landings, recreational landings, and dead discards. Dead discards were not estimated from the commercial fishery due to insufficient data. The CV for total removals of Almaco Jack was 0.22.

5.3 RESEARCH RECOMMENDATIONS

See recommendations in Sections 3.6 and 4.6.

5.4 TABLES

Table 5.4.1. Red Drum landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1981-2014. Coefficients of variation of landings and discards are also included.

Year	Commercial				Recreational				Total Removals
	Landings	CV landings	Dead discards	CV dead discards	Landings	CV landings	Dead discards	CV dead discards	
1981	2,747,934	0.75	n/a	n/a	6,251,413		254,398		9,253,745
1982	2,425,176	0.75	n/a	n/a	8,533,283		289,599		11,248,058
1983	3,127,031	0.75	n/a	n/a	11,161,319		507,477		14,795,827
1984	4,334,193	0.75	n/a	n/a	11,035,273		489,085		15,858,552
1985	6,342,733	0.75	n/a	n/a	8,299,627		302,770		14,945,131
1986	14,127,803	0.75	n/a	n/a	9,798,826	0.19	547,036	0.33	24,473,665
1987	4,890,774	0.75	n/a	n/a	7,459,428	0.27	1,632,164	0.29	13,982,366
1988	291,842	0.75	n/a	n/a	6,303,439	0.25	1,858,662	0.18	8,453,943
1989	166,446	0.75	n/a	n/a	9,984,463	0.20	1,238,770	0.24	11,389,680
1990	7,572	0.75	n/a	n/a	7,316,426	0.23	810,295	0.25	8,134,293
1991	22,162	0.75	n/a	n/a	7,817,956	0.25	2,832,862	0.26	10,672,980
1992	62,551	0.75	n/a	n/a	13,917,850	0.11	2,922,611	0.13	16,903,012
1993	85,588	0.75	n/a	n/a	15,137,837	0.13	2,189,065	0.17	17,412,490
1994	43,203	0.75	n/a	n/a	13,796,652	0.12	2,292,646	0.15	16,132,501
1995	24,110	0.75	n/a	n/a	22,970,212	0.14	2,347,506	0.15	25,341,828
1996	32,493	0.75	n/a	n/a	21,565,918	0.14	2,135,483	0.14	23,733,894
1997	25,831	0.75	n/a	n/a	21,761,113	0.15	2,807,360	0.14	24,594,305
1998	35,567	0.75	n/a	n/a	13,466,112	0.13	2,436,747	0.13	15,938,426
1999	40,202	0.75	n/a	n/a	15,592,345	0.12	2,125,584	0.14	17,758,131
2000	38,084	0.75	n/a	n/a	23,793,539	0.11	2,818,101	0.13	26,649,724
2001	22,695	0.75	n/a	n/a	21,357,130	0.12	2,671,181	0.14	24,051,006
2002	19,997	0.75	n/a	n/a	18,696,233	0.12	2,579,954	0.15	21,296,184
2003	26,646	0.75	n/a	n/a	21,128,871	0.12	3,130,154	0.14	24,285,672
2004	32,318	0.75	n/a	n/a	23,135,486	0.08	2,933,602	0.09	26,101,406
2005	52,898	0.75	n/a	n/a	17,970,315	0.09	2,803,494	0.10	20,826,708
2006	32,324	0.75	n/a	n/a	19,983,113	0.09	3,019,574	0.08	23,035,011
2007	26,440	0.75	n/a	n/a	20,846,926	0.08	3,047,809	0.09	23,921,175
2008	31,260	0.75	n/a	n/a	22,414,238	0.09	3,449,455	0.08	25,894,954
2009	35,290	0.75	n/a	n/a	19,457,069	0.09	2,881,729	0.09	22,374,088
2010	46,002	0.75	n/a	n/a	22,296,423	0.08	3,445,357	0.10	25,787,781
2011	35,223	0.75	n/a	n/a	25,941,508	0.08	3,228,199	0.08	29,204,931
2012	43,620	0.75	n/a	n/a	20,975,884	0.08	3,391,667	0.08	24,411,171
2013	44,907	0.75	n/a	n/a	20,506,929	0.06	2,748,212	0.06	23,300,048
2014	66,365	0.75	n/a	n/a	11,315,736	0.09	1,256,785	0.11	12,638,887
Grand Total	39,387,280	0.75	n/a	n/a	541,988,894	0.02	73,425,397	0.03	654,801,571

Table 5.4.2. Lane Snapper landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1986-2014. Coefficients of variation of landings and discards are also included.

Table 5.4.2. Lane Snapper landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1986-2014. Coefficients of variation of landings and discards are also included.

Year	Commercial		Recreational				Total Removals
	Landings	CV landings	Landings	CV landings	Dead discards	CV dead discards	
1986	60,174	0.20	336,131	0.80	1,610	0.71	397,915
1987	51,972	0.20	502,056	0.85	1,467	0.65	555,495
1988	57,659	0.20	386,803	0.57	2,302	0.51	446,764
1989	93,596	0.20	722,596	0.65	4,314	0.63	820,506
1990	81,358	0.20	198,216	0.65	787	0.88	280,361
1991	119,289	0.20	674,031	0.53	15,141	0.43	808,461
1992	99,127	0.20	493,230	0.41	8,259	0.29	600,616
1993	107,136	0.20	406,980	0.55	12,709	0.34	526,825
1994	91,729	0.20	417,652	0.43	11,324	0.21	520,705
1995	71,294	0.20	453,172	0.51	9,786	0.24	534,252
1996	54,581	0.20	202,538	0.54	8,241	0.24	265,360
1997	61,251	0.20	443,230	0.49	7,388	0.29	511,869
1998	31,750	0.20	280,810	0.47	3,695	0.28	316,255
1999	49,233	0.20	193,570	0.43	3,454	0.30	246,257
2000	47,684	0.20	144,029	0.51	5,585	0.34	197,298
2001	48,782	0.20	342,576	0.58	4,349	0.29	395,707
2002	52,970	0.20	206,380	0.61	6,884	0.37	266,234
2003	50,584	0.20	312,097	0.84	3,411	0.31	366,092
2004	50,755	0.20	305,294	0.28	4,478	0.40	360,527
2005	39,951	0.20	363,554	0.41	4,810	0.32	408,315
2006	49,340	0.20	295,007	0.40	2,848	0.46	347,195
2007	29,222	0.20	219,537	0.36	6,838	0.41	255,597
2008	25,475	0.20	227,689	0.22	7,242	0.33	260,406
2009	35,848	0.20	285,426	0.28	7,143	0.31	328,417
2010	17,262	0.20	99,125	0.31	1,817	0.44	118,204
2011	14,365	0.20	108,201	0.29	1,873	0.71	124,439
2012	28,928	0.20	214,281	0.39	1,530	0.23	244,739
2013	23,189	0.20	262,068	0.18	7,456	0.30	292,713
2014	29,948	0.20	285,875	0.20	8,646	0.25	324,469
Grand Total	1,574,452	0.20	9,382,151	0.12	165,389	0.07	11,121,992

Table 5.4.3. Wenchman landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1997-2014. Coefficients of variation of landings and discards are also included.

Year	Commercial		Recreational				Total Removals
	Landings	CV landings	Landings	CV landings	Dead discards	CV dead discards	
1997	6,492	0.35	14	0	0	0	6,506
1998	12,292	0.35	0	0	0	0	12,292
1999	17,391	0.35	0	0	0	0	17,391
2000	46,640	0.35	0	0	0	0	46,640
2001	103,827	0.35	0	0	0	0	103,827
2002	66,210	0.35	0	0	0	0	66,210
2003	53,106	0.35	0	0	0	0	53,106
2004	64,318	0.35	163	1.00	0	0	64,481
2005	63,301	0.35	0	0	0	0	63,301
2006	40,137	0.35	27	0.74	0	0	40,164
2007	40,431	0.35	0	0	0	0	40,431
2008	44,427	0.35	39	1.00	0	0	44,466
2009	30,447	0.35	0	0	0	0	30,447
2010	31,621	0.35	0	0	0	0	31,621
2011	34,549	0.35	0	0	0	0	34,549
2012	31,761	0.35	0	0	0	0	31,761
2013	23,949	0.35	0	0	0	0	23,949
2014	20,784	0.35	29	0	0	0	20,813
Grand Total	731,683	0.35	272	0.74	0	0	731,955

Table 5.4.4. Yellowmouth Grouper landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1990-2014. Coefficients of variation of landings and discards are also included. Commercial landings by year were confidential. Due to confidential data presentation rules, total removals by year are also confidential.

Year	Commercial				Recreational				Total Removals
	Landings	CV landings	Dead discards	CV dead discards	Landings	CV landings	Dead discards	CV dead discards	
1990	*		n/a	n/a	1,256		0	0.00	*
1991	*		n/a	n/a	1,558	1.24	0	0.00	*
1992	*		n/a	n/a	31,933	0.97	0	0.00	*
1993	*		n/a	n/a	46,749	0.93	1,042	0.83	*
1994	*		n/a	n/a	26,731	0.83	1,639	0.83	*
1995	*		n/a	n/a	239		0	0.00	*
1996	*		n/a	n/a	59		0	0.00	*
1997	*		n/a	n/a	146		0	0.00	*
1998	*		n/a	n/a	1,530	1.15	0	0.00	*
1999	*		n/a	n/a	610	0.77	0	0.00	*
2000	*		n/a	n/a	4,240	0.96	0	0.00	*
2001	*		n/a	n/a	126		0	0.00	*
2002	*		n/a	n/a	50		146	0.71	*
2003	*		n/a	n/a	248		0	0.00	*
2004	*		n/a	n/a	3,667	0.65	0	0.00	*
2005	*		n/a	n/a	1,806	0.74	584	1.00	*
2006	*		n/a	n/a	923		2	0.00	*
2007	*		n/a	n/a	307		1	0.00	*
2008	*		n/a	n/a	990	0.71	0	0.00	*
2009	*		n/a	n/a	117		744	1.00	*
2010	*		n/a	n/a	167		1	0.00	*
2011	*		n/a	n/a	53		3	0.00	*
2012	*		n/a	n/a	548	1.00	0	0.00	*
2013	*		n/a	n/a	1,259	0.31	2	0.00	*
2014	*		n/a	n/a	1,152	0.91	0	0.00	*
1991-2014	9,419	1.0	n/a	n/a	-	-	-	-	
Grand Total	9,419	1.0	n/a	n/a	126,464	0.48	4,164	0.45	140,046

Table 5.4.5. Snowy Grouper landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1990-2014. Coefficients of variation of landings and discards are also included.

Year	Commercial				Recreational				Total Removals
	Landings	CV landings	Dead discards	CV dead discards	Landings	CV landings	Dead discards	CV dead discards	
1990	138,452	0.12			34,514	3.69	858	0.75	173,824
1991	142,584	0.12			8,544	1.92	471	0.75	151,599
1992	202,437	0.12			53	0.00	5,934	1.90	208,424
1993	137,158	0.12	4,490	12.03	1,162	1.97	2,441	0.75	145,251
1994	108,796	0.12	5,093	12.03	3,734	1.46	0	0.00	117,623
1995	103,960	0.12	5,740	12.03	142	0.00	0	0.00	109,842
1996	76,652	0.12	3,851	12.03	2,597	3.74	0	0.00	83,100
1997	124,638	0.12	5,545	12.03	1,803	3.90	0	0.00	131,986
1998	94,893	0.12	3,967	12.03	10,339	0.96	0	0.00	109,199
1999	118,060	0.12	4,273	12.03	9,129	0.60	577	0.38	132,039
2000	175,354	0.12	8,659	12.03	3,818	0.95	0	0.00	187,831
2001	176,850	0.12	7,965	12.03	8,151	0.53	57	0.75	193,023
2002	130,689	0.12	5,702	12.03	6,460	3.09	6,355	1.83	149,206
2003	217,020	0.12	9,026	12.03	2,514	1.24	0	0.00	228,560
2004	181,982	0.12	8,725	12.03	23,198	0.76	14,139	0.68	228,044
2005	184,364	0.12	5,723	12.03	4,649	0.55	1,123	1.00	195,859
2006	193,040	0.12	6,804	12.03	1,846	0.55	31,323	0.69	233,013
2007	177,683	0.12	171	14.66	14,738	0.54	2,010	0.72	194,602
2008	208,395	0.12	1,290	8.24	6,542	0.58	5,988	1.00	222,215
2009	183,424	0.12	6,711	6.86	42,777	0.91	38,242	0.80	271,154
2010	99,902	0.12	18,514	7.75	25,476	0.60	14,647	0.00	158,539
2011	158,905	0.12	3,527	10.49	7,718	0.71	11,321	0.00	181,471
2012	199,989	0.12	1,933	14.76	159,095	0.73	9,963	0.00	370,980
2013	127,727	0.12	3,401	11.45	41,457	0.46	6,475	0.98	179,060
2014	177,196	0.12	2,699	9.83	30,644	0.30	1,974	0.74	212,513
Grand Total	3,840,150	0.12	123,809	12.03	451,102	0.41	153,897	0.37	4,568,958

Table 5.4.6. Speckled Hind landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1997-2014. Coefficients of variation of landings and discards are also included.

Year	Commercial				Recreational				Total Removals
	Landings	CV landings	Dead discards	CV dead discards	Landings	CV landings	Dead discards	CV dead discards	
1997	49,596	0.30	16,186	10.12	43		173,101	1.98	238,926
1998	39,432	0.30	12,668	10.12	17,431	2.67	63,609	1.91	133,140
1999	45,967	0.30	14,419	10.12	48,287	1.42	89,691	2.02	198,364
2000	64,262	0.30	19,338	10.12	944	0.46	0	0.00	84,544
2001	63,672	0.30	20,477	10.12	8,728	0.77	556	1.51	93,433
2002	48,753	0.30	15,090	10.12	2,086	0.44	719	1.40	66,648
2003	82,192	0.30	25,450	10.12	10,571	2.30	29,575	4.97	147,788
2004	98,296	0.30	28,750	10.12	16,858	0.85	16,563	0.99	160,467
2005	89,021	0.30	26,130	10.12	170	1.00	351	1.00	115,672
2006	77,789	0.30	23,489	10.12	19,346	0.76	21,189	0.88	141,813
2007	86,612	0.30	1,046	6.56	5,047	0.88	108	0.00	92,813
2008	49,250	0.30	643	5.38	1,023	0.65	28,305	0.98	79,221
2009	68,884	0.30	1,169	7.25	981	0.77	426	1.00	71,460
2010	18,393	0.30	20,361	6.80	9,730	0.95	1,663	0.79	50,147
2011	28,935	0.30	9,788	7.27	2,754	0.64	30	0.00	41,507
2012	51,090	0.30	9,339	7.36	2,752	0.77	4,536	0.74	67,717
2013	41,316	0.30	20,372	6.97	212	1.05	2,686	0.65	64,586
2014	74,903	0.30	25,914	8.42	357	0.68	894	0.87	102,068
Grand Total	1,078,363	0.30	290,628	10.12	147,320	0.62	434,005	1.00	1,950,316

Table 5.4.7. Lesser Amberjack landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1990-2009 and sensitivity time period, 1990-2014. Coefficients of variation of landings and discards are also included. Prior to 1996 commercial landings by year were confidential. Commercial landings were summed for the years 1991-1995 and that total is shown for 1995. Due to confidentiality restrictions, total removals by year for 1991-1995 are also confidential. Total removals summed for the years 1991-1995 are shown in the 1995 row.

Year	Commercial				Recreational				Total Removals
	Landings	CV landings	Dead discards	CV dead discards	Landings	CV landings	Dead discards	CV dead discards	
1991	*	0.5	n/a	n/a	794		0	0.00	*
1992	*	0.5	n/a	n/a	4,238		0	0.00	*
1993	*	0.5	n/a	n/a	48,816	0.51	750	2.89	*
1994	*	0.5	n/a	n/a	3,249		0	0.00	*
1995	160,875	0.5	n/a	n/a	22		0	0.00	217,995
1996	68,697	0.5	n/a	n/a	86		0	0.00	68,783
1997	42,453	0.5	n/a	n/a	223	0.49	128	2.89	42,804
1998	26,041	0.5	n/a	n/a	1,963	0.17	1090	1.28	29,094
1999	29,035	0.5	n/a	n/a	10,153	0.11	0	0.00	39,188
2000	42,300	0.5	n/a	n/a	1,305	0.14	43	2.89	43,648
2001	46,843	0.5	n/a	n/a	697	0.17	94	2.89	47,634
2002	110,257	0.5	n/a	n/a	3,050	0.20	106	1.80	113,413
2003	72,953	0.5	n/a	n/a	5,785	1.32	778	2.89	79,516
2004	67,850	0.5	n/a	n/a	8,943	0.81	5	0.00	76,798
2005	43,785	0.5	n/a	n/a	920	1.00	3	0.00	44,708
2006	41,190	0.5	n/a	n/a	165		2	0.00	41,357
2007	26,996	0.5	n/a	n/a	1,465	1.00	52	0.00	28,513
2008	24,359	0.5	n/a	n/a	366	0.71	6	0.00	24,732
2009	46,475	0.5	n/a	n/a	3,545	1.00	23	0.00	50,043
2010	26,993	0.5	n/a	n/a	440	0.00	979	1.00	28,412
2011	6,414	0.5	n/a	n/a	756	1.00	28	0.00	7,198
2012	5,490	0.5	n/a	n/a	3,002		102	0.00	8,595
2013	20,577	0.5	n/a	n/a	2,801	1.03	13	0.00	23,392
2014	2,262	0.5	n/a	n/a	3,184	1.07	400	1.07	5,845
Grand Total	911,845	0.5	n/a	n/a	105,968	0.46	4,603	0.83	1,022,416

Table 5.4.8. Almaco Jack landings and dead discards from the commercial and recreational fisheries in pounds whole weight for the recommended time period, 1991-2014. Coefficients of variation of landings and discards are also included. Prior to 1996 commercial landings by year were confidential. Commercial landings were summed for the years 1991-1995 and that total is shown for 1995. Due to confidentiality restrictions, total removals by year for 1991-1995 are also confidential. Total removals summed for the years 1991-1995 are shown in the 1995 row.

Year	Commercial				Recreational				Total Removals
	Landings	CV landings	Dead discards	CV dead discards	Landings	CV landings	Dead discards	CV dead discards	
1991	*	0.5	n/a	n/a	33,037	0.84	666	0.88	*
1992	*	0.5	n/a	n/a	10,848	0.42	91	1.18	*
1993	*	0.5	n/a	n/a	263,344	0.93	11,163	5.53	*
1994	*	0.5	n/a	n/a	85,139	0.48	11,416	4.23	*
1995	163,082	0.5	n/a	n/a	102,382	1.67	16,658	7.57	657,831
1996	31,803	0.5	n/a	n/a	13,212	0.85	14,750	4.87	59,765
1997	44,976	0.5	n/a	n/a	44,317	0.53	598	0.85	89,890
1998	31,999	0.5	n/a	n/a	9,616	0.26	0	0.00	41,615
1999	43,452	0.5	n/a	n/a	54,512	0.49	1,164	0.40	99,128
2000	43,616	0.5	n/a	n/a	37,363	0.48	1,432	0.43	82,412
2001	56,827	0.5	n/a	n/a	114,342	0.69	5,834	7.25	177,003
2002	46,881	0.5	n/a	n/a	60,413	0.25	71,987	3.16	179,281
2003	35,887	0.5	n/a	n/a	56,445	0.24	1,388	0.29	93,720
2004	28,254	0.5	n/a	n/a	59,785	0.24	40,089	0.97	128,128
2005	18,724	0.5	n/a	n/a	32,443	0.19	17,017	0.95	68,185
2006	15,148	0.5	n/a	n/a	52,499	0.25	7,699	0.55	75,346
2007	30,601	0.5	n/a	n/a	63,017	0.32	12,619	0.72	106,237
2008	24,406	0.5	n/a	n/a	105,689	0.31	7,358	0.63	137,453
2009	37,351	0.5	n/a	n/a	207,641	0.43	9,800	0.87	254,792
2010	27,964	0.5	n/a	n/a	23,493	0.41	14,204	0.92	65,661
2011	36,800	0.5	n/a	n/a	36,342	0.37	1,690	0.43	74,832
2012	47,366	0.5	n/a	n/a	89,391	0.43	6,195	0.66	142,952
2013	32,110	0.5	n/a	n/a	109,493	0.40	15,869	0.37	157,472
2014	39,732	0.5	n/a	n/a	131,227	0.23	1,319	0.54	172,279
Grand Total	837,813	0.5	n/a	n/a	1,795,989	0.21	271,007	1.07	2,904,809

5.5 FIGURES

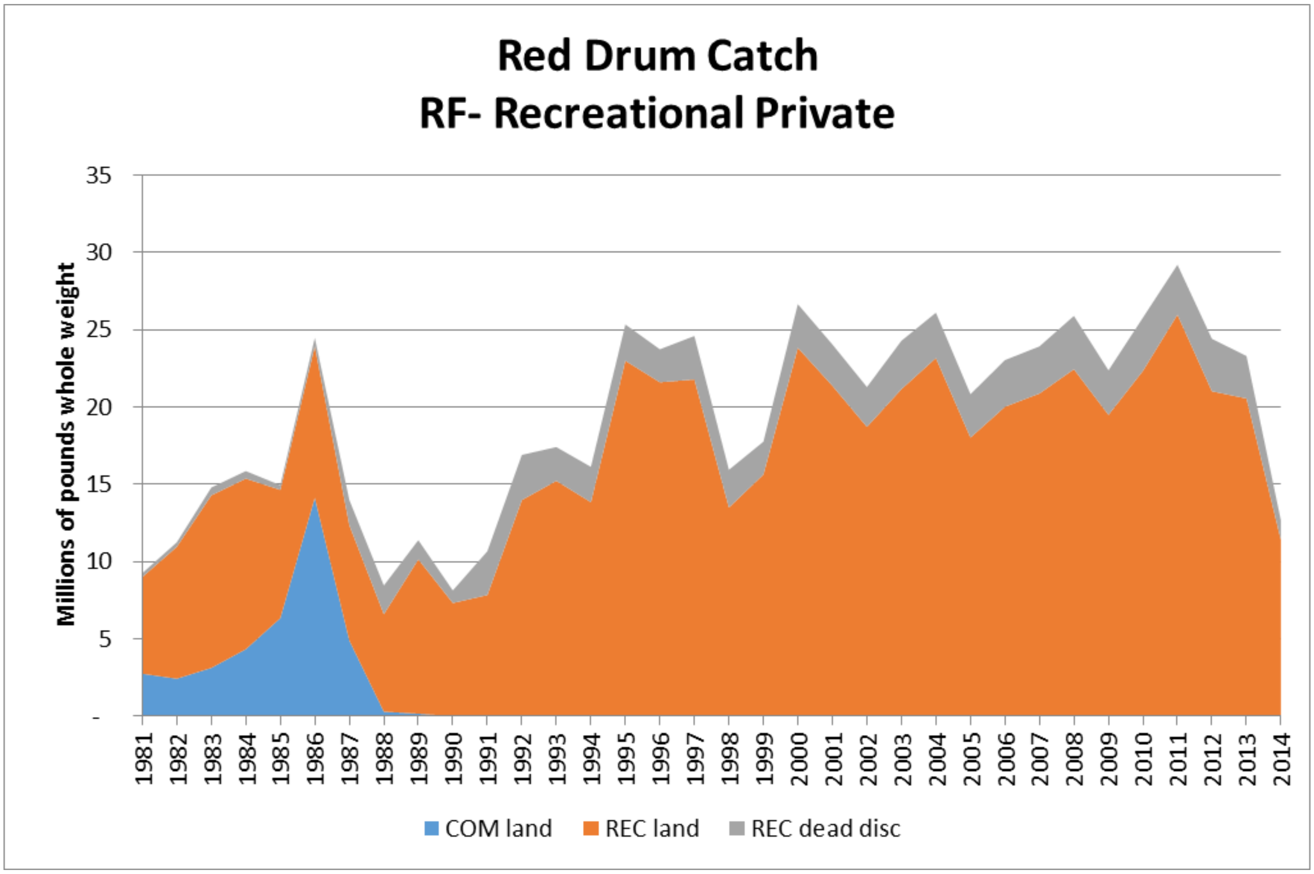

Figure 5.5.1. Total removals from the recreational and commercial fisheries of Red Drum in the US Gulf of Mexico. Removals includes landings and dead discards. Removals are in millions of pounds whole weight of Red Drum. RF=representative fleet, used for the management strategy evaluation.

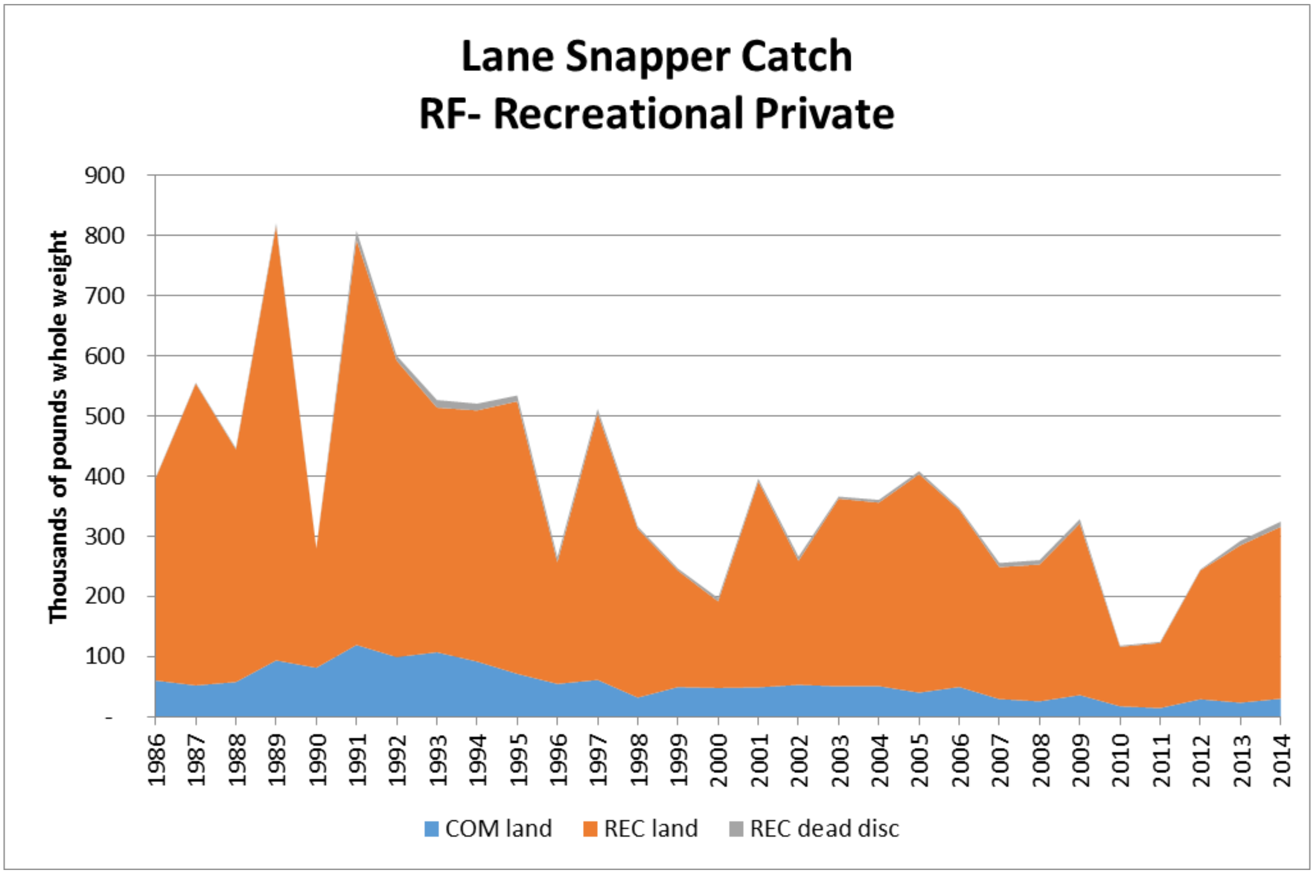

Figure 5.5.2. Total removals from the recreational and commercial fisheries of Lane Snapper in the US Gulf of Mexico. Removals includes landings and dead discards. Removals are in thousands of pounds whole weight of Lane Snapper. RF=representative fleet, used for the management strategy evaluation.

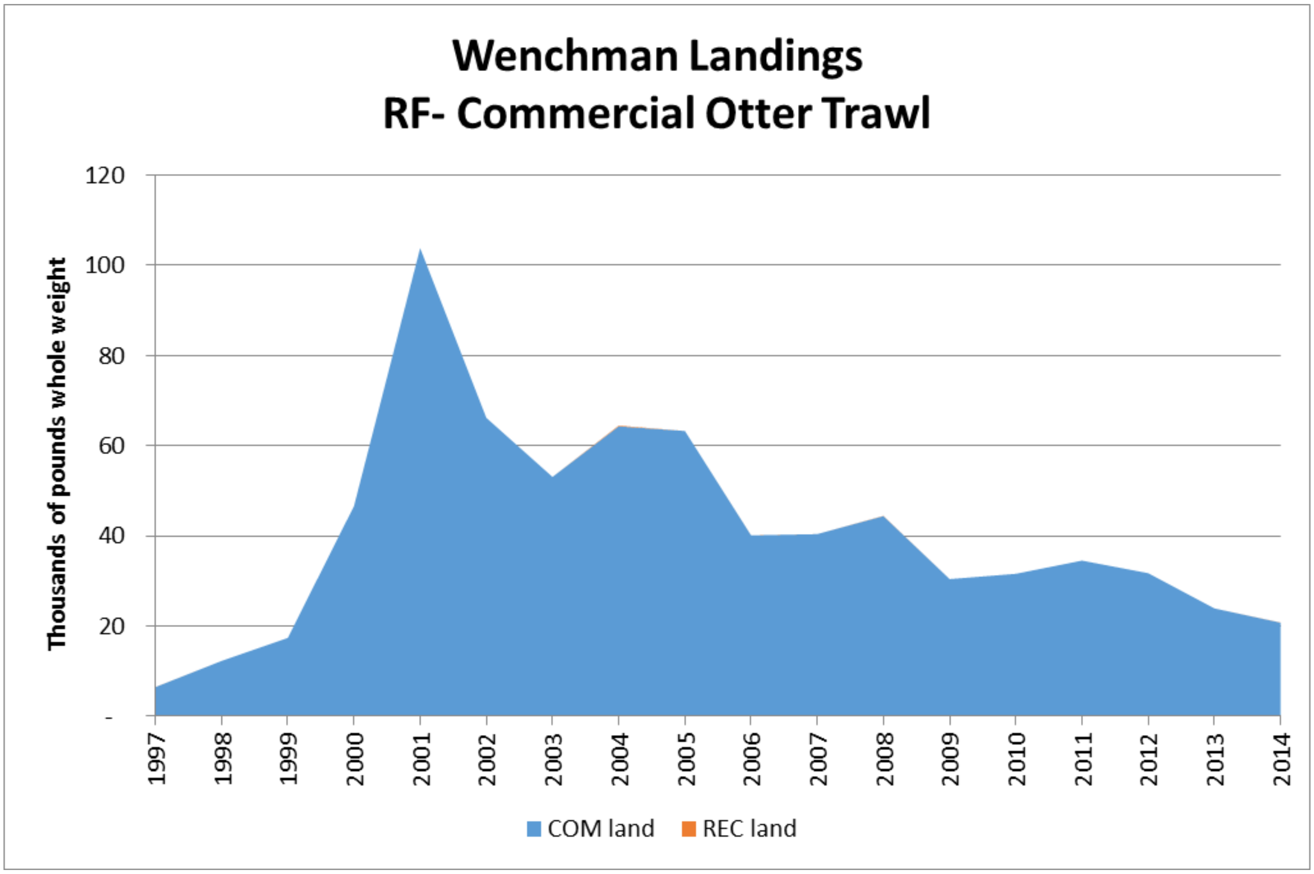

Figure 5.5.3. Total removals from the recreational and commercial fisheries of Wenchman in the US Gulf of Mexico. Removals included commercial and recreational landings. Removals are in thousands of pounds whole weight of Wenchman. RF=representative fleet, used for the management strategy evaluation.

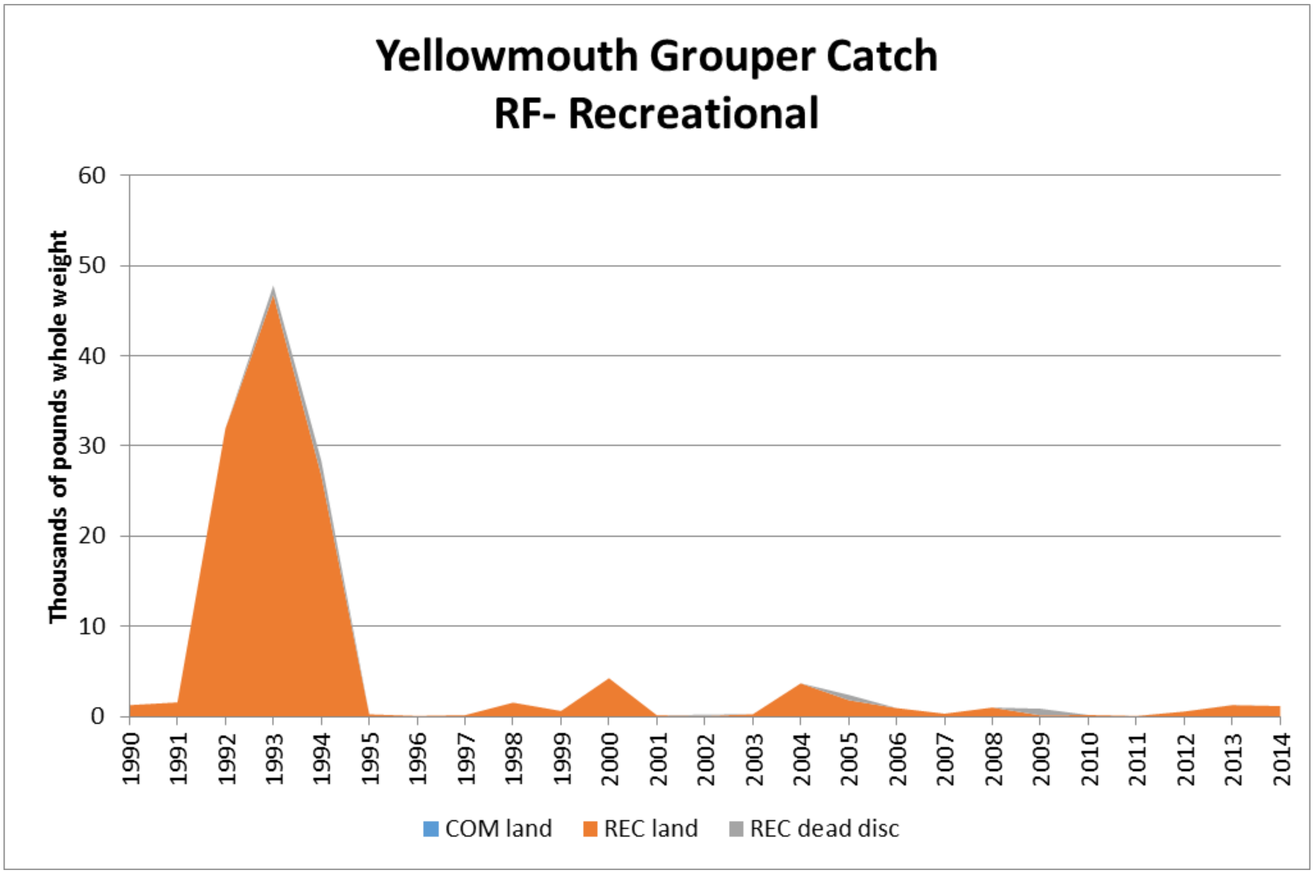

Figure 5.5.4. Total removals from the recreational and commercial fisheries of Yellowmouth Grouper in the US Gulf of Mexico. Removals includes landings and dead discards. Removals are in thousands of pounds whole weight of Yellowmouth Grouper. RF=representative fleet, used for the management strategy evaluation.

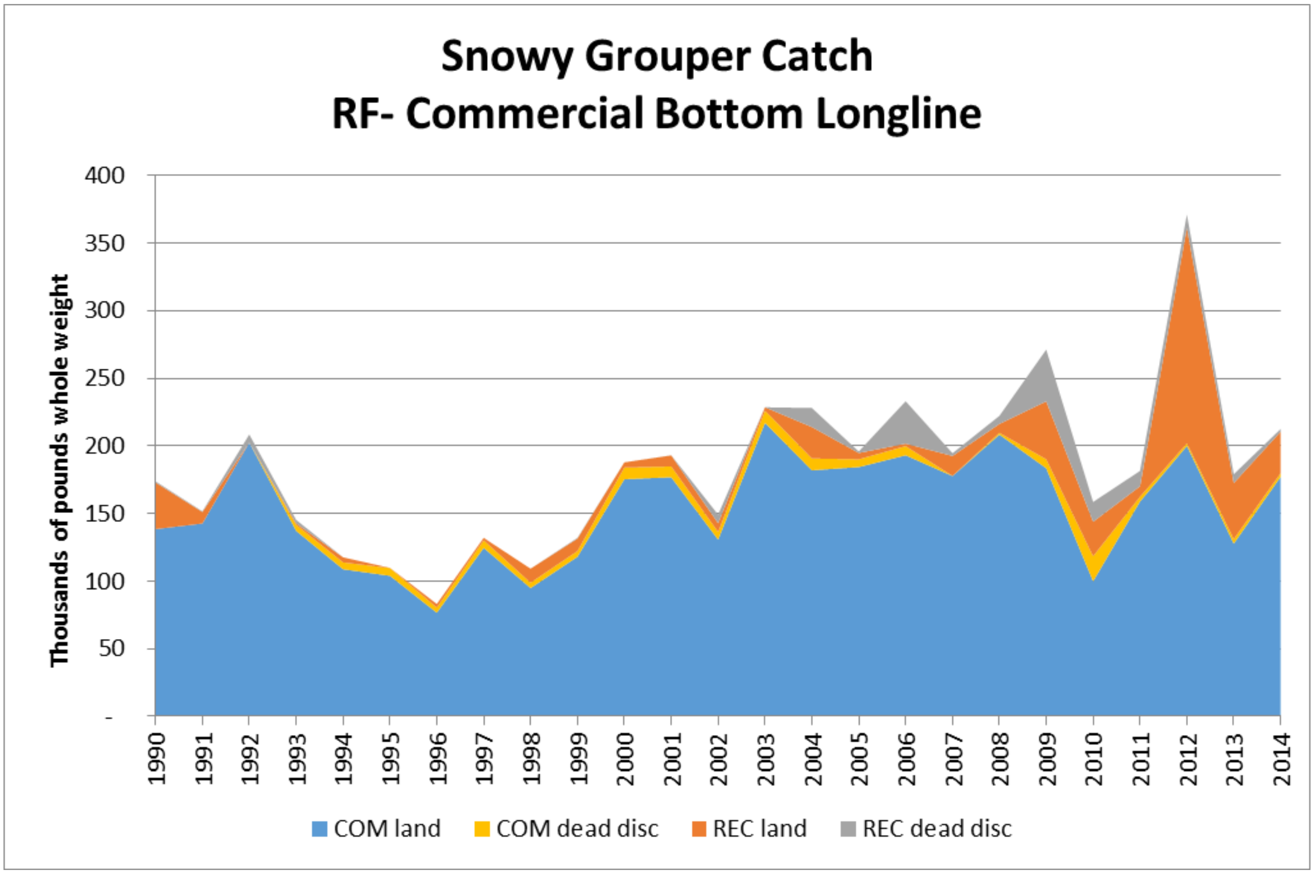

Figure 5.5.5. Total removals from the recreational and commercial fisheries of Snowy Grouper in the US Gulf of Mexico. Removals includes landings and dead discards. Removals are in thousands of pounds whole weight of Snowy Grouper. RF=representative fleet, used for the management strategy evaluation.

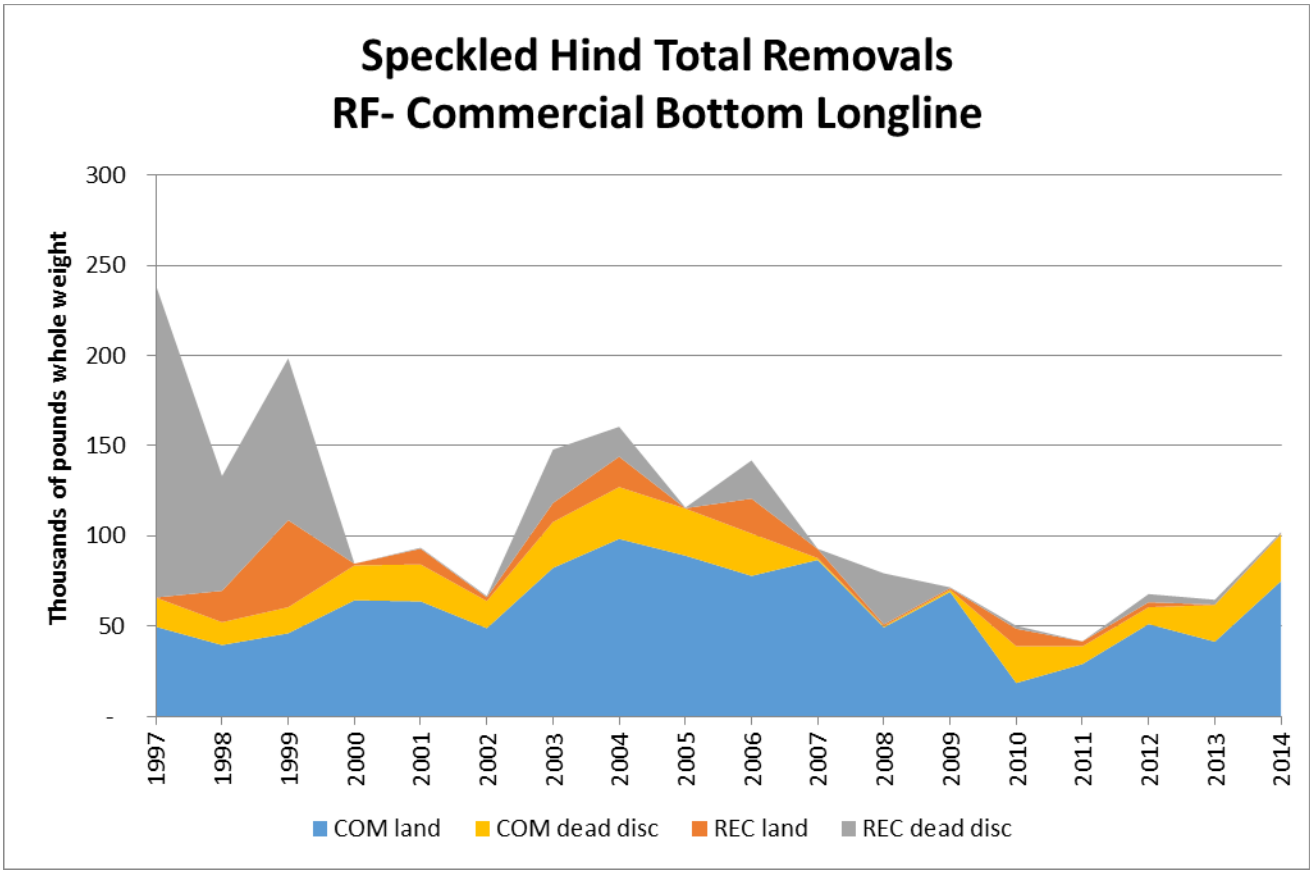

Figure 5.5.6. Total removals from the recreational and commercial fisheries of Speckled Hind in the US Gulf of Mexico. Removals includes landings and dead discards. Removals are in thousands of pounds whole weight of Speckled Hind. RF=representative fleet, used for the management strategy evaluation.

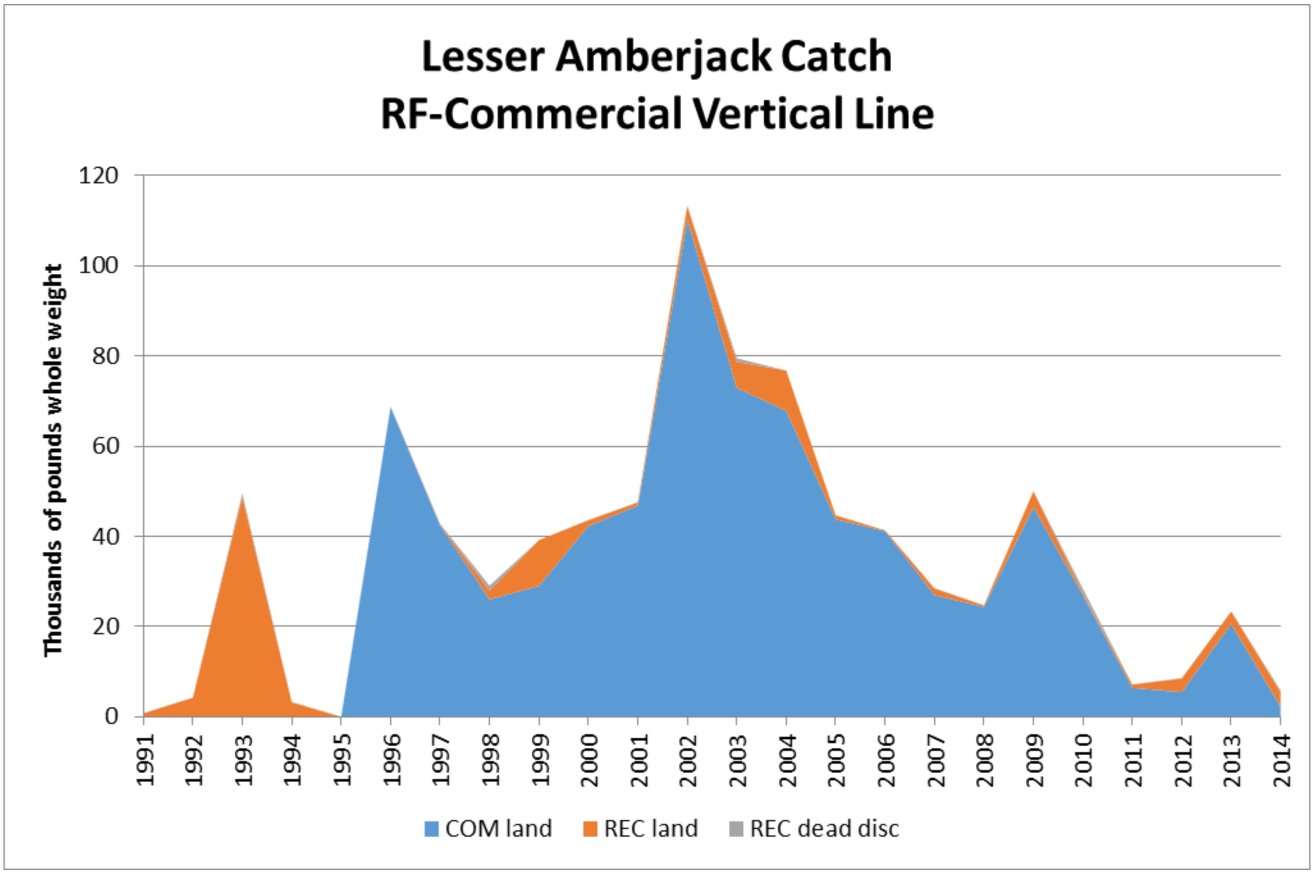

Figure 5.5.7. Total removals from the recreational and commercial fisheries of Lesser Amberjack in the US Gulf of Mexico. Removals includes landings and dead discards. Removals are in thousands of pounds whole weight of Lesser Amberjack. RF=representative fleet, used for the management strategy evaluation.

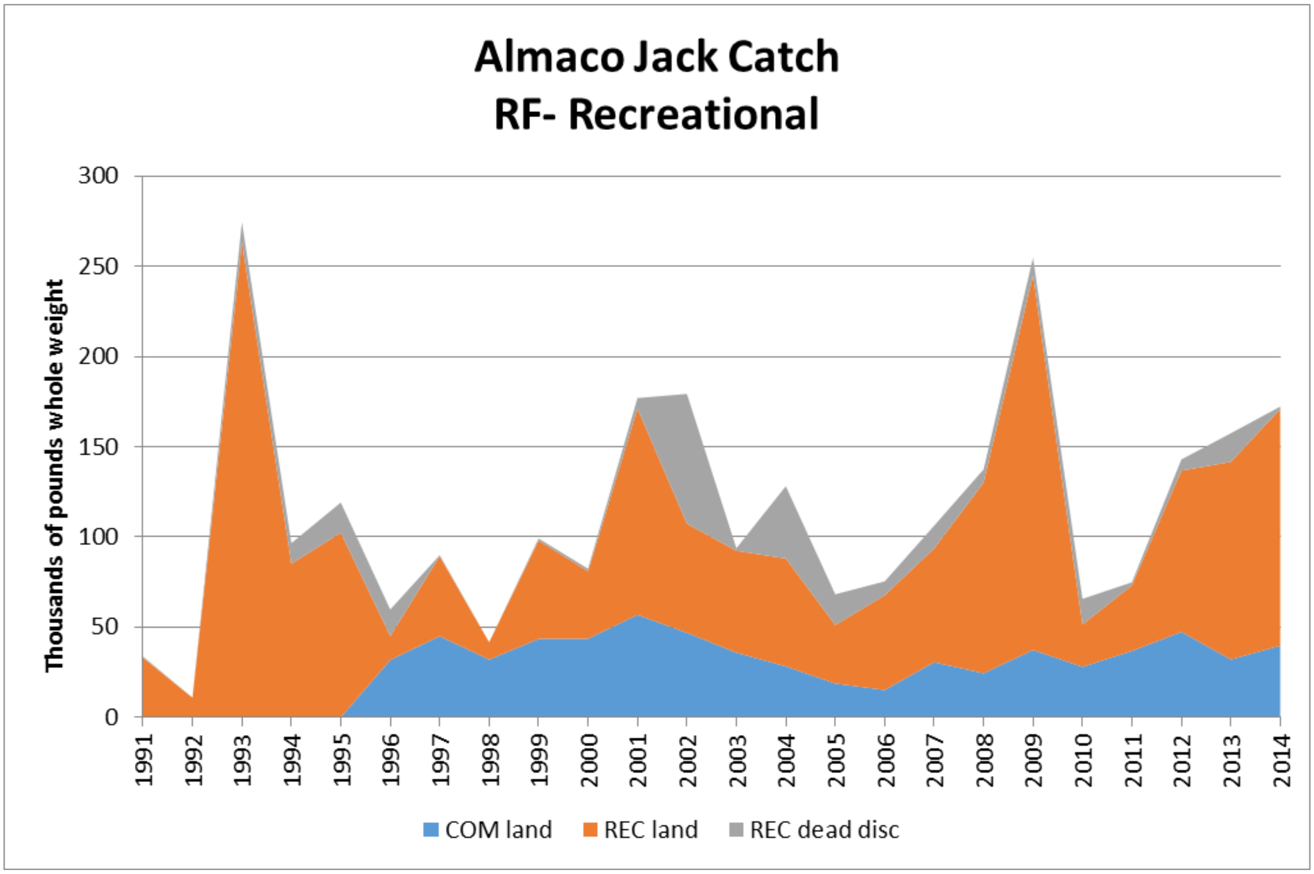

Figure 5.5.8. Total removals from the recreational and commercial fisheries of Almaco Jack in the US Gulf of Mexico. Removals includes landings and dead discards. Removals are in thousands of pounds whole weight of Almaco Jack. RF=representative fleet, used for the management strategy evaluation.

6 MEASURES OF FISHING EFFORT

6.1 OVERVIEW

Fishing effort was summed by year for each of the representative fleets. Recreational data was recommended by the combined recreational-commercial workgroup to be most representative for Red Drum, Lane Snapper, Almaco Jack, and Yellowmouth Grouper. Commercial data was recommended by the workgroup as most representative for Speckled Hind (bottom longline data), Snowy Grouper (bottom longline data), Lesser Amberjack (vertical line data), and Wenchman (finfish trawl data).

6.2 REPRESENTATIVENESS

The fleet that accounted for the largest proportion of the total removals was selected as the representative fleet for each species (but see Lane Snapper and Wenchman). The time series was selected based on concurrent landings information from both the commercial and recreational fisheries.

6.2.1 Red Drum

PR mode was chosen as the representative fleet for Red Drum, with a 1981-2014 time series. Due to the closure of the commercial Red Drum fishery in the EEZ in 1987, the majority of the total removals come from the recreational private mode. The combined angler trip estimates for the representative fleet are tabulated in Table 6.3.1 by year, include all Gulf of Mexico states from Louisiana to West Florida (excluding the Florida Keys), and are shown in Figure 6.4.1.

6.2.2 Lane Snapper

PR mode in FLW was chosen as the representative fleet for Lane Snapper, with a 1986-2014 time series. The majority (95 percent) of landings came from the PR mode in FLW. The combined angler trip estimates for the representative fleet are tabulated in Table 6.3.2 by year, include all Gulf of Mexico states from Louisiana to West Florida (excluding the Florida Keys), and are shown in Figure 6.4.2.

6.2.3 Wenchman

As noted in Section 3.3.3, the representative fleet for Wenchman was identified as the Gulf fish (probably Butterfish) trawl fishery. As the NMFS logbook does not cover this fishery, the only source of effort data available is the FL trip ticket data. A review of the positive trips for Wenchman demonstrated that the Butterfish and unclassified fishes represented 76 percent of the landings for these trips. An examination of the gear used in these trips indicates that 59 percent of the landings were caught with unknown gear and 40 percent were caught by a trawl. The fact that unknown gear class disappears from FL trip tickets once trawl gear is identified with these trips suggests that most of the catches with unknown gear are attributable to trawl gear.

We also looked at the positive Wenchman trips with respect to the area fished and the size of the catches of the combined Butterfish and unclassified finfish catches. Of the positive Wenchman trips, 97 percent of the combined Butterfish and unclassified finfish pounds landed came from fishing grid eight (Figure 6.4.3), indicating trips from this area may be attributable to the fish trawl fishery. An examination of the combined Butterfish and unclassified finfish pounds landed per trip indicated that 90 percent of landings occurred on trips landing more than 6,605 pounds.

In an attempt to limit the effort series developed for this fishery to those trips that had characteristics similar to those that catch Wenchman, we restricted the time series of trips to those FL trip tickets landing more than 6,605 pounds of combined weight from Butterfish and unclassified finfish from fishing grid eight using unknown gear or trawl gear. Yearly total trips are provided in Table 6.3.3.

6.2.4 Yellowmouth Grouper

The recreational fleet (CH, PR and HB only) was chosen as the representative fleet for Yellowmouth Grouper, with a 1990-2014 time series. There were no SH mode landings. Yellowmouth Grouper is not a targeted species, therefore landings in the commercial fleet are extremely low, amounting to only 6.9 percent of the overall landings for the entire time series. The majority of the total removals came from the combined recreational modes. The combined angler trip estimates for the representative fleets are tabulated in Table 6.3.4 by year, include all Gulf of Mexico states from Louisiana to West Florida (excluding the Florida Keys), and are shown in Figure 6.4.4.

6.2.5 Snowy Grouper

The commercial bottom longline fishery was recommended as the representative fleet for the management strategy evaluation for Snowy Grouper. The number of bottom longline commercial fishing trips reporting to the coastal logbook program was summed by year as an estimate of fishing effort. Other effort measures (e.g., hooks fished, hook hours fished) were not used because many of those data have been reported months after the fishing trip was completed and may be unreliable (e.g., fishing effort incorrectly recalled if reporting was delayed for six weeks). In other cases, data from trips were clearly erroneous (10,000's of hooks fished per set). Although details of fishing trips (number of sets fished, for example) may have been misreported after long reporting delays, the number of fishing trips was assumed to be consistently and accurately reported and was recommended as the effort measure for the representative fleet. Data included all commercial bottom longline trips reporting fishing in areas 1-21 (Figure 6.4.3) because landings of Snowy Grouper were reported from fishing throughout the Gulf of Mexico.

Coastal logbook reporting has been required of all commercial vessels with federal fishing permits since 1993. Uncertainty in the total reported number of commercial bottom longline trips per year may be due to unreported trips or duplicate reports. Data QA/QC procedures have improved over the years of coastal logbook reporting; however, early in the time series higher numbers of unreported trips may have occurred. Unreported trips were assumed due to the discrepancy between total landings of Snowy Grouper reported to the coastal logbook program compared to landings data available through the Accumulated Landing System (ALS).

The percent difference in Snowy Grouper landings reported to the coastal logbook program and those from the ALS were used to estimate uncertainty in fishing effort (trips) by year. For example, where coastal logbook reported landings were 10 percent less than the landings total the ALS, a 10 percent underreporting of trips was assumed. Where coastal logbook reported landings exceeded the ALS landings, duplicate reporting was assumed equal to the percentage of logbook over reporting. An additional five percent uncertainty was assumed because differences in landings (logbook and ALS) may not be linearly correlated with differences in number of trips.

The number of bottom longline trips in fishery statistical areas 1-21 by year are provided in Table 6.3.5 and Figure 6.4.5. Coastal logbook reported landings exceeded the ALS landings during numerous years throughout the period 1993-2014, but not in all years. In other years, logbook landings were less than ALS landings. Uncertainty was assumed to be symmetric around the yearly landings estimate during all years due to a combination of possible duplicate reporting and underreporting.

6.2.6 Speckled Hind

The commercial bottom longline fishery was recommended as the representative fleet for the management strategy evaluation for Speckled Hind. As with Snowy Grouper (Section 6.2.5.), the number of bottom longline commercial fishing trips reporting to the coastal logbook program was summed by year as an estimate of fishing effort. Data were limited to those commercial bottom longline trips reporting fishing in areas 2-7 (Figure 6.4.3) where approximately 96 percent of Speckled Hind reported landings occurred.

The number of bottom longline trips in fishery statistical areas 2-7 by year are provided in Table 6.3.6 and Figure 6.4.6. Coastal logbook reported landings did not exceed the ALS landings prior to 2010; therefore, total trips were assumed to be underreported up to 2010. Uncertainty was assumed to be asymmetric prior to 2011 (i.e., number of logbook reported trips were a minimum estimate of effort). Uncertainty was assumed to be symmetric around the estimate during the years 2010-2014 due to a combination of possible duplicate reporting and underreporting. See Section 6.2.5 for additional explanation of uncertainty assumptions.

6.2.7 Lesser Amberjack

The commercial vertical line (handline and hydraulic/electric reels - aka bandit rigs) fishery was recommended as the representative fleet for the management strategy evaluation for Lesser Amberjack. The number of vertical line commercial fishing trips reporting to the coastal logbook program was summed by year as an estimate of fishing effort. Data included all commercial vertical line trips reporting fishing in areas 1-21 (Figure 6.4.3) because landings of Lesser Amberjack were reported from statistical areas throughout the US Gulf of Mexico.

The number of vertical line trips in fishery statistical areas 1-21 by year are provided in Table 6.3.7 and Figure 6.4.7. Coastal logbook reported landings exceeded the ALS landings during numerous years throughout the period 1993-2014, but not in all years. In other years, logbook landings were less than ALS landings. Uncertainty was assumed to be symmetric around the yearly landings estimate during all years due to a combination of possible duplicate reporting and underreporting. The workgroup concluded that misidentification or misreporting of Lesser Amberjack was also contributing to uncertainty in the landings estimates. See Section 6.2.5 for additional explanation of uncertainty assumptions.

6.2.8 Almaco Jack

The recreational fleet (CH, PR and HB only) was chosen as the representative fleet for Almaco Jack, with a 1991-2014 time series. SH mode landings were an insignificant portion of the overall recreational landings and occurred only in FLW in 2006, and therefore were not included in the total removals or effort estimates. The combined angler trip estimates for the representative fleets are tabulated in Table 6.3.8 by year, include all Gulf of Mexico states from Louisiana to West Florida (excluding the Florida Keys), and are shown in Figure 6.4.8.

6.3 TABLES

Table 6.3.1. Estimated angler trips in the recreational private mode (Red Drum representative fleet) with upper and lower bound estimates, 1981-2014.

Year	Lower bound	Estimated angler trips	Upper Bound
1981	4,780,722	7,764,455	10,748,187
1982	4,738,739	5,438,965	6,139,191
1983	6,372,907	7,245,446	8,117,986
1984	7,076,114	8,219,537	9,362,960
1985	6,425,630	7,770,206	9,114,781
1986	8,196,303	9,036,876	9,877,449
1987	8,956,254	9,618,816	10,281,377
1988	11,147,854	11,741,222	12,334,591
1989	8,981,415	9,624,854	10,268,294
1990	7,584,515	8,053,014	8,521,512
1991	9,369,128	9,938,503	10,507,879
1992	9,980,756	10,356,641	10,732,525
1993	9,686,638	10,036,191	10,385,745
1994	10,131,281	10,478,867	10,826,454
1995	10,302,313	10,650,486	10,998,659
1996	10,089,277	10,449,891	10,810,505
1997	10,801,513	11,196,234	11,590,955
1998	9,540,954	9,911,095	10,281,235
1999	9,919,545	10,301,512	10,683,478
2000	12,399,482	12,888,710	13,377,937
2001	12,862,659	13,358,909	13,855,159
2002	12,152,518	12,599,996	13,047,473
2003	14,548,197	15,118,566	15,688,936
2004	15,792,942	16,649,976	17,507,010
2005	13,729,959	14,538,034	15,346,109
2006	13,819,462	14,614,151	15,408,840
2007	15,019,901	15,884,230	16,748,558
2008	15,245,298	16,100,628	16,955,959
2009	13,554,621	14,362,249	15,169,877
2010	12,793,200	13,553,128	14,313,056
2011	13,221,880	13,874,314	14,526,749
2012	13,016,372	13,714,615	14,412,858
2013	13,691,571	14,514,461	15,337,351
2014	12,646,021	13,522,838	14,399,656

Table 6.3.2. Estimated angler trips in the recreational private mode from FLW (Lane Snapper representative fleet) with upper and lower bound estimates, 1986-2014.

Year	Lower bound	Estimated angler trips	Upper Bound
1986	4,598,971	5,294,131	5,989,292
1987	5,452,695	5,988,021	6,523,346
1988	7,113,420	7,609,586	8,105,752
1989	5,757,565	6,286,971	6,816,377
1990	4,823,852	5,191,075	5,558,299
1991	6,188,337	6,643,368	7,098,398
1992	6,352,309	6,625,517	6,898,725
1993	5,851,280	6,086,848	6,322,416
1994	6,322,772	6,568,329	6,813,886
1995	5,992,863	6,226,194	6,459,524
1996	6,073,766	6,309,765	6,545,765
1997	6,559,888	6,838,737	7,117,587
1998	5,824,210	6,095,735	6,367,259
1999	5,812,265	6,078,906	6,345,546
2000	7,545,456	7,892,650	8,239,845
2001	7,879,741	8,224,635	8,569,529
2002	7,900,514	8,235,453	8,570,393
2003	8,827,349	9,221,723	9,616,098
2004	9,464,001	10,171,629	10,879,257
2005	8,813,830	9,491,039	10,168,248
2006	8,702,154	9,381,944	10,061,734
2007	9,279,977	10,005,041	10,730,104
2008	9,436,531	10,144,673	10,852,815
2009	7,985,269	8,622,953	9,260,637
2010	7,544,141	8,160,223	8,776,305
2011	7,032,373	7,520,024	8,007,675
2012	7,330,789	7,864,728	8,398,667
2013	7,665,781	8,328,407	8,991,033
2014	7,529,194	8,115,304	8,701,413

Table 6.3.3. Commercial fishing effort in the northern Gulf of Mexico finfish trawl (probably Butterfish) fishery (Wenchman representative fleet) in numbers of trips with associated coefficients of variation, 1997-2014. Years with no trips and CVs included confidential data and cannot be shown.

Year	Trips	CV
1997	46	1.0
1998	68	1.0
1999	*	*
2000	79	1.0
2001	87	0.7
2002	72	0.7
2003	63	0.7
2004	72	0.7
2005	44	0.7
2006	*	*
2007	25	0.7
2008	*	*
2009	*	*
2010	*	*
2011	45	0.7
2012	39	0.7
2013	*	*
2014	*	*

Table 6.3.4. Estimated angler trips in the recreational private, charterboat, and headboat modes (Yellowmouth Grouper representative fleet) with upper and lower bound estimates, 1990-2014.

Year	Lower bound	Estimated angler trips	Upper Bound
1990	8,386,462	8,888,669	9,390,875
1991	10,159,060	10,756,334	11,353,609
1992	10,818,017	11,216,925	11,615,834
1993	10,859,835	11,241,879	11,623,923
1994	11,440,258	11,821,101	12,201,945
1995	11,722,870	12,108,937	12,495,004
1996	11,459,523	11,856,066	12,252,609
1997	12,248,009	12,685,942	13,123,874
1998	10,726,138	11,111,495	11,496,852
1999	10,928,304	11,321,511	11,714,718
2000	13,656,834	14,162,373	14,667,912
2001	14,025,091	14,536,166	15,047,240
2002	13,310,994	13,772,372	14,233,750
2003	15,625,163	16,209,608	16,794,052
2004	17,002,439	17,877,524	18,752,610
2005	14,752,909	15,577,817	16,402,725
2006	15,047,313	15,861,655	16,675,996
2007	16,331,314	17,219,598	18,107,881
2008	16,411,824	17,284,576	18,157,329
2009	14,743,694	15,570,577	16,397,461
2010	13,689,080	14,465,523	15,241,967
2011	14,381,638	15,052,497	15,723,357
2012	14,403,754	15,126,377	15,849,000
2013	15,014,035	15,858,457	16,702,879
2014	12,694,985	13,504,492	14,313,999

Table 6.3.5. Commercial bottom longline fishing effort (Snowy Grouper representative fleet) in statistical areas 1-21 in numbers of trips with upper and lower bounds, 1993-2014.

Year	Lower bound	Bottom LL trips	Upper bound
1993	813	1,338	1,863
1994	1,511	1,755	1,999
1995	1,545	1,913	2,281
1996	1,258	2,234	3,210
1997	1,889	2,026	2,163
1998	481	1,844	3,207
1999	1,378	1,959	2,540
2000	1,480	1,872	2,264
2001	1,755	1,905	2,055
2002	1,665	1,936	2,207
2003	1,569	2,115	2,661
2004	1,808	2,131	2,454
2005	1,849	1,946	2,043
2006	1,747	2,061	2,375
2007	1,258	1,328	1,398
2008	1,303	1,359	1,415
2009	765	788	811
2010	424	525	626
2011	858	857	856
2012	936	1,018	1,100
2013	954	1,143	1,332
2014	1,212	1,316	1,420

Table 6.3.6. Commercial bottom longline fishing effort (Speckled Hind representative fleet) in statistical areas 2-7 in numbers of trips with upper and lower bounds, 1997-2014. Note that bottom longline trips during 1997-2010 were assumed to be the lower limit of estimated effort.

Year	Lower bound	Bottom LL trips	Upper bound
1997	1,553	1,553	1,786
1998	1,399	1,399	1,903
1999	1,419	1,419	1,859
2000	1,245	1,245	1,830
2001	1,337	1,337	1,792
2002	1,288	1,288	1,765
2003	1,455	1,455	1,790
2004	1,477	1,477	1,817
2005	1,376	1,376	1,734
2006	1,512	1,512	1,950
2007	1,079	1,079	1,457
2008	1,037	1,037	1,276
2009	558	558	636
2010	361	384	407
2011	567	610	653
2012	591	635	679
2013	544	598	652
2014	592	651	710

Table 6.3.7. Commercial vertical line fishing effort (Lesser Amberjack representative fleet) in statistical areas 1-21 in numbers of trips with upper and lower confidence intervals, 1993-2014.

Year	Lower bound	Vertical line trips	Upper bound
1993	0	11,145	22,511
1994	0	11,734	33,027
1995	9,151	11,903	14,655
1996	6,044	11,457	16,870
1997	4,687	11,726	18,765
1998	5,302	12,065	18,828
1999	2,059	12,737	23,415
2000	598	12,573	24,548
2001	7,326	12,244	17,162
2002	11,392	12,469	13,546
2003	5,935	12,437	18,939
2004	2,375	12,023	21,671
2005	2,177	9,946	17,715
2006	5,652	9,505	13,358
2007	5,206	6,962	8,718
2008	4,541	7,035	9,529
2009	3,194	7,751	12,308
2010	2,020	5,492	8,964
2011	295	6,211	12,127
2012	0	6,463	17,680
2013	4,459	6,042	7,625
2014	0	6,727	37,002

Table 6.3.8. Estimated angler trips in the recreational private, charterboat, and headboat modes (Almaco Jack representative fleet) with upper and lower bound estimates, 1991-2014.

Year	Lower bound	Estimated angler trips	Upper Bound
1991	10,159,060	10,756,334	11,353,609
1992	10,818,017	11,216,925	11,615,834
1993	10,859,835	11,241,879	11,623,923
1994	11,440,258	11,821,101	12,201,945
1995	11,722,870	12,108,937	12,495,004
1996	11,459,523	11,856,066	12,252,609
1997	12,248,009	12,685,942	13,123,874
1998	10,726,138	11,111,495	11,496,852
1999	10,928,304	11,321,511	11,714,718
2000	13,656,834	14,162,373	14,667,912
2001	14,025,091	14,536,166	15,047,240
2002	13,310,994	13,772,372	14,233,750
2003	15,625,163	16,209,608	16,794,052
2004	17,002,439	17,877,524	18,752,610
2005	14,752,909	15,577,817	16,402,725
2006	15,047,313	15,861,655	16,675,996
2007	16,331,314	17,219,598	18,107,881
2008	16,411,824	17,284,576	18,157,329
2009	14,743,694	15,570,577	16,397,461
2010	13,689,080	14,465,523	15,241,967
2011	14,381,638	15,052,497	15,723,357
2012	14,403,754	15,126,377	15,849,000
2013	15,014,035	15,858,457	16,702,879
2014	12,694,985	13,504,492	14,313,999

6.4 FIGURES

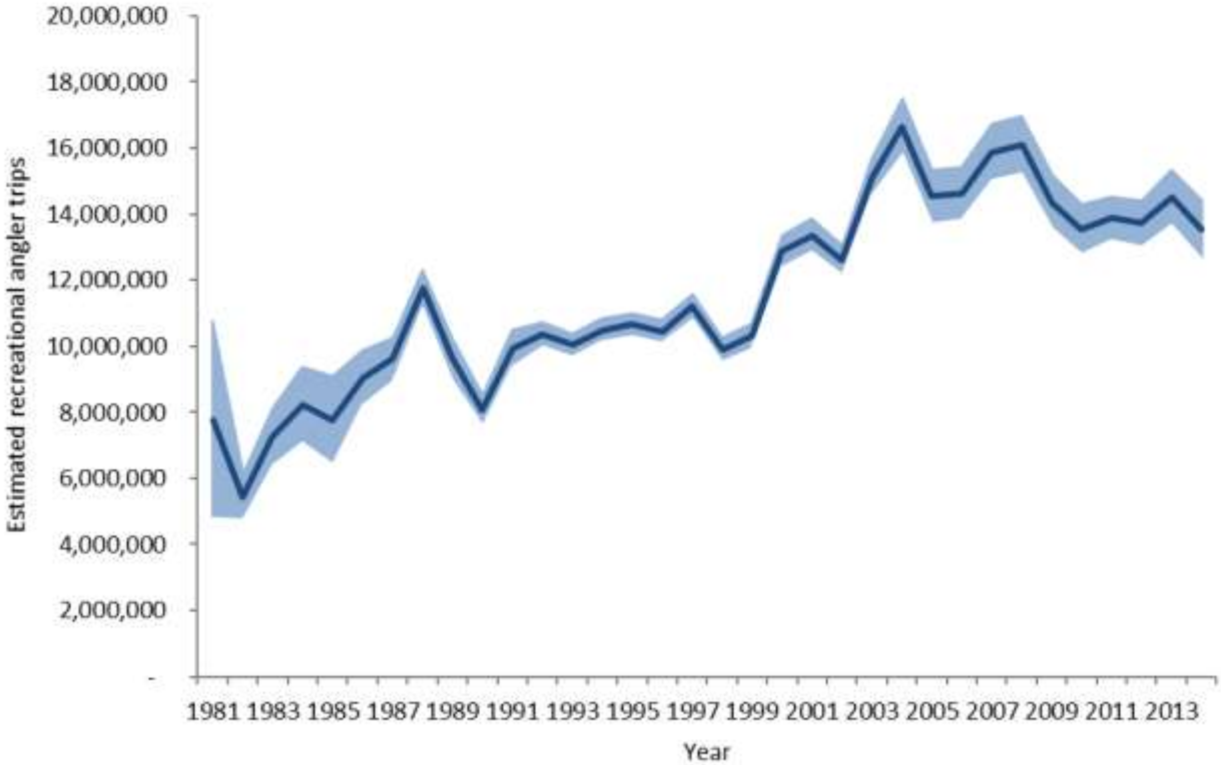

Figure 6.4.1. Estimated recreational angler trips in the private mode (Red Drum representative fleet) with upper and lower bounds, 1981-2014.

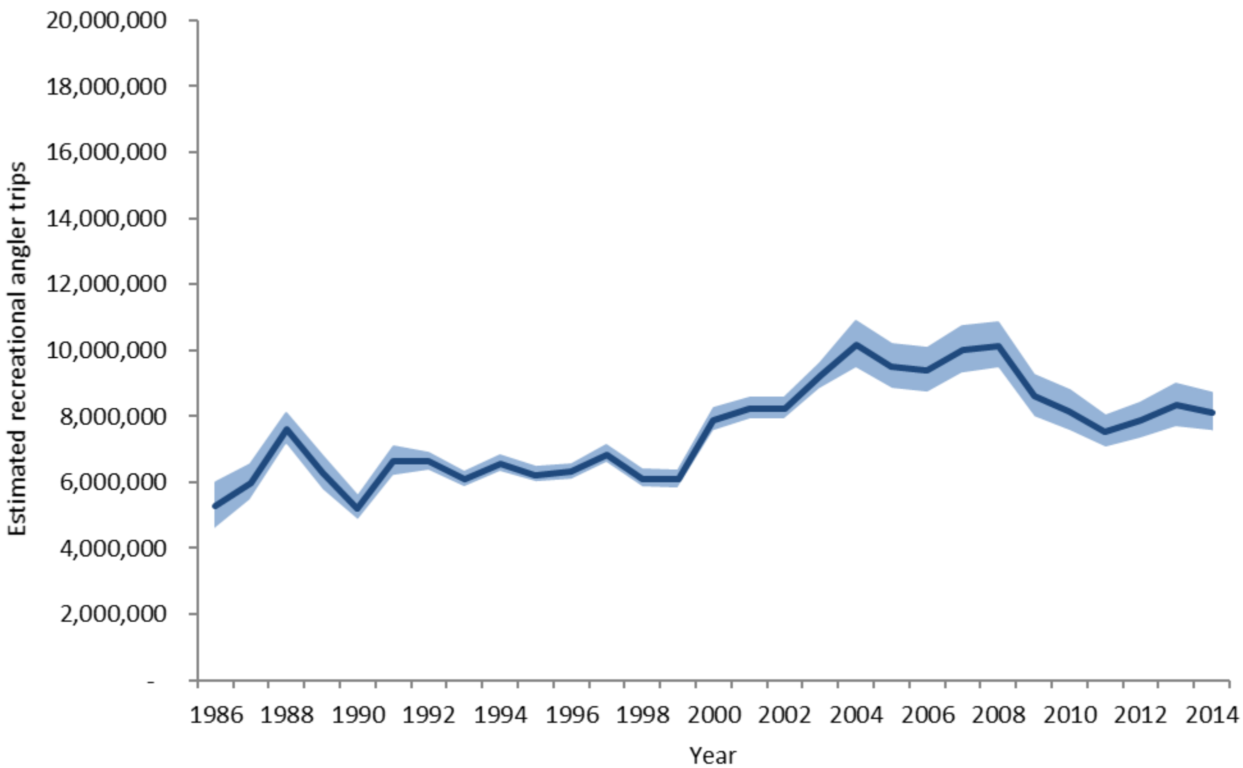

Figure 6.4.2. Estimated recreational angler trips in the private mode in FLW (Lane Snapper representative fleet) with upper and lower bounds, 1986-2014.

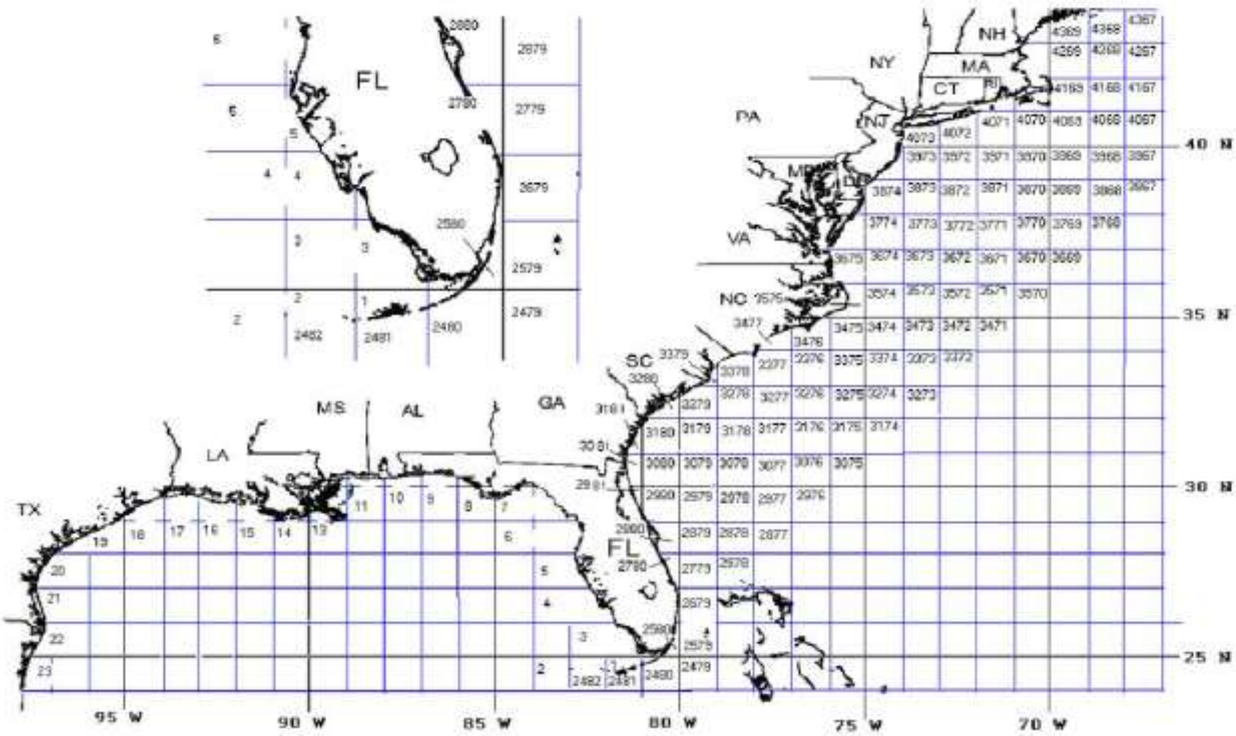

Figure 6.4.3. Commercial fishing statistical grids.

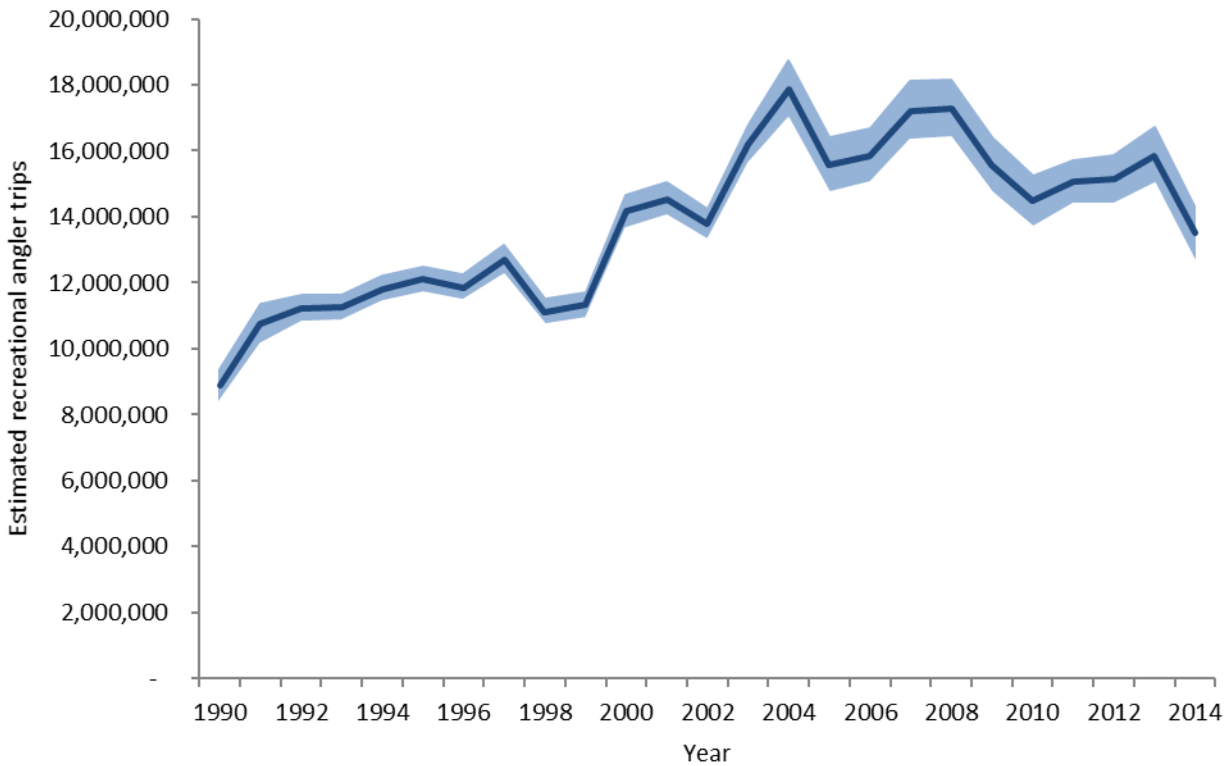

Figure 6.4.4. Estimated recreational angler trips in the private, charterboat, and headboat modes (Yellowmouth Grouper representative fleet) with upper and lower bounds, 1990-2014.

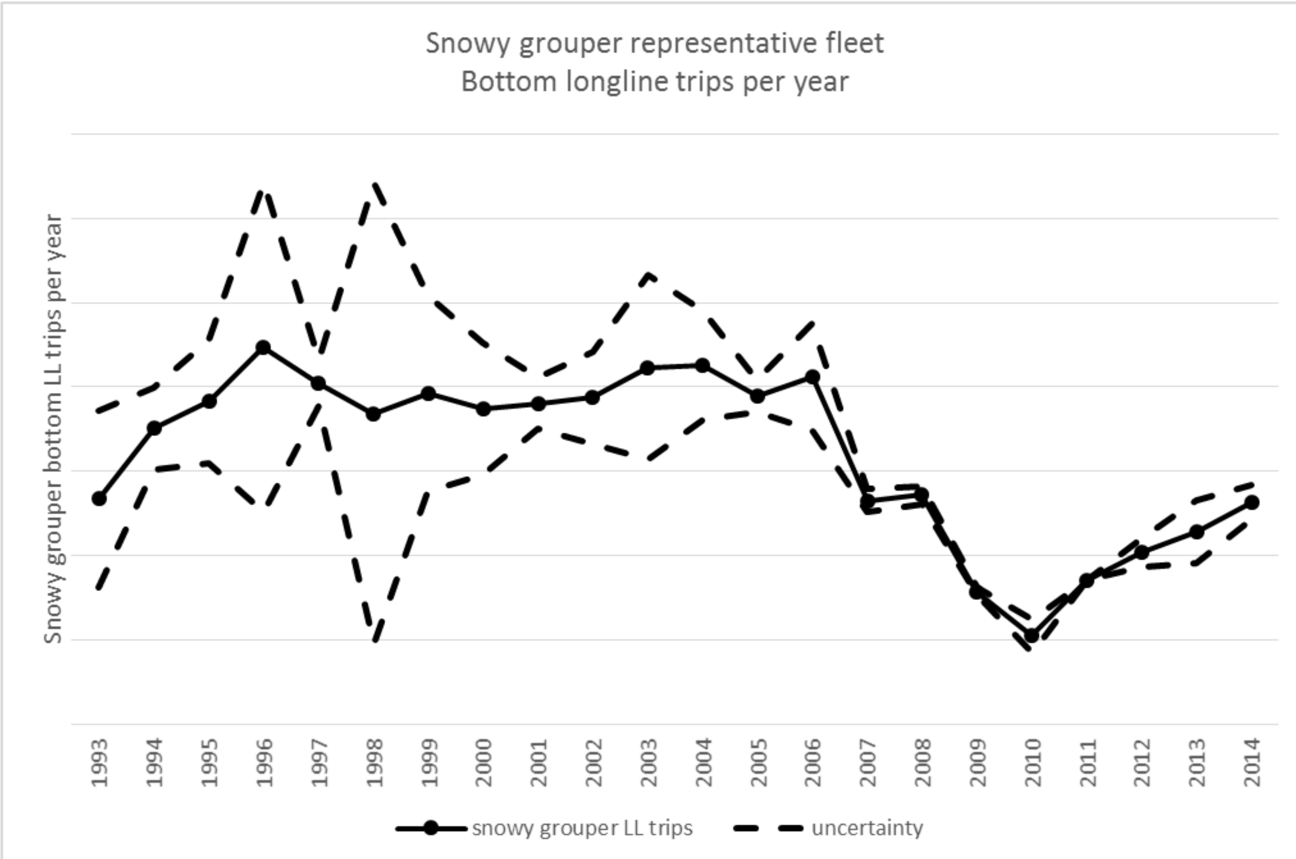

Figure 6.4.5. Bottom longline fishing effort (number of trips) in statistical areas 1-21 (Snowy Grouper representative fleet) with upper and lower bounds, 1993-2014. Uncertainty (upper and lower bounds) shown as dashed lines.

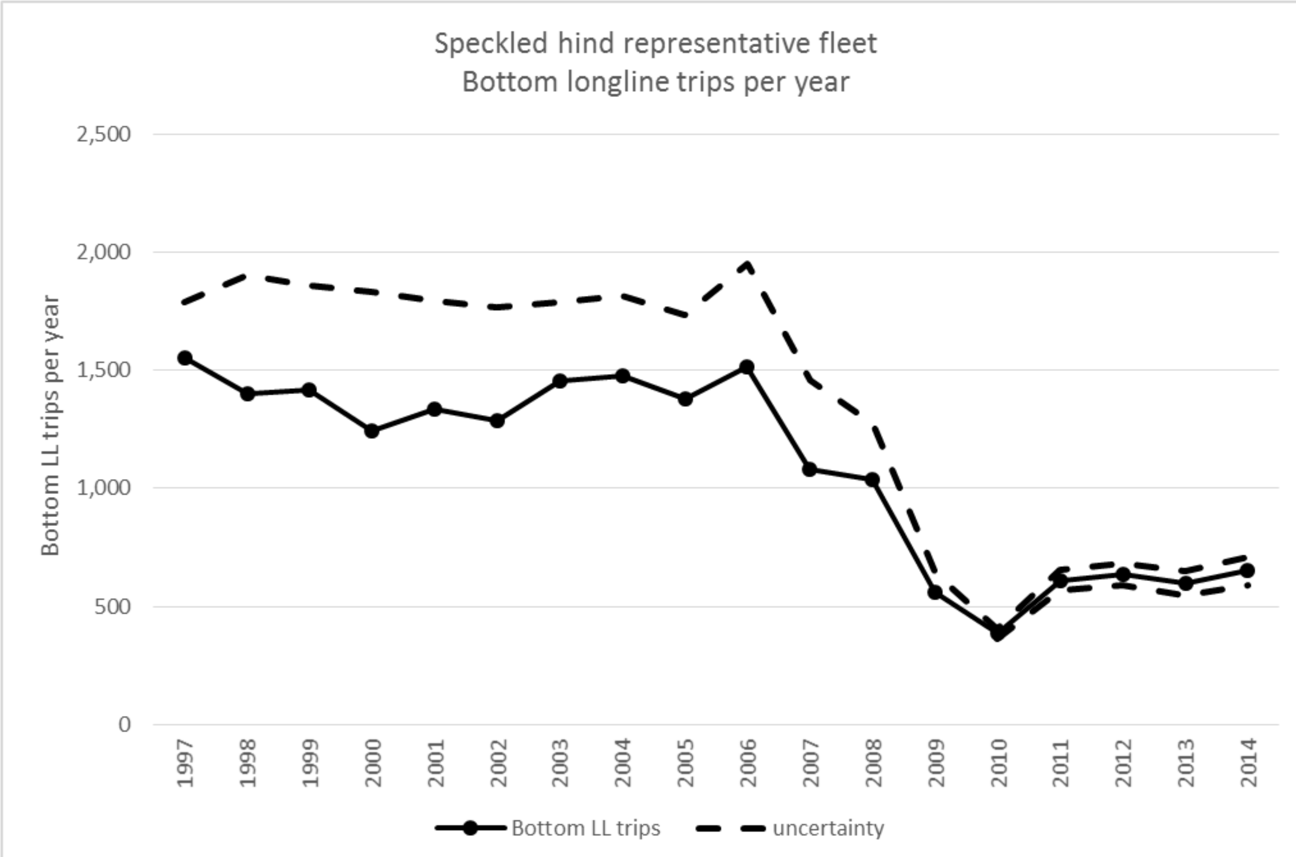

Figure 6.4.6. Bottom longline fishing effort (number of trips) in statistical areas 2-7 (Speckled Hind representative fleet) with upper and lower bounds, 1997-2014. Uncertainty (upper and lower bounds) shown as dashed lines. Uncertainty prior to 2010 assumed to be asymmetric; i.e., estimated trips during 1997-2010 assumed to be a lower limit of estimated effort.

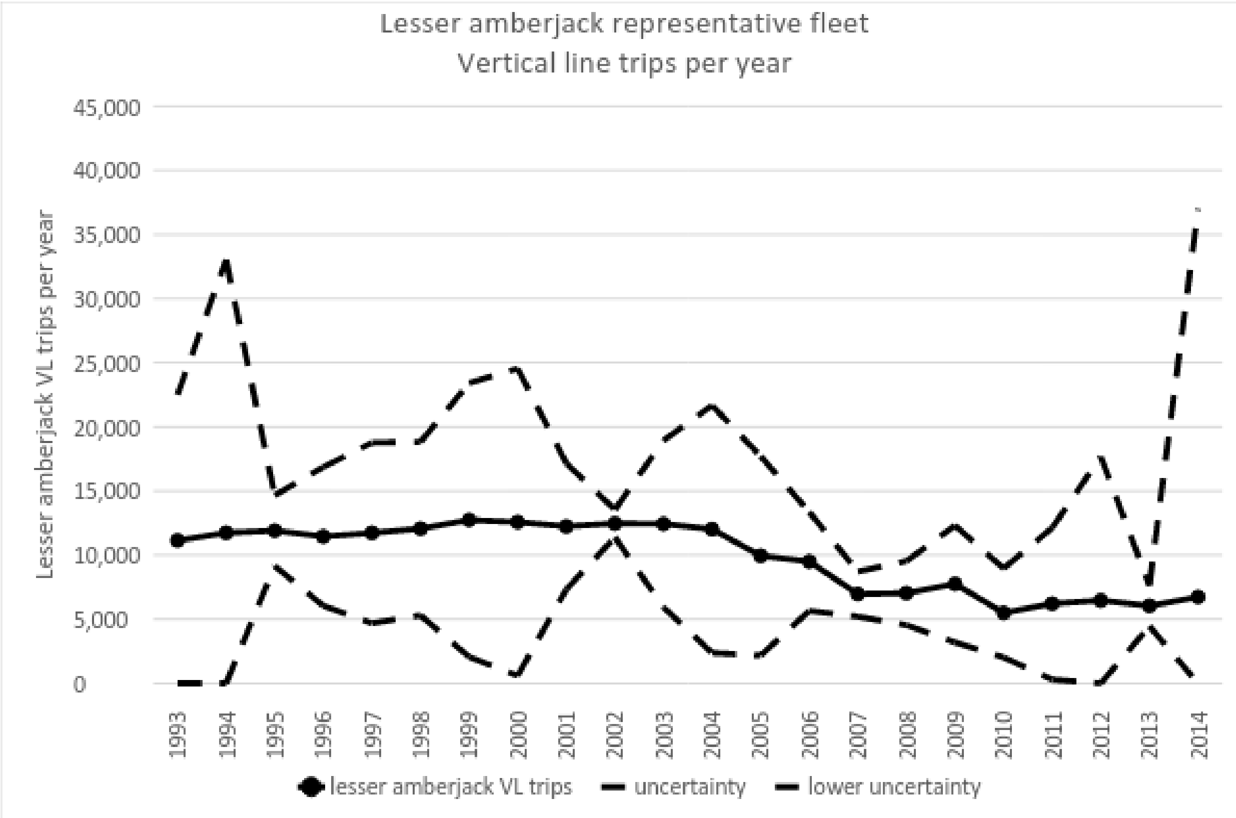

Figure 6.4.7. Vertical line fishing effort (number of trips) in statistical areas 1-21 (Lesser Amberjack representative fleet) with upper and lower bounds, 1993-2014. Uncertainty (upper and lower bounds) shown as dashed lines.

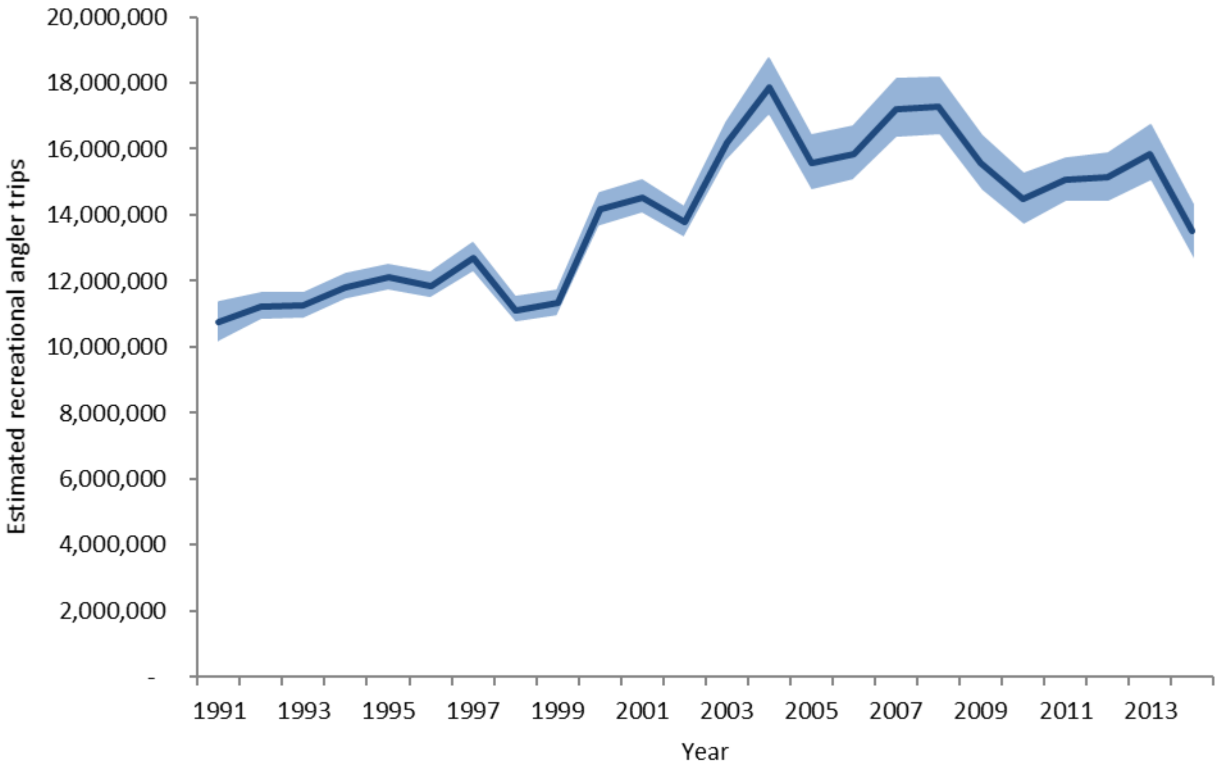

Figure 6.4.8. Estimated recreational angler trips in the private, charterboat, and headboat modes (Almaco Jack representative fleet) with upper and lower bounds, 1991-2014.

6.5 RESEARCH RECOMMENDATIONS

See recommendations in Sections 3.6 and 4.6.

7 MEASURES OF POPULATION ABUNDANCE

7.1 OVERVIEW

7.1.1 Group Membership

Matthew W. Smith (lead)	NMFS/SEFSC, Miami, FL
David Hanisko	NMFS/SEFSC, Pascagoula, MS
Adam Pollack	NMFS/SEFSC, Pascagoula, MS
Jeff Isely	NMFS/SEFSC, Miami, FL
Mary Christman	MCC Statistical Consulting, Gainesville, FL
Michael Drexler	Ocean Conservancy
Matthew Campbell	NMFS/SEFSC, Pascagoula, MS

7.2 REVIEW OF WORKING PAPERS

A substantial number of working papers were submitted for review to the SEDAR 49 Indices Working Group (IWG). These working papers covered fishery-dependent and -independent surveys and provided data for all eight of the species evaluated during SEDAR 49. In addition to the working papers listed, information on candidate indices derived from the commercial logbook data were presented to the IWG by Kevin McCarthy NMFS/SEFSC Miami, FL. No working paper was submitted for this data set; however, the relevant commercial logbook indices were described below in Section 7.4.

SEDAR49-DW-02: Catch per unit effort indices and effort time-series for SEDAR 49 Data Limited Species captured in the Gulf of Mexico Recreational Headboat Fishery (1986 – 2015).

Provides descriptions of the methods used to quality control and subset the headboat survey data as well as the approach utilized to produce a standardized index of abundance for Gulf of Mexico Lane Snapper (*Lutjanus synagris*) and Almaco Jack (*Seriola rivoliana*).

SEDAR49-DW-03: Catch per unit effort indices derived from the recreational for hire and private fisheries operating in the Gulf of Mexico (1981 – 2015).

Provides descriptions of the methods used to quality control and subset the Gulf of Mexico MRFSS/MRIP survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Lane Snapper, Almaco Jack and Red Drum (*Sciaenops ocellatus*). Report provides estimated indices of relative abundance for Lane Snapper, Almaco Jack, and Red Drum as well as an estimate of uncertainty for the indices.

SEDAR49-DW-06: Lane Snapper *Lutjanus synagris* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey 2004-2014.

Provides descriptions of the methods used to quality control and subset the NMFS Panama City laboratory camera survey data as well as the approach utilized to produce a nominal index of abundance with accompanying measures of uncertainty for Gulf of Mexico Lane Snapper. Reports estimated nominal index of relative abundance and error as well as data on annual length frequency obtained from the trap portion of the survey.

SEDAR49-DW-09: SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Almaco Jack

Provides descriptions of the methods used to quality control and subset the SEAMAP reef fish video survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Almaco Jack. Reports estimated standardized index of abundance and estimated error.

SEDAR49-DW-10: SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Lane Snapper.

This report contains a description of the methods used to quality control and subset the SEAMAP reef fish video survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Lane Snapper. Reports estimated standardized index of abundance and estimated error.

SEDAR49-DW-11: SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Lesser Amberjack.

This report contains a description of the methods used to quality control and subset the SEAMAP reef fish video survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Lesser Amberjack (*Seriola fasciata*). Reports estimated standardized index of abundance and estimated error.

SEDAR49-DW-12: SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Snowy Grouper.

This report contains a description of the methods used to quality control and subset the SEAMAP reef fish video survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Snowy Grouper (*Hyporthodus niveatus*). Reports estimated standardized index of abundance and estimated error.

SEDAR49-DW-13: SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Speckled Hind.

This report contains a description of the methods used to quality control and subset the SEAMAP reef fish video survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Speckled Hind (*Epinephelus drummondhayi*). Reports estimated standardized index of abundance and estimated error.

SEDAR49-DW-15: Almaco Jack, *Seriola rivoliana,* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey 2004-2014.

This report contains a description of the methods used to quality control and subset the NMFS Panama City laboratory camera survey data as well as the approach utilized to produce a nominal index of abundance with accompanying measures of uncertainty for Gulf of Mexico Almaco Jack.

SEDAR49-DW-17: Lane Snapper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico.

This report contains a description of the methods used to quality control and subset the summer and fall SEAMAP groundfish survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Lane Snapper.

SEDAR49-DW-18: Wenchman Abundance Indices from MSLABS Small Pelagics Surveys in the Northern Gulf of Mexico.

This report contains a description of the methods used to quality control and subset the MSLABS small pelagics survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Wenchman (*Pristipomoides aquilonaris*).

SEDAR49-DW-19: Wenchman Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico.

This report contains a description of the methods used to quality control and subset the summer and fall SEAMAP groundfish survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Wenchman.

SEDAR49-DW-20: SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Wenchman.

This report contains a description of the methods used to quality control and subset the SEAMAP reef fish video survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Wenchman. Reports estimated standardized index of abundance and estimated error.

SEDAR49-DW-21: SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Yellowmouth Grouper.

This report contains a description of the methods used to quality control and subset the SEAMAP reef fish video survey data as well as the approach utilized to produce a standardized index of abundance with accompanying measures of uncertainty for Gulf of Mexico Yellowmouth Grouper (*Mycteroperca interstitialis*). Reports estimated standardized index of abundance and estimated error.

SEDAR49-RD-02: Evaluating the current status of Red Drum (*Sciaenops ocellatus*) in offshore waters of the North Central Gulf of Mexico: age and growth, abundance, and mercury concentration; and **SEDAR49-DW-16**: Current Status of Adult Red Drum (*Sciaenops ocellatus*) in the North Central Gulf of Mexico: An Update of Abundance, Age Composition, and Mortality Estimates.

These documents contain details about the bottom longline survey operating in coastal waters of Alabama in the northern Gulf of Mexico. The data obtained from this survey were used to produce an index of relative abundance of large Red Drum that was considered as a candidate index for use in SEDAR 49.

7.3 FISHERY INDEPENDENT SURVEYS

7.3.1 SEAMAP Summer Groundfish

The Southeast Area Monitoring and Assessment Program (SEAMAP) is a collaborative effort between federal, state and university programs, designed to collect, manage and distribute fishery-independent data throughout the region. This semi-annual groundfish trawl survey is conducted in the summer (June – July) and fall (October – November) and provides a valuable source of fisheries-independent information on many commercially and recreationally important species throughout the northern Gulf of Mexico (GOM). Currently, the SEAMAP survey samples the area between Brownsville, TX and the Florida Keys, FL from 9 – 110 m; however, prior to 2008, sampling only took place between Brownsville, TX and Mobile Bay, AL. A review and discussion about the survey design and specific data caveats can be found in Pollack et al. (2016a) and Pollack et al. (2016b).

Delta-lognormal modeling methods were used to estimate relative abundance indices from the SEAMAP Groundfish Survey for Lane Snapper and Wenchman. Two relative abundance indices were produced for each species: one covering the area between Brownsville, TX and Mobile

Bay, AL from 1988 − 2007, one covering the area between Brownsville, TX and Cape San Blas, FL from 2009 − 2014 for Wenchman and one covering the area between Cape San Blas, FL and the Florida Keys, FL from 2009 − 2014 (summer survey only) for Lane Snapper. Abundance indices from 2009 − 2014 were limited spatially for both species because of a lack of positive occurrences in the northwestern GOM for Lane Snapper and in the northeastern GOM for Wenchman. A full review of the indices and diagnostic plots for Lane Snapper can be found in Pollack et al. (2016a) and for Wenchman in Pollack et al. (2016b).

7.3.2 MSLABS Small Pelagics Surveys

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories (MSLABS) small pelagics Survey was initiated in October of 2002 as an outer shelf and upper slope survey (i.e., between 110 and 500 m station depth). It began in order to investigate if the distributional range of species collected in Southeast Area Monitoring and Assessment Program (SEAMAP) groundfish trawls extended beyond the geographical boundaries of the commercial shrimping grounds. Therefore, in order to more effectively evaluate these extensions of distributional range, trawling stations began to be allocated in shallower depth strata to allow geographic overlap with SEAMAP groundfish effort. By 2004, the survey became a mid to outer shelf and upper slope survey (i.e., between 50 and 500 m station depth). A review and discussion about the survey design and specific data caveats can be found in Pollack et al. (2016c).

Delta-lognormal modeling methods were used to estimate relative abundance indices from the MSLABS small pelagics survey for Wenchman (*Pristipomoides aquilonaris*). A relative abundance index was produced for northern Gulf of Mexico from 2002 – 2013 between Brownsville, TX and the Florida Keys, FL between 50 and 500 m. Gaps in the survey occurred in 2005 because of Hurricane Katrina and in 2006 and 2014 because of vessel issues that prevented the full survey from being completed. A full review of the indices and diagnostic plots for Wenchman can be found in Pollack et al. (2016c).

7.3.3 SEAMAP Reef Fish Video Survey

The primary objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) reef fish video survey is to provide an index of the relative abundances of fish species associated with topographic features (e.g., reefs, banks, and ledges) located on the continental shelf of the Gulf of Mexico (GOM) from Brownsville, TX to the Dry Tortugas, FL. Secondary objectives include quantification of habitat types sampled (optical and acoustic data), and collection of environmental data throughout the survey. Because the survey is conducted on topographic features, the species assemblages targeted are typically classified as reef, but occasionally fish more commonly associated with pelagic environments are observed. The survey has been executed from 1992 − 1997 and 2001 − present and historically takes place from April − May, however in limited years the survey was conducted through the end of August. The 2001 and 2003 surveys were abbreviated due to ship scheduling which severely limited spatial coverage and total samples in those years and thus are not included in the analyses. A review and discussion about the survey design and specific data caveats can be found in Campbell et al. (2016a-g).

Video data frequently have high numbers of 'zero-counts' commonly referred to as 'zero-inflated' data distributions. Delta lognormal models have been frequently used to model video count data (Campbell et al. 2012) but recent exploration of models using negative-binomial, Poisson (SEDAR 2015), zero-inflated negative-binomial, and zero-inflated Poisson models (Guenther et al. 2014) have been accepted for use in assessments in the southeast United States. For the SEDAR 49 Data Workshop, models were fit using delta-lognormal, Poisson and negative binomial error distributions to construct relative abundance indices for each of the species in question. Preferred error distributions were determined using a suite of information theoretic and likelihood-based model fit statistics.

SEAMAP Reef Fish Video Survey indices were produced for all SEDAR 49 species with the exception of Red Drum. Details on the temporal and spatial distribution of samples, sampling intensity and proportion positive, model selection criteria, index of abundance and measures of uncertainty can be found in working papers for Almaco Jack (Campbell et al. 2016a), Lane Snapper (Campbell et al. 2016b), Lesser Amberjack (Campbell et al. 2016c), Snowy Grouper (Campbell et al. 2016d), Speckled Hind (Campbell et al. 2016e), Wenchman (Campbell et al. 2016f), and Yellowmouth Grouper (Campbell et al. 2016g).

7.3.4 NMFS Panama City Laboratory Trap and Camera Survey

In 2002 the Panama City NMFS lab began development of a fishery-independent trap survey of natural reefs on the inner shelf of the eastern Gulf of Mexico off Panama City, FL, with the primary objective of establishing an age-based annual index of abundance for pre-recruit (age 0-3) Gag Grouper (*Mycteroperca microlepis*), Scamp (*M. phenax*), and Red Grouper (*Epinephelus morio*). Secondary objectives included examining regional catch, recruitment, demographic, and distribution patterns of other exploited reef fish species. Beginning in 2005, the collection of visual (stationary video) data was added to the survey to provide insight on trap selectivity, more complete information on community structure, relative abundance estimates on species rarely or never caught in the trap, and additional, independent estimates of abundance on species typically caught in the traps. Video sampling was only done in Apalachee Bay that first year, but was expanded to the entire survey in 2006. Also, in 2005 the target species list was expanded to include the other exploited reef fishes common in the survey area, i.e., Red Snapper (*Lutjanus campechanus*), Vermilion Snapper (*Rhomboplites aurorubens*), Gray Snapper (*L. griseus*), and

Lane Snapper; Red Porgy (*Pagrus pagrus*), White Grunt (*Haemulon plumieri*), Black Seabass (*Centropristis striata*), and Hogfish (*Lachnolaimus maximus*). From 2005 through 2008, each site was sampled with the camera array followed immediately by a single trap. Beginning in 2009, trap effort was reduced ~50%, with one deployed at about every other video site, starting with the first site of the day. This was done to increase the number of video samples, and thereby the accuracy and precision of the video abundance estimates.

Censored data sets were used in deriving the indices of relative abundance from video data. All video samples were screened and censored (excluded) from calculations of relative abundance if (1) no visible hard or live bottom and no visible species of fish strongly associated with hard bottom habitat; or (2) the view was obscured because of poor visibility, bad camera angle, video out of focus, etc. In 2014, 10 video samples from an area with an ongoing severe red tide bloom, and which showed no or virtually no evidence of living fish, were also censored. The CPUE and proportion positive findings for the trap survey were based on all samples except those from sites which had already been sampled in a given year and 8 sites in 2014 located in an ongoing red tide bloom.

The Panama City Laboratory Camera Survey produced nominal indices of abundance for Lane Snapper and Almaco Jack for SEDAR 49. Details on the temporal and spatial distribution of samples, sampling intensity and proportion positive, index of abundance and measures of uncertainty can be found in working papers for Lane Snapper (DeVries et al. 2016a) and Almaco Jack (DeVries et al. 2016b).

7.3.5 DISL Bottom Longline

A bottom longline survey, run out of Dauphin Island Sea Lab, has been operating monthly in the coastal waters of Alabama and Mississippi as well as federal offshore waters from May 2006 through the present by the Dauphin Island Sea Lab. Data from this survey were available through October 2015 for use in the SEDAR 49 assessment. Longline set locations were determined using a stratified random sampling approach with strata designated by east-west and north-south sampling blocks overlaid on the continental shelf. Sampling occurred from the shoreline (2 m depth) to the 20-m isobaths. Twelve stations were selected each month, allocated evenly across strata and depth. Beginning in 2009, nearshore sampling was complemented with offshore transect sampling. Transects were determined by randomly selecting a line of longitude within the boundaries of Alabama. Once selected, the transect line was sampled from the shoreline to approximately 200 m depth. However, for the purposes of SEDAR 49, only data collected from samples taken shoreward of the 20-m isobath were used to calculate indices of abundance. This was done in order to create a more heterogeneous data set which was better suited for index construction. Each longline set was fished using commercial-style bottom longline gear. A monofilament mainline was deployed off the stern of the vessel with high flyer buoys used at the start and end of the set. Five kilogram weights (one at the start, middle and end of the set) were attached and 3.66 meter gangions with 15/0 circle hooks were clipped to the mainline during deployment. Hooks were baited with Atlantic Mackerel (*Scomber scombrus*) cut to fit the circle hooks.

Nominal catch per unit effort (CPUE) of Red Drum caught in the survey was calculated as Red Drum per 100 hook-hours. Standardized CPUE's were calculated using the delta-lognormal approach as described by Lo et al. (1992). Data used to estimate positive catches and probability of occurrence were assumed to have lognormal and binomial distributions, respectively. Linear models were fitted to the data with year and month as factors. The final standardized index was calculated as the product of back-transformed year effects of the proportion positive and positive catch rate GLMs and uncertainty was estimated via a jackknife routine. Additional details on the sampling design and index calculation methodology can be found in SEDAR49-RD-02 as well as Powers et al. (2012).

7.4 FISHERY-DEPENDENT SURVEYS

7.4.1 Headboat Survey

The Headboat Survey covers the Gulf of Mexico headboats starting in 1986. Total catch per trip is reported in logbooks provided to all headboats in TX through NC. Agents collect these logbook trip reports and sample a subset of trips to gather size data. Although reporting via the logbooks is mandatory, 100% compliance is rare. Substitutes for missing reports are created based on data for similar vessels or time periods, thus providing estimates of total catch by month (or groups of months) and area. Each vessel is assigned to one of 28 Gulf of Mexico and South Atlantic areas, based on the port from which the vessel operates and the general fishing area.

Catch-per-unit effort (CPUE) was derived from the headboat data using total fish caught on a given trip divided by the amount of angler-hours spent fishing. Effort was estimated in angler-hours where the number of hours spent fishing (i.e., 5, 7, 10 or >10 hours) coincided with the type of trip (i.e., half, three-quarters, full or multi-day, respectively). Trips were eliminated if they had missing values for any of the key factors, were in anyway incomplete, appeared to be misreported (e.g., reported zero anglers) or represented multiple entries for a single trip.

An indirect method was necessary to infer targeting behavior of fishermen, because no direct information was available. The species associates subsetting routine proposed by Stephens and MacCall (2004) was implemented to select trips for use in the analyses. An alternate approach to trip subsetting which involved identifying a guild of species that frequently co-occur with the target species was also attempted but rejected in favor of the Stephens and MacCall approach. A two-step delta-lognormal general linearized model (GLM; Lo et al. 1992) was used to standardize for variability and non-randomness in CPUE data collection methods not caused by the year effect (i.e., to factor out year to year variations in CPUE not due to changes in abundance).

The NMFS Headboat Survey produced standardized indices of abundance for Lane Snapper and Almaco Jack for SEDAR 49. Details on the trip selection process, standardization procedure, index of abundance and measures of uncertainty can be found in the working paper for the headboat survey (Smith and Rios 2016a).

7.4.2 Marine Recreational Fisheries Statistics Survey (MRFSS)/ Marine Recreational Information Program (MRIP)

The MRFSS began in 1981 and 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 only through 1985 and did not include all modes in all years. Starting in 1986, MRFSS stopped covering headboats in the Gulf of Mexico and South Atlantic. In recent years MRIP has re-incorporated headboats in some states, but these headboat estimates are not official. Official headboat estimates for the South Atlantic and Gulf of Mexico come from the Headboat Survey. Before 1986, charterboats and headboats were combined as one mode in the South Atlantic and the Gulf of Mexico No survey was conducted in wave 1 of 1981. Survey data for TX in 1981 − 1985, Wave 4, are no longer available. Catch estimates are 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").

The Marine Recreational Information Program (MRIP) was developed to provide more accurate recreational catch estimates by accounting for potential biases such as possible differences in catch rates at high-activity and low-activity fishing sites, or the amount of fishing occurring at different parts of the day. Revised catch and effort estimates, based on this improved estimation method, were released on January 25, 2012. 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 were developed in order to maintain one consistent time-series for the recreational estimates.

A delta-lognormal approach (Lo et al., 1992) was used to develop standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion of interviews that observed the target species and the catch rates for positive interviews to construct a single standardized index of abundance. A forward stepwise approach based on AIC was used during the construction of each GLM. In addition to screening using

AIC, factors were also screened and not added to the model if the reduction in deviance per degree of freedom was less than one percent.

The MRFSS/MRIP Survey produced standardized indices of abundance for Lane Snapper, Almaco Jack and Red Drum for SEDAR 49. Details on the trip selection process, standardization procedure, index of abundance and measures of uncertainty can be found in the working paper Smith and Rios (2016b).

7.4.3 Commercial Logbook

The NMFS Gulf of Mexico Reef Fish Logbook Program collects catch and effort data by trip for permitted vessels that participate in fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The program began in 1990 with a complete census of commercial reef fish trips by vessels permitted in TX, LA, MS and AL. A 20% sample of vessels permitted in FL was required until 1993, when all permitted reef fish vessels were required to submit logs.

The dominant gear deployed in the commercial fishery varied for the SEDAR 49 species with the groupers (Speckled Hind, Yellowmouth and Snowy) being predominately caught on longline gear and the jacks and snappers being predominantly caught on vertical line gear (handline and electric reel). Nominal indices presented at the Data Workshop were constructed using only the records from the dominant gear. The logbook database includes unique trip and vessel identifiers and information regarding trip date, gear class, fishing area (identical to shrimp statistical grid), days at-sea, fishing effort, species caught and landed weight. A vessel may fish in multiple areas using multiple gears on a single trip. However, while catch is reported by gear and area, effort is not. Instead, total effort by gear is reported for each trip. Therefore it is not possible to calculate the catch per unit effort by area on trips that fished in more than one area. For this reason, trips that fished in multiple areas were excluded from the analysis. In addition, data were restricted to those trips occurring within the U.S Gulf of Mexico.

The commercial logbook data appeared to be potentially useful for developing indices of relative abundance for Speckled Hind and Snowy Grouper based on sample sizes and spatial/temporal coverage. However, the nominal indices for these species were not sufficient for use due to the fact that substantial changes in effort as well as fishing success which coincided with a number of pertinent regulatory changes indicated that major changes in the commercial fleet operations had likely occurred and were not being accounted for in the nominal index. Consequently, the IWG recommended that the commercial logbook data for Speckled Hind and Snowy Grouper be put through additional analyses to determine whether or not credible indices of relative abundance could be produced from the data.

7.5 CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATION

7.5.1 Red Drum

Indices of abundance for Red Drum were available from the MRFSS data set and the Dauphin Island Sea Lab bottom longline data set. The IWG identified the bottom longline data set as the preferred index for the SEDAR 49 stock assessment. The MRFSS data had broader temporal and spatial coverage as well as greater sample sizes than the bottom longline survey. However, the IWG determined that the bottom longline survey was more likely to be sampling the target population, mature Red Drum that predominately occupy the offshore federally managed waters, and was also preferable due to its data being derived from a fishery-independent source. While the limited spatial coverage of the bottom longline survey is concerning, support for the index was bolstered by the fact that the trend in the bottom longline index was nearly identical to the MRFSS index for the overlapping years. The bottom longline survey index of relative abundance indicated a generally flat trend in abundance (Figure 7.10.1). The model indicated a possible modest decline in relative abundance from 2010 to 2012; however, the index subsequently recovered to the time-series average (Figure 7.10.1). Annual estimated coefficients of variation for the bottom longline index were high and ranged from 65% to 118% (Table 7.9.1). The IWG generally recommended that the largest annual CV be used for the assessment when plausible. Given the magnitude of the CV’s estimated for the bottom longline survey, it may be prudent to conduct sensitivity analyses varying the magnitude of uncertainty.

7.5.2 Lane Snapper

Lane Snapper indices of abundance were available from the SEAMAP summer and fall groundfish surveys, the headboat survey, the commercial logbook data, the SEAMAP reef fish video survey, and the Panama City laboratory camera survey. After review of all candidate indices, the IWG selected the standardized headboat survey as most reliable and representative of the relative abundance for Gulf of Mexico Lane Snapper. The headboat survey had large annual sample sizes for Lane Snapper as well as high proportion positive catch after species associate trip selection was completed (Smith and Rios 2016a). Nominal indices based on data subsets obtained by using guild-based and Stephens and MacCall (2004) (SMAC) based species associate trip selection protocols showed similar trends through the full time-series (1986 – 2014) (Figure 7.10.2). Standardizing the index resulted in the elimination of the increasing trend seen in the nominal indices from 2010 – 2014 and instead indicated relatively stable abundance from approximately 2003 onward (Figure 7.10.2). Model estimated annual CV’s for the headboat index ranged from 3 − 6% (Table 7.9.2). The magnitude of the estimated error was substantially lower than what was observed for the other Lane Snapper indices and the indices produced for the other SEDAR 49 species. Consequently, the IWG recommended CV’s of 15 – 30% be used in sensitivity runs during the assessment.

7.5.3 Wenchman

Wenchman indices of abundance were available from the SEAMAP summer and fall groundfish surveys, the SEAMAP small pelagics survey, and the SEAMAP reef fish video survey. After review of all candidate indices, the IWG selected the standardized SEAMAP small pelagics survey as most reliable and representative of the relative abundance for Gulf of Mexico Wenchman. The small pelagics survey had high catch rates throughout the Gulf of Mexico and captured Wenchman in deep-water habitat which was not sampled by the video or groundfish surveys. The deep-water sampling of the small pelagics survey was especially valuable off the western coast of Florida were the survey captured large numbers of deep-water Wenchman that were unavailable to the other surveys examined for index consideration (Figure 7.10.3). The index of relative abundance for Wenchman is relatively flat with a slight upward trend for the most recent part of the time-series (Figure 7.10.4). Standardized index values, CV's, sample sizes and proportion positive values are presented in Table 7.9.3. The IWG recommends that the largest annual CV (26%) be used in the assessment.

Data for 2014 is not available from the SEAMAP small pelagics survey. The SEAMAP groundfish survey (Pollack et al. 2016b), which displayed a trend similar to the small pelagics index, indicated that 2014 relative abundance was on par with the 2012 and 2013 values. Consequently, if it is necessary to fill the 2014 data point for the assessment, the IWG recommends that either the 2013 data point be repeated (1.639) or the average of the 2013 and 2012 data points (1.7375) be used for 2014. The latter is the preferred alternative.

7.5.4 Yellowmouth Grouper

The only index available for Yellowmouth Grouper was from the SEAMAP reef fish video survey. The IWG decided that the SEAMAP video index was credible for use during SEDAR 49; however, the quantity of data available for constructing the index was small and will likely limit the utility of the index for the purpose of stock assessment modeling. Frequency of Yellowmouth Grouper in the video samples ranged from 1 to 10% per year with most years observing Yellowmouth Grouper in 5% or fewer samples (Table 7.9.4). Consequently, uncertainty around the resulting index of relative abundance was high with annual CV's ranging well above 30% for most years (Table 7.9.4). The index itself is noisy but relatively flat, especially when the magnitude of the uncertainty is considered (Figure 7.10.5). The IWG recommends that the largest annual CV (50%) be used in the assessment.

7.5.5 Snowy Grouper

Snowy Grouper indices of abundance were available for the SEAMAP reef fish video survey and the commercial logbook data. After review, the IWG recommends using the commercial logbook data pending a more thorough review of the commercial logbook data and standardized index construction. The sample sizes for the reef fish video survey were very small, with Snowy Grouper observed in less than 1% of annual samples. The trend in abundance from the reef fish video survey was flat with the model indicating a non-significant year effect.

Sample sizes from the commercial logbook longline gear were quite large and had potential for index development. Further analysis was needed to determine whether or not changes in relative abundance could be separated from changes in fleet dynamics and fishing behavior brought on by a series of regulatory changes enacted during the latter part of the time-series. Analysis of the commercial longline logbook data will be completed and available for the assessment team prior to the assessment workshop.

7.5.6 Speckled Hind

Speckled Hind indices of abundance were available for the SEAMAP reef fish video survey and the commercial logbook data. After review, the IWG recommends using the commercial logbook data pending a more thorough review of the commercial logbook data and standardized index construction. The sample sizes for the reef fish video survey were small, with Speckled Hind observed in 1 to 8% of annual samples with the majority of years at or below 3%. The trend in abundance from the reef fish video survey was flat with a single increase in relative abundance estimated for 2012 and 2013.

Sample sizes from the commercial logbook longline gear are quite large with proportion positive ranging from 25 – 50% annually. Further analysis was needed to determine whether or not changes in relative abundance in the commercial data set can be separated from changes in fleet dynamics and fishing behavior brought on by a series of regulatory changes enacted during the latter part of the time-series. Analysis of the commercial longline logbook data will be completed and available for the assessment team prior to the assessment workshop.

7.5.7 Lesser Amberjack

Lesser Amberjack indices of abundance were available for the SEAMAP reef fish video survey and the commercial logbook data. After review, the IWG recommends using the reef fish video survey for the SEDAR 49 assessment. The sample sizes for the reef fish video survey were small, with Lesser Amberjack observed in 1 to 9% of annual samples with the majority of years at or below 5%. While the low sample sizes in the reef fish video survey are concerning, it was still preferable to the commercial data for which a known and substantial species identification issue was identified. The commercial data are likely a mixture of Lesser Amberjack, Greater

Amberjack (*Seriola dumerili*), and Almaco Jack with no apparent way to separate the data at this time.

The trend in relative abundance from the reef fish video survey was noisy and flat throughout the whole time-series (1993 – 2015; Figure 7.10.6). CV's for the reef fish video survey ranged from between 12 and 15% and are listed in Table 7.9.5 with sample sizes, proportion positives and the standardized index. CV's for this index seemed rather low given the low sample sizes of Lesser Amberjack. The IWG recommends that a CV of 15% be used in the analysis; however, it may be prudent to conduct a sensitivity analysis with a CV of 30% to test the robustness of the assessment model to more realistic levels of uncertainty around the index.

7.5.8 Almaco Jack

Almaco Jack indices of abundance were available from the headboat survey, the commercial logbook data, the SEAMAP reef fish video survey and the Panama City laboratory camera survey. After review of all candidate indices, the IWG selected the SEAMAP reef fish video survey as the most reliable and representative of the relative abundance for Gulf of Mexico Almaco Jack. The sample sizes for the reef fish video survey were adequate, with Almaco Jack observed in 11 to 43% of annual samples (Table 7.9.6). The trend in relative abundance from the reef fish video survey was relatively flat when taken as a whole; however, when only the most recent part of the time-series was considered the index indicated a downward trend in relative abundance (Figure 7.10.7). CV's for the reef fish video survey ranged from between 24 and 36% and are listed in Table 7.9.6 with sample sizes, proportion positives and the standardized index. The IWG recommends that a CV of 36% be used in the assessment.

7.6 RESEARCH RECOMMENDATIONS

7.6.1 Red Drum

Given the importance of Red Drum to the recreational fishing interests of the Gulf Coast States, it was surprising to find that a survey designed to comprehensively sample both the near shore and offshore portions of the Gulf of Mexico stock does not exist. It is recommended that discussions be initiated into expanding an existing survey or developing a new survey to sample and characterize the composition and relative abundance of the Gulf of Mexico Red Drum stock, especially in federally managed waters where little data are available.

7.6.2 Lane Snapper

No research recommendations were suggested for Lane Snapper.

7.6.3 Wenchman

The small pelagics survey used as the index of abundance for SEDAR 49 is no longer in operation. The deep-water sampling of this survey provided the only data on a largely otherwise un-surveyed portion of the Gulf of Mexico Wenchman stock. Additional resources need to be put forward to promote and expand deep-water sampling efforts in the Gulf for species like Wenchman and numerous other deep-water species.

7.6.4 Yellowmouth Grouper

Additional information about Yellowmouth Grouper distribution and habitat utilization is needed to determine if low counts in the reef fish video survey are due to low abundance or survey habitat mismatch.

7.6.5 Snowy Grouper

Surveys designed to better cover deep-water habitat are needed to adequately sample the Snowy Grouper stock as well as many other reef fish managed under the reef fish FMP.

7.6.6 Speckled Hind

Surveys designed to better cover deep-water habitat are needed to adequately sample the Speckled Hind stock as well as many other reef fish managed under the reef fish FMP.

7.6.7 Lesser Amberjack

Species identification issues are of paramount concern for Lesser Amberjack, especially when dealing with fishery-dependent data sources. Efforts should be undertaken to determine whether port sampling data can be used to estimate the rate at which species like Lesser Amberjack are misidentified on an annual basis. This information could be used to adjust fishery-dependent landings data, allowing them to be used to construct indices of relative abundance.

7.6.8 Almaco Jack

Species identification issues are of paramount concern for Almaco Jack, especially when dealing with fishery-dependent data sources. Efforts should be undertaken to determine whether port sampling data can be used to estimate the rate at which species like Almaco Jack are misidentified on an annual basis. This information could be used to adjust fishery-dependent landings data, allowing them to be used to construct indices of relative abundance.

7.7 CURRENT DEPLETION

Estimates of current depletion were not available for the majority of the species under assessment during SEDAR 49. An estimate for Red Drum was available from the 2015 Florida Fish and Wildlife Conservation Commission's assessment which assessed the stock status in Florida waters (Table 7.9.7). For the remaining species under consideration for SEDAR 49, similar species have been assessed using Stock Synthesis which estimates depletion for each year of the assessment period. Table 7.9.7 shows the terminal (i.e., current year of each assessment) and corresponding estimates of current depletion for these species. Given the lack of information for the SEDAR 49 species, these estimates could be used as proxies of current depletion if their exploitation patterns and stock status are relatively similar.

Analyses by the assessment team could provide additional estimates of current depletion from within DLMtool once all data inputs are compiled. A function exists which determines the depletion level and corresponding equilibrium F that arises from input data regarding mean length of current catches, natural mortality rate, steepness of the stock recruitment curve, maximum length, maximum growth rate, age at maturity, vulnerability, maximum age, and number of historical years of fishing. A useful analysis would be to compare these derived values with the estimates for similar species presented in Table 7.9.7.

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7.9 TABLES

Table 7.9.1 Results of delta-lognormal index of relative abundance standardization procedure on Red Drum CPUE data collected from the Dauphin Island Sea Lab bottom longline survey off the coast of Alabama and Mississippi. CV's are presented in their natural units and not as a percentage of the mean.

Year	Index	SE	CV
2006	0.99	1.04	1.05
2007	1.08	0.90	0.83
2008	0.98	0.83	0.85
2009	1.04	0.91	0.88
2010	0.81	0.68	0.84
2011	0.54	0.61	1.14
2012	0.39	0.46	1.18
2013	1.17	0.99	0.85
2014	0.88	0.57	0.65
2015	1.20	1.23	1.02

Table 7.9.2 U.S. Gulf of Mexico Lane Snapper catch per unit effort (CPUE) indices derived from data collected from the headboat fishery. Prior to index construction, the data were subset based on species association as determined by Stephens and MacCall (2004) (SMAC).

Year	n	CV	Std. Index	Nominal Index
1986	1207	0.064	0.73	0.47
1987	1310	0.060	0.86	0.39
1988	1894	0.056	0.42	0.24
1989	1920	0.050	0.65	0.42
1990	2565	0.041	1.04	0.72
1991	2772	0.038	1.33	0.93
1992	3112	0.035	1.27	1.19
1993	3390	0.034	1.57	1.87
1994	2956	0.037	1.25	1.18
1995	2458	0.041	0.86	0.86
1996	1954	0.048	0.66	0.55
1997	1634	0.051	0.60	0.39
1998	1635	0.055	0.59	0.55
1999	1336	0.055	0.51	0.25
2000	1759	0.047	0.76	0.45
2001	1779	0.051	0.59	0.42
2002	1892	0.046	0.88	0.64
2003	1924	0.044	1.15	1.14
2004	2056	0.043	1.14	0.75
2005	2193	0.042	1.52	1.16
2006	1793	0.049	1.11	1.11
2007	2173	0.045	1.09	0.87
2008	2400	0.041	1.23	0.89
2009	2609	0.037	1.41	1.26
2010	1581	0.048	1.11	1.10
2011	2151	0.045	1.05	1.38
2012	2235	0.042	1.10	1.32
2013	2391	0.040	1.12	1.53
2014	2505	0.040	1.13	1.49

Table 7.9.3 Index of Wenchman abundance derived from MSLABS small pelagics survey from 2002 to 2013. The nominal frequency of occurrence (Prop. Pos), the number of samples (N), the standardized index of abundance (Index) and the coefficient of variation on the mean are listed. (Note: No survey was conducted in 2005 due to hurricane Katrina and in 2006, the vessel was repurposed after leg 1 of sampling resulting in an incomplete data year).

Year	Prop. Pos.	N	Index	CV
2002	0.701	127	1.164	0.202
2003	0.664	146	0.903	0.195
2004	0.693	101	0.558	0.242
2005				
2006				
2007	0.623	146	0.677	0.199
2008	0.604	164	0.994	0.195
2009	0.686	121	1.096	0.188
2010	0.425	127	0.588	0.259
2011	0.442	129	0.545	0.252
2012	0.586	111	1.836	0.218
2013	0.573	117	1.639	0.220

Table 7.9.4 Index of Yellowmouth Grouper abundance derived from the SEAMAP video survey from 1993 to 2015 with data holidays from 1998 – 2001 and 2003. The nominal frequency of occurrence (Prop. Pos), the number of samples (N), the standardized index of abundance (Index) and the coefficient of variation on the mean (as a percentage) are listed.

Year	N	Prop. Pos.	Index	CV
1993	141	0.01	0.01	46.28
1994	98	0.04	0.1	49.63
1995	78	0.05	0.09	44.33
1996	230	0.09	0.11	34.85
1997	233	0.1	0.19	37.53
2002	222	0.09	0.13	30.63
2004	165	0.05	0.08	36.51
2005	290	0.04	0.08	32.67
2006	281	0.02	0.03	33.55
2007	320	0.04	0.05	30.08
2008	207	0.06	0.09	27.03
2009	249	0.02	0.03	30.38
2010	203	0.05	0.06	32.6
2011	240	0.05	0.08	35.15
2012	285	0.06	0.11	43.07
2013	194	0.09	0.21	47.28
2014	195	0.07	0.11	43.39
2015	86	0.07	0.1	47.14

Table 7.9.5 Index of Lesser Amberjack abundance derived from the SEAMAP video survey from 1993 to 2015 with data holidays from 1998 – 2001 and 2003. The nominal frequency of occurrence (Prop. Pos), the number of samples (N), the standardized index of abundance (Index) and the coefficient of variation of the mean (as a percentage) are listed.

Year	N	Prop. Pos.	Index	CV
1993	158	0.01	0.18	14.53
1994	127	0.02	0.05	14.51
1995	99	0.09	0.16	14.57
1996	298	0.03	0.05	14.32
1997	294	0.01	0.01	14.39
2002	275	0.04	0.08	14.02
2004	239	0.05	0.10	14.52
2005	498	0.03	0.09	14.49
2006	536	0.05	0.17	14.38
2007	621	0.04	0.15	14.42
2008	410	0.05	0.11	14.47
2009	485	0.05	0.10	14.46
2010	359	0.03	0.10	14.46
2011	440	0.05	0.22	14.42
2012	555	0.02	0.10	13.55
2013	379	0.04	0.12	12.95
2014	476	0.04	0.09	13.54
2015	193	0.06	0.23	12.31

Table 7.9.6 Index of Almaco Jack abundance derived from the SEAMAP video survey from 1993 to 2015. Data are missing from 1998 – 2001 and 2003. The nominal frequency of occurrence (Prop. Pos), the number of samples (N), the standardized index of abundance (Index) and the coefficient of variation on the mean (as a percentage) are listed.

Year	N	Prop. Pos.	Index	CV
1993	154	0.11	0.22	31.54
1994	117	0.16	0.33	32.14
1995	84	0.18	0.39	29.38
1996	264	0.19	0.34	26.24
1997	259	0.18	0.31	27.33
2002	244	0.43	1.07	24.17
2004	196	0.37	0.98	28.76
2005	408	0.32	0.65	28.78
2006	408	0.24	0.48	29.35
2007	467	0.29	0.56	28.56
2008	314	0.31	0.67	28.33
2009	373	0.27	0.43	28.33
2010	278	0.21	0.32	28.85
2011	338	0.2	0.35	28.95
2012	411	0.27	0.47	33.73
2013	298	0.23	0.48	35.5
2014	272	0.22	0.38	33.75
2015	153	0.18	0.26	36.09

Table 7.9.7 Summary of current depletion estimates for species similar to the SEDAR 49 species.

Reference	Group	Species	Current Year	Current Depletion
Chagaris et al. 2015	Drum	Red Drum (*Sciaenops ocellatus*)	2013	0.55
SEDAR 2016	Snapper	Vermilion Snapper (*Rhomboplites aurorubens*)	2014	0.31
SEDAR 2013	Snapper	Red Snapper (*Lutjanus campechanus*)	2014	0.15
SEDAR 2015	Grouper	Red Grouper (*Epinephelus morio*)	2013	0.36
SEDAR 2014a	Grouper	Gag Grouper (*Mycteroperca microlepis*)	2012	0.48
SEDAR 2011	Grouper	Yellowedge Grouper (*Hyporthodus flavolimbatus*)	2009	0.32
SEDAR 2014b	Amberjack	Greater Amberjack (*Seriola dumerili*)	2012	0.13

7.10 FIGURES

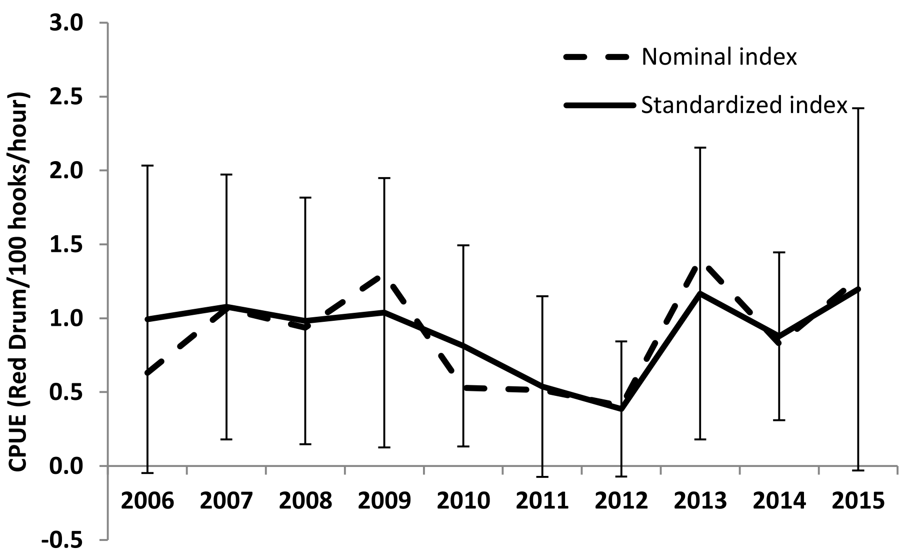

Figure 7.10.1 Nominal and standardized index of relative abundance obtained for Gulf of Mexico Red Drum from the Dauphin Island Sea Lab bottom longline survey. Error bars depict plus and minus one standard error.

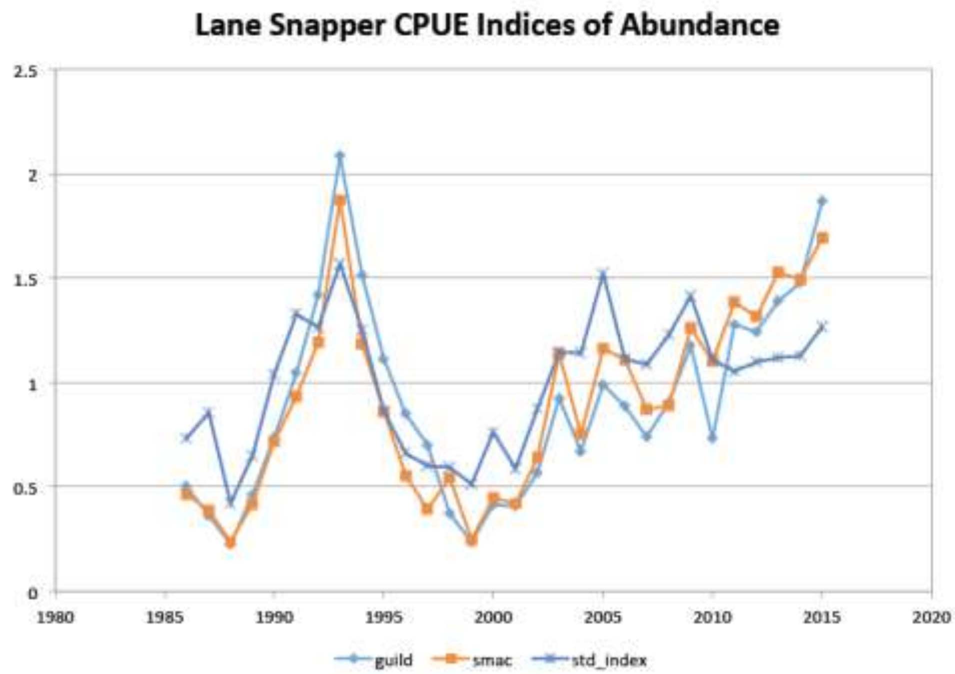

Figure 7.10.2 Nominal and standardized indices of abundance for Gulf of Mexico Lane Snapper when surveyed trips were subset based on the guild approach (guild) and the method of Stephens and MacCall (SMAC). Standardized index (std_index) is based on the SMAC data subset.

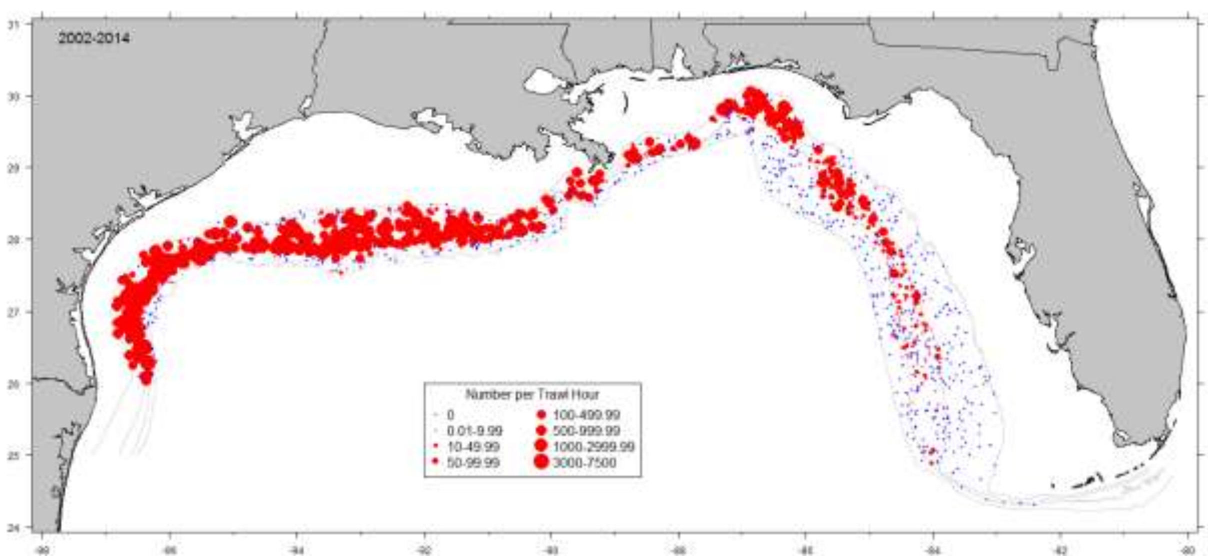

Figure 7.10.3 Stations sampled from 2002 to 2013 during the MSLABS small pelagics survey with the CPUE for Wenchman displayed with scaled bubbles. Contour lines are 50, 110, 200 and 500 meters, respectively.

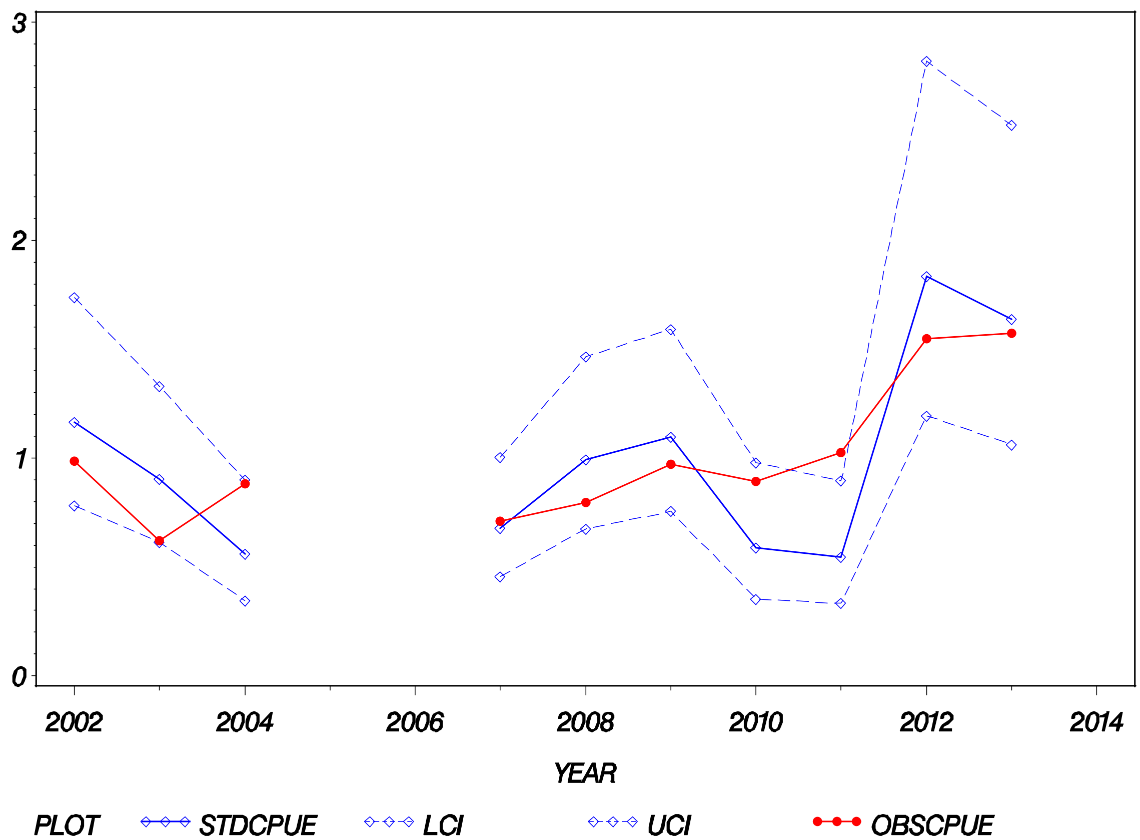

Figure 7.10.4 Annual index of abundance for Wenchman from the MSLABS small pelagics survey from 2002 – 2013.

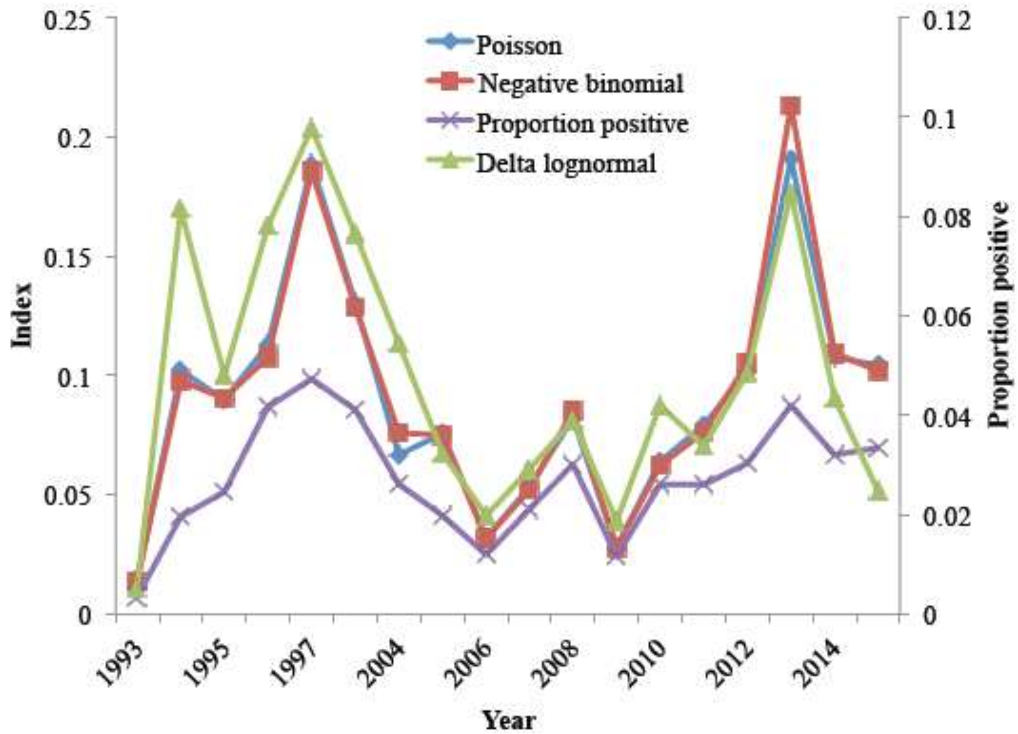

Figure 7.10.5 Annual indices of abundance and proportion positive for Yellowmouth Grouper from the SEAMAP video survey. The negative binomial model was the preferred model and was used to produce the index for SEDAR 49.

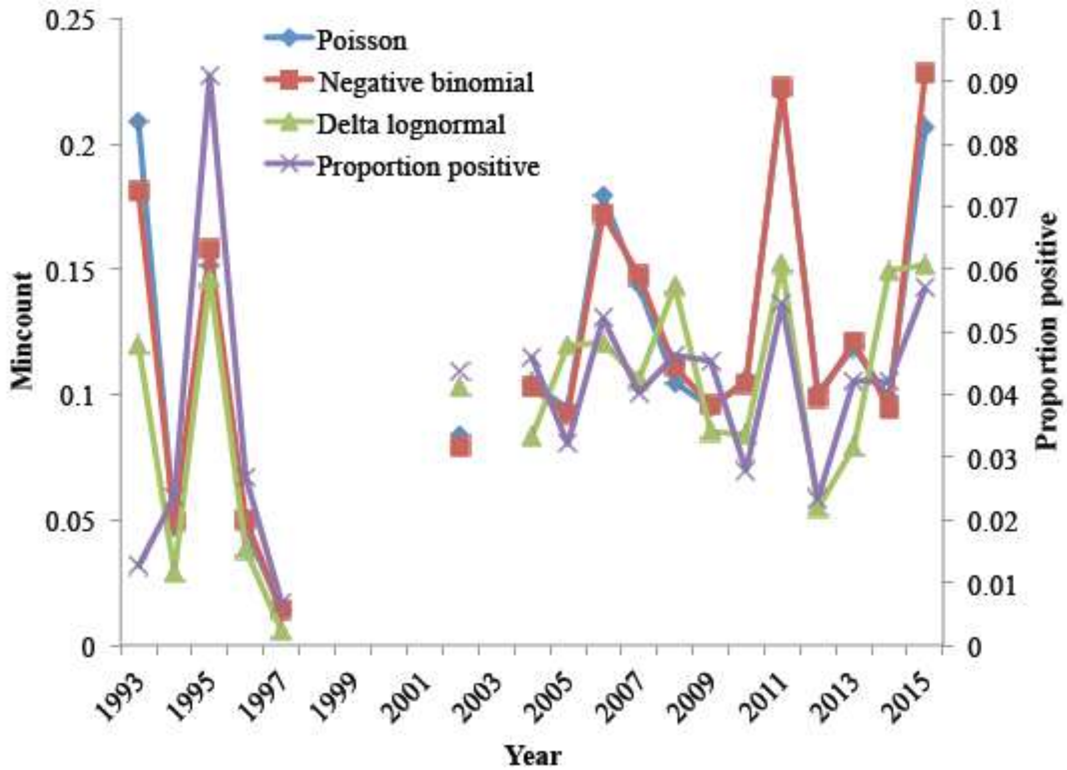

Figure 7.10.6 Annual indices of abundance and proportion positive for Lesser Amberjack from the SEAMAP video survey. The negative binomial model was the preferred model and was used to produce the index for SEDAR 49.

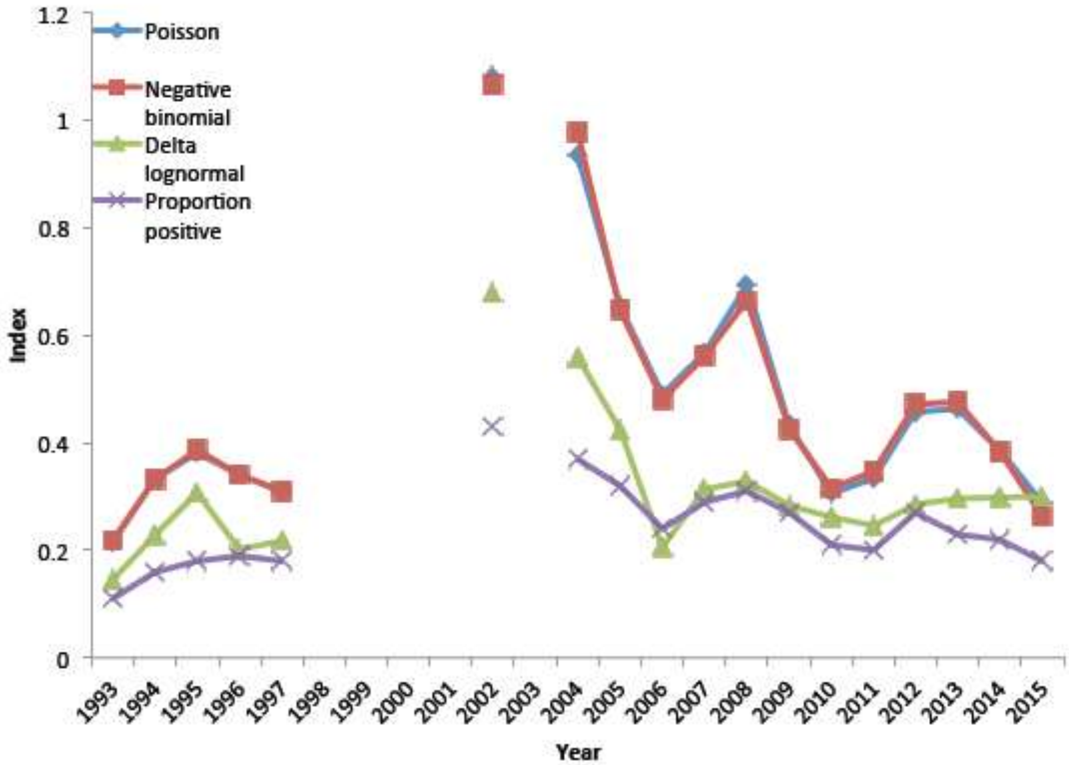

Figure 7.10.7 Annual indices of abundance and proportion positive for Almaco Jack from the SEAMAP video survey. The negative binomial model was the preferred model and was used to produce the index for SEDAR 49.

8 LENGTH-FREQUENCY DATA

8.1 OVERVIEW

The NOAA Fisheries, Southeast Fisheries Science Center Trip Interview Program (TIP) is a port sampling program that collects data on individual size and weight, to complement information that is collected through logbook reporting. Length samples from commercial fisheries were obtained from the Trip Interview Program (TIP) database housed at the Southeast Fisheries Science Center (SEFSC). Length samples for recreational fisheries were obtained from the Marine Recreational Fisheries Statistics Survey (i.e., the Marine Recreational Information Program, MRIP), the Head Boat Survey, the Texas Parks and Wildlife Department database (TPWD), the Florida Fish and Wildlife Conservation Commission (FWC), the Gulf States Marine Fisheries Commission FIN database (GFIN), and the TIP database. A summary of overall sample sizes is provided in Chih (2016).

Where available, length samples were obtained from fishery-independent surveys including the NMFS small pelagics survey (Pollack et al. 2016b), SEAMAP groundfish survey (Pollack et al. 2016a,c), SEAMAP reef video survey (Campbell et al. 2016a,b,c,d,e,f), Panama City video survey (DeVries et al. 2016a,b), and Panama City trap survey (DeVries et al. 2016b). For all species except Red Drum and Wenchman, annual sample sizes were too small for analysis.

Some data-limited approaches in the Data-Limited Methods Toolkit use length composition in conjunction with the mean length estimator to calculate current stock abundance or current stock depletion. Length samples were obtained from a variety of fishery-independent and fishery-dependent data sources for all eight species under assessment:

1. Red Drum
    - *Fishery-dependent*:
        i. Commercial handline
        ii. Commercial longline
        iii. Commercial other
        iv. Recreational (private, charterboat, headboat, shore)
        v. Alabama Deep Sea Fishing Rodeo (ADSFR) survey (from DISL)
    - *Fishery-independent*:
        i. Mississippi Department of Marine Resources (MDMR) gill net survey
        ii. NMFS Miami handline survey
        iii. Dauphin Island Sea Lab (DISL) bottom longline survey
        iv. Florida Fish and Wildlife Research Institute (FWRI) purse seine surveys
        v. Dauphin Island Sea Lab (DISL) purse seine survey
        vi. Louisiana State University (LSU) and NMFS Pascagoula purse seine surveys
2. Lane Snapper
    - *Fishery-dependent*:
        i. Commercial handline
        ii. Commercial longline
        iii. Commercial other
        iv. Recreational (private, charterboat, headboat, shore)
    - *Fishery-independent*:
        i. NMFS groundfish survey
        ii. SEAMAP reef fish video survey
        iii. Panama City video survey
3. Wenchman
    - *Fishery-dependent*:
        i. Commercial handline
        ii. Commercial longline
        iii. Commercial other
        iv. Recreational (charterboat)
    - *Fishery-independent:*
        i. NMFS small pelagics survey

   ii. NMFS groundfish survey
4. Yellowmouth Grouper
   - *Fishery-dependent*:
      i. Commercial handline
      ii. Commercial longline
      iii. Recreational (private, charterboat, headboat)
   - *Fishery-independent:*
      i. SEAMAP reef fish video survey
5. Snowy Grouper
   - *Fishery-dependent*:
      i. Commercial handline
      ii. Commercial longline
      iii. Recreational (private, charterboat, headboat)
   - *Fishery-independent:*
      i. SEAMAP reef fish video survey
6. Speckled Hind
   - *Fishery-dependent*:
      i. Commercial handline
      ii. Commercial longline
      iii. Recreational (private, charterboat, headboat)
   - *Fishery-independent:*
      i. SEAMAP reef fish video survey
7. Lesser Amberjack
   - *Fishery-dependent*:
      i. Commercial handline
      ii. Commercial longline
      iii. Recreational (private, charterboat, headboat, shore)
   - *Fishery-independent:*
      i. SEAMAP reef fish video survey
8. Almaco Jack
   - *Fishery-dependent*:
      i. Commercial handline
      ii. Commercial longline
      iii. Recreational (private, charterboat, headboat)
   - *Fishery-independent:*
      i. SEAMAP reef fish video survey
      ii. Panama City video survey

Lengths were measured in either fork lengths or total lengths. Historically there have been two ways to measure total length. Maximal total lengths were measured by compressing the caudal fin toward the center line of the fish to obtain the maximal possible total length (e.g., total length from historical TIP data and TPWD data). Natural total lengths were measured without compressing the caudal fin (e.g., total length from the Head Boat survey).

In addition to length composition data, the Data-Limited Methods Toolkit and mean length estimator approach require information on the selectivity at length including the size at first capture (or size at first recruitment to the gear) and the size at full recruitment to the gear. Size at first recruitment is defined as the size when the cumulative number sampled reaches 5% of the total number sampled and was determined using a cumulative distribution function of the length data. Size at full recruitment, also referred to as the critical length (Lc) in a mean length estimator context, is defined as the modal size of all captures, or the smallest size at full selection. Length frequency plots for each fleet and gear were used to inform decisions about the size at full recruitment for each species and gear since the assessment approach requires the characterization of a fleet considered most representative in terms of selectivity and exploitation pattern for the simulation.

8.2 REPRESENTATIVENESS

8.2.1 Red Drum

The predominant gear selected for data-limited assessment of Red Drum was the recreational private fishery spanning 1981 to 2014. Development of a weighted length composition was recommended by the panel to provide the best representation in terms of historical extractions, where all available length composition data by fleet and gear would be weighted by landings.

Length data from the recreational private mode accounted for 77% of total length observations. A few (n = 15) length observations in the data exceeded the maximum observed length for Red Drum in the Gulf of Mexico, with all fish caught in Texas waters (Table 8.5.1).

For the recreational private mode, the estimated length at first capture and length at full recruitment from the data were 43 and 52 cm FL, respectively (Figure 8.6.1). An estimate of variability was obtained for each parameter by estimating the relative absolute error between the estimates obtained from the fishermen and the available data (Table 8.5.2). Estimates of length at first capture were very different between the selectivity parameter estimates provided by fishermen at the Data Workshop and the estimates obtained from the available data (Table 8.5.2). In contrast, there was less variation in the length at full selection reported by the fishermen compared to the available data.

Fishery-independent data sources were also considered as viable options for length composition to represent historical extractions. The Life History Working Group (LHWG) discussed the consideration of the length composition from two additional length sources as sensitivity analyses. The first dataset recommended for sensitivity analysis was length composition derived from the combined purse seine surveys (Figure 8.6.2), since this gear was considered most appropriate in characterizing the size composition of adult Red Drum because this gear tends to be least selective and relatively non-biased (Hightower et al. 2016). Although slight differences were evident in the gear dimensions of the purse seines employed in each survey (Table 8.5.3), the LHWG agreed that the purse seine data could be combined to represent size composition for Red Drum under assessment, with the caveats that survey sites vary between studies (e.g., central Florida vs. Alabama), the purse seine gear dimensions are not identical, and sampling occurred at both inshore (<3 miles) and offshore (up to 10 miles) sites (Table 8.5.3). Trends in size composition revealed differences between years, which could be artifacts of different sampling locations (Figure 8.6.3).

The second fishery-independent data source considered for a sensitivity analysis was the length composition derived from the DISL bottom longline survey since this survey also samples larger Red Drum (Figure 8.6.4). This survey has been conducted since 2006 and randomly samples selected sites following the Southeastern Monitoring and Assessment Program (SEAMAP) standardized protocols. It is important to note that this survey has undergone several survey design changes to include further offshore waters within and outside of the Alabama Reef Permit Zone. Additional details are provided in Hightower et al. (2016). The size composition over time appears to follow a very similar trend (Figure 8.6.5).

8.2.2 Lane Snapper

The predominant gear selected for data-limited assessment of Lane Snapper was the recreational private fishery spanning 1986 to 2014. Development of a weighted length composition was recommended by the panel to provide the best representation in terms of historical extractions, where all available length composition data by fleet and gear would be weighted by landings.

Length data from the recreational private mode accounted for only 9% of total length observations. The largest maximum observed length for Lane Snapper in the Gulf of Mexico was 67.3 cm TL as reported by Johnson et al. (1995); however, this record may be an outlier. Johnson’s next largest Lane Snapper was 52 cm TL (Table 8.5.1), and approximately 20 length measurements exceeded this length.

For the recreational private mode, the estimated length at first capture and length at full recruitment from the data were 20 and 24 cm FL, respectively (Figure 8.6.6). An estimate of variability was obtained for each parameter by estimating the relative absolute error between the estimates obtained from the fishermen and the available data (Table 8.5.2). Estimates of length at first capture were relatively similar between the selectivity parameter estimates provided by fishermen at the Data Workshop and the estimates obtained from the available data (Table 8.5.2). In contrast, there was more variation in the length at full selection reported by the fishermen compared to the available data.

8.2.3 Wenchman

The predominant gear selected for data-limited assessment of Wenchman was the commercial trawl fishery targeting butterfish from 1997 to 2014, although length composition data were sparse. For the commercial "other" fishery, assumed to reflect the trawl fishery, the estimated length at first capture and length at full recruitment from the data were 12 and 19 cm FL, respectively (Figure 8.6.7). No estimates were provided by fishermen because of the rarity of this species in their fishing experience, and therefore no estimates of variability were available (Table 8.5.2).

Length composition data collected by the fishery-independent NMFS small pelagics survey were considered most representative in terms of historical extractions by length class. Length data were collected from 2002 through 2013 with the exception of 2005, with annual sample sizes ranging from 565 to 1,209 length measurements. The survey primarily captured Wenchman below 25 cm FL, with two peaks around 5 and 20 cm FL (Figure 8.6.8). The bimodal distribution was also evident when examining length composition by year (Figure 8.6.9).

8.2.4 Yellowmouth Grouper

The predominant gear selected for data-limited assessment of Yellowmouth Grouper was the recreational fishery spanning 1990 to 2014, although it was evident that this species was rarely encountered in either commercial or recreational fisheries. Development of a weighted length composition was recommended by the panel to provide the best representation in terms of historical extractions, where all available length composition data by fleet and gear would be weighted by landings. However, concerns were noted regarding species misidentification due the similarity in appearance of Yellowmouth Grouper and Scamp.

Length data from the recreational fishery only accounted for 11% of total length observations, however the reliability of the commercial data was questioned because of the potential for misidentification of Yellowmouth Grouper as Scamp. In the commercial handline fishery, a 100 cm FL Yellowmouth Grouper exceeds the maximum observed length of Yellowmouth Grouper in the Southeast US Atlantic (Table 8.5.1).

For the recreational fishery, the estimated length at first capture and length at full recruitment from the data were 29 and 37 cm FL, respectively (Figure 8.6.10). An estimate of variability was obtained for each parameter by estimating the relative absolute error between the estimates obtained from the data and the estimates provided by the fishermen (Table 8.5.2). Estimates of length at first capture and length at full selection were not similar between the selectivity parameter estimates provided by fishermen at the Data Workshop and the estimates obtained from the available data (Table 8.5.2). It important to note that all information derived from length composition is highly uncertain for Yellowmouth Grouper due to the rarity of collection and potential for misidentification.

8.2.5 Snowy Grouper

The predominant gear selected for data-limited assessment of Snowy Grouper was the commercial longline fishery spanning 1990 to 2014. Development of a weighted length composition was recommended by the panel to provide the best representation in terms of historical extractions, where all available length composition data by fleet and gear would be weighted by landings.

Length data from the commercial longline accounted for 67% of total length observations. Only one Snowy Grouper exceeded the largest maximum observed length for Snowy Grouper in the Gulf of Mexico (Table 8.5.1).

For the commercial longline fishery, the estimated length at first capture and length at full recruitment from the data were 42 and 58 cm FL, respectively (Figure 8.6.11). An estimate of variability was obtained for each parameter by estimating the relative absolute error between the estimates obtained from the available data and the estimates provided by the fishermen (Table 8.5.2). Estimates of length at first capture were very similar between the selectivity parameter estimates provided by fishermen at the Data Workshop and the estimates obtained from the available data (Table 8.5.2). In contrast, there was more variation in the length at full selection reported by the fishermen compared to the available data.

8.2.6 Speckled Hind

The predominant gear selected for data-limited assessment of Speckled Hind was the commercial longline fishery spanning 1997 to 2014. A more recent start year was decided upon by the Panel due to misidentification of groupers. Development of a weighted length composition was recommended by the panel to provide the best representation in terms of historical extractions, where all available length composition data by fleet and gear would be weighted by landings.

Length data from the commercial longline accounted for 85% of total length observations. Although a few (n = 28) Speckled Hind length measurements exceeded the maximum observed length for Speckled Hind from the Southeast US, all fish were landed in Florida by the commercial longline fishery (Table 8.5.1).

For the commercial longline fishery, the estimated length at first capture and length at full recruitment from the data were 35 and 43 cm FL, respectively (Figure 8.6.12). An estimate of variability was obtained for each parameter by estimating the relative absolute error between the estimates obtained from the data and the estimates provided by the fishermen (Table 8.5.2).

Estimates of length at first capture and full selection were relatively similar between the selectivity parameter estimates provided by fishermen at the Data Workshop and the estimates obtained from the available data (Table 8.5.2).

8.2.7 Lesser Amberjack

The predominant gear selected for data-limited assessment of Lesser Amberjack was the commercial handline fishery spanning 1991 to 2009. An earlier terminal year was decided upon due to the implementation of individual fishing quotas for the commercial grouper and tilefish fisheries in 2010 which may have changed fishing behavior of commercial fishermen. Development of a weighted length composition was recommended by the panel to provide the best representation in terms of historical extractions, where all available length composition data by fleet and gear would be weighted by landings.

Length data from the commercial handline accounted for 71% of total length observations. Lesser Amberjack measuring over 67 cm FL exceed the maximum observed length of Lesser Amberjack in the Gulf of Mexico (Table 8.5.1), although it is important to note that the documented maximum lengths are based on low sample sizes. It is possible that larger “Lesser Amberjack” may have been Greater Amberjack.

For the commercial handline fishery, the estimated length at first capture and length at full recruitment from the data were 30 and 37 cm FL, respectively (Figure 8.6.13). An estimate of variability was obtained for each parameter by estimating the relative absolute error between the estimates obtained from the data and the estimates provided by the fishermen (Table 8.5.2). Substantial uncertainty surrounding Lesser Amberjack selectivity was discussed at the Data Workshop due to the rarity of fishermen catching Lesser Amberjack. Estimates of length at first capture were very different between the selectivity parameter estimates provided by fishermen at the Data Workshop and the estimates obtained from the available data, whereas no estimate of length at full selection was provided by the fishermen due to their lack of catching large Lesser Amberjack (Table 8.5.2).

8.2.8 Almaco Jack

The predominant gear selected for data-limited assessment of Almaco Jack was the combined recreational fishery (charterboat, private, headboat) spanning 1991 to 2014. Development of a weighted length composition was recommended by the panel to provide the best representation in terms of historical extractions, where all available length composition data by fleet and gear would be weighted by landings.

Length data from the combined recreational fishery only accounted for 35% of total length observations but were determined to be a better representation since Almaco Jack are bycatch in the recreational fishery. A few length measurements (n = 8; 7 fish landed in FL, 1 fish landed in TX) exceeded the maximum observed length of Almaco Jack in the Gulf of Mexico (Table 8.5.1).

For the combined recreational fishery, the estimated length at first capture and length at full recruitment from the data were 28 and 36 cm FL, respectively (Figure 8.6.14). An estimate of variability was obtained for each parameter by estimating the relative absolute error between the estimates obtained from the available data and the estimates provided by the fishermen (Table 8.5.2). Estimates of the lengths at first capture and full selection were vastly different between the selectivity parameter estimates provided by fishermen at the Data Workshop and the estimates obtained from the available data (Table 8.5.2).

8.3 RESEARCH RECOMMENDATIONS

8.3.1 Red Drum

- Continue and expand fishery-independent collection efforts to collect length measurements at varying sizes, seasons or months, and locations, particularly for offshore Red Drum

8.3.2 Lane Snapper

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months
- Pursue statistical approaches to address sampling inconsistencies between random selection of small and large individuals in the SEAMAP groundfish survey, which could enable the use of length composition derived from the SEAMAP groundfish survey

8.3.3 Wenchman

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months
- Create sampling protocols to obtain lengths from NMFS Pascagoula small pelagic survey

8.3.4 Yellowmouth Grouper

- Expand collection efforts to collect genetic samples to ensure species identification along with length measurements at varying locations, seasons or months

8.3.5 Snowy Grouper

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months

8.3.6 Speckled Hind

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months

8.3.7 Lesser Amberjack

- Expand collection efforts to collect genetic samples to ensure species identification along with length measurements at varying locations, seasons or months

8.3.8 Almaco Jack

- Expand collection efforts to collect genetic samples to ensure species identification along with length measurements at varying locations, seasons or months

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8.5 TABLES

Table 8.5.1 Maximum observed lengths of the SEDAR 49 species obtained from a life history meta-analysis of fishes in the Southeast US conducted during the SEDAR 46 and 49 Data Triages. *Indicates suspected outlier. See Adams et al. (2016) for more details.

Species	Sampling Location	Timeframe	Maximum length	Length type (Units)	Reference
Red Drum	Alabama	2013	119.5	TL (cm)	Hightower et al. 2016
Red Drum	Mississippi	2010	115.0	TL (cm)	SEDAR 49 data - MDMR
Red Drum	Northern Gulf of Mexico	2006-2011	110.1	TL (cm)	Powers et al. 2012
Red Drum	Northern Gulf of Mexico	--	101	TL (cm)	Murphy and Taylor 1986a
Red Drum	Louisiana	1967-1968	93.2	SL (cm)	Boothby and Avault Jr 1971
Red Drum	Northern Gulf of Mexico	1986-1992	111.5	FL (cm)	Wilson and Nieland 1994
Red Drum	Florida East Coast	1981-1983	111	FL (cm)	Murphy and Taylor 1990
Red Drum	Florida West Coast	1997	108.5	TL (cm)	Winner et al. 2014
Red Drum	Louisiana	2002	111	FL (cm)	McInerny and Potts unpub.
Red Drum	Florida	1981-1983	98	FL (cm)	Murphy and Taylor 1990
Red Drum	Texas	1988	114.9	TL (cm)	Wilson and Nieland 2002
Lane Snapper	SE US Gulf	1991-1994	67.3*(52)	TL (cm)	Johnson et al. 1995
Lane Snapper	Atlantic N	1977-1982	51.2	TL (cm)	Manooch and Mason 1984
Yellowmouth Grouper	SE US Atlantic	1980-2012	85.9	FL (cm)	Burton et al. 2014
Yellowmouth Grouper	Florida	1978-1992	76.1	TL (cm)	Bullock and Murphy 1994
Snowy Grouper	Florida Keys	1978-1981	124.9	TL (cm)	Moore and Labisky 1984
Snowy Grouper	Gulf of Mexico	1984-2004	109.6	FL (cm)	Kowal 2010
Speckled Hind	SE US Atlantic	1993	97.3	TL (cm)	Ziskin et al. 2011
Lesser Amberjack	Gulf of Mexico	--	61.3	TL (cm)	Szedlmayer 1996
Lesser Amberjack	Louisiana	--	67.6	FL (cm)	Thompson et al. 1996
Lesser Amberjack	Louisiana	--	61.3	FL (cm)	Thompson et al. 1996
Almaco Jack	Louisiana	--	100	FL (cm)	Thompson et al. 1996
Almaco Jack	Louisiana	--	94.5	FL (cm)	Thompson et al. 1996

Table 8.5.2 The number of length measurements for each representative fleet and gear across all years and the corresponding selectivity parameters from available data (Isely et al. 2016) and fishermen input from the Data Workshop. Selectivity parameters include the length at first recruitment (LFC) and the length at full recruitment (LFS). Bias refers to variability in selectivity parameters and was quantified as the difference between estimates provided by the fishermen at the Data Workshop and the available data. Note that the values for SEDAR 49 may have changed from Isely et al. (2016) due to filtering of the data to those time periods where data were deemed reliable for assessment.

Species	Time period	Gear	N	SEDAR 49		Fishermen input		LFC bias	LFS bias	Selectivity pattern
				LFC	LFS	LFC	LFS			
Red Drum	1981-2014	Recreational Private	248,246 (77%)	43	52	15	46	0.65	0.12	Double-logistic
Lane Snapper	1986-2014	Recreational Private	3,227 (9%)	20	24	18	30	0.11	0.27	Asymptotic
Wenchman	1997-2014	Commercial Fish Trawl	227 (58%)	12	19	NA	NA	NA	NA	NA
Yellowmouth Grouper	1990-2014	Recreational (Charterboat, Private, Headboat)	96 (11%)	29	37	20	30	0.30	0.18	Asymptotic
Snowy Grouper	1990-2014	Commercial Longline	14,313 (67%)	42	58	41	46	0.03	0.21	Asymptotic
Speckled Hind	1997-2014	Commercial Longline	10,712 (85%)	35	43	41	46	0.16	0.06	Asymptotic
Lesser Amberjack	1991-2009 (base)	Commercial Handline	1,007 (71%)	30	37	13	NA	0.58	NA	Dome-shaped
Almaco Jack	1991-2014	Recreational (Charterboat, Private, Headboat)	4,215 (35%)	28	36	13	15	0.55	0.58	Dome-shaped

Table 8.5.3 Summary of studies employing purse seines to sample the size structure of the adult population of Red Drum present offshore in the Gulf of Mexico.

Data Source	**Louisiana State University (LSU), NMFS Pascagoula**	**Florida Fish and Wildlife Research Institute (FWRI)**	**Florida Fish and Wildlife Research Institute (FWRI)**	**Dauphin Island Sea Lab (DISL)**
Year(s) collected	1986-1988, 1997-1998	1996-1998 and 2006-2008	2012-2014	2014
Sampling	Fishery-independent purse seine, spotter plane	Fishery-independent purse seine, spotter plane	Fishery-independent purse seine, spotter plane	Fishery-independent purse seine
Gear dimension	457 x 30 m	Several hundred yards long x 30 feet deep or more	640 x 12 m	None provided
Distance from shore	Not reported	97-98: 1-9 miles 06-08: 4 – 6 miles	8 – 10 miles	Not reported
Number of records	2,312	1,725	8,888	468
Spatial coverage	Coastal waters between Texas and Alabama	Coastal waters off Tampa Bay, Florida	Coastal waters off Tampa Bay, Florida	Coastal waters off Alabama
Number of lengths	2,263	1,723	8,888	468
Source	Wilson and Nieland 1994; Mitchell and Henwood 1999; Wilson and Nieland 2000	Murphy and Crabtree 2001; Winner et al. 2014	Lowerre-Barbieri et al. 2016, Lowerre-Barbieri et al. in press	Powers et al. 2012; Hightower et al. 2016

8.6 FIGURES

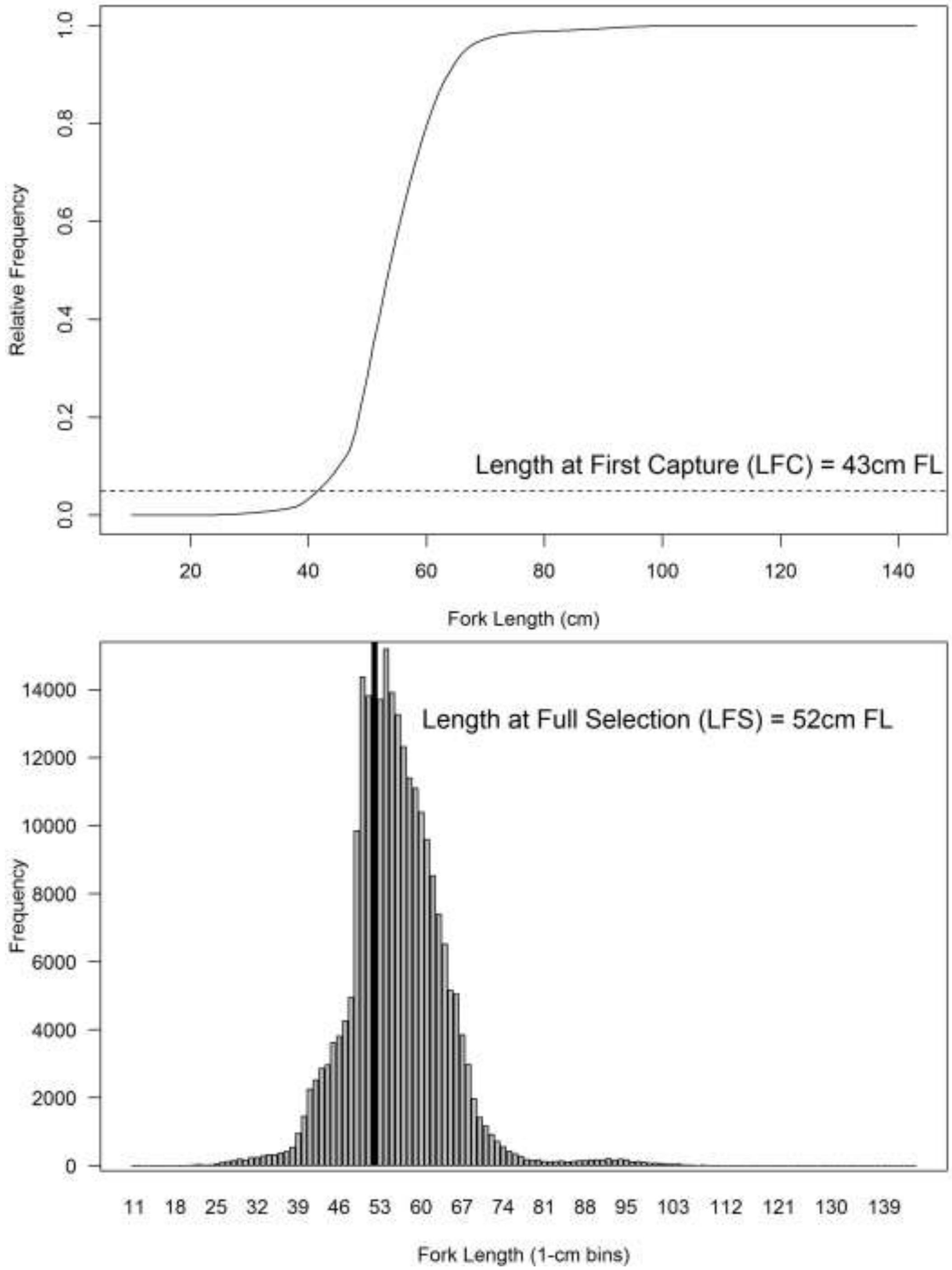


Figure 8.6.1 Length at first capture and length at full selection for Red Drum by the recreational private fishing mode across all years (1981 – 2014). In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.

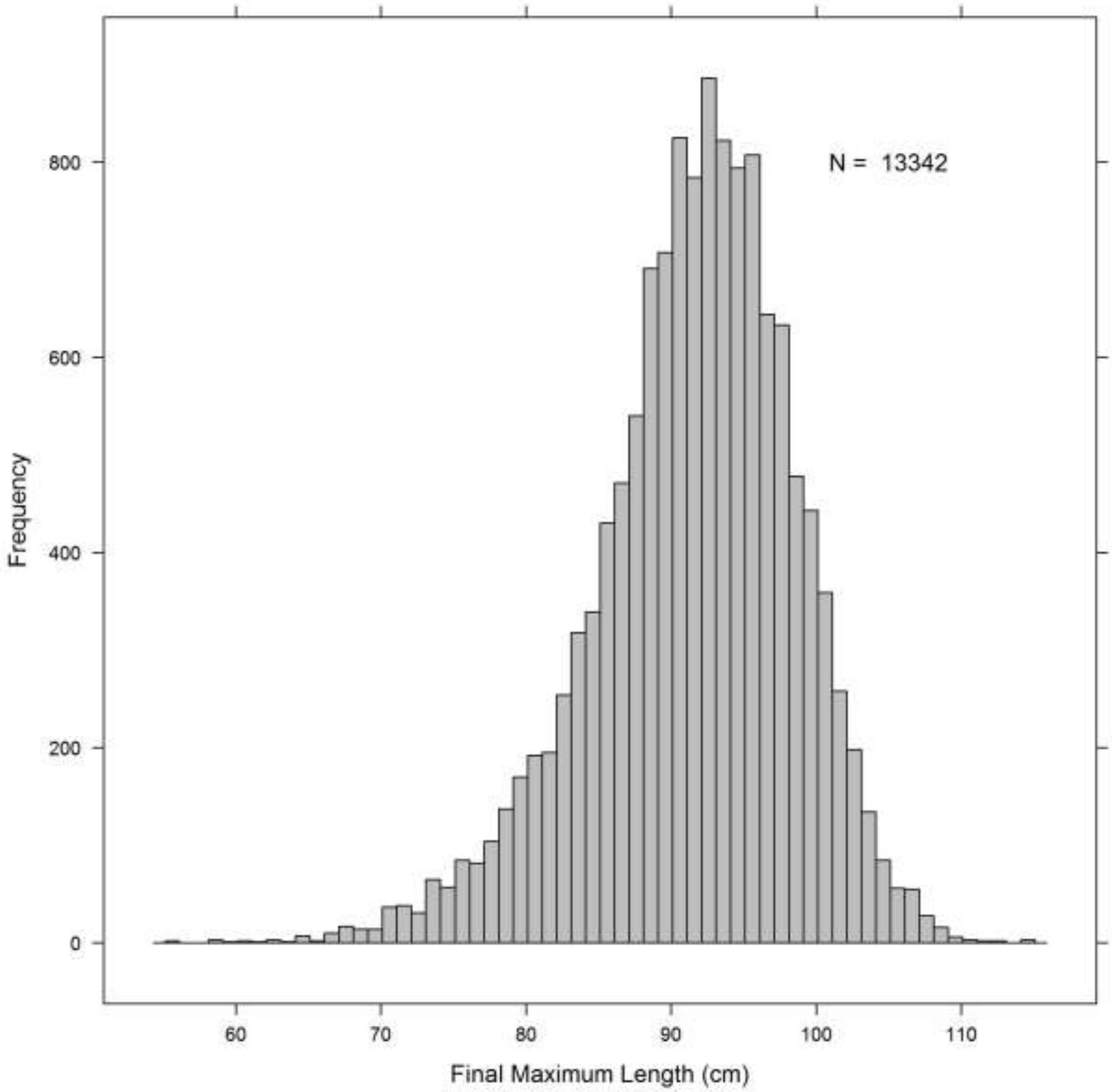


Figure 8.6.2 Length frequency across all years for Red Drum collected from purse seine surveys. Note that lengths are in maximum total length (cm).

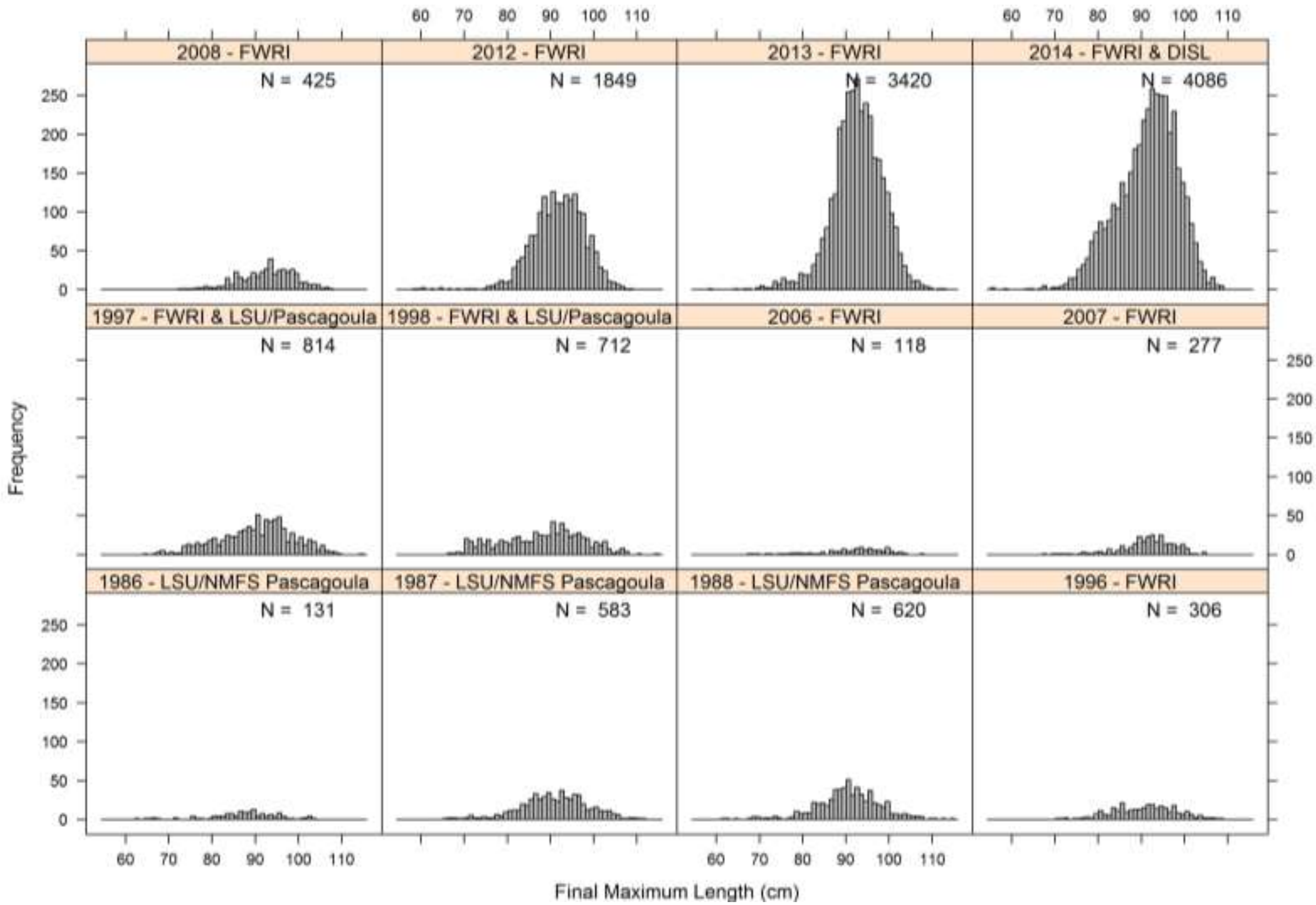


Figure 8.6.3 Annual length frequency histograms for Red Drum caught during fishery-independent purse seine surveys. Note that length frequencies from 1997 and 1998 include both FWRI and LSU/NMFS Pascagoula samples and from 2014 include both FWRI and DISL samples. Each bar represents a 1-cm length bin. See Table 8.5.3 for details on each data source.

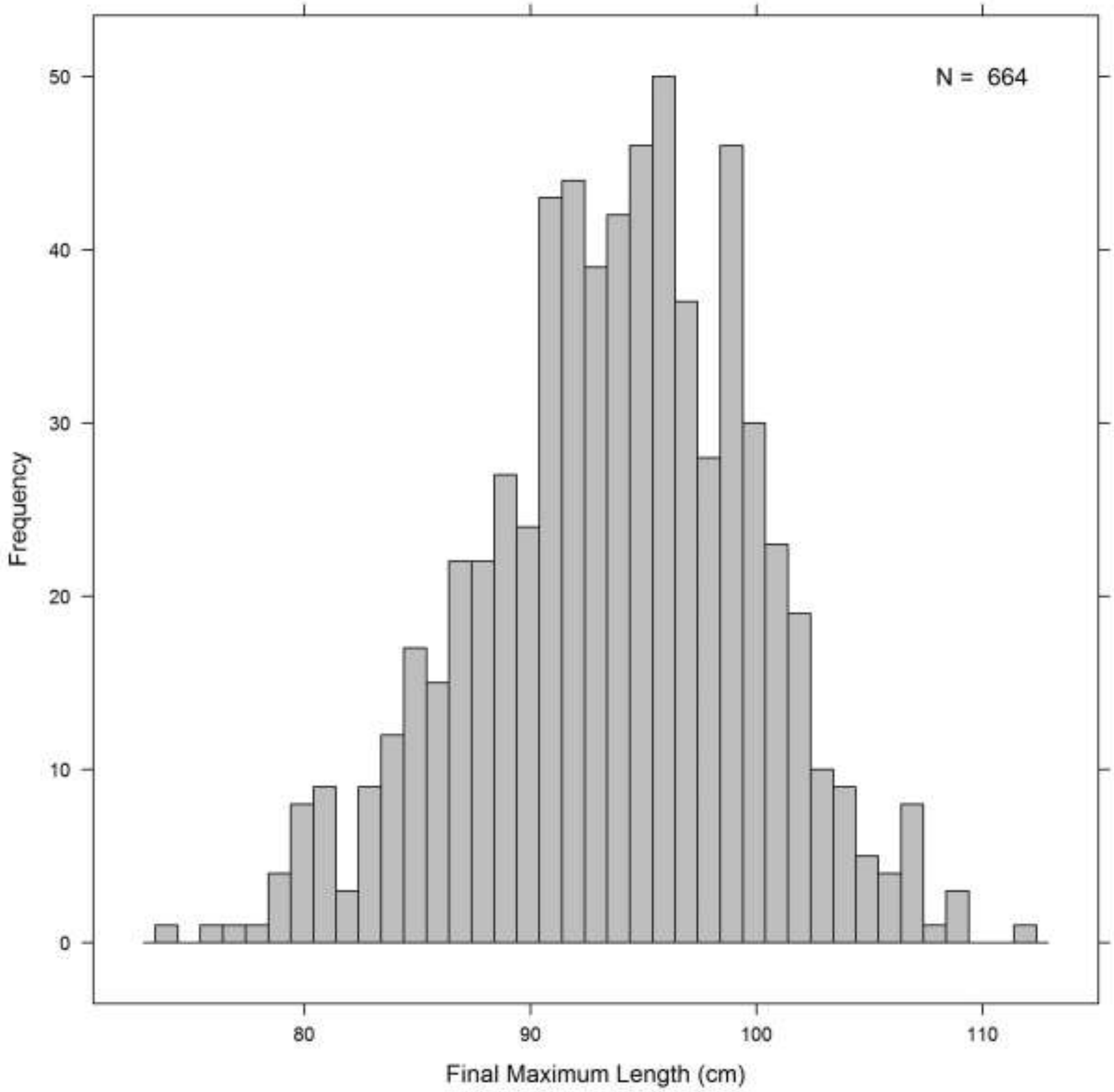


Figure 8.6.4 Length frequency across all years for Red Drum collected from the DISL bottom longline survey.

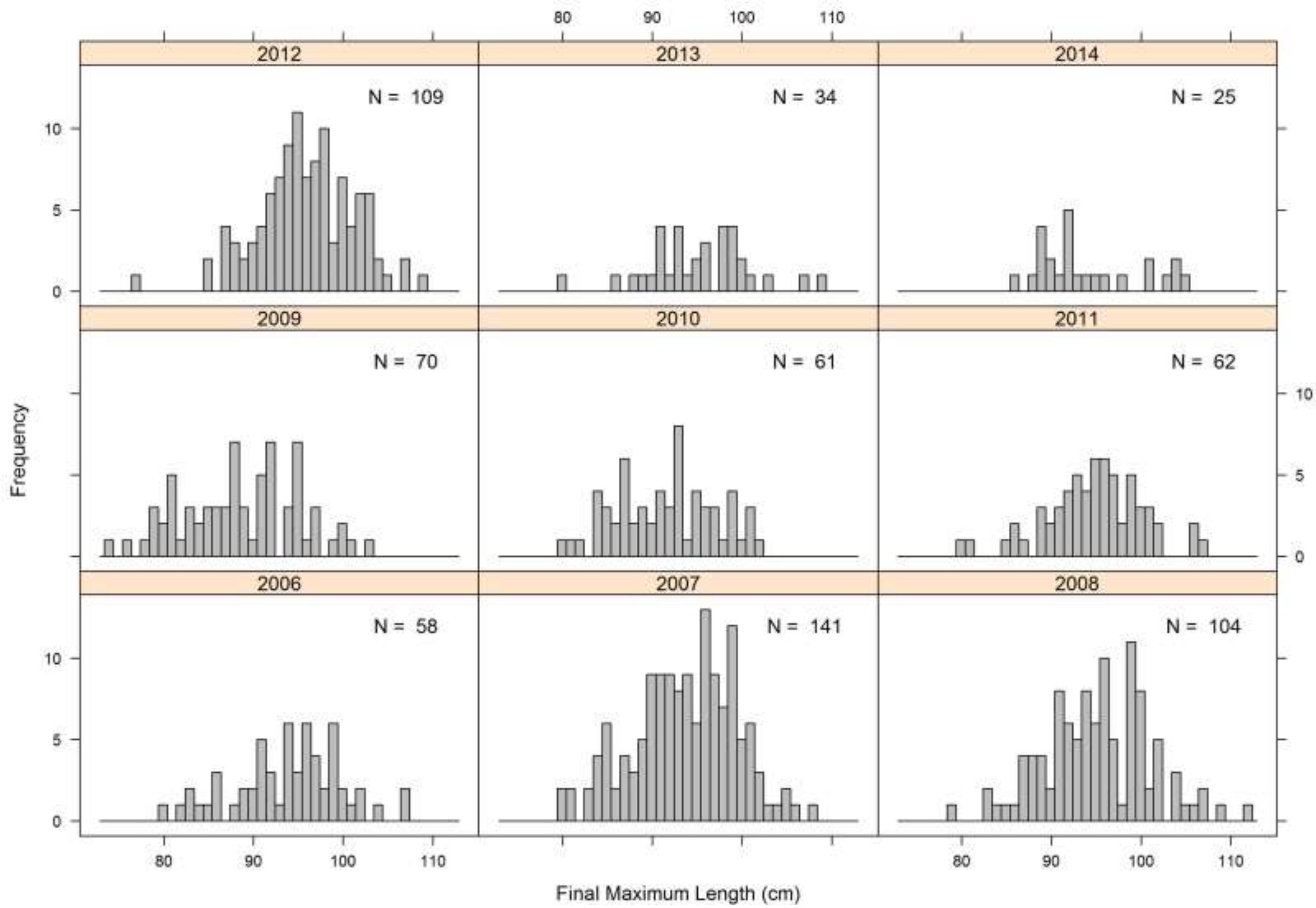


Figure 8.6.5 Annual length frequency histograms for Red Drum caught during the fishery-independent DISL bottom longline survey. Each bar represents a 1-cm length bin.

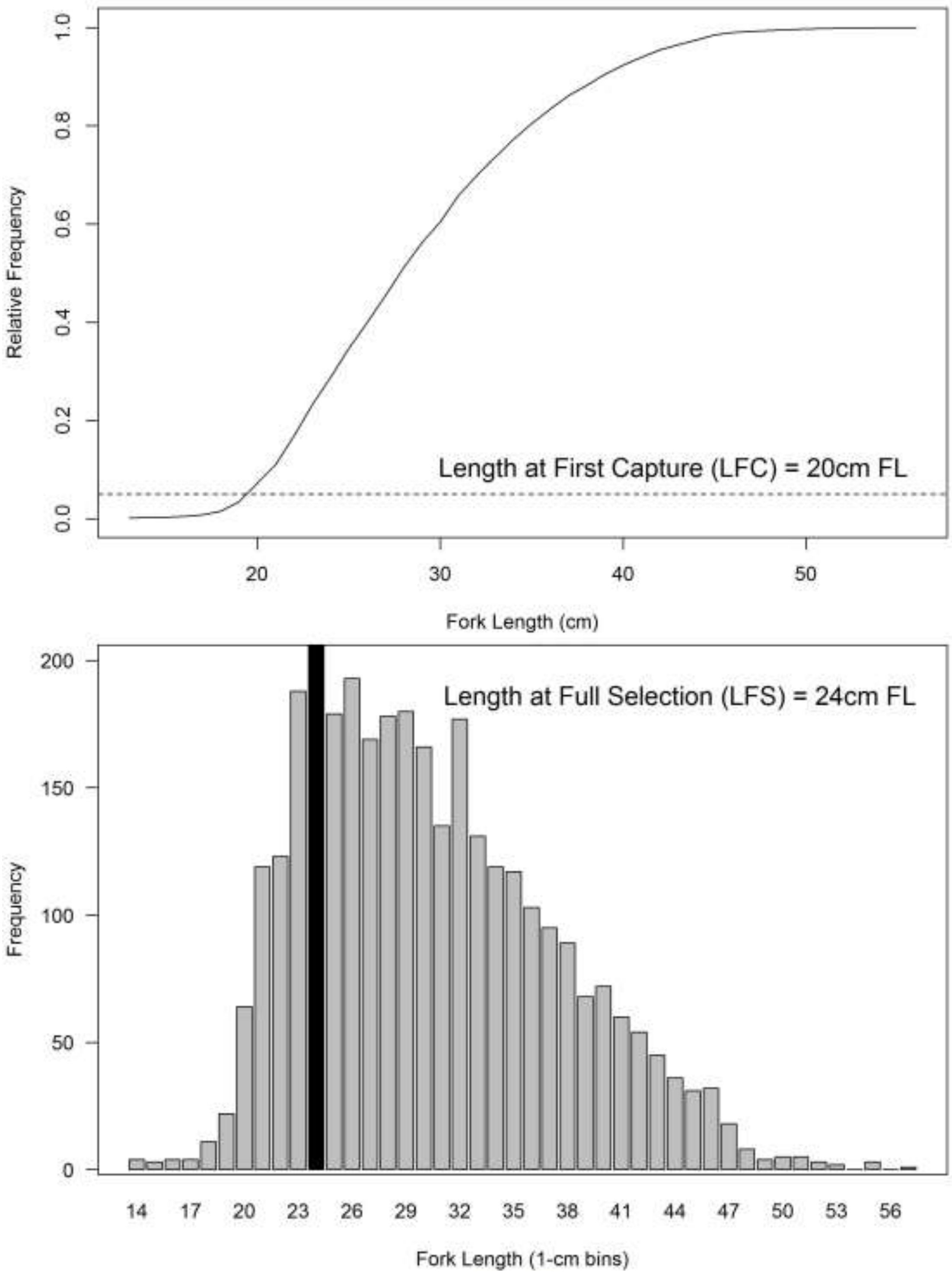


Figure 8.6.6 Length at first capture and length at full selection for Lane Snapper by the recreational private fishing mode across all years (1986 – 2014). In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.

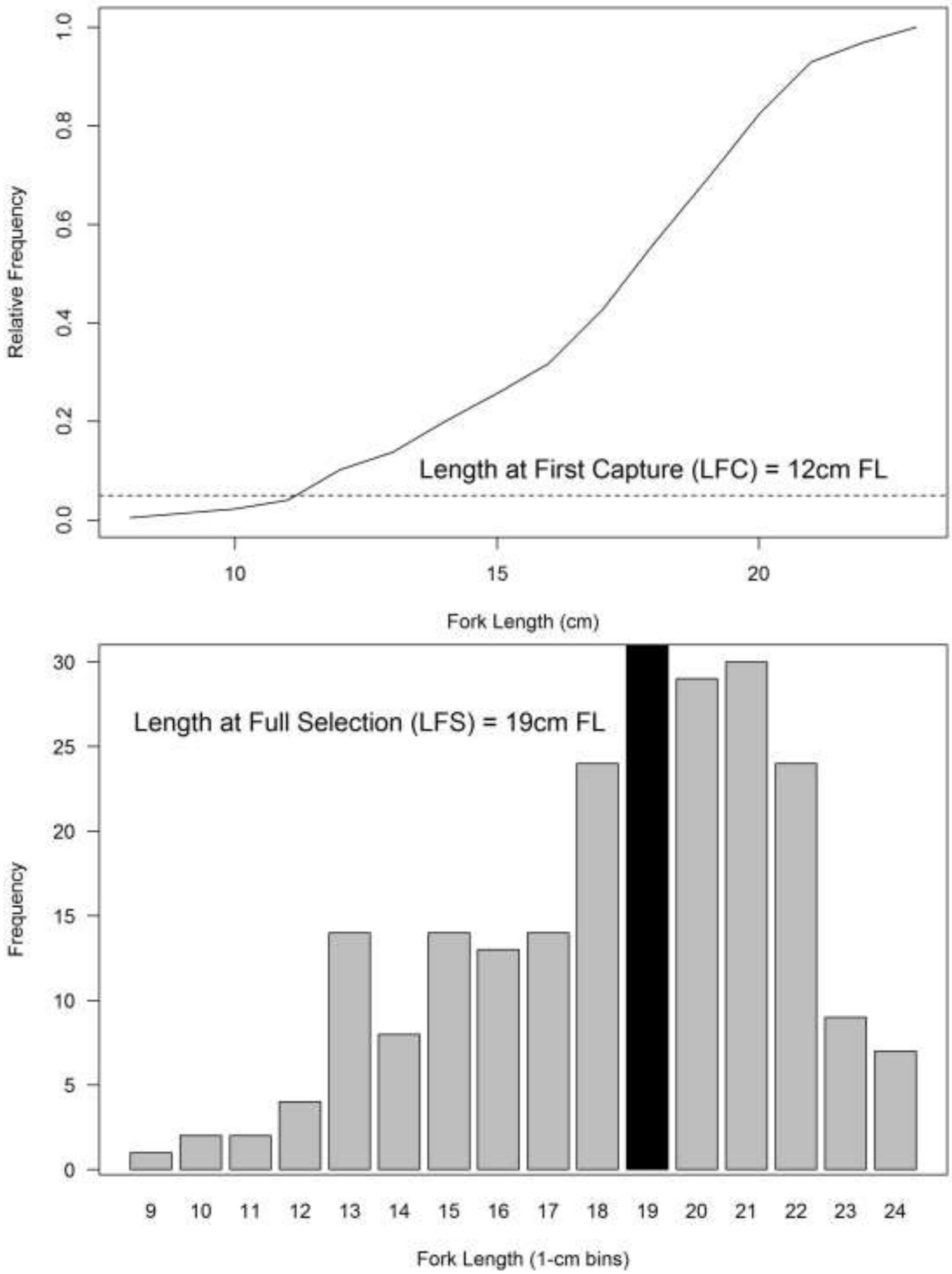


Figure 8.6.7 Length at first capture and length at full selection for Wenchman by the commercial "other" fishery across all years (1997 – 2014). In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.

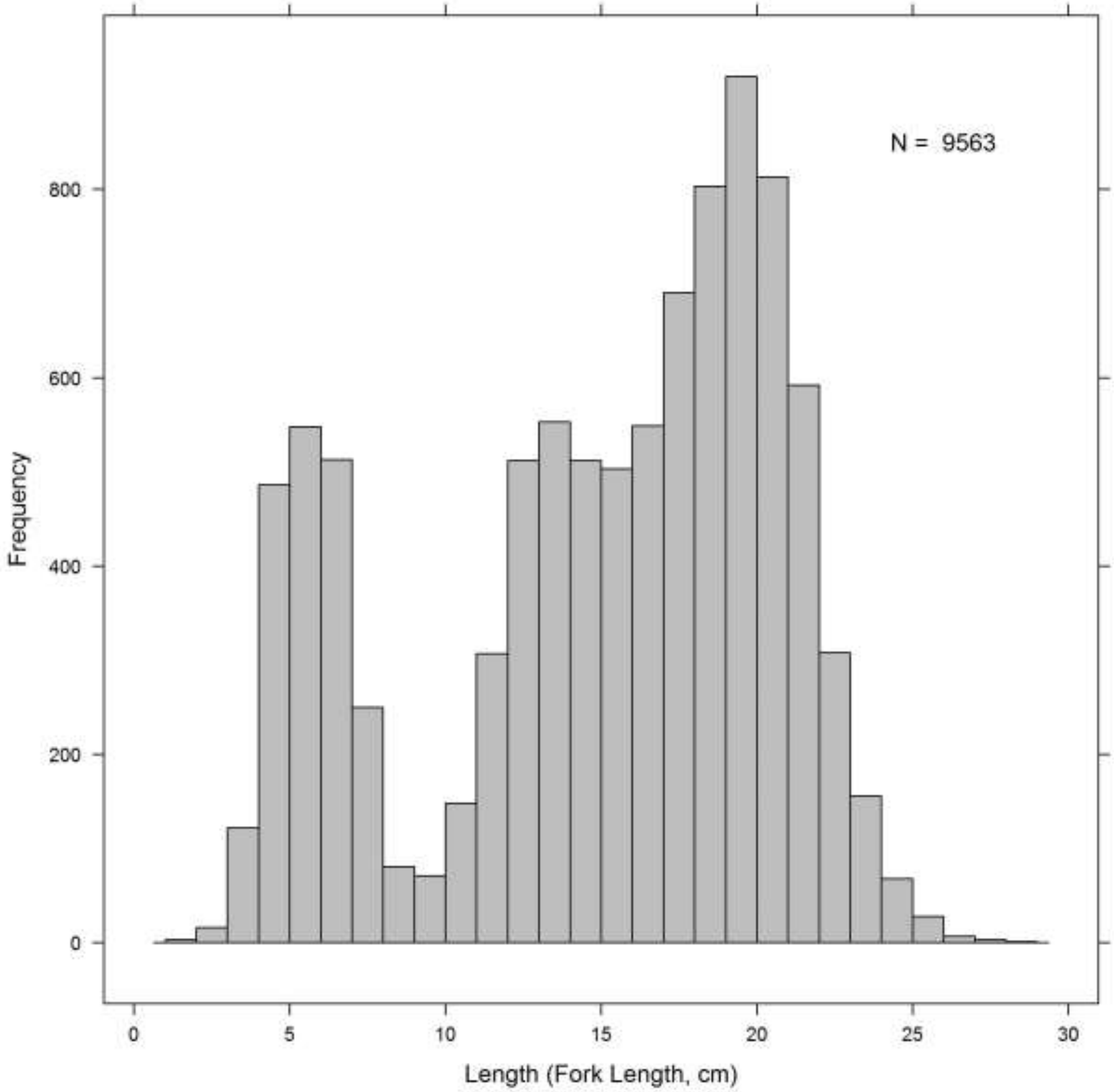


Figure 8.6.8 Length frequency across all years (2002 – 2013) for Wenchman caught by the NMFS small pelagics trawl survey. Number in the upper right-hand corner indicates the number of lengths. Each bar represents a 1-cm length bin.

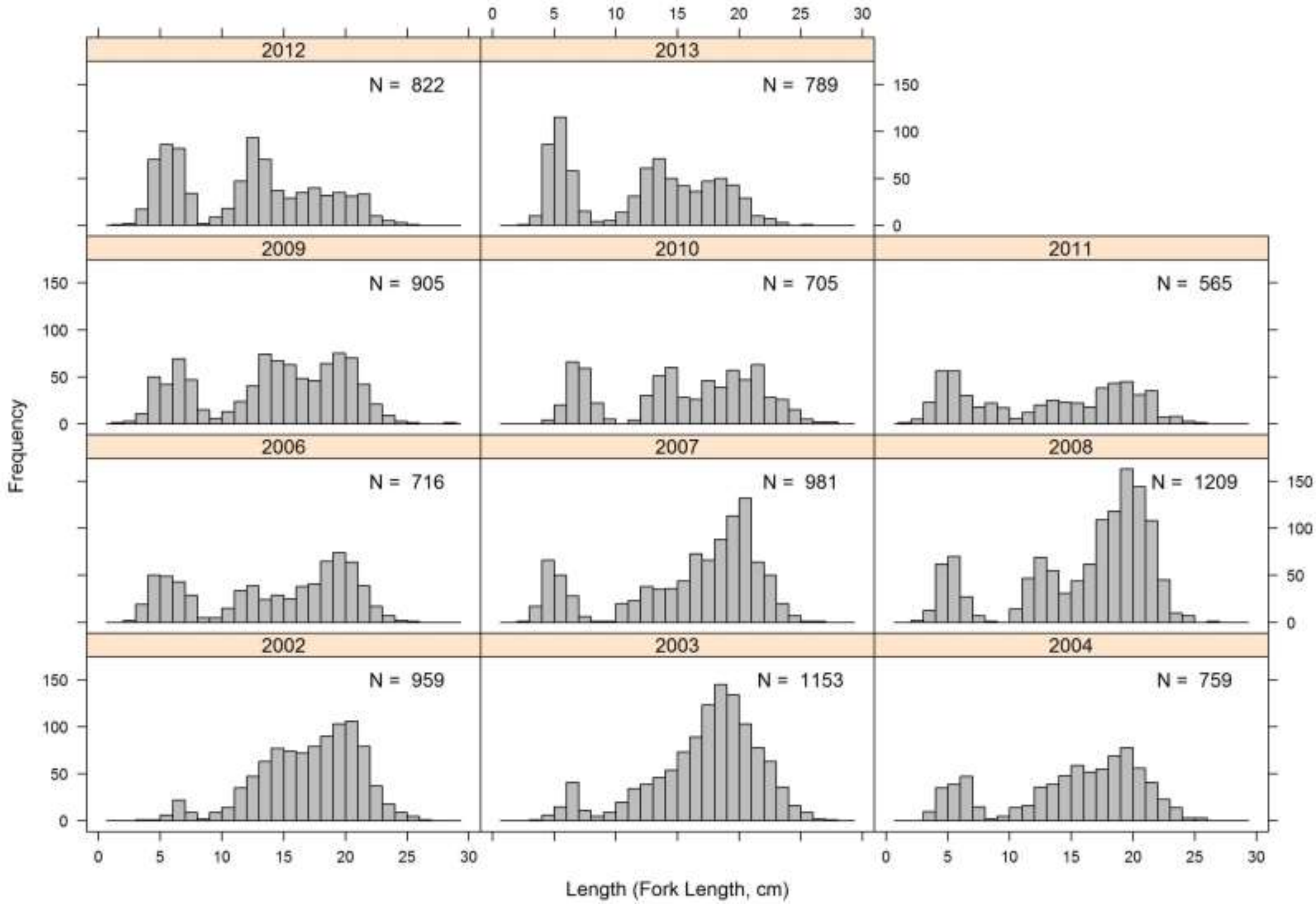


Figure 8.6.9 Annual length frequency histograms for Wenchman caught by the fishery-independent NMFS small pelagics trawl survey in the Gulf of Mexico. Numbers in the upper right-hand corner of each panel indicate the number of lengths per year. Each bar represents a 1-cm length bin.

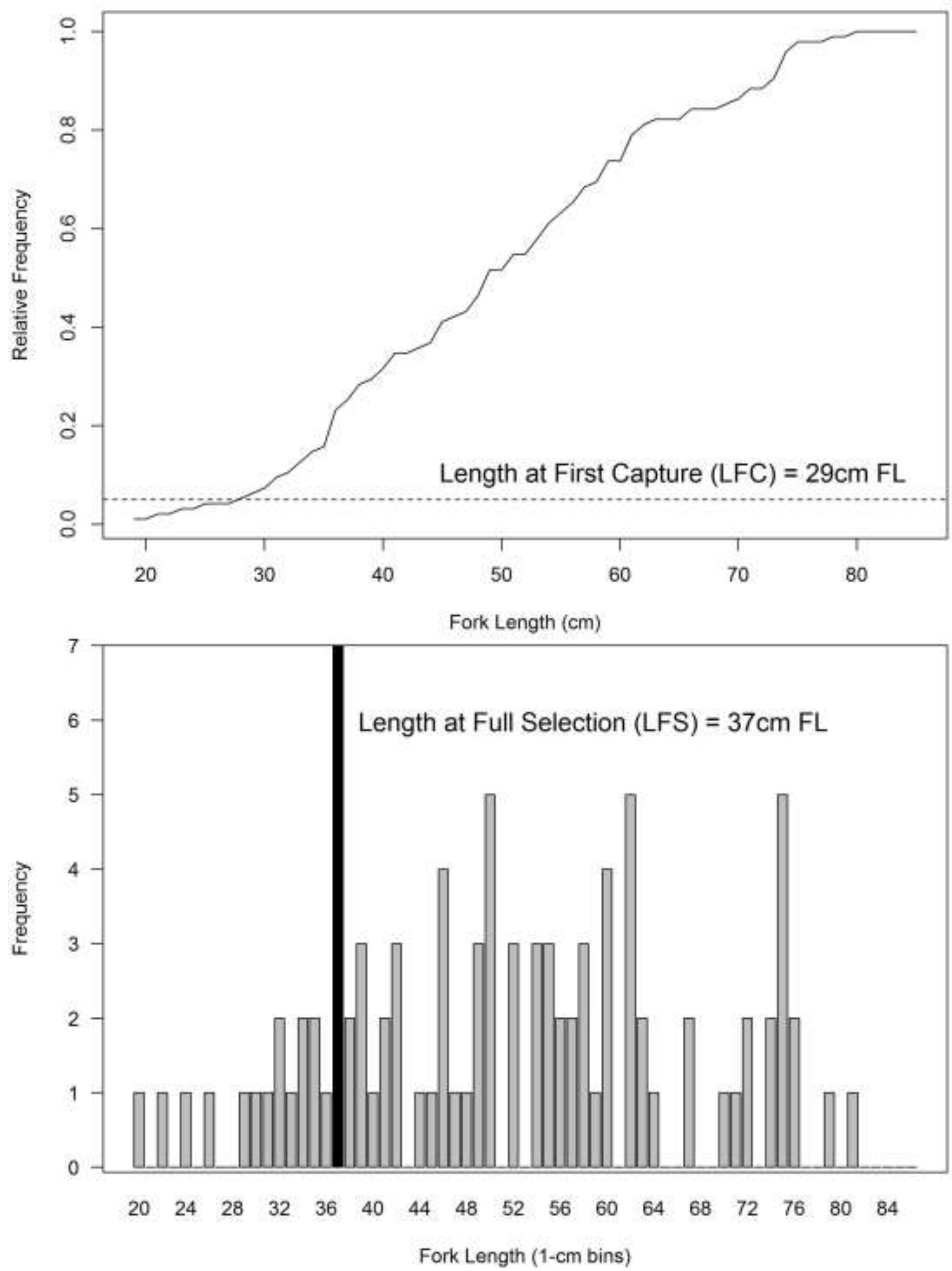
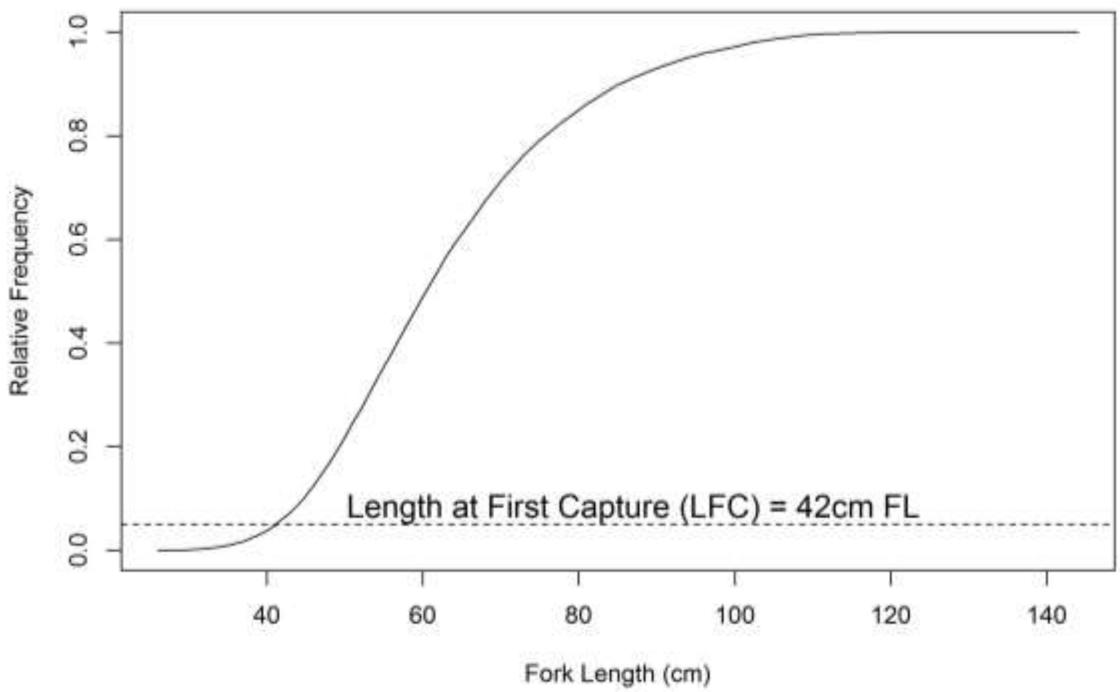


Figure 8.6.10 Length at first capture and length at full selection for Yellowmouth Grouper by the combined recreational fishery (charterboat, private, headboat) across all years (1990-2014). In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.



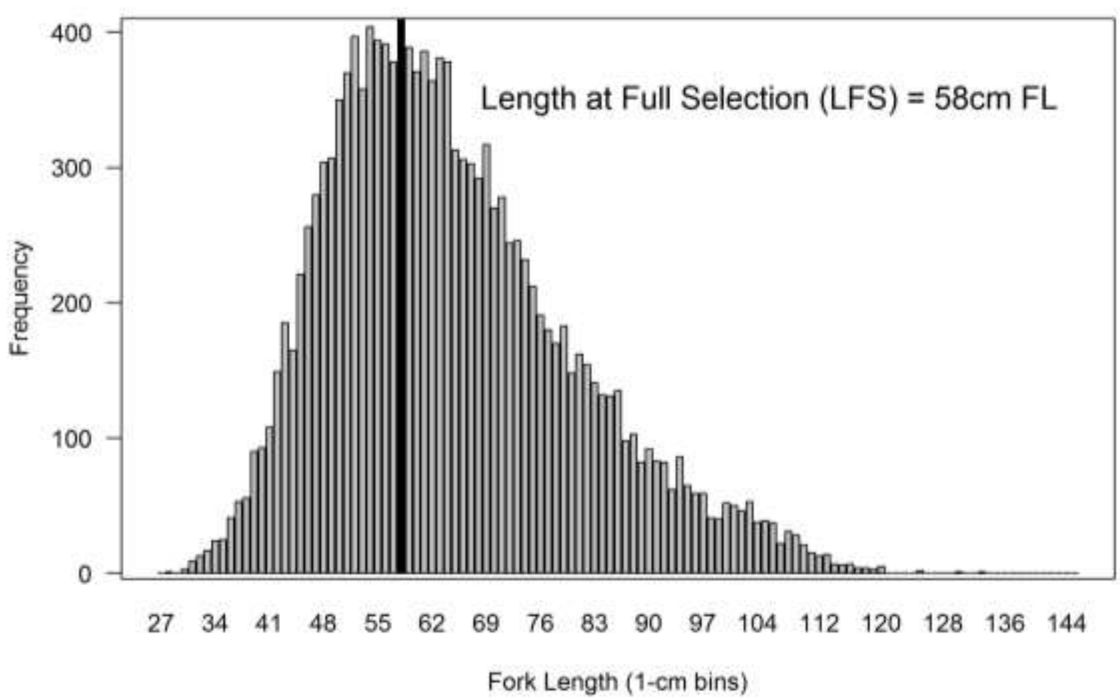


Figure 8.6.11 Length at first capture and length at full selection for Snowy Grouper by the commercial longline fishery across all years (1990 – 2014). In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.

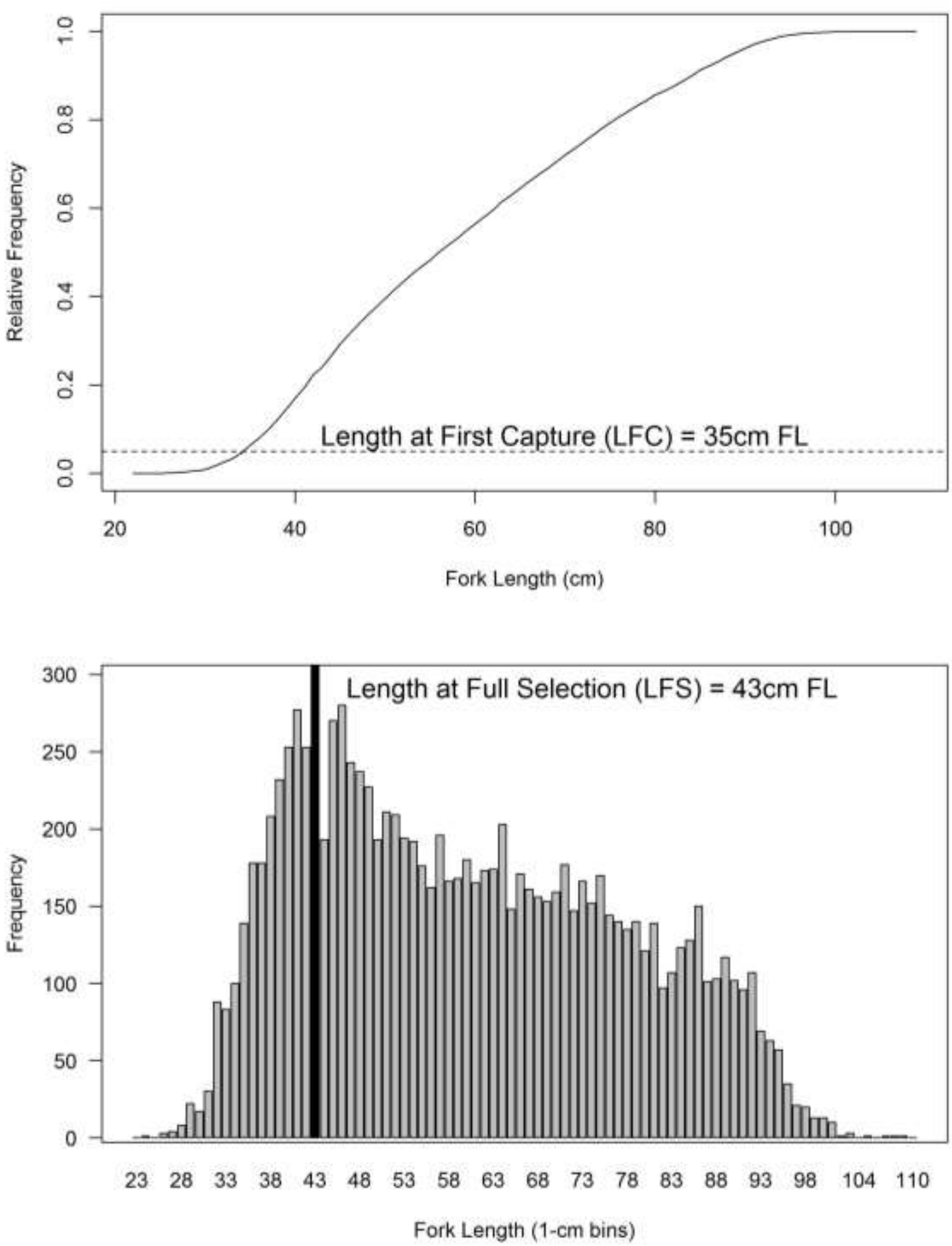
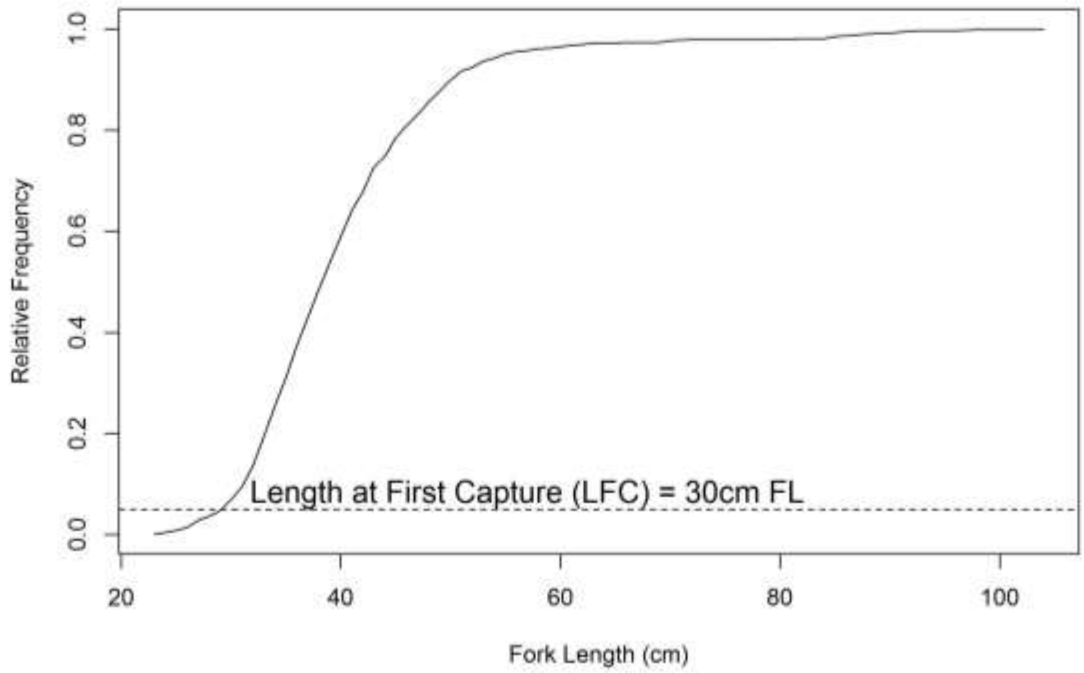


Figure 8.6.12 Length at first capture and length at full selection for Speckled Hind by the commercial longline fishery across all years (1997 – 2014). In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.



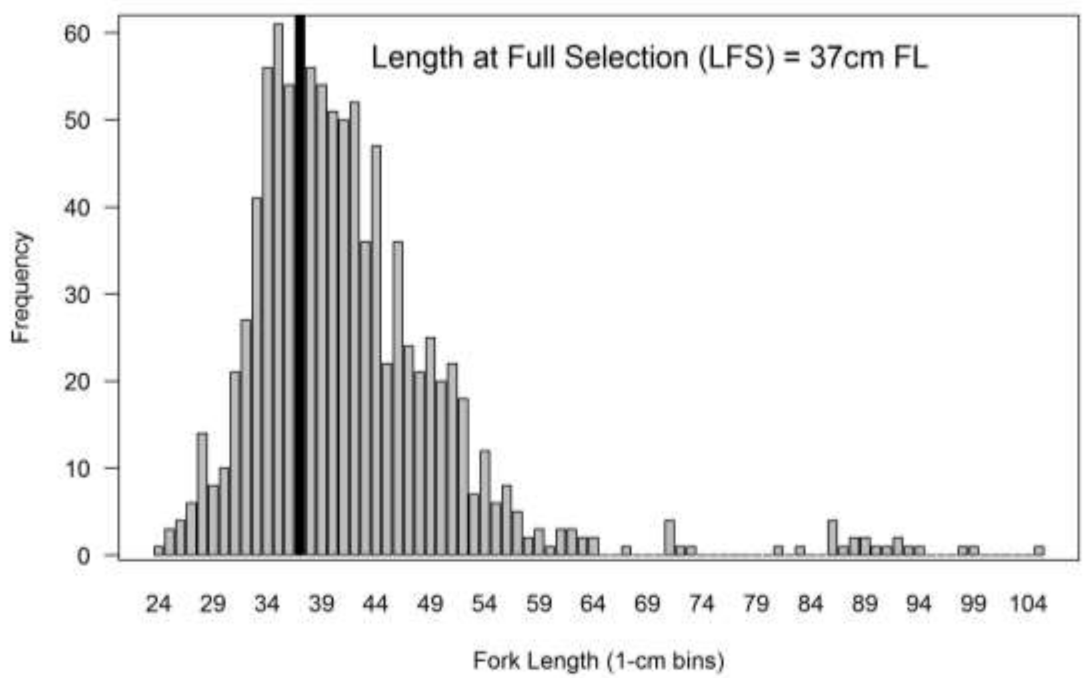


Figure 8.6.13 Length at first capture and length at full selection for Lesser Amberjack for the commercial handline fishery across the selected time period for analysis (1991 – 2009). Note that usage of data from 1991 through 2014 (as suggested as a sensitivity run) results in the same estimates of LFC and LFS. In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.

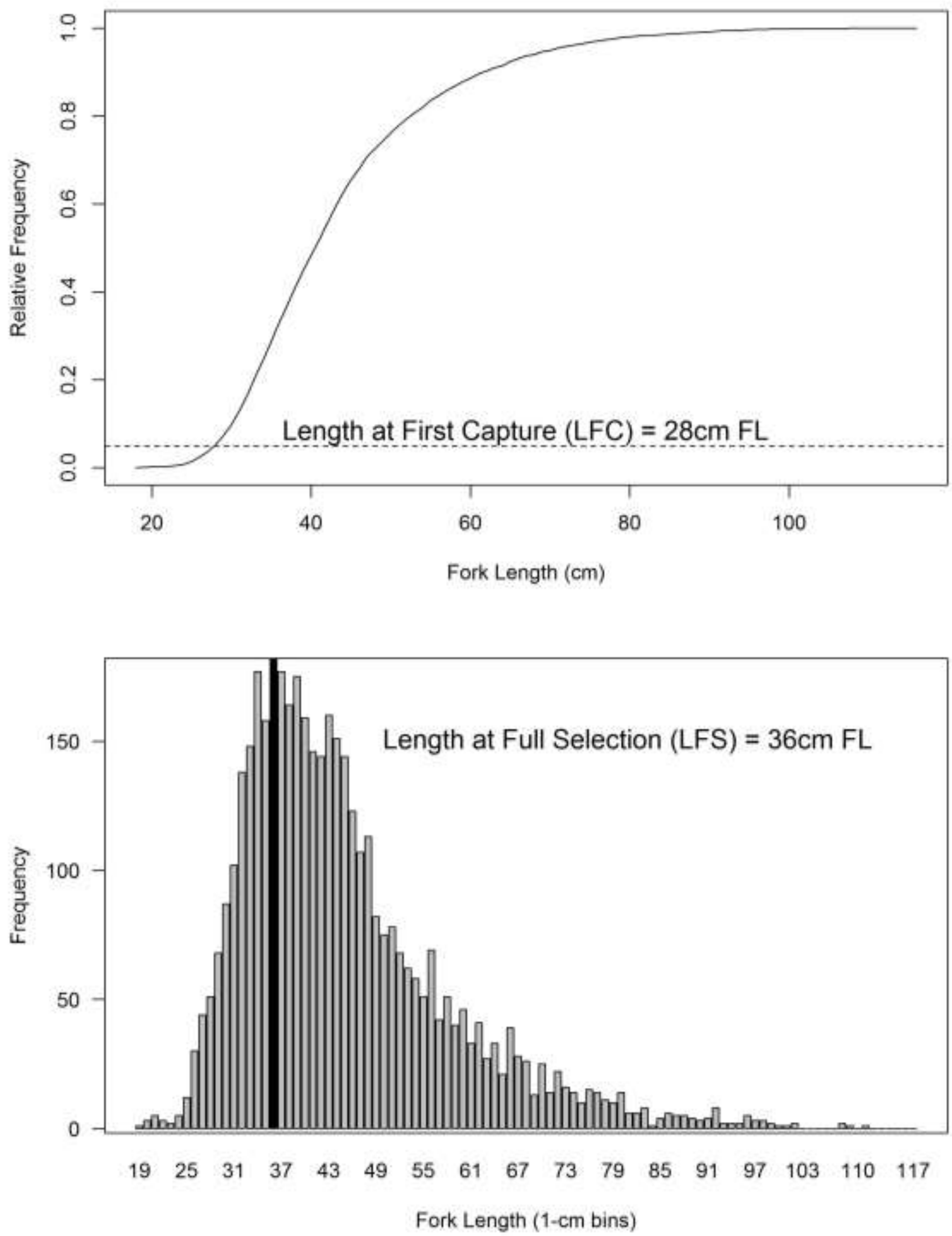


Figure 8.6.14 Length at first capture and length at full selection for Almaco Jack for the combined recreational fishery (charterboat, private, headboat) across all years (1991 – 2014). In the top panel, the dashed line identifies the 5% frequency. In the bottom panel, each bar represents a 1-cm length bin with the black bar identifying the smallest modal length.

9 AGE -FREQUENCY DATA

9.1 OVERVIEW

Some data-limited approaches in the Data-Limited Methods Toolkit can estimate current abundance using catch curve analysis. Age samples were obtained from a variety of fishery-independent and fishery-dependent data sources for three of the eight species under assessment:

1. Red Drum
   - *Fishery-dependent*:
     i. Alabama Deep Sea Fishing Rodeo (ADSFR) survey
   - *Fishery-independent*:
     i. Mississippi Department of Marine Resources (MDMR) gill net survey
     ii. NMFS Miami handline survey
     iii. Dauphin Island Sea Lab (DISL) bottom longline survey
     iv. Florida Fish and Wildlife Research Institute (FWRI) purse seine surveys
     v. Dauphin Island Sea Lab (DISL) purse seine survey
     vi. Louisiana State University (LSU) and NMFS Pascagoula purse seine surveys
2. Wenchman
   - *Fishery-independent:*
     i. NMFS small pelagics survey
3. Snowy Grouper
   - *Fishery-dependent:*
     i. Commercial handline
     ii. Commercial longline
   - *Fishery-independent:*
     i. NMFS bottom longline survey

For Red Drum, age was calculated by the number of annuli due to inconsistencies in the reporting of edge type across datasets (Tables 9.5.1-2). For Wenchman, age was calculated as the number of increments (Anderson et al. 2009), although no validation of annual age increments was undertaken due to the sporadic nature of sampling. For Snowy Grouper, calendar age was re-calculated from Kowal (2010) to reflect integer age for the number of annuli and edge type; however, there are still inconsistency in the interpretation of annuli and the validation of the timing of band deposition (Harris 2005).

9.2 REPRESENTATIVENESS

9.2.1 Red Drum

Red Drum otoliths were obtained from multiple studies varying over space and time that targeted the offshore adult population using purse seines (Table 9.5.1) and other gears (Table 9.5.2). The Life History Working Group (LHWG) selected the purse seine gear as most appropriate in characterizing the age composition of adult Red Drum because this gear tends to be least selective and relatively non-biased (Hightower et al. 2016). Although slight differences were evident in the gear dimensions of the purse seines employed in each survey (Table 9.5.1), the LHWG agreed that the purse seine data could be combined to represent age composition for Red Drum under assessment, with the caveats that survey sites vary between studies (e.g., central Florida vs. Alabama), the purse seine gear dimensions are not identical, and sampling occurred at both inshore (<3 miles) and offshore (up to 10 miles) sites (Table 9.5.1). Red Drum collected by purse seine ranged from 1 to 41 years in age, although no individuals were observed between 34 and 40 years (Figure 9.6.1). The overall age distribution of Red Drum was highly skewed towards younger age classes, likely an artifact of purse seines also sampling inshore waters in addition to offshore waters (Figures 9.6.1-2). Annual age frequencies and sample sizes shown in Figure 9.6.3 reflect differences in age samples collected from various data sources and regions.

Gears other than purse seines were also employed by various studies but sampled younger Red Drum compared to the purse seines (Figure 9.6.4). The LHWG discussed the consideration of the age composition from the DISL bottom longline survey as a sensitivity run since this survey also samples a large portion of older Red Drum (Figure 9.6.5). This survey has been conducted since 2006, samples randomly selected sites, and follows the Southeastern Monitoring and Assessment Program (SEAMAP) standardized protocols. It is important to note that this survey has undergone several survey design changes to include further offshore waters within and outside of the Alabama Reef Permit Zone, which are discussed in Hightower et al. (2016). Ages of Red Drum collected by the DISL bottom longline survey ranged from 2 to 36 years with a mode of 21 years (Figure 9.6.5). Annual age frequencies and sample sizes shown in Figure 9.6.6 reveal relatively similar trends in age distribution with peaks between 15 and 20 years, although annual sample sizes are relatively low.

9.2.2 Lane Snapper

No age samples were provided for Lane Snapper.

9.2.3 Wenchman

Wenchman otoliths (n = 115) were collected off Louisiana and Florida during October and November of 2007 during the NMFS Pascagoula fishery-independent groundfish (bottom trawl) survey and analyzed in Anderson et al. (2009). Due to the limited collection of samples in only 2 months of 2007, annual age composition was not available for inclusion in this assessment for Wenchman.

9.2.4 Yellowmouth Grouper

No age samples were provided for Yellowmouth Grouper.

9.2.5 Snowy Grouper

Snowy Grouper otoliths (n = 265 handline; n = 773 longline) from the northern and eastern regions of the Gulf of Mexico were collected from commercial fisheries and the NMFS bottom longline survey between 1984 and 2004 and analyzed by Kowal (2010). Annual sample sizes range from 0 to 87 and from 19 to 328 for the commercial handline and longline fisheries, respectively. Due to the sporadic nature of collections and the low number of samples per year, age composition for Snowy Grouper was not recommended by the LHWG for inclusion in this assessment.

9.2.6 Speckled Hind

No age samples were provided for Speckled Hind.

9.2.7 Lesser Amberjack

No age samples were provided for Lesser Amberjack.

9.2.8 Almaco Jack

No age samples were provided for Almaco Jack.

9.3 RESEARCH RECOMMENDATIONS

9.3.1 Red Drum

- Develop common practices for aging, interpreting edge, assigning annual or co-hort age, and calculating fractional age (or biological age) for Red Drum across federal and state agencies
- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations, particularly for offshore fish

9.3.2 Lane Snapper

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations

- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001)

9.3.3 Wenchman

- Increase collection of age samples at varying sizes, seasons or months, and locations
- Determination of the reproductive season to assist in determining when growth increments are deposited
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001)

9.3.4 Yellowmouth Grouper

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

9.3.5 Snowy Grouper

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

9.3.6 Speckled Hind

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

9.3.7 Lesser Amberjack

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Improvement of methods for aging *Seriola* sp. due to the difficulty in interpreting annuli marks
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001)

9.3.8 Almaco Jack

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Improvement of methods for aging *Seriola* sp. due to the difficulty in interpreting annuli marks
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

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9.5 TABLES

Table 9.5.1 Summary of studies employing purse seines to sample the age structure of adult population of Red Drum present offshore in the Gulf of Mexico.

Data Source	**Louisiana State University (LSU), NMFS Pascagoula**	**Florida Fish and Wildlife Research Institute (FWRI)**	**Dauphin Island Sea Lab (DISL)**
Year(s) collected	1986-1988, 1997-1998	1996-1998 and 2006-2008	2014
Describe sampling	Fishery-independent purse seine, spotter plane	Fishery-independent purse seine, spotter plane	Fishery-independent purse seine
Dimensions of gear	457 x 30 m	Several hundred yards long x 30 feet deep or more	None provided
Number of records	2,312	1,725	468
Spatial coverage	Coastal waters between Texas and Alabama	Coastal waters off Tampa Bay, Florida	Coastal waters off Alabama
Distance from shore	Not reported	1997-1998: 1-9 miles 2006-2008: 4 – 6 miles	Not reported
Type age structures	Thin-sectioned otoliths	Thin-sectioned otoliths	Thin sectioned otoliths
Number of samples aged	2,279	1,725	464
Age assignment	Aged using annual ring count and assigned edge types (1-6) (Beckmann et al. 1989)	No edge types assigned Fractional age adjusted for birthday of October 1 and date of capture	Aged using annual ring count and assigned edge types (opaque, translucent) (Beckmann et al. 1989)
Reader agreement	None - only one reader	Assume two readers given description (Murphy and Taylor 1990); none reported	99.998% agreement between two readers
Supporting report(s)/ manuscript(s)	Wilson and Nieland 1994; Mitchell and Henwood 1999; Wilson and Nieland 2000	Murphy and Crabtree 2001; Winner et al. 2014	Powers et al. 2012; Hightower et al. 2016

Table 9.5.2 Summary of studies employing other gears to sample Red Drum in the Gulf of Mexico.

Data Source	**NMFS Panama City**	**Dauphin Island Sea Lab (DISL)**	**Mississippi Department of Marine Resources (MDMR)**	**Dauphin Island Sea Lab (DISL)**
Year(s) collected	2002	2009, 2011-2014	2006-2014	2006-2014
Describe sampling	Fishery-independent, hook and line	Fishery-dependent survey, Alabama Deep Sea Fishing Rodeo, hook and line	Fishery-independent gill net	Randomized block fishery-independent bottom longline
Number of records	1,146	757	2,008	712
Spatial coverage	Texas to Florida panhandle	Coastal waters off Alabama	Mississippi coastal Waters	Inshore and offshore waters off Alabama
Type age structures	Thin-sectioned otoliths	Thin-sectioned otoliths	Thin-sectioned otoliths	Thin-sectioned otoliths
Number of samples aged	1,116	621	1,158	455
Age assignment	Calendar and fractional age – adjusted for edge type (opaque, translucent), month of capture and birthdate of October 1. Calendar Age = [(2 + (12*#_of_Annuli) + month)/12]	Aged using annual ring count and assigned edge types (opaque, translucent) (Beckmann et al. 1989)	Calendar age advance # of annuli given capture date and edge type (1, 2, 3, 4). Fractional age based on birthday of October 1. Adjustment for age zero fish and fish with at least one annuli.	Aged using annual ring count and assigned edge types (opaque, translucent) (Beckmann et al. 1989)
Reader agreement	Percent agreements calculated between readers (co-authors, 96%) and between external ageing facility (87% ± 1 band 90%)	99.998% agreement between two readers	two out of three readers agree, no indices of precision	99.998% agreement between two readers
Supporting report/manuscript	McInerny and Potts unpublished manuscript	Powers et al. 2012; Hightower 2013; Hightower et al. 2016	None	Powers et al. 2012; Hightower 2013; Hightower et al. 2016

9.6 FIGURES

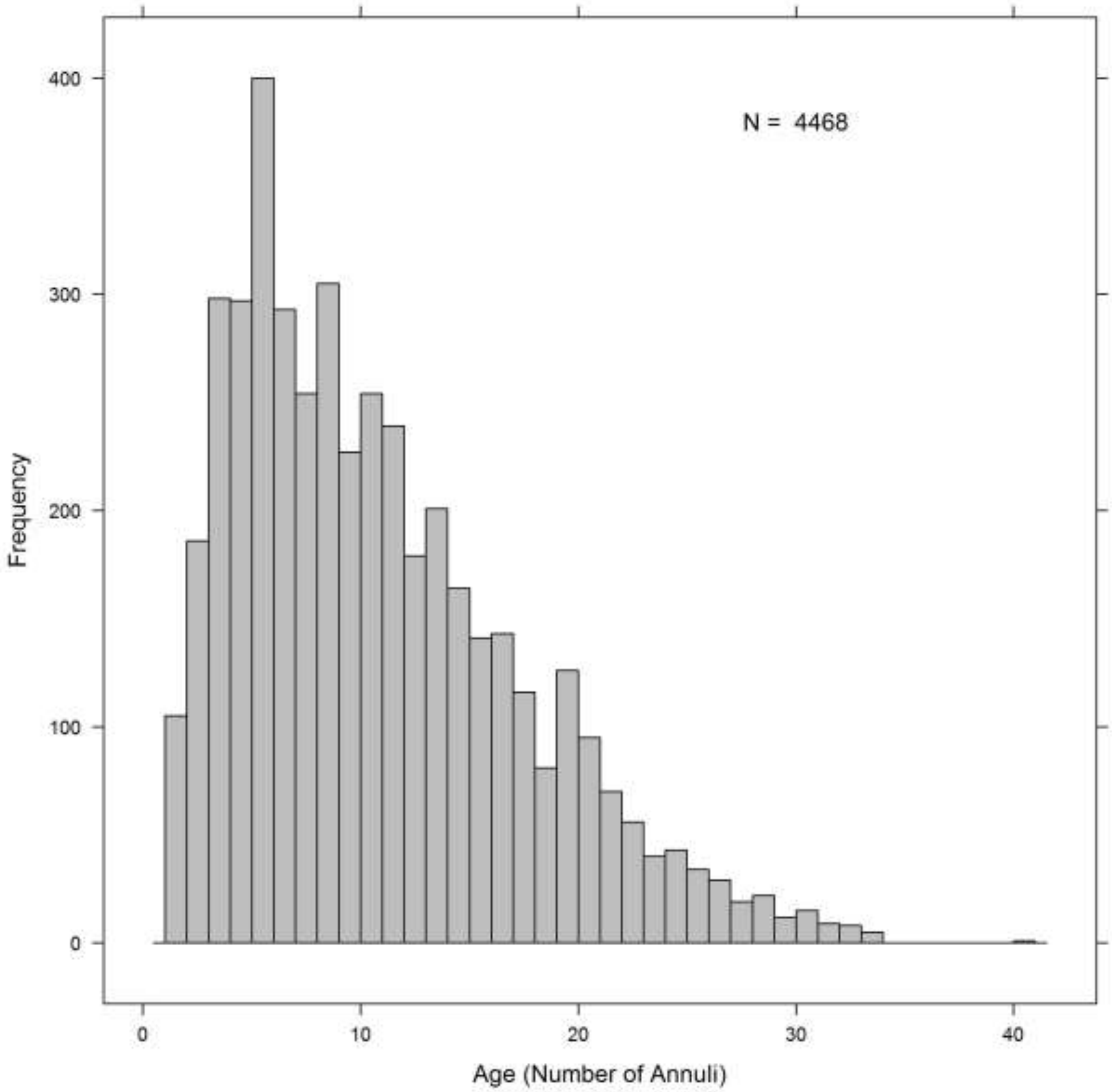

Figure 9.6.1 Age frequency across all years for Red Drum collected from purse seine surveys.

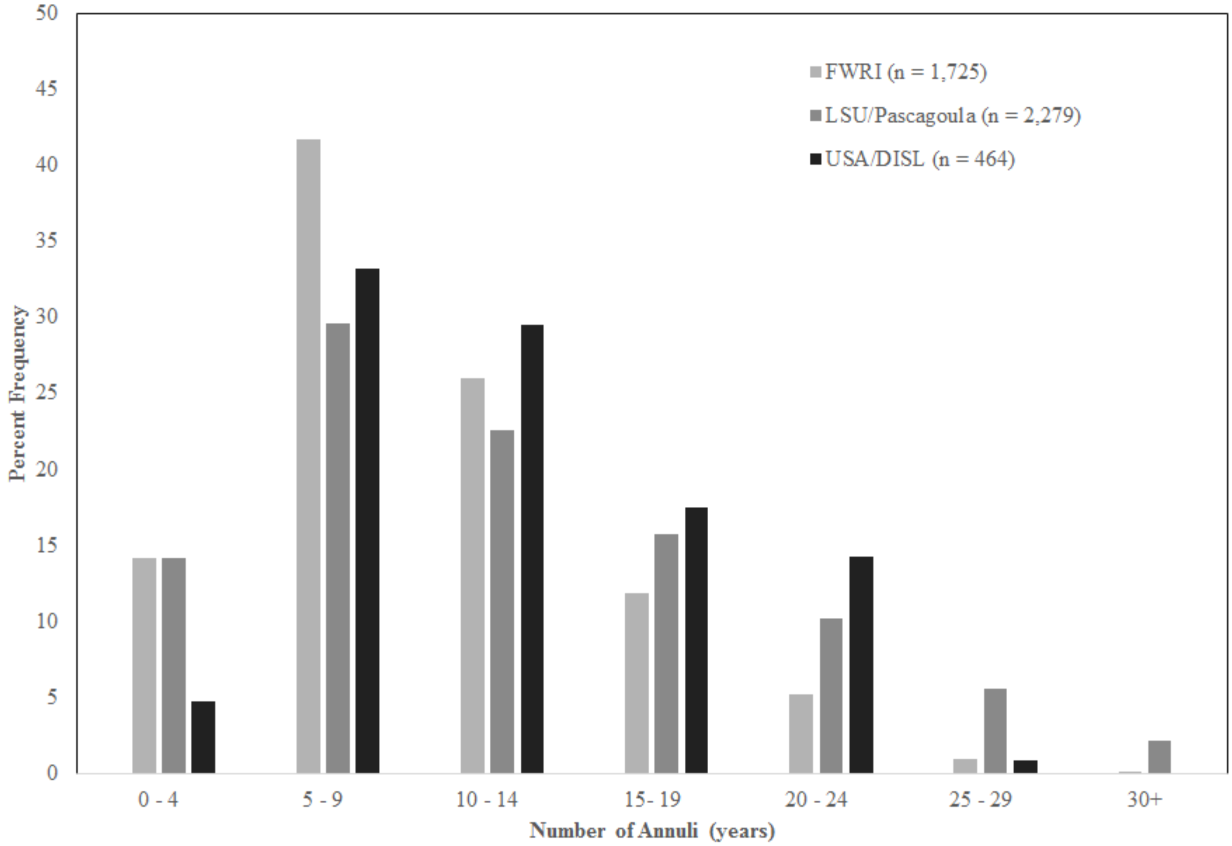

Figure 9.6.2 Age frequency in 5-year bins from all data sources providing age data for Red Drum from purse seine gear.

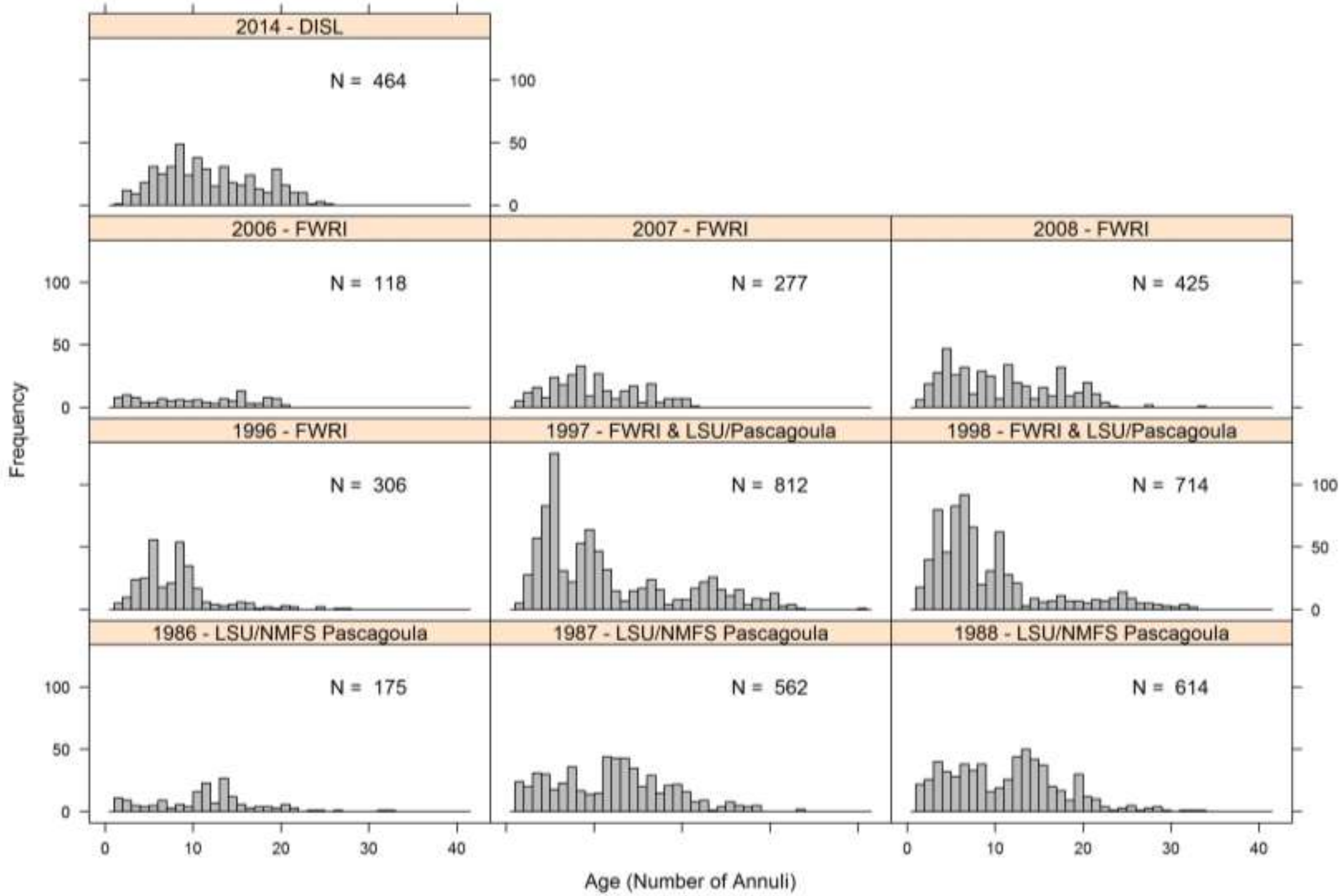

Figure 9.6.3 Annual age frequency histograms for Red Drum caught during fishery-independent purse seine surveys. Note that age frequencies from 1997 and 1998 include both FWRI and LSU/NMFS Pascagoula samples. Each bar represents a 1-year age bin.

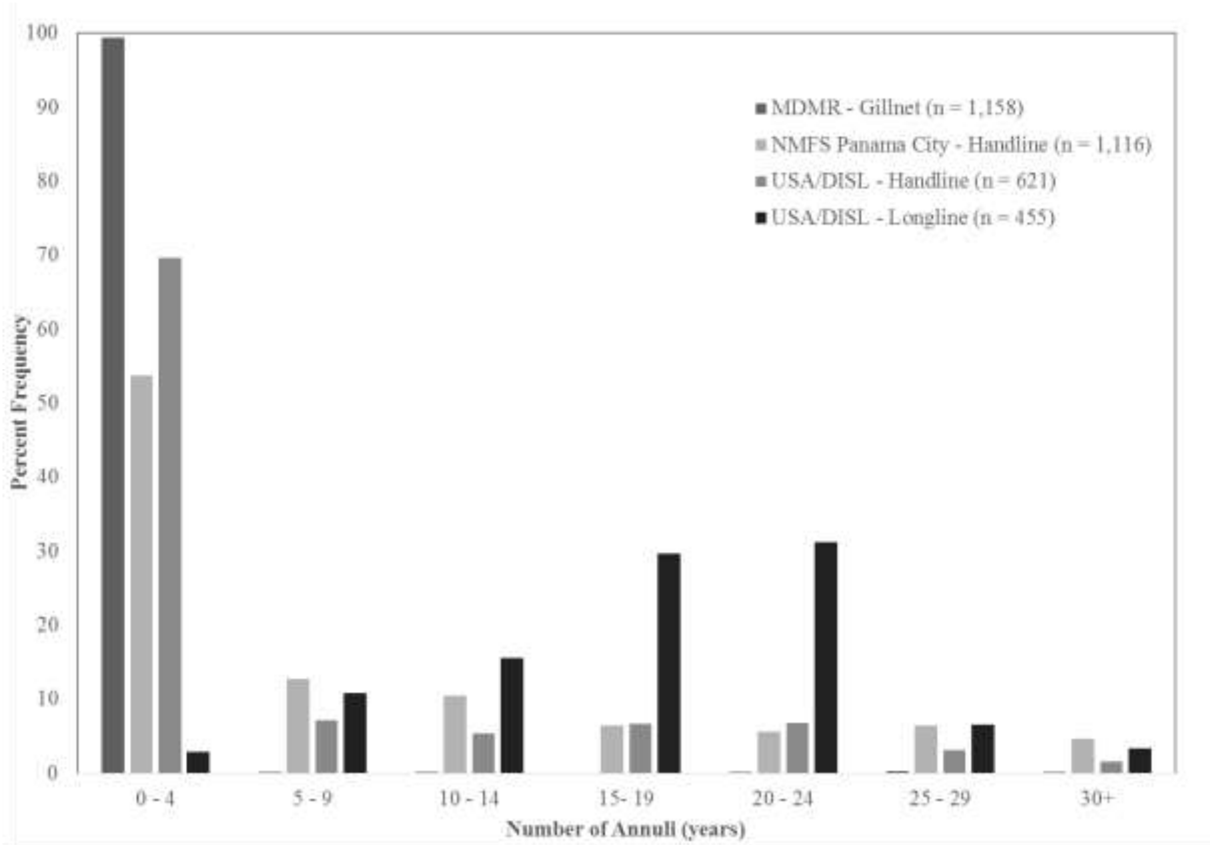

Figure 9.6.4 Age frequency in 5-year bins from all data sources providing age data for Red Drum from other gears.

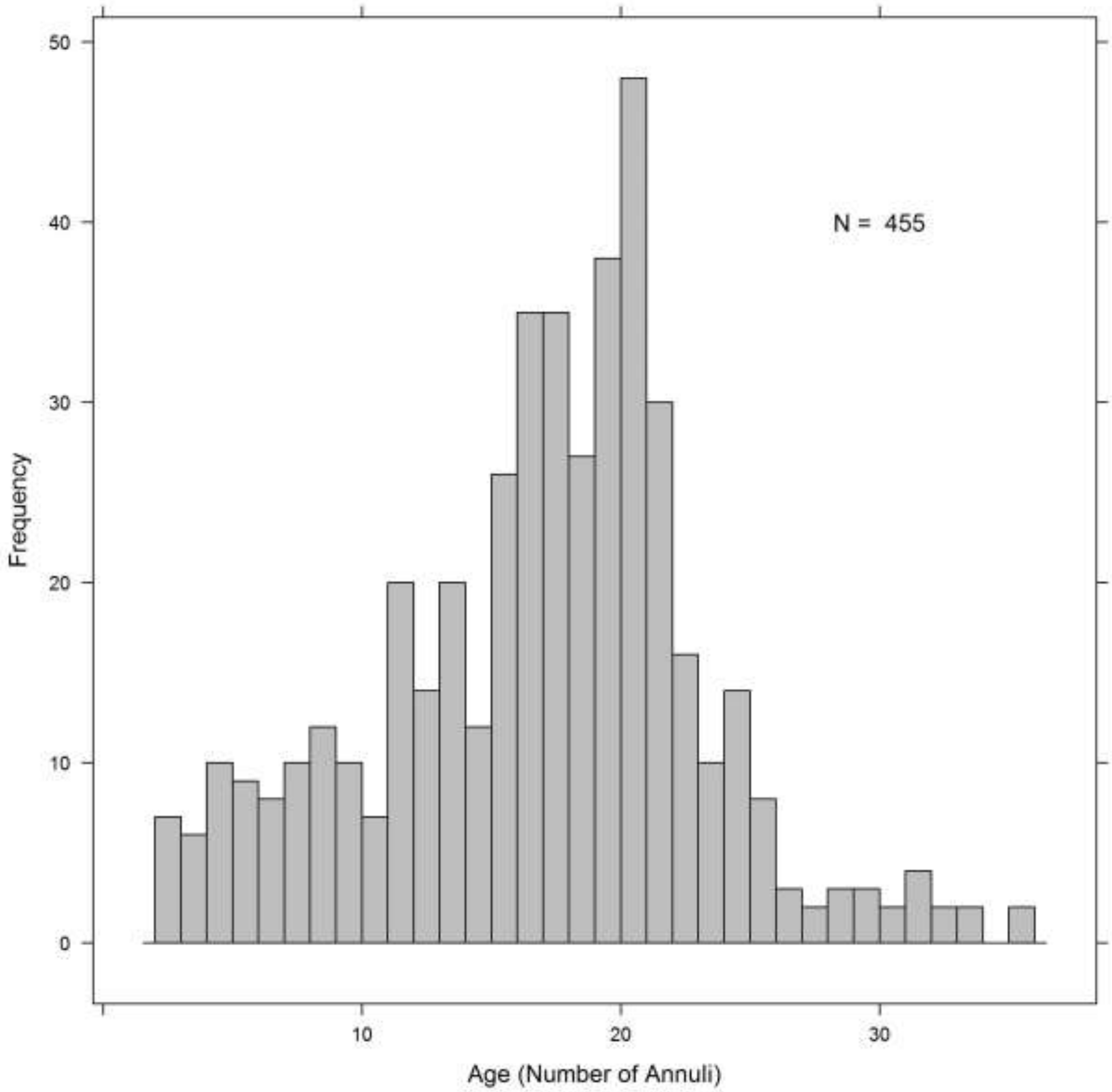

Figure 9.6.5 Age frequency across all years for Red Drum collected from the DISL bottom longline survey.

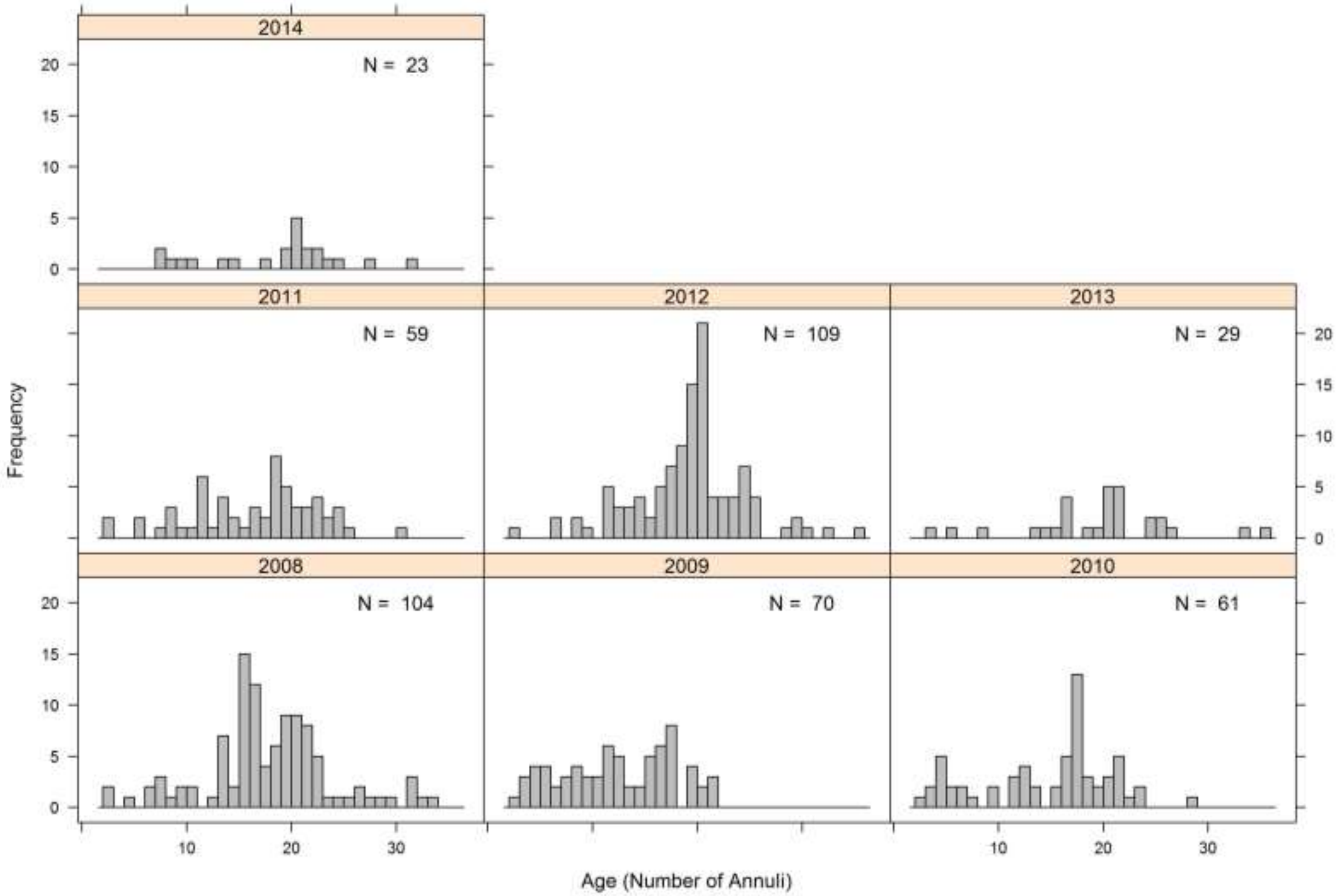

Figure 9.6.6 Annual age frequency histograms for Red Drum caught during the fishery-independent DISL bottom longline survey. Each bar represents a 1-year age bin.

10 CONTRIBUTIONS FROM STAKEHOLDERS

10.1 OVERVIEW

Assessment of data-limited stocks is often limited to simple approaches due to the lack of sufficient information to conduct more traditional stock assessments. For many data-limited species, fishermen and stakeholders can possess insights into stock or fleet dynamics not necessarily captured in available data, which can be limited in both quantity and quality. A simulation study which creates a hypothetical stock and fishing fleet as close to reality as possible can help assess whether data-limited methods will produce viable management advice. Incorporation of fishermen and stakeholder knowledge can greatly enhance the characterizations of stock and fleet dynamics and help capture uncertainties.

10.2 SPECIES ENCOUNTERS

Variable accounts of species encounters were described by the fishermen and stakeholders in attendance, as well as whether these species were caught as target or bycatch species. A summary of the information discussed at the Data Workshop is provided in Table 10.8.1.

10.3 SPECIES MISIDENTIFICATION

The potential for misidentification of SEDAR 49 species was discussed with various fishermen and stakeholders at the Data Workshop. Concerns are summarized below by species.

10.3.1 Red Drum

No species identification issues were discussed for Red Drum.

10.3.2 Lane Snapper

No species identification issues were discussed for Lane Snapper.

10.3.3 Wenchman

There were concerns raised regarding the identification of Wenchman in recreational fisheries. Since this species is rarely encountered, species identification may not be known at the time of capture. It is possible that Wenchman may be reported as unidentified bony fish.

10.3.4 Yellowmouth Grouper

There were concerns raised regarding the identification of Yellowmouth Grouper in both commercial and recreational fisheries. This species can easily be confused with Scamp (*Mycteroperca phenax*) due to similarity in body color and markings (Heemstra and Randall 1993). Although a "yellow mouth" is used as an identification marker for Yellowmouth Grouper, Scamp can also possess a yellow mouth (Gilmore and Jones 1992). An inquiry to federal Trip Interview Program port agents on Yellowmouth Grouper identification further supported the potential for confusion of these species, stating "both species also both have yellow coloration on the mouth, however that yellow coloration is much more prominent and covers more area on and inside the mouth of the Yellowmouth Grouper than on the mouth of the Scamp."

10.3.5 Snowy Grouper

Concerns were also raised regarding the potential misidentification of Snowy Grouper by recreational fishermen. Juveniles of both Snowy Grouper and Warsaw Grouper (*Epinephelus nigritus*) are similar in appearance as both have whitish spots on their body (Heemstra and Randall 1993). In addition, there was also discussion of the potential reporting of Snowy Grouper as Black Grouper in recreational fisheries in the early years of recreational reporting.

10.3.6 Speckled Hind

No species identification issues were discussed for Speckled Hind.

10.3.7 Lesser Amberjack

There were repeated concerns raised regarding the potential misidentification of Lesser Amberjack in both commercial and recreational fisheries. Lesser Amberjack resemble other members of the genus *Seriola* including Almaco Jack, Banded Rudderfish (*Seriola zonata*), and juvenile Greater Amberjack (*Seriola dumerili*). Berry and Burch (1979) provided guidance on species identification of individuals larger than 30 cm FL based on meristics, highlighting the difficulty of identifying individuals of each species below that size. All four species are nearly identical in appearance and meristics such as fin-ray counts can overlap between species (Renshaw and Gold 2009). Of particular concern is the potential mistaken identity of undersized Greater Amberjack as Lesser Amberjack (Renshaw and Gold 2009), which could result in the landing of "illegal fish" (Thompson et al. 1996). Generally, if fishermen catch an amberjack below the size limit, it is discarded as a precaution.

10.3.8 Almaco Jack

There were also concerns raised regarding the potential misidentification of Almaco Jack for the same reasons as discussed above in 10.3.7 for Lesser Amberjack.

10.4 FISHERY CHARACTERISTICS

Discussions with various fishermen and stakeholders at the Data Workshop helped with the parameterization of fleet characteristics for the majority of the SEDAR 49 species. For each species, topics addressed included the smallest size caught (akin to the length at first capture), the most common size caught (akin to the length at full selection), the vulnerability of older age classes to the fishery (selectivity), the historical period of exploitation by the fishery, and the inter-annual variability in fishing mortality rate. A summarization of comments is provided in Table 10.8.2.

10.5 DISCARD MORTALITY AND SIZE OF DISCARDS

Information on discard mortality, reasons for discarding, and size of discards for the SEDAR 49 species was obtained through discussion with various fishermen and stakeholders at the Data Workshop. A summary of contributed information is provided below for each species.

10.5.1 Red Drum

The recreational Red Drum fishery primarily occurs in shallow estuarine waters where immature Red Drum reside (Flaherty et al. 2013). A literature search suggested a low discard mortality rate of 5 to 8% for Red Drum, which was substantiated by fishermen in attendance based on their fishing experiences. When released due to regulatory, slot, or bag limits, low discard mortality was supported by release in shallow waters and their tough/hardy reputation. An average size of discarded fish was discussed to assist with converting recreational dead discards from numbers to weights (see Section 4.4).

10.5.2 Lane Snapper

Similarly to Red Drum, a low discard mortality rate was suggested for Lane Snapper because this species is not coming up from depth and therefore does not experience barotrauma, or any injury caused by a change in air pressure. Individuals are often discarded if they are small (< 8 inches).

10.5.3 Wenchman

No information on discards of Wenchman was available due to their rarity in occurrence.

10.5.4 Yellowmouth Grouper

The fishermen discussed the rarity of releasing Yellowmouth Grouper unless a species aggregate limit was reached. They also agreed that shallow-water grouper species generally experience relatively low discard mortality. An average size of discarded fish was discussed to assist with converting recreational dead discards from numbers to weights (see Section 4.4).

10.5.5 Snowy Grouper

Discard mortality of deep-water groupers can be much higher because fish brought up from deep water often experience barotrauma. However, there was some discussion regarding recreational versus commercial discard mortality and the behavior of fishermen. When fishing with an electric reel as in the recreational fishery, deep-water grouper may come up slowly and not necessarily fall victim to barotrauma, resulting in below 100% discard mortality. However, in a commercial fishing operation where speed of gear retrieval tends to be faster, discard mortality is thought to be closer to 100%. Snowy Grouper are generally only discarded if the recreational bag limit is reached. An average size of discarded fish was discussed to assist with converting recreational dead discards from numbers to weights (see Section 4.4).

10.5.6 Speckled Hind

Insights into discard mortality of Speckled Hind were identical to those discussed in Section 10.5.5 for Snowy Grouper.

10.5.7 Lesser Amberjack

In data-limited assessments, it is often common practice to borrow information from similar species. In the case of Lesser Amberjack, the fishermen were adamant about using caution with Greater Amberjack information as a substitute for Lesser Amberjack, particularly concerning discard mortality. Lesser Amberjack appear to be hardier than Greater Amberjack, although they are also caught at depth and potentially vulnerable to barotrauma. A moderate discard mortality rate was supported by the fishermen based on their experiences catching Lesser Amberjack. When caught, Lesser Amberjack are generally discarded if they are below the size limit.

10.5.8 Almaco Jack

As mentioned for Lesser Amberjack, the fishermen were adamant about using caution with Greater Amberjack information as a substitute for Almaco Jack, particularly concerning discard mortality. Fishing behavior was suggested to differ between how Greater Amberjack are being fished and how Almaco Jack are being caught. Greater Amberjack often come up from depth and fight harder than other amberjacks, whereas Almaco Jack are generally not caught at depth and considered a more hardy fish. Almaco Jack may be caught near the surface as the line is being reeled in. As a result, a discard mortality rate below 10% was supported by the fishermen in attendance. Smaller individuals are often discarded, although some may be kept and used as bait to target other species.

10.6 ECOSYSTEM CONSIDERATIONS

A few ecosystem considerations were brought up during the SEDAR 49 Data Workshop. A decline in Red Drum catches in the recreational fishery during 2015 was attributed to the influence of cold winter temperatures. For Almaco Jack, an association with floating *Sargassum* was also mentioned by recreational fishermen. A previous study off North Carolina identified the association of pelagic species with pelagic *Sargassum* habitats by assessing the diets of fishes including both Almaco Jack (n = 160) and Lesser Amberjack (n = 51) (Casazza 2008).

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10.8 TABLES

Table 10.8.1 Frequency of encounters and comments of desirability for the species under assessment.

Species	Exposure	Notes
Red Drum	High	Targeted by the recreational fishery in estuarine and inshore waters, due to a closure of fishing in federal waters
Lane Snapper	High	Popular "candy" fish targeted by the recreational fishery, which includes a modest shore component
Wenchman	Rare	Wenchman are rarely encountered by recreational fishermen as bycatch
Yellowmouth Grouper	Rare	Not targeted by any fishery but typically kept if caught. Not as desirable as other groupers
Snowy Grouper	Moderate	Not targeted by any fishery but typically kept if caught. Not as desirable as other groupers
Speckled Hind	Moderate	Not targeted by any fishery but typically kept if caught. Not as desirable as other groupers
Lesser Amberjack	Rare	Not targeted by any fishery and rarely encountered. Low desirability and demand
Almaco Jack	Moderate	Primarily landed and used as bait for target species

Table 10.8.2 Preliminary information characterizing the fleets selected as most representative for each species. Fleet/Gear include Commercial (Comm) and Recreational (Recr), Private (PR), Combined (Comb), Longline (LL), and Handline (HL).

Species	Fleet / Gear	Smallest size caught by the fishery?	Most frequent size caught by the fishery?	Are the oldest fish vulnerable?	How many years has the stock been exploited?	Interannual variability in fishing mortality
Red Drum	Recr PR	~6-7 inches	Gulf-wide: ~18-19 inches but regional differences exist: LA (small), FL (large)	No, size limits impose double-logistic selectivity pattern	~150 years; lots of fishing early on for Red Drum, particularly in Texas	Low
Lane Snapper	Recr PR	~7 inches	~12 inches	Yes, asymptotic selectivity	~100 years (corresponds with year railroad was extended to Key West, FL)	Low
Wenchman	Comm Net	Unknown	Unknown	Unknown	Unknown	Unknown
Yellowmouth Grouper	Recr Comb	~8 inches	~12 inches	Yes, asymptotic selectivity	~75 years (onset of headboat fishery)	Low
Snowy Grouper	Comm LL	~16 inches	~18 inches	Yes, asymptotic selectivity	~45 years (when bottom longline fishing begin; ramped up in the 1970s)	Moderate, due to changes in regulations, quotas
Speckled Hind	Comm LL	~16 inches	~18 inches	Yes, asymptotic selectivity	~45 years (when bottom longline fishing begin; ramped up in the 1970s)	Moderate, due to changes in regulations, quotas
Lesser Amberjack	Comm HL	~5 inches	NA (rarely caught)	Dome-shaped selection	~75 years	Unknown, rarely caught
Almaco Jack	Recr Comb	~5 inches	~6 inches	No, due to hook size used (dome-shaped selection)	~75 years (onset of headboat fishery)	Low

SEDAR

Southeast Data, Assessment, and Review

SEDAR 49

Gulf of Mexico Data-limited Species:

Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, and Lesser Amberjack

SECTION III: Assessment Workshop Report

October 2016

******For Final Results documenting any changes requested by the Review Panel, please see Section VI – Addendum of this document******

SEDAR
4055 Faber Place Drive, Suite 201

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1 INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

A series of webinars was held in lieu of an in-person assessment workshop. The webinars were held between June and September 2016.

1.2 TERMS OF REFERENCE

1. *Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration for each model considered.*

Section 3 describes the analytical approach used in the SEDAR 49 evaluation. Pertinent details are briefly described here. Multiple analytical models were used to conduct this assessment. The Data-Limited Methods Toolkit (DLMtool), a software program that allows evaluation of the performance of multiple data-limited assessment models in a simulation environment using management strategy evaluation (MSE), was the primary modeling platform used in this assessment to estimate reference or target catch levels. In addition to the DLMtool, a mean length estimator approach assuming nonequilibrium conditions was used to estimate total mortality from length-frequency data. Lastly, a catch curve analysis was employed where possible to estimate the total mortality rate.

Model assumptions and configurations for each model considered are provided in Table 3.1.3 for the DLMtool analyses, in Section 3.2.2 for the mean length estimator approach, and Section 3.3.2 for catch curve analysis. Input data for the eight species under assessment are documented in Tables 3.1.5 through 3.1.12 for the DLMtool analyses, Table 3.2.1 for the mean length estimator analysis, and Table 3.3.1 for the catch curve analysis.

2. *Provide estimates of population benchmarks or management criteria consistent with available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards (e.g. OFL, ABC) or other indicators (e.g. trends in F or Z, probability of overfishing) that may be used to inform managers about stock trends and conditions?*

The main results from each approach evaluated are prescribed below. For each method and species assessed, the following table identifies the Sections summarizing results and management advice. – indicates method deemed not feasible.

Species	DLMtool, Catch Recommendations (in pounds)	Mean Length Estimator (trends in Z and F)	Catch Curve Analysis (trends in Z and F)	Overall Evaluation Summary
Red Drum	Section 4.1.3	Section 4.2	Section 4.3	Figure 12.1
Lane Snapper	Section 5.1.3	Section 5.2	–	Figure 12.2
Wenchman	Section 6.1.3	Section 6.2	–	Figure 12.3
Yellowmouth Grouper	–	–	–	–
Snowy Grouper	Section 8.1.3	Section 8.2	–	Figure 12.4
Speckled Hind	Section 9.1.3	Section 9.2	–	Figure 12.5
Lesser Amberjack	Section 10.1.3	–	–	Figure 12.6
Almaco Jack	Section 11.1.3	–	–	Figure 12.7

3. Characterize uncertainty in the assessment and estimated values.

- *Consider uncertainty in input data, modeling approach, and model configuration.*
- *Provide appropriate measures of model performance, reliability, and 'goodness of fit'.*
- *Provide measures of uncertainty for estimated parameters.*

The following table identifies the Sections summarizing sensitivity examinations conducted to characterize uncertainty in the evaluation and estimated values. – indicates method deemed not feasible.

Species	DLMtool			
	Method Performance/ Convergence in MSE	Uncertainty in MSE (i.e. Operating Model Sensitivity) and Model Configuration	Measures of Uncertainty for Catch Recommendations	Uncertainty in Data (Sensitivity of Catch Recommendations)
Red Drum	Section 4.1.1	Section 4.1.2	Section 4.1.3	Section 4.1.4
Lane Snapper	Section 5.1.1	Section 5.1.2	Section 5.1.3	Section 5.1.4
Wenchman	Section 6.1.1	Section 6.1.2	Section 6.1.3	Section 6.1.4
Yellowmouth Grouper	-	-	-	-
Snowy Grouper	Section 8.1.1	Section 8.1.2	Section 8.1.3	Section 8.1.4
Speckled Hind	Section 9.1.1	Section 9.1.2	Section 9.1.3	Section 9.1.4
Lesser Amberjack	Section 10.1.1	Section 10.1.2	Section 10.1.3	Section 10.1.4
Almaco Jack	Section 11.1.1	Section 11.1.2	Section 11.1.3	Section 11.1.4

4. Provide recommendations for future research to improve stock assessment (e.g. sampling, fishery monitoring, methodological enhancements.)

Recommendations for future research can be found in Section 14 of this report.

5. Prepare an Assessment Process report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section III of the SEDAR assessment report).

This document serves as the Assessment Workshop report.

1.3 LIST OF PARTICIPANTS

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Staff
Julie Neer .... SEDAR
Ryan Rindone.. GMFMC

1.4 LIST OF ASSESSMENT WORKSHOP WORKING PAPERS & REFERENCE DOCUMENTS

Document #	Title	Authors	Date Submitted
Documents Prepared for the Assessment Process			
SEDAR49-AW-01	Review of Operating Model Parameters for SEDAR 49: Almaco Jack	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 July 2016
SEDAR49-AW-02	Review of Operating Model Parameters for SEDAR 49: Lane Snapper	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 July 2016 Updated: 12 August 2016
SEDAR49-AW-03	Review of Operating Model Parameters for SEDAR 49: Lesser Amberjack	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 July 2016
SEDAR49-AW-04	Review of Operating Model Parameters for SEDAR 49: Red Drum	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 July 2016 Updated: 12 August 2016
SEDAR49-AW-05	Review of Operating Model Parameters for SEDAR 49: Wenchman	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 July 2016 Updated: 12 August 2016
SEDAR49-AW-06	Review of Operating Model Parameters for SEDAR 49: Yellowmouth Grouper	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 July 2016 Updated: 12 August 2016
SEDAR49-AW-07	Synthesis of Literature on Von Bertalanffy Growth Parameter Correlations	Nancie Cummings, Skyler Sagarese and Bill Harford	29 July 2016
SEDAR49-AW-08	Review of Operating Model Parameters for SEDAR 49: Speckled Hind	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 August 2016
SEDAR49-AW-09	Review of Operating Model Parameters for SEDAR 49: Snowy Grouper	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	12 August 2016
SEDAR49-AW-	Technical description of operating	William J. Harford,	30 August

10	models in data-limited methods toolkit (DLMtool)	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	2016

Reference Documents

SEDAR49-RD01	Spatial and size distribution of red drum caught and released in Tampa Bay, Florida, and factors associated with the post-release hooking mortality	Kerry E. Flaherty, Brent L. Winner, Julie L. Vecchio, and Theodore S. Switzer
SEDAR49-RD02	Evaluating the current status of red drum (*Sciaenops ocellatus*) in offshore waters of the North Central Gulf of Mexico: age and growth, abundance, and mercury concentration	Crystal LouAllen Hightower
SEDAR49-RD03	DLMtool: Data-Limited Methods Toolkit (v3.2)	Tom Carruthers and Adrian Hordyk
SEDAR49-RD04	Evaluating methods for setting catch limits in data-limited fisheries	Thomas R. Carruthers, André E. Punt, Carl J. Walters, Alec MacCall, Murdoch K. McAllister, Edward J. Dick, Jason Cope
SEDAR49-RD05	Evaluating methods for setting catch limits in data-limited fisheries: Supplemental Appendix A	Thomas R. Carruthers, André E. Punt, Carl J. Walters, Alec MacCall, Murdoch K. McAllister, Edward J. Dick, Jason Cope
SEDAR49-RD06	Performance review of simple management procedures	Thomas R. Carruthers, Laurence T. Kell, Doug D. S. Butterworth, Mark N. Maunder, Helena F. Geromont, Carl Walters, Murdoch K. McAllister, Richard Hillary, Polina Levontin, Toshihide Kitakado, and Campbell R. Davies
SEDAR49-RD07	Performance review of simple management procedures: Supplemental Appendix A	Thomas R. Carruthers, Laurence T. Kell, Doug D. S. Butterworth, Mark N. Maunder, Helena F. Geromont, Carl Walters, Murdoch K. McAllister, Richard Hillary, Polina Levontin, Toshihide Kitakado, and Campbell R. Davies
SEDAR49-RD08	Generic management procedures for data-poor fisheries: forecasting with few data	H. F. Geromont and D. S. Butterworth

2 DATA REVIEW AND UPDATE

The SEDAR 49 stock assessment for Gulf of Mexico Data-limited Species began with a Data Workshop (DW) held May 2 – 6, 2016 in New Orleans, Louisiana. The reader is referred to the SEDAR 49 Data Workshop Report (DW Report) for details on the data sources reviewed and data recommended for assessment. A brief review is provided below in Section 2.1 as well as a brief summary of data issues raised and analyses conducted since the DW (Section 2.2 and 2.3, respectively). Lastly, semi-quantitative scores of reliability are provided for various data sources including life history, total removals, indices of abundance, and size composition to assist with model evaluations and recommendations (Section 2.4).

2.1 DATA REVIEW

Graphical summaries of the data reviewed and recommended for use in the SEDAR 49 stock evaluations are provided in Figures 2.1 – 2.8.

2.2 REVISITING TOTAL REMOVALS FOR LANE SNAPPER

Lane Snapper discards were revisited during Assessment Webinar I. Expert opinion from the Assessment Workshop (AW) Panel indicated that the initial assumption of a negligible impact from discards may be too optimistic, thus possibly introducing a negative bias in the level of total removals. The initial recommendation by the Total Removals Working Group was to assume low discard mortality for Lane Snapper as this species is frequently caught at shallow depths, including landings from bottom longline gear (assumed caught as the gear was retrieved). A summary of the landings indicates the recreational sector is the dominant source of removals, thus, it was suggested to conduct a sensitivity run on the magnitude of total removals to determine what the potential impact could be of excluding commercial discards for Lane Snapper.

2.3 MEASURES OF TRENDS IN POPULATION ABUNDANCE

Measures of trends in population abundance were derived from multiple fishery-independent and -dependent data sources. For species with multiple potential indices of abundance, the Index Working Group (IWG) developed consensus recommendations for the preferred index for use in the SEDAR 49 evaluations. Two species, Snowy Grouper and Speckled Hind, were not assigned a preferred index during the DW. Although data were available for both species from the SEAMAP reef fish video survey and the commercial logbook program, at the time of the DW, species-specific SEAMAP indices were determined to be unsuitable for use in assessment of these two species, and indices from commercial logbook data had not yet been constructed.

The commercial logbook data from the longline fleet were explored as a potential source for constructing indices of abundance for both Snowy Grouper and Speckled Hind. The longline data were chosen over the handline or vertical line data because the longline fleet had been designated as the "representative fleet" and was the most common gear recorded in the logbook data for both species. Preliminary analysis of the commercial longline logbook data revealed that effort declined substantially after 2009 coincident with the implementation of the Gulf of Mexico grouper and tilefish IFQ program. Contrary to effort, catch remained relatively stable after 2009, which led to a substantial increase in catch per unit effort. Further exploration of the logbook data revealed that the longline fleet capturing Snowy Grouper and Speckled Hind not only changed how it was operating (i.e. effort reductions) but also where it was operating, with effort being increasingly expended in deeper water and in areas west of the Mississippi River. Consequently the assessment team determined that any potential index constructed from the commercial logbook data would not be reflective of changes in abundance, and therefore, inappropriate for use in assessment for both Snowy Grouper and Speckled Hind. As a result, no index of abundance was available to the assessment team for Snowy Grouper or Speckled Hind.

2.4 DATA RELIABILITY SCORES

To aid with the selection of methods recommended for providing management advice, a semi-quantitative approach was used to score the reliability of each data input considered (i.e. life history, total removals, indices of abundance, and size composition). For the life history information, reliability scores were provided by the Life History Working Group (LHWG) for pertinent references and data inputs. The only exception was the length-weight relationship reliability scores which were based on sample sizes of data processed for SEDAR 49 (Table 2.1). The reliability scores for total removals were computed as 1.0 minus the CV recommended by the Total Removals Working Group so values close to 1 were more desirable (Table 2.2). This approach was deemed appropriate as the overall CV specified for the total removals was based on CVs for each component of landings or discards and accounted for the various uncertainties inherent within the data (e.g. potential for misidentification). Multiple aspects of the indices of abundance construction were used to score the reliability of the index including the proportion positive observations, sample size, range in CV, and average CV (Table 2.3). Lastly, the reliability of both the length and age composition data, when available, were based on the data source, sampling gear used, sample size, extent of spatial coverage, and selectivity pattern (Table 2.4).

2.5 TABLES

Table 2.1 Summary of data reliability for life history parameters. Note that all recommendations with the exception of the length-weight relationship and the steepness parameter remain identical to the recommendations from the LHWG. The scoring table below details how the data reliability scores were determined. Colors are indicative of quality (Green = Good, Yellow = Fair, Red = Poor or absent).

Species	Sampling Score	Age	Growth	Length-Weight	Maturity	Mortality	Steepness
Red Drum	0.72	0.63	1.00	0.75	1.00	0.63	0.50
Lane Snapper	0.55	0.69	0.94	1.00	0.29	0.69	0.00
Wenchman	0.70	0.64	0.64	1.00	0.00	0.64	0.00
Yellowmouth Grouper	0.60	0.69	0.69	0.00	0.64	0.69	0.00
Snowy Grouper	0.83	0.69	0.69	0.00	0.86	0.69	0.50
Speckled Hind	0.59	0.56	0.88	0.00	0.79	0.56	0.00
Lesser Amberjack	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Almaco Jack	0.00	0.00	0.00	0.75	0.00	0.00	0.00

Source	Scoring
Sampling	Mean sampling score derived by the LHWG for references used
Age-Growth	Derived by LHWG or assigned a value of 1.0 if recent data were used (i.e. red drum aging data provided for SEDAR 49)
Length-Weight	0 = <250 overall number of observations
	0.25 = 250-500 overall number of observations
	0.5 = 500-1,000 overall number of observations
	0.75 = 1,000-5,000 overall number of observations
	1.0 = > 5,000 overall number of observations
Maturity	Determined by the LHWG
Mortality	LH score for maximum age estimate as determined by the LHWG
Steepness	0 = no information
	0.5 = steepness from previous assessment

Table 2.2 Summary of data reliability for total removals. Note that 1 – CV was used as an indicator of reliability for total removals, where the CV was prescribed by the Total Removals Working Group. Colors are indicative of quality (Green = Good and Yellow = Fair).

Species	Overall (1-CV)
Red Drum	0.95
Lane Snapper	0.90
Wenchman	0.65
Yellowmouth Grouper	0.56
Snowy Grouper	0.89
Speckled Hind	0.72
Lesser Amberjack	0.55
Almaco Jack	0.78

Table 2.3 Summary of data reliability for indices of abundance. Colors are indicative of quality (Green = Good, Yellow = Fair, Red = Poor). The scoring table below details how the data reliability scores were determined. SMAC indicates the Stephens and MacCall (2004) approach to subsetting data. Asterisk (*) for Snowy Grouper indicates a consistently low CV due to very low proportion positive.

Species	Selected Index	Proportion Positive	Annual Mean Sample Size (2010-2014)	Range (CV)	Mean CV	Use index based methods
Red Drum	Dauphin Island Sea Lab bottom longline survey	0.33	32	(0.65 - 1.18)	0.93	Yes (because MRFSS confirms)
Lane Snapper	Headboat	0.60 (SMAC)	2245 (SMAC)	(0.040 - 0.048)	0.043	Yes
Wenchman	SEAMAP small pelagics	0.54 (2009 - 2013)	121 (2009 - 2013)	(0.188 - 0.259)	0.223	Yes
Yellowmouth Grouper	SEAMAP video	0.064	223	(0.326 - 0.473)	0.403	No
Snowy Grouper	SEAMAP video	0.008	290	(0.14 - 0.145)*	0.14*	No
Speckled Hind	SEAMAP video	0.042	290	(1.01 - 1.36)	1.18	No
Lesser Amberjack	SEAMAP video	0.036	442	(0.13 - 0.145)	0.138	Yes with caution
Almaco Jack	SEAMAP video	0.23	319	(0.285 - 0.355)	0.321	Yes

Qualitative Scoring Criteria determined by IWG Leader			
Metric	Poor	Fair	Good
Proportion Positive	**< 5%**	**5% - 15%**	**> 15%**
Annual Sample Size	**< 250**	**250 - 1000**	**> 1000**
CV	**> 0.5**	**0.5 - 0.25**	**< 0.25**

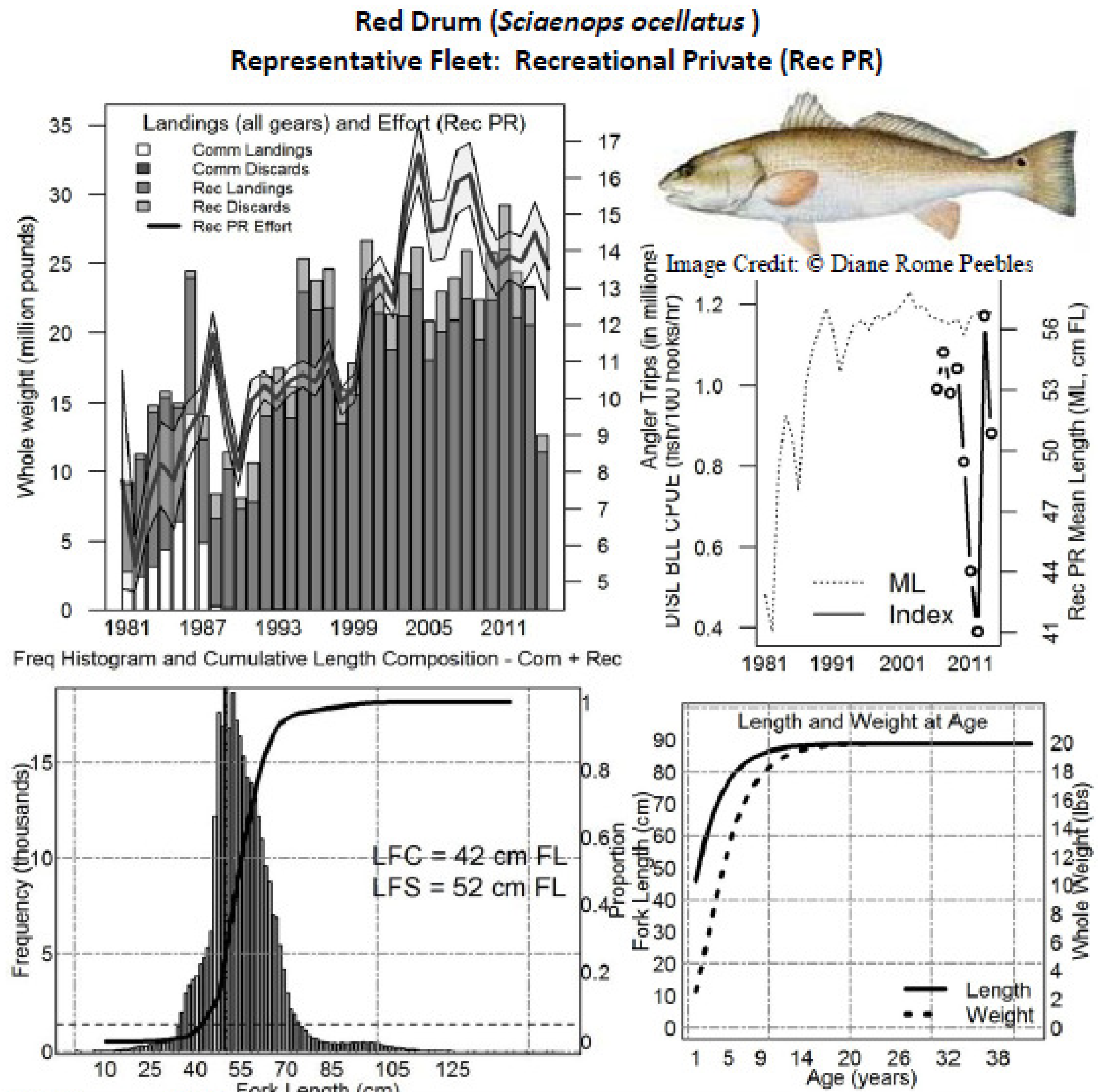
Table 2.4 Summary of data reliability for length and age composition data. Colors are indicative of quality (Green = Good, Yellow = Fair, Red = Poor). The scoring table below details how the data reliability scores were determined. – indicates no data available. MRFSS = Marine Recreational Fisheries Statistics Survey, Purse seine data aggregated across fishery-independent surveys conducted by Louisiana State University, NMFS Pascagoula, Florida Fish and Wildlife Conservation Commission, and Dauphin Island Sea Laboratory. Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

Species	Data Source / Gear	Source	Sampling Gear	Spatial Coverage	Annual Mean Sample Size	Selectivity	Average
Length Composition							
Red Drum	MRFSS private and charterboat	0.5	0.5	1	1	0	0.60
	Purse seine (aggregated)	1	1	0.5	0.75	1	0.85
	Dauphin Island Sea Laboratory bottom longline	1	0.5	0.5	0	0	0.40
Lane Snapper	Commercial longline and handline	0.5	0.5	1	0.25	1	0.65
	MRFSS private and headboat	0.5	0.5	1	0.5	1	0.70
Wenchman	NMFS small pelagics	1	1	1	0.5	0	0.70
Yellowmouth Grouper	–	–	–	–	–	–	–
Snowy Grouper	Commercial longline	0.5	0.5	1	0.5	1	0.70
	Commercial handline	0.5	0.5	1	0.25	1	0.65
Speckled Hind	Commercial longline	0.5	0.5	0.5	0.5	1	0.60
Lesser Amberjack	-	–	–	–	–	–	–
Almaco Jack	MRFSS charterboat, private and headboat	0.5	0.5	1	0	0	0.40
Age Composition							
Red Drum	Purse seine (aggregated)	1	1	0.5	0.25	1	0.75
	Dauphin Island Sea Laboratory bottom longline	1	0.5	0.5	0	0	0.40

Table 2.4 (continued)

Source	Scoring
Source	0.5 = fishery-dependent 1 = fishery-independent
Sampling gear	0.5 = Passive gear (e.g. hook and line) 1 = Active gear (e.g. mobile nets and seines)
Spatial Coverage	0.5 = limited (region-specific) 1 = broad (samples from all Gulf states)
Annual Mean Sample Size	0 = <250 average number of observations per year 0.25 = 250-500 average number of observations per year 0.5 = 500-1,000 average number of observations per year 0.75 = 1,000-5,000 average number of observations per year 1.0 = >5,000 average number of observations per year
Selectivity	0 = dome-shaped pattern or double logistic which may bias results 1 = no concern over selectivity pattern

2.6 FIGURES



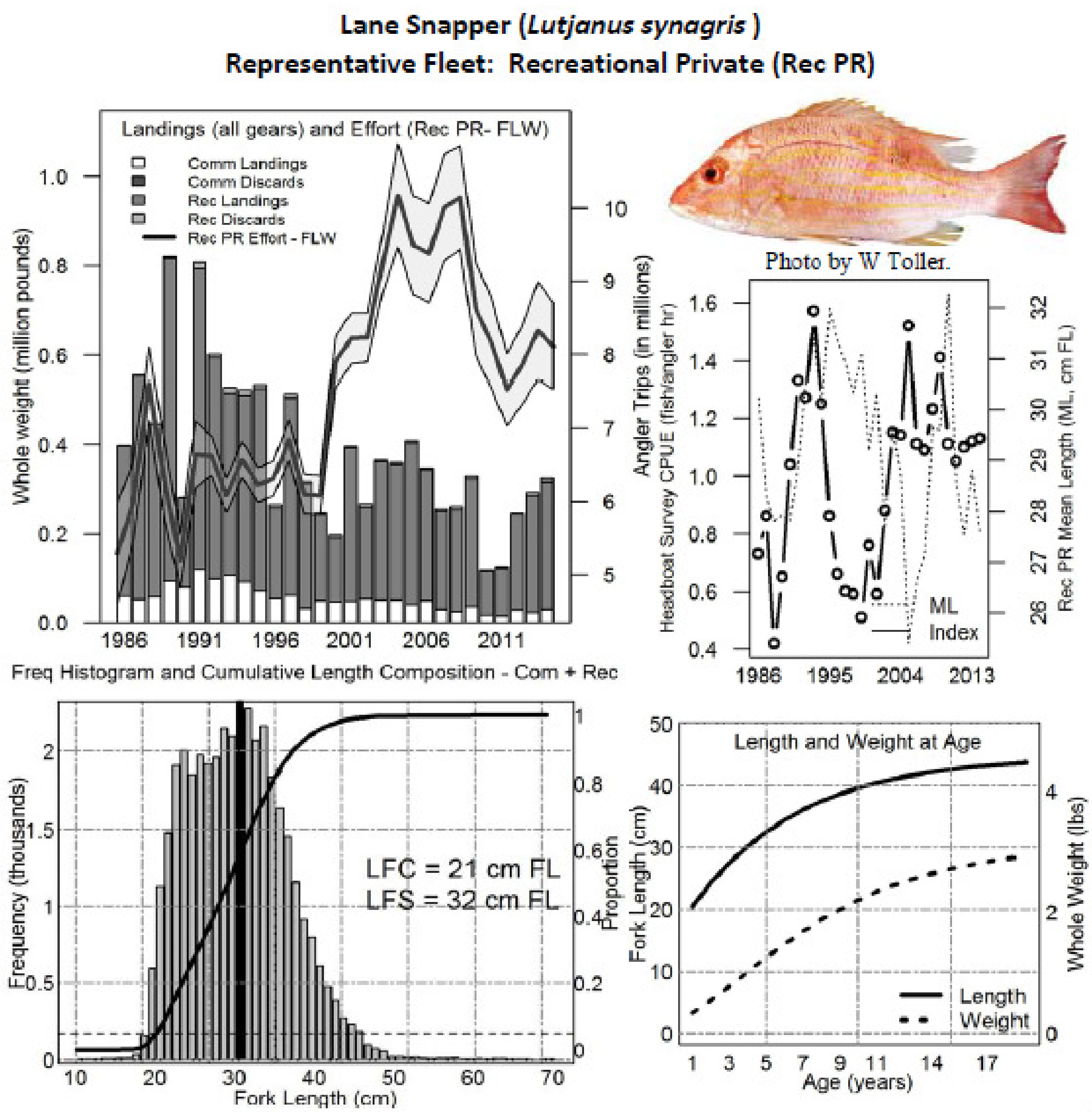
Life History and Selectivity

	MaxAge	vbLinf	vbK	vbt0	wla	wlb	L50	L95	Mort	LFC	LFS
	Maximum Age	Asympt-otic Len.	Growth Coeff.	Age at Len. 0	Wt-Len scalar	Wt-Len power	Len. at Matur.	Len. at Full Matur.	Natural Mortality	Len. 1st Capture	Len. Full Selection
Parameter	42	88.1	0.32	-1.29	1.43E-05	3.15	68	81	0.16	42	52
CV	--	(0.001)	(0.01)	(0.03)	(0.08)	(0.01)	(0.3)	(0.3)	(0.32)	(0.5)	(0.5)
Units	y	cm FL	y^{-1}	y	cm-lbs	cm-lbs	cm FL	cm FL	y^{-1}	cm FL	cm FL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Comm 0 per person/day, Rec 1 per person/day)	19 Dec 1986	15 Oct 1987
Bag limit (Comm 0 per person/day, Rec 1 per person/day)	16 Oct 1987	28 Jun 1988
Fishery closure - quota (Com, Gulf of Mexico EEZ)	20 Jun 1986	22 Dec 1986
Fishery closure - ban (Com & Rec, EEZ off Florida and Texas)	16 Oct 1987	28 Jul 1988
Fishery closure - ban (Com & Rec, Gulf of Mexico EEZ)	29 Jul 1988	Ongoing

Figure 2.1 Summarized information available for the DLMtool stock evaluation for Red Drum in the Gulf of Mexico.



Life History and Selectivity

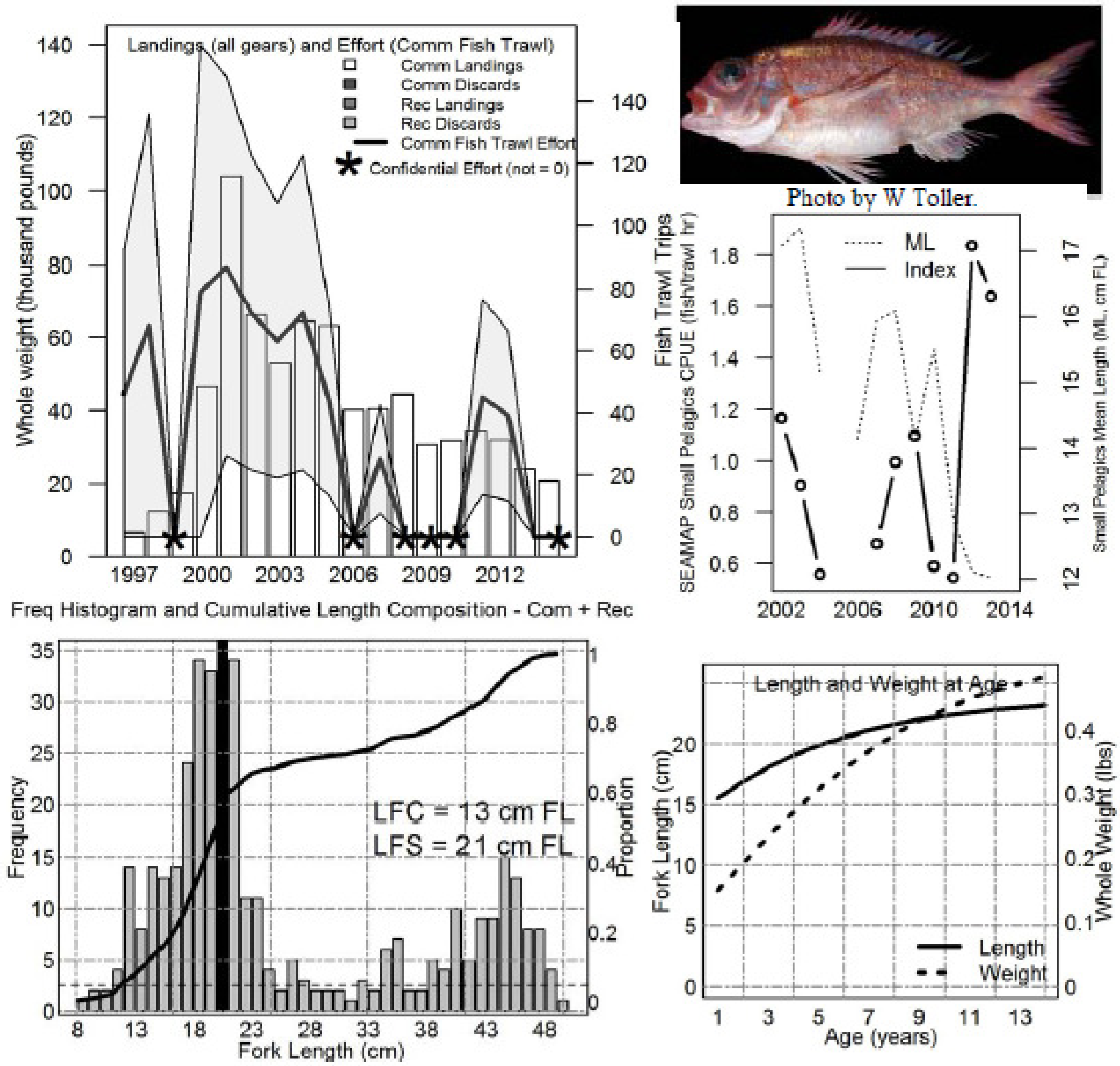
	MaxAge	vbLinf	vbK	vbt0	wla	wlb	L50	L95	Mort	LFC	LFS
	Maximum Age	Asympt-otic Len.	Growth Coeff.	Age at Len. 0	Wt-Len scalar	Wt-Len power	Len. at Matur.	Len. at Full Matur.	Natural Mortality	Len. 1st Capture	Len. Full Selection
Parameter	19	44.9	0.17	-2.59	5.92E-05	2.86	24	27	0.33	21	32
CV	--	(0.04)	(0.16)	(0.26)	(0.06)	(0.01)	(0.3)	(0.3)	(0.32)	(0.5)	(0.5)
Units	y	cm FL	y^{-1}	y	cm-lbs	cm-lbs	cm FL	cm FL	y^{-1}	cm FL	cm FL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Rec, 20 reef fish aggregate per person per day)	15 Jan 1997	Ongoing
Size limit (Com and Rec, 8 inches Total Length)	21 Feb 1990	Ongoing

Figure 2.2 Summarized information available for the DLMtool stock evaluation for Lane Snapper in the Gulf of Mexico.

Wenchman Snapper (*Pristipomoides aquilonaris*)
Representative Fleet: Commercial Fish Trawl

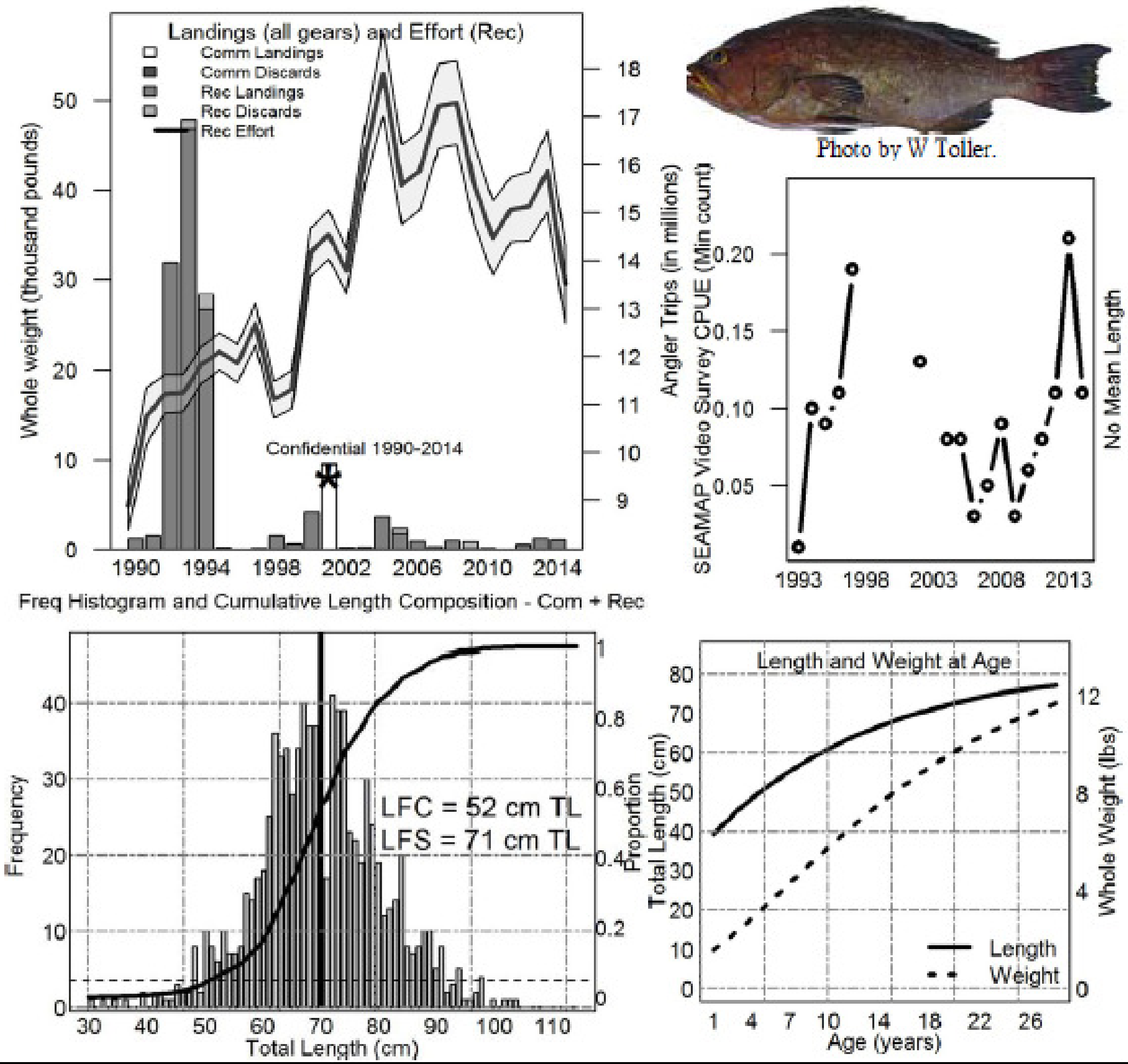


Life History and Selectivity	MaxAge	vbLinf	vbK	vbt0	wla	wlb	L50	L95	Mort	LFC	LFS
	Maximum Age	Asympt-otic Len.	Growth Coeff.	Age at Len. 0	Wt-Len scalar	Wt-Len power	Len. at Matur.	Len. at Full Matur.	Natural Mortality	Len. 1st Capture	Len. Full Selection
Parameter	14	24	0.18	-4.75	5.30E-05	2.9	--	--	0.437	13	21
CV	--	(0.2)	(0.2)	(0.5)	(0.04)	(0.004)	--	--	(0.32)	--	--
Units	y	cm FL	y^{-1}	y	cm-lbs	cm-lbs	cm FL	cm FL	y^{-1}	cm FL	cm FL

Relevant federal regulations http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Rec, 20 reef fish aggregate per person per day)	15 Jan 1997	Ongoing

Figure 2.3 Summarized information available for the DLMtool stock evaluation for Wenchman in the Gulf of Mexico.

Yellowmouth Grouper (*Mycteroperca interstitialis*)
Representative Fleet: Recreational Combined (Charterboat, Private, Headboat)



Life History and Selectivity

	MaxAge	vbLinf	vbK	vbt0	wla	wlb	L50	L95	Mort	LFC	LFS
	Maximum Age	Asympt-otic Len.	Growth Coeff.	Age at Len. 0	Wt-Len scalar	Wt-Len power	Len. at Matur.	Len. at Full Matur.	Natural Mortality	Len. 1st Capture	Len. Full Selection
Parameter	28	82.8	0.076	-7.50	2.77E-05	2.98	42.5	47.5	0.231	52	71
CV	--	(0.05)	(0.21)	(0.21)	(0.25)	(0.02)	(0.3)	(0.3)	(0.32)	(0.5)	(0.5)
Units	y	cm TL	y^{-1}	y	cm-lbs	cm-lbs	cm TL	cm TL	y^{-1}	cm TL	cm TL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*

Continued on next page…

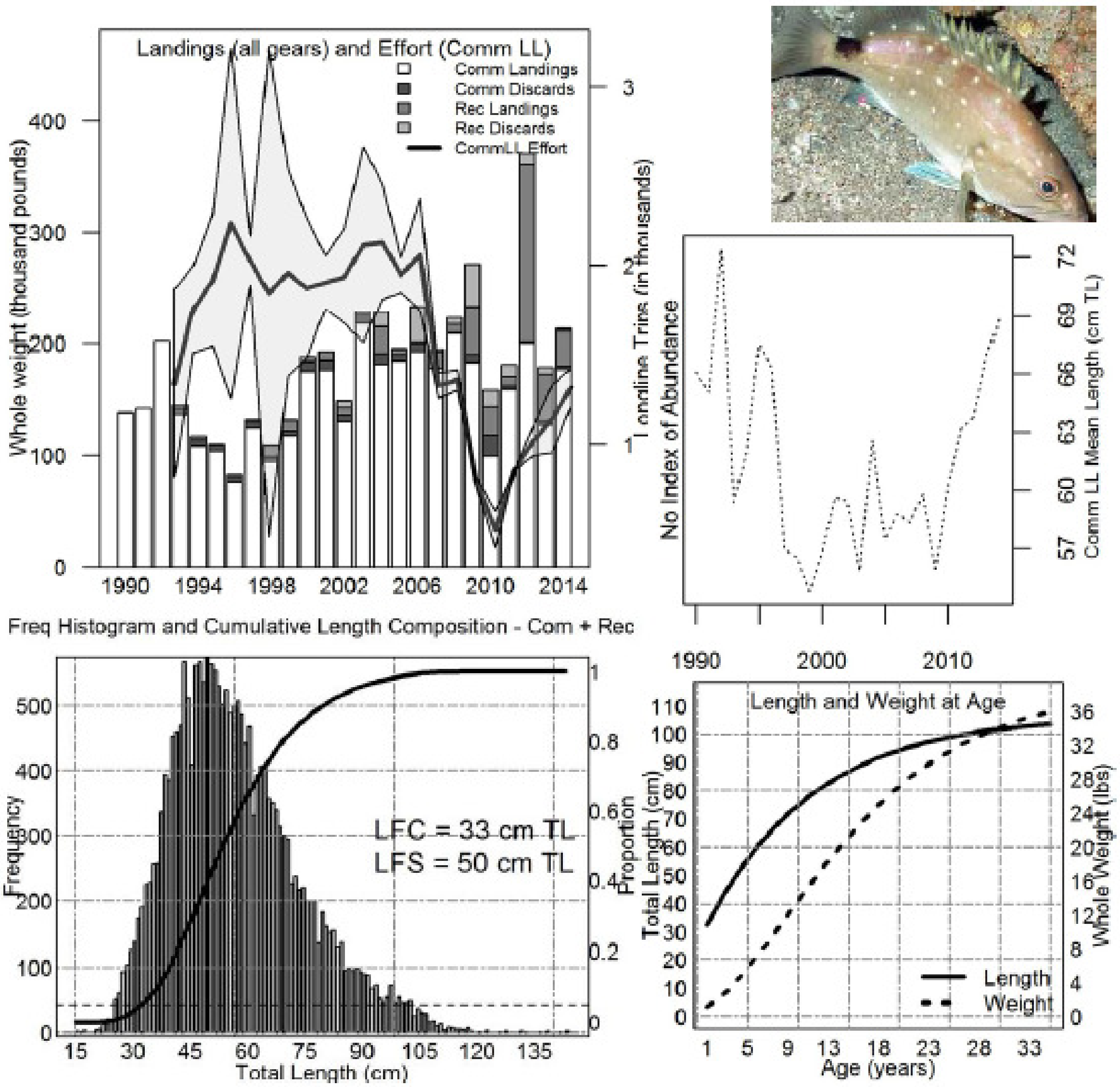
Figure 2.4 Summarized information available for the DLMtool stock evaluation for Yellowmouth Grouper in the Gulf of Mexico.

Yellowmouth Grouper (*Mycteroperca interstitialis*)
Representative Fleet: Recreational Combined (Charterboat, Private, Headboat)

Relevant federal regulations http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Rec, 5 grouper aggregate per person per day)	21 Feb 1990	17 May 2009
Bag limit (Com, 10,000 lbs gw per boat per day; DWG & SWG)	3 Mar 2005	8 Jun 2005
Bag limit (Com, 7,500 lbs gw per boat per day; DWG & SWG)	9 Jun 2005	3 Aug 2005
Bag limit (Com, 5,500 lbs gw per boat per day; SWG)	4 Aug 2005	31 Dec 2005
Bag limit (Com, 6,000 lbs gw per boat per day; DWG & SWG)	1 Jan 2006	31 Dec 2009
Bag limit (Rec, 4 grouper aggregate per person per day)	18 May 2009	Ongoing
Bag limit (Com, IFQ)	1 Jan 2010	Ongoing
Fishery closure - quota (Com, Gulf of Mexico EEZ)	15 Nov 2004	31 Dec 2004
Fishery closure - quota (Com, Gulf of Mexico EEZ)	10 Oct 2005	31 Dec 2005
Fishery closure - seasonal (Rec, Gulf of Mexico EEZ)	18 Apr 2009	4 Jul 2013
Fishery closure - seasonal (Rec, Gulf of Mexico EEZ > 20 fathoms)	5 Jul 2013	ongoing

Figure 2.4 (continued) Summarized information available for the DLMtool stock evaluation for Yellowmouth Grouper in the Gulf of Mexico.

Snowy Grouper (*Hyporthodus niveatus*)
Representative Fleet: Commercial Bottom Longline (Comm LL)



Life History and Selectivity

	MaxAge	vbLinf	vbK	vbt0	wla	wlb	L50	L95	Mort	LFC	LFS
	Maximum Age	Asympt-otic Len.	Growth Coeff.	Age at Len. 0	Wt-Len scalar	Wt-Len power	Len. at Matur.	Len. at Full Matur.	Natural Mortality	Len. 1st Capture	Len. Full Selection
Parameter	35	106.5	0.094	-2.88	3.56E-05	2.98	60	75	0.189	33	50
CV	--	(0.06)	(0.22)	(0.33)	(0.2)	(0.02)	(0.3)	(0.3)	(0.32)	(0.5)	(0.5)
Units	y	cm TL	y^{-1}	y	cm-lbs	cm-lbs	cm TL	cm TL	y^{-1}	cm TL	cm TL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*

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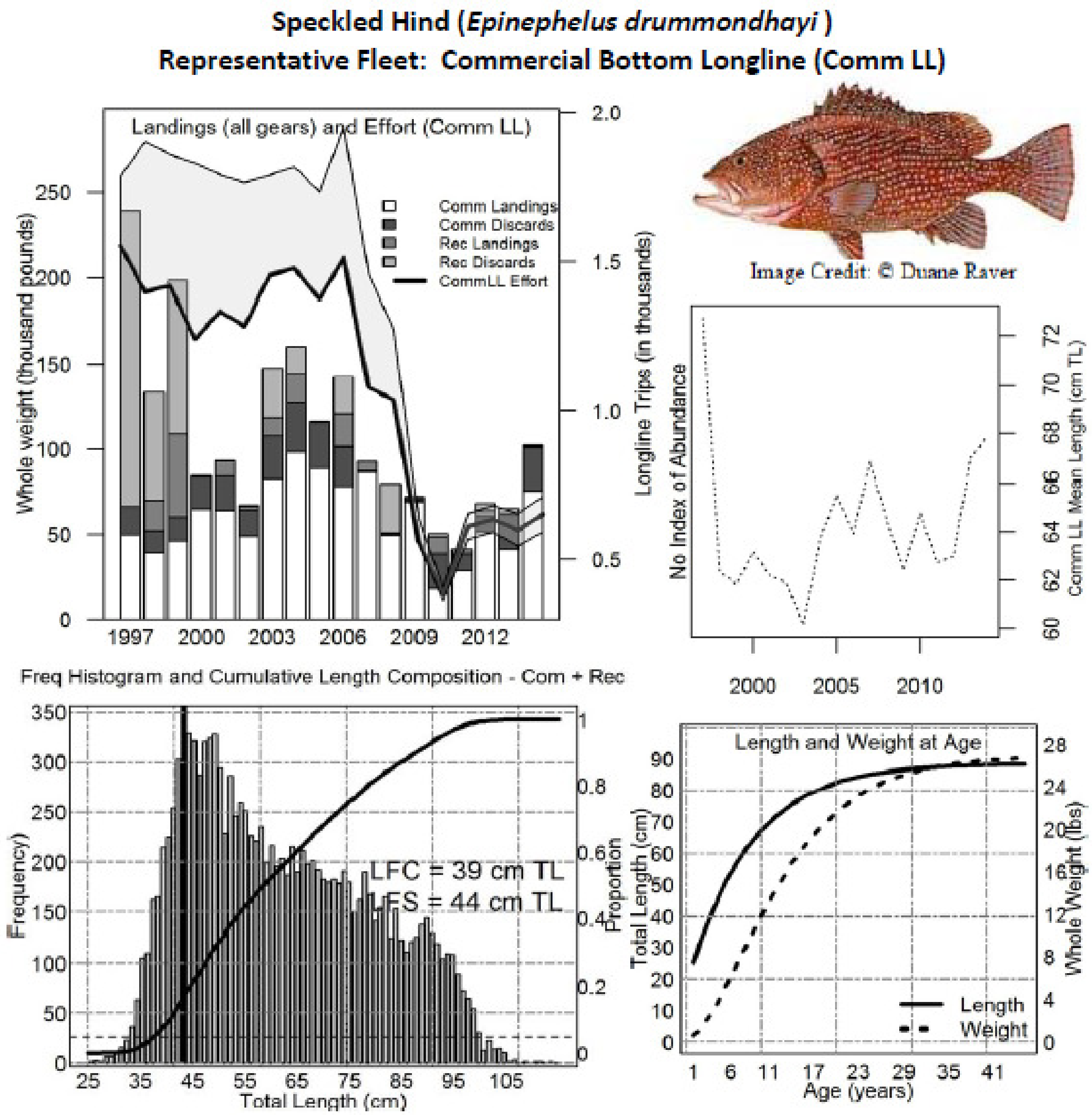
Figure 2.5 Summarized information available for the DLMtool stock evaluation for Snowy Grouper in the Gulf of Mexico.

Snowy Grouper (*Hyporthodus niveatus*)
Representative Fleet: Commercial Bottom Longline (Comm LL)

Relevant federal regulations http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Rec, 5 grouper aggregate per person per day)	21 Feb 1990	17 May 2009
Bag limit (Com, 10,000 lbs gw per boat per day; DWG & SWG)	3 Mar 2005	8 Jun 2005
Bag limit (Com, 7,500 lbs gw per boat per day; DWG & SWG)	9 Jun 2005	31 Dec 2005
Bag limit (Com, 6,000 lbs gw per boat per day; DWG & SWG)	1 Jan 2006	31 Dec 2009
Bag limit (Rec, 4 grouper aggregate per person per day)	18 May 2009	Ongoing
Bag limit (Com, IFQ)	1 Jan 2010	Ongoing
Fishery closure - quota (Com, Gulf of Mexico EEZ)	15 Jul 2004	31 Dec 2004
Fishery closure - quota (Com, Gulf of Mexico EEZ)	23 Jun 2005	31 Dec 2005
Fishery closure - quota (Com, Gulf of Mexico EEZ)	27 Jun 2006	31 Dec 2006
Fishery closure - quota (Com, Gulf of Mexico EEZ)	2 Jun 2007	31 Dec 2007
Fishery closure - quota (Com, Gulf of Mexico EEZ)	10 Apr 2008	31 Oct 2008
Fishery closure - quota (Com, Gulf of Mexico EEZ)	27 Jun 2009	31 Dec 2009

Figure 2.5 (continued) Summarized information available for the DLMtool stock evaluation for Snowy Grouper in the Gulf of Mexico.



Life History and Selectivity

	MaxAge	vbLinf	vbK	vbt0	wla	wlb	L50	L95	Mort	LFC	LFS
	Maximum Age	Asympt-otic Len.	Growth Coeff.	Age at Len. 0	Wt-Len scalar	Wt-Len power	Len. at Matur.	Len. at Full Matur.	Natural Mortality	Len. 1st Capture	Len. Full Selection
Parameter	45	88.8	0.12	-1.80	4.42E-05	2.97	53.2	67.5	0.15	39	44
CV	--	(0.08)	(0.17)	(0.5)	(0.33)	(0.03)	(0.3)	(0.3)	(0.32)	(0.5)	(0.5)
Units	y	cm TL	y^{-1}	y	cm-lbs	cm-lbs	cm TL	cm TL	y^{-1}	cm TL	cm TL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*

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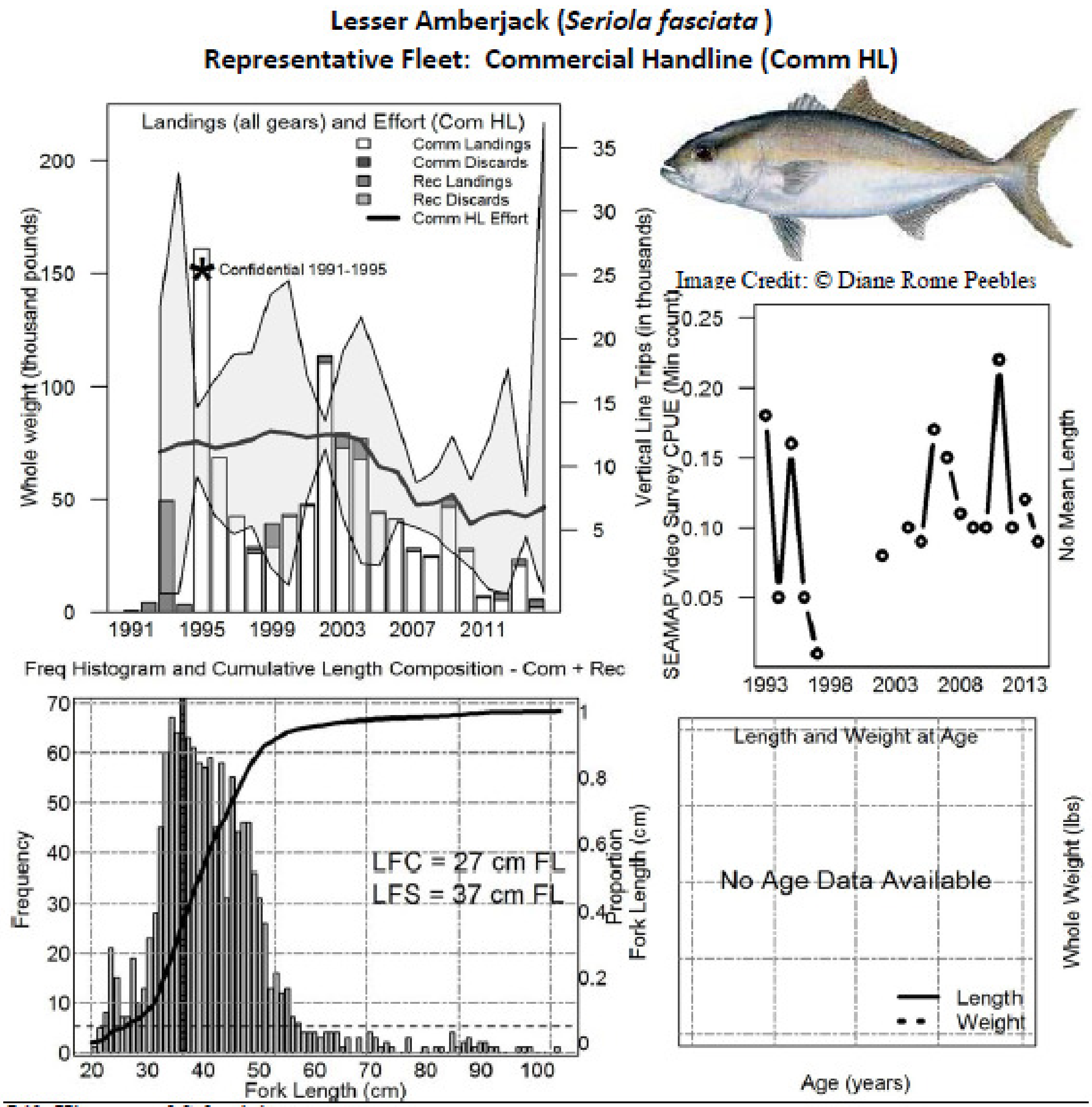
Figure 2.6 Summarized information available for the DLMtool stock evaluation for Speckled Hind in the Gulf of Mexico.

Speckled Hind (*Epinephelus drummondhayi*)
Representative Fleet: Commercial Bottom Longline (Comm LL)

Relevant federal regulations http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Rec, 5 grouper aggregate per person per day)	21 Feb 1990	23 Nov 2009
Bag limit (Rec, 5 grouper aggregate per person per day, 1 per boat per day)	24 Nov 1999	17 May 2009
Bag limit (Com, 10,000 lbs gw per boat per day; DWG & SWG)	3 Mar 2005	8 Jun 2005
Bag limit (Com, 7,500 lbs gw per boat per day; DWG & SWG)	9 Jun 2005	31 Dec 2005
Bag limit (Com, 6,000 lbs gw per boat per day; DWG & SWG)	1 Jan 2006	31 Dec 2009
Bag limit (Rec, 4 grouper aggregate per person per day)	18 May 2009	Ongoing
Bag limit (Com, IFQ)	1 Jan 2010	Ongoing
Fishery closure - quota (Com, Gulf of Mexico EEZ)	15 Jul 2004	31 Dec 2004
Fishery closure - quota (Com, Gulf of Mexico EEZ)	23 Jun 2005	31 Dec 2005
Fishery closure - quota (Com, Gulf of Mexico EEZ)	27 Jun 2006	31 Dec 2006
Fishery closure - quota (Com, Gulf of Mexico EEZ)	2 Jun 2007	31 Dec 2007
Fishery closure - quota (Com, Gulf of Mexico EEZ)	10 Apr 2008	31 Oct 2008
Fishery closure - quota (Com, Gulf of Mexico EEZ)	27 Jun 2009	31 Dec 2009

Figure 2.6 (continued) Summarized information available for the DLMtool stock evaluation for Speckled Hind in the Gulf of Mexico.



Life History and Selectivity

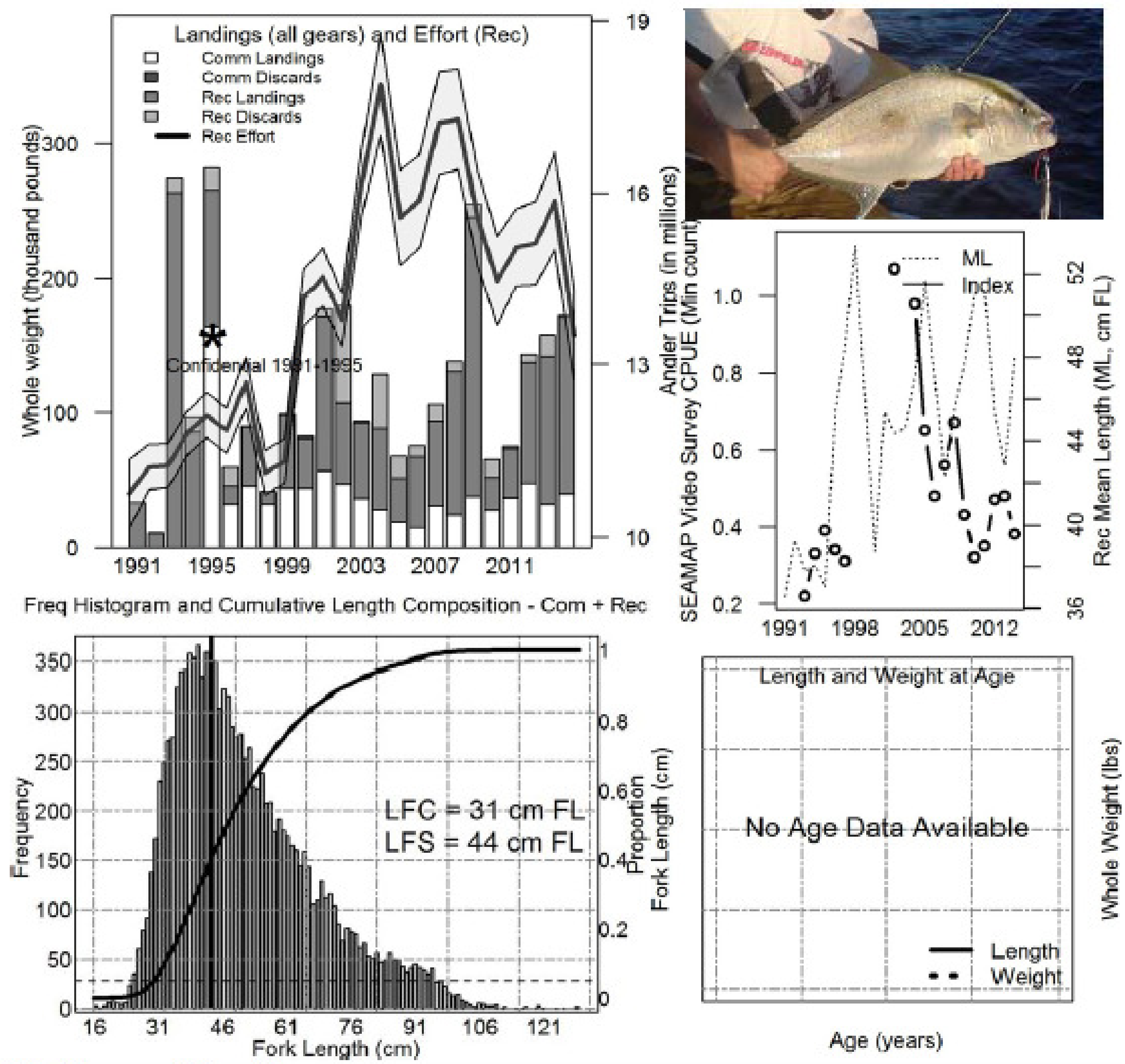
	MaxAge Maximum Age	vbLinf Asympt-otic Len.	vbK Growth Coeff.	vbt0 Age at Len. 0	wla Wt-Len scalar	wlb Wt-Len power	L50 Len. at Matur.	L95 Len. at Full Matur.	Mort Natural Mortality	LFC Len. 1st Capture	LFS Len. Full Selection
Parameter	--	--	--	--	1.68E-05	2.6	--	--	--	27	37
CV	--	--	--	--	(1.04)	(0.01)	--	--	--	(0.5)	(0.5)
Units	y	cm FL	y^{-1}	y	cm-lbs	cm-lbs	cm FL	cm FL	y^{-1}	cm FL	cm FL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Rec, 20 reef fish aggregate per person per day)	15 Jan 1997	23 Nov 1999
Bag limit (Rec, 5 aggregate with Banded Rudderfish per person per day)	24 Nov 1999	Ongoing
Size limit (Com and Rec, 14 - 22 inches Fork Length)	24 Nov 1999	Ongoing

Figure 2.7 Summarized information available for the DLMtool stock evaluation for Lesser Amberjack in the Gulf of Mexico.

Almaco Jack (*Seriola rivoliana*)
Representative Fleet: Recreational Combined (Charterboat, Private, Headboat)



Life History and Selectivity

	MaxAge	vbLinf	vbK	vbt0	wla	wlb	L50	L95	Mort	LFC	LFS
	Maximum Age	Asympt-otic Len.	Growth Coeff.	Age at Len. 0	Wt-Len scalar	Wt-Len power	Len. at Matur.	Len. at Full Matur.	Natural Mortality	Len. 1st Capture	Len. Full Selection
Parameter	--	--	--	--	9.09E-05	2.76	--	--	--	31	44
CV	--	--	--	--	(0.10)	(0.01)	--	--	--	(0.5)	(0.5)
Units	y	cm FL	y^{-1}	y	cm-lbs	cm-lbs	cm FL	cm FL	y^{-1}	cm FL	cm FL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	*Start Date*	*End Date*
Bag limit (Rec, 20 reef fish aggregate per person per day)	15 Jan 1997	23 Nov 1999
Bag limit (Rec, 5 aggregate with Banded Rudderfish per person per day)	24 Nov 1999	Ongoing
Size limit (Com and Rec, 14 - 22 inches Fork Length)	24 Nov 1999	Ongoing

Figure 2.8 Summarized information available for the DLMtool stock evaluation for Almaco Jack in the Gulf of Mexico.

3 DATA-LIMITED EVALUATION APPROACH

A multi-model approach was used to conduct this assessment. A brief introduction is provided here, followed by specific details of each evaluation component.

The Data-Limited Methods Toolkit (DLMtool; Carruthers et al. 2014, Carruthers et al. 2015, Carruthers and Hordyk 2016) is a software program that implements a standardized analytical process for evaluating the performance of multiple data-limited assessment models in a simulation environment using management strategy evaluation (MSE). Once viable methods are identified within the MSE, these methods are then utilized to determine a catch recommendation based on the best available data. In 2014, the DLMtool and its utility were extensively reviewed at a workshop on the "Science and Management of Data-Limited Fisheries" convened by the Natural Resources Defense Council, where widespread support for the DLMtool was garnered by Workshop participants (Newman et al. 2014).

The second analytical approach was the application of a mean length-based mortality estimator assuming non-equilibrium conditions to estimate the total mortality rate (Gedamke and Hoenig 2006). A yield-per-recruit and spawner-per-recruit analysis was then conducted to evaluate stock status relative to fishing mortality.

The third analytical approach was the application of a catch curve analysis employed where adequate information existed to estimate the total mortality rate (Beverton and Holt 1957).

3.1 DATA-LIMITED METHODS TOOLKIT

3.1.1 Overview

The DLMtool focuses on the development of management advice for data-limited fisheries stocks through the evaluation of data-limited stock assessment models and harvest control rules. This approach, paired with a framework that facilitates simulation and sensitivity examinations, helps to streamline the assessment process to evaluate data-limited stocks (Carruthers et al. 2015). The DLMtool procedure was developed under the R programming language and is freely available for download through the CRAN-R repository at http://cran.rproject.org/web/packages/DLMtool /index.html. Version 3.2.1 was used for all SEDAR 49 analyses leading up to the Assessment Report.

The accessibility and user-friendly design of the DLMtool has introduced some concern regarding potential abuse of its utility, a topic discussed at the 30th Lowell Wakefield Fisheries Symposium on Tools and Strategies for Assessment and Management of Data-Limited Fish Stocks held in May 2015 (Dowling et al. 2015). Rather than apply all possible data-limited methods to available data and select a catch recommendation considered most desirable (e.g. highest catch), a structured procedure is recommended (Carruthers 2015). Further, many methods currently in the DLMtool were designed for specific regional fisheries and may require tuning to more appropriately reflect management objectives in regions such as the Gulf of Mexico. To evaluate the potential utility of the DLMtool in providing management advice, a three-step approach was followed for SEDAR 49 as recommended by the DLMtool developers:

(1) Determination of feasible methods based on data availability (see Table 3.1.1);
(2) Simulation testing of feasible methods (through MSE) to eliminate methods which exhibit pathological behavior (e.g. chronic overfishing) and to identify viable methods based on the

stock and fleet dynamics as parameterized in the operating model (see Section 3.1.2 for details); and

(3) Application of viable methods for providing management advice (see Section 3.1.6).

3.1.2 Management Strategy Evaluation (Operating Model)

For each species to be assessed, a simulation analysis was used to explore the relative performance among data-limited methods using MSE (Butterworth et al. 2010, Carruthers et al. 2014). MSE is a scientific approach used to identify the management option(s) that is (are) most robust to assumptions and uncertainties in data inputs, such as whether performance remains consistent across multiple ranges of stock status relative to an unfished state (i.e. the depletion level) as well as robustness to mis-specified model structure (e.g. bias in natural mortality). The use of MSE provides an objective procedure for evaluating tradeoffs between alternative management strategies with particular attention to varying performance interests (e.g. conservation vs harvest) (Punt et al. 2014).

Briefly, the theory behind MSE consists of capturing system dynamics assumed to represent the “simulated reality” (i.e. truth) and “observed” system dynamics via simulation of (i) biological sampling, (ii) scientific analysis such as a conventional fisheries stock assessment or a data-limited procedure, and (iii) harvest control rules or management implementation (Sainsbury et al. 2000, Kell et al. 2007). The simulated reality is then projected forward in time and updated according to the harvest control rule generated by a particular management strategy (Carruthers et al. 2014). A feedback loop between the management strategy and operating model ensures the linkage of observed system dynamics to true system dynamics (Kell et al. 2007), which helps to distinguish MSE from simple risk assessment (Punt et al. 2014).

In application, the primary requirements of the MSE approach were: (1) a variety of candidate data-limited stock assessment methods, harvest control rules, or models (hereafter referred to as “methods”) that are feasible based on available data (method data requirements are summarized in Table 3.1.1); (2) an operating model that describes the “true” simulated population (described in this section and accompanying Assessment Process working documents for SEDAR 49 identified below); and (3) criteria for evaluating the performance of data-limited methods (Section 3.1.4). For SEDAR 49, the DLMtool application focused on evaluating data-limited methods which do not include buffered inputs (i.e. methods which implement a harvest control rule using 100% of average catch rather than using 70% of average catch). Candidate methods were modified as necessary to remove buffered inputs (see Appendix 17.1 for code used). A MSE was conducted for each species selected for evaluation. Specific details pertaining to the operating model structure, data inputs, and other technical aspects (e.g. model parameters, assumed distributions, and equations) are provided in Harford et al. (2016). Currently, no implementation error is considered in Version 3.2.1 of the DLMtool.

Input Parameters and Justification

A review of operating model inputs, recommended input parameters, and justifications is provided for each species in their respective SEDAR 49 Assessment Process working papers: Red Drum (Sagarese et al. 2016d), Lane Snapper (Sagarese et al. 2016b), Wenchman (Sagarese et al. 2016g), Yellowmouth Grouper (Sagarese et al. 2016h), Snowy Grouper (Sagarese et al.

2016e), Speckled Hind (Sagarese et al. 2016f), Lesser Amberjack (Sagarese et al. 2016c), and Almaco Jack (Sagarese et al. 2016a).

Herein, we only provide a brief summary of modifications made to the operating models following the posting of parameters in these working documents, which are available from the SEDAR website (http://sedarweb.org/sedar-49-assessment-process).

Stock Depletion

A plausible range of stock depletion is required to condition the operating model in the MSE. Historical stock dynamics are reconstructed to achieve the depletion level specified in the last year of the historical time period (i.e. terminal year of data available for assessment). As no information regarding depletion was provided at the DW for any of the eight species, plausible ranges of depletion were initially determined based on current depletion estimates for similar assessed species (as detailed in each operating model working paper).

Within the DLMtool, the ML2D function can be used to estimate current stock depletion (Carruthers and Hordyk 2016). However, since this application provides *highly uncertain* estimates of current stock biomass and equilibrium fishing mortality, the results using this data input should be interpreted with caution. The function uses recent mean length observations and samples from various parameter distributions of operating model parameters including maximum age, von Bertalanffy growth parameters, length-weight parameters, fishery selectivity, steepness, and natural mortality. This approach was used to refine the initial range of depletion estimates for Red Drum, Snowy Grouper, and Almaco Jack, which are compared to the original values below:

Depletion ($B_{now}/B_{unfished}$)	Original Depletion Range in Base	Updated Depletion Range in Base
Red Drum	0.05 – 0.55	0.42 – 0.59
Snowy Grouper	0.05 – 0.30	0.15 – 0.40
Almaco Jack	0.10 – 0.13	0.07 – 0.32

Observation error for catch, index of abundance, and catch-at-length

Operating model inputs for the observation error in total removals (Cobs), the observation error in the index of abundance (Iobs), and the variability in the catch-at-length (CALcv) were modified to have wider ranges. For Iobs and CALcv, the range was updated to cover the minimum and maximum observed CVs for the index of abundance and the catch-at-length data. For total removals, the range of error was based on the value recommended at the DW (i.e. CV for total removals) and twice the value, assuming more variation than originally specified (i.e. a fixed range was originally used).

Specification of areas in the operating model

The fraction of the unfished biomass ('habitat') in area 1 was set very low (0.01) to mimic a well-mixed single unit stock.

3.1.3 Sensitivity of Operating Model Assumptions

Alternative operating models were developed to test whether different assumptions (e.g. depletion range, maximum age) influenced the performance and recommendation of methods within the MSE. An example of how to interpret the role of uncertainty in MSE is provided in Section 3 of Harford et al. (2016).

3.1.4 Performance Metrics

Following the SEDAR 46 evaluation for U.S. Caribbean Data-limited Species, thresholds for three performance metrics were specified by the SEDAR 49 AW Panel: (1) the probability of not overfishing to remain above 50%; (2) the probability of the biomass being above half of biomass at maximum sustainable yield to remain above 50%; and (3) at least a 50% chance of the average inter-annual variability in yield remaining within 15%. Three additional metrics are provided to assist in comparing model performance for SEDAR 49: (4) long-term yield; (5) short-term yield; and (6) the probability of the biomass being below 20% of the biomass at maximum sustainable yield. Each metric is detailed below with a simple example demonstrated in Figure 3.1.

Probability of not overfishing (PNOF)

The probability of not overfishing (PNOF) metric reported in the MSE results is calculated with the following equation:

$$PNOF\ (\%) = \frac{\sum_{n=1}^{n=nsim} \frac{F}{F_{MSY}} < 1}{nsim * Proyears} \times 100 \qquad \text{Equation (3.1.1)}$$

where *nsim* is the number of simulations (1,000), the numerator is the number of projection years where fishing mortality rate *F* is below the fishing mortality rate at maximum sustainable yield (F_{MSY}), and *Proyears* is the total number of projection years. All projection years are included within this calculation. The SEDAR 49 AW Panel defined a threshold for PNOF not to drop below 50% in concordance with the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), National Standard 1 (NS1) Guidelines.

Probability of the biomass being above 50% biomass at maximum sustainable yield (B50)

The probability of the biomass being above 50% biomass at maximum sustainable yield (B_{MSY}) metric reported in the MSE results is calculated with the following equation:

$$B50\ (\%) = \frac{\sum_{n=1}^{n=nsim} \frac{B}{B_{MSY}} > 0.5}{nsim * Proyears} \times 100 \qquad \text{Equation (3.1.2)}$$

where *nsim* is the number of simulations (1,000), the numerator is the number of projection years where biomass is above 50% biomass at maximum sustainable yield (B_{MSY}), and *Proyears* is the total number of projection years. All projection years are included within this calculation. The SEDAR 49 AW Panel agreed upon *B50* > 50% to adhere to the MSFCMA, NS1.

Average inter-annual variability in yield to remain within 15% (VY15)

The average annual variability in yield (AAVY) is the mean difference in the yield of adjacent projection years (starting from the last historical year) divided by the mean yield over the same time period.

$$AAVY = \frac{(n_p+1)\sum_{y=n_h}^{n_h+n_p-1}|Cat_{y+1}-Cat_y|}{n_p\overline{Cat}_y} \qquad \text{Equation (3.1.3)}$$

where n_p is the number of projection years, n_h is the number of historical years, Cat_y is the true simulated total removals in year *y*, and $\overline{Cat}_y$ is the mean yield of adjacent projection years. The SEDAR 49 AW Panel selected a cutoff of 15% allowable variation on annual yield:

$$VY15\ (\%) = \frac{\sum_{y=t_1}^{y=t_2} simulations\ where\ AAVY < 0.15}{Total\ simulations} \times 100 \qquad \text{Equation (3.1.4)}$$

where t_1 is the start year of projection years and t_2 is the end year of projection years. This performance metric identifies the methods that achieve maintaining the year to year variability in yield to below 15%, with a specified threshold of at least 50%.

Long-term yield (LTY)

The long-term yield (LTY) metric reported in the MSE results is calculated with the following equation:

$$LTY\ (\%) = \frac{\sum_{n=t_2-4}^{n=t_2} \frac{Catch}{RefY} > 0.5}{nsim * 5} \times 100 \qquad \text{Equation (3.1.5)}$$

where *t* is the final projection year and *RefY* is the highest LTY (mean over the last five years of projection) obtained from a fixed *F* strategy. Only the last five projection years are included within this calculation.

Short-term yield (STY)

The short-term yield (STY) was calculated in a similar fashion to LTY, with the exception that the first five years were used in the equation instead of the last five years (i.e. from t_1 to t_{1+4}). Only the first five projection years are included within the calculation.

Probability of the biomass dropping below 20% biomass at maximum sustainable yield (Bbelow20)

The probability of the biomass dropping below 20% biomass at maximum sustainable yield (B_{MSY}) was calculated in a similar fashion to B50, with the exception that this metric used the fraction of projection years in which biomass is below 20% B_{MSY}. All projection years are included within this calculation. This metric can serve as a proxy for potential stock collapse, with higher probabilities pointing to a greater chance of stock collapse.

3.1.5 Model Convergence

The convergence of performance metrics for each method tested within the MSE was evaluated by assessing whether performance metrics stabilized or whether additional simulations were needed. A threshold of 0.05% was used for SEDAR 49, meaning that mean performance metrics were within 0.05% by the end of simulations (1,000).

3.1.6 Calculating Catch Recommendations

Overall, 11 methods were considered feasible for providing catch recommendations for at least one species based on data availability (Table 3.1.1) and data quality scoring. Required data inputs for each feasible method ranged from a time series of total removals to more moderate requirements such as an index of abundance, as indicated in Table 3.1.1 by gray shading.

In order to facilitate comparison of method performance between feasible methods considered during SEDAR 49 and the current method used (i.e. Tier 3A or Tier 3B reference period landings), R code for a management method specific to each species was developed and incorporated into the DLMtool MSE to mimic the historical reference period of landings and function (e.g. mean or median) implemented by the Gulf of Mexico Fishery Management Council (Table 3.1.2).

For viable methods, a distribution of catch recommendations (in pounds) was developed by stochastically drawing data inputs 10,000 times.

Assumptions

Assumptions of each feasible method as well as strengths and weaknesses of each approach are provided in Tables 3.1.3 and 3.1.4, respectively.

Input Parameters and Justifications

Parameters required for the DLMtool analyses are provided in Tables 3.1.5 through 3.1.12 for each species under evaluation.

3.1.7 Sensitivity Analysis for Catch Recommendations

The sensitivity of catch recommendations to input data was explored to address how uncertainty in parameter inputs could influence recommended catches. Sensitivity analyses were conducted using the Sense() function in the DLMtool which determines the inputs for a given method, where the range of the input parameter is based on the user-specified CV, and analyses the sensitivity of catch recommendations to marginal differences in each input. For each species and method, 1,000 sensitivity runs were conducted.

Sensitivity analyses were also undertaken for different data inputs to address recommendations made by the DW Working Groups. The sensitivity of the catch recommendation to the CV on total removals for each species was assessed to determine the influence of uncertainty in the total removals. For example, this analysis was used to assess the influence of negatively biased total removals for Lane Snapper due to the exclusion of commercial discards. Although sensitivity analyses using different CV estimates for the index of abundance were recommended at the Data Workshop by the IWG, the index-based methods considered during SEDAR 49 do not use the CV. Instead, these methods use the index of abundance and derived values (i.e. averages across a recent of historical time period). The sensitivity of catch recommendations to the index of abundance was explored to address how uncertainty in parameter inputs could influence recommended catches.

3.1.8 Tables

Table 3.1.1 Summary of methods considered with corresponding data requirements (shaded in gray). Data inputs include natural mortality (Mort or *M*), von Bertalanffy asymptotic size (vbLinf), growth rate (vbK), and length at age 0 (vbt0), length-weight relationship parameters a and b (wla, wlb), steepness (steep), maximum age (MaxAge), total removals (Cat; includes both landings and discards), an index of abundance (Ind), length at first capture (LFC), annual mean length (ML), annual catch-at-age (CAA), and the ratio of F_{MSY} to M (FMSY_M).

Method	Description	Reference	Data Inputs														
			Life History								Catch	Index	Length			Age	Ref
			Mort	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	LFC	LFS	ML	CAA	FMSY_M
Catch-based																	
CC1	Constant catch linked to average catches from last 5 years	Geromont and Butterworth (2014); Carruthers et al. (2015)															
CC1_Ref	Constant catch linked to average catches from reference period	Modified CC1 for SEDAR 49															
Tier3A/3B Status Quo	Average catch from reference period specific to each species	GMFMC (2011)															
Index-based																	
Islope0	CPUE slope, maintain constant CPUE	Modified Islope1 from Geromont and Butterworth (2014) for SEDAR 49															
Itarget0	CPUE target, catch recommendation adjusted to achieve a target CPUE	Modified Itarget1 from Geromont and Butterworth (2014) for SEDAR 49															
Length-based																	
LstepCC0	Mean length, mean length relative to historical levels used to alter catch recommendation	Modified LstepCC1 from Geromont and Butterworth (2014) for SEDAR															
Ltarget0	Length target, catch recommendation adjusted to reach a target mean length	Modified Ltarget1 from Geromont and Butterworth (2014) for SEDAR 49															
Age-based																	
Fratio_CC	F_{MSY} to M ratio method that uses a Catch Curve to estimate current abundance based on current catch and recent *F*	Gulland (1971); Walters and Martell (2002); Martell and Froese (2012)															
BK_CC_LVBcor	Beddington and Kirkwood life history method that uses Catch Curve to estimate current abundance based on current catch and recent *F* and accounts for correlations between growth	Modified from Beddington and Kirkwood (2005) for SEDAR 49															
YPR_CC_LVBcor	Yield per recruit analysis that uses a Catch Curve to estimate recent abundance and accounts for correlations between growth parameters	developed by M. Bryan (SEFSC); Modified from Carruthers and Hordyk (2016) for SEDAR 49															
Fdem_CC_LVBcor	Demographic FMSY method that uses a Catch Curve to estimate recent Z and accounts for correlations between growth	Modified from McAllister et al. (2001) for SEDAR 49															

Table 3.1.2 Reference time periods specified for each SEDAR 49 species in GMFMC (2011) that were used to program the current approach implemented by the Gulf of Mexico Fishery Management Council. Tiers relate to the GMFMC's categorical process that prescribes the methods used for obtaining the overfishing limit (OFL) and allowable biological catch (ABC). – indicates no data available.

Species	Tier	Years	Method for Calculating OFL	Method for Calculating ABC
Red Drum	–	–	–	–
Lane Snapper	3A	1999-2008	Mean + 2 SD	Mean + 1 SD
Wenchman	3A	1999-2008	Mean + 2 SD	Mean + 1 SD
Yellowmouth Grouper	3A	1995-2008	Mean + 2 SD	Mean + 1 SD
Snowy Grouper	3B	1992-2008	Mean	Mean
Speckled Hind	3B	1992-2008	Mean	Mean
Lesser Amberjack	3A	2000-2008	Mean + 2 SD	Mean + 1 SD
Almaco Jack	3A	2000-2008	Mean + 2 SD	Mean + 1 SD

Table 3.1.3 Method assumptions and equations for calculating the catch recommendations. *Catch Rec* = catch recommendation for SEDAR 49 (in pounds), *y* = year, *Cat* = total removals, *t* = number of years with total removals, t_1 = start year of time period, t_2 = end year of time period, *N* = number of years in specified time period, *SD* = standard deviation, *M* = natural mortality rate, F_{MSY} = fishing mortality rate at maximum sustainable yield.

Method	Catch Recommendation Equation	Assumptions	References
Catch-based			
CC1_Ref and CC1	$Catch\ Rec_{y+1} = \frac{\sum_{y=t_1}^{y=t_2} Cat_y}{1+t_2-t_1} = C^{AVE}$ where: time period is last five years (CC1) or the reference period (CC1_Ref) as specified in Table 3.1.2 for each species	• Catch known exactly for specified reference period • Data have reasonable information content • Associated observation error is low	Modified from Geromont and Butterworth (2014)
Tier 3A or 3B StatusQuo	$3A$: $OFL_{y+1} = \frac{\sum_{y=t_1}^{y=t_2} Cat_y}{1+t_2-t_1} + 2\ SD$ $ABC_{y+1} = \frac{\sum_{y=t_1}^{y=t_2} Cat_y}{1+t_2-t_1} + 1\ SD$ $3B$: $OFL_{y+1} = \frac{\sum_{y=t_1}^{y=t_2} Cat_y}{1+t_2-t_1}$ $ABC_{y+1} = OFL_{y+1}$	• Fishery is at or near a sustainable equilibrium and the stock is stable • Qualitative determination of stock status possible • Catch statistic derived from the time series of historical catches based on reliable landings as specified in GMFMC (2011)	GMFMC (2011), Berkson et al. (2011)
Index-based			
Islope0	$Catch\ Rec_{y+1}^{\mathrm{slope}} = C^{AVE} \times (1 + \boldsymbol{\lambda} \times S_y)$ where: S_y = CPUE slope (gradient of a log-linear regression) for the most recent five years and C^{AVE} as specified in CC1 and lambda (λ) = **0.4**. Note that scalar $\boldsymbol{\lambda}$ can be modified during tuning.	• Catch statistic derived from the time series of historical catches based on reliable landings as specified in GMFMC (2011) • Any trend in the index of abundance is a reliable indicator of the trend in resource biomass	Modified from Geromont and Butterworth (2014)

Method	Catch Recommendation Equation	Assumptions	References
Itarget0	If $I_y^{recent} > I^0$, $Catch\ Rec_{y+1} = C^{AVE}\left[1 + \frac{(I_y^{recent} - I^0)}{(I^{target} - I^0)}\right]$ If $I_y^{recent} \leq I^0$, $Catch\ Rec_{y+1} = C^{AVE}\left[\frac{I_y^{recent}}{I^0}\right]^2$ where: I_y^{recent} = mean CPUE for recent time period (2010-2014), I^{AVE} = mean CPUE for reference period as specified in Table 3.1.2 for each species, I^0 = **0.8** I^{AVE}, I^{target} = **1.5** I^{AVE}, and C^{AVE} as specified in CC1. Note that scalars **0.8** and **1.5** can be modified during tuning.	• Catch statistic derived from the time series of historical catches based on reliable landings as specified in GMFMC (2011) • Any trend in the index of abundance is a reliable indicator of the trend in resource biomass	Modified from Geromont and Butterworth (2014)
Length-based			
LstepCC0	If $L_y^{recent} / L^{AVE} <$ **0.96**, $\text{Catch Rec}_{y+1} = C^{AVE} - 2 * (0.05 * C^{AVE})$ If $L_y^{recent} / L^{AVE} <$ **0.98**, $\text{Catch Rec}_{y+1} = C^{AVE} - (0.05 * C^{AVE})$ If $L_y^{recent} / L^{AVE} >$ **1.05**, $\text{Catch Rec}_{y+1} = C^{AVE} + (0.05 * C^{AVE})$ where: L_y^{recent}= mean length for the recent time period (2010-2014), L^{AVE} = mean length for the specified reference period as specified in Table 3.1.2 for each species, and C^{AVE} as specified in CC1. Note that thresholds **0.96, 0.98** and **1.05** can be modified during tuning.	• Catch statistic derived from the time series of historical catches based on reliable landings as specified in GMFMC (2011) • Mean length of fish caught is taken to be an indirect index of abundance • 5% step size fixed input to control for random fluctuations in average size	Modified from Geromont and Butterworth (2014)

Method	Catch Recommendation Equation	Assumptions	References
Ltarget0	If $L_y^{recent} > L^0$, $$Catch\ Rec_{y+1} = C^{AVE}\left[1 + \frac{(L_y^{recent} - L^0)}{(L^{target} - L^0)}\right]$$ If $L_y^{recent} \leq L^0$, $$Catch\ Rec_{y+1} = C^{AVE}\left[\frac{L_y^{recent}}{L^0}\right]^2$$ where: L_y^{recent}= mean length for recent time period (2010-2014), L^{AVE} = mean length for specified reference period as specified in Table 3.1.2 for each species, L^0 = **0.9** L^{AVE}, L^{target} = **1.05** L^{AVE}, and C^{AVE} as specified in CC1. Note that scalars **0.9** and **1.05** can be modified during tuning.	• Catch statistic derived from the time series of historical catches based on reliable landings as specified in GMFMC (2011) • Mean length of fish caught is taken to be an indirect index of abundance	Modified from Geromont and Butterworth (2014)
Age-based			
Fratio_CC	$$\text{Catch Rec}_{y+1} = \frac{\text{Cat}}{(1-exp^{-F})} \text{ x } M \text{ x } FMSY\_M$$ where: *F* is derived from a catch curve (total mortality (*Z*) – *M* = *F*) and *Cat* is total removals in the terminal year (2014)	• Constant and known natural mortality • Assumptions inherent in catch curve analysis (see Section 3.3.2)	Gulland (1971); Walters and Martell (2002); Martell and Froese (2013)
BK_CC _LVBcor	$$\text{Catch Rec}_{y+1} = \frac{\text{Cat}}{(1 - exp^{-F})} * \frac{0.6 * Kc}{0.67 - \left(\frac{Lc}{Linfc}\right)}$$ where: *F* is derived from a catch curve (*Z* – *M* = *F*), *Cat* is total removals in the terminal year (2014), *Lc* is the length at first capture, and *Linfc* and *Kc* are the von Bertalanffy asymptotic size and growth rate parameters	• Equal vulnerability of fish larger than length at capture • Constant natural mortality over time • Assumptions inherent in catch curve analysis (see Section 3.3.2) • Correlations between vbLinf, vbK, and vbt0 from meta-analysis appropriate (see Cummings et al. (2016) for details)	Beddington and Kirkwood (2005)

Method	Catch Recommendation Equation	Assumptions	References
Fdem_CC _LVBcor	$\text{Catch Rec}_{y+1} = \frac{\text{Cat}}{(1-exp^{-F})} \text{ x } F_{MSY}$ where: *F* is derived from a catch curve (*Z* – *M* = *F*) and *Cat* is total removals in the terminal year (2014)	• F_{MSY} = r/2 where r is obtained from a demographic *r* prior method • Assumptions inherent in catch curve analysis (see Section 3.3.2) • Correlations between vbLinf, vbK, and vbt0 from meta-analysis appropriate (see Cummings et al. (2016) for details)	McAllister et al. (2001)
YPR_CC_ LVBcor	$\text{Catch Rec}_{y+1} = \frac{\text{Cat}}{(1-exp^{-F})} \text{ x } F_{MSY}$ where: *F* is derived from a catch curve (*Z* – *M* = *F*) and *Cat* is total removals in the terminal year (2014)	• Distinct spawning period and all fish recruit at the same time and age • Growth parameters do not change over time, stock size, or age • Constant and known natural mortality • Fishing mortality constant over all ages • Recruitment constant • Complete mixing of stock • Length-weight relationship has an exponent of value = 3 • No dependence between stock size and recruitment • Static conditions • Assumptions inherent in catch curve analysis (see Section 3.3.2) • Correlations between vbLinf, vbK, and vbt0 from meta-analysis appropriate (see Cummings et al. (2016) for details)	Beverton and Holt (1957), modified by M. Bryan as discussed in Carruthers and Hordyk (2016)

Table 3.1.4 Summary of the strengths and weaknesses of each method applied in SEDAR 49.

Method	Strengths	Weaknesses
Catch-based		
CC1_Ref and CC1	• Readily understood by all parties typically involved in the management of the resource including stakeholders, managers and analysts	• Quality of information determines whether method is reacting to real trends in biomass or simply following noise • May require an unacceptably large drop in catch recommendation in the first year of implementation • No feedback control
Tier 3A or 3B StatusQuo	• Readily understood by all parties typically involved in the management of the resource including stakeholders, managers and analysts	• Assumptions of a stable stock which is at or near sustainable equilibrium can often not be verified
	• Can easily be applied even by those not specifically trained in stock assessment procedures • Broadly applicable across species with different biological characteristics	• If fishing effort is highly variable or if a fishery is in development or experiencing overfishing, then the catch data stream will be problematic • No feedback control
Index-based		
Islope0	• Readily understood by all parties typically involved in the management of the resource including stakeholders, managers and analysts	• Quality of information determines whether method is reacting to real trends in biomass or simply following noise
	• Does not require long time series for index of abundance	• Data-rich in the sense that an index of abundance reflective of stock trends is required
Itarget0	• Same as Islope0	• Same as Islope0 • Assuming a target of 1.5 * Average Index over reference period is sufficient
Length-based		
LstepCC0	• Readily understood by all parties typically involved in the management of the resource including stakeholders, managers and analysts	• Quality of information determines whether method is reacting to real trends in biomass or simply following noise
	• Requires mean length which can be relatively simple to collect	• May require an unacceptably large drop in catch recommendation in the first year

		of implementation • Requires length measurements which accurately reflect trends in the population during both recent and reference periods • Average size may not be a direct measure of abundance, size data are often noisy and thus trends in population size may be difficult to quantify, and there is a time lag with change in size picking up the drop in abundance (i.e. biomass) thus precautionary tuning measures need to be incorporated • Assuming 5% step size adequate
Ltarget0	• Same as LstepCC0	• Same as LstepCC0 • Assuming a target of 1.05 * Average Length over reference period is sufficient
Age-based		
Fratio_CC	• Few data requirements (F_{MSY}, *Mort*) • Does not require estimate of stock abundance	• Assumes F_{MSY} value from meta-analysis appropriate • Requires age composition which accurately reflects trends in the population • Assumptions inherent in catch curve analysis • Using terminal year (2014) catch
BK_CC LVBcor	• Few data requirements (vbLinf, vbK, LFC) • Does not require estimate of stock abundance	• Requires age composition which accurately reflects trends in the population • Assumptions inherent in catch curve analysis • Using terminal year (2014) catch
YPR_CC LVBcor	• Does not require estimate of stock abundance	• Requires age composition which accurately reflects trends in the population • Assumptions inherent in catch curve analysis • Using terminal year (2014) catch • Does not take into account maturity information
Fdem_CC LVBcor	• Does not require estimate of stock abundance	• Requires age composition which accurately reflects trends in the population • Assumptions inherent in catch curve analysis • Using terminal year (2014) catch

Table 3.1.5 Summary of data inputs used to provide catch recommendations for Red Drum using the DLMtool. Superscripts identify data inputs derived from the LHWG [1], Total Removals WG

[2], and the Index WG [3]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Life-history		
Mort [1]	0.160 y^{-1} (0.32)	Calculated from Then et al. (2014) using maximum age; CV from cross-validation prediction error of updated Hoenig
vbLinf [1]	88.1 cm FL (0.001)	SEDAR 49 analysis for Fork Length (FL, in cm); CV calculated from SE
vbK [1]	0.32 (0.01)	SEDAR 49 analysis for FL; CV calculated from SE
vbt0 [1]	-1.29 (0.03)	SEDAR 49 analysis for FL; CV calculated from SE
wla [1]	1.43E-05 (0.08)	SEDAR 49 data analysis from FL to W Weight (W Wt); CV calculated from SE
wlb [1]	3.15 (0.01)	SEDAR 49 data analysis from FL to W Wt; CV calculated from SE
Steep [1]	0.9 (0.11)	Based on midpoint of range (Adams et al. 2016); CV calculated as maximum value of: abs[(range estimate-point estimate)/point estimate]
MaxAge [1]	42 y	Maximum age observed (Wilson and Nieland 2000)
Fishery		
Cat [2]	8,134,293 – 29,204,931 pounds (0.049)	Total removals from time period considered most appropriate for evaluation (1981-2014; DW Report Section 5.2.1)
LFC	42 cm FL (0.5)	Length at first capture (5th percentile of frequency curve for all data combined)
LFS	52 cm FL (0.5)	Modal length of all data combined
Composition		
CAA	10 y x 42 ages	Purse Seine aggregated catch-at-age (DW Report Section 9.2.1)
Abundance		
Ind [3]	0.39 – 1.17 fish per 100 hooks/ hour (1.18)	Dauphin Island Sea Laboratory bottom longline survey (DW Report Section 7.5.1)
Reference		
FMSY_M	0.87 (0.11)	Meta-analysis of 245 fish species worldwide (Zhou et al. 2012)

Table 3.1.6 Summary of data inputs used to provide catch recommendations for Lane Snapper using the DLMtool. Superscripts identify data inputs derived from the Total Removals WG [2] and the Index WG [3]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Fishery		
Cat [2]	118,204 – 820,506 pounds (0.103)	Total removals from time period considered most appropriate for evaluation (1986-2014; DW Report Section 5.2.2)
Composition		
ML	25 – 32 cm TL	Mean length from recreational private and headboat from 1986-2014
Abundance		
Ind [3]	0.42 – 1.57 fish per angler hour (0.064)	Headboat survey (DW Report Section 7.5.2)

Table 3.1.7 Summary of data inputs used to provide catch recommendations for Wenchman using the DLMtool. Superscripts identify data inputs derived from the Total Removals WG [2] and the Index WG [3]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Fishery		
Cat [2]	6,506 – 103,827 pounds (0.35)	Total removals from time period considered most appropriate for evaluation (DW Report Section 5.2.3)
Composition		
ML	12 – 17 cm FL	Mean length from NMFS small pelagics survey from 2002-2004 and 2006-2013
Abundance		
Ind [3]	0.545 – 1.836 fish per trawl hour (0.26)	NMFS small pelagics survey (DW Report Section 7.5.3)

Table 3.1.8 Summary of data inputs used to provide catch recommendations for Yellowmouth Grouper using the DLMtool. Superscripts identify data inputs derived from the Total Removals WG [2] and the Index WG [3]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Fishery		
Cat [2]	59 – 47,791 pounds (0.439)	Total removals from time period considered most appropriate for evaluation (1990-2014; DW Report Section 5.2.4)
Abundance		
Ind [3]	0.01 – 0.21 minimum count (0.50)	SEAMAP video survey (DW Report Section 7.5.4)

Table 3.1.9 Summary of data inputs used to provide catch recommendations for Snowy Grouper using the DLMtool. Superscripts identify data inputs derived from the Total Removals WG [2]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Fishery		
Cat [2]	83,100 – 370,980 pounds (0.11)	Total removals from time period considered most appropriate for evaluation (1990-2014; DW Report Section 5.2.5)

Table 3.1.10 Summary of data inputs used to provide catch recommendations for Speckled Hind using the DLMtool. Superscripts identify data inputs derived from the Total Removals WG [2]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Fishery		
Cat [2]	41,507 – 238,926 pounds (0.282)	Total removals from time period considered most appropriate for evaluation (1997-2014; DW Report Section 5.2.6)

Table 3.1.11 Summary of data inputs used to provide catch recommendations for Lesser Amberjack using the DLMtool. Superscripts identify data inputs derived from the Total Removals WG [2] and the Index WG [3]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Fishery		
Cat [2]	20,950 – 113,413 pounds (0.45)	Total removals from time period considered most appropriate for evaluation (1991-2009; DW Report Section 5.2.7)
Abundance		
Ind [3]	0.01 – 0.18 minimum count (0.15)	SEAMAP video survey (DW Report Section 7.5.7)

Table 3.1.12 Summary of data inputs used to provide catch recommendations for Almaco Jack using the DLMtool. Superscripts identify data inputs derived from the Total Removals WG [2] and the Index WG [3]. Data inputs are as defined in Table 3.1.1. Note that values for Cat and Ind are summarized by a range.

DLM input	Value (CV)	Source
Fishery		
Cat [2]	40,654 – 298,650 pounds (0.22)	Total removals from time period considered most appropriate for evaluation (1991-2014, DW Report Section 5.2.8)
Composition		
ML	37 – 53 cm FL	Mean length from recreational charterboat, private, and headboat from 1991-2014
Abundance		
Ind [3]	0.22 – 1.07 minimum count (0.36)	SEAMAP video survey (DW Report Section 7.5.8)

3.1.9 Figures

Performance Metric Demonstration

Total Number of Projection Years = 4
Total Number of Projection Years Used in Calculation = 4

	ProYear1	ProYear2	ProYear3	ProYear4
Sim1	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	F/FMSY>1
Sim2	**F/FMSY<1**	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**
Sim3	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	F/FMSY>1
Sim4	F/FMSY>1	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**
Sim5	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	F/FMSY>1

PNOF:
In the following simple example, the **PNOF** would be

$$PNOF\ (\%) = \frac{\sum_{n=1}^{n=nsim} \frac{F}{F_{MSY}} < 1}{nsim * Proyears} \times 100 = \frac{11}{5\ \times 4} \times 100 = 55\%$$

Would meet the specified performance criteria of > 50%

B50:
In the following simple example, the **B50** would be:

	ProYear1	ProYear2	ProYear3	ProYear4
Sim1	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**
Sim2	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**	B/BMSY<0.5
Sim3	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**	B/BMSY<0.5
Sim4	**B/BMSY>0.5**	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**
Sim5	B/BMSY<0.5	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**

$$B50\ (\%) = \frac{\sum_{n=1}^{n=nsim} \frac{B}{B_{MSY}} > 0.5}{nsim * Proyears} \times 100 = \frac{14}{5\ \times\ 4} \times 100 = 70\%$$

Would meet the specified performance criteria of > 50%

VY15:
In the following simple example, the **VY15** would be:

	Combined Across Years
Sim1	**AAVY<15%**
Sim2	**AAVY<15%**
Sim3	**AAVY<15%**
Sim4	AAVY>15%
Sim5	**AAVY<15%**

$$VY15\ (\%) = \frac{\sum_{y=t_1}^{y=t_2} simulations\ where\ AAVY < \ 0.15}{Total\ simulations} \times 100 = \frac{4}{5} \times 100 = 80\%$$

Would meet the specified performance criteria of > 50%

Figure 3.1 Simple example of how the performance metrics are calculated within the DLMtool.

Performance Metric Demonstration

Total Number of Projection Years = 10
Total Number of Projection Years Used in Calculation = 5

LTY:
In the following simple example, the **LTY** would be:

	ProYear6	ProYear7	ProYear8	ProYear9	ProYear10
Sim1	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**
Sim2	Catch/RefY < 0.5	Catch/RefY < 0.5	**Catch/RefY > 0.5**	Catch/RefY < 0.5	Catch/RefY < 0.5
Sim3	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	Catch/RefY < 0.5
Sim4	Catch/RefY < 0.5	Catch/RefY < 0.5	Catch/RefY < 0.5	Catch/RefY < 0.5	**Catch/RefY > 0.5**
Sim5	Catch/RefY < 0.5	Catch/RefY < 0.5	Catch/RefY < 0.5	**Catch/RefY > 0.5**	Catch/RefY < 0.5

$$LTY = \frac{\sum simulations\ where \frac{Catch}{RefY} > 0.5}{Total\ simulations * NProyears} \times 100 = \frac{12}{5 \times 5} \times 100 = 48\%$$

Which would have moderate long-term performance in terms of yield

Figure 3.1 (continued) Simple example of how the performance metrics are calculated within the DLMtool.

3.2 MEAN LENGTH ESTIMATOR

3.2.1 Overview

Length frequency data from multiple data sources were evaluated for use for five of the eight SEDAR 49 species: Red Drum, Lane Snapper, Wenchman, Snowy Grouper, and Speckled Hind. Sample sizes and temporal coverage were examined to determine whether analysis was supported.

3.2.2 Model Configuration and Assumptions

For each species and selected data source, total mortality (Z) estimates and changes in mortality were calculated using a variant of the Beverton-Holt length-based mortality estimator (Beverton and Holt 1956). The Beverton-Holt mortality estimator is based on the assumption of equilibrium conditions and has received widespread use, especially in data-limited situations, owing mainly to minimal parameter inputs. Required parameters include the von Bertalanffy growth coefficient (K) and the asymptotic length (L_∞) parameters, the length at full selection or recruitment (L_c, which is akin to LFS in the DLMtool application), defined as the smallest size at which animals are fully vulnerable to the fishery or to the sampling gear, and the mean length of the animals ($\bar{L}$) larger than L_c:

$$Z = \frac{K\,(L_\infty - \bar{L})}{\bar{L} - L_c} \qquad \text{Equation (3.2.1)}$$

Although this approach is data-limited, it can be considered assumption-rich as it assumes:

1. Growth is asymptotic with known parameters K and L_∞ that are constant over time;
2. No individual variability in growth;
3. Constant and continuous recruitment over time;
4. Mortality rate is constant with age for all ages $t > t_c$, where t_c is the age at first capture, and fishing mortality is knife-edge;
5. Mortality rate is constant over time; and
6. Population is in equilibrium (i.e. enough time has passed following any change in mortality that $\bar{L}$ now reflects the new mortality level).

The method has been criticized, however, because the assumption of equilibrium (6) is very difficult to meet in real world situations where any change in fishing pressure disrupts the equilibrium stable age distribution. Equilibrium takes even longer to achieve when fishing pressure is decreased, as only time will allow the smaller and younger animals to grow and the mean length to increase and reflect the current mortality rate. In the case of increased fishing pressure, it takes less time for the mean length of the population to respond to the removal of larger and older animals and reflect the current mortality rate.

To ease the assumption of equilibrium conditions, Gedamke and Hoenig (2006) developed an extension of the Beverton-Holt length-based mortality estimator for use in non-equilibrium situations where mortality rate may change over time. The transitional form of the model allows mortality estimates to be made within a few years of a change rather than waiting for the mean length to stabilize at a new equilibrium level. As soon as a decline in $\bar{L}$ is detected, this model can be applied and the trajectory of decline can be used to estimate the new total mortality rate and how $\bar{L}$ will change over time. The method is described in detail in Gedamke and Hoenig

(2006) and has the same data requirements discussed above for the Beverton and Holt mortality estimator. Gedamke and Hoenig (2006) demonstrated the utility of this approach using both simulated data and an application to data for goosefish caught in the Northeast Fisheries Science Center fall groundfish trawl survey.

The mean length in a population can be calculated d years after a single permanent change in total mortality from Z_1 to Z_2 y^{-1} by the following equation:

$$\bar{L} = L_\infty - \frac{Z_1 Z_2 (L_\infty - L_c)\{Z_1 + K + (Z_2 - Z_1) exp(-(Z_2 + K)d)\}}{(Z_1 + K)(Z_2 + K)(Z_1 + (Z_2 - Z_1)\exp(-Z_2 d))} \qquad \text{Equation (3.2.2)}$$

For SEDAR 49, a maximum of two changes in total mortality was allowed. An algorithm programmed in AD Model Builder in a maximum likelihood framework was used to estimate mortality rates from the observed mean lengths as in SEDAR (2014). A shell program was written in R to conduct a grid search of potential year(s) of change and also to conduct a sensitivity analysis to input parameters. Models were run starting with the simplest model (i.e. no change in mortality) and then sequentially by adding an additional year of change and therefore increasing complexity (i.e. each year of change adds two parameters). Akaike information criterion with a correction for small sample size (AICc) was calculated for each scenario. The change in AIC or ΔAIC was calculated to compare models. ΔAIC was calculated sequentially by subtracting the AIC of the more parsimonious model from the AIC of the less parsimonious model. When comparing models, a reduction of ΔAIC by more than 2 units was interpreted as strong support for the less parsimonious model.

3.2.3 Input Parameters and Data Sources

The input parameters for the mean length estimator include:

1. $\bar{L}$, the mean length for the selected data source;
2. L_c, the length at which animals are fully vulnerable to the gear or survey;
3. K, the von Bertalanffy growth coefficient; and
4. L_∞, the von Bertalanffy asymptotic length.

For each species, length data were plotted by data source and gear to assess feasibility of employing the mean length estimator. Data sources were combined where similar selectivity patterns were evident (e.g. charterboat and private recreational fishing modes). In instances where one data source consisted of the majority of landings and length observations, the mean length estimator was applied to this dominant data source.

Annual length-frequency plots were constructed for each species and selected data source to enable investigation of changes in L_c over time. The L_c was selected as the modal length for all combined length frequency data and was also explored visually from the annual length-frequency distributions (Thorson and Prager 2011) while considering the annual sample size. Trends in the modal length over time could reflect changes in selectivity or recruitment. Annual mean lengths were calculated from lengths that were larger than L_c. A summary of data inputs is provided in Table 3.2.1 for each species.

3.2.4 Estimated Parameters

The parameters estimated by the non-equilibrium length-based mortality estimator are total mortality rate(s) (Z) and the year(s) of change.

3.2.5 Uncertainty and Measures of Precision

A sensitivity analysis was conducted for each species and gear selected. The analysis evaluated sensitivity in the estimates of total mortality and in the year(s) of change (if applicable) to changes in the growth parameters and values of L_c. Growth pairs were randomly generated from a truncated multivariate normal distribution using the input values K and L_∞, their respective coefficient of variation estimates, and an assumed correlation of -0.9. The sensitivity of the mean length estimator to the selection of L_c was explored using two alternative assumptions, the value chosen by visual inspection and used in the initial analysis (base run), and other potential modal lengths based on visual inspection of the annual length-frequency distributions for the selected data source. An increasing trend in Z with increasing L_c may suggest dome-shaped selectivity whereas no trend would suggest asymptotic selectivity.

3.2.6 Estimates of Fishing Mortality

For each species, fishing mortality (F) was calculated using the equation ($F = Z - M$), where Z was the estimate of current total mortality from the mean length estimator and M was the estimate of natural mortality provided by the LHWG.

3.2.7 Per Recruit Analysis

Due to issues with model output for all species examined, which are briefly described in their respective results sections (Sections 4.2 – 11.2), catch recommendations derived from per recruit analysis will not be displayed for either yield-per-recruit or spawner-per-recruit analyses.

3.2.8 Tables

Table 3.2.1 Summary of data sources and parameters for estimating total mortality using the non-equilibrium mean length estimator for the species under evaluation. MRFSS = Marine Recreational Fisheries Statistics Survey, Purse Seine data aggregated across fishery-independent surveys conducted by Louisiana State University, NMFS Pascagoula, Florida Fish and Wildlife Conservation Commission, and Dauphin Island Sea Laboratory. Length types include Fork Length (FL, in cm) and Total Length (TL, in cm). – indicates no data available. Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

Species	Data Source and Gear	von Bertalanffy L_∞	von Bertalanffy K	L_c
Red Drum	MRFSS private and charterboat	88.1 cm FL (0.001)	0.32 (0.01)	52 cm FL
	Purse seine (aggregated)	88.1 cm FL (0.001)	0.32 (0.01)	86 cm FL
	Dauphin Island Sea Laboratory bottom longline	88.1 cm FL (0.001)	0.32 (0.01)	88 cm FL
Lane Snapper	MRFSS private and headboat	44.9 cm FL (0.04)	0.17 (0.16)	24 cm FL
	Commercial longline and handline	44.9 cm FL (0.04)	0.17 (0.16)	32 cm FL
Wenchman	SEAMAP small pelagics	24.0 cm FL (0.2)	0.18 (0.2)	19 cm FL
Yellowmouth Grouper	none	–	–	–
Snowy Grouper	Commercial longline	106.5 cm TL (0.06)	0.094 (0.22)	50 cm TL
	Commercial handline	106.5 cm TL (0.06)	0.094 (0.22)	44 cm TL
Speckled Hind	Commercial longline	88.8 cm TL (0.08)	0.12 (0.17)	44 cm TL
Lesser Amberjack	none	–	–	–
Almaco Jack	none	–	–	–

3.3 CATCH CURVE ANALYSIS

3.3.1 Overview

Population parameters were estimated using an analysis of catch-age data.

3.3.2 Model Configuration and Assumptions

Catch curves are characterized by plots of the lognormally distributed catch-at-age (C_a) against age (a) with the following equation (Quinn and Deriso 1999):

$$E\ (\ln C_a) = \left[\ln\left(\mu\ N_f\right) + fZ\right] - Za \qquad \text{Equation (3.3.1)}$$

where μ is the probability of catching a fish, N_f is the abundance at the start of age a, and Z is the total mortality at age a.

The estimate of Z is the negative of the slope estimated from the linear regression, and its standard error is equal to the SE of the slope. The corresponding estimate of survival at age (S_a) is exp(Z). A catch curve often shows an increasing section of the curve for younger ages, due to increasing availability of fish or selectivity of the gear. A decreasing trend is characteristic for older ages due to increased mortality, and stems from full selectivity by the fishing or survey gear.

Catch curve analysis is based on the following assumptions:

1. Decrease in number of individuals across age structure is due to mortality;
2. Aged animals representative of population;
3. Fish are aged accurately;
4. Total mortality (Z) is constant across age classes and between years;
5. Recruitment is constant between years; and
6. Vulnerability to fishing gear or survey gear is equal for all ages and constant over year classes.

3.3.3 Input Parameters and Data Sources

The input data for catch curve analysis include:

1. Catch-at-age; and
2. The age at which animals are fully vulnerable to the gear or survey.

Data inputs are provided in Table 3.3.1.

3.3.4 Estimated Parameters

The parameters estimated using catch curve analysis are total mortality rate (Z).

3.3.5 Estimates of Fishing Mortality

Fishing mortality (F) was calculated using the equation ($F = Z - M$), where Z was the estimate of current total mortality from the catch curve analysis and M was the estimate of natural mortality provided by the LHWG.

3.3.6 Tables

Table 3.3.1 Summary of data sources and parameters for estimating total mortality using catch curve analysis for Red Drum. Age data (in years, y) were not provided for any other species under evaluation. Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

Data Source	Years Surveyed	Age at Full Selection
Alabama Deep-Sea Fishing Rodeo handline	2009, 2011-2014	22 y (8 observations)
Dauphin Island Sea Laboratory (DISL) bottom longline	2008-2014	22 y (30 observations)
Aggregated fishery-independent purse seine (PS)	1986-1988, 1996-1998, 2006-2008, 2014	7 y (293 observations)
Louisiana State University (LSU) / NMFS Pascagoula PS	1986-1988	15 y (89 observations)
Florida Fish and Wildlife Conservation Commission (FWRI) & LSU/NMFS Pascagoula PS	1996-1998	7 y (141 observations)
FWRI PS	2006-2008	10 y (39 observations)
DISL PS	2014	10 y (24 observations)

4 RED DRUM DATA-LIMITED EVALUATION RESULTS

4.1 Data-Limited Methods Toolkit

Six methods were feasible in the DLMtool for Red Drum based on data availability and reliability (Table 4.1). Overall, most data inputs were scored fairly reliable or higher, with life history inputs and total removals scored as highly reliable (Table 4.2). The index of abundance derived from the Dauphin Island Sea Laboratory bottom longline survey had a large CV and low sample size; however, the index was scored as highly reliable because the trend in abundance was similar to the trend in abundance from the fishery-dependent Marine Recreational Fisheries Statistics Survey index. Minor issues with data quality (i.e. fair scoring, 33-67%) were evident for natural mortality which was based on a maximum age estimate from an older study (Wilson and Nieland 2000) and steepness which was derived from other Red Drum assessments (Florida, Atlantic). Available length composition from the recreational private and charterboat fishing modes was not used in length-based indicator methods due to analyst concerns that these data may not be representative of the population due to state-specific regulations such as variable slot limits (Table 4.3) as well as other regulations such as bag limits or allowances of a single fish larger than the slot limit in some Gulf States.

4.1.1 Management Strategy Evaluation

Of the six feasible methods, Islope0 was the only method to meet the performance criteria for PNOF, B50, and VY15 (Table 4.4). No convergence issues were detected as all performance metrics converged to within 0.05% (Figure 4.1). Performance metrics tended to converge by about 200 simulations, although it is important to note that some simulations resulted in no removals (i.e. catch), potentially a function of the dome-shaped selectivity, suggesting further tuning of the operating model may be necessary. When trends over the 40 year projection period were examined, Islope0 consistently resulted in mean ratios of biomass to biomass at maximum sustainable yield (B/B_{MSY}) above the 1.0 threshold and fishing mortality to fishing mortality at maximum sustainable yield (F/F_{MSY}) below the 1.0 threshold (Figure 4.2).

An examination of tradeoffs was not necessary since no other methods met the PNOF, B50 and VY15 performance criteria.

4.1.2 Sensitivity of method performance to assumptions in the operating model

Different assumptions regarding a plausible range of stock depletion were assumed in different operating models within the MSE:

- A severely depleted state (D = 0.05 – 0.2);
- A moderately depleted state (D = 0.2 – 0.6); and
- A lightly depleted state (D = 0.6 – 0.9).

In the lightly (D = 0.6 – 0.9) and severely (D = 0.05 – 0.2) depleted states of nature assumed, the operating model could not reach the specified depletion level and therefore were excluded from analyses. Islope0 did not meet the performance criteria under the moderately depleted state (D = 0.2 – 0.6; Figure 4.3).

Examination of varying lambda values as scalars (see Table 3.1.3 for equation) on the index of abundance in Islope0 revealed relatively similar trends in performance metrics (within 3.4%) with the largest difference evident in VY15 (11.2%; Table 4.5). Larger lambda values result in much lower VY15, with lambda values over 0.8 failing to meet performance metrics for VY15.

4.1.3 Calculation of Catch Recommendation

The median catch recommendation obtained using Islope0 is 23,847,838 pounds (± 1,073,038 pounds, SD) (Table 4.6), which is slightly larger than the average catch between 2010 and 2014 (Figure 4.4). This catch recommendation applies gulf-wide, and is based on data including both inshore and offshore removals and discards. Given the uncertainty surrounding the ad-hoc reference period (i.e. 2010-2014) used to calculate average catch in Islope0, this method is not recommended for providing management advice without further refinements. Total removals by the commercial and recreational fisheries are shown in comparison to the commercial landings (in pounds) and recreational landings (in numbers) reported in the previous Gulf-wide Red Drum assessment (Porch 2000) (Figure 4.5).

4.1.4 Sensitivity of Catch Recommendations

The catch recommendation from Islope0 is sensitive to the magnitude of total removals (Figure 4.6). If total removals in the last five years are higher than specified (e.g. exclusion of removals from sources such as bycatch in other fisheries), a larger catch recommendation would be recommended (Figure 4.6). For Islope0, an increase in the slope (positive) of the index of abundance leads to a higher catch recommendation (Figure 4.6). For example, when multiplying the index of abundance by 2 as in Figure 4.6, the catch recommendation would increase to approximately 24,000,000 pounds.

Overall, the CV on total removals had a minor impact on the median catch recommendation for Islope0, with a lower catch recommendation (~10,000 pounds) obtained if the CV is larger than observed (i.e. doubled) (Table 4.7).

4.2 Mean Length Estimator

The mean length estimator analysis was pursued for Red Drum to estimate total mortality using length composition derived from multiple data sources including the recreational private and charterboat fleets (Figure 4.7), Dauphin Island Sea Laboratory (DISL) bottom longline survey (Figure 4.8), and aggregated fishery-independent purse seine surveys (Figure 4.9). However, results are only briefly described here due to analyst concerns regarding violated assumptions and unexpected results. Initial exploratory attempts using the recreational data subset to data within a common slot limit did not produce defensible results due to an incomplete spectrum of the growth curve considered. For both the DISL bottom longline and fishery-independent purse seine datasets, total mortality was estimated at 0.001, which could be expected given that most samples were derived from offshore where fishing is prohibited.

4.3 Catch Curve Analysis

Catch curve analysis was performed for Red Drum using a variety of data sources, with the majority of analyses producing expected *F*s of 0 given the moratorium (Table 4.8). For the aggregated fishery-independent purse seine data spanning the 1980s (1986-1988) through 2010s (2014), total mortality was estimated as 0.14 (Figure 4.10), which was lower than the SEDAR 49 LHWG natural mortality estimate (0.16). When analyzed by decade, total mortality was highest during 1986-1988 and lowest during 1996-1998 (Figure 4.11). An interesting pattern emerged during the 2000s, where a separation of younger fish and older fish was evident (Figure 4.12). The total mortality estimate of 0.054 for the younger fish during the recovery period may reflect an estimate of natural mortality, substantially below the SEDAR 49 LHWG recommended value (0.16). However, it is important to note that some individuals in the FWRI fishery-independent purse seine may have been collected in state waters, where fishing was allowed. In addition, these results are dependent upon the assumptions inherent within catch curve analysis, such as asymptotic selectivity.

4.4 Tables

Table 4.1 Feasible methods for the DLMtool evaluation for Red Drum. Data inputs are as defined in Table 3.1.1.

Method	Data Inputs													
	Mort	FMSY_M	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	LFC	LFS	CAA
Catch-based														
CC1														
Indicator (Index-based)														
Islope0														
Age-based														
Fratio_CC														
BK_CC_LVBcor														
YPR_CC_LVBcor														
Fdem_CC_LVBcor														

Table 4.2 Guidance table for Red Drum documenting data requirements for each method and reliability scores for each data input. Colors reflect poor quality (red; 0-33%), fair quality (yellow; 34-67%), and good quality (green; 68-100%), and are based on the information content reliability scores discussed in Section 2.4. Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

Method	Data Requirement	Reliability Score
CC1	Total Removals: Known and informative for 2010-2014	Good
Islope0	Total Removals: Known and informative for 2010-2014	Good
	Index: DISL bottom longline representative of trend in population abundance (2010-2014)	Good
Fratio_CC	Total Removals: Known and informative for 2014	Good
	Mort: Known and constant across ages	Fair
	FMSY_M: Meta-analysis value derived from Zhou et al. (2012) appropriate; includes a few southeast US species (groupers, snappers, Red Drum and Greater Amberjack)	Fair
	CAA: Aggregated purse seine data accurately represent historical extractions by age (1986-1988, 1996-1998, 2006-2008, 2014)	Good
BK_CC_LVBcor	Total Removals: Known and informative for 2014	Good
	Mort: Known and constant across ages	Fair
	Growth: Representative of stock (derived from various gears, see Table 2.12.3 in DW Report)	Good
	Total Removals: Known and informative for 2014	Good
	LFC: Representative of selectivity	Good
	CAA: Aggregated purse seine data accurately represent historical extractions by age (1986-1988, 1996-1998, 2006-2008, 2014)	Good
YPR_CC_LVBcor	Total Removals: Known and informative for 2014	Good
	Mort: Known and constant across ages	Fair
	Growth: Representative of stock (derived from various gears, see Table 2.12.3 in DW Report)	Good
	Length-Weight: Representative of stock (SEDAR 49 data)	Good
	LFC: Representative of selectivity	Good
	CAA: Aggregated purse seine data accurately represent historical extractions by age (1986-1988, 1996-1998, 2006-2008, 2014)	Good

Method	Data Requirement	Reliability Score
Fdem_CC_LVBcor	Total Removals: Known and informative for 2014	Good
	Mort: Known and constant across ages	Fair
	Growth: Representative of stock (derived from various gears, see Table 2.12.3 in DW Report)	Good
	Steep: Known and representative of stock (mid-point of range from previous Red Drum assessments [Florida and Atlantic])	Fair
	CAA: Aggregated purse seine data accurately represent historical extractions by age (1986-1988, 1996-1998, 2006-2008, 2014)	Good

Table 4.3 Comparison of historic (1987) and current (2014) state-specific slot limits for Red Drum in Total Length (inches) for state waters, which complicates the aggregate use of length composition derived from the recreational private and charterboat fishing modes. Regulations were obtained from GMFMC (1988) and GSMFC (2014) for historical and current regulations, respectively.

State	1987 slot limit		2014 slot limit	
	Minimum	Maximum	Minimum	Maximum
Florida	18	27	18	27
Alabama	14	32	16	26
Mississippi	14	30	18	30
Louisiana	14	30	16	27
Texas	18	30	20	28
Range	Largest Minimum 18	Smallest Maximum 27	Largest Minimum 20	Smallest Maximum 26

Table 4.4 Performance metrics for methods meeting performance criteria for Red Drum. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing; B50 = Probability of the biomass being above 50% B_{MSY}; VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY}. Note that performance for Bbelow20 is reversed, where a low probability is preferable.

Method	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	99.5	99.8	54.3	12.7	30.4	0.0

Table 4.5 Comparison of model performance for different configurations of Islope0 by varying the lambda scalar on the index of abundance, with the default value highlighted in bold. Performance metrics are as defined in Table 4.4. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Configurations are shown which do not meet the 50% threshold for VY15 (noted in red) to provide insight into the tradeoffs between scalar values and performance metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Lambda	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	0.1	99.4	100.0	53.6	13.7	31.8	0.0
	0.2	99.2	99.8	53.6	14.1	31.6	0.0
	0.3	99.2	99.7	53.3	13.6	31.2	0.0
	0.4	99.4	99.9	52.3	13.8	31.4	0.0
	0.5	98.9	99.5	51.8	13.5	31.0	0.0
	0.6	98.7	99.3	51.5	13.4	30.8	0.0
	0.7	98.9	99.4	49.6	13.8	30.7	0.0
	0.8	98.7	99.2	50.5	13.6	30.9	0.0
	0.9	98.6	99.2	48.0	13.5	30.9	0.0
	1.0	98.5	99.1	48.6	14.0	30.3	0.0
	1.1	97.9	98.5	47.0	13.4	31.2	0.0
	1.2	98.1	98.7	46.6	14.0	31.0	0.0
	1.3	97.7	98.3	47.0	14.0	31.1	0.0
	1.4	97.6	98.2	46.1	13.7	31.3	0.0
	1.5	97.2	97.8	44.9	14.3	31.2	0.0
	1.6	96.8	97.5	45.6	14.1	30.9	0.0
	1.7	96.3	97.0	44.6	13.5	31.0	0.0
	1.8	97.2	97.8	43.5	14.5	30.5	0.0
	1.9	96.3	97.0	43.1	13.4	31.1	0.0
	2.0	96.0	96.7	42.4	15.1	31.6	0.0
	Minimum	96.0	96.7	42.4	13.4	30.3	0.0
	Maximum	99.4	100.0	53.6	15.1	31.8	0.0
	Difference	3.4	3.3	11.2	1.7	1.5	0.0

Table 4.6 Summary statistics of the catch recommendation (in pounds) for Islope0, the only viable method for Red Drum. Due to concerns regarding model assumptions (i.e. the validity of the recent reference period of 2010 – 2014 used in this analysis), this method is not recommended for providing management advice without additional discussions regarding the appropriateness of this or another selected reference period.

Statistic	Islope0
25%	23,043,008
40%	23,481,614
50%	23,748,838
75%	24,464,449
Mean	23,763,717
SD	1,073,038
CV	0.045

Table 4.7 Sensitivity of catch recommendations for Red Drum to the CV specified for the total removals (Cat CV) required for Islope0. Statistics reported for the catch recommendation include the 25th, 40th, 50th, and 75th percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV). Due to concerns regarding model assumptions (i.e. the validity of the recent reference period of 2010 – 2014 used in this analysis), this method is not recommended for providing management advice without additional discussions regarding the appropriateness of this or another selected reference period.

Statistic	Cat CV	
	0.049	0.098
25%	23,043,008	22,802,891
40%	23,481,614	23,371,293
50%	23,748,838	23,738,216
75%	24,464,449	24,690,663
Mean	23,763,717	23,769,355
SD	1,073,038	1,406,690
CV	0.045	0.059

Table 4.8 Summary of catch curve analysis conducted for Red Drum. Purse Seine data aggregated across fishery-independent surveys conducted by Louisiana State University (LSU), NMFS Pascagoula, Florida Fish and Wildlife Conservation Commission (FWRI), and Dauphin Island Sea Laboratory (DISL). Purse seine data sources are described in detail in Table 8.5.3 of the DW Report. Parameters include the coefficient of determination (R^2), total mortality rate (Z), standard error (SE), survival (S), natural mortality rate (M), and fishing mortality rate (F).

Data Source	Years Surveyed	R^2	Z	Z SE	S	M	Z - M	F
Alabama Deep-Sea Fishing Rodeo handline	2009, 2011-2014	0.76	0.124	0.018	0.88	0.16	-0.04	0.00
DISL bottom longline	2008-2014	0.78	0.208	0.031	0.81	0.16	0.05	0.05
Aggregated purse seine (PS)	1986-1988, 1996-1998, 2006-2008, 2014	0.95	0.144	0.006	0.87	0.16	-0.02	0.00
LSU/NMFS Pascagoula PS	1986-1988	0.85	0.210	0.021	0.81	0.16	0.05	0.05
FWRI & LSU/NMFS Pascagoula PS	1996-1998	0.73	0.116	0.014	0.89	0.16	-0.04	0.00
FWRI PS	2006-2008	0.76	0.179	0.025	0.84	0.16	0.02	0.02
DISL PS	2014	0.65	0.170	0.031	0.84	0.16	0.01	0.01

4.5 Figures

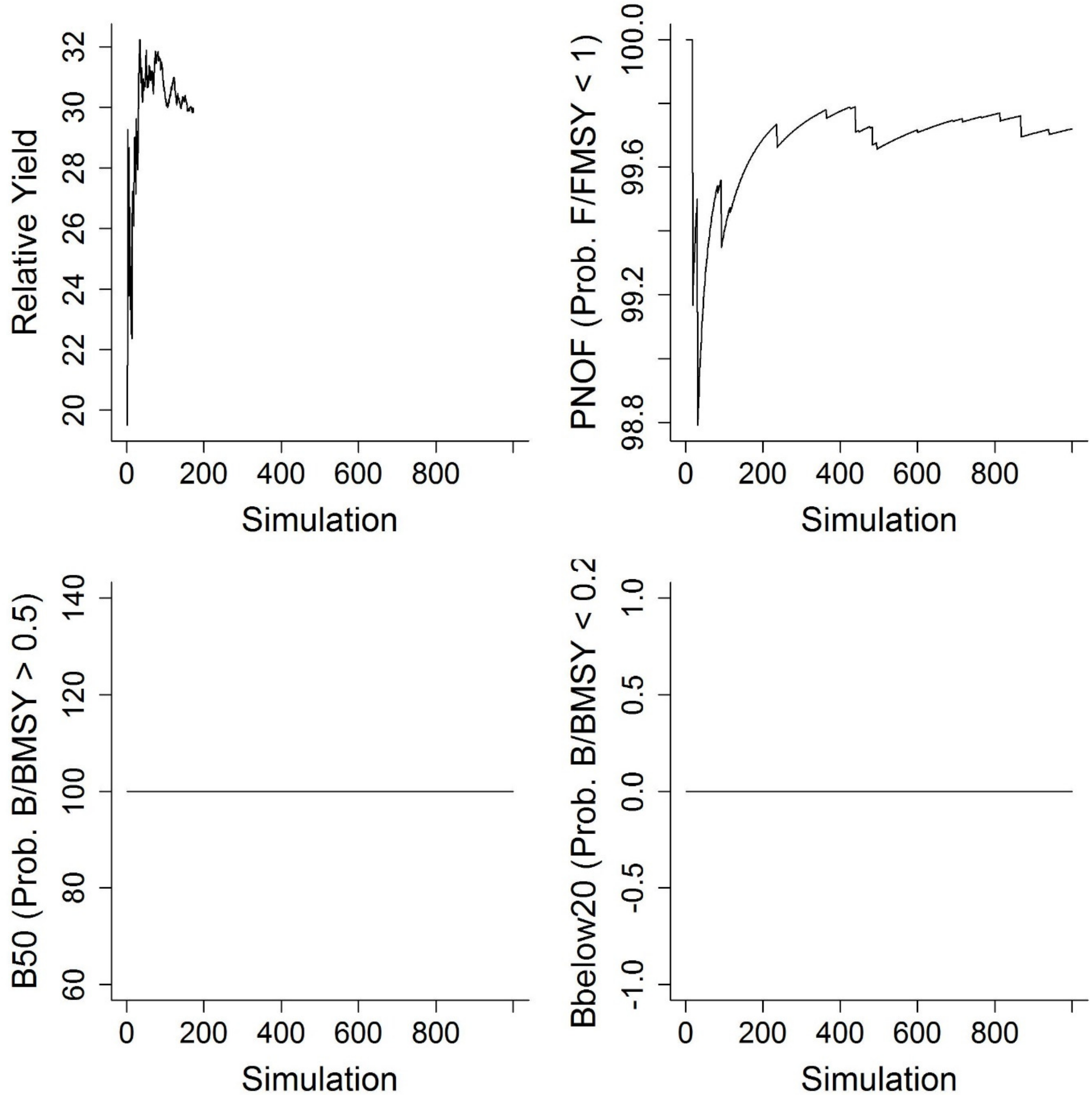


Figure 4.1 Convergence plot confirming that performance criteria for each viable method converged to within 0.05%, indicating that the number of simulations was sufficient for Red Drum. Black line identifies Islope0. Relative yield corresponds to the LTY divided by the reference yield, which is the highest mean yield over the last five years of the projection period that can be obtained from a fixed *F* strategy.

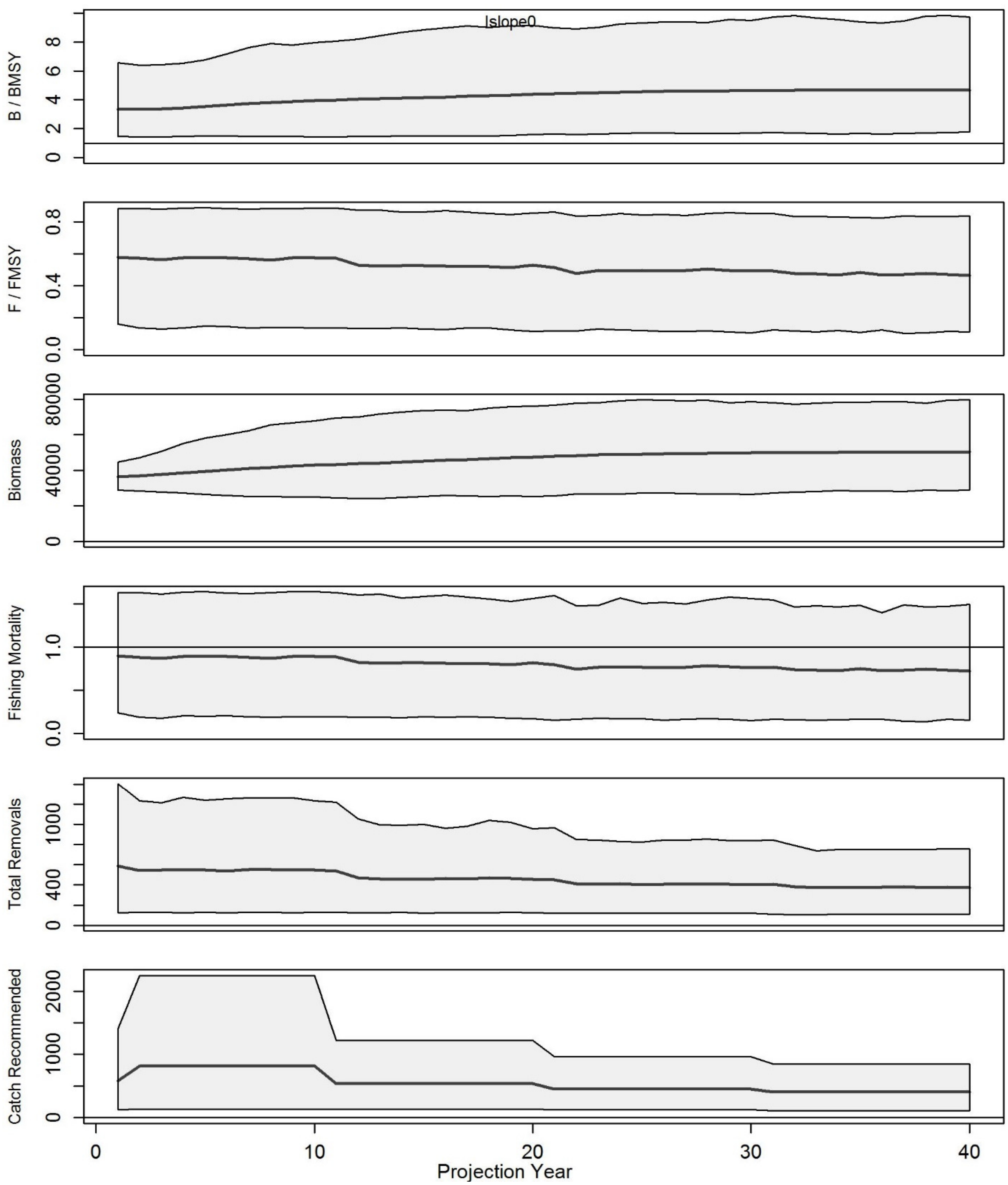


Figure 4.2 Comparison of stock status outputs and catches for Red Drum for the 40-year projection period where an assessment is conducted in years 1, 11, 21, and 31. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, total removals (in pounds), and the catch recommendation (in pounds) for Islope0. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 5th and 95th percentiles.

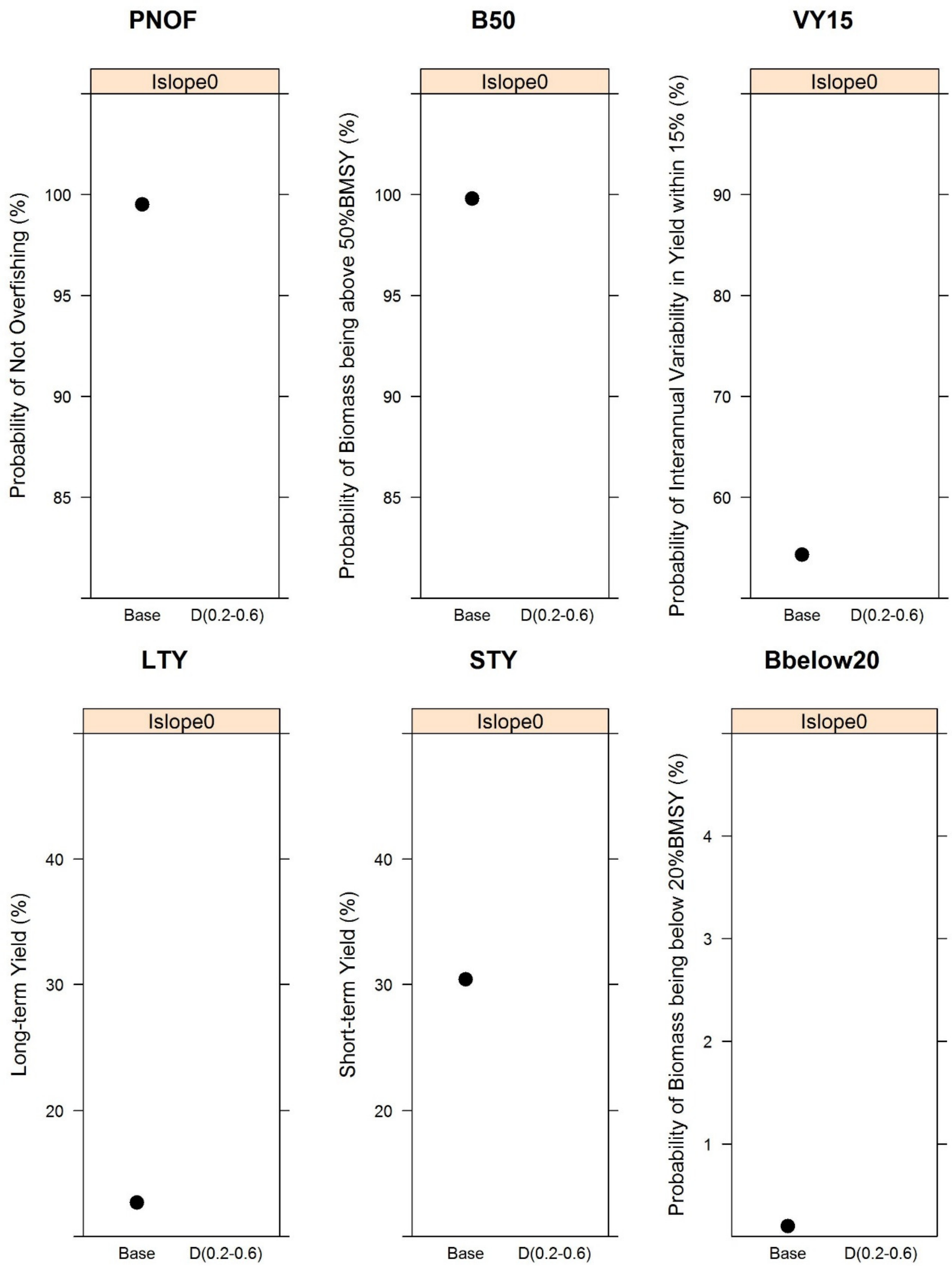


Figure 4.3 Method performance for Red Drum assuming the base level of depletion (base; D = 0.42 – 0.59 based on recent mean length and the ML2D function in the DLMtool) and a moderately depleted state (D = 0.2 – 0.6). Results for the severely (D = 0.05 – 0.2) and lightly depleted states (D = 0.6 – 0.9) are not shown because the depletion levels could not be reached. The absence of points indicates that the performance metric(s) did not meet the specified criteria (> 50%) for PNOF, B50, and VY15.

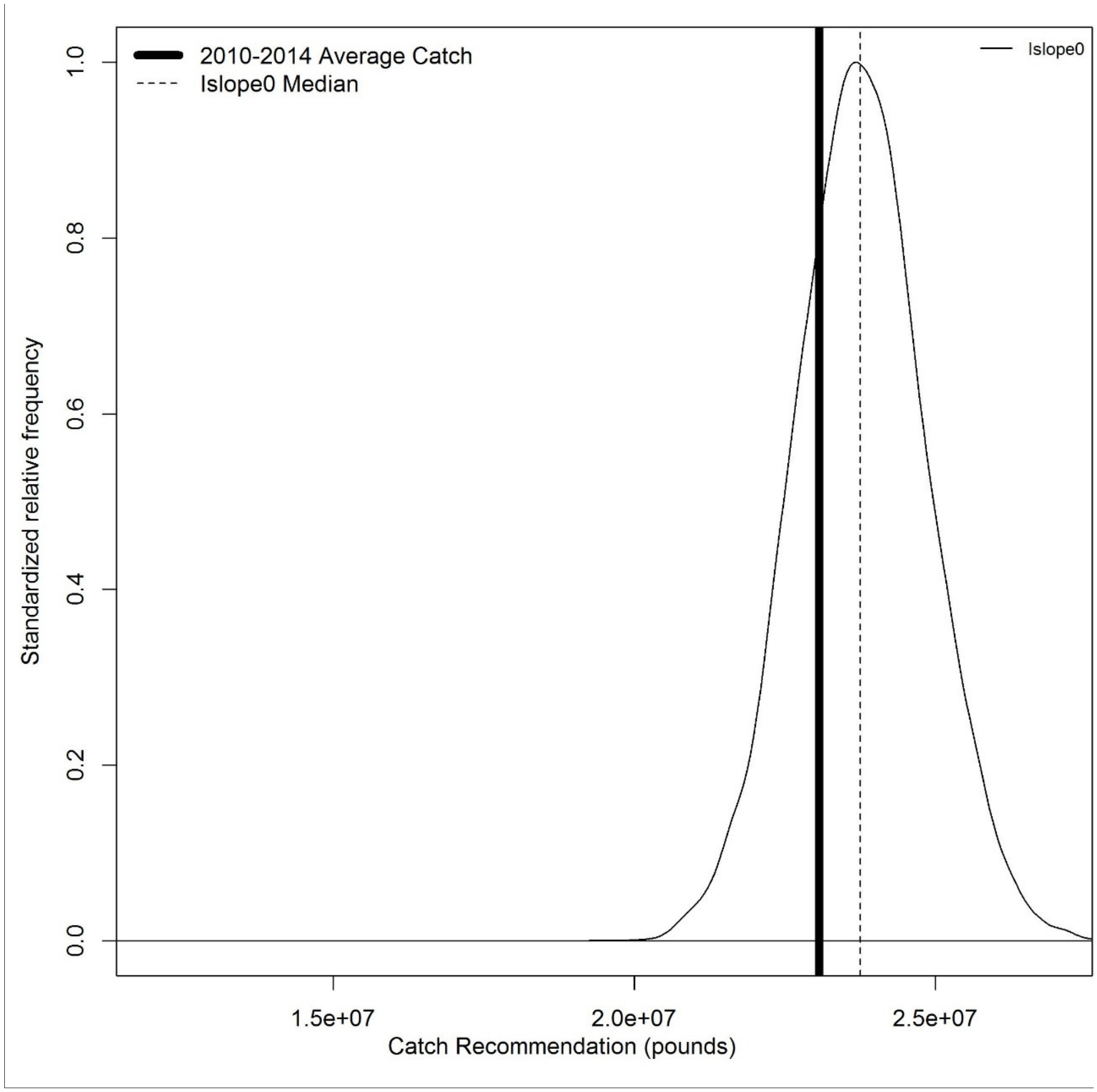


Figure 4.4 Distribution of the catch recommendation (in pounds) for Red Drum recommended by the only viable method, Islope0. The average catch between 2010 and 2014 (thick black line) is included for comparison. Due to concerns regarding model assumptions (i.e. the validity of the recent reference period of 2010 – 2014 used in this analysis), this method is not recommended for providing management advice without additional discussions regarding the appropriateness of this or another selected reference period.

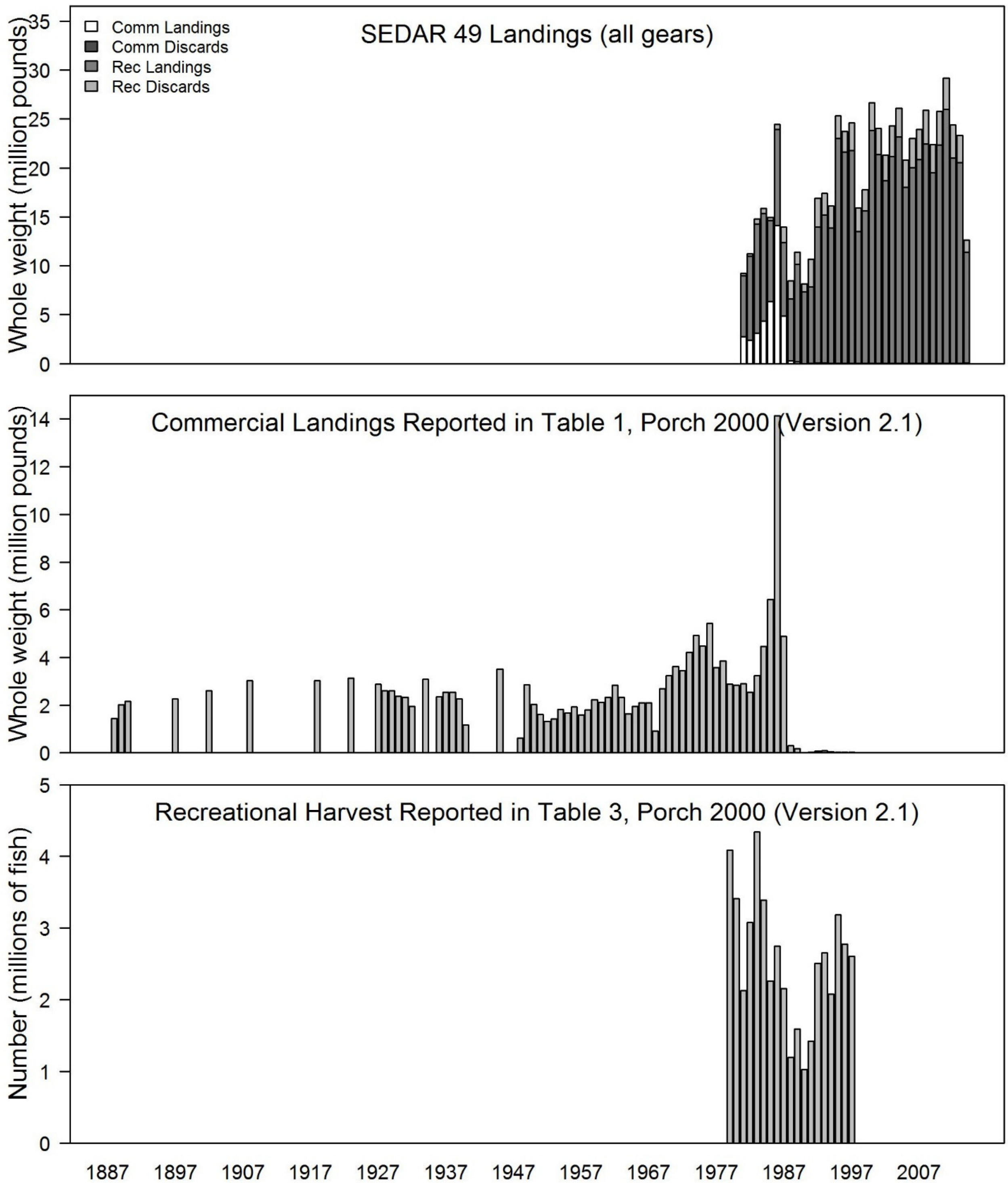


Figure 4.5 Comparison of total removals reported for SEDAR 49 and commercial and recreational landings prior to the moratorium. Note that total removals for SEDAR 49 include commercial landings and discards and recreational landings and discards.

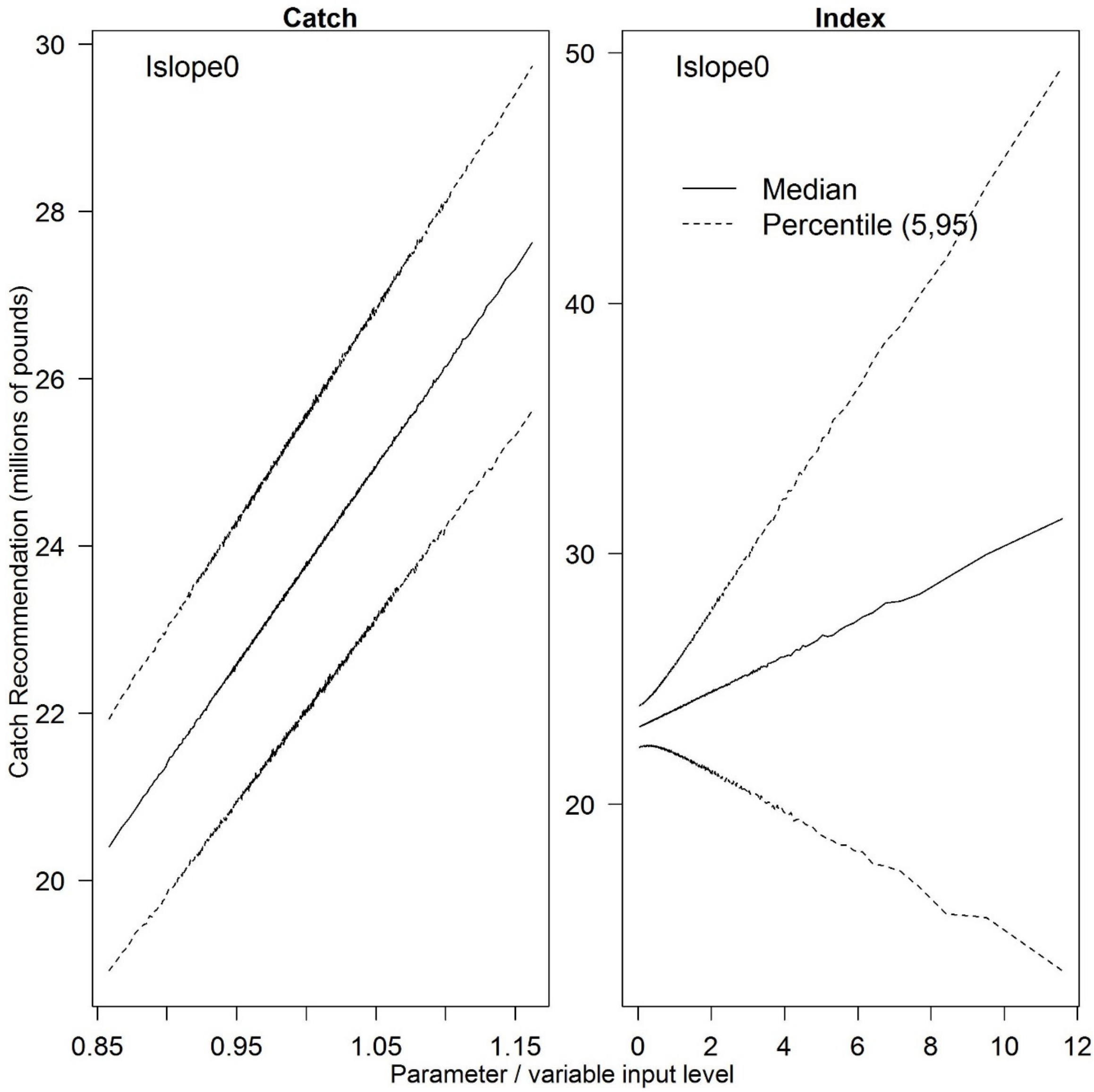


Figure 4.6 Sensitivity of the catch recommendation for Red Drum to marginal changes in the required data inputs for Islope0 (Catch and index of abundance). Note that ranges for parameter ranges are derived from the CV for each parameter, with the *x*-axis referring to a multiplier of either the time series of catch (e.g. 1.05 times the Cat) or the index of abundance (e.g. 2 times the Ind).

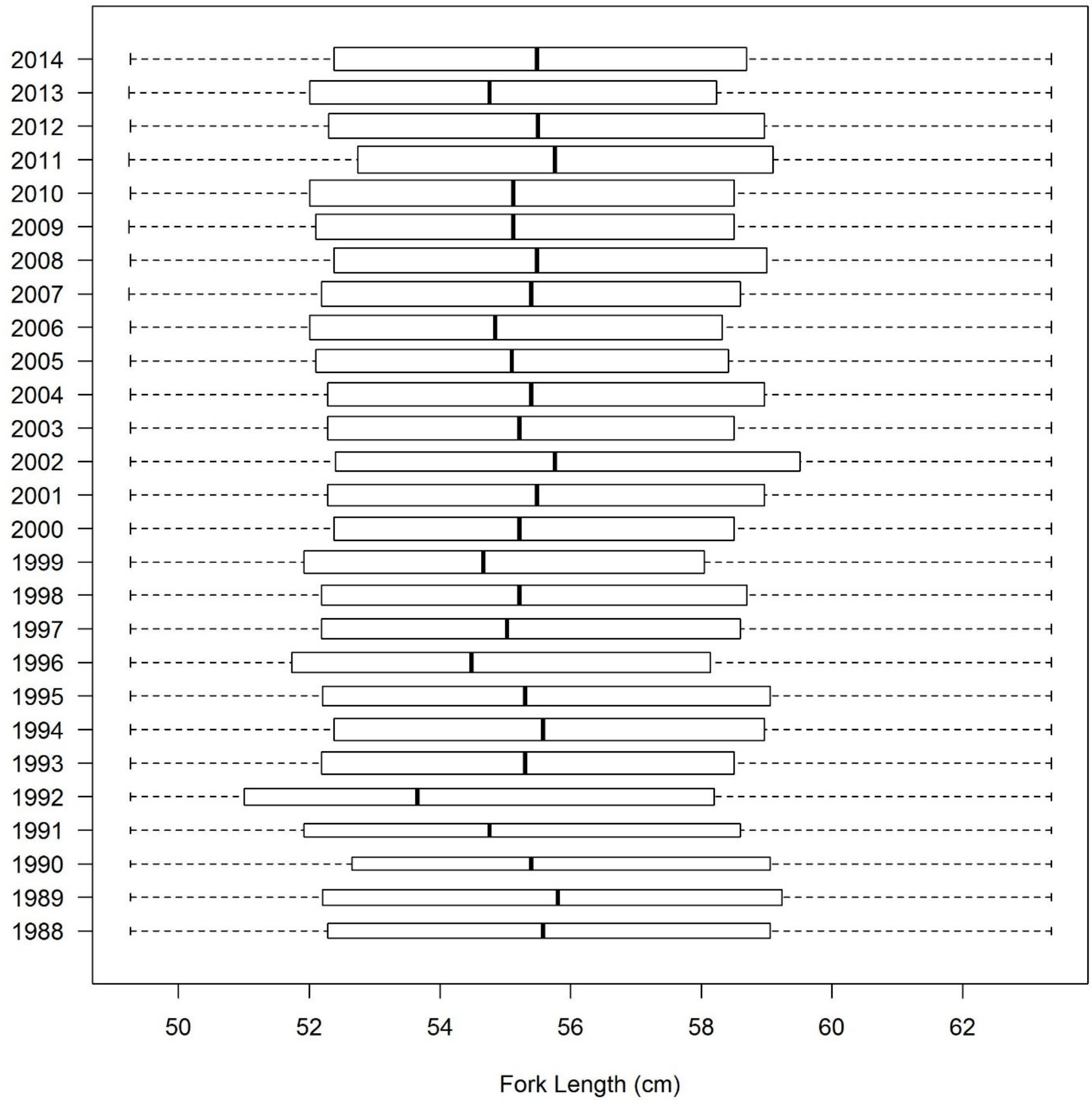


Figure 4.7 Length frequency of Red Drum from the MRFSS private and charterboat fishing modes which exhibited similar selectivity patterns. Length data were subset to within the slot limits (49.2 cm FL to 63.4 cm FL, converted from TL presented in Table 4.3 to FL using equation in Table 2.12.6 of the DW Report) between 1988 and 2014. The boxplots represent the inter-quartile range, the solid lines represent the medians, and the box height represents the relative sample size (box height is equal to the square-root of sample size). Note that the whiskers are truncated at the upper and lower slot limits.

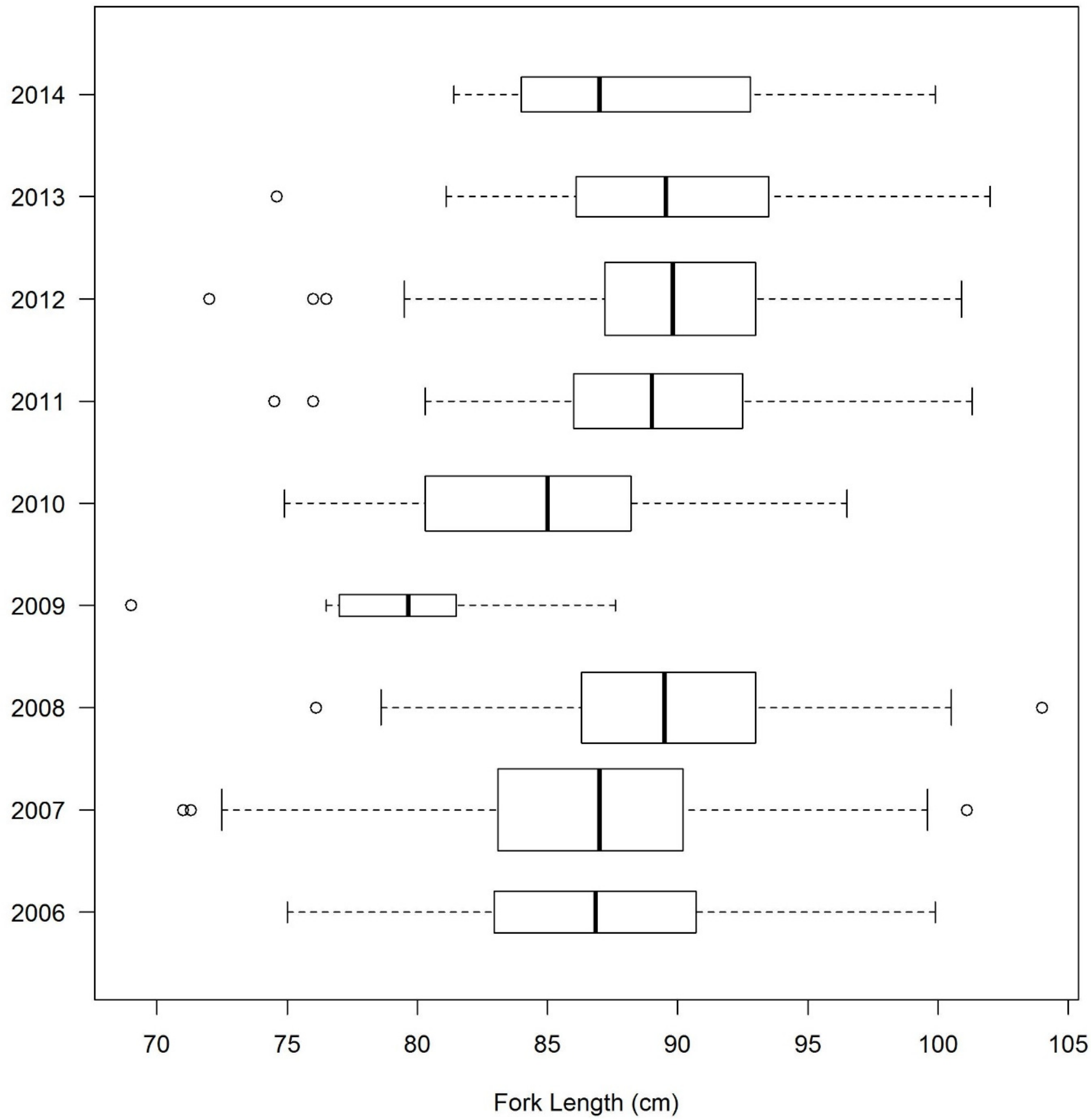


Figure 4.8 Length frequency of Red Drum from the Dauphin Island Sea Laboratory bottom longline survey between 2006 and 2014. The boxplots represent the inter-quartile range, the solid lines represent the medians, the open circles represent outliers, and the box height represents the relative sample size (box height is equal to the square-root of sample size).

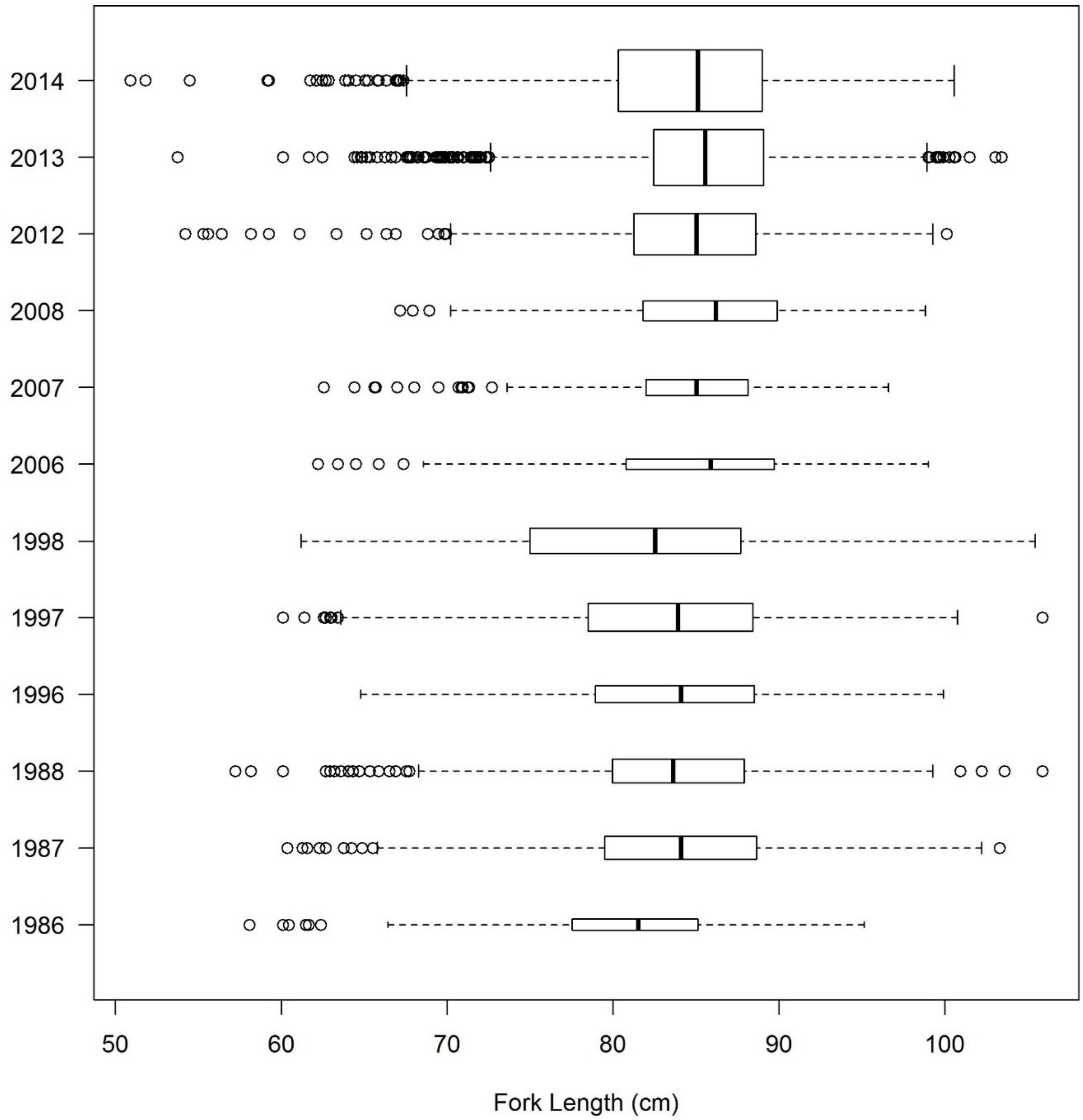


Figure 4.9 Length frequency of Red Drum from the aggregated fishery-independent purse seine surveys. The boxplots represent the inter-quartile range, the solid lines represent the medians, the open circles represent outliers, and the box height represents the relative sample size (box height is equal to the square-root of sample size). Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

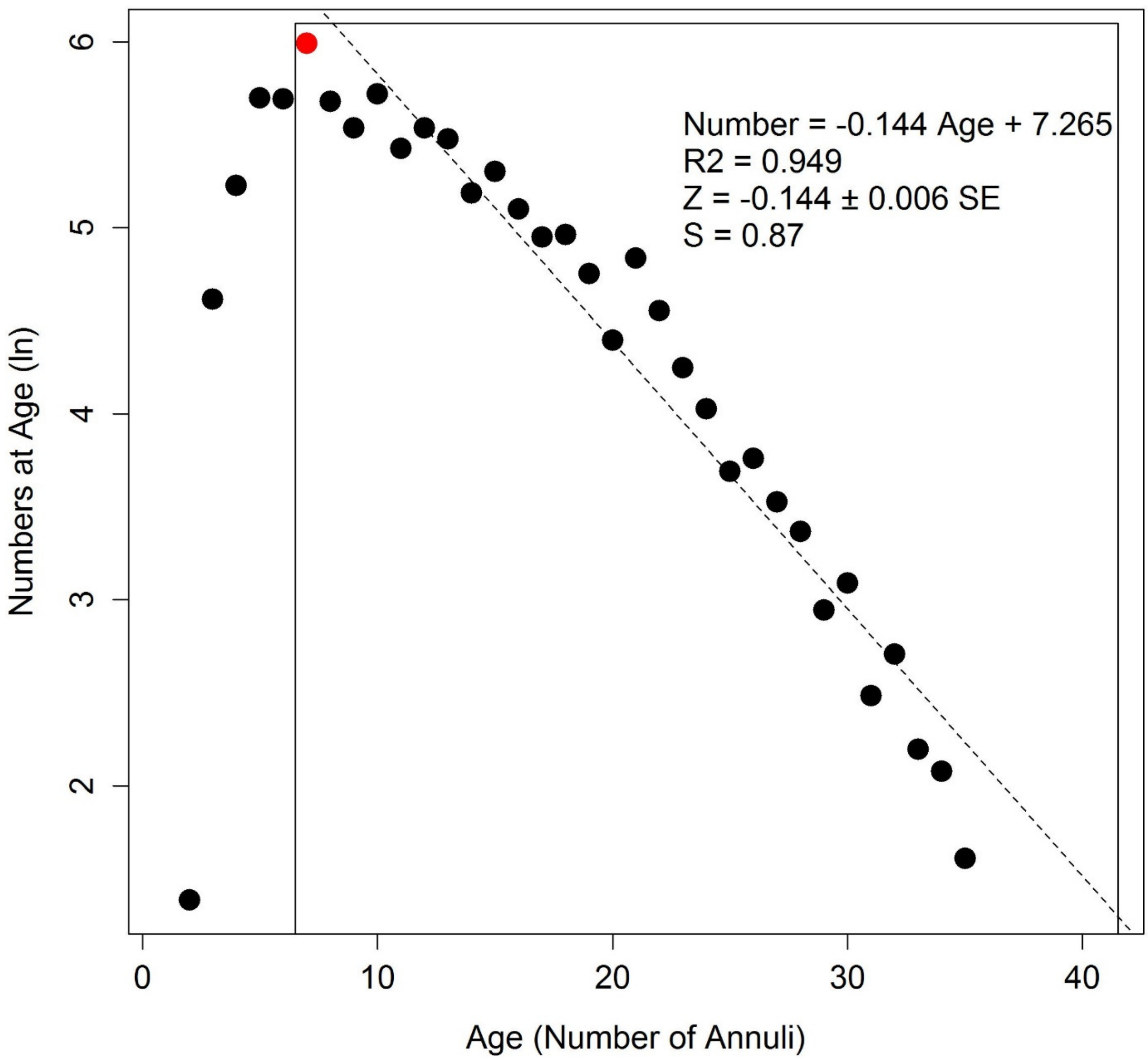


Figure 4.10 Catch curve analysis of Red Drum from the aggregated fishery-independent purse seine data between 1986 and 2014 (not a continuous time series). The red dot reflects the age fully selected for by the gear. Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

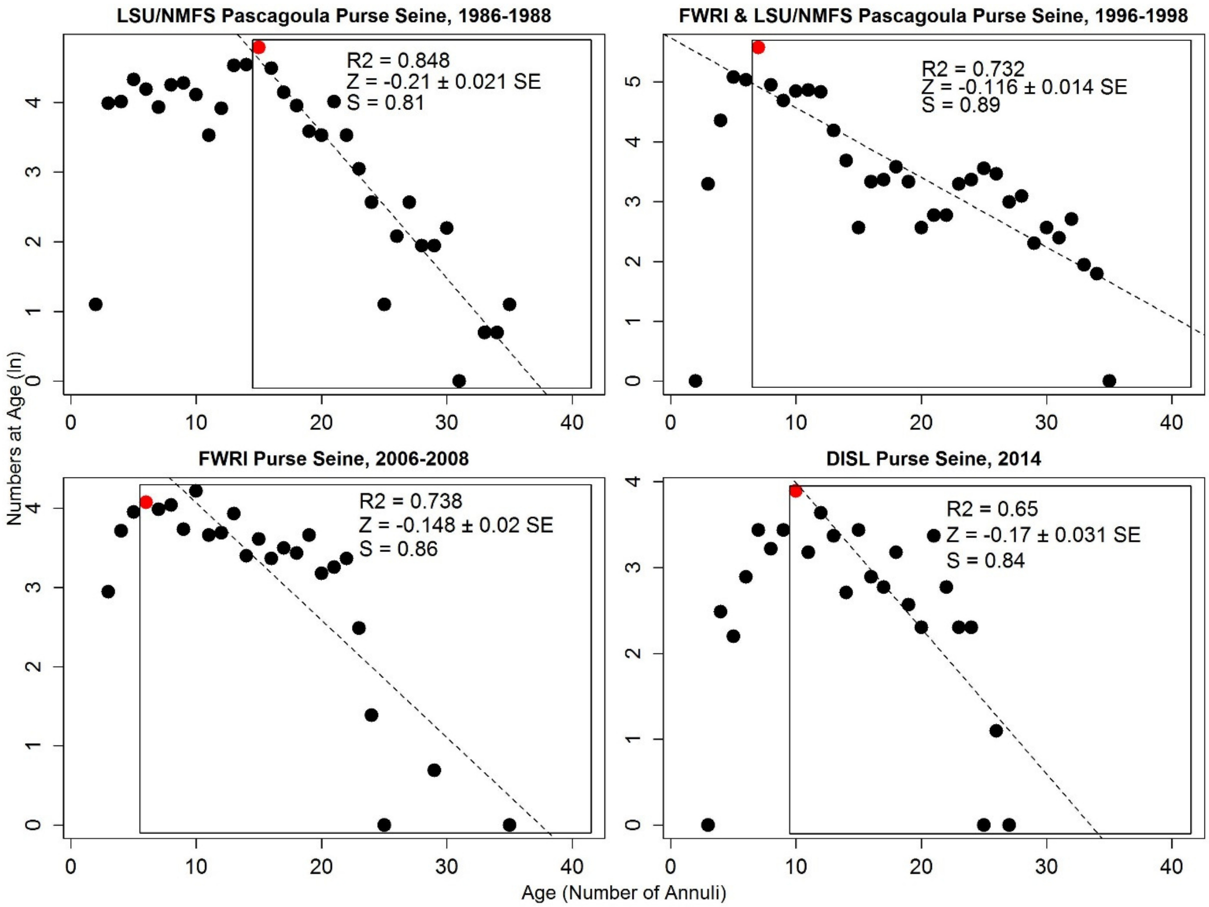


Figure 4.11 Catch curve analysis of Red Drum from the aggregated fishery-independent purse seine data by decade. The red dots reflect the age fully selected for by the gear. Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

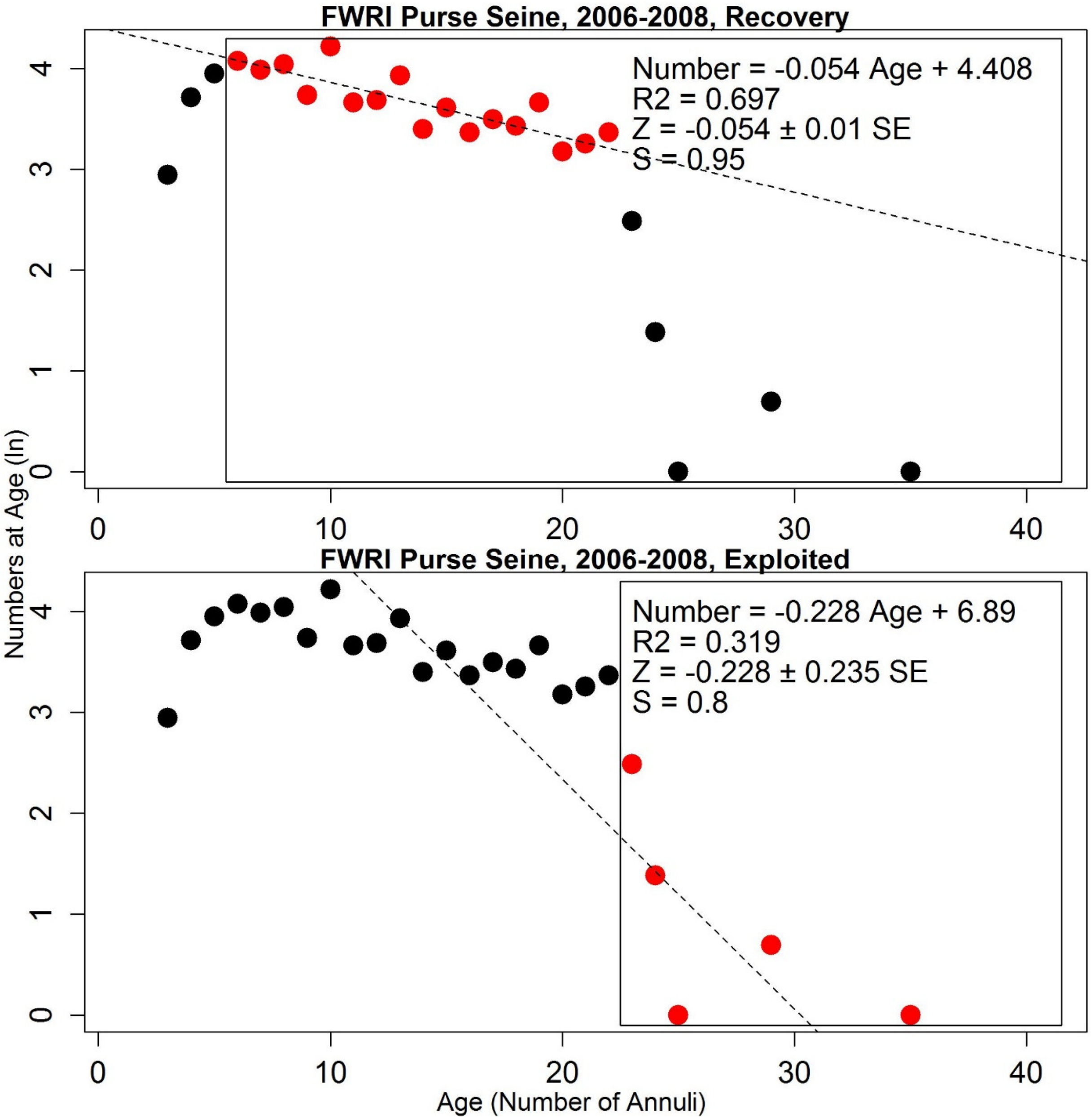


Figure 4.12 Catch curve analysis of Red Drum from the aggregated fishery-independent purse seine data for the 2000s showing differences in total mortality between unexploited fish (younger fish, upper panel) and exploited fish (older fish, lower panel). The red dots reflect the data points used in analysis. Purse seine data sources are described in detail in Table 8.5.3 of the DW Report.

5 LANE SNAPPER DATA-LIMITED EVALUATION RESULTS

5.1 Data-Limited Methods Toolkit

Six methods were feasible in the DLMtool for Lane Snapper based on data availability and reliability (Table 5.1). Overall, all data inputs were scored as highly reliable (Table 5.2). The index of abundance derived from the headboat survey received a good quality score and was recommended for analysis because of a high proportion positive of observations, large sample size, and a relatively low CV (Table 5.2).

5.1.1 Management Strategy Evaluation

Of the six feasible methods, only Islope0 and LstepCC0 met the performance criteria for PNOF, B50, and VY15 (Table 5.3). No convergence issues were detected for any feasible method as all performance metrics converged to within 0.05% (Figure 5.1). All metrics appeared to stabilize around 600 simulations. When trends in the three performance metrics were examined over the 40 year projection period, the Tier3AStatusQuo_ABC method consistently resulted in mean ratios of biomass to biomass at maximum sustainable yield (B/B_{MSY}) below the 1.0 threshold and fishing mortality to fishing mortality at maximum sustainable yield (F/F_{MSY}) above the 1.0 threshold (Figure 5.2). Both the Islope0 and LstepCC0 methods produced mean B/B_{MSY} ratios across simulations above 1.0 whereas mean F/F_{MSY} ratios across simulations remained near the 1.0 threshold at the beginning of the projection period and decreased thereafter (Figure 5.2).

Performance metrics were relatively similar between Islope0 and LstepCC0 and therefore both methods were recommended for providing management advice. Since the reliability of data inputs was deemed comparable, an equal weighting approach was recommended by the AW Panel.

5.1.2 Sensitivity of method performance to assumptions in the operating model

Different assumptions regarding the plausible range of stock depletion were assumed in the MSE:

- A severely depleted state (D = 0.05 – 0.2);
- A moderately depleted state (D = 0.2 – 0.6); and
- A lightly depleted state (D = 0.6 – 0.9).

In the lightly depleted (D = 0.6 – 0.9) state of nature assumed, the operating model could not reach the specified depletion level and therefore was excluded from analyses. Regardless of the depletion assumptions tested, the overall recommendations regarding viable methods were the same in that both Islope0 and LstepCC0 met the performance criteria (Figure 5.3). Intuitively, assuming a less depleted stock (D = 0.2 – 0.6), performance metrics were higher than when assuming a severely depleted stock (D = 0.05 – 0.2) for all methods. For Itarget0, the PNOF for the base run was just below the threshold; this method met the performance metrics if a severely (D = 0.05 – 0.2) or moderately (D = 0.2 – 0.6) depleted stock was assumed (Figure 5.3). CC1_Ref met the performance metrics solely under a moderately depleted state.

Examination of varying lambda values as scalars (see Table 3.1.3 for equation) on the index of abundance in Islope0 revealed relatively similar values in performance metrics (within 2.6%) with the largest difference evident in VY15 (2.6%; Table 5.4). Larger lambda values result in marginally lower performance metrics.

Examination of varying mean length threshold values (see Table 3.1.3) in LstepCC0 revealed relatively similar values in performance metrics (within 4.7%) with the largest difference evident in LTY (4.7%; Table 5.5). Smaller thresholds resulted in slightly lower PNOF, B50, and VY15 and higher LTY and STY.

5.1.3 Calculation of Catch Recommendations

Based on equal weighting of both methods in a joint distribution for reasons discussed in Section 5.1.1, the median of the catch recommendation distribution is 310,818 pounds (± 14,503 pounds, SD), which is less than the Tier3AStatusQuo (Table 5.6). When compared to the average catch between 2010 and 2014, the catch recommendation for the equally weighted joint distribution is higher (Figure 5.4).

5.1.4 Sensitivity of Catch Recommendations

The catch recommendations from both recommended methods are sensitive to the magnitude of total removals (Figure 5.5). If total removals in the reference period are higher than specified (e.g. due to exclusion of removals from the shrimp fishery as bycatch or exclusion of discards), a larger catch recommendation would result (Figure 5.5). For Islope0, the catch recommendation remains relatively similar with changes to the index of abundance (Figure 5.5).

Overall, the CV on total removals had a minor impact on the median catch recommendation for Islope0 and LstepCC0, with a lower catch recommendation obtained if the CV is larger than observed (i.e. doubled) (Table 5.7).

5.2 Mean Length Estimator

The mean length-based mortality estimator was pursued for Lane Snapper to estimate total mortality using length composition from the recreational private and headboat fishing modes (Figure 5.6). Results are only briefly described here due to analyst concerns. The total mortality estimated was less than the SEDAR 49 LHWG natural mortality estimate (0.33), which constrained the estimate of F to 0.0. Particular concerns were noted regarding the representativeness of the von Bertalanffy growth curve as well as conflicts in the length frequency data and life history (mainly natural mortality).

5.3 Tables

Table 5.1 Feasible methods for the DLMtool evaluation for Lane Snapper. Data inputs are as defined in Table 3.1.1.

Method	Data Inputs														
	Mort	FMSY_M	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	LFC	LFS	ML	CAA
Catch-based															
CC1_Ref															
Tier3AStatusQuo_ABC															
Indicator (Index-based)															
Islope0															
Itarget0															
Indicator (Length-based)															
Ltarget0															
LstepCC0															

Table 5.2 Guidance table for Lane Snapper documenting data requirements for each method and reliability scores for data inputs. Colors reflect poor quality (red; 0-33%), fair quality (yellow; 34-67%), and good quality (green; 68-100%), and are based on the information content reliability scores discussed in Section 2.4.

Method	Data Requirement	Reliability Score
Tier 3AStatusQuo _ABC	Total removals: Known and informative for 1999-2008	Good
CC1_Ref	Total removals: Known and informative for 1999-2008	Good
Islope0	Total removals: Known and informative for 1999-2008	Good
	Index: Headboat index representative of trend in population abundance (2010-2014)	Good
Itarget0	Total removals: Known and informative for 1999-2008	Good
	Index: Headboat index representative of population abundance; uses trend over reference period (1999-2008) and recent period (2010-2014)	Good
LstepCC0 /	Total removals: Known and informative for 1999-2008	Good

Ltarget0	Mean Length: Mean length of catch from recreational private and headboat fleets an indirect and informative indicator of the trend in resource abundance; uses mean length over reference period (1999-2008) and over recent period (2010-2014)	Good

Table 5.3 Performance metrics for methods meeting performance criteria for Lane Snapper. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing; B50 = Probability of the biomass being above 50% B_{MSY}; VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY}. Note that performance for Bbelow20 is reversed, where a low probability is preferable.

Method	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	69.2	75.5	87.8	48.4	73.5	14.4
LstepCC0	70.4	76.3	88.1	46.3	73.7	14.0
Tier3AStatusQuo_ABC	29.1	45.4	53.3	55.4	92.4	33.0

Table 5.4 Comparison of model performance for different configurations of Islope0 by varying the lambda scalar on the index of abundance, with the default value highlighted in bold. Performance metrics are as defined in Table 5.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Lambda	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	0.1	71.2	77.7	90.6	54.5	76.2	12.2
	0.2	71.0	77.7	90.6	55.0	76.2	12.1
	0.3	71.1	77.7	90.4	55.2	75.5	12.2
	0.4	70.9	77.6	90.3	54.6	75.5	12.2
	0.5	71.0	77.7	90.6	55.0	75.6	12.2
	0.6	70.8	77.6	90.2	54.9	75.4	12.2
	0.7	70.6	77.5	90.4	55.3	75.1	12.2
	0.8	71.1	77.9	90.0	55.2	75.6	12.0
	0.9	71.0	77.7	90.4	55.0	74.7	12.2
	1	70.7	77.5	89.7	55.0	74.9	12.3
	1.1	70.9	77.6	89.7	54.6	75.0	12.1
	1.2	70.6	77.5	90.3	54.3	74.6	12.3
	1.3	70.5	77.5	89.5	54.9	74.9	12.2
	1.4	70.6	77.5	89.5	53.9	74.9	12.2
	1.5	70.0	77.4	88.9	54.5	74.6	12.2
	1.6	70.1	77.2	89.3	54.4	74.4	12.1
	1.7	70.2	77.4	89.0	53.3	74.8	12.1

1.8	69.9	77.5	88.0	54.6	74.7	11.9
1.9	69.8	77.4	88.1	53.0	74.0	12.0
Minimum	69.8	77.2	88.0	53.0	74.0	11.9
Maximum	71.2	77.9	90.6	55.3	76.2	12.3
Difference	1.4	0.7	2.6	2.3	2.2	0.4

Table 5.5 Comparison of model performance for different configurations of LstepCC0 by varying the mean length ratio limits (3 threshold values), with the default values highlighted in bold. Performance metrics are as defined in Table 5.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Threshold Lower	Threshold Middle	Threshold Upper	PNOF	B50	VY15	LTY	STY	Bbelow20
LstepCC0	0.92	0.96	1.00	70.2	77.1	90.8	54.9	76.3	12.4
	0.92	0.96	1.05	71.5	77.8	91.2	52.9	75.7	12.0
	0.92	0.96	1.10	71.6	77.9	91.2	52.8	75.7	12.0
	0.92	0.98	1.00	70.6	77.4	91.0	54.1	75.8	12.2
	0.92	0.98	1.05	72.0	78.2	91.4	52.0	75.3	11.8
	0.92	0.98	1.10	72.1	78.3	91.4	52.0	75.3	11.8
	0.92	1.00	1.05	72.9	78.7	91.9	51.2	75.0	11.5
	0.92	1.00	1.10	73.0	78.8	91.9	51.1	75.0	11.4
	0.94	0.96	1.00	70.2	77.1	90.8	54.2	76.3	12.4
	0.94	0.96	1.05	71.6	77.9	91.2	52.2	75.7	12.0
	0.94	0.96	1.10	71.7	78.0	91.2	52.1	75.7	12.0
	0.94	0.98	1.00	70.7	77.6	91.0	53.2	75.8	12.2
	0.94	0.98	1.05	72.0	78.3	91.4	51.2	75.3	11.8
	0.94	0.98	1.10	72.1	78.4	91.4	51.2	75.3	11.8
	0.94	1.00	1.05	73.0	78.8	91.9	50.3	75.0	11.5
	0.94	1.00	1.10	73.1	78.9	91.9	50.2	75.0	11.4
	0.96	0.98	1.00	71.0	77.8	91.3	53.3	75.3	12.1
	0.96	**0.98**	**1.05**	72.4	78.6	91.5	51.3	74.7	11.7
	0.96	0.98	1.10	72.5	78.7	91.5	51.2	74.7	11.6
	0.96	1.00	1.05	73.3	79.1	92.0	50.4	74.4	11.4
	0.96	1.00	1.10	73.4	79.2	92.0	50.3	74.4	11.3
			Minimum	70.2	77.1	90.8	50.2	74.4	11.3
			Maximum	73.4	79.2	92.0	54.9	76.3	12.4
			Difference	3.2	2.1	1.2	4.7	1.9	1.1

Table 5.6 Summary statistics of the catch recommendation (in pounds) for each viable method for Lane Snapper and an equally weighted joint distribution of Islope0 and LstepCC0, which was recommended for providing management advice. The Tier3AStatusQuo (i.e. current OFL) is included for comparison. Recommended method is highlighted in bold.

Method	25%	40%	50%	75%	Mean	SD	CV
Tier3AStatusQuo	357,845	357,845	357,845	357,845	357,845	0	0
Islope0	301,844	307,686	311,243	321,267	311,638	14,576	0.047
LstepCC0	300,528	306,586	310,367	319,910	310,476	14,407	0.046
Joint Distribution (Equal weight)	**301,201**	**307,167**	**310,818**	**320,601**	**311,057**	**14,503**	**0.047**

Table 5.7 Sensitivity of catch recommendations for Lane Snapper to the CV specified for the total removals (Cat CV) required for both methods. Statistics reported for the catch recommendation include the 25th, 40th, 50th, and 75th percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV).

Method	Cat CV	25%	40%	50%	75%	Mean	SD	CV
Islope0	0.103	301,844	307,686	311,243	321,267	311,638	14,576	0.047
	0.206	292,036	303,281	310,367	329,649	311,417	28,544	0.092
LstepCC0	0.103	300,528	306,586	310,367	319,910	310,476	14,407	0.046
	0.206	290,494	302,119	309,180	329,330	310,763	28,940	0.093

5.4 Figures

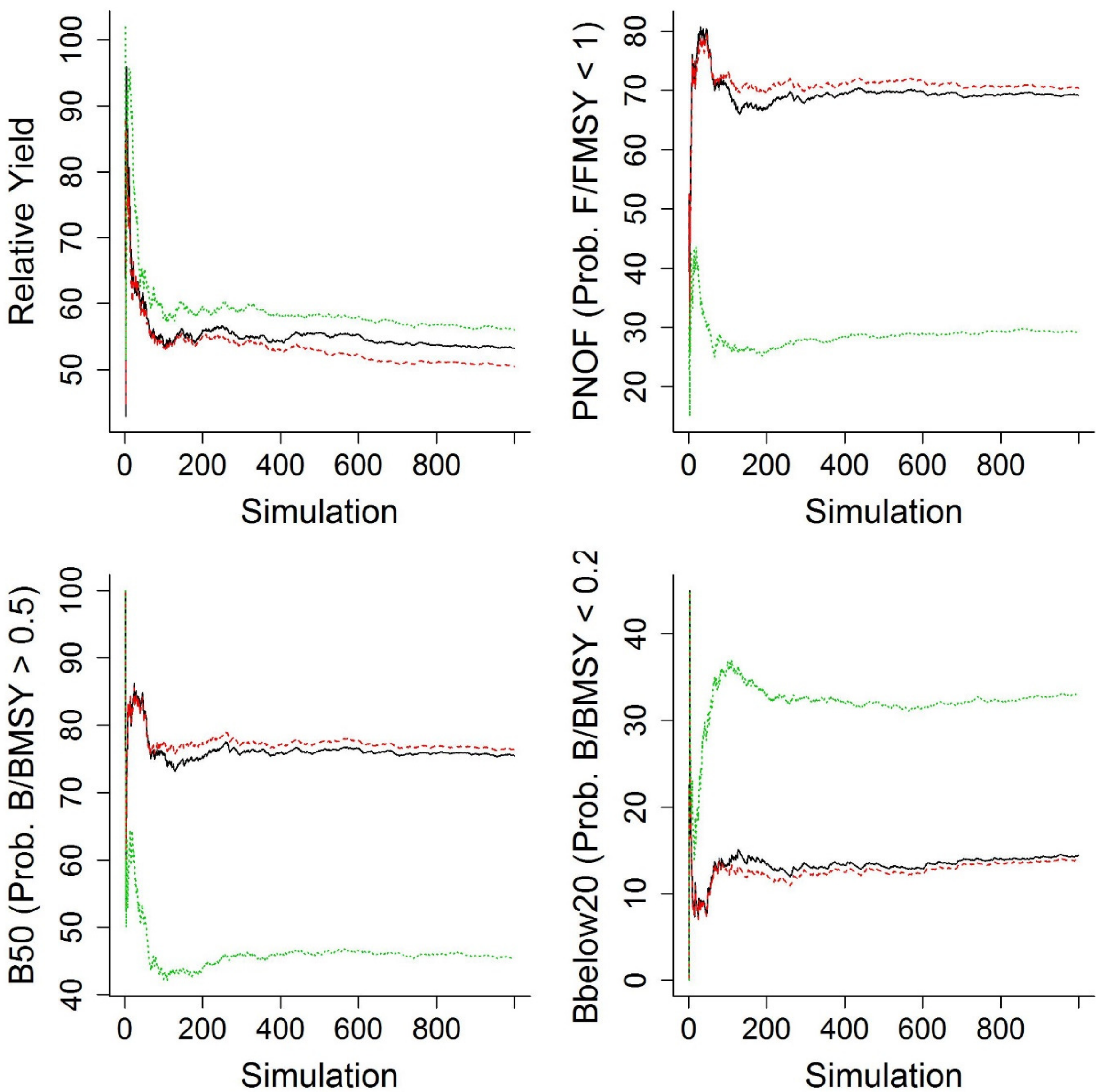


Figure 5.1 Convergence plot confirming that performance criteria for each viable method converged to within 0.05%, indicating that the number of simulations was sufficient for Lane Snapper. Each colored line identifies the following method: LstepCC0 (red), Islope0 (black), and Tier3AStatusQuo (green). Relative yield corresponds to the LTY divided by the reference yield,

which is the highest mean yield over the last five years of the projection period that can be obtained from a fixed *F* strategy.

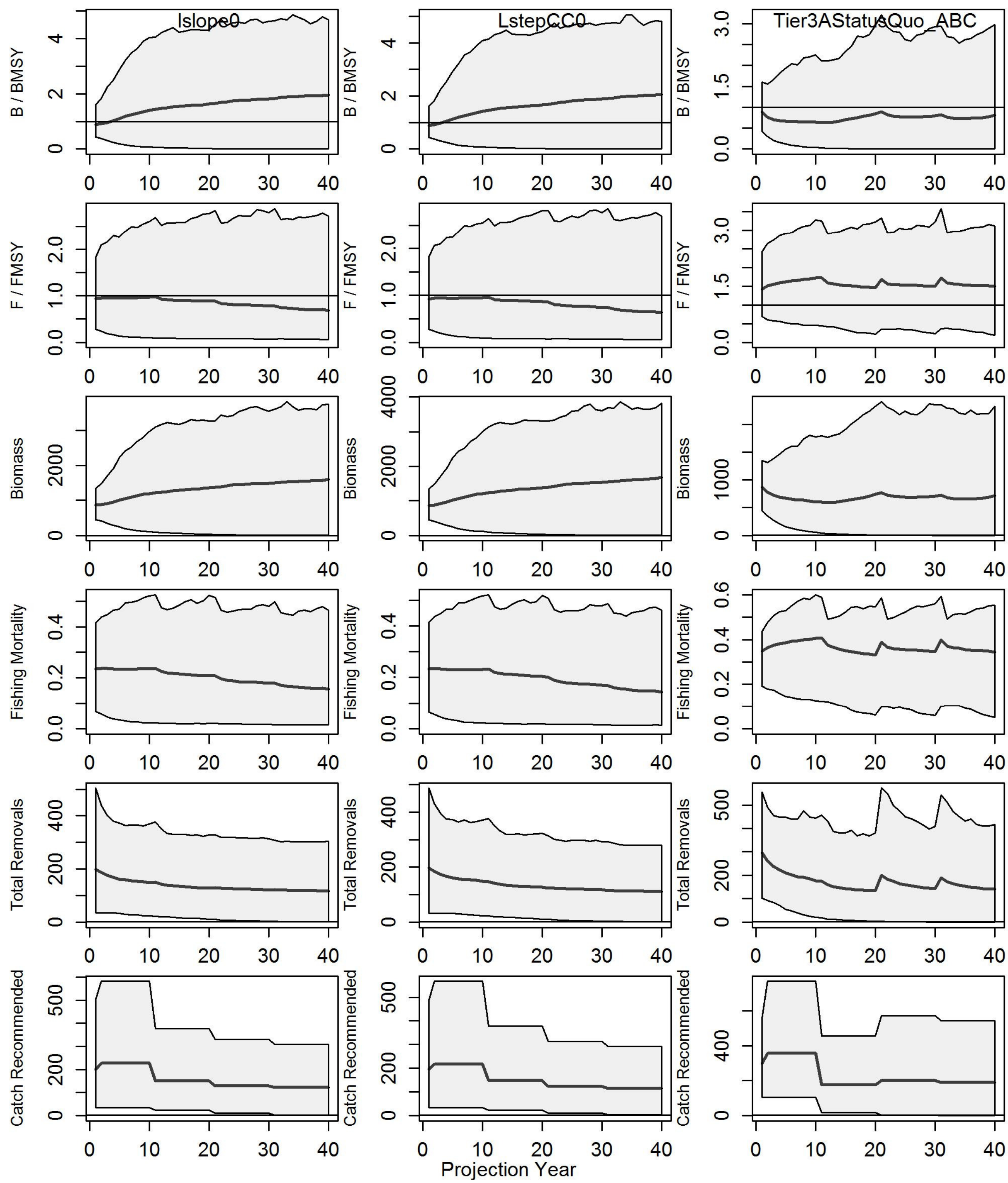


Figure 5.2 Comparison of stock status outputs and catches for Lane Snapper for the 40-year projection period where an assessment is conducted in years 1, 11, 21, and 31. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, total removals (in pounds), and the catch recommendation (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 5th and 95th percentiles.

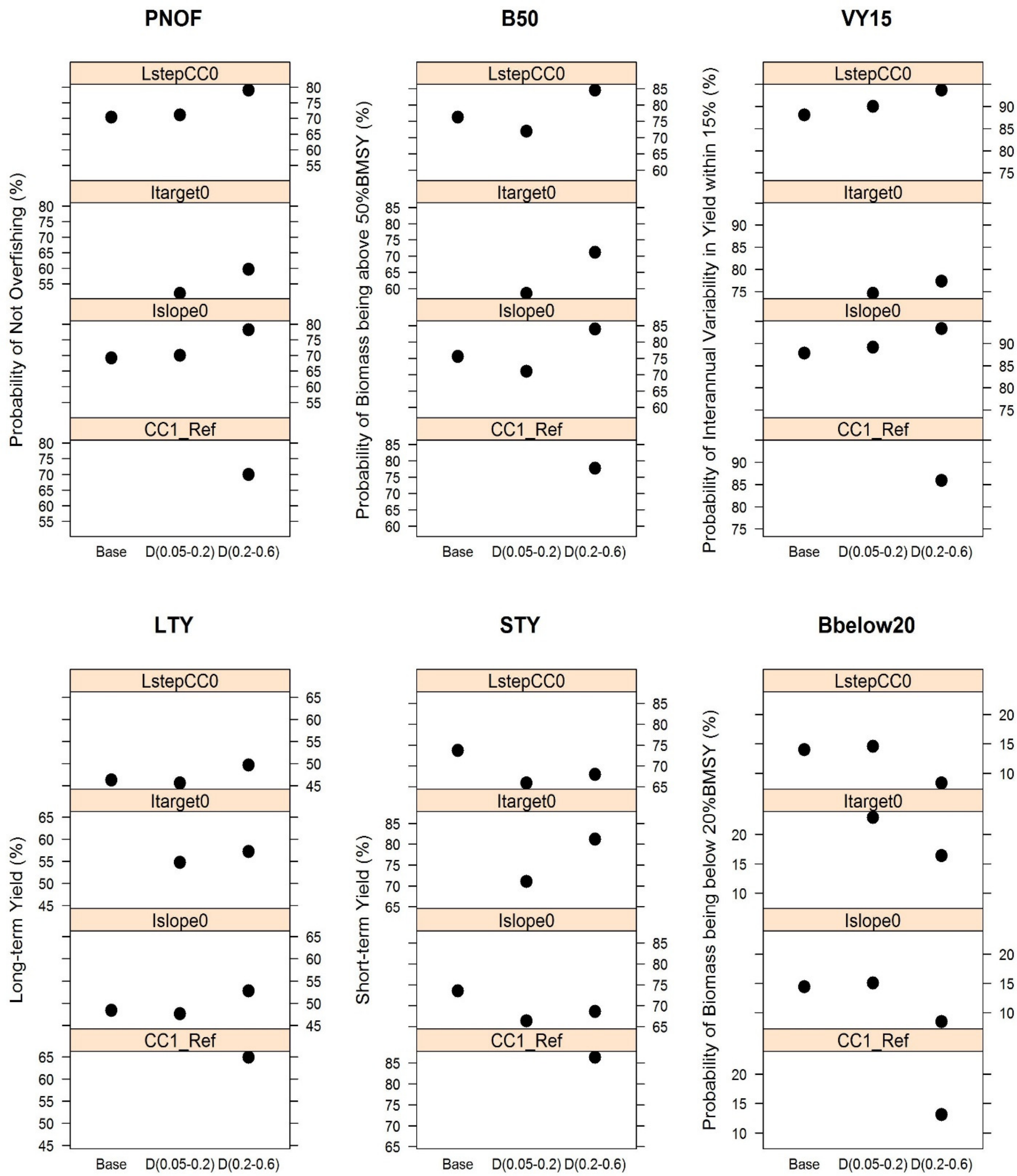


Figure 5.3 Method performance for Lane Snapper assuming the base level of depletion (base; D = 0.12 – 0.31 based on other Lutjanidae), a severely depleted state (D = 0.05 – 0.2), and a moderately depleted state (D = 0.2 – 0.6). Results for the lightly depleted state (D = 0.6 – 0.9) are not shown because the depletion levels could not be reached. The absence of points indicates that the performance metric(s) did not meet the specified criteria (> 50%) for PNOF, B50, and VY15. Tier3AStatusQuo_ABC did not meet the performance metrics for any sensitivity run.

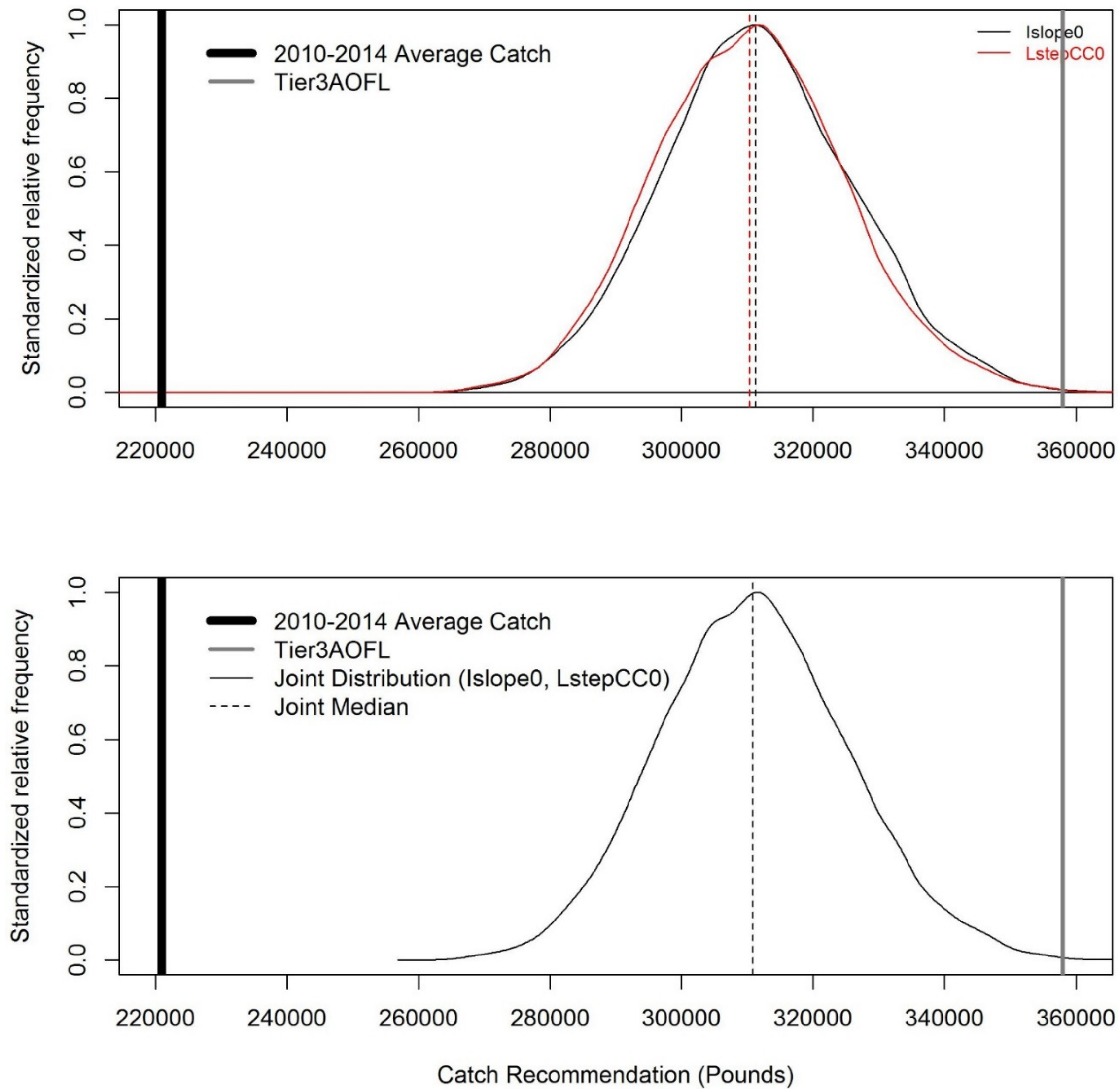


Figure 5.4 Distribution of the catch recommendation (in pounds) for Lane Snapper recommended by the two viable methods, Islope0 and LstepCC0 (top panel; dashed vertical lines identify medians) and a joint distribution assuming equal weighting (bottom panel). The average catch between 2010 and 2014 (thick black line) and the OFL specified by the Tier3AStatusQuo (thick gray line) are included for comparison. The joint distribution (bottom panel) is recommended for providing management advice.

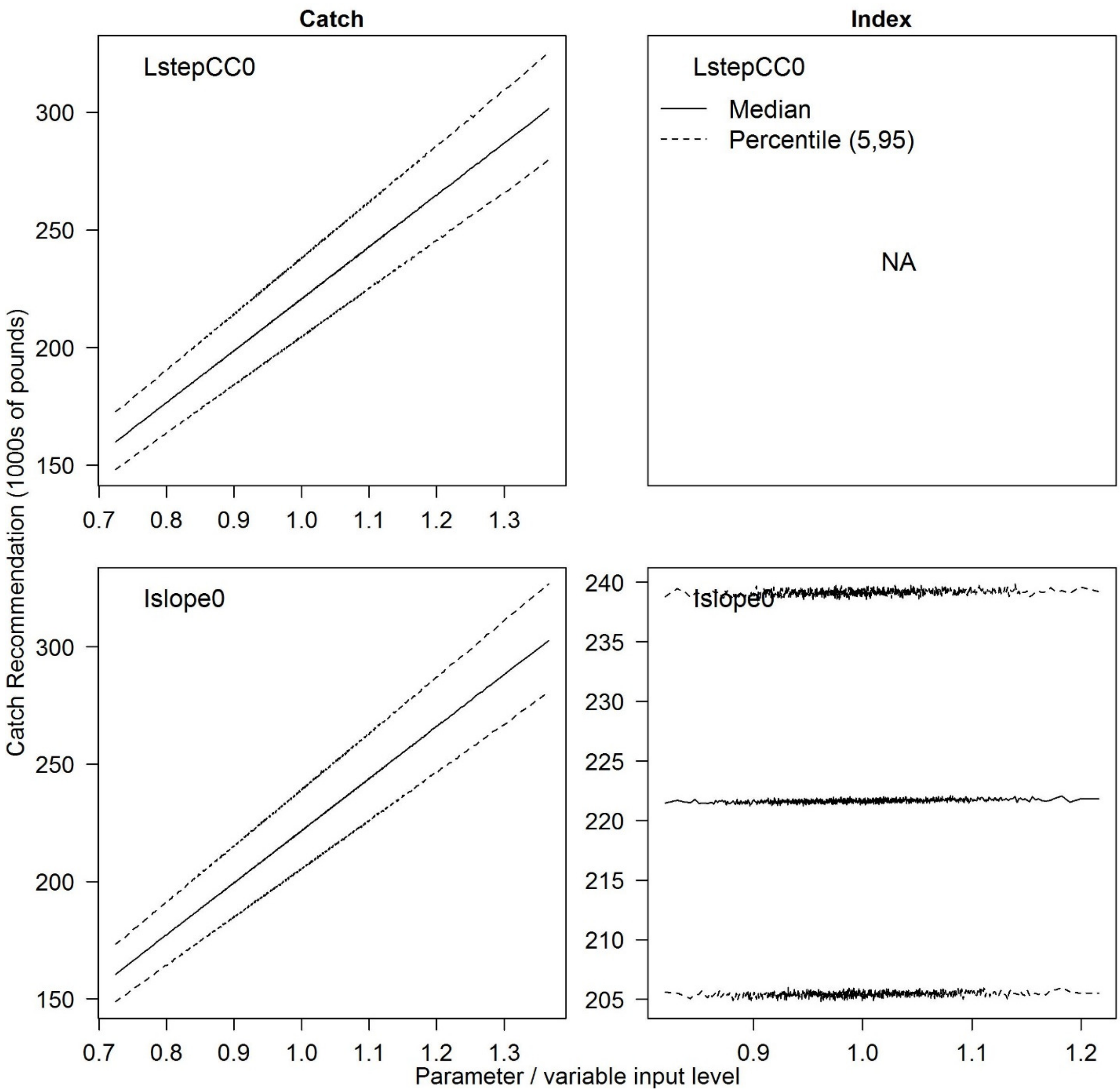


Figure 5.5 Sensitivity of the catch recommendation for Lane Snapper to marginal changes in the required data inputs for LstepCC0 (only catch considered in sensitivity analysis) and Islope0 (Catch and index of abundance). Note that ranges for parameter ranges are derived from the CV for each parameter. NA indicates that the data input is not required.

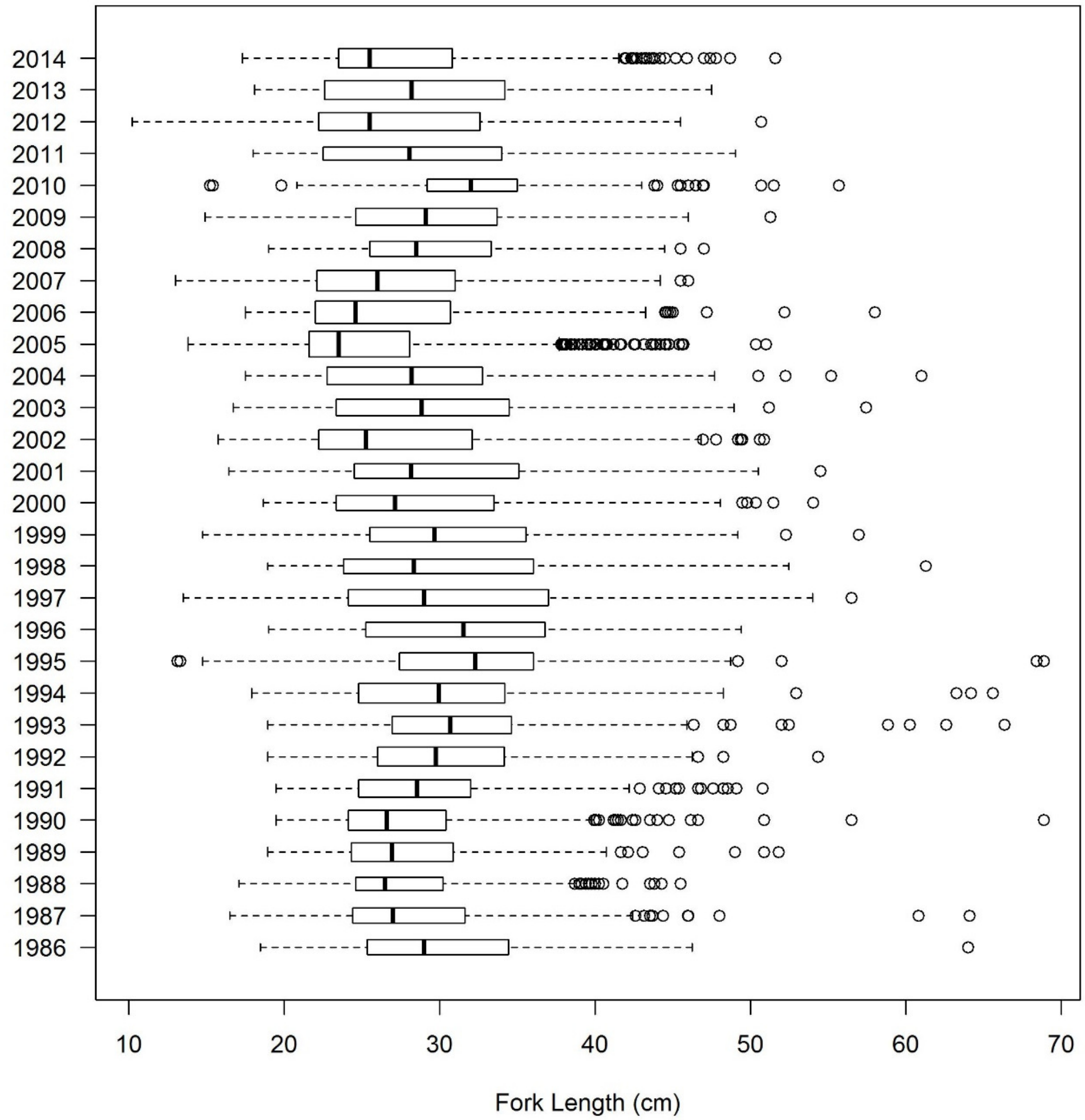


Figure 5.6 Length frequency of Lane Snapper from the MRFSS private and headboat fishing modes which exhibited similar selectivity patterns. The boxplots represent the inter-quartile range, the solid lines represent the medians, the open circles represent outliers, and the box height represents the relative sample size (box height is equal to the square-root of sample size).

6 WENCHMAN DATA-LIMITED EVALUATION RESULTS

6.1 Data-Limited Methods Toolkit

Six methods were feasible in the DLMtool for Wenchman based on data availability and reliability (Table 6.1). Total removals were scored as fairly reliable whereas the indices of abundance and mean length derived from the SEAMAP small pelagics survey both received a good quality score. The index of abundance was recommended for analysis because of a high proportion positive of observations and a relatively low CV (Table 6.2).

6.1.1 Management Strategy Evaluation

Of the six feasible methods, all met the performance criteria for PNOF, B50, and VY15 (Table 6.3). No convergence issues were detected as all performance metrics converged to within 0.05% (Figure 6.1). All metrics tended to converge around 400 simulations although there was a slight trend in metrics for Ltarget0. When trends over the 40 year projection period were examined, all methods, including the Tier3AStatusQuo_ABC method, displayed mean ratios of biomass to biomass at maximum sustainable yield (B/B_{MSY}) above the 1.0 threshold and mean ratios of fishing mortality to fishing mortality at maximum sustainable yield (F/F_{MSY}) below the 1.0 threshold (Figure 6.2).

All methods were deemed feasible based on performance criteria, although Itarget0 tended to show higher performance metrics (e.g. LTY and STY). A key advantage of implementing the Itarget0 method over continuing the status quo is that this approach allows a feedback mechanism in which a change (e.g. an increase) in the index of abundance may adjust the catch recommendation as opposed to using a fixed catch as implemented in the status quo.

However, basing results on performance in the MSE was not recommended by the AW Panel as this result is dependent upon the assumptions inherent within the analysis. A more appropriate approach supported by the AW Panel was to develop a joint distribution of the top index-based and length-based methods based on performance in the MSE to reduce redundancy of data inputs (e.g. both Itarget0 and Islope0 use identical data types). Although CC1_Ref also met the performance criteria, the inclusion of this information would be redundant to both Itarget0 and Ltarget0. Since the reliability of data inputs was comparable, an equal weighting approach was recommended by the AW Panel.

6.1.2 Sensitivity of method performance to assumptions in the operating model

Different assumptions regarding the plausible range of stock depletion were assumed in the MSE:

- A severely depleted state (D = 0.05 – 0.2);
- A moderately depleted state (D = 0.2 – 0.6); and
- A lightly depleted state (D = 0.6 – 0.9).

In the lightly depleted state (D = 0.6 – 0.9), the operating model could not reach the specified depletion level and therefore was excluded from analysis. All methods met the performance criteria regardless of the assumed depletion state, although differences in percentages were noted for all metrics (Figure 6.3).

Examination of varying lambda values as scalars (see Table 3.1.3 for equation) on the index of abundance in Islope0 revealed relatively similar values for most performance metrics examined (range: 0.3 – 9.3%; Table 6.4). Larger lambda values result in marginally lower performance metrics with the exception of LTY, although many scalar values resulted in performance metrics failing to meet performance criteria.

Varying scalar values on the threshold (I^0) and I^{target} (see Table 3.1.3 for equation) on the index of abundance in Itarget0 revealed variable performance metrics for PNOF (range: 11.9%) and VY15 (range: 24%; Table 6.5). Larger target values (i.e. 1.5 versus 1.0) result in higher performance metrics for PNOF, B50, VY15, and Bbelow20, whereas a lower I^0 scalar resulted in higher relative LTY and STY.

Examination of varying mean length threshold values (see Table 3.1.3 for equation) in LstepCC0 revealed relatively similar values in performance metrics (within 3.1%) with the largest difference evident in LTY (3.1%; Table 6.6). Smaller thresholds resulted in marginally lower PNOF, B50, and VY15 but higher LTY and STY.

Varying scalar values on the threshold (L^0) and L^{target} (see Table 3.1.3 for equation) on the mean length in Ltarget0 revealed variable performance metrics for PNOF (range: 16.6%), VY15 (range: 32.3%), and STY (range: 14.6%; Table 6.7). Larger target values (i.e. 1.25 versus 1.0) result in higher performance metrics for PNOF, B50, VY15, and Bbelow20 but lower LTY and STY. A lower L^0 scalar resulted in higher relative LTY and STY.

6.1.3 Calculation of Catch Recommendations

Using a joint distribution between the top performing index-based (Itarget0) and length-based (Ltarget0) methods for reasons discussed in Section 6.1.1, the median catch recommendation is 64,943 pounds (±27,856, SD), which is below the Tier3AStatusQuo (Table 6.8). When compared to the average catch between 2010 and 2014, the recommended catch is higher (Figure 6.4). Joint distributions assuming other method combinations resulted in lower median catch recommendations (Table 6.8).

6.1.4 Sensitivity of Catch Recommendation

The catch recommendations from CC1_Ref, Islope0, and Itarget0 are sensitive to the magnitude of total removals (Figure 6.5). If total removals in the reference period are higher than specified (e.g. due to exclusion of removals from the shrimp fishery as bycatch), a larger catch recommendation would result (Figure 6.5). For Islope0 and Itarget0, the catch recommendation remains relatively similar with small changes to the index of abundance (Figure 6.5).

Overall, the CV on total removals had a minor impact on the median catch recommendations for all methods, with a lower catch recommendation (range of reduction: 1,300 to 2,800) obtained if the CV is larger than observed (i.e. doubled) (Table 6.9).

6.2 Mean Length Estimator

The mean length-based mortality estimator was pursued for Wenchman to estimate total mortality using the length composition from the SEAMAP small pelagics (Figure 6.6). Results are only briefly described here due to analyst concerns. The total mortality estimated was less than the SEDAR 49 LHWG natural mortality estimate (0.44), which constrained the estimate of *F* to 0.0.

6.3 Tables

Table 6.1 Feasible methods for the DLMtool evaluation for Wenchman. Data inputs are as defined in Table 3.1.1.

Method	Data Inputs														
	Mort	**FMSY_M**	**vbLinf**	**vbK**	**vbt0**	**wla**	**wlb**	**steep**	**MaxAge**	**Cat**	**Ind**	**LFC**	**LFS**	**ML**	**CAA**
Catch-based															
CC1_Ref															
Tier3AStatusQuo_ABC															
Indicator (Index-based)															
Islope0															
Itarget0															
Indicator (Length-based)															
Ltarget0															
LstepCC0															

Table 6.2 Guidance table for Wenchman documenting data requirements for each method and reliability scores for data inputs. Colors reflect poor quality (red; 0-33%), fair quality (yellow; 34-67%), and good quality (green; 68-100%), and are based on the information content reliability scores discussed in Section 2.4.

Method	Data Requirements	Reliability Score
CC1_Ref	Total removals: Known and informative for 1999-2008	Fair
Tier3AStatusQuo_ABC	Total removals: Known and informative for 1999-2008	Fair
Islope0	Total removals: Known and informative for 1999-2008	Fair
	Index: Small pelagics index representative of trend in population abundance (2010-2014)	Good
Itarget0	Total removals: Known and informative for 1999-2008	Fair
	Index: Small pelagics index representative of population abundance; uses trend from reference period (1999-2008) and recent period (2010-2014)	Good
LstepCC0 /	Total removals: Known and informative for 1999-2008	Fair
Ltarget0	Mean Length: Mean length of catch from small pelagics an indirect and informative indicator of the trend in resource abundance; uses mean length over reference period (1999-2008) and mean length over recent period (2010-2014)	Good

Table 6.3 Performance metrics for methods meeting performance criteria for Wenchman. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing; B50 = Probability of the biomass being above 50% B_{MSY}; VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY}. Note that performance for Bbelow20 is reversed, where a low probability is preferable.

Method	PNOF	B50	VY15	LTY	STY	Bbelow20
Itarget0	62.6	74.2	58.5	71.1	81.2	10.6
Tier3AStatusQuo_ABC	66.9	76.7	60.8	70.5	82.3	9.8
Ltarget0	70.3	79.0	67.3	66.2	76.6	8.5
CC1_Ref	83.9	87.4	85.5	59.6	65.2	5.4
Islope0	88.9	91.0	92.7	43.7	50.5	3.5
LstepCC0	89.2	91.2	93.3	40.0	50.6	3.4

Table 6.4 Comparison of model performance for different configurations of Islope0 by varying the lambda scalar on the index of abundance, with the default value highlighted in bold. Performance metrics are as defined in Table 6.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Lambda	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	0.1	88.9	91.0	94.9	42.4	51.4	3.5
	0.2	88.9	91.0	95.1	42.1	51.0	3.6
	0.3	88.9	91.0	94.2	41.9	50.9	3.6
	0.4	88.9	90.9	94.3	42.0	50.9	3.6
	0.5	88.7	90.8	93.7	42.4	50.2	3.6
	0.6	88.7	90.8	93.2	44.1	50.2	3.5
	0.7	88.4	90.7	92.9	43.3	50.0	3.6
	0.9	88.2	90.5	92.7	43.6	49.1	3.7
	1.7	85.4	88.3	85.8	43.2	45.5	3.8
	1.9	84.8	88.1	86.3	43.0	44.8	3.6
	Minimum	84.8	88.1	85.8	41.9	44.8	3.5
	Maximum	88.9	91.0	95.1	44.1	51.4	3.8
	Difference	4.1	2.9	9.3	2.2	6.6	0.3

Table 6.5 Comparison of model performance for different configurations of Itarget0 by varying the scalar parameters on the threshold (I^0) and the target (Itarget) values for the index of abundance with the default value highlighted in bold. Performance metrics are as defined in Table 6.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Configurations are shown which do not meet the 50% threshold for VY15 (noted in red) to provide insight into the tradeoffs between scalar values and performance metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	I^0	Itarget	PNOF	B50	VY15	LTY	STY	Bbelow20
Itarget0	0.7	1.0	55.1	69.4	42.0	70.1	84.3	12.6
	0.7	1.1	57.1	70.8	47.9	70.7	84.0	12.0
	0.7	1.2	58.8	72.0	53.4	71.6	83.6	11.4
	0.7	1.3	60.2	73.0	56.2	71.6	83.2	11.0
	0.7	1.4	61.8	74.1	59.1	71.6	82.7	10.6
	0.7	1.5	63.2	75.0	61.6	71.5	82.1	10.1
	0.8	1.0	55.4	69.5	41.8	69.5	83.6	12.4
	0.8	1.1	57.6	71.2	47.8	70.1	83.2	11.7
	0.8	1.2	59.3	72.6	53.4	70.2	83.0	11.1
	0.8	1.3	60.9	73.6	56.9	70.4	82.4	10.6
	0.8	1.4	62.7	74.8	59.8	71.4	81.8	10.1
	0.8	**1.5**	64.3	75.8	62.5	71.1	81.2	9.7
	0.9	1.0	56.0	70.0	41.1	68.4	83.1	12.2
	0.9	1.1	58.3	71.7	46.8	68.8	82.4	11.5
	0.9	1.2	60.2	73.3	53.5	69.4	82.2	10.7
	0.9	1.3	62.0	74.5	57.6	70.1	81.5	10.2
	0.9	1.4	63.7	75.7	60.4	70.7	81.2	9.6
	0.9	1.5	65.6	76.9	63.3	70.3	80.3	9.1
	1.0	1.0	56.6	70.4	39.4	66.6	81.1	12.2
	1.0	1.1	59.2	72.4	45.4	67.5	80.8	11.2
	1.0	1.2	61.3	74.0	52.4	67.6	79.6	10.4
	1.0	1.3	63.3	75.5	57.1	68.5	79.2	9.7
	1.0	1.4	65.1	76.7	60.7	68.6	78.4	9.2
	1.0	1.5	67.0	77.9	63.4	68.9	77.7	8.7
		Minimum	55.1	69.4	39.4	66.6	77.7	8.7
		Maximum	67.0	77.9	63.4	71.6	84.3	12.6
		Difference	11.9	8.5	24.0	5.0	6.6	3.9

Table 6.6 Comparison of model performance for different configurations of LstepCC0 by varying the mean length ratio limits (3 values), with the default values highlighted in bold. Performance metrics are as defined in Table 6.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Threshold Lower	Threshold Middle	Threshold Upper	PNOF	B50	VY15	LTY	STY	Bbelow20
LstepCC0	0.92	0.96	1.00	88.9	91.0	95.1	42.3	51.7	3.5
	0.92	0.96	1.05	89.0	91.1	95.2	41.2	51.6	3.5
	0.92	0.96	1.10	89.2	91.2	95.3	40.6	51.3	3.5
	0.92	0.98	1.00	89.0	91.1	95.1	41.5	51.6	3.5
	0.92	0.98	1.05	89.1	91.2	95.2	40.4	51.5	3.5
	0.92	0.98	1.10	89.3	91.3	95.3	40.0	51.2	3.4
	0.92	1.00	1.05	89.1	91.2	95.1	40.1	51.5	3.5
	0.92	1.00	1.10	89.3	91.3	95.2	39.7	51.2	3.4
	0.94	0.96	1.00	88.9	91.1	95.1	42.1	51.7	3.5
	0.94	0.96	1.05	89.0	91.2	95.2	41.0	51.6	3.5
	0.94	0.96	1.10	89.2	91.3	95.3	40.5	51.3	3.4
	0.94	0.98	1.00	89.0	91.1	95.1	41.3	51.6	3.5
	0.94	0.98	1.05	89.1	91.2	95.2	40.2	51.5	3.5
	0.94	0.98	1.10	89.3	91.3	95.3	39.9	51.2	3.4
	0.94	1.00	1.05	89.2	91.2	95.1	39.8	51.5	3.5
	0.94	1.00	1.10	89.4	91.3	95.2	39.5	51.2	3.4
	0.96	0.98	1.00	89.1	91.2	95.2	41.3	51.4	3.5
	0.96	**0.98**	**1.05**	89.2	91.3	95.3	40.2	51.3	3.5
	0.96	0.98	1.10	89.4	91.4	95.4	39.7	51.0	3.4
	0.96	1.00	1.05	89.3	91.3	95.2	39.6	51.3	3.5
	0.96	1.00	1.10	89.5	91.4	95.3	39.2	51.0	3.4
			Minimum	88.9	91.0	95.1	39.2	51.0	3.4
			Maximum	89.5	91.4	95.4	42.3	51.7	3.5
			Difference	0.6	0.4	0.3	3.1	0.7	0.1

Table 6.7 Comparison of model performance for different configurations of Ltarget0 by varying the scalar parameters on the threshold (L^0) and the target (L^{target}) values for the mean length, with the default value highlighted in bold. Performance metrics are as defined in Table 6.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Configurations are shown which do not meet the 50% threshold for VY15 (noted in red) to provide insight into the tradeoffs between scalar values and performance metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	L^0	L^{target}	PNOF	B50	VY15	LTY	STY	Bbelow20
Ltarget0	0.8	1.00	65.8	76.3	59.7	70.6	82.5	9.8
	0.8	1.05	67.9	77.7	62.1	70.7	81.8	9.3
	0.8	1.10	69.6	78.7	64.7	69.9	80.7	9.0
	0.8	1.15	71.2	79.7	67.6	68.6	79.2	8.7
	0.8	1.20	72.5	80.4	69.5	68.0	78.6	8.4
	0.8	1.25	73.5	81.0	71.1	67.8	78.0	8.2
	0.9	1.00	67.3	77.1	59.3	68.9	79.6	9.4
	0.9	**1.05**	70.2	79.0	64.1	68.2	78.7	8.7
	0.9	1.10	72.4	80.5	67.7	67.1	77.4	8.3
	0.9	1.15	74.1	81.5	71.1	66.2	75.7	8.0
	0.9	1.20	75.4	82.4	73.8	66.1	75.1	7.7
	0.9	1.25	76.6	83.0	75.5	65.6	74.0	7.4
	1.0	1.00	64.1	74.5	47.6	64.0	76.6	10.9
	1.0	1.05	72.2	80.2	63.9	63.7	73.1	8.4
	1.0	1.10	75.6	82.3	69.9	63.0	71.5	7.7
	1.0	1.15	77.7	83.7	74.9	62.1	69.9	7.2
	1.0	1.20	79.4	84.7	77.7	61.5	68.5	6.7
	1.0	1.25	80.7	85.5	79.9	60.8	67.9	6.3
		Minimum	64.1	74.5	47.6	60.8	67.9	6.3
		Maximum	80.7	85.5	79.9	70.7	82.5	10.9
		Difference	16.6	11.0	32.3	9.9	14.6	4.6

Table 6.8 Summary statistics of the catch recommendations (in pounds) for each viable method for Wenchman and multiple weighted joint distributions in comparison to the Tier3AStatusQuo (i.e. current OFL). The recommended method, a joint distribution of the top index-based (Itarget0) and length-based (Ltarget0) methods as determined by MSE is highlighted in bold.

Method	25%	40%	50%	75%	Mean	SD	CV
Tier3AStatusQuo	99,669	99,669	99,669	99,669	99,669	0	0
Itarget0	85,163	90,789	94,335	105,084	95,650	15,126	0.158
Ltarget0	40,167	42,858	44,544	49,518	45,182	7,042	0.156
CC1_Ref	48,023	51,373	53,546	59,316	54,075	8,519	0.158
Islope0	55,798	60,060	62,718	70,433	63,534	10,905	0.172
LstepCC0	43,272	46,165	48,031	53,224	48,520	7,548	0.156
Joint Distribution (Itarget0, Ltarget0, equal weight)	**44,544**	**50,729**	**64,943**	**94,333**	**70,416**	**27,856**	**0.396**
Joint Distribution (Itarget0, Ltarget0, CC1_Ref, equal weight)	45,977	51,066	55,274	85,225	64,969	24,512	0.377
Joint Distribution (All, equal weight)	46,464	51,241	54,844	70,766	61,392	20,914	0.341

Table 6.9 Sensitivity of catch recommendations for Wenchman to the CV specified for the total removals (Cat CV) required for all methods. Statistics reported for the catch recommendation include the 25th, 40th, 50th, and 75th percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV).

Method	Cat CV	25%	40%	50%	75%	Mean	SD	CV
Itarget0	0.35	85,163	90,789	94,335	105,084	95,650	15,126	0.158
	0.70	74,355	84,647	91,583	112,779	96,321	30,317	0.315
Ltarget0	0.35	40,167	42,858	44,544	49,518	45,182	7,042	0.156
	0.70	35,187	39,933	43,259	52,839	45,149	14,031	0.311
CC1_Ref	0.35	48,023	51,373	53,546	59,316	54,075	8,519	0.158
	0.70	42,072	47,859	51,420	63,209	53,939	16,630	0.308
Islope0	0.35	55,798	60,060	62,718	70,433	63,534	10,905	0.172
	0.70	48,997	55,929	60,555	75,201	63,796	20,527	0.322
LstepCC0	0.35	43,272	46,165	48,031	53,224	48,520	7,548	0.156

0.70	37,566	43,104	46,573	57,226	48,639	15,144	0.311

6.4 Figures

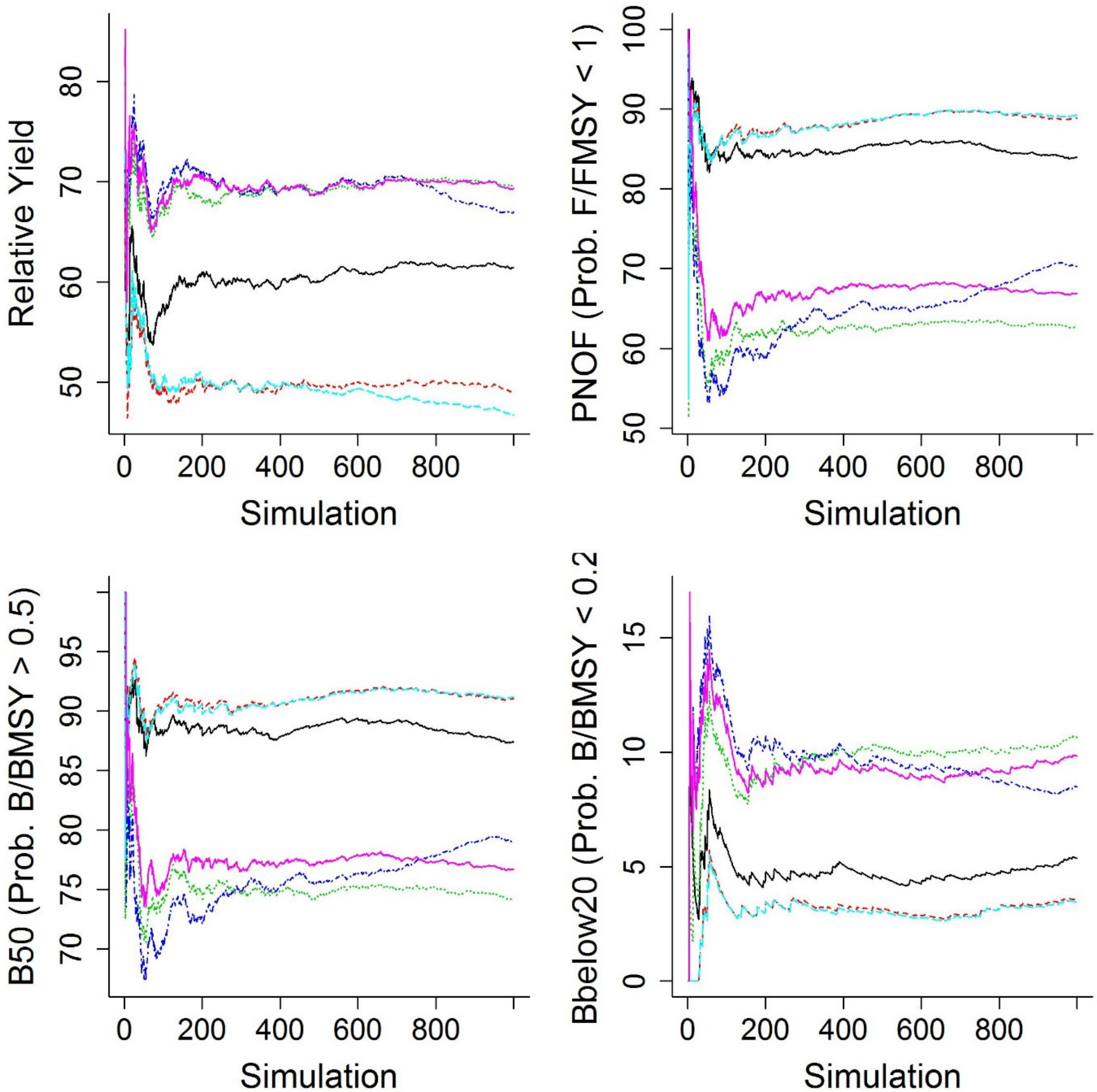


Figure 6.1 Convergence plot confirming that performance criteria for each viable method converged to within 0.05%, indicating that the number of simulations was sufficient for Wenchman. Each colored line identifies the following method: LstepCC0 (aqua), Islope0 (red), CC1_Ref (black), Ltarget0 (blue), Tier3AStatusQuo_ABC (pink), and Itarget0 (green). Relative yield corresponds to the LTY divided by the reference yield, which is the highest mean yield over the last five years of the projection period that can be obtained from a fixed *F* strategy.

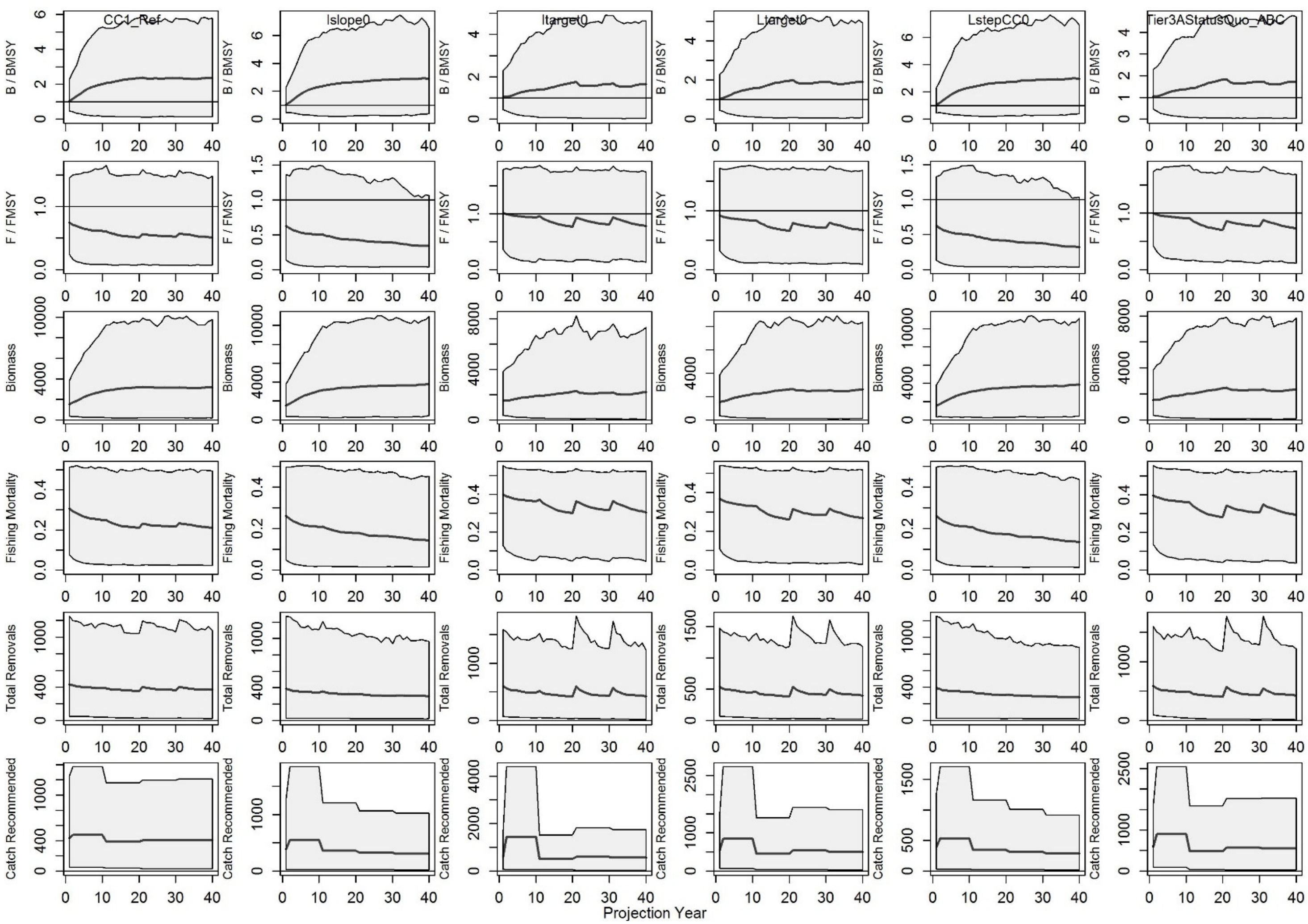


Figure 6.2 Comparison of stock status outputs and catches for Wenchman for the 40-year projection period where an assessment is conducted in years 1, 11, 21, and 31. Outputs include the ratio of biomass to biomass at maximum sustainable yield (*B*/*B*$_{MSY}$), the ratio of fishing mortality to fishing mortality at maximum sustainable yield (*F*/*F*$_{MSY}$), biomass (in pounds), fishing mortality, total removals (in pounds), and the catch recommendation (in pounds) for each viable method. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 5th and 95th percentiles.

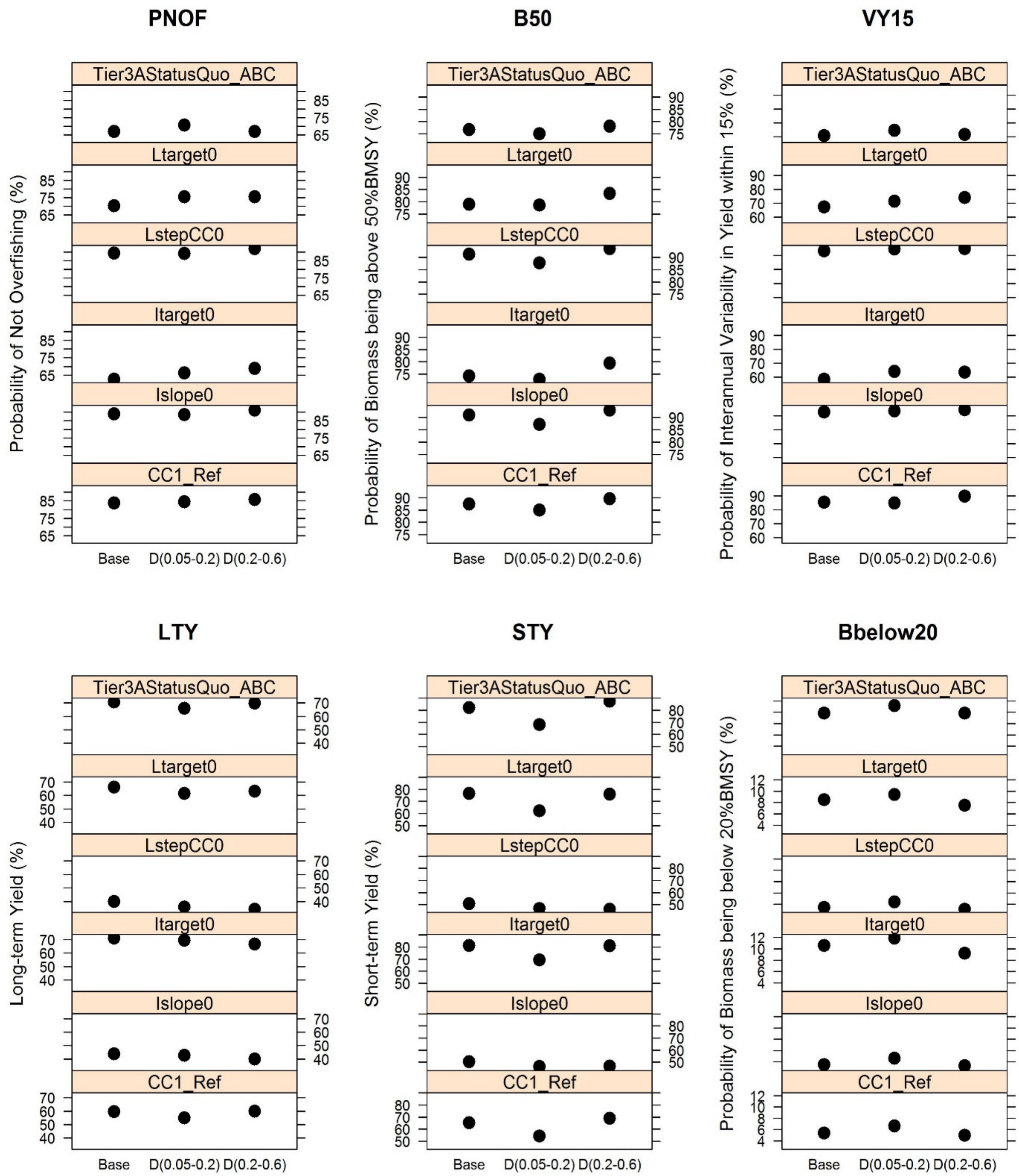


Figure 6.3 Method performance for Wenchman assuming the base level of depletion (base; D = 0.12 – 0.31 based on other Lutjanidae), a severely depleted state (D = 0.05 – 0.2), and a moderately depleted state (D = 0.2 – 0.6). Results for the lightly depleted state (D = 0.6 – 0.9) are not shown because the depletion levels could not be reached. The absence of points indicates that the performance metric(s) did not meet the specified criteria (> 50%) for PNOF, B50, and VY15.

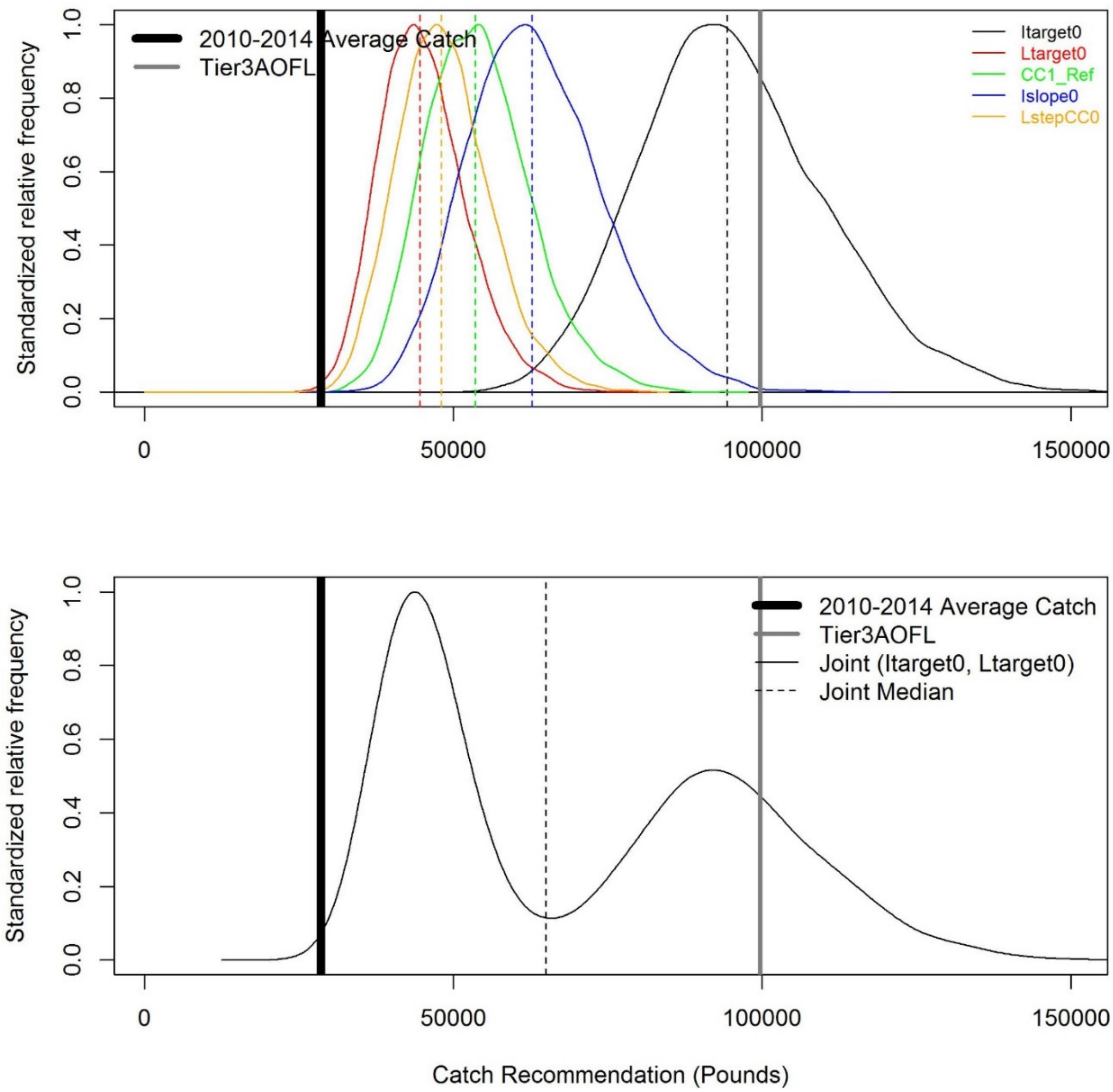


Figure 6.4 Distribution of the catch recommendation (in pounds) for Wenchman recommended by the five viable methods (top panel; dashed vertical lines identify medians) and a joint distribution assuming equal weighting of the top index-based (Itarget0) and length-based (Ltarget0) methods according to performance in the MSE (bottom panel). The average catch between 2010 and 2014 (thick black line) and the OFL specified by the Tier3AStatusQuo (thick gray line) are included for comparison. The joint distribution (bottom panel) is recommended for providing management advice.

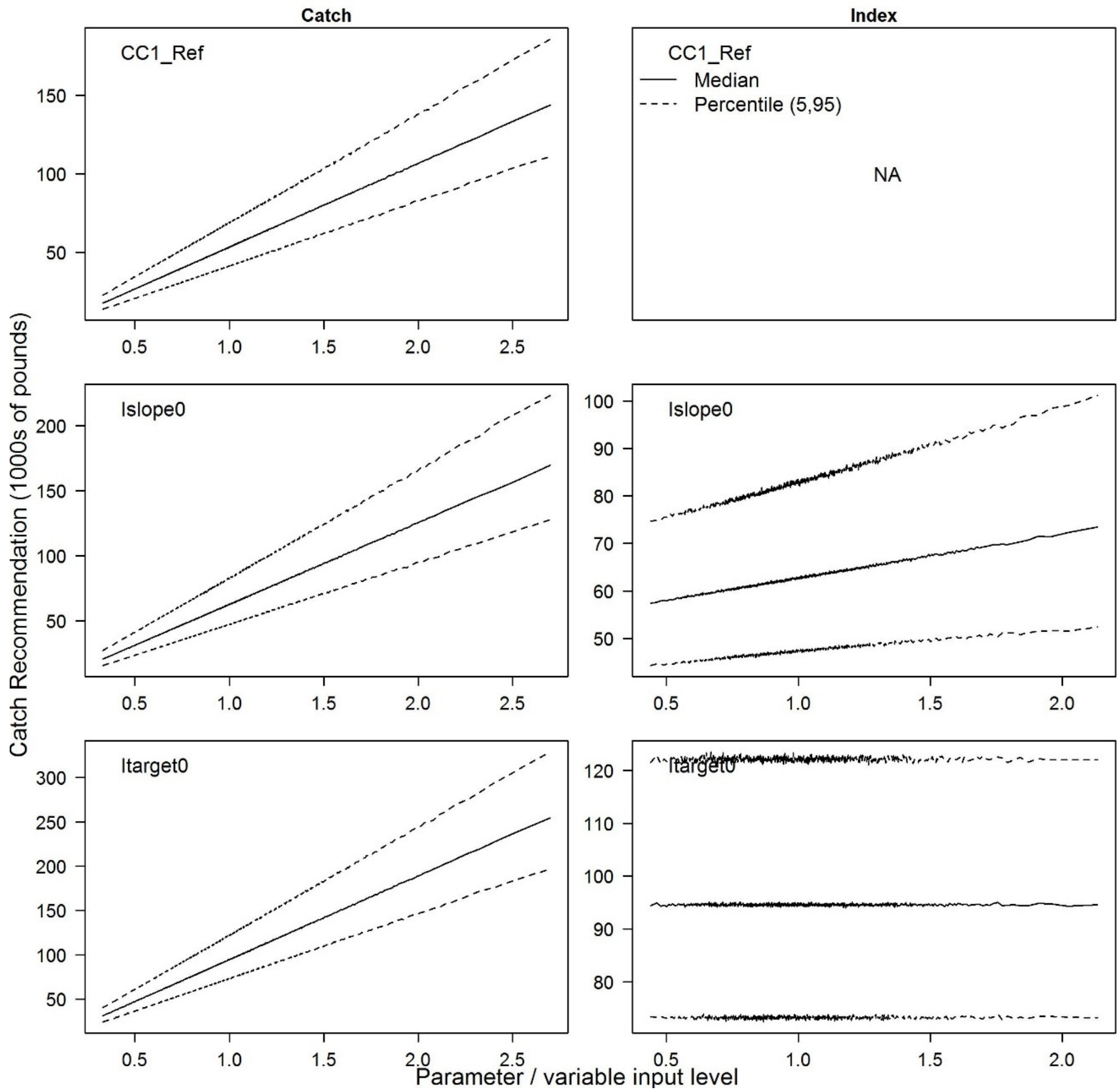


Figure 6.5 Sensitivity of the catch recommendation for Wenchman to marginal inputs in the required data inputs for CC1_Ref (catch only) and the index-based methods Islope0 and Itarget0 (Catch and index of abundance). Note that ranges for parameter ranges are derived from the CV for each parameter. NA indicates that the data input is not required. Sensitivity runs resulted in errors for both LstepCC0 and Ltarget0 and are therefore not shown.

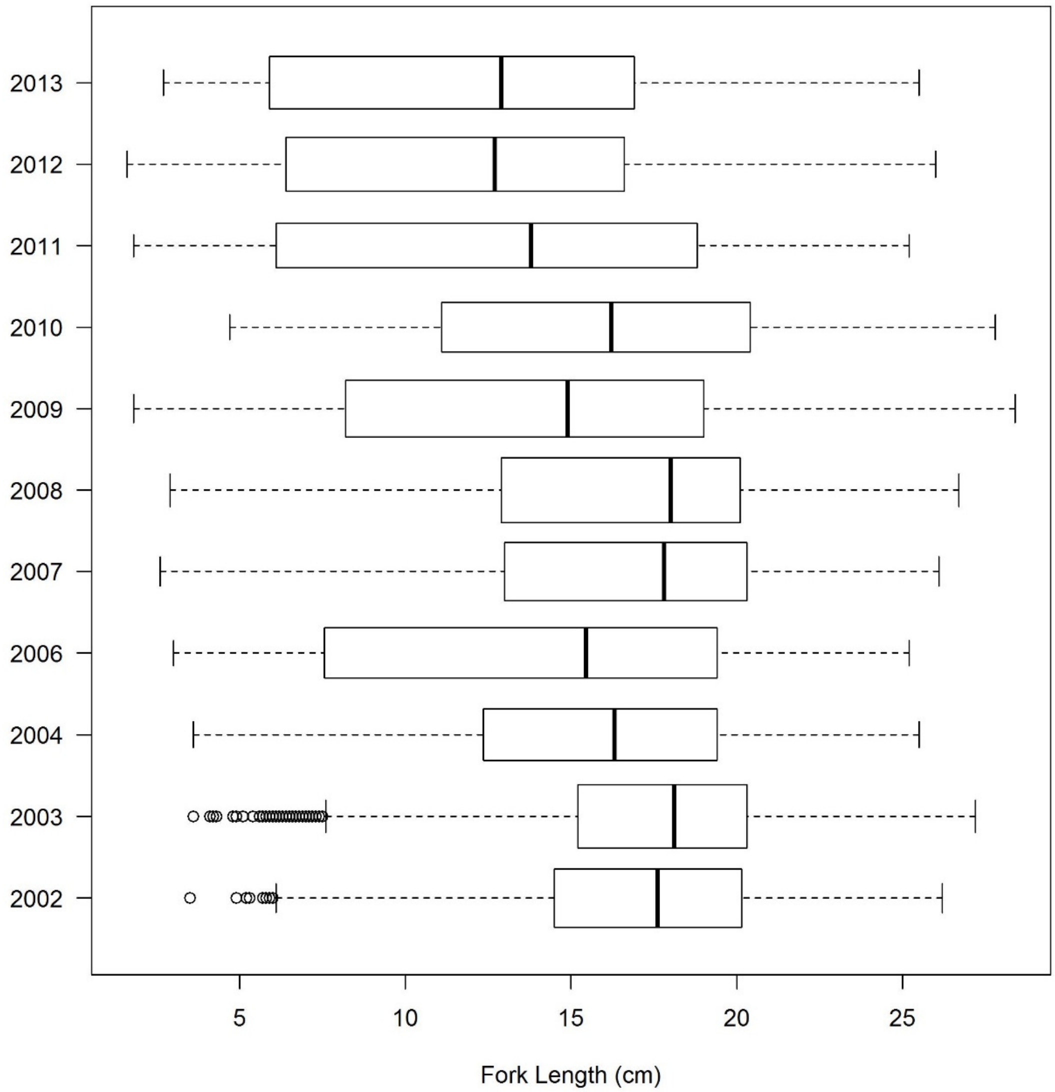


Figure 6.6 Length frequency of Wenchman from the NMFS small pelagics survey. The boxplots represent the inter-quartile range, the solid lines represent the medians, the open circles represent outliers, and the box height represents the relative sample size (box height is equal to the square-root of sample size).

7 YELLOWMOUTH GROUPER DATA-LIMITED EVALUATION RESULTS

7.1 Data-limited Methods Toolkit

The AW Panel recommended the exclusion of Yellowmouth Grouper in the assessment process due to severe data limitations surrounding misidentification. Substantial concerns were raised regarding sporadic data inputs and the large possibility of misidentifying Yellowmouth Grouper as Scamp in both landings and derived length composition. It was recommended that Yellowmouth Grouper be considered during the upcoming Scamp assessment because Yellowmouth Grouper represents the minority of the combined catches. Given the uncertainties regarding total removals, the index of abundance, and composition data, no results are shown for Yellowmouth Grouper.

8 SNOWY GROUPER DATA-LIMITED EVALUATION RESULTS

8.1 Data-Limited Methods Toolkit

Two methods were feasible for Snowy Grouper based on data availability and reliability (CC1_Ref and Tier3BStatusQuo_ABC), as well as a third method added, which is based on a recent catch history (CC1; 2010-2014 total removals from all fishery sources) (Table 8.1). As discussed in Section 2.3, abundance and mean length data derived from the commercial logbook for the longline fishery were discouraged for use due to concerns over recent shifts in fisher behavior and spatial distribution. Therefore, both the index of abundance and length composition from the commercial longline fishery were excluded from any analysis. Total removals combined for all fishery sources were scored as highly reliable (Table 8.2). Although the majority of removals are coming from the commercial longline fishery, which shifted distribution around 2009, it is assumed that the fishing pattern has remained constant between 2010 and 2014.

8.1.1 Management Strategy Evaluation

Of the three feasible methods, CC1, which is based on a current catch history, was the only method to meet the performance criteria for PNOF, B50, and VY15 (Table 8.3). No convergence issues were detected as all performance metrics converged to within 0.05%, with metrics stabilizing around 400 simulations (Figure 8.1). When trends over the 40 year projection period were examined, the latter portion of the projection period for CC1 revealed mean biomass to biomass at maximum sustainable yield (B/B_{MSY}) ratios below the 1.0 threshold and mean fishing mortality to fishing mortality at maximum sustainable yield (F/F_{MSY}) ratios above the 1.0 threshold (Figure 8.2). However, these metrics were still an improvement when compared to the trends for the Tier3BStatusQuo_ABC, where mean B/B_{MSY} and F/F_{MSY} ratios across simulations were generally below and above 1.0, respectively (Figure 8.2).

Overall, CC1 resulted in lower STY compared to the Tier3BStatusQuo_ABC but displayed superior metrics including:

- PNOF above the 50% threshold (54%);
- B50 above the 50% threshold (74%);
- A higher VY15 (92%);
- A higher LTY (57.0%); and
- A lower Bbelow20 (21%).

A key disadvantage of the CC1 method is that this method uses a reference period of recent catch (2010-2014) rather than the historical reference period (1992-2008) specified in GMFMC (2011). Given this caveat, this method is not appropriate for providing management advice unless the merits of a recent catch history are evaluated and/or a change in the reference period is warranted.

8.1.2 Sensitivity of method performance to assumptions in the operating model

Different assumptions regarding the plausible range of stock depletion and maximum age were tested in the MSE:

- A severely depleted state (D = 0.05 – 0.2);
- A moderately depleted state (D = 0.2 – 0.6);
- A lightly depleted state (D = 0.6 – 0.9); and
- An older maximum age (44 years as suggested by the LHWG).

Based on different assumed states of nature regarding depletion and maximum age, the overall recommendations were the same in that CC1 met the performance criteria for all runs except the severely depleted state (D = 0.05 – 0.2), in which no methods met the criteria (Figure 8.3). The Tier3BStatusQuo_ABC met the performance metrics in a lightly exploited depletion state (D = 0.6 – 0.9). Results were similar among performance metrics given an older maximum age (44 years) compared to the base (35 years).

8.1.3 Calculation of Catch Recommendations

The median catch recommendation from CC1 exceeded the Tier3BStatusQuo (Table 8.4) because recent total removals have exceeded the current OFL (Figure 8.4). Because the reference period for CC1 does not match the selected reference period as described in GMFMC (2011), this method is not recommended for providing management advice.

8.1.4 Sensitivity of Catch Recommendation

The catch recommendation from CC1 is sensitive to the magnitude of total removals, with larger catches corresponding to larger catch recommendations (Figure 8.5).

Overall, the CV on total removals had a minor impact on the median catch recommendation for CC1, with a lower catch recommendation (~ 500 pounds) obtained if the CV is larger than observed (i.e. doubled) (Table 8.5).

8.2 Mean Length Estimator

The mean length-based mortality estimator was pursued for Snowy Grouper to estimate total mortality using length composition from the commercial longline data (Figure 8.6). However, as discussed in Section 2.3, results are not presented due to analyst concerns regarding the representativeness of the data collected. In the more recent period, the total mortality estimated was equal to 0.001, due to a drastic increase in mean length in recent years. It is believed that a shift in fisher distribution was behind the large increase in mean length, as increased effort in deeper waters may have changed the selectivity pattern of the fleet. Landings for Snowy Grouper have remained relatively high in recent years, particularly in 2012 (see Figure 2.5).

8.3 Tables

Table 8.1 Feasible methods for the DLMtool evaluation for Snowy Grouper. Data inputs are as defined in Table 3.1.1.

Method	Data Inputs														
	Mort	FMSY_M	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	LFC	LFS	ML	CAA
Catch-based															
CC1															
CC1_Ref															
Tier3BStatusQuo_ABC															

Table 8.2 Guidance table for Snowy Grouper documenting data requirements for each method and reliability scores for data inputs. Colors reflect poor quality (red; 0-33%), fair quality (yellow; 34-67%), and good quality (green; 68-100%), and are based on the information content reliability scores discussed in Section 2.4.

Method	Data Requirements	Reliability Score
CC1	Total removals: Known and informative for 2010-2014	Good

CC1_Ref	Total removals: Known and informative for 1992-2008	Good
Tier3BStatusQuo	Total removals: Known and informative for 1992-2008	Good

Table 8.3 Performance metrics for methods meeting performance criteria for Snowy Grouper. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing; B50 = Probability of the biomass being above 50% B_{MSY}; VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY}. Note that performance for Bbelow20 is reversed, where a low probability is preferable.

Method	PNOF	B50	VY15	LTY	STY	Bbelow20
CC1	58.6	73.5	91.8	57.0	86.1	20.8
Tier3BStatusQuo_ABC	23.9	46.7	72.5	37.0	99.6	42.2

Table 8.4 Summary statistics of the catch recommendations (in pounds) for the sole viable method for Snowy Grouper, in comparison to the Tier3BStatusQuo (i.e. current OFL). Note that CC1 is not recommended for providing management advice because it is based on a recent reference period for total removals which does not match the reference period specified in GMFMC (2011). Although CC1_Ref was tested in the MSE, it did not meet the specified performance criteria.

Method	25%	40%	50%	75%	Mean	SD	CV
Tier3BStatusQuo	134,067	134,067	134,067	134,067	134,067	0	0
CC1	213,074	217,426	220,074	227,708	220,448	10,972	0.050

Table 8.5 Sensitivity of catch recommendations for Snowy Grouper to the CV specified for the total removals (Cat CV) required for CC1. Statistics reported for the catch recommendation include the 25th, 40th, 50th, and 75th percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV).

Method	Cat CV	25%	40%	50%	75%	Mean	SD	CV
CC1	0.11	213,074	217,426	220,074	227,708	220,448	10,972	0.050
	0.22	205,004	214,212	219,681	234,097	220,389	21,645	0.098

8.4 Figures

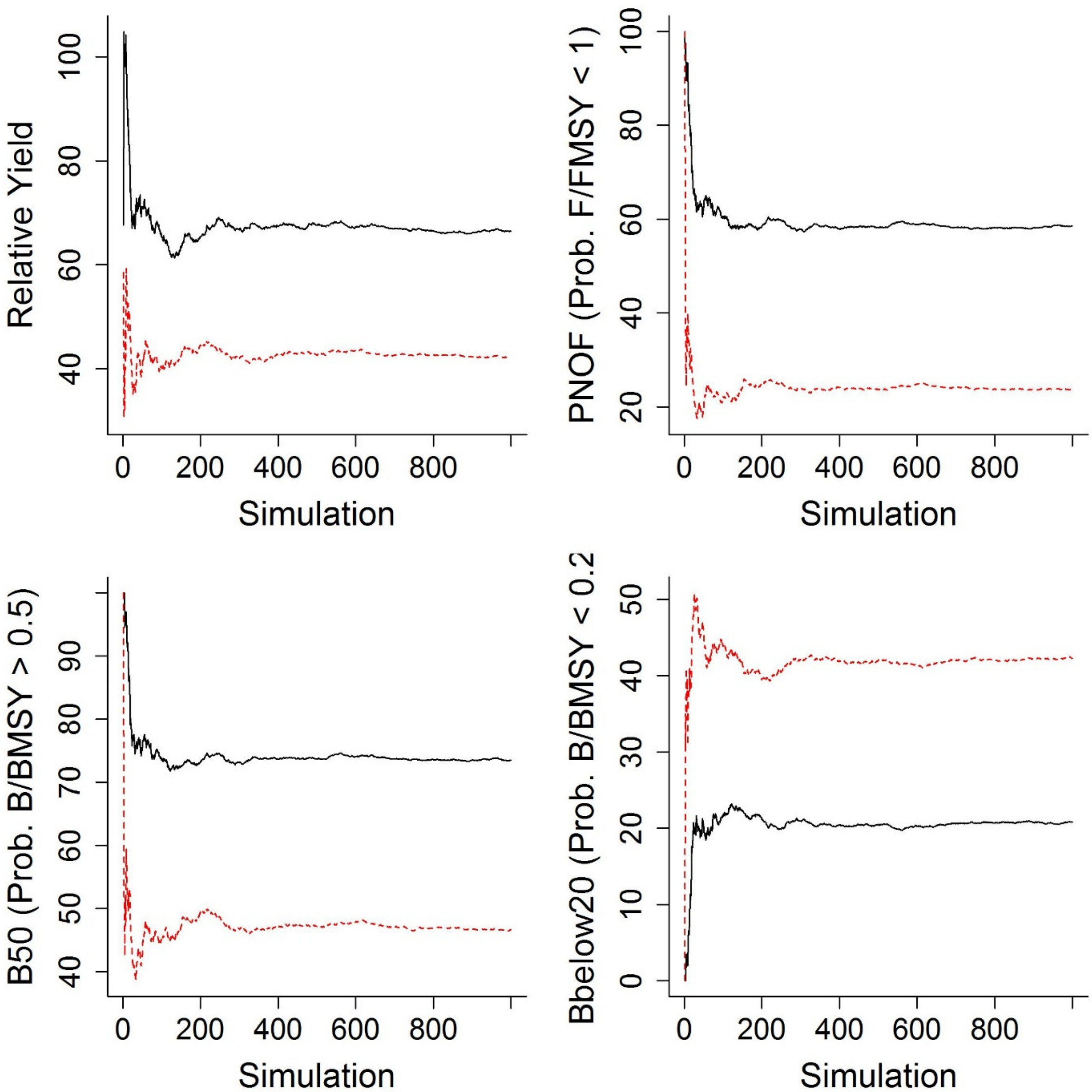


Figure 8.1 Convergence plot confirming that performance criteria for each viable method converged to within 0.05%, indicating that the number of simulations was sufficient for Snowy Grouper. Each colored line identifies the following methods: CC1 (black) and Tier3BStatusQuo_ABC (red). Relative yield corresponds to the LTY divided by the reference

yield, which is the highest mean yield over the last five years of the projection period that can be obtained from a fixed *F* strategy.

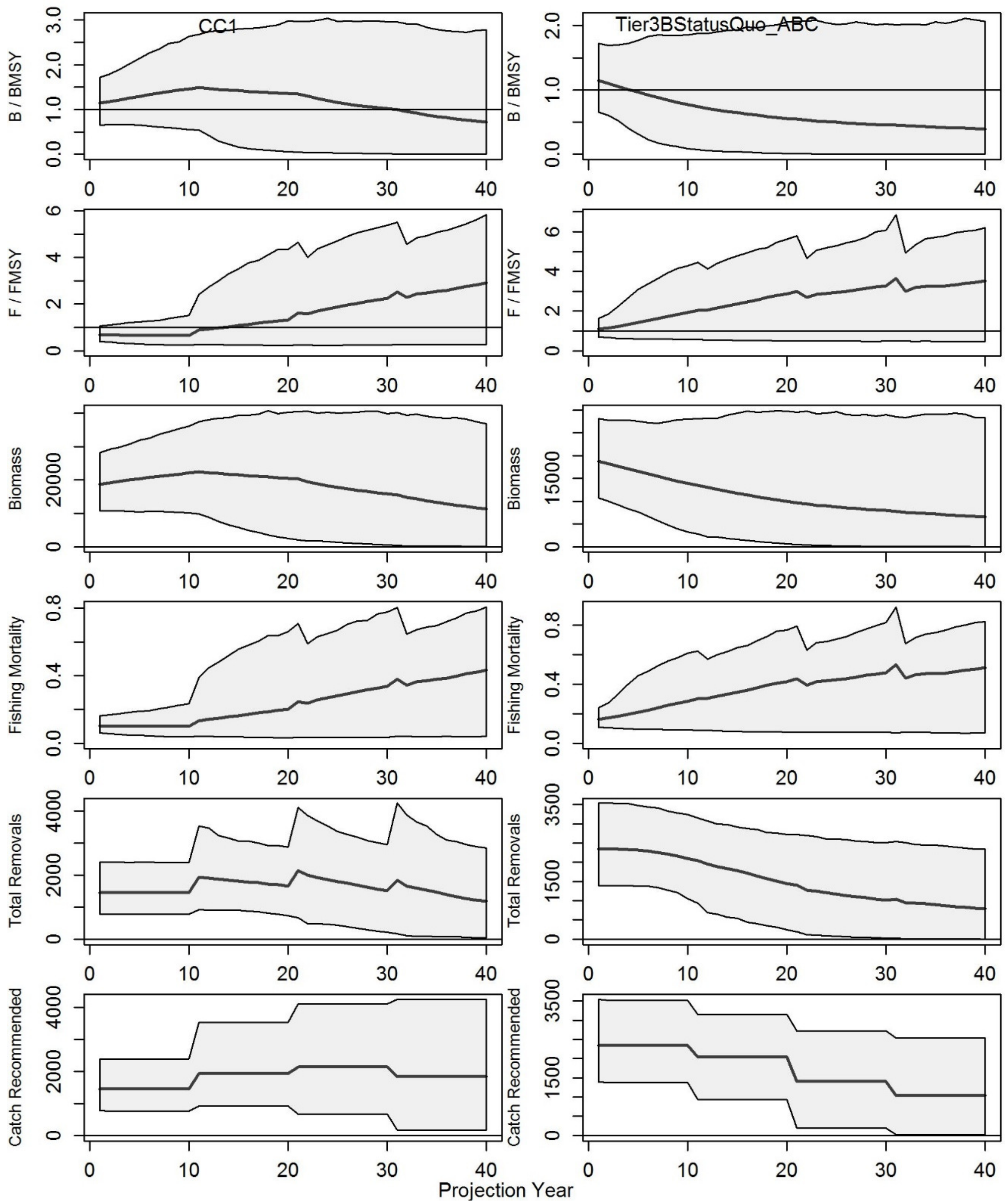


Figure 8.2 Comparison of stock status outputs and catches for Snowy Grouper for the 40-year projection period where an assessment is conducted in years 1, 11, 21, and 31. Outputs include

the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, total removals (in pounds), and the catch recommendation (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 5^{th} and 95^{th} percentiles.

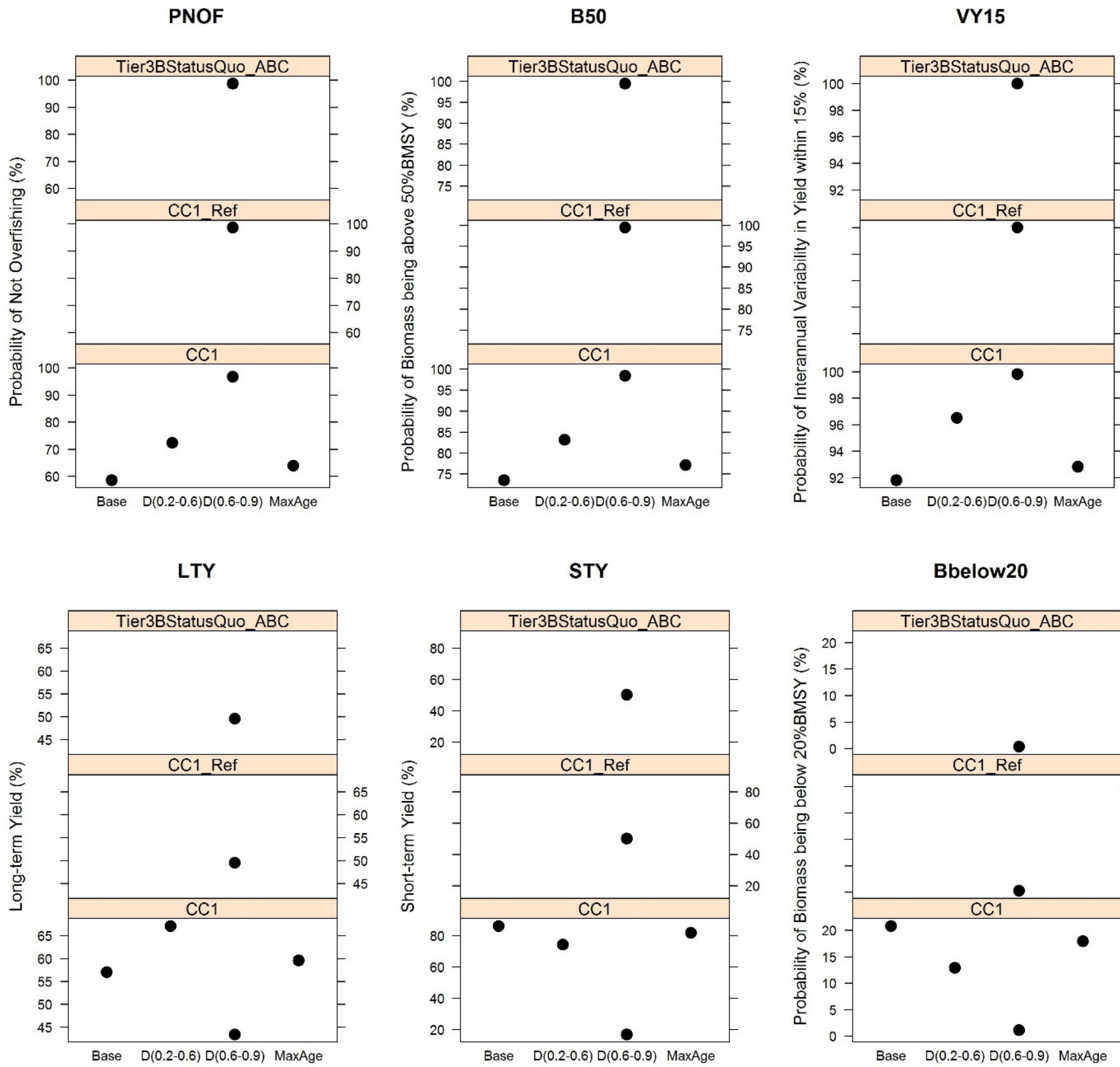


Figure 8.3 Method performance for Snowy Grouper assuming the base level of depletion (base; D = 0.15 – 0.40 based on current mean length and the ML2D function in the DLMtool), a moderately depleted state (D = 0.2 – 0.6), a lightly depleted state (D = 0.6 – 0.9), and an older maximum age (44 y versus 35 y).The absence of points indicates that the performance metric(s) did not meet the specified criteria (> 50%) for PNOF, B50, and VY15. No methods met the criteria for the severely depleted state (D = 0.05 – 0.2).

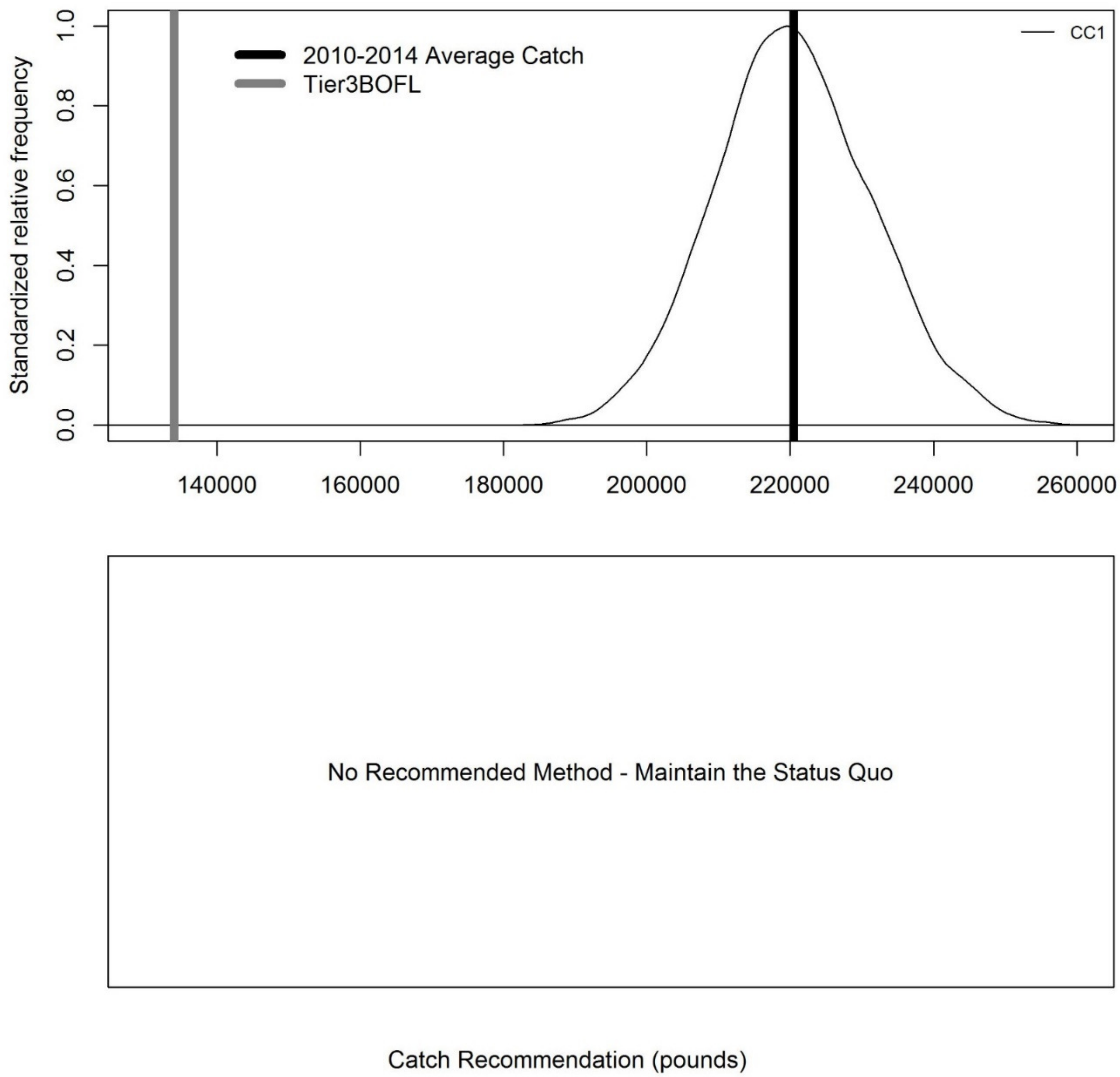


Figure 8.4 Distribution of the catch recommendation (in pounds) for Snowy Grouper recommended by the only viable method, CC1 (top panel). The average catch between 2010 and 2014 (thick black line) and the OFL specified by the Tier3BStatusQuo (thick gray line) are included for comparison. Note that the dashed vertical line identifying the median for CC1 is directly below the 2010-2014 Average Catch line. No method is recommended (bottom panel) for providing management advice.

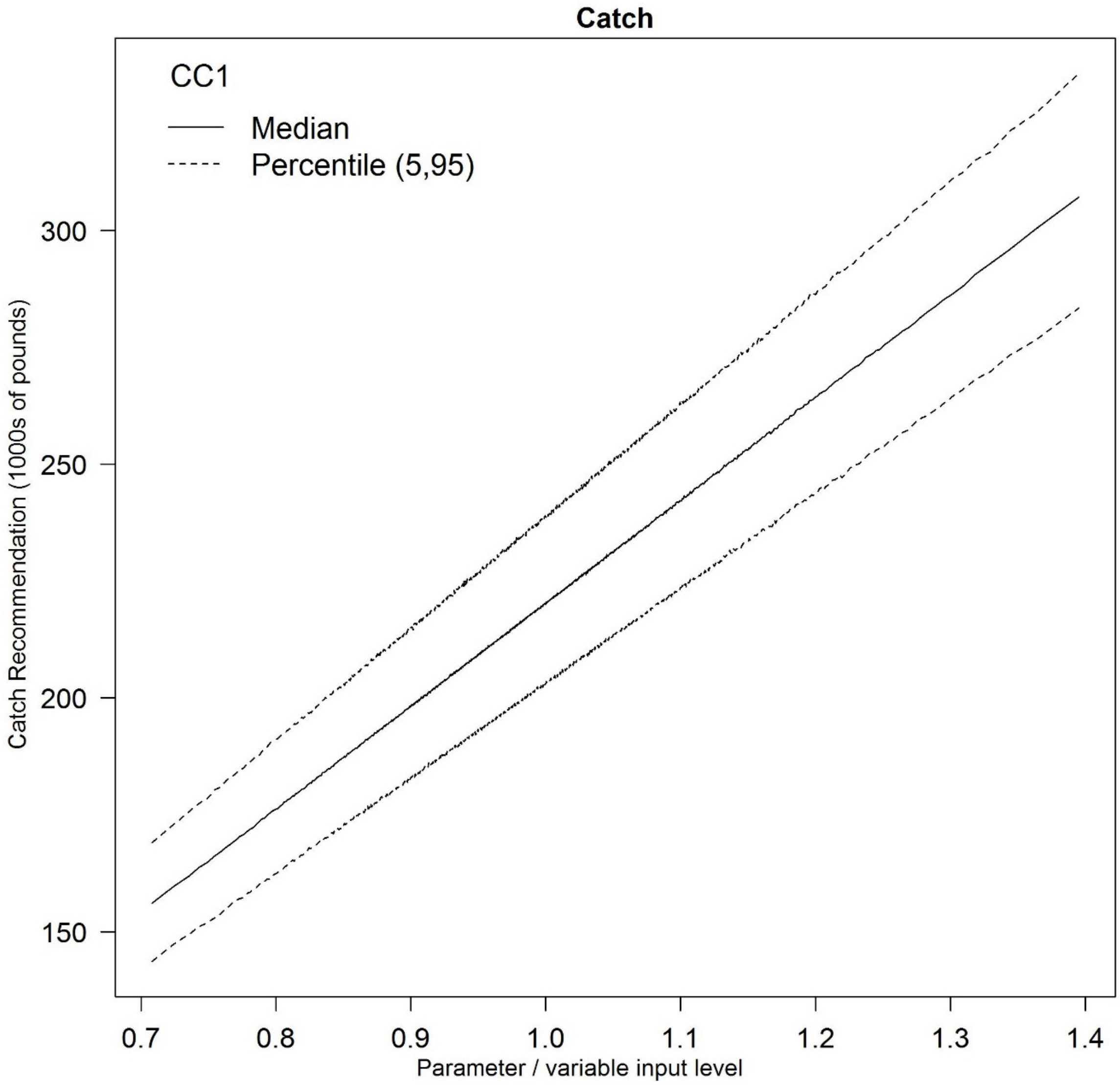


Figure 8.5 Sensitivity of the catch recommendation for Snowy Grouper to marginal changes in the required data inputs for CC1 (catch only). Note that ranges for parameter ranges are derived from the CV for each parameter.

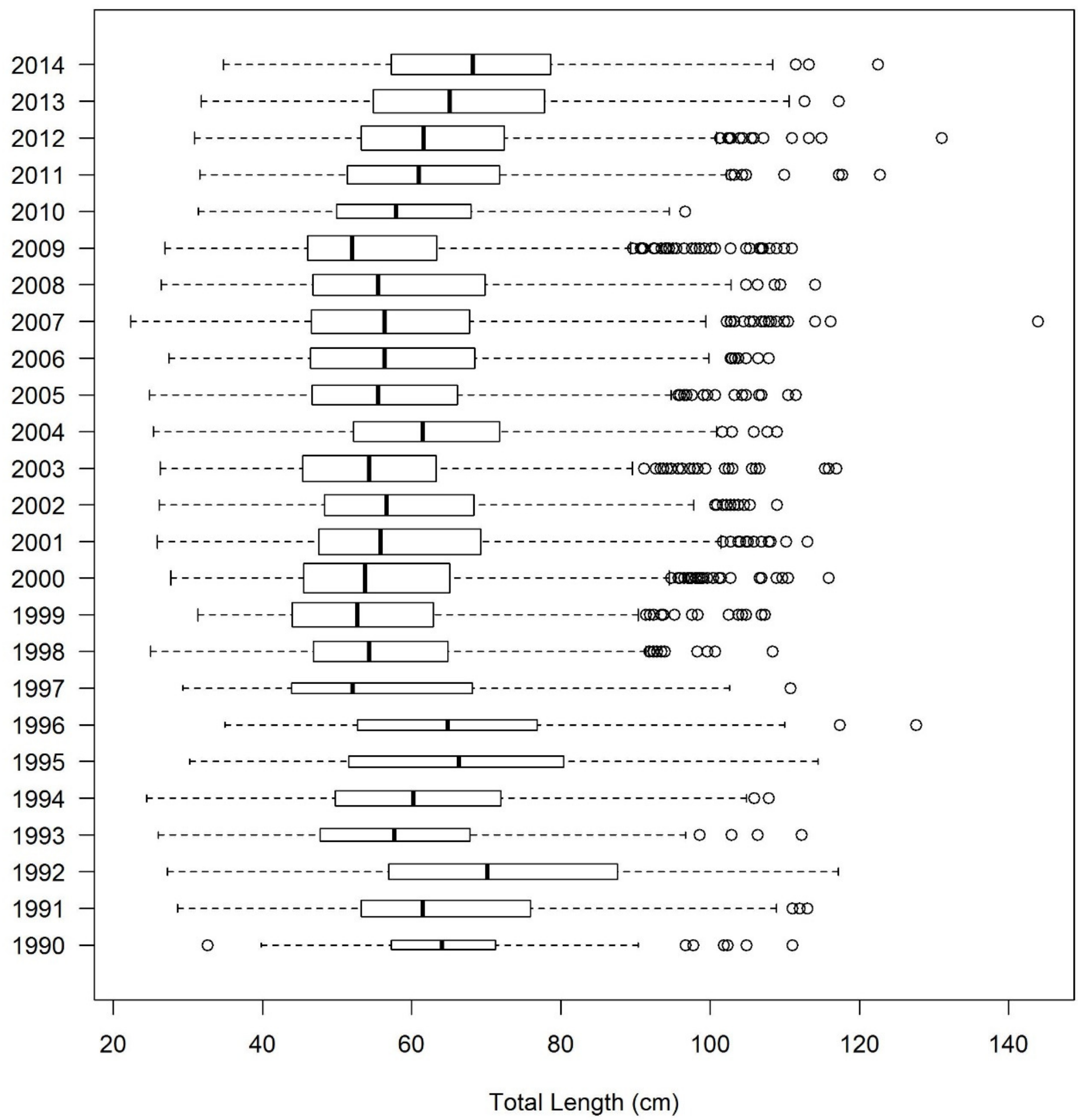


Figure 8.6 Length frequency of Snowy Grouper from the commercial longline fishery. The boxplots represent the inter-quartile range, the solid lines represent the medians, the open circles represent outliers, and the box height represents the relative sample size (box height is equal to the square-root of sample size).

9 SPECKLED HIND DATA-LIMITED EVALUATION RESULTS

9.1 Data-Limited Methods Toolkit

Two methods were feasible for Speckled Hind based on data availability and reliability, as well as a third method added, which is based on a recent catch history (CC1; 2010-2014 total removals from all fishery sources) (Table 9.1). As discussed in Section 2.3 and in Section 8.1 for Snowy Grouper, abundance and mean length data derived from the commercial logbook for the longline fishery were discouraged for use due to concerns over recent shifts in fisher behavior and spatial distribution. Therefore, both the index of abundance and length composition from the commercial longline fishery were not included in any analysis. Total removals combined for all fishery sources were scored as highly reliable (Table 9.2). Although the majority of removals are coming from the commercial longline fishery, which shifted distribution around 2009, it is assumed that the fishing pattern has remained constant between 2010 and 2014.

9.1.1 Management Strategy Evaluation

Of the three feasible methods, CC1, which is based on a current catch history, was the only method to meet the performance criteria for PNOF and B50 (Table 9.3). No convergence issues were detected as all performance metrics converged to within 0.05%, with metrics stabilizing around 800 simulations (Figure 9.1). When trends over the 40 year projection period were examined for CC1, the latter portion of the projection period revealed mean fishing mortality to fishing mortality at maximum sustainable yield (F/F_{MSY}) ratios above the 1.0 threshold (Figure 9.2). However, these metrics were still an improvement when compared to the trends for Tier3BStatusQuo_ABC, where mean B/B_{MSY} and F/F_{MSY} ratios across simulations were generally below and above 1.0, respectively (Figure 9.2).

Overall, CC1 resulted in lower STY but displayed more desirable metrics including:

- A PNOF above the 50% threshold (73%);
- A B50 above the 50% threshold (77%);
- A higher VY15 (88%);
- A slightly higher LTY (41%); and
- A lower Bbelow20 (15%).

A key disadvantage of the CC1 method is that this method uses a reference period of recent total removals rather than the historical reference period specified in GMFMC (2011). Given this caveat, this method is not appropriate for providing management advice unless the merits of a recent catch history are evaluated and/or a change in the reference period is warranted.

9.1.2 Sensitivity of method performance to assumptions in the operating model

Different assumptions regarding the plausible range of stock depletion and maximum age were tested in the MSE:

- A severely depleted state (D = 0.05 – 0.2);
- A moderately depleted state (D = 0.2 – 0.6);
- A lightly depleted state (D = 0.6 – 0.9); and
- A lower maximum age (35 years as suggested by the LHWG).

In the lightly depleted state (D = 0.6 – 0.9), the operating model could not reach the specified depletion level and therefore was excluded from analyses. Based on different assumed states of depletion and maximum age, the overall recommendations were the same in that CC1 met the performance criteria (Figure 9.3). The Tier3BStatusQuo and CC1_Ref only met the performance metrics if a moderately depleted stock (D = 0.2 – 0.6) was assumed. Results were very similar among performance metrics given a younger maximum age (35 years) compared to the base (45 years).

9.1.3 Calculation of Catch Recommendation

The median catch recommendation from CC1 exceeded the Tier3BStatusQuo (Table 9.4) because recent catches have exceeded the current OFL (Figure 9.4). Because the reference period for CC1 does not match what has been selected for management specified in GMFMC (2011), this method is not recommended for providing management advice.

9.1.4 Sensitivity of Catch Recommendation

The catch recommendation from CC1 is sensitive to the magnitude of total removals, with larger catches corresponding to larger catch recommendations (Figure 9.5).

Overall, the CV on total removals had a minor impact on the median catch recommendation for CC1, with a lower catch recommendation (~1,000 pounds) obtained if the CV is larger than observed (i.e. doubled) (Table 9.5).

9.2 Mean Length Estimator

The mean length-based mortality estimator was pursued for Speckled Hind to estimate total mortality using length composition from the commercial longline data (Figure 9.6). However, as discussed in Section 2.3, results are not presented due to analyst concerns regarding the representativeness of the data collected. The total mortality estimated was less than the SEDAR 49 LHWG natural mortality estimate (0.15), which constrained the estimate of *F* to 0.0. As discussed in Section 2.3, it is believed that a shift in fisher distribution was behind the large increase in mean length, as increased effort in deeper waters may have changed the selectivity pattern of the fleet.

9.3 Tables

Table 9.1 Feasible methods for the DLMtool evaluation for Speckled Hind. Data inputs are as defined in Table 3.1.1.

Method	Data Inputs														
	Mort	**FMSY_M**	**vbLinf**	**vbK**	**vbt0**	**wla**	**wlb**	**steep**	**MaxAge**	**Cat**	**Ind**	**LFC**	**LFS**	**ML**	**CAA**
Catch-based															
CC1															
CC1_Ref															
Tier3BStatusQuo_ABC															

Table 9.2 Guidance table for Speckled Hind documenting data requirements for each method and reliability scores for data inputs. Colors reflect poor quality (red; 0-33%), fair quality (yellow; 34-67%), and good quality (green; 68-100%), and are based on the information content reliability scores discussed in Section 2.4.

Method	Data Requirements	Reliability Score
CC1	Total removals: Known and informative for 2010-2014	Good
CC1_Ref	Total removals: Known and informative for 1992-2008	Good
Tier3BStatusQuo_ABC	Total removals: Known and informative for 1992-2008	Good

Table 9.3 Performance metrics for methods meeting performance criteria for Speckled Hind. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing; B50 = Probability of the biomass being above 50% B_{MSY}; VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY}. Note that performance for Bbelow20 is reversed, where a low probability is preferable.

Method	PNOF	B50	VY15	LTY	STY	Bbelow20
CC1	73.0	77.2	87.9	41.3	50.9	14.8
Tier3BStatusQuo_ABC	33.1	45.1	60.6	37.4	89.3	43.8

Table 9.4 Summary statistics of the catch recommendation (in pounds) for the sole viable method for Speckled Hind, CC1, in comparison to the Tier3BStatusQuo (i.e. current OFL). Note that CC1 is not recommended for providing management advice because it is based on a recent reference period for total removals which does not match the reference period specified in GMFMC (2011). Although CC1_Ref was tested in the MSE, it did not meet the specified performance criteria.

Method	25%	40%	50%	75%	Mean	SD	CV
Tier3BStatusQuo	52,473	52,473	52,473	52,473	52,473	0	0
CC1	59,445	62,597	64,563	70,441	65,164	8,306	0.127

Table 9.5 Sensitivity of catch recommendations for Speckled Hind to the CV specified for the total removals (Cat CV) required for CC1. Statistics reported for the catch recommendation include the 25^{th}, 40^{th}, 50^{th}, and 75^{th} percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV).

Method	Cat CV	25%	40%	50%	75%	Mean	SD	CV
CC1	0.282	59,445	62,597	64,563	70,441	65,164	8,306	0.127
	0.564	53,441	59,522	63,588	74,868	65,338	16,530	0.253

9.4 Figures

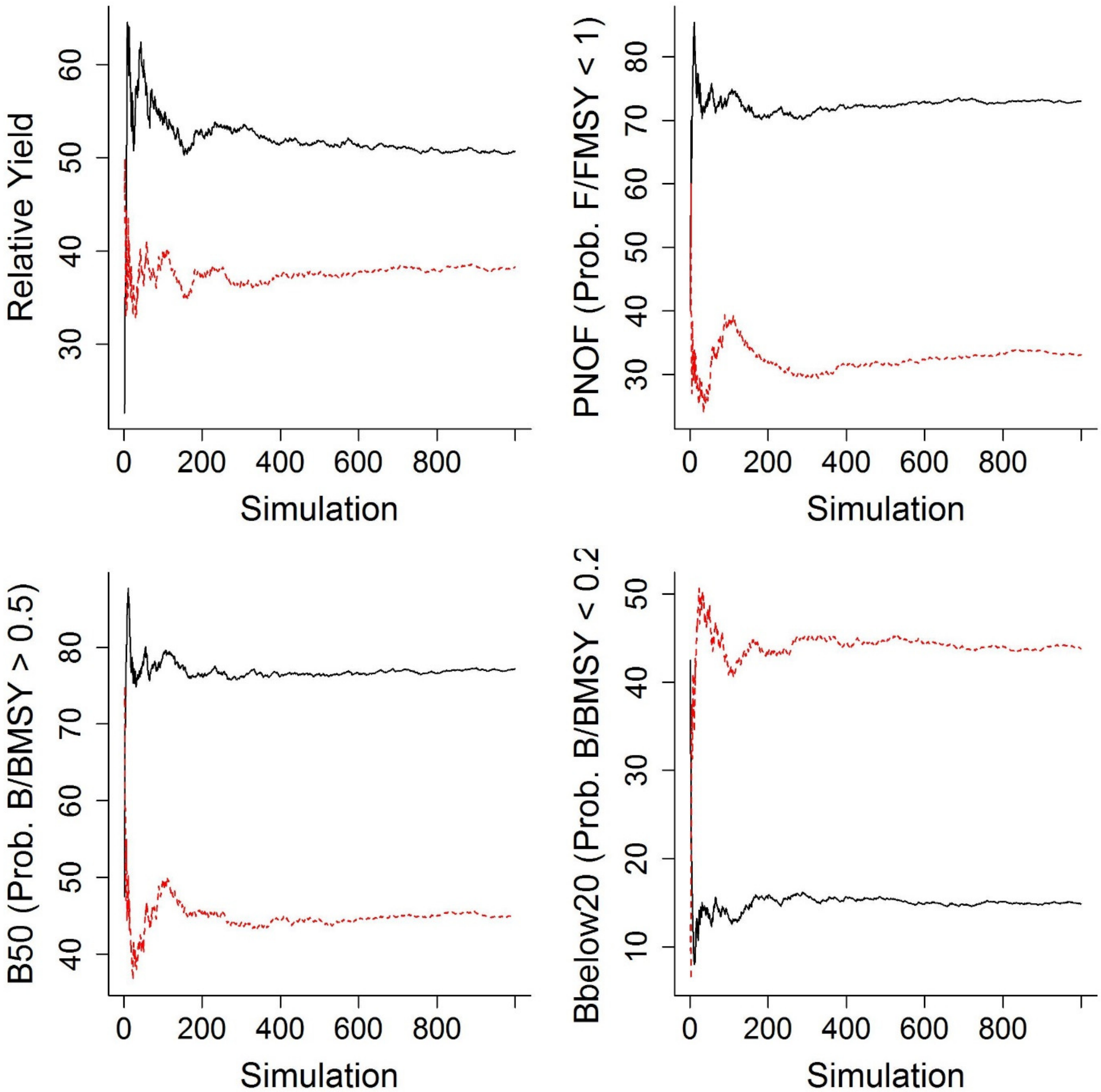


Figure 9.1 Convergence plot confirming that performance criteria for each viable method converged to within 0.05%, indicating that the number of simulations was sufficient for Speckled Hind. Each colored line identifies the following methods: CC1 (black) and Tier3BStatusQuo_ABC (red). Relative yield corresponds to the LTY divided by the reference yield, which is the highest mean yield over the last five years of the projection period that can be obtained from a fixed *F* strategy.

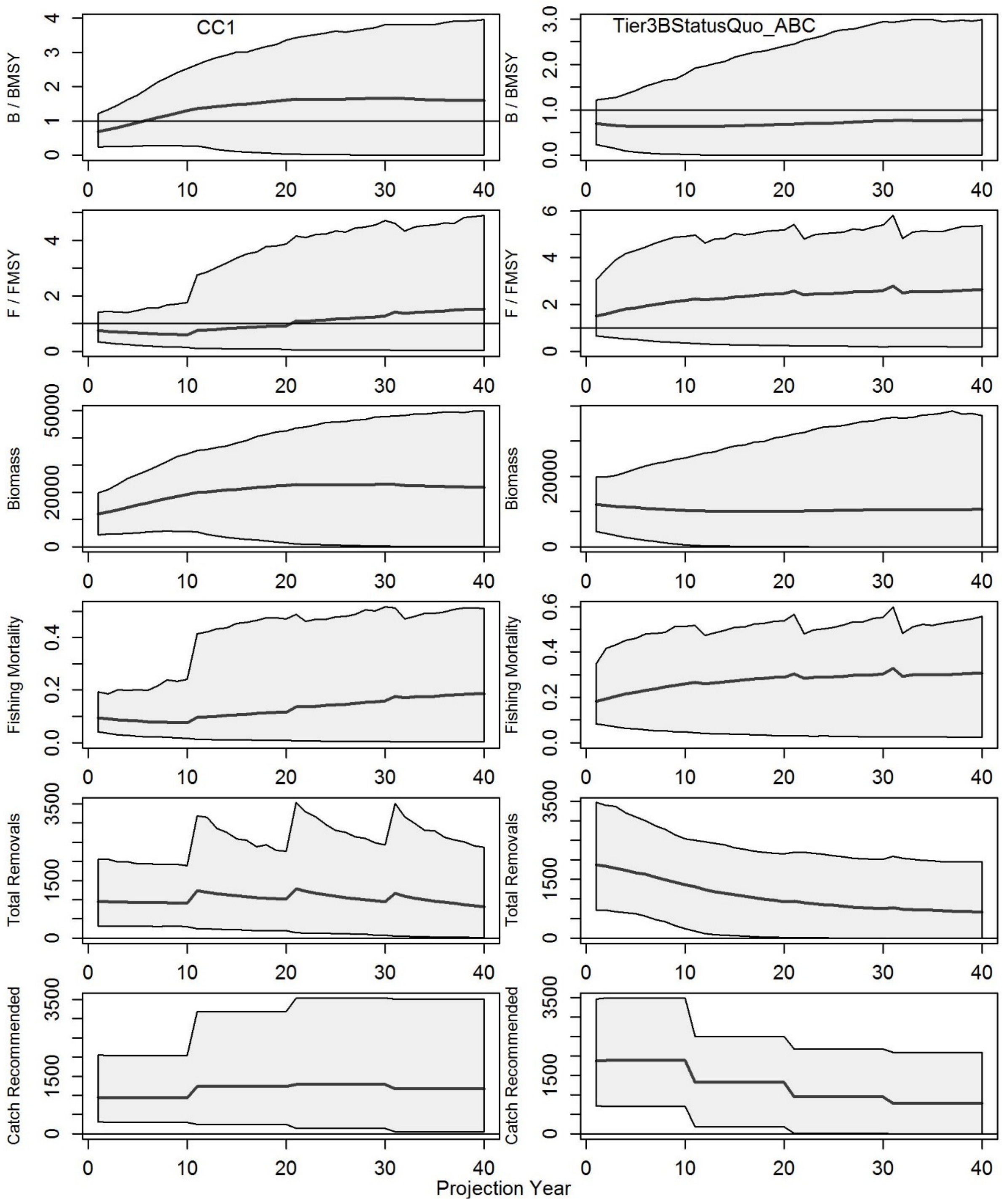


Figure 9.2 Comparison of stock status outputs and catches for Speckled Hind for the 40-year projection period where an assessment is conducted in years 1, 11, 21, and 31. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, total removals (in pounds), and the catch recommendation (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 5th and 95th percentiles.

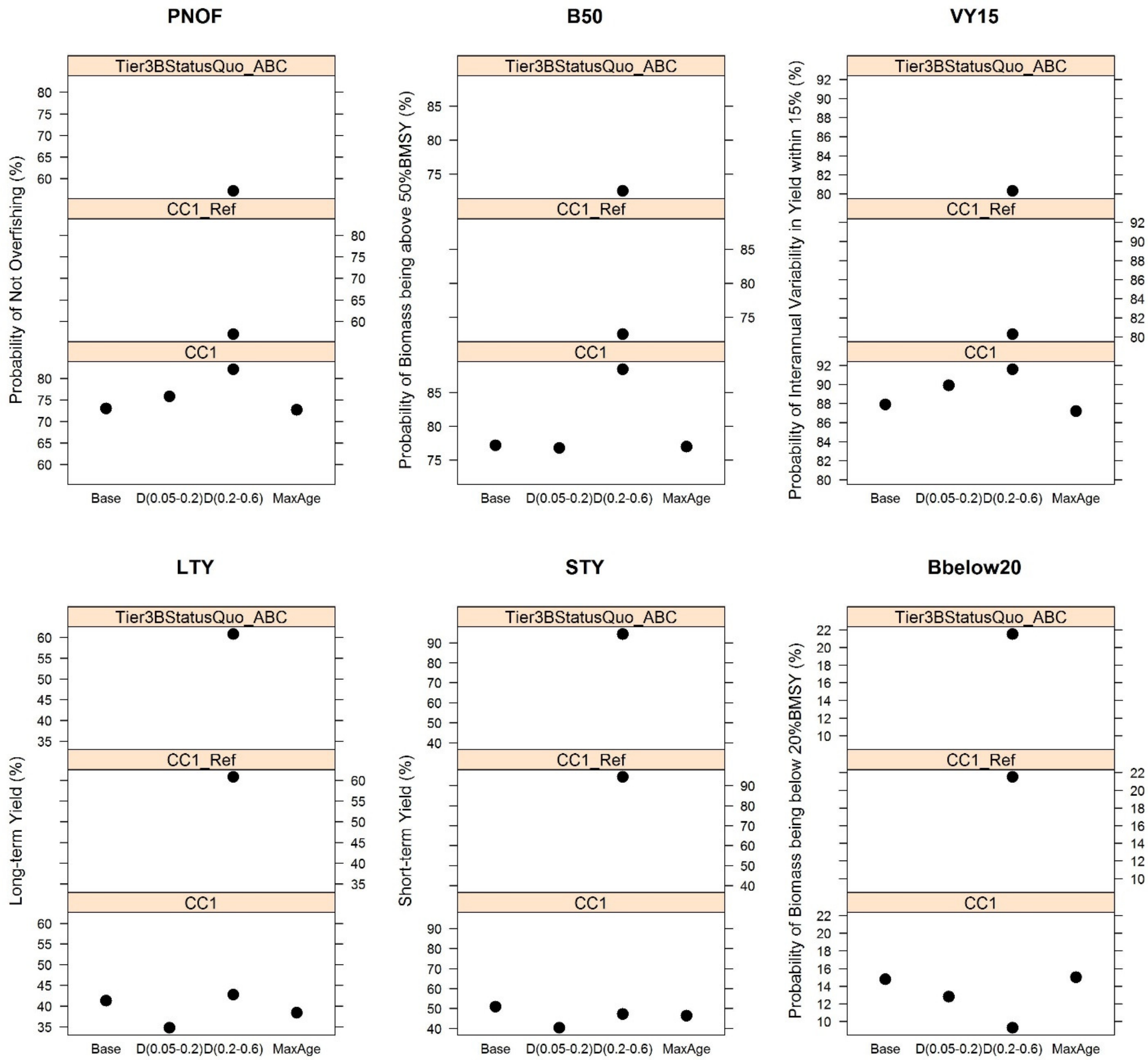


Figure 9.3 Method performance for Speckled Hind assuming the base level of depletion (base; D = 0.05 – 0.3 based on other deep-water grouper), a severely depleted state (D = 0.05 – 0.2), a moderately depleted state (D = 0.2 – 0.6), and a younger maximum age (35 y vs 45 y). Results for the lightly depleted state (D = 0.6 – 0.9) are not shown because the depletion levels could not be reached. The absence of points indicates that the performance metric(s) did not meet the specified criteria (> 50%) for PNOF, B50, and VY15.

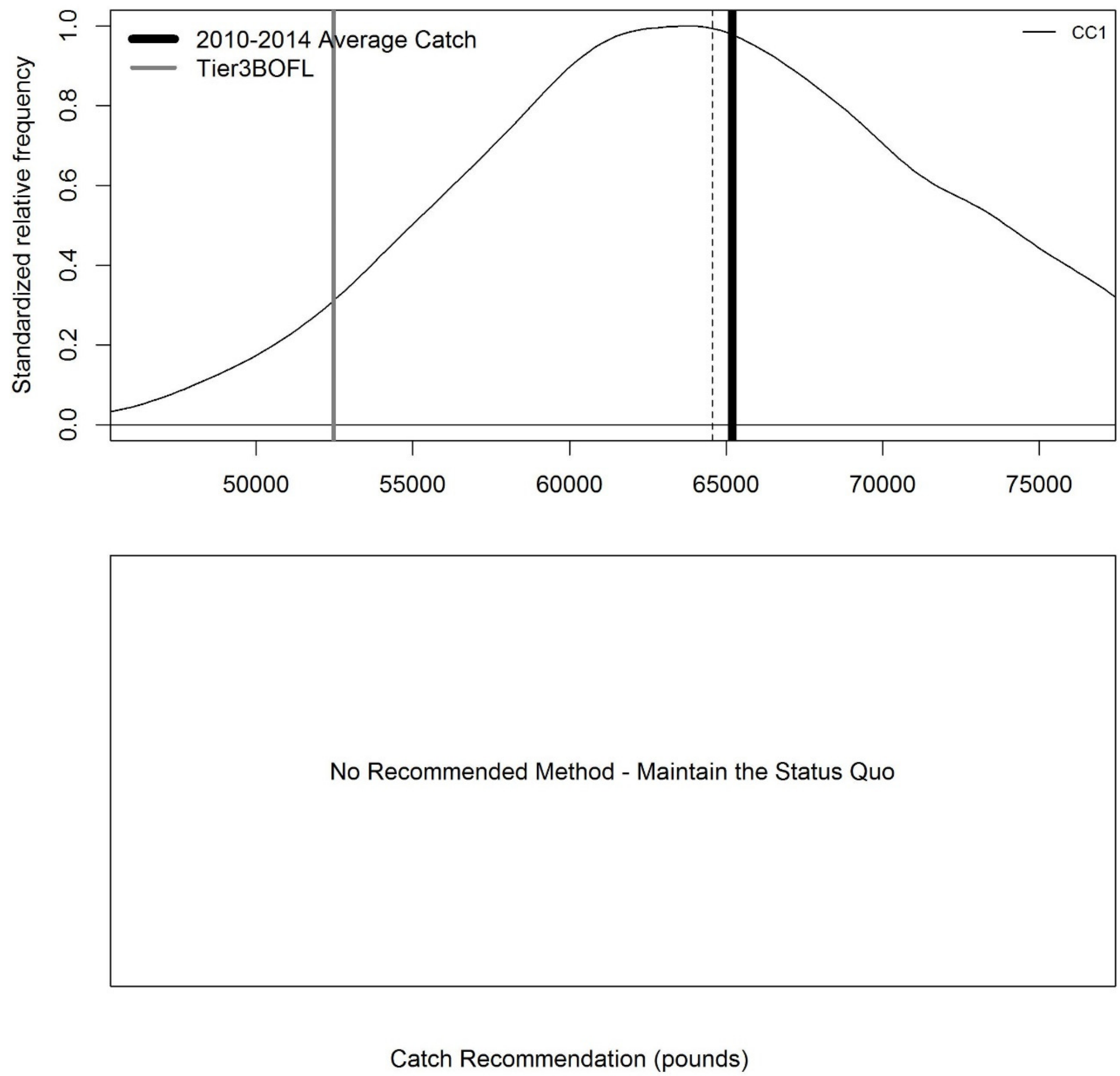


Figure 9.4 Distribution of the catch recommendation (in pounds) for Speckled Hind recommended by the only viable method, CC1 (top panel; dashed vertical line identifies median). The average catch between 2010 and 2014 (thick black line) and the OFL specified by the Tier3BStatusQuo (thick gray line) are included for comparison. Note that no method is recommended (bottom panel) for providing management advice.

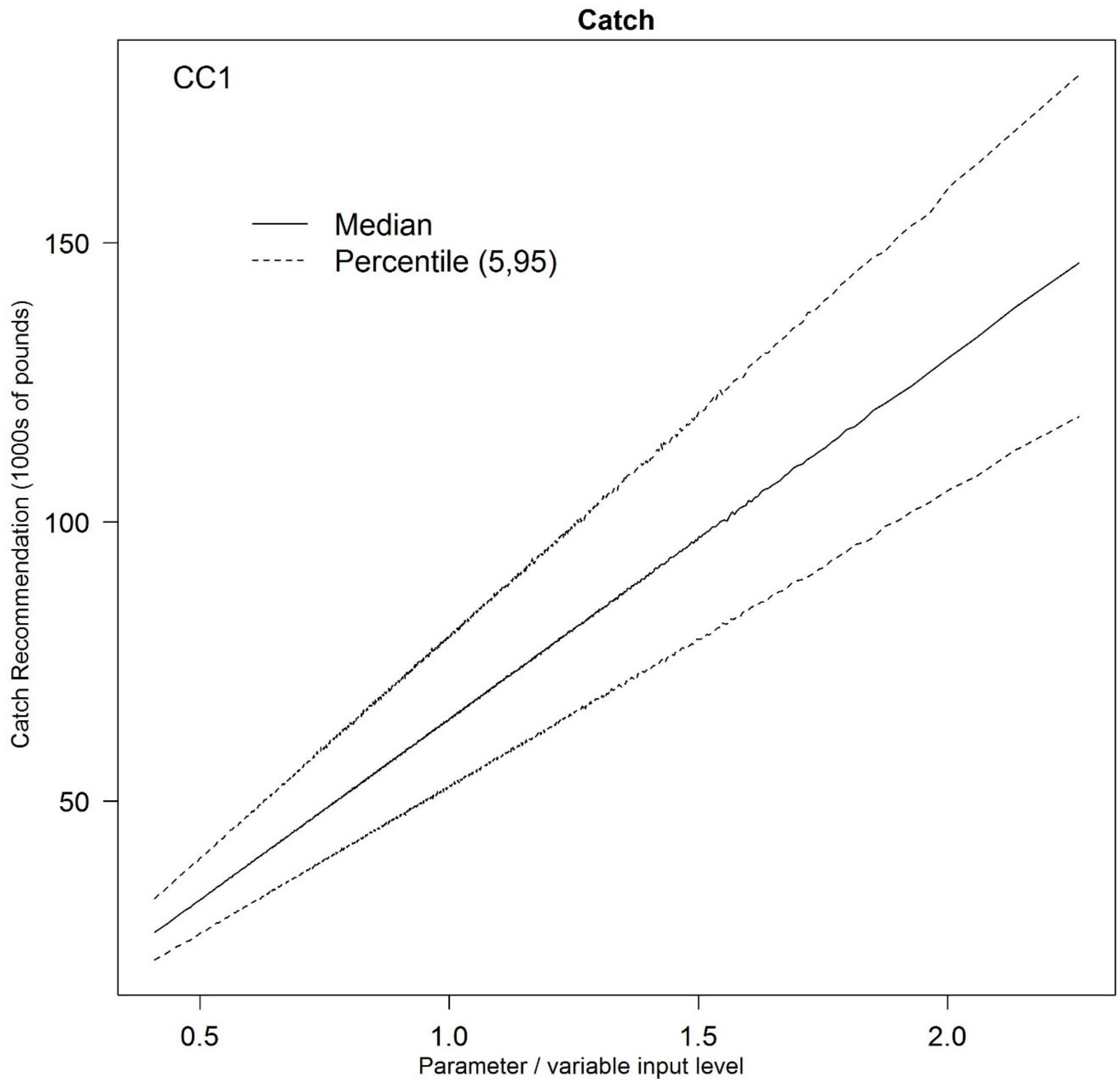


Figure 9.5 Sensitivity of the catch recommendation for Speckled Hind to marginal changes in the required data inputs for CC1 (catch only). Note that ranges for parameter ranges are derived from the CV for each parameter.

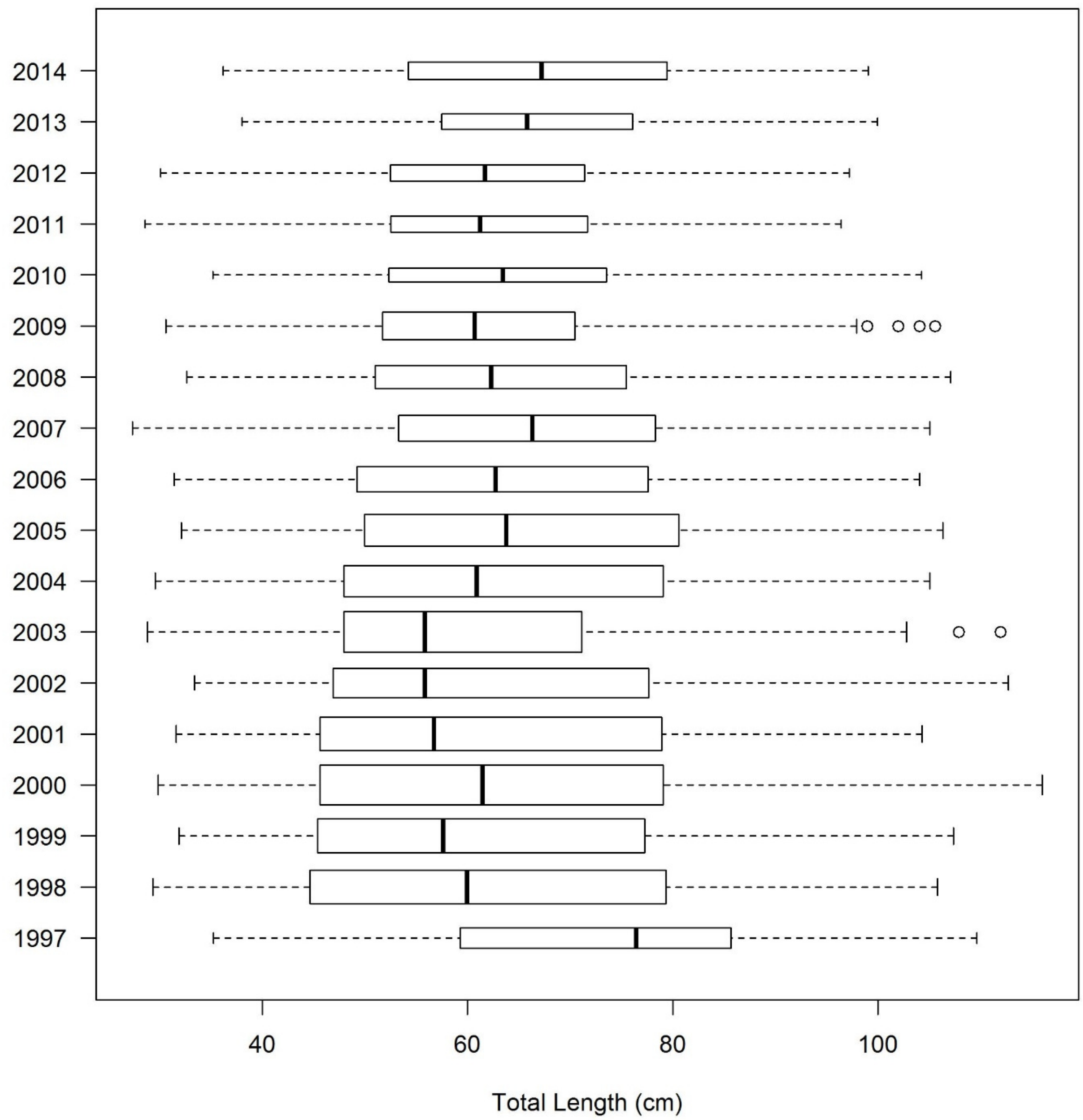


Figure 9.6 Length frequency of Speckled Hind from the commercial longline fishery. The boxplots represent the inter-quartile range, the solid lines represent the medians, the open circles represent outliers, and the box height represents the relative sample size (box height is equal to the square-root of sample size).

10 LESSER AMBERJACK DATA-LIMITED EVALUATION RESULTS

10.1 Data-Limited Methods Toolkit

Four methods were feasible for Lesser Amberjack based on data availability and reliability (Table 10.1). Various issues with data inputs were identified and discussed at the DW and documented in the DW Report (see DW Report Sections 3.5.7, 4.5, 10.3.7). Total removals were scored as fairly reliable due to concerns with misidentification of Lesser Amberjack with other *Seriola* spp. In addition, the index of abundance derived from the SEAMAP video survey received a fair quality score. This index was recommended for analysis with caution because of a low proportion positive of observations (Table 10.2).

10.1.1 Management Strategy Evaluation

Of the four feasible methods, all met the performance criteria for PNOF, B50, and VY15 (Table 10.3). No convergence issues were detected as all performance metrics converged to within 0.05%, with metrics stabilizing around 800 simulations (Figure 10.1). For both CC1_Ref and Islope0, trends in the mean ratios of biomass to biomass at maximum sustainable yield (B/B_{MSY}) and mean ratios of fishing mortality to fishing mortality at maximum sustainable yield (F/F_{MSY}) generally remained above and below the 1.0 threshold, respectively, with the exception of the beginning of the projection period (Figure 10.2). In contrast, the trends for Tier3AStatusQuo_ABC in the mean ratios of F/F_{MSY} remained below or near the 1.0 threshold throughout much of the projection period (Figure 10.2).

Overall, performance metrics were similar between Islope0 and CC1_Ref, with the exception of STY. However, a key advantage of using the Islope0 method is that it includes a feedback mechanism. For example, a positive slope in the index of abundance leads to a higher catch recommendation than simply using the average catch during the reference period (i.e. CC1_Ref).

10.1.2 Sensitivity of method performance to assumptions in the operating model

Different assumptions regarding the plausible range of stock depletion were tested in the MSE:

- A severely depleted state (D = 0.05 – 0.2);
- A moderately depleted state (D = 0.2 – 0.6); and
- A lightly depleted state (D = 0.6 – 0.9).

In the lightly depleted (D = 0.6 – 0.9) state of nature assumed, the operating model could not reach the specified depletion level and therefore was excluded from analysis. Based on different assumed states of nature regarding depletion, the overall recommendations were the same in that CC1_Ref and Islope0 met the performance criteria (Figure 10.3). The Tier3AStatusQuo also met the performance criteria for any assumed depletion range, whereas Itarget0 only met the criteria if a moderately depleted stock (D = 0.6 – 0.9) was assumed (Figure 10.3).

Examination of varying lambda values as scalars (see Table 3.1.3 for equation) on the index of abundance in Islope0 revealed relatively similar trends in performance metrics (within 5.0%) with a larger difference evident in VY15 (12.4%; Table 10.4). Larger lambda values generally result in lower performance metrics with the exception of Bbelow20 which increased slightly.

10.1.3 Calculation of Catch Recommendation

Using Islope0 as the recommended method for reasons discussed in Section 10.1.1, the recommended median catch recommendation is 54,269 pounds (± 11,243 pounds, SD), which is considerably smaller than the Tier3AStatusQuo (Table 10.5). When compared to the average catch between 2005 and 2009, the catch recommendation for Islope0 is higher (Figure 10.4).

10.1.4 Sensitivity of Catch Recommendation

The catch recommendations from both CC1_Ref and Islope0 are sensitive to the magnitude of total removals, with larger removals corresponding to higher catch recommendations (Figure 10.5). For Islope0, the catch recommendation remains relatively similar with changes to the index of abundance (Figure 10.5).

Overall, the recommended CV on the total removals had a minor impact on the median catch recommendation for Islope0 and CC1_Ref, with median catch recommendations (reduction range: 2,900 – 3,200 pounds) slightly lower when a greater CV was assumed (Table 10.6).

The specification of the terminal year, which influenced the portion of the index of abundance included within Islope0, had a large impact on the median catch recommendation (Table 10.7). The recommended catch was nearly half the recommendation when using data through 2014, due to a drastic decline in the slope of the index of abundance (see Figure 2.7).

10.2 Mean Length Estimator

The mean length estimator was not pursued for Lesser Amberjack due to an absence of data on age and growth.

10.3 Tables

Table 10.1 Feasible methods for the DLMtool evaluation for Lesser Amberjack. Data inputs are as defined in Table 3.1.1.

Method	Data Inputs														
	Mort	FMSY_M	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	LFC	LFS	ML	CAA
Catch-based															
CC1_Ref															
Tier3AStatusQuo_ABC															
Indicator (Index-based)															
Islope0															
Itarget0															

Table 10.2 Guidance table for Lesser Amberjack documenting data requirements for each method and reliability scores for data inputs. Colors reflect poor quality (red; 0-33%), fair quality (yellow; 34-67%), and good quality (green; 68-100%), and are based on the information content reliability scores discussed in Section 2.4.

Method	Data Requirements	Reliability Score
CC1_Ref	Total removals: Known and informative for 2000-2008	Fair
Tier3AStatusQuo_ABC	Total removals: Known and informative for 2000-2008	Fair
Islope0	Total removals: Known and informative for 2000-2008	Fair
	Index: SEAMAP video index representative of trend in population abundance (2005-2009; using 2009 as terminal year in base as recommended by Total Removals Working Group)	Fair
Itarget0	Total removals: Known and informative for 2000-2008	Fair
	Index: SEAMAP video index representative of population abundance; uses trend from reference period (2000-2008) and recent period (2005-2009; using 2009 as terminal year in base)	Fair

Table 10.3 Performance metrics for methods meeting performance criteria for Lesser Amberjack. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing; B50 = Probability of the biomass being above 50% B_{MSY}; VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY}. Note that performance for Bbelow20 is reversed, where a low probability is preferable.

Method	PNOF	B50	VY15	LTY	STY	Bbelow20
Tier3AStatusQuo_ABC	52.4	59.4	67.3	56.2	72.2	21.0
CC1_Ref	76.5	78.8	88.7	47.3	53.0	9.8
Islope0	61.3	64.0	84.0	42.8	67.5	20.3

Table 10.4 Comparison of model performance for different configurations of Islope0 by varying the lambda scalar on the index of abundance, with the default value highlighted in bold. Performance metrics are as defined in Table 10.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Lambda	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	0.1	61.8	64.5	82.8	39.0	65.1	21.0
	0.2	61.6	64.3	82.5	39.2	64.7	21.2
	0.3	61.5	64.3	81.7	39.5	64.9	21.2
	0.4	61.2	64.1	81.7	40.2	64.5	21.2
	0.5	60.9	63.9	81.5	40.2	65.2	21.4
	0.6	60.7	63.4	80.7	40.2	64.2	21.5
	0.7	60.8	63.9	79.8	41.7	64.3	21.5
	0.8	60.1	63.2	78.7	40.9	64.5	21.5
	0.9	60.1	63.2	78.1	41.0	64.7	21.6
	1.0	59.9	63.0	78.7	41.3	64.5	21.5
	1.1	59.7	63.0	77.0	40.6	64.7	21.4
	1.2	59.0	62.5	77.7	40.6	63.4	21.5
	1.3	59.1	62.2	76.2	40.5	64.2	21.6
	1.4	58.6	62.2	76.1	41.3	63.5	22.0
	1.5	58.6	62.1	74.8	40.2	65.1	22.1
	1.6	57.9	61.7	73.6	42.0	63.0	21.9
	1.7	57.8	61.4	72.7	40.8	63.1	21.5
	1.8	56.8	60.7	72.2	41.4	63.3	22.2
	1.9	56.8	60.5	70.4	38.3	63.0	22.3
	2.0	56.8	60.6	71.8	39.8	63.0	22.2
	Minimum	56.8	60.5	70.4	38.3	63.0	21.0
	Maximum	61.8	64.5	82.8	42.0	65.2	22.3
	Difference	5.0	4.0	12.4	3.7	2.2	1.3

Table 10.5 Summary statistics of the catch recommendation (in pounds) for each viable method for Lesser Amberjack and an equally weighted joint distribution of Islope0 and CC1_Ref in comparison to the Tier3AStatusQuo (i.e. current OFL). Recommended method is highlighted in bold.

Method	25%	40%	50%	75%	Mean	SD	CV
Tier3AStatusQuo	114,825	114,825	114,825	114,825	114,825	0	0
Islope0	**47,563**	**51,632**	**54,269**	**62,215**	**55,442**	**11,243**	**0.203**
CC1_Ref	47,624	51,923	54,750	62,416	55,685	11,262	0.202
Joint Distribution (Islope0, CC1_Ref, Equal weight)	47,583	51,769	54,506	62,344	55,564	11,253	0.203

Table 10.6 Sensitivity of catch recommendations for Lesser Amberjack to the CV specified for total removals (Cat CV) required for both CC1_Ref and Islope0. Statistics reported for the catch recommendation include the 25th, 40th, 50th, and 75th percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV).

Method	Cat CV	25%	40%	50%	75%	Mean	SD	CV
Islope0	0.45	47,563	51,632	54,269	62,215	55,442	11,243	0.203
	0.90	39,560	46,645	51,342	66,451	55,064	21,374	0.388
CC1_Ref	0.45	47,624	51,923	54,750	62,416	55,685	11,262	0.202
	0.90	39,769	46,740	51,559	66,527	55,142	21,571	0.391

Table 10.7 Sensitivity of catch recommendations for Lesser Amberjack to the terminal year selected for assessment. Statistics reported for the catch recommendation include the 25th, 40th, 50th, and 75th percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV). Note that the terminal year influences the portion of the index of abundance used in Islope0.

Method	Terminal Year	25%	40%	50%	75%	Mean	SD	CV
Islope0	2009	47,563	51,632	54,269	62,215	55,442	11,243	0.203
	2014	24,263	26,428	27,855	31,857	28,420	5,769	0.203

10.4 Figures

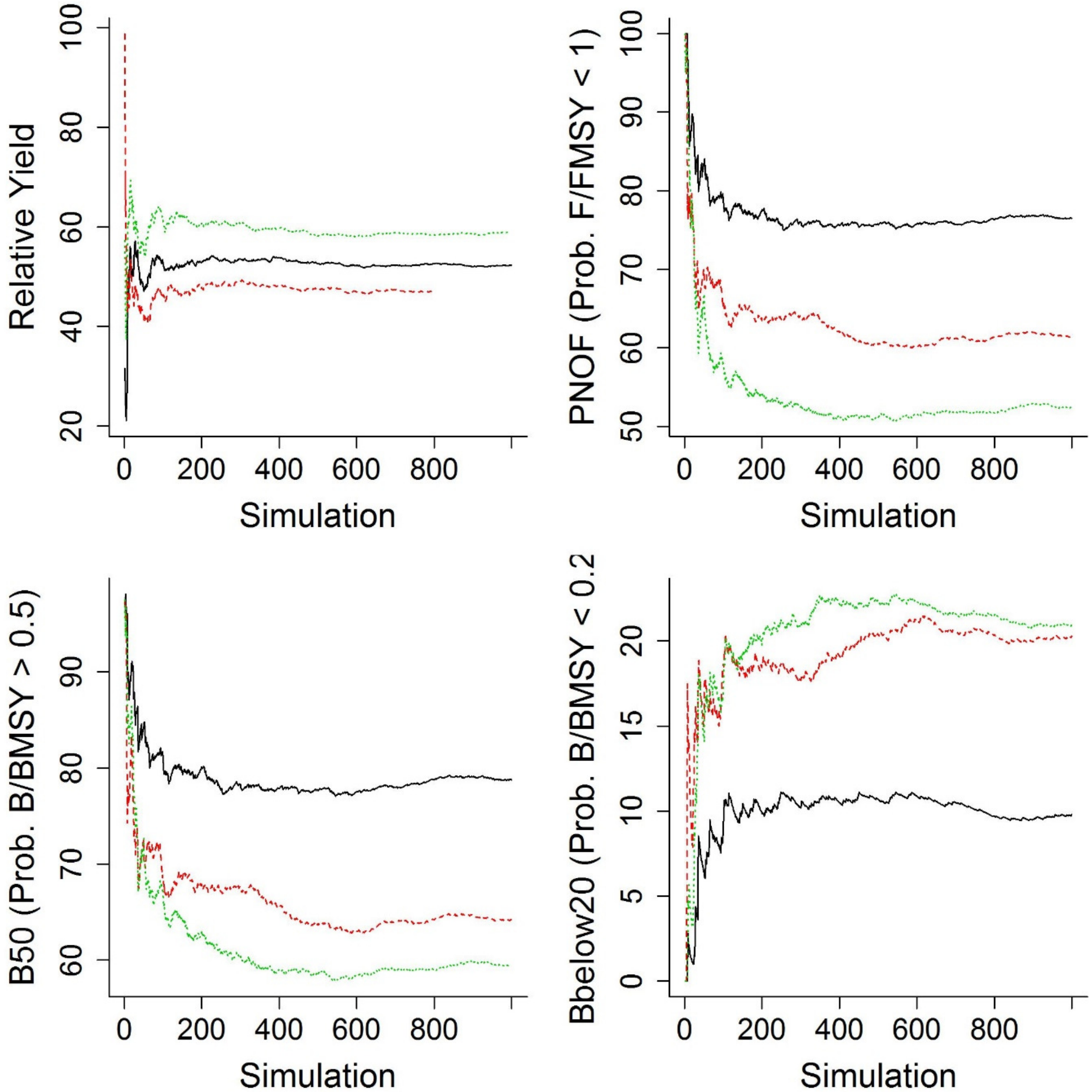


Figure 10.1 Convergence plot confirming that performance criteria for each viable method converged to within 0.05%, indicating that the number of simulations was sufficient for Lesser Amberjack. Each colored line identifies the following methods: Islope0 (red), CC1_Ref (black) and Tier3AStatusQuo_ABC (green). Relative yield corresponds to the LTY divided by the reference yield, which is the highest mean yield over the last five years of the projection period that can be obtained from a fixed *F* strategy.

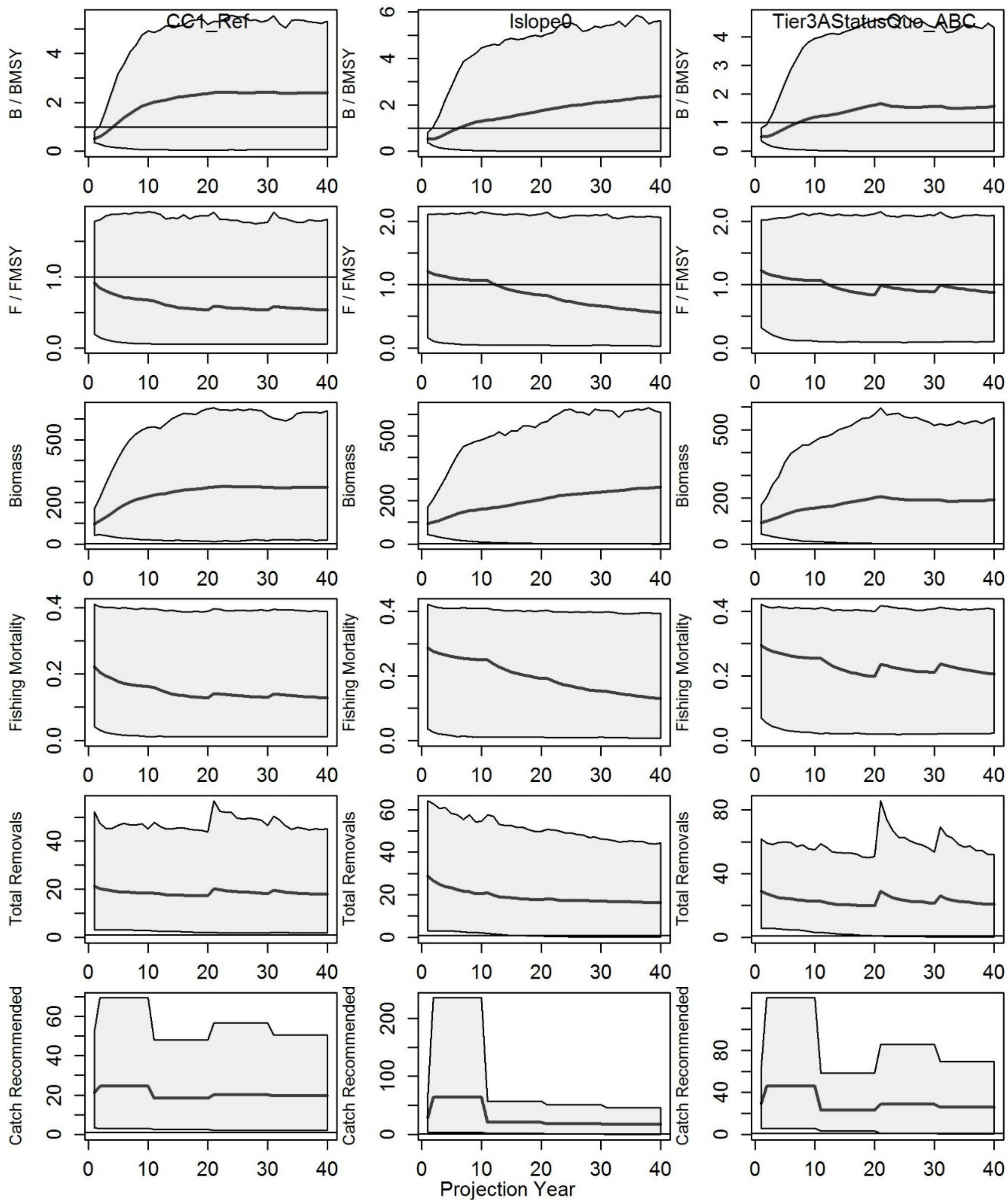


Figure 10.2 Comparison of stock status outputs and catches for Lesser Amberjack for the 40-year projection period where an assessment is conducted in years 1, 11, 21, and 31. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, total removals (in pounds), and the catch recommendation (in pounds) for each viable method. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 5th and 95th percentiles.

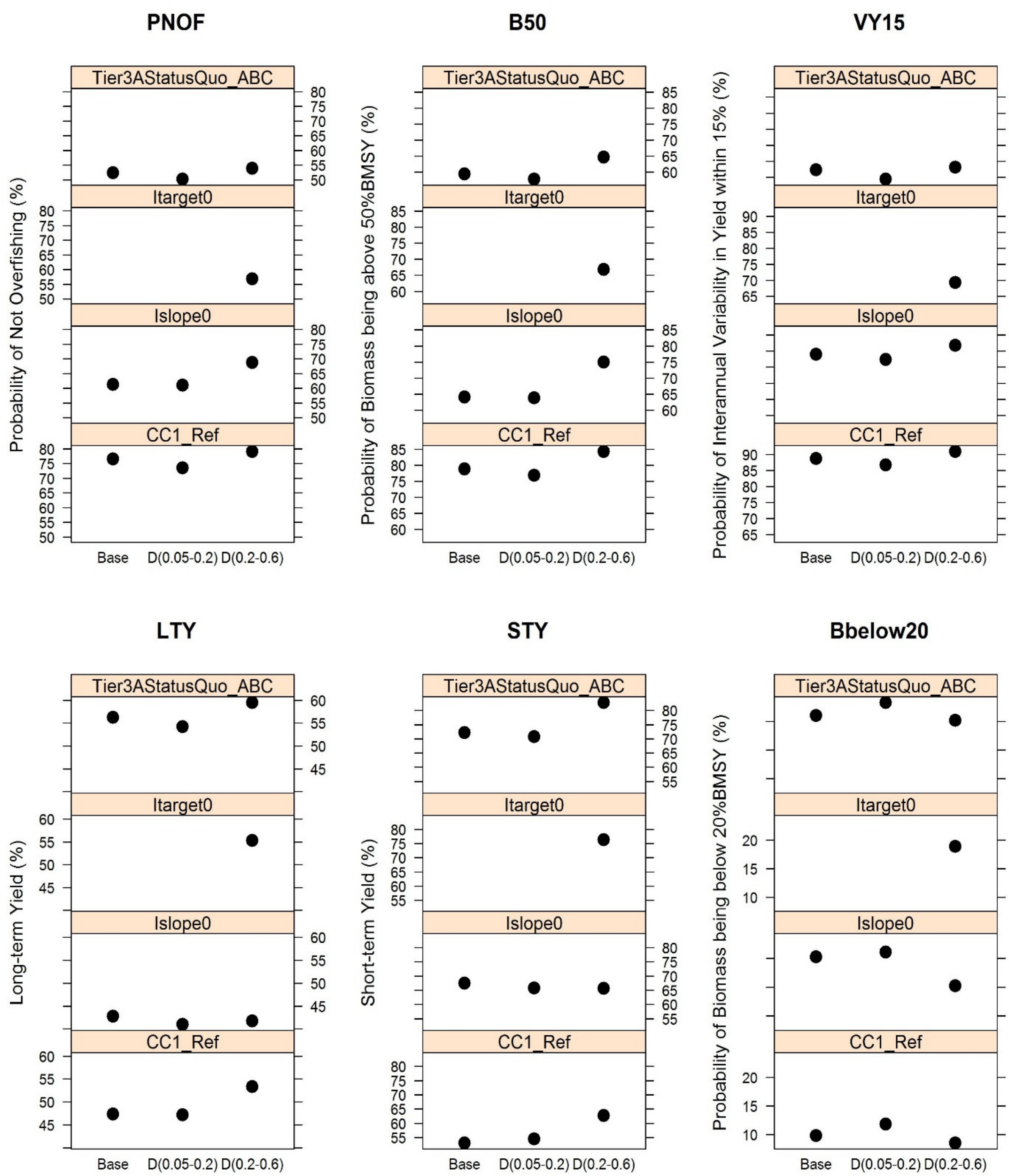
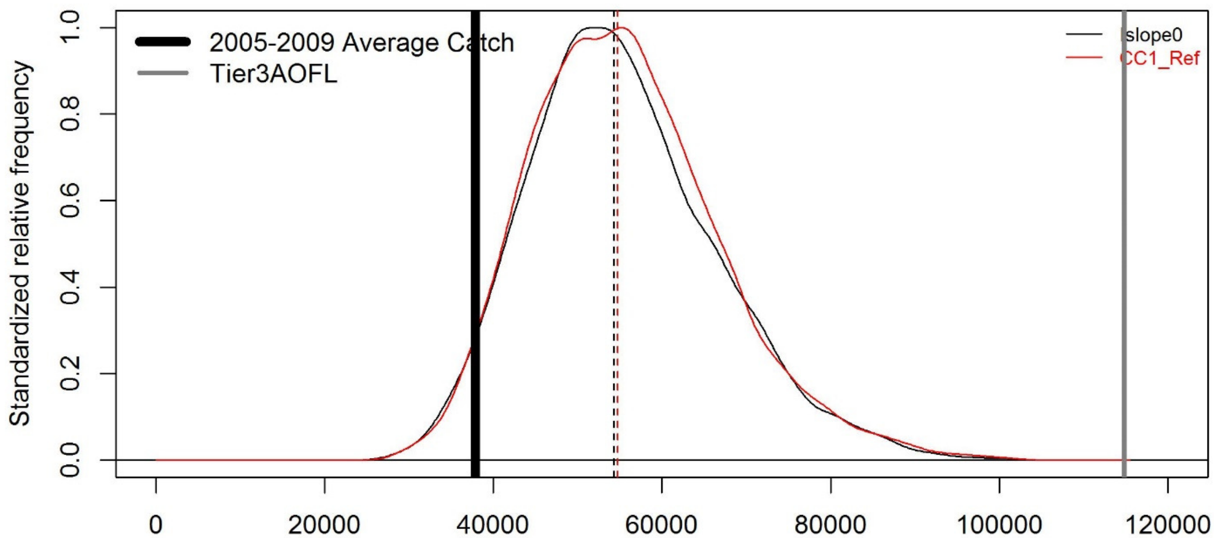


Figure 10.3 Method performance for Lesser Amberjack assuming the base level of depletion (base; D = 0.10 – 0.13 based on recent depletion estimated for Greater Amberjack), a severely depleted state (D = 0.05 – 0.2), and a moderately depleted state (D = 0.2 – 0.6). Results for the lightly depleted state (D = 0.6 – 0.9) are not shown because the depletion levels could not be reached. The absence of points indicates that the performance metric(s) did not meet the specified criteria (> 50%) for PNOF, B50, and VY15.



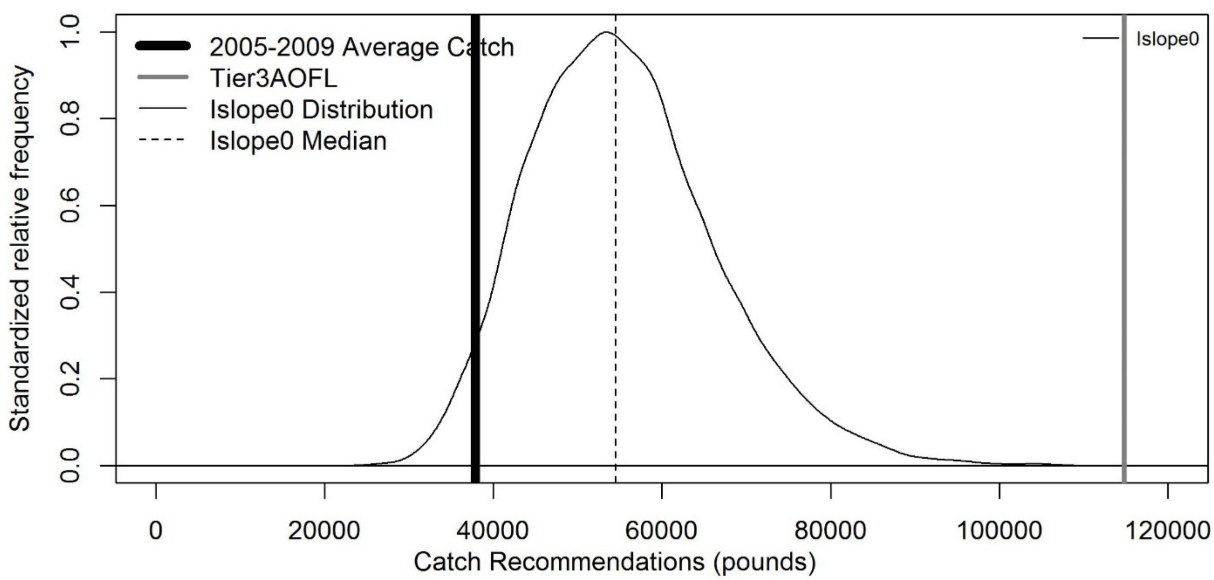


Figure 10.4 Distribution of the catch recommendation (in pounds) for Lesser Amberjack recommended for each viable method, Islope0 and CC1_Ref (top panel; dashed vertical lines identify medians). The average catch in 2005-2009 (thick black line) and the OFL specified by the Tier3AStatusQuo (thick gray line) are included for comparison. The Islope0 distribution (bottom panel) is recommended for providing management advice.

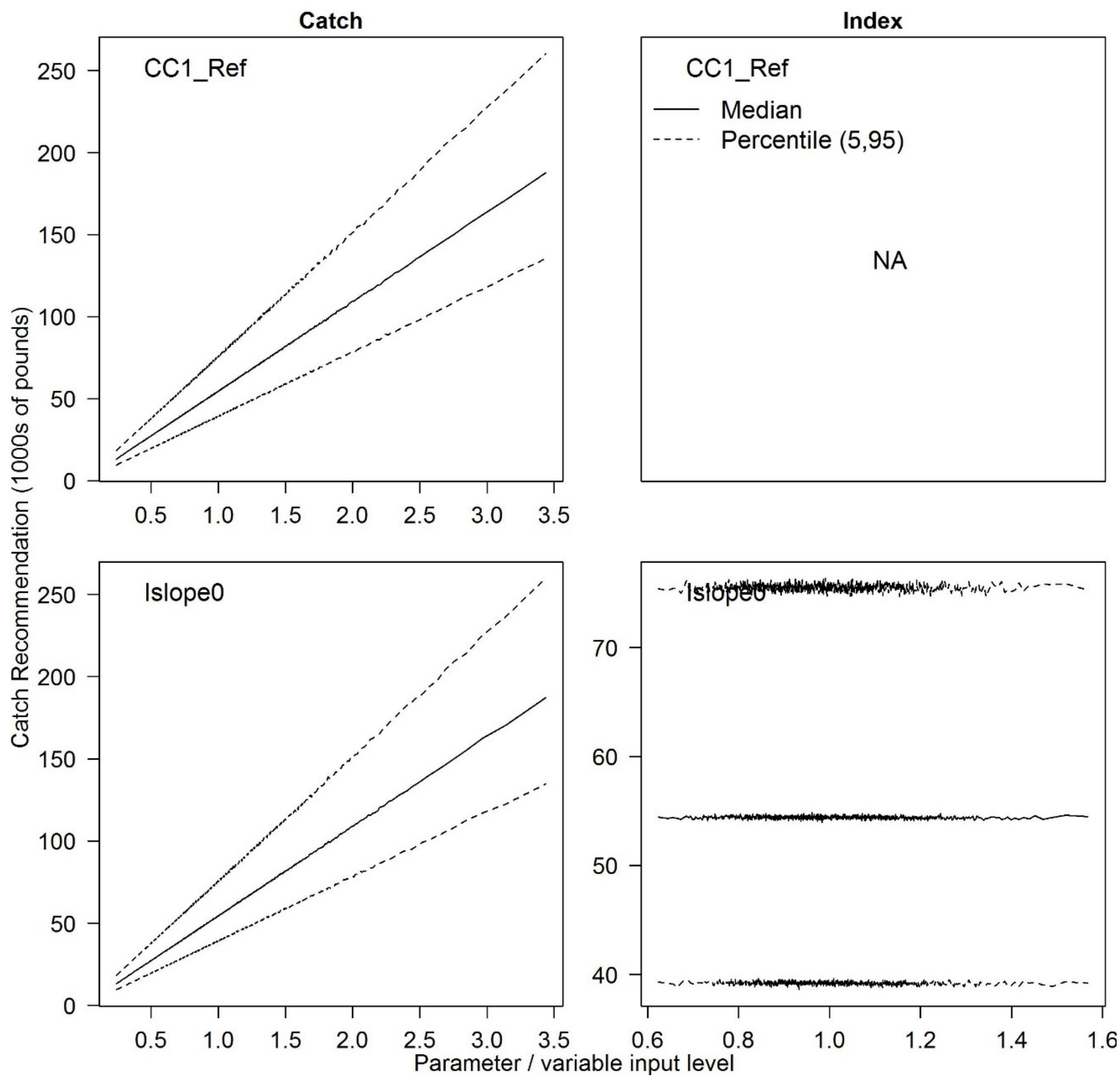


Figure 10.5 Sensitivity of the catch recommendations for Lesser Amberjack to marginal changes in the required data inputs for CC1_Ref (catch only) and Islope0 (catch and index of abundance). Note that ranges for parameter ranges are derived from the CV for each parameter. NA indicates that the data input is not required.

11 ALMACO JACK DATA-LIMITED EVALUATION RESULTS

11.1 Data-Limited Methods Toolkit

Six methods were feasible for Almaco Jack based on data availability and reliability (Table 11.1). Various issues with data inputs were identified and discussed at the DW and documented in the DW Report (see DW Report Sections 3.5.8, 4.5, 10.3.8). Although concerns with misidentification of Almaco Jack with other *Seriola* spp. were raised, total removals were scored as highly reliable (Table 11.2). The index of abundance derived from the SEAMAP video survey received a good quality score and was recommended for analysis because of a higher proportion positive of observations (Table 11.2). Length samples were available from the recreational charterboat, private and headboat fishing modes, but were scored as fair due to low sample sizes.

11.1.1 Management Strategy Evaluation

Of the six feasible methods, only Islope0 and LstepCC0 met the performance criteria for PNOF, B50, and VY15 (Table 11.3). No convergence issues were detected as all performance metrics converged to within 0.05%, with metrics stabilizing around 400 simulations (Figure 11.1). When trends over the 40 year projection period were examined, the Tier3AStatusQuo_ABC method consistently resulted in mean ratios of biomass to biomass at maximum sustainable yield (B/B_{MSY}) below the 1.0 threshold and fishing mortality to fishing mortality at maximum sustainable yield (F/F_{MSY}) above the 1.0 threshold (Figure 11.2). In contrast, mean B/B_{MSY} ratios across simulations remained above 1.0 for both Islope0 and LstepCC0, with the exception of the beginning of the projection period, and mean F/F_{MSY} ratios remained at or below the threshold of 1.0 (Figure 11.2).

Performance metrics were relatively similar and therefore both Islope0 and LstepCC0 were recommended for providing catch recommendations for management advice. Based on the qualitative scoring of reliability, where the index of abundance received a higher score than the length composition, the decision to weight Islope0 higher than LstepCC0 was supported by the AW Panel.

11.1.2 Sensitivity of method performance to assumptions in the operating model

Different assumptions regarding the plausible range of stock depletion were assumed in the MSE:

- A severely depleted state (D = 0.05 – 0.2);
- A moderately depleted state (D = 0.2 – 0.6); and
- A lightly depleted state (D = 0.6 – 0.9).

In the lightly depleted state (D = 0.6 – 0.9) of nature assumed, the operating model could not reach the specified depletion level and therefore was excluded from analyses. Regardless of the depletion assumptions tested, the overall recommendations regarding viable methods were the same in that both Islope0 and LstepCC0 met the performance criteria (Figure 11.3). Intuitively, performance metrics were higher when assuming a less depleted stock (D = 0.2 – 0.6) than when assuming a severely depleted stock (D = 0.05 – 0.2) for all methods. The Itarget0 and CC1_Ref methods met the performance metrics if a moderately depleted range (D = 0.2 – 0.6) was assumed (Figure 11.3). The Tier3AStatusQuo did not meet the performance metrics for any assumed depletion range.

Examination of varying lambda values as scalars (see Table 3.1.3 for equation) on the index of abundance in Islope0 revealed relatively similar values in performance metrics (within 3.8%) with the largest difference evident in LTY (4.3%; Table 11.4). Larger lambda values result in marginally lower performance metrics with the exception of Bbelow20 which increased slightly.

Examination of varying mean length threshold values in LstepCC0 revealed relatively similar values in performance metrics (within 2.2%) with the largest difference evident in PNOF (2.5%; Table 11.5). Smaller thresholds resulted in marginally lower PNOF, B50, and VY15 but higher LTY and STY.

11.1.3 Calculation of Catch Recommendation

Assuming that Islope0 is twice as reliable as LstepCC0, the recommended median catch recommendation is 118,451 pounds (± 12,084 pounds, SD), which is below the Tier3AStatusQuo (Table 11.6). When compared to the average catch between 2010 and 2014, the catch recommendation for the weighted joint distribution is lower (Figure 11.4). Given the difficulty in quantifying the difference in data input reliability (i.e. how to justify 2X more reliable), the recommended median catch assuming equal weighting between Islope0 and LstepCC0 is very similar (119,328 ±12,173 pounds, SD).

11.1.4 Sensitivity of Catch Recommendations

The catch recommendations from all methods are sensitive to the magnitude of total removals, with larger removals corresponding to higher catch recommendations (Figure 11.5). For Islope0, the catch recommendation remains relatively similar with changes to the index of abundance (Figure 11.5).

Overall, the CV on total removals had a minor impact on the median catch recommendation for both Islope0 and LstepCC0, with a lower catch recommendation (reduction range: 1,500 – 2,200 pounds) obtained if the CV is larger than observed (i.e. doubled) (Table 11.7).

11.2 Mean Length Estimator

The mean length estimator was not pursued for Almaco Jack due to an absence of data on age and growth.

11.3 Tables

Table 11.1 Feasible methods for the DLMtool evaluation for Almaco Jack. Data inputs are as defined in Table 3.1.1.

Method	Data Inputs														
	Mort	FMSY_M	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	LFC	LFS	ML	CAA
Catch-based															
CC1_Ref															
Tier3AStatusQuo_ABC															
Indicator (Index-based)															
Islope0															
Itarget0															
Indicator (Length-based)															
Ltarget0															
LstepCC0															

Table 11.2 Guidance table for Almaco Jack documenting data requirements for each method and reliability scores for data inputs. Colors reflect poor quality (red; 0-33%), fair quality (yellow; 34-67%), and good quality (green; 68-100%), and are based on the information content reliability scores discussed in Section 2.4.

Method	Data Requirement	Reliability Score
CC1_Ref	Total removals: Known and informative for 2000-2008	Good
Tier3AStatusQuo_ABC	Total removals: Known and informative for 2000-2008	Good
Islope0	Total removals: Known and informative for 2000-2008	Good
	Index: SEAMAP Video index representative of trend in population abundance (2010-2014)	Good
Itarget0	Total removals: Known and informative for 2000-2008	Good
	Index: SEAMAP Video index representative of population abundance; uses trend from reference period (2000-2008) and trend from recent period (2010-2014)	Good
LstepCC0 / Ltarget0	Total removals: Known and informative for 2000-2008	Good
	Mean Length: Mean length of catch from recreational private, headboat, and charterboat fishing modes an indirect and informative indicator of the trend in resource abundance; uses mean length over reference period	Fair

(2000-2008) and over recent period (2010-2014)

Table 11.3 Performance metrics for methods meeting performance criteria for Almaco Jack. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing; B50 = Probability of the biomass being above 50% B_{MSY}; VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY}. Note that performance for Bbelow20 is reversed, where a low probability is preferable.

Method	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	69.9	73.7	85.8	44.2	67.6	19.2
LstepCC0	69.7	73.7	85.3	41.8	67.9	19.4
Tier3AStatusQuo_ABC	16.6	24.5	34.2	32.0	93.0	62.0

Table 11.4 Comparison of model performance for different configurations of Islope0 by varying the lambda scalar on the index of abundance, with the default value highlighted in bold. Performance metrics are as defined in Table 11.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Lambda	PNOF	B50	VY15	LTY	STY	Bbelow20
Islope0	0.1	67.8	71.9	85.2	43.6	70.8	21.1
	0.2	67.9	71.9	85.5	43.4	70.9	21.1
	0.3	67.8	71.9	85.1	44.0	71.3	21.1
	0.4	67.6	71.8	85.3	44.3	70.4	21.1
	0.5	67.4	71.8	85.2	43.6	70.2	21.1
	0.6	67.4	71.7	85.1	43.4	70.5	21.2
	0.7	67.6	72.1	84.9	43.7	71.3	21.0
	0.8	67.0	71.6	84.8	43.3	71.1	21.2
	0.9	67.5	72.0	85.0	43.2	71.0	20.9
	1.0	67.0	71.8	85.3	43.7	70.6	21.2
	1.1	66.5	71.3	84.5	44.1	71.0	21.3
	1.2	66.7	71.4	84.2	43.0	70.1	21.5
	1.3	66.3	71.3	84.3	42.6	70.2	21.4
	1.4	66.0	71.1	83.9	42.0	70.5	21.6
	1.5	65.9	70.9	83.3	42.7	70.5	21.7
	1.6	66.3	71.3	83.1	40.0	70.5	21.4
	1.7	66.5	71.4	82.6	40.2	69.7	21.2
	1.8	66.2	70.9	82.4	41.3	70.0	21.9
	1.9	65.3	70.4	81.8	41.6	69.7	21.9
	2.0	65.7	70.8	81.7	41.8	68.9	21.7
	Minimum	65.3	70.4	81.7	40.0	68.9	20.9

Maximum	67.9	72.1	85.5	44.3	71.3	21.9
Difference	2.6	1.7	3.8	4.3	2.4	1.0

Table 11.5 Comparison of model performance for different configurations of LstepCC0 by varying the mean length ratio limits (3 values), with the default values highlighted in bold. Performance metrics are as defined in Table 11.3. Note that a gradation color scheme (for PNOF across to STY: low [red] to high [green]; for Bbelow20: low [green] to high [red]) is used to highlight differences between metrics. Specifics on the equation and scalars are provided in Table 3.1.3.

Method	Threshold Lower	Threshold Middle	Threshold Upper	PNOF	B50	VY15	LTY	STY	Bbelow20
LstepCC0	0.92	0.96	1.00	66.5	71.0	84.8	45.0	71.5	21.7
	0.92	0.96	1.05	67.6	71.9	85.2	44.7	70.6	20.9
	0.92	0.96	1.10	68.3	72.5	85.2	44.6	70.0	20.5
	0.92	0.98	1.00	66.7	71.1	84.8	45.0	71.3	21.6
	0.92	0.98	1.05	67.8	72.1	85.2	44.2	70.4	20.8
	0.92	0.98	1.10	68.4	72.7	85.2	44.1	69.8	20.4
	0.92	1.00	1.05	68.0	72.3	85.2	43.7	70.3	20.7
	0.92	1.00	1.10	68.7	72.8	85.3	42.9	69.6	20.3
	0.94	0.96	1.00	66.6	71.1	84.8	44.5	71.5	21.7
	0.94	0.96	1.05	67.8	72.1	85.2	44.6	70.6	20.8
	0.94	0.96	1.10	68.4	72.6	85.2	44.5	70.0	20.4
	0.94	0.98	1.00	66.8	71.2	84.8	44.5	71.3	21.6
	0.94	0.98	1.05	67.9	72.2	85.2	44.1	70.4	20.7
	0.94	0.98	1.10	68.6	72.8	85.2	44.0	69.8	20.3
	0.94	1.00	1.05	68.2	72.4	85.2	43.6	70.3	20.6
	0.94	1.00	1.10	68.8	73.0	85.3	42.8	69.6	20.2
	0.96	0.98	1.00	66.9	71.3	84.8	44.5	71.2	21.5
	0.96	**0.98**	**1.05**	68.0	72.3	85.2	44.2	70.3	20.6
	0.96	0.98	1.10	68.7	72.9	85.2	44.0	69.7	20.2
	0.96	1.00	1.05	68.3	72.5	85.2	43.6	70.2	20.5
	0.96	1.00	1.10	69.0	73.1	85.3	42.8	69.5	20.1
			Minimum	66.5	71.0	84.8	42.8	69.5	20.1
			Maximum	69.0	73.1	85.3	45.0	71.5	21.7
			Difference	2.5	2.1	0.5	2.2	2.0	1.6

Table 11.6 Summary statistics of the recommended catch for each viable method for Almaco Jack, an equally weighted joint distribution of both methods, and a joint distribution reflecting a higher weight on the index-based method due to better data quality. The Tier3AStatusQuo (i.e. current OFL) is included for comparison. The weighted joint distribution is recommended and highlighted in bold.

Method	25%	40%	50%	75%	Mean	SD	CV
Tier3AStatusQuo	151,514	151,514	151,514	151,514	151,514	0	0
Islope0	109,488	114,063	116,896	125,067	117,517	11,740	0.1
LstepCC0	113,837	118,785	121,930	130,062	122,338	12,121	0.099
Joint Distribution (equal weight)	111,478	116,269	119,328	127,890	119,928	12,173	0.102
Joint Distribution (2X weight to Islope0)	**110,804**	**115,546**	**118,451**	**126,986**	**119,124**	**12,084**	**0.101**

Table 11.7 Sensitivity of catch recommendations for Almaco Jack to the CV specified for the total removals (Cat CV) required for both methods. Statistics reported for the catch recommendation include the 25th, 40th, 50th, and 75th percentiles, the mean, standard deviation (SD), and the coefficient of variation (CV).

Method	Cat CV	25%	40%	50%	75%	Mean	SD	CV
Islope0	0.22	109,488	114,063	116,896	125,067	117,517	11,740	0.100
	0.44	100,860	109,872	115,421	131,125	117,401	23,134	0.197
LstepCC0	0.22	113,837	118,785	121,930	130,062	122,338	12,121	0.099
	0.44	105,393	114,414	119,776	136,631	122,224	23,824	0.195

11.4 Figures

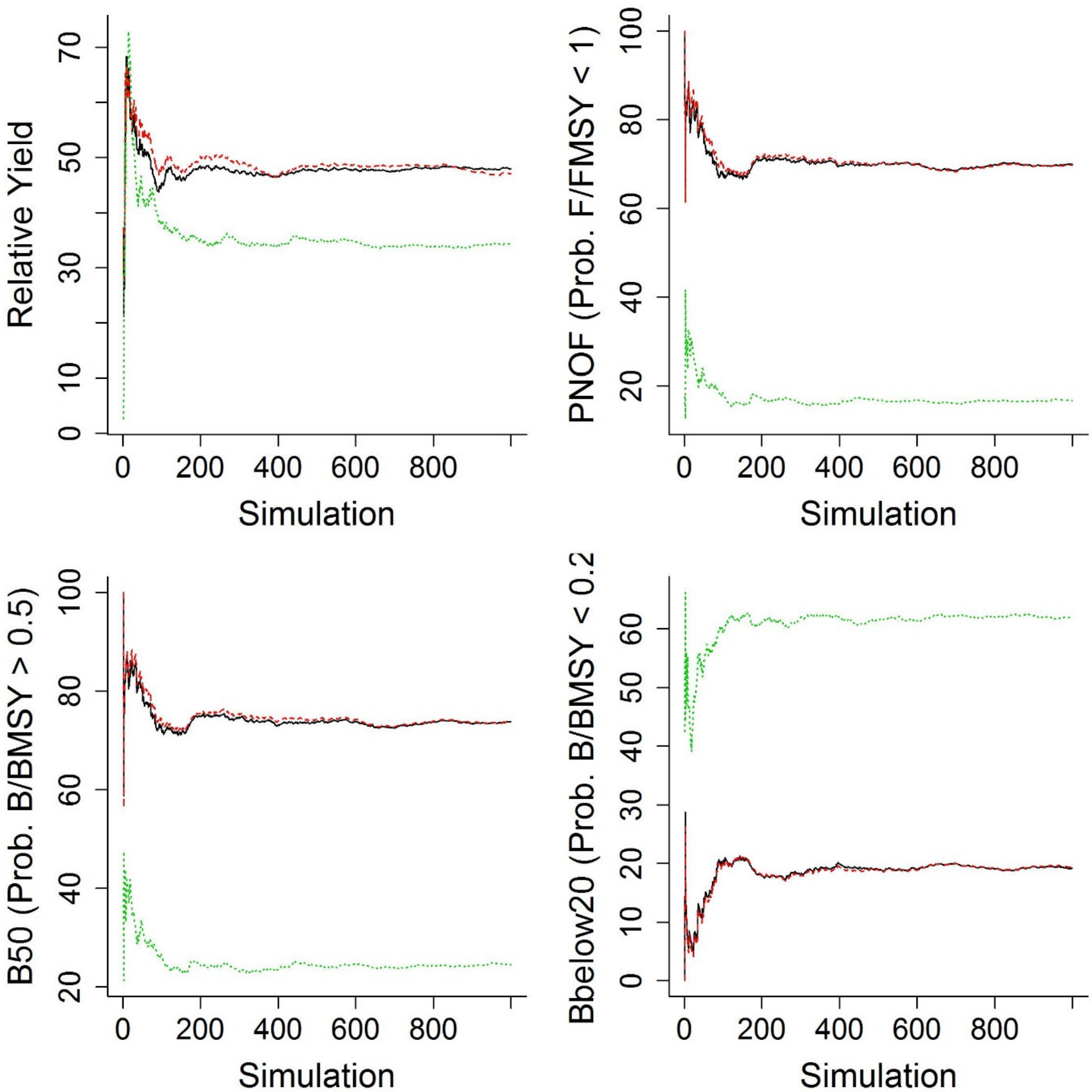


Figure 11.1 Convergence plot confirming that performance criteria for each viable method converged to within 0.05%, indicating that the number of simulations was sufficient for Almaco Jack. Each colored line identifies the following methods: Islope0 (black), LstepCC0 (red), and Tier3AStatusQuo_ABC (green). Relative yield corresponds to the LTY divided by the reference yield, which is the highest mean yield over the last five years of the projection period that can be obtained from a fixed *F* strategy.

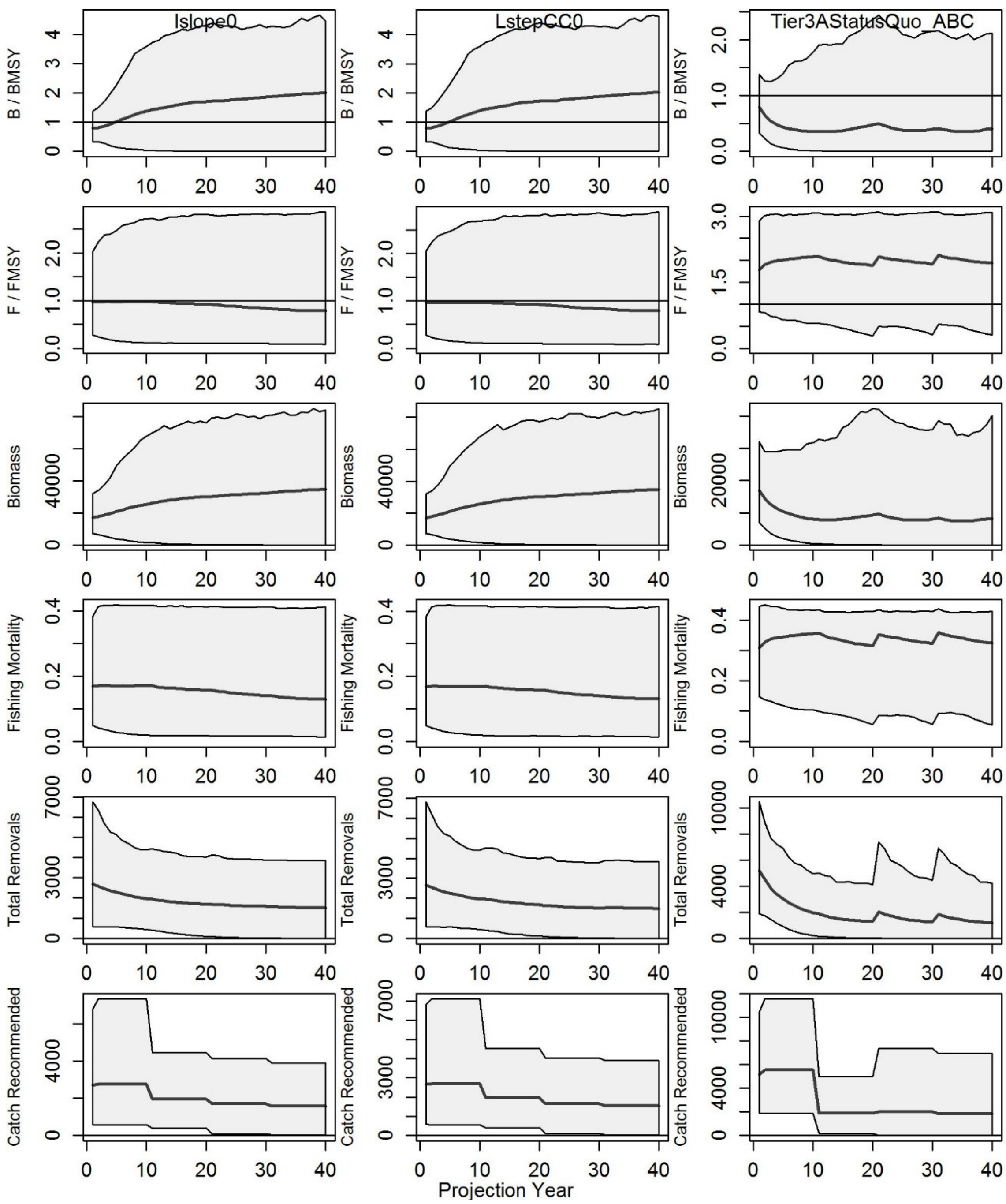


Figure 11.2 Comparison of management strategy outputs for Almaco Jack for the 40-year projection period where an assessment is conducted in years 1, 11, 21, and 31. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), fishing mortality, total removals (in pounds), and the catch recommendation (in pounds) for each viable method. Solid

black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 5th and 95th percentiles.

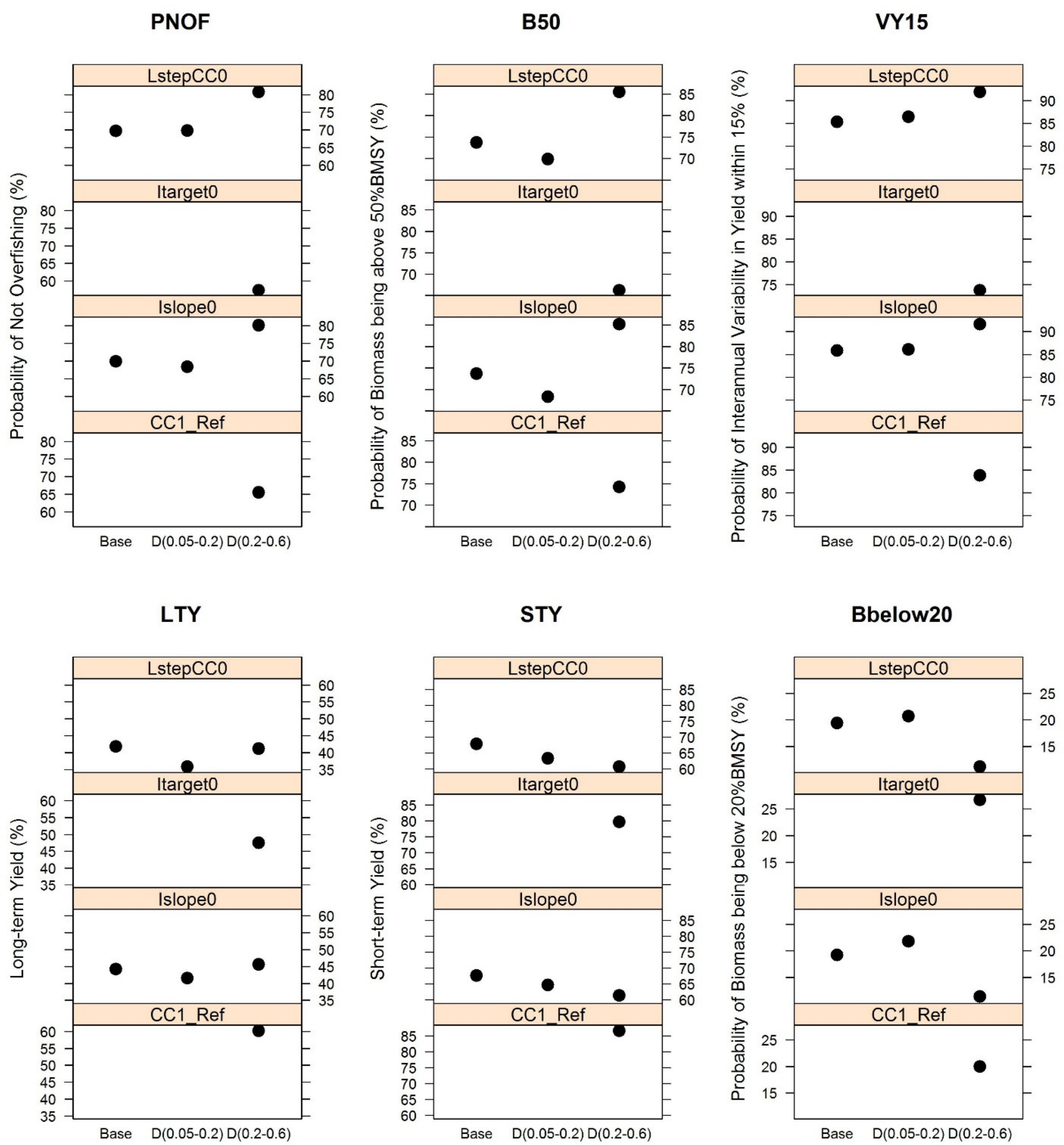


Figure 11.3 Method performance for Almaco Jack assuming the base level of depletion (base; D = 0.08 – 0.32 based on recent mean length and the ML2D function in the DLMtool), a severely depleted state (D = 0.05 – 0.2), and a moderately depleted state (D = 0.2 – 0.6). Results for the lightly depleted state (D = 0.6 – 0.9) are not shown because the depletion levels could not be reached. The absence of points indicates that the performance metric(s) did not meet the specified criteria (> 50%) for PNOF, B50, and VY15. Tier3AStatusQuo_ABC did not meet the performance metrics for any sensitivity run.

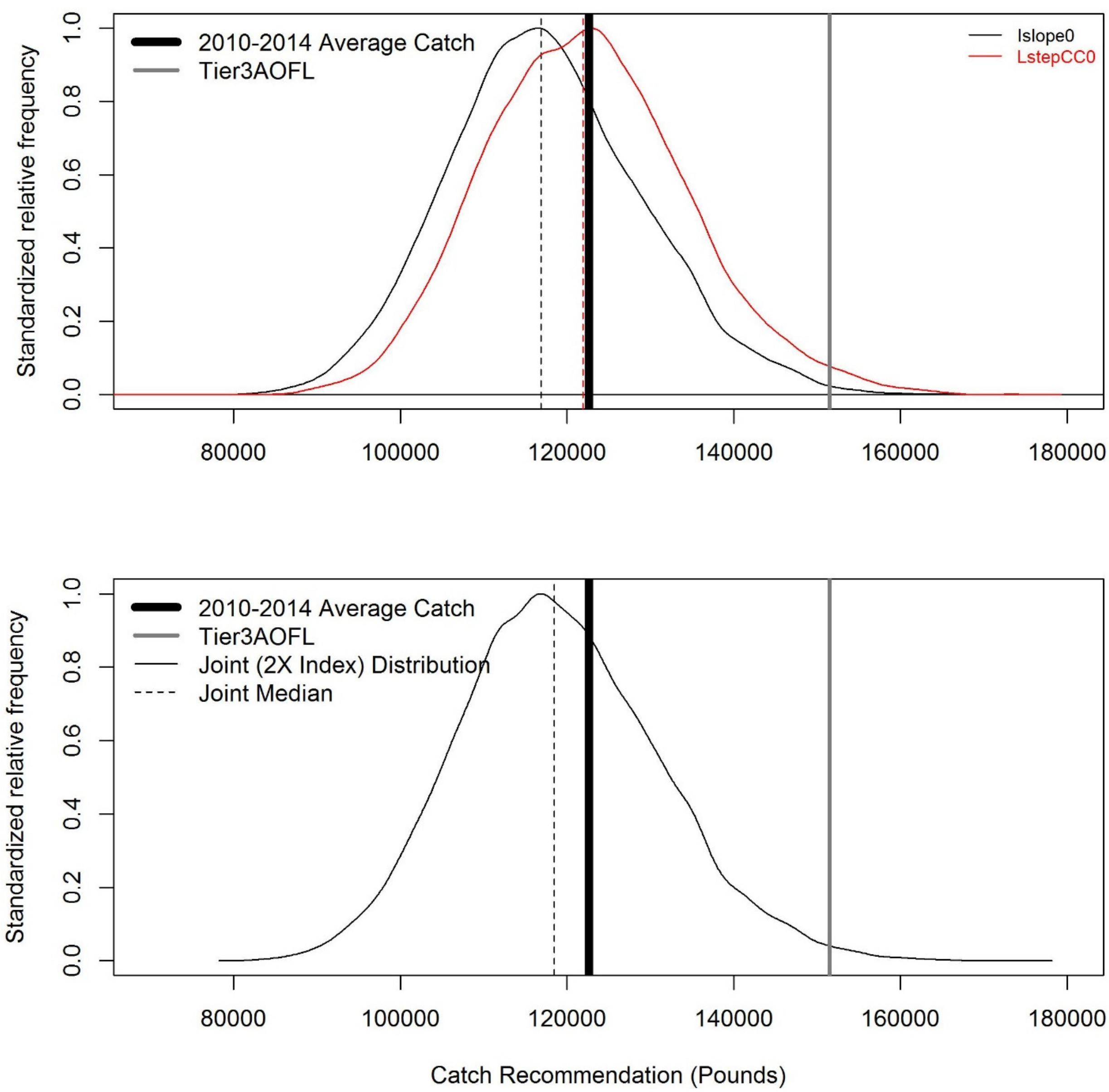


Figure 11.4 Distribution of the catch recommendation (in pounds) for Almaco Jack recommended by the two viable methods, Islope0 and LstepCC0 (top panel; dashed vertical lines identify medians) and a joint distribution assuming a greater weight (double weighting to Islope0) for the index-based method than the length-based method due to differences in data quality (bottom panel). The average catch between 2010 and 2014 (thick black line) and the OFL specified by the Tier3AStatusQuo (thick gray line) are included for comparison. The joint distribution (bottom panel) is recommended for providing management advice.

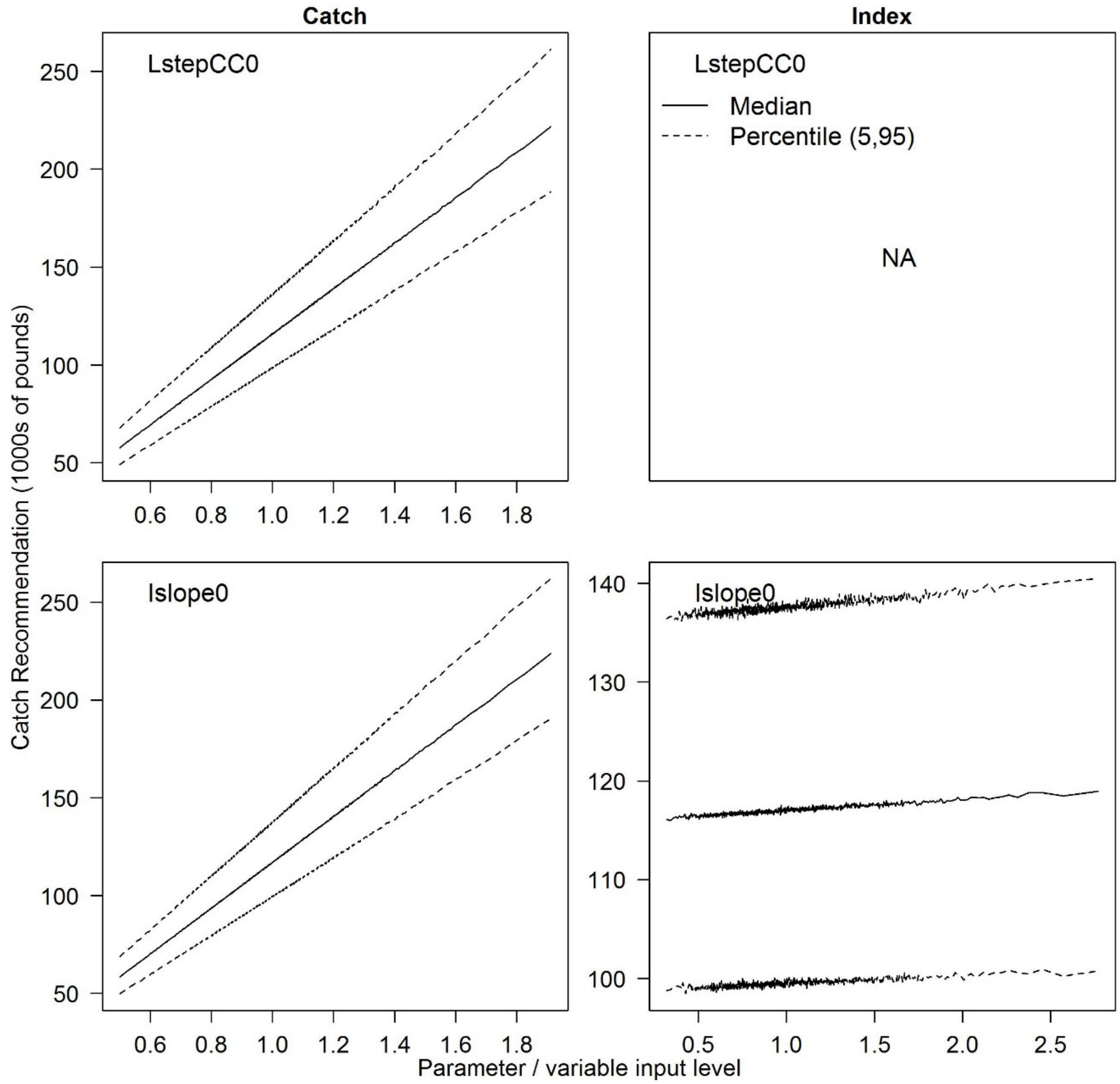


Figure 11.5 Sensitivity of the catch recommendation for Almaco Jack to marginal changes in the required data inputs for LstepCC0 (only catch considered in sensitivity analysis) and Islope0 (Catch and index of abundance). Note that ranges for parameter ranges are derived from the CV for each parameter. NA indicates that the data input is not required.

12 EVALUATION SUMMARY

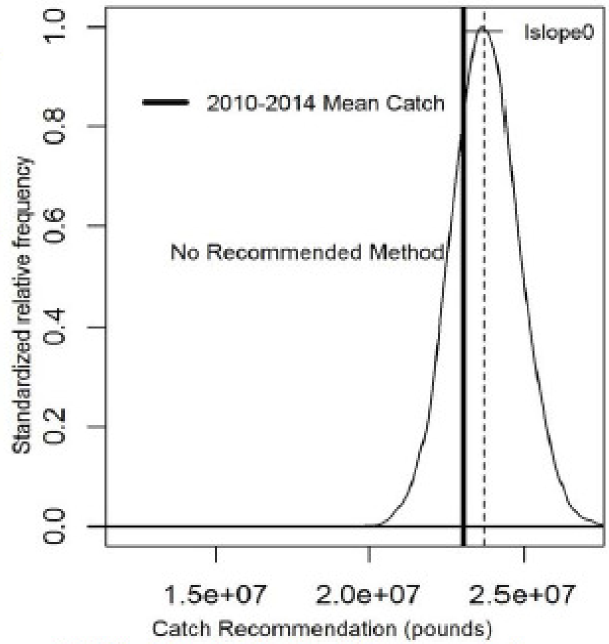
12.1 Stock Evaluation Results

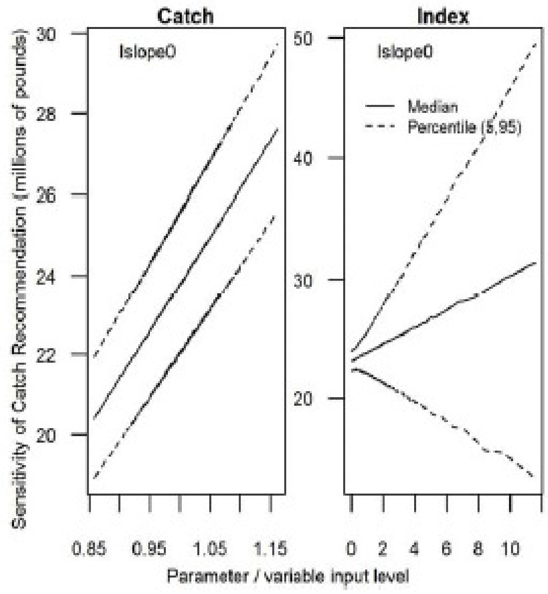
Graphical summaries of the SEDAR 49 evaluations are provided in Figures 12.1 – 12.7.

12.2 Figures

Gulf of Mexico Red Drum (*Sciaenops ocellatus*)

Method	Data Requirement	Data Quality
CPUE slope (Islope0)	**Catch**: 2010-2014	Good
	Index: Dauphin Island Sea Laboratory Bottom Longline survey (2010-2014)	Good





DLMtool Results for Catch Recommendations

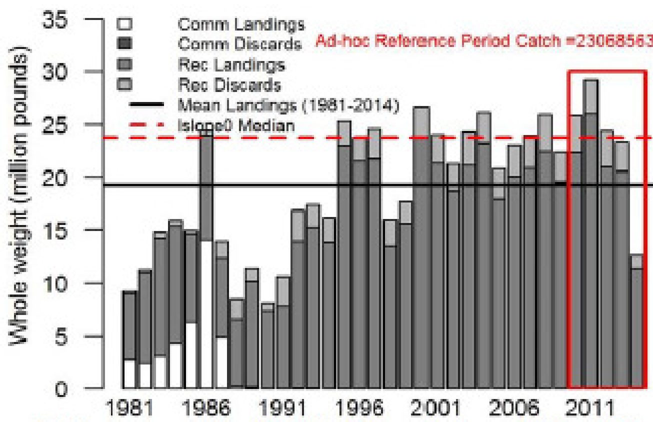
Method	Median	75th	Mean	SD
Islope0	23,748,838	24,464,449	23,763,717	1,073,038

Not recommended for providing management advice due to reliance on ad-hoc assumption of recent catch history.

Sensitivity of Catch Recommendations (Catch CV)

Method	CV_Cat	Median	Mean	SD
Islope0	0.049	23,748,838	23,763,717	1,073,038
	0.098	23,738,216	23,769,355	1,406,690

Note that no reference period was provided in the Red Drum FMP. Therefore, catch over the reference period is based on 2010-2014.



MSE Evaluation of Model Performance

Method	PNOF	B50	VY15
Islope0	99.5	99.8	54.3
Method	**LTY**	**STY**	**B<20**
Islope0	12.7	30.4	0.0
Shading:	Poor	Fair	Good

Performance metrics: **PNOF** = Prob. of not overfishing, **B50** = Prob. of biomass being above 50% BMSY, **VY15** = Prob. interannual variability in yield remains <15%, **LTY** and **STY** = long and short-term yield, **B<20** = Prob. of biomass being below 20% BMSY

Figure 12.1 Summary of SEDAR 49 assessment results for Gulf of Mexico Red Drum.

Gulf of Mexico Red Drum (*Sciaenops ocellatus*)

Summary of catch curve analysis conducted for Red Drum.

Data Source	Years Surveyed	*Z*	*Z* SE	*M*	*F*
Alabama Deep-Sea Fishing Rodeo	2009, 2011-2014	0.124	0.018	0.16	0
Dauphin Island Sea Laboratory Bottom Longline	2008-2014	0.208	0.031	0.16	0.05
Aggregate Purse Seine (PS)	1986-1988, 1996-1998, 2006-2008, 2014	0.144	0.006	0.16	0
LSU/NMFS Pascagoula PS	1986-1988	0.210	0.021	0.16	0.05
FWRI & LSU/NMFS Pascagoula PS	1996-1998	0.116	0.014	0.16	0
FWRI PS	2006-2008	0.179	0.025	0.16	0.02
DISL PS	2014	0.170	0.031	0.16	0.01

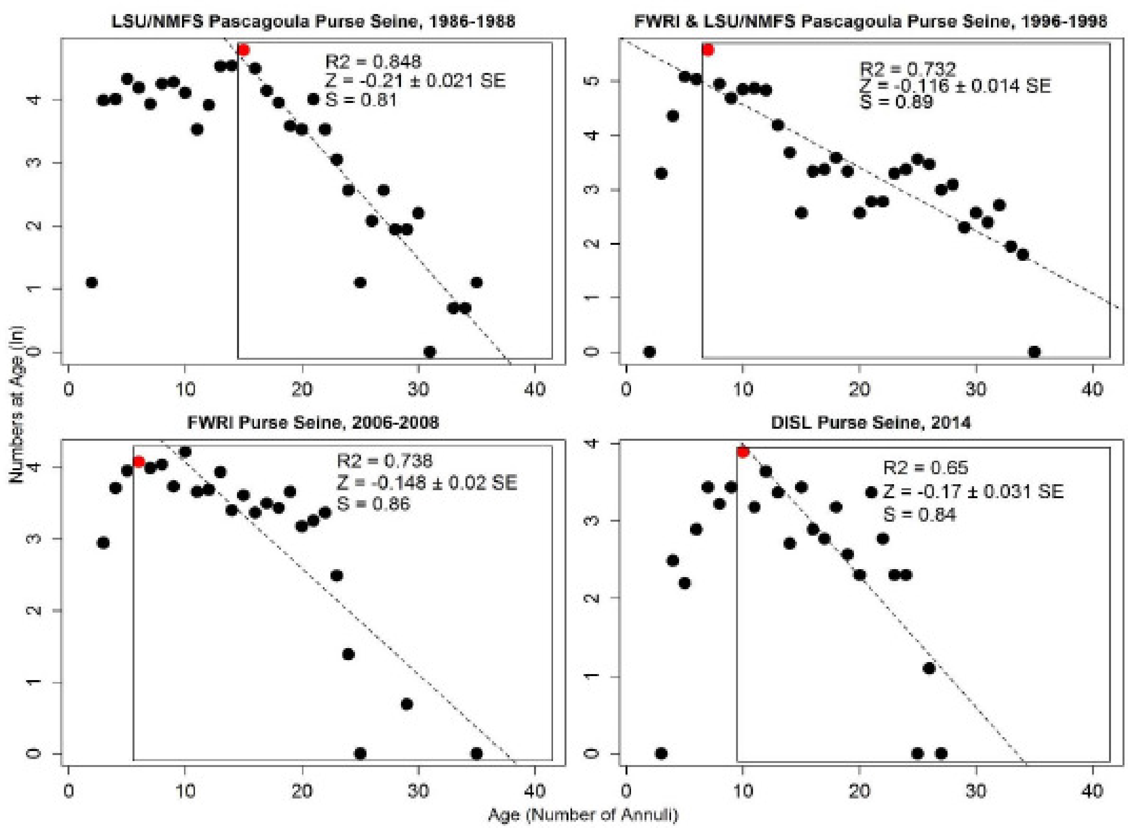
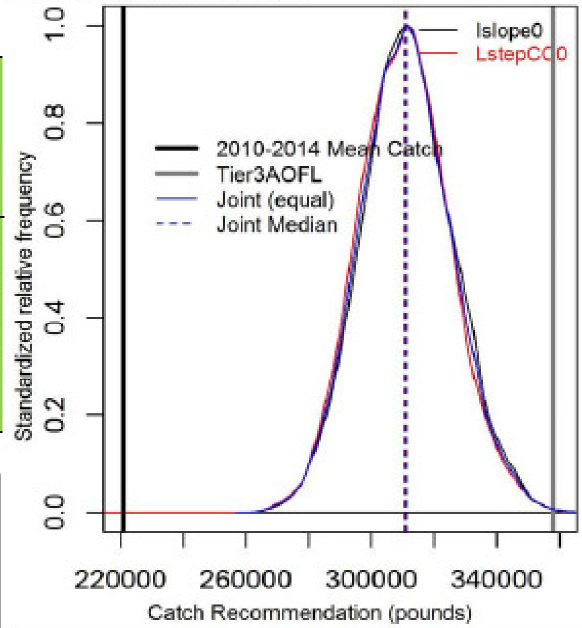
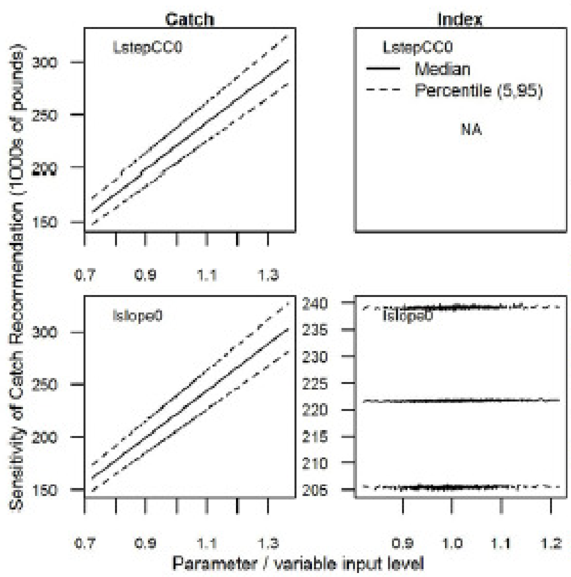


Figure 12.1 (continued) Summary of SEDAR 49 assessment results for Gulf of Mexico Red Drum.

Gulf of Mexico Lane Snapper (*Lutjanus synagris*)

Method	Data Requirement	Data Quality
CPUE slope (Islope0)	**Catch**: 1999-2008	Good
	Index: Headboat index 2010-2014	Good
Mean length step (LstepCC0)	**Catch**: 1999-2008	Good
	Mean Length: Recreational (private, headboat) mean length for reference period (1999-2008) and recent period (2010-2014)	Good



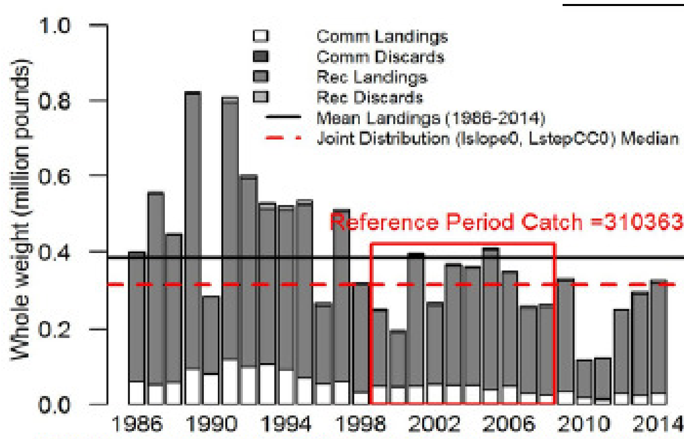


DLMtool Results for Catch Recommendations

Method	Median	75th	Mean	SD
Islope0	311,243	321,267	311,638	14,576
LstepCC0	310,367	319,910	310,476	14,407
Joint (equal)	**310,818**	**320,601**	**311,057**	**14,503**

Sensitivity of Catch Recommendations (Catch CV)

Method	CV_Cat	Median	Mean	SD
Islope0	0.103	311,243	311,638	14,576
	0.206	310,367	311,417	28,544
LstepCC0	0.103	310,367	310,476	14,407
	0.206	309,180	310,763	28,940



MSE Evaluation of Model Performance

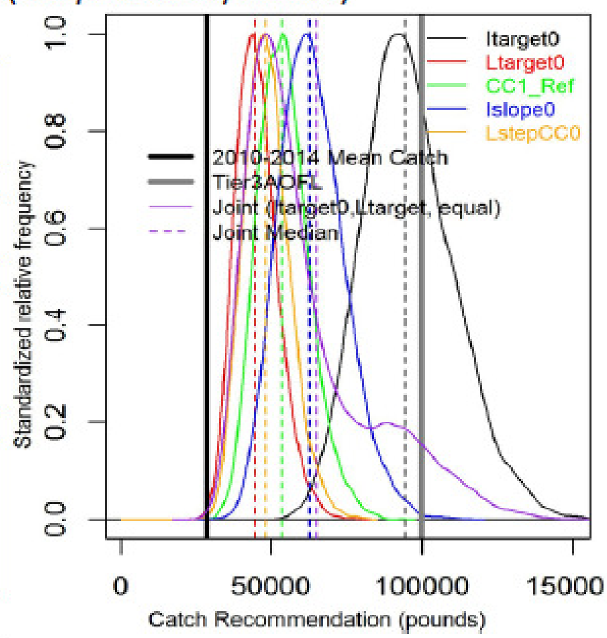
Method	PNOF	B50	VY15
Tier3A ABC	29.1	45.4	53.3
Islope0	69.2	75.5	87.8
LstepCC0	70.4	76.3	88.1
Method	**LTY**	**STY**	**B<20**
Tier3A ABC	55.4	92.4	33.0
Islope0	48.4	73.5	14.4
LstepCC0	46.3	73.7	14.0
Shading:	Poor	Fair	Good

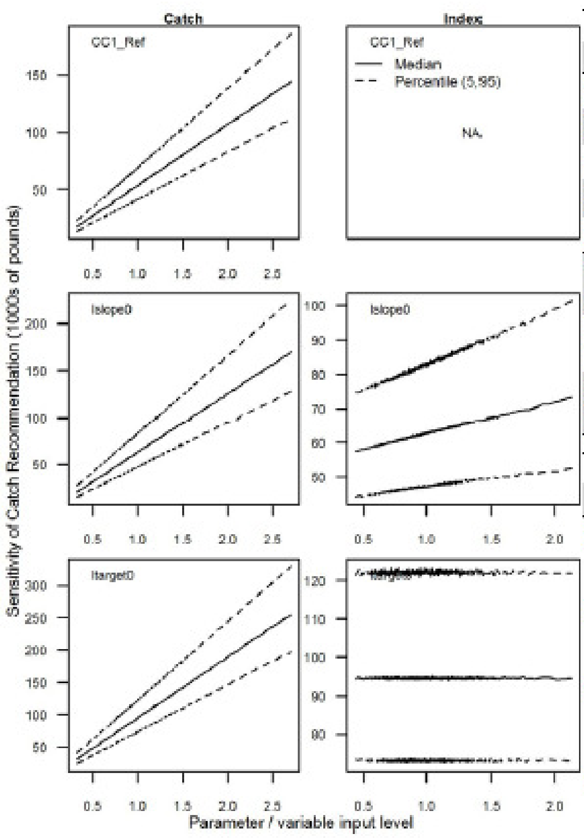
Performance metrics: **PNOF** = Prob. of not overfishing, **B50** = Prob. of biomass being above 50% BMSY, **VY15** = Prob. interannual variability in yield remains <15%, **LTY** and **STY** = long and short-term yield, **B<20** = Prob. of biomass being below 20% BMSY

Figure 12.2 Summary of SEDAR 49 assessment results for Gulf of Mexico Lane Snapper.

Gulf of Mexico Wenchman (*Pristipomoides aquilonaris*)

Method	Data Requirement	Data Quality
Constant catch (CC1_Ref)	**Catch**: 1999-2008	Fair
CPUE slope (Islope0)	**Catch**: 1999-2008	Fair
	Index: Small Pelagics index (2010-2014)	Good
CPUE target (Itarget0)	**Catch**: 1999-2008	Fair
	Index: Small Pelagics index for reference period (1999-2008) and recent period (2010-2014)	Good
Mean length target (Ltarget0) and mean length step (LstepCC0)	**Catch**: 1999-2008	Fair
	Mean Length: Small Pelagics mean length for reference period (1999-2008) and recent period (2010-2014)	Good





DLMtool Results for Catch Recommendations

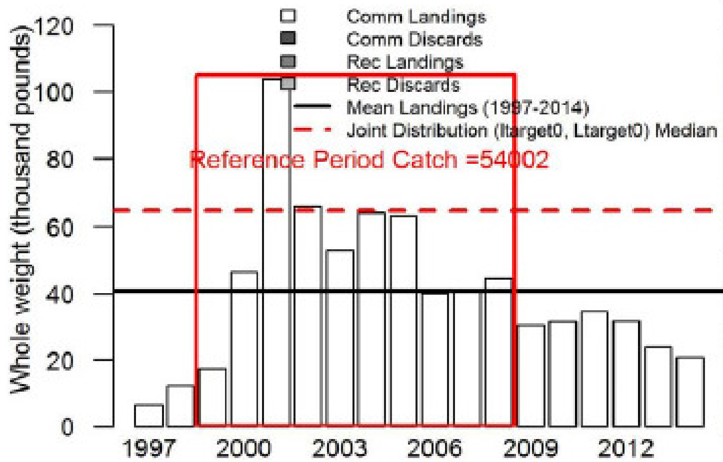
Method	Median	75th	Mean	SD
Itarget0 [1]	94,335	105,084	95,650	15,126
Ltarget0 [2]	44,544	49,518	45,182	7,042
CC1_Ref [3]	53,546	59,316	54,075	8,519
Islope0 [4]	62,718	70,433	63,534	10,905
LstepCC0 [5]	48,031	53,224	48,520	7,548
Joint 1-2 (equal)	**64,943**	**94,333**	**70,416**	**27,856**
Joint 1-3 (equal)	55,274	85,225	64,969	24,512
Joint 1-5 (equal)	54,844	70,766	61,392	20,914

Sensitivity of Catch Recommendations (Catch CV)

Method	CV_Cat	Median	Mean	SD
Itarget0	0.35	94,335	95,650	15,126
	0.70	91,583	96,321	30,317
Ltarget0	0.35	44,544	45,182	7,042
	0.70	43,259	45,149	14,031
CC1_Ref	0.35	53,546	54,075	8,519
	0.70	51,420	53,939	16,630
Islope0	0.35	62,718	63,534	10,905
	0.70	60,555	63,796	20,527
LstepCC0	0.35	48,031	48,520	7,548
	0.70	46,573	48,639	15,144

Figure 12.3 Summary of SEDAR 49 assessment results for Gulf of Mexico Wenchman.

Gulf of Mexico Wenchman (*Pristipomoides aquilonaris*)



MSE Evaluation of Model Performance			
Method	**PNOF**	**B50**	**VY15**
Itarget0	62.6	74.2	58.5
Tier3A ABC	66.9	76.7	60.8
Ltarget0	70.3	79	67.3
CC1_Ref	83.9	87.4	85.5
Islope0	88.9	91	92.7
LstepCC0	89.2	91.2	93.3
Method	**LTY**	**STY**	**B<20**
Itarget0	71.1	81.2	10.6
Tier3A ABC	70.5	82.3	9.8
Ltarget0	66.2	76.6	8.5
CC1_Ref	59.6	65.2	5.4
Islope0	43.7	50.5	3.5
LstepCC0	40	50.6	3.4
Shading:	Poor	Fair	Good

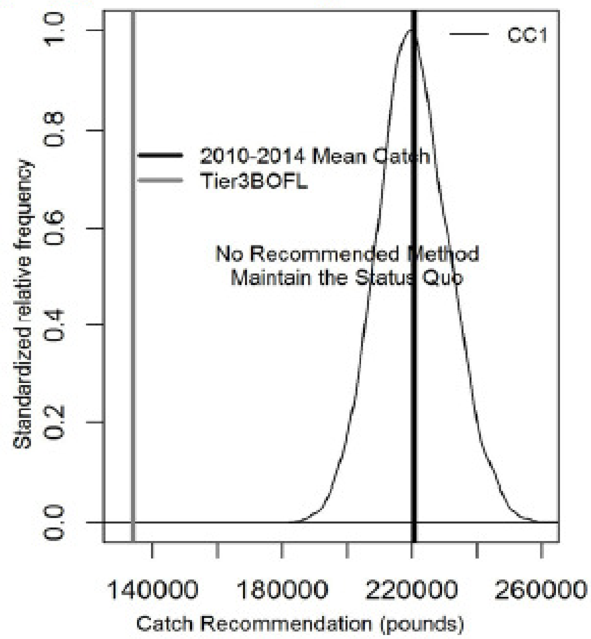
Performance metrics: **PNOF** = Prob. of not overfishing, **B50** = Prob. of biomass being above 50% BMSY, **VY15** = Prob. interannual variability in yield remains <15%, **LTY** and **STY** = long and short-term yield, **B<20** = Prob. of biomass being below 20% BMSY

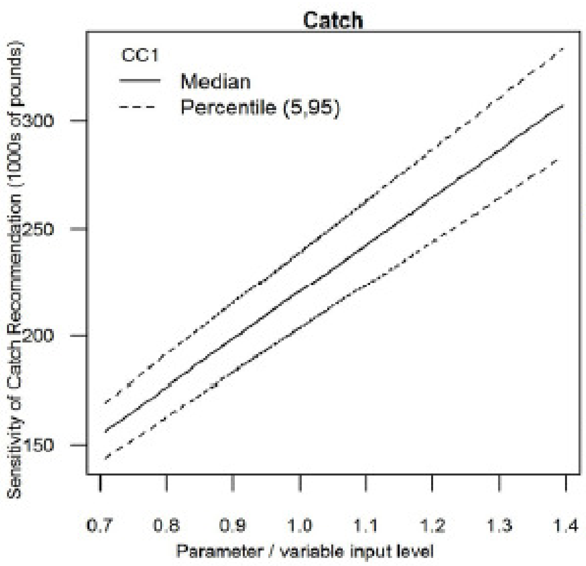
Figure 12.3 (continued) Summary of SEDAR 49 assessment results for Gulf of Mexico Wenchman.

Gulf of Mexico Snowy Grouper (*Hyporthodus niveatus*)

Method	Data Requirements	Data Quality
Constant catch (CC1)	Catch: 2010-2014	Good

Note that indicator-based methods using either an index of abundance or mean length data inputs were not feasible during SEDAR49 analyses due to concerns over a potential shift in the distribution of the dominant fishery.





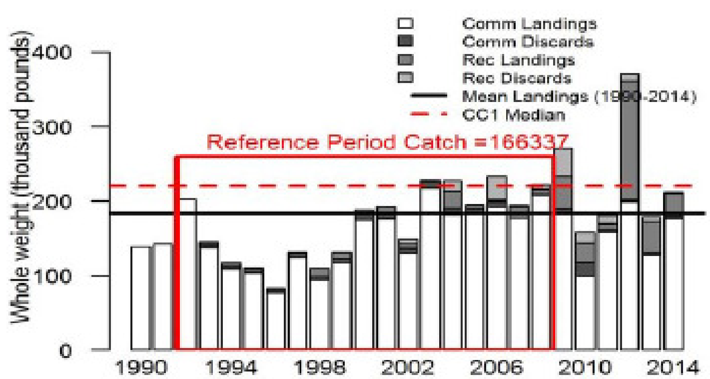
DLMtool Results for Catch Recommendations

Method	Median	75th	Mean	SD
CC1	220,074	227,708	220,448	10,972

Not recommended for providing management advice due to reliance on assumption of recent catch history. The catch-based method based on the reference period (CC1_Ref) did not meet the performance criteria in the management strategy evaluation.

Sensitivity of Catch Recommendations (Catch CV)

Method	CV Cat	Median	Mean	SD
CC1	0.11	220,074	220,448	10,972
	0.22	219,681	220,389	21,645



MSE Evaluation of Model Performance

Method	PNOF	B50	VY15
CC1	58.6	73.5	91.8
Tier3B ABC	23.9	46.7	72.5
Method	**LTY**	**STY**	**B<20**
CC1	57.0	86.1	20.8
Tier3B ABC	37.0	99.6	42.2
Shading:	Poor	Fair	Good

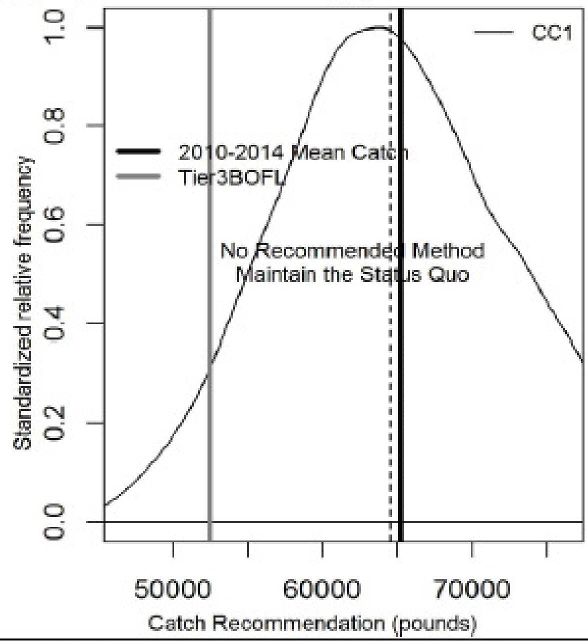
Performance metrics: **PNOF** = Prob. of not overfishing, **B50** = Prob. of biomass being above 50% BMSY, **VY15** = Prob. interannual variability in yield remains <15%, **LTY** and **STY** = long and short-term yield, **B<20** = Prob. of biomass being below 20% BMSY

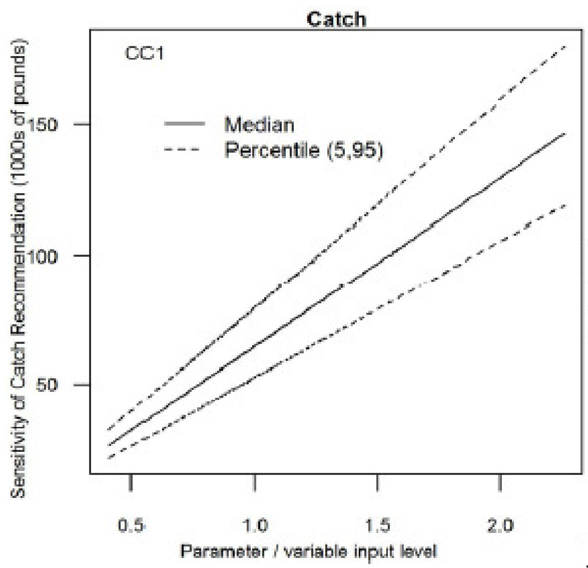
Figure 12.4 Summary of SEDAR 49 assessment results for Gulf of Mexico Snowy Grouper.

Gulf of Mexico Speckled Hind (*Epinephelus drummondhayi*)

Method	Data Requirements	Data Quality
Constant catch (CC1)	Catch: 2010-2014	Good

Note that indicator-based methods using either an index of abundance or mean length data inputs were not feasible during SEDAR49 analyses due to concerns over a potential shift in the distribution of the dominant fishery.





DLMtool Results for Catch Recommendations

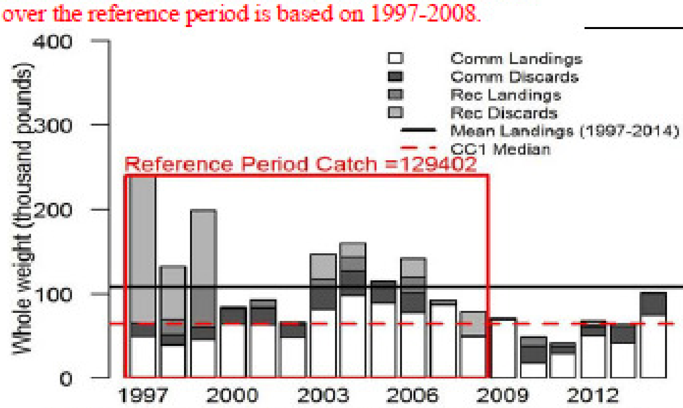
Method	Median	75th	Mean	SD
CC1	64,563	70,441	65,164	8,306

Not recommended for providing management advice due to reliance on assumption of recent catch history. CC1 based on the reference period (CC1_Ref) did not meet the performance criteria in the management strategy evaluation.

Sensitivity of Catch Recommendations (Catch CV)

Method	CV_Cat	Median	Mean	SD
CC1	0.282	64,563	65,164	8,306
	0.564	63,588	65,338	16,530

Note that the Total Removals Working Group recommended 1997 as the start year. Therefore, catch over the reference period is based on 1997-2008.



MSE Evaluation of Model Performance

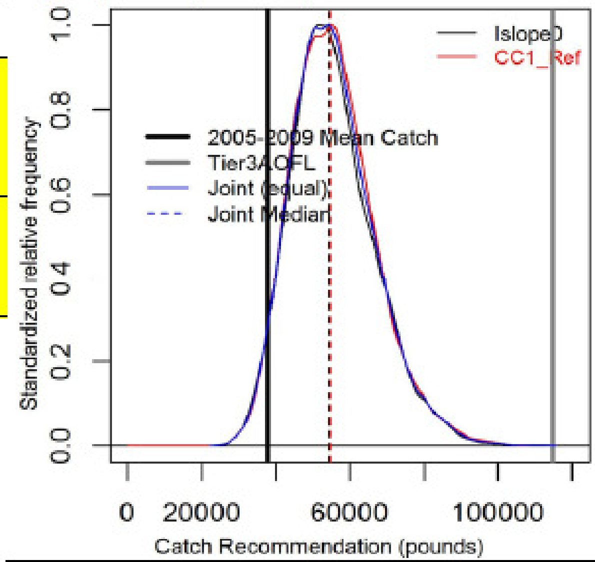
Method	PNOF	B50	VY15
CC1	73.0	77.2	87.9
Tier3B ABC	33.1	45.1	60.6
Method	**LTY**	**STY**	**B<20**
CC1	41.3	50.9	14.8
Tier3B ABC	37.4	89.3	43.8
Shading:	Poor	Fair	Good

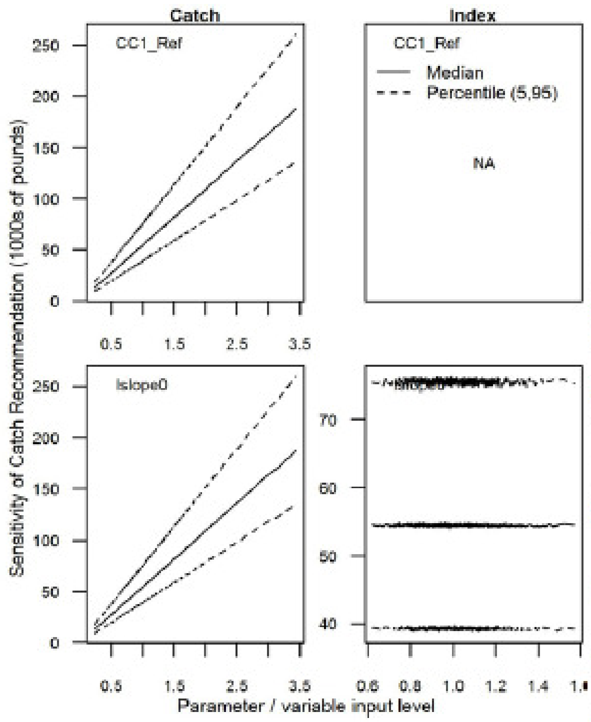
Performance metrics: **PNOF** = Prob. of not overfishing, **B50** = Prob. of biomass being above 50% BMSY, **VY15** = Prob. interannual variability in yield remains <15%, **LTY** and **STY** = long and short-term yield, **B<20** = Prob. of biomass being below 20% BMSY

Figure 12.5 Summary of SEDAR 49 assessment results for Gulf of Mexico Speckled Hind.

Gulf of Mexico Lesser Amberjack (*Seriola fasciata*)

Method	Data Requirements	Data Quality
Constant catch (CC1_Ref)	**Catch**: 2000-2008	Fair
CPUE slope (Islope0)	**Catch**: 2000-2008	Fair
	Index: SEAMAP Video index (2005-2009)	Fair





DLMtool Results for Catch Recommendations

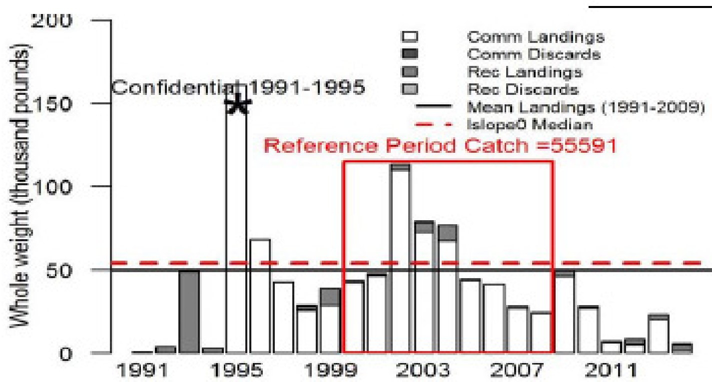
Method	Median	75th	Mean	SD
Islope0	54,269	62,215	55,442	11,243
CC1_Ref	54,750	62,416	55,685	11,262
Joint (equal)	54,506	62,344	55,564	11,253

Sensitivity of Catch Recommendations (Catch CV)

Method	CV_Cat	Median	Mean	SD
Islope0	0.45	54,269	55,442	11,243
	0.9	51,342	55,064	21,374
CC1_Ref	0.45	54,750	55,685	11,262
	0.9	51,559	55,142	21,571

Sensitivity of Catch Recommendations (Terminal Year)

Method	Year	Median	Mean	SD
Islope0	2009	54,269	55,442	11,243
	2014	27,855	28,420	5,769



MSE Evaluation of Model Performance

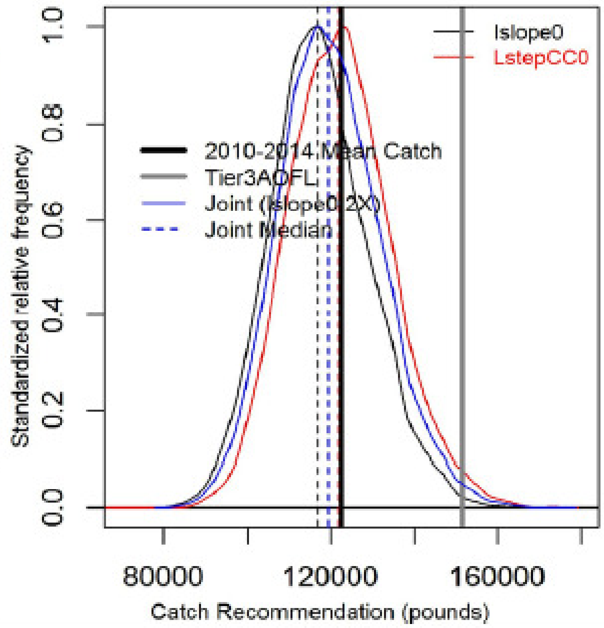
Method	PNOF	B50	VY15
Tier3A ABC	52.4	59.4	67.3
CC1_Ref	76.5	78.8	88.7
Islope0	61.3	64.0	84.0
Method	**LTY**	**STY**	**B<20**
Tier3A ABC	56.2	72.2	21.0
CC1_Ref	47.3	53.0	9.8
Islope0	42.8	67.5	20.3
Shading:	Poor	Fair	Good

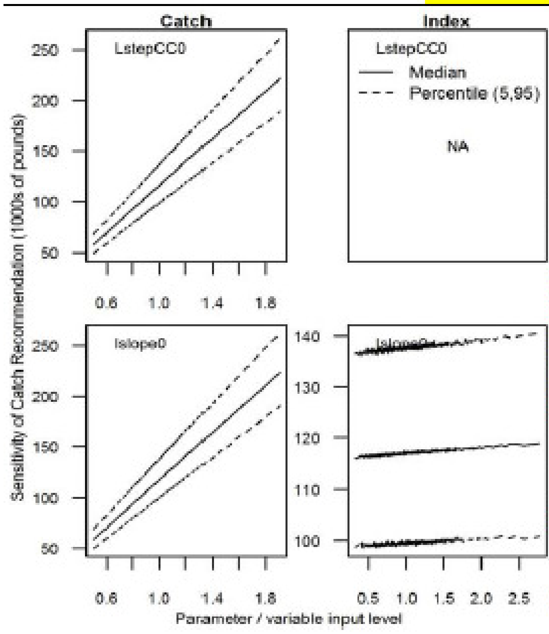
Performance metrics: **PNOF** = Prob. of not overfishing, **B50** = Prob. of biomass being above 50% BMSY, **VY15** = Prob. interannual variability in yield remains <15%, **LTY** and **STY** = long and short-term yield, **B<20** = Prob. of biomass being below 20% BMSY

Figure 12.6 Summary of SEDAR 49 assessment results for Gulf of Mexico Lesser Amberjack.

Gulf of Mexico Almaco Jack (*Seriola rivoliana*)

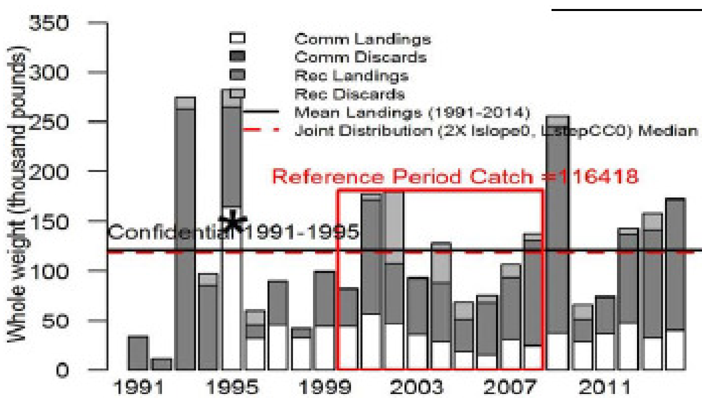
Method	Data Requirement	Data Quality
CPUE slope (Islope0)	**Catch**: 2000-2008	Good
	Index: SEAMAP Video index (2010-2014)	Good
Mean length step (LstepCC0)	**Catch**: 2000-2008	Good
	Mean Length: Recreational (private, headboat, charterboat) mean length for reference period (2000-2008) and recent period (2010-2014)	Fair





DLMtool Results for Catch Recommendations				
Method	**Median**	**75th**	**Mean**	**SD**
Islope0	116,896	125,067	117,517	11,740
LstepCC0	121,930	130,062	122,338	12,121
Joint (equal)	119,328	127,890	119,928	12,173
Joint (2X index)	118,451	126,986	119,124	12,084

Sensitivity of Catch Recommendations (Catch CV)				
Method	**CV Cat**	**Median**	**Mean**	**SD**
Islope0	0.22	116,896	117,517	11,740
	0.44	115,421	117,401	23,134
LstepCC0	0.22	121,930	122,338	12,121
	0.44	119,776	122,224	23,824



MSE Evaluation of Model Performance			
Method	**PNOF**	**B50**	**VY15**
Islope0	69.9	73.7	85.8
LstepCC0	69.7	73.7	85.3
Tier3A ABC	16.6	24.5	34.2
Method	**LTY**	**STY**	**B<20**
Islope0	44.2	67.6	19.2
LstepCC0	41.8	67.9	19.4
Tier3A ABC	32.0	93.0	62.0
Shading:	Poor	Fair	Good

Performance metrics: **PNOF** = Prob. of not overfishing, **B50** = Prob. of biomass being above 50% BMSY, **VY15** = Prob. interannual variability in yield remains <15%, **LTY** and **STY** = long and short-term yield, **B<20** = Prob. of biomass being below 20% BMSY

Figure 12.7 Summary of SEDAR 49 assessment results for Gulf of Mexico Almaco Jack.

13 DISCUSSION

The SEDAR 49 assessment identified various methods which could be employed to provide management advice for many of the species considered. Index-based and mean-length based methods appeared to be viable approaches after meeting the performance metrics selected by the AW Panel. For all species with the exception of Red Drum, at least one method was identified as having preferable performance compared to a status quo metric developed to mimic the current approach for setting the OFL for Tier 3A and 3B species (GMFMC 2011).

The development of the DLMtool package in R (Carruthers and Hordyk 2016) has consolidated many of the data-limited assessment methods developed worldwide and enabled simultaneous analysis, which has greatly enhanced the efficiency of data-limited assessment (Carruthers et al. 2014, Newman et al. 2014, Newman et al. 2015). A previous SEDAR employing the DLMtool, SEDAR 46 in the U.S. Caribbean, focused on six species-island units and was one of the first applications using the DLMtool for U.S. fisheries management. While this approach has proven very promising, there are certain aspects of the approach that can complicate rapid utility in the U.S.

Many of the approaches included within the DLMtool, for example the indicator based methods of Geromont and Butterworth (2014) which use either an index of abundance or mean length, were tuned to specific regions outside of the United States to address questions of interest. As a result, some methods in the DLMtool produce total allowable catches using methods which internally buffer the catch recommendation (e.g. using 70% of average catch) and do not provide estimates of the overfishing limit, as required for U.S. fisheries. An attempt was made during SEDAR 49 to exclude any methods which included such “buffers” or modify the method to eliminate the buffer (e.g., modified Islope1 in Geromont and Butterworth (2014) to use 100% of average catch as opposed to 80%).

Attempts at testing different scalar values were undertaken for the index-based (Islope0 and Itarget0) and length-based (LstepCC0 and Ltarget0) methods, which revealed relatively similar performance across scalar values tested for all species and methods. For SEDAR 49, the MSE was used to eliminate poorly performing methods, and may not necessarily provide a good basis for selecting one method (or variant of a method based on different scalars) over another. Additional tuning to meet specific performance criteria is suggested in future evaluations, although caution is warranted in interpreting the results from the MSE in absolute terms (i.e. is a LTY of 50.1 really better than a LTY of 50.0 based on the MSE?).

14 RESEARCH RECOMMENDATIONS

A number of research recommendations were identified throughout the SEDAR 49 stock evaluation and are described below. Research recommendations for improvements to input data, which were provided at the end of each relevant section in the Data Report, are also reiterated by the analysts.

1. Fine-tuning of the index-based and length-based methods reported herein to achieve target performance metrics (e.g. probability of not overfishing closest to 50% or the highest LTY).

2. Exploration of the cost or benefit of specifying an operating model incorrectly and how this influences method selection over a range of operating model input parameters.

3. Calculation and presentation of performance metrics in relation to the status quo rather than a reference method.

4. Simulation testing of the non-equilibrium mean length estimator and yield-per recruit approach to assess method performance in comparison to other available methods, as well as testing different assumptions inherent in the approach (e.g. whether to use a time series of recent total removals or the terminal year's total removals in catch recommendations).

5. Evaluation of the updated Hoenig equation (described in Then et al. 2014) for estimating natural mortality using maximum age. The updated equation tends to produce higher estimates of natural mortality, which can have important implications for applications such as the mean length estimator.

6. Region-specific estimates of correlation coefficients for growth parameters derived from growth curves specific to the Gulf of Mexico.

7. Investigation of more justifiable estimates of stock depletion such as through Productivity-Susceptibility Analysis (Cope et al. 2015).

8. Estimation of current stock abundance from tagging studies (e.g. Red Drum), which could be used in methods such as the Beddington and Kirkwood (2005) approach.

9. Identification of a reference period for catches for Red Drum.

10. Discussions regarding the appropriateness of the reference period selected for each species.

11. Evaluation of the appropriateness of target catch or index levels which could be used in conjunction with catch and index time series.

12. Evaluation of the appropriateness of target length levels which could be used in conjunction with catch and a length frequency series.

13. Incorporation of observation error into the application of index-based (Islope0, Itarget0) and length-based (Ltarget0, LstepCC0) methods.

14. Future data-limited assessments should ensure that the reliability scores for data inputs are agreed upon at the conclusion of the Data Workshop to provide a more quantitative means of weighting methods for catch recommendations.

Within the modeling framework used in SEDAR 49, many limitations are acknowledged within the MSE approach. Pragmatically, results are a product of the specific conditions of the simulation, which are assumed to be as simplistic as possible but contain sufficient complexity to reflect the system in a representative way. Thus, additional considerations towards confirmation of the stock and fleet subclass components of the operating models explored in SEDAR 49 are warranted. In addition, no implementation error was considered in the current analysis which employed the DLMtool Version 3.2.1.

Recommendations for enhancing the practical use of the DLMtool from the analytical team.

1. Revisions of the DLMtool software to enhance the model functionality to allow multiple fishing fleets.

2. Revision of the DLMtool software to allow age varying natural mortality.

3. Allow for implementation error of the harvest control rule (e.g. catch recommendation overages) within the implementation model in the MSE.

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17 APPENDIX

17.1 Relevant R code for species-specific feasible functions used in SEDAR 49.

Useful Functions

```
TACfilter<-function(TAC) {
 TAC[TAC<0]<-NA
 TAC[TAC>(mean(TAC,na.rm=T)+5*sd(TAC,na.rm=T))]<-NA
```

```
  return(TAC)
}
sdconv<-function(m,sd) {(log(1+((sd^2)/(m^2))))^0.5}
mconv<-function(m,sd) {log(m)-0.5*log(1+((sd^2)/(m^2}
trlnorm<-function(reps,mu,cv) {return(rlnorm(reps,mconv(mu,mu*cv),sdconv(mu,mu*cv)))}
```

<u>Species-specific feasible methods</u>

Red Drum

```
CC1<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
{
   C_dat <- DLM_data@Cat[x, (length(DLM_data@Year) - (yrsmth -
      1)):length(DLM_data@Year)]
   TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
   TACfilter(TAC)
}
Islope0<-function (x, DLM_data, reps = 100, yrsmth = 5, lambda = 0.4,
          xx = 0.0)
  {
   ind <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #last 5 years
   ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
   C_dat <- DLM_data@Cat[x, ind]
   if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
       ylast + 1) {
     TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
   }
   else {
     TACstar <- rep(DLM_data@MPrec[x], reps)
   }
   I_hist <- DLM_data@Ind[x, ind]
   yind <- 1:yrsmth
   slppar <- summary(lm(I_hist ~ yind))$coefficients[2, 1:2]
   Islp <- rnorm(reps, slppar[1], slppar[2])
   TAC <- TACstar * (1 + lambda * Islp)
   TACfilter(TAC)
  }
Fratio_CC<-function (x, DLM_data, reps = 100, Fmin = 0.005)
{
   MuC <- DLM_data@Cat[x, length(DLM_data@Cat[x, ])]
   Cc <- trlnorm(reps, MuC, DLM_data@CV_Cat[x])
   Mdb <- trlnorm(reps * 10, DLM_data@Mort[x], DLM_data@CV_Mort[x])
   Zdb <- CC(x, DLM_data, reps = reps * 10)
   Fdb <- Zdb - Mdb
   ind <- (1:(reps * 10))[Fdb > 0.005][1:reps]
   Fdb <- Fdb[ind]
   Mdb <- Mdb[ind]
   SM <- sum(is.na(ind))
   if (SM > 0) {
      Mdb[is.na(ind)] <- trlnorm(SM, DLM_data@Mort[x], DLM_data@CV_Mort[x])
      Fdb[is.na(ind)] <- Fmin
```

```
    }
    Ac <- Cc/(1 - exp(-Fdb))
    TAC <- Ac * Mdb * trlnorm(reps, DLM_data@FMSY_M[x], DLM_data@CV_FMSY_M[x])
    TACfilter(TAC)
}
```

BK_CC_LVBcor<-function (x, DLM_data, reps = 100, Fmin = 0.005)

```
{
  Lc <- trlnorm(reps, DLM_data@LFC[x], 0.2)
  LVB<-multivarLVB(x, DLM_data, reps=reps)
  Linfc <- LVB$Linf_out
  Kc <- LVB$K_out
  Mdb <- trlnorm(reps * 10, DLM_data@Mort[x], DLM_data@CV_Mort[x])
  MuC <- DLM_data@Cat[x, length(DLM_data@Cat[x, ])]
  Cc <- trlnorm(reps, MuC, DLM_data@CV_Cat[x])
  Zdb <- CC(x, DLM_data, reps = reps * 10)
  Fdb <- Zdb - Mdb
  ind <- (1:(reps * 10))[Fdb > Fmin][1:reps]
  Fdb <- Fdb[ind]
  Mdb <- Mdb[ind]
  SM <- sum(is.na(ind))
  if (SM > 0) {
    Mdb[is.na(ind)] <- trlnorm(SM, DLM_data@Mort[x], DLM_data@CV_Mort[x])
    Fdb[is.na(ind)] <- Fmin
  }
  Ac <- Cc/(1 - exp(-Fdb))
  TAC <- Ac * (0.6 * Kc)/(0.67 - (Lc/Linfc))
  TACfilter(TAC)
}
```

Fdem_CC_LVBcor<-function (x, DLM_data, reps = 100, Fmin = 0.005)

```
{
  Mvec <- trlnorm(reps * 10, DLM_data@Mort[x], DLM_data@CV_Mort[x])
  LVB<-multivarLVB(x, DLM_data, reps=reps)
  Linfc <-LVB$Linf_out
  Kc <-LVB$K_out
  t0c <-LVB$t0_out
  hvec <- trlnorm(reps, DLM_data@steep[x], DLM_data@CV_steep[x])
  MuC <- DLM_data@Cat[x, length(DLM_data@Cat[x, ])]
  Cc <- trlnorm(reps, MuC, DLM_data@CV_Cat[x])
  Zdb <- CC(x, DLM_data, reps = reps * 10)
  Fdb <- Zdb - Mvec
  ind <- (1:(reps * 10))[Fdb > Fmin][1:reps]
  Fdb <- Fdb[ind]
  SM <- sum(is.na(ind))
  if (SM > 0) {
    Fdb[is.na(ind)] <- Fmin
  }
  Ac <- Cc/(1 - exp(-Fdb))
  FMSY <- getr(x, DLM_data, Mvec, Kc, Linfc, t0c, hvec, maxage = DLM_data@MaxAge,
             r_reps = reps)/2
```

```
  TAC <- FMSY * Ac
  TACfilter(TAC)
}
```
YPR_CC_LVBcor<-function (x, DLM_data, reps = 100, Fmin = 0.005)
```
{
  LVB<-multivarLVB(x, DLM_data, reps=reps)
  Linfc <-LVB$Linf_out
  Kc <-LVB$K_out
  t0c <-LVB$t0_out
  LFS <- trlnorm(reps, DLM_data@LFS[x], DLM_data@CV_LFS[x])
  a <- DLM_data@wla[x]
  b <- DLM_data@wlb[x]
  MuC <- DLM_data@Cat[x, length(DLM_data@Cat[x, ])]
  Cc <- trlnorm(reps, MuC, DLM_data@CV_Cat[x])
  Mdb <- trlnorm(reps * 10, DLM_data@Mort[x], DLM_data@CV_Mort[x])
  Zdb <- CC(x, DLM_data, reps = reps * 10)
  Fdb <- Zdb - Mdb
  ind <- (1:(reps * 10))[Fdb > Fmin][1:reps]
  Fdb <- Fdb[ind]
  Mdb <- Mdb[ind]
  SM <- sum(is.na(ind))
  if (SM > 0) {
    Mdb[is.na(ind)] <- trlnorm(SM, DLM_data@Mort[x], DLM_data@CV_Mort[x])
    Fdb[is.na(ind)] <- Fmin
  }
  Ac <- Cc/(1 - exp(-Fdb))
  FMSY <- YPRopt(Linfc, Kc, t0c, Mdb, a, b, LFS, DLM_data@MaxAge,
               reps)
  TAC <- Ac * FMSY
  TACfilter(TAC)
}
```

Lane Snapper

Tier3AStatusQuo_ABC<-function(x,DLM_data,reps){
```
  AverC<-mean(c(DLM_data@Cat[x,85:94])) #Years 85-94 of 100 year historical period [1999-2008]
  sdC<-sd(c(DLM_data@Cat[x,85:94]))
  AverC+(1*sdC)}
```
CC1_Ref<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
```
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
  C_dat <- DLM_data@Cat[x, ind]
  TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  TACfilter(TAC)
}
```
Islope0<-function (x, DLM_data, reps = 100, yrsmth = 5, lambda = 0.4, xx = 0)
```
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) #Reference period for CATCH (1999-2008)
```

```
  ind2 <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #period for index: last 5
years
  C_dat <- DLM_data@Cat[x, ind]
  if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
      ylast + 1) {
    TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  }
  else {
    TACstar <- rep(DLM_data@MPrec[x], reps)
  }
  I_hist <- DLM_data@Ind[x, ind2] #period for index: last 5 years
  yind <- 1:yrsmth
  slppar <- summary(lm(I_hist ~ yind))$coefficients[2, 1:2]
  Islp <- rnorm(reps, slppar[1], slppar[2])
  TAC <- TACstar * (1 + lambda * Islp)
  TACfilter(TAC)
}
```

Itarget0

```
Itarget0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, Imulti = 1.5)
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
  ind2 <- ((ylast - (yrsmth - 1)):ylast) #period for index: last 5 years
  C_dat <- DLM_data@Cat[x, ind]
  TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat,na.rm=T), DLM_data@CV_Cat/(yrsmth^0.5))
  Irecent <- mean(DLM_data@Ind[x, ind2],na.rm=T) #mean of recent Index
  Iave <- mean(DLM_data@Ind[x, ind],na.rm=T)     #mean of average Index - 1999-2008
  Itarget <- Iave * Imulti
  I0 <- 0.8 * Iave
  if (Irecent > I0) {
    TAC <- TACstar * (1 + ((Irecent - I0)/(Itarget - I0)))
  }
  else {
    TAC <- TACstar * (Irecent/I0)^2
  }
  TACfilter(TAC)
}
```

LstepCC0

```
LstepCC0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, stepsz = 0.05,
        llim = c(0.96, 0.98, 1.05))
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
  ind2 <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #period for index: last 5
years
  C_dat <- DLM_data@Cat[x, ind]
  if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
      ylast + 1) {
    TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  }
  else {
```

```
    TACstar <- rep(DLM_data@MPrec[x], reps)
  }
  step <- stepsz * TACstar
  Lrecent <- mean(DLM_data@ML[ind2],na.rm=T) #mean of recent ML
  Lave <- mean(DLM_data@ML[ind])            #mean of average ML - 1999-2008
  rat <- Lrecent/Lave
  if (rat < llim[1]) {
    TAC <- TACstar - 2 * step
  }
  else if (rat < llim[2]) {
    TAC <- TACstar - step
  }
  else if (rat > llim[3]) {
    TAC <- TACstar + step
  }
  else {
    TAC <- TACstar
  }
  TACfilter(TAC)
}
```

Ltarget0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, xL = 1.05)

```
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
  ind2 <- ((ylast - (yrsmth - 1)):ylast) #period for index: last 5 years
  C_dat <- DLM_data@Cat[x, ind]
  TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat,na.rm=T), DLM_data@CV_Cat/(yrsmth^0.5))
  Lrecent <- mean(DLM_data@ML[ind2],na.rm=T) #mean of recent ML
  Lave <- mean(DLM_data@ML[ind],na.rm=T)     #mean of average ML - 1999-2008
  L <- 0.9 * Lave
  Ltarget <- xL * Lave
  if (Lrecent > L0) {
    TAC <- TACstar * (1 + ((Lrecent - L0)/(Ltarget - L0)))
  }
  else {
    TAC <- TACstar * (Lrecent/L0)^2
  }
  TACfilter(TAC)
}
```

Wenchman

Tier3AStatusQuo_ABC<-function(x,DLM_data,reps){

```
  AverC<-mean(c(DLM_data@Cat[x,15:24])) #Years 15-24 of 30 year historical period [1999-2008]
  sdC<-sd(c(DLM_data@Cat[x,15:24]))
  AverC+(1*sdC)}
```

CC1_Ref<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)

```
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
```

```
  C_dat <- DLM_data@Cat[x, ind]
  TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  TACfilter(TAC)
}
Islope0<-function (x, DLM_data, reps = 100, yrsmth = 5, lambda = 0.4, xx = 0)
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
  ind2 <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #period for index: last 5
years
  C_dat <- DLM_data@Cat[x, ind]
  if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
      ylast + 1) {
    TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  }
  else {
    TACstar <- rep(DLM_data@MPrec[x], reps)
  }
  I_hist <- DLM_data@Ind[x, ind2] #period for index: last 5 years
  yind <- 1:yrsmth
  slppar <- summary(lm(I_hist ~ yind))$coefficients[2, 1:2]
  Islp <- rnorm(reps, slppar[1], slppar[2])
  TAC <- TACstar * (1 + lambda * Islp)
  TACfilter(TAC)
}
Itarget0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, Imulti = 1.5)
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
  ind2 <- ((ylast - (yrsmth - 1)):ylast) #period for index: last 5 years
  C_dat <- DLM_data@Cat[x, ind]
  TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat,na.rm=T), DLM_data@CV_Cat/(yrsmth^0.5))
  Irecent <- mean(DLM_data@Ind[x, ind2],na.rm=T) #mean of recent Index
  Iave <- mean(DLM_data@Ind[x, ind],na.rm=T)     #mean of average Index - 1999-2008
  Itarget <- Iave * Imulti
  I0 <- 0.8 * Iave
  if (Irecent > I0) {
    TAC <- TACstar * (1 + ((Irecent - I0)/(Itarget - I0)))
  }
  else {
    TAC <- TACstar * (Irecent/I0)^2
  }
  TACfilter(TAC)
}
LstepCC0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, stepsz = 0.05,
        llim = c(0.96, 0.98, 1.05))
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
```

```
  ind2 <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #period for index: last 5
years
  C_dat <- DLM_data@Cat[x, ind]
  if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
      ylast + 1) {
    TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  }
  else {
    TACstar <- rep(DLM_data@MPrec[x], reps)
  }
  step <- stepsz * TACstar
  Lrecent <- mean(DLM_data@ML[ind2],na.rm=T) #mean of recent ML
  Lave <- mean(DLM_data@ML[ind],na.rm=T)            #mean of average ML - 1999-2008
  rat <- Lrecent/Lave
  if (rat < llim[1]) {
    TAC <- TACstar - 2 * step
  }
  else if (rat < llim[2]) {
    TAC <- TACstar - step
  }
  else if (rat > llim[3]) {
    TAC <- TACstar + step
  }
  else {
    TAC <- TACstar
  }
  TACfilter(TAC)
}
```
Ltarget0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, xL = 1.05)
```
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 15): (ylast-6)) # Reference period for CATCH (1999-2008)
ind2 <- ((ylast - (yrsmth - 1)):ylast) #period for index: last 5 years
  C_dat <- DLM_data@Cat[x, ind]
  TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat,na.rm=T), DLM_data@CV_Cat/(yrsmth^0.5))
  Lrecent <- mean(DLM_data@ML[ind2],na.rm=T) #mean of recent ML
  Lave <- mean(DLM_data@ML[ind],na.rm=T)     #mean of average ML - 1999-2008
  L0 <- 0.9 * Lave
  Ltarget <- xL * Lave
  if (Lrecent > L0) {
    TAC <- TACstar * (1 + ((Lrecent - L0)/(Ltarget - L0)))
  }
  else {
    TAC <- TACstar * (Lrecent/L0)^2
  }
  TACfilter(TAC)
}
```

Snowy Grouper

```
Tier3BStatusQuo_ABC<-function(x,DLM_data,reps){
 AverC<-mean(c(DLM_data@Cat[x,23:39])) #Years 23-39 of 45 year historical period [1992-2008]
 AverC }
CC1_Ref<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 22): (ylast-6)) #Reference period for CATCH (1992-2008)
 C_dat <- DLM_data@Cat[x, ind]
 TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
 TACfilter(TAC)
}
CC1<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
{
  C_dat <- DLM_data@Cat[x, (length(DLM_data@Year) - (yrsmth -
     1)):length(DLM_data@Year)]
  TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  TACfilter(TAC)
}
```

Speckled Hind

```
Tier3BStatusQuo_ABC<-function(x,DLM_data,reps){
 AverC<-mean(c(DLM_data@Cat[x,23:39])) #Years 23-39 of 45 year historical period [1992-2008]
 AverC }
CC1_Ref<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 22): (ylast-6)) #Reference period for CATCH (1992-2008)
 C_dat <- DLM_data@Cat[x, ind]
 TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
 TACfilter(TAC)
}
CC1<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
{
  C_dat <- DLM_data@Cat[x, (length(DLM_data@Year) - (yrsmth -
     1)):length(DLM_data@Year)]
  TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  TACfilter(TAC)
}
```

Lesser Amberjack

```
Tier3AStatusQuo_ABC<-function(x,DLM_data,reps){
 AverC<-mean(c(DLM_data@Cat[x,51:59])) #Years 51-59 of 65 year historical period [2000-2008]
 sdC<-sd(c(DLM_data@Cat[x,51:59]))
 AverC+(1*sdC)}
CC1_Ref<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 14): (ylast-6)) #Reference period for CATCH (2000-2008)
```

```
  C_dat <- DLM_data@Cat[x, ind]
  TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  TACfilter(TAC)
}
Islope0<-function (x, DLM_data, reps = 100, yrsmth = 5, lambda = 0.4, xx = 0)
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 14): (ylast-6)) # Reference period for CATCH (2000-2008)
  ind2 <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #period for index: last 5
years
  C_dat <- DLM_data@Cat[x, ind]
  if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
      ylast + 1) {
    TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  }
  else {
    TACstar <- rep(DLM_data@MPrec[x], reps)
  }
  I_hist <- DLM_data@Ind[x, ind2] #period for index: last 5 years
  yind <- 1:yrsmth
  slppar <- summary(lm(I_hist ~ yind))$coefficients[2, 1:2]
  Islp <- rnorm(reps, slppar[1], slppar[2])
  TAC <- TACstar * (1 + lambda * Islp)
  TACfilter(TAC)
}
Itarget0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, Imulti = 1.5)
{
  ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
  ind <- c((ylast - 14): (ylast-6)) # Reference period for CATCH (2000-2008)
  ind2 <- ((ylast - (yrsmth - 1)):ylast) #period for index: last 5 years
  C_dat <- DLM_data@Cat[x, ind]
  TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat,na.rm=T), DLM_data@CV_Cat/(yrsmth^0.5))
  Irecent <- mean(DLM_data@Ind[x, ind2],na.rm=T) #mean of recent Index
  Iave <- mean(DLM_data@Ind[x, ind],na.rm=T)     #mean of average Index - 2000-2008
  Itarget <- Iave * Imulti
  I0 <- 0.8 * Iave
  if (Irecent > I0) {
    TAC <- TACstar * (1 + ((Irecent - I0)/(Itarget - I0)))
  }
  else {
    TAC <- TACstar * (Irecent/I0)^2
  }
  TACfilter(TAC)
}
--------------------------------------------------------------------------------------------------------------------------
Almaco Jack
Tier3AStatusQuo_ABC<-function(x,DLM_data,reps){
  AverC<-mean(c(DLM_data@Cat[x,51:59])) #Years 51-59 of 65 year historical period [2000-2008]
  sdC<-sd(c(DLM_data@Cat[x,51:59]))
```

```
 AverC+(1*sdC)}
CC1_Ref<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0)
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 14): (ylast-6)) #Reference period for CATCH (2000-2008)
 C_dat <- DLM_data@Cat[x, ind]
 TAC <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
 TACfilter(TAC)
}
Islope0<-function (x, DLM_data, reps = 100, yrsmth = 5, lambda = 0.4, xx = 0)
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 14): (ylast-6)) # Reference period for CATCH (2000-2008)
 ind2 <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #period for index: last 5
years
 C_dat <- DLM_data@Cat[x, ind]
 if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
     ylast + 1) {
   TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
  }
 else {
   TACstar <- rep(DLM_data@MPrec[x], reps)
  }
 I_hist <- DLM_data@Ind[x, ind2] #period for index: last 5 years
 yind <- 1:yrsmth
 slppar <- summary(lm(I_hist ~ yind))$coefficients[2, 1:2]
 Islp <- rnorm(reps, slppar[1], slppar[2])
 TAC <- TACstar * (1 + lambda * Islp)
 TACfilter(TAC)
}
Itarget0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, Imulti = 1.5)
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 14): (ylast-6)) # Reference period for CATCH (2000-2008)
 ind2 <- ((ylast - (yrsmth - 1)):ylast) #period for index: last 5 years
 C_dat <- DLM_data@Cat[x, ind]
 TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat,na.rm=T), DLM_data@CV_Cat/(yrsmth^0.5))
 Irecent <- mean(DLM_data@Ind[x, ind2],na.rm=T) #mean of recent Index
 Iave <- mean(DLM_data@Ind[x, ind],na.rm=T)     #mean of average Index - 2000-2008
 Itarget <- Iave * Imulti
 I0 <- 0.8 * Iave
 if (Irecent > I0) {
   TAC <- TACstar * (1 + ((Irecent - I0)/(Itarget - I0)))
  }
 else {
   TAC <- TACstar * (Irecent/I0)^2
  }
 TACfilter(TAC)
}
```

```
LstepCC0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, stepsz = 0.05,
          llim = c(0.96, 0.98, 1.05))
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 14): (ylast-6)) # Reference period for CATCH (2000-2008)
 ind2 <- (length(DLM_data@Year) - (yrsmth - 1)):length(DLM_data@Year) #period for index: last 5
years
 C_dat <- DLM_data@Cat[x, ind]
 if (is.na(DLM_data@MPrec[x]) || length(DLM_data@Year) ==
    ylast + 1) {
  TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat), DLM_data@CV_Cat/(yrsmth^0.5))
 }
 else {
  TACstar <- rep(DLM_data@MPrec[x], reps)
 }
 step <- stepsz * TACstar
 Lrecent <- mean(DLM_data@ML[ind2],na.rm=T) #mean of recent ML
 Lave <- mean(DLM_data@ML[ind])         #mean of average ML - 2000-2008
 rat <- Lrecent/Lave
 if (rat < llim[1]) {
  TAC <- TACstar - 2 * step
 }
 else if (rat < llim[2]) {
  TAC <- TACstar - step
 }
 else if (rat > llim[3]) {
  TAC <- TACstar + step
 }
 else {
  TAC <- TACstar
 }
 TACfilter(TAC)
}
Ltarget0<-function (x, DLM_data, reps = 100, yrsmth = 5, xx = 0, xL = 1.05)
{
 ylast <- (DLM_data@LHYear - DLM_data@Year[1]) + 1
 ind <- c((ylast - 14): (ylast-6)) # Reference period for CATCH (2000-2008)
 ind2 <- ((ylast - (yrsmth - 1)):ylast) #period for index: last 5 years
 C_dat <- DLM_data@Cat[x, ind]
 TACstar <- (1 - xx) * trlnorm(reps, mean(C_dat,na.rm=T), DLM_data@CV_Cat/(yrsmth^0.5))
 Lrecent <- mean(DLM_data@ML[ind2],na.rm=T) #mean of recent ML
 Lave <- mean(DLM_data@ML[ind],na.rm=T)   #mean of average ML - 2000-2008
 L0 <- 0.9 * Lave
 Ltarget <- xL * Lave
 if (Lrecent > L0) {
  TAC <- TACstar * (1 + ((Lrecent - L0)/(Ltarget - L0)))
 }
 else {
  TAC <- TACstar * (Lrecent/L0)^2
```

```
  }
  TACfilter(TAC)
}
```

SEDAR

Southeast Data, Assessment, and Review

SEDAR 49

Gulf of Mexico Data-limited Species

Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, Lesser Amberjack

SECTION IV: Research Recommendations

SEDAR
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1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 LIFE HISTORY RESEARCH RECOMMENDATIONS

Red Drum

The SEDAR 49 Gulf of Mexico data-limited stock assessment represents the initial attempt at assessing Gulf of Mexico Red Drum since the federal harvest moratorium. A comprehensive review of the literature, as well as inclusion of the most recent datasets available, provided the most up to date life history information possible (Table 2.12.1, 2.12.4). Through this review of the literature, it is apparent that GOM Red Drum remain a data-limited species. Below we provide the following research recommendations:

1. Increase offshore sampling across the entire GOM, especially at the individual school level, for biological samples (e.g., meristics, otoliths, reproductive tissues, fin clips). We recommend purse seine as the least size-selective sampling gear for this species in offshore waters.
2. Consensus and consistency is needed in assigning calendar age, calculating fractional ages and recording edge type across the GOM to ensure the age data collected are comparable between studies.

3. A concerted effort should be made to identify and record reproductive phase for oocyte development, both macroscopically and histologically. This is particularly true given that the most recent reproductive estimates are greater than 20 years old. Improved quantification (e.g., binary logistic regression) is needed for better point estimates of size and age at 50% and 95% maturity.
4. Collection of tissues (e.g., fin clips) is a low-cost and easy-to-archive means to ensure future studies examining stock delineation, site fidelity, effective population size, etc. for this species are possible.

Lane Snapper

A primary open question in the life history analyses is how the recreational fishery has impacted the stock since the early 1990's. There are no data available to make inferences about how age frequency in the fishery and stock may have changed over the time series.

Primary research needs identified by the team included the following. These are listed below in order of priority based on perceived priority:

1. Increase the precision (by increasing sample size and thorough validation) of estimates of length-at-age and maturity-at-age to provide rigorous estimates. This would require an increase in dockside and at-sea sampling for biostatistical information, especially the collection of otoliths and reproductive tissue.
2. Design random sampling protocol for NMFS Pascagoula's groundfish and small pelagic surveys to collect length- and age-composition of Lane Snapper encountered by these surveys.
3. Perform a survey of the genetic structure of the stock to more precisely understand spatial stock structure, in particular the potential for hybridization with other Lutjanids.

Wenchman

Due to the limited sampling of life history parameters (two months of data in a single year), more research is needed for all life history aspects of Wenchman. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material).
2. An aging study that includes validation with increased sample sizes.
3. Design a random sampling protocol for NMFS Pascagoula groundfish and small pelagic surveys.
4. Collect reproductive maturity estimates.

Yellowmouth Grouper

Additional research is needed to obtain more recent estimates of all life history parameters for Yellowmouth Grouper. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase in dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material) for the GOM.
2. Conduct an updated age and growth study for GOM samples, including a validation study based on radiochemical dating.
3. Conduct an updated reproductive study for the GOM to examine not only maturity but the size and age of transition.

Snowy Grouper

Additional research is needed to obtain more recent estimates of all life history parameters for Snowy Grouper in the GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase in dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material) for the GOM.
2. Conduct an updated age and growth study for GOM samples, which also includes a more extensive validation study based on radiochemical dating (see Harris 2005).
3. An increase in dockside and other sampling programs to complete a more comprehensive and an updated reproductive study for GOM to examine not only maturity but size and age of transition.

Speckled Hind

Additional research is needed to obtain estimates of all life history parameters for Speckled Hind in the northern GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following:

1. Increase in dockside and at-sea sampling for biological samples (age structures, reproductive tissues, and genetic material) for the GOM.
2. Conduct an updated age and growth study for GOM samples, using the new criteria of counting narrower groups of translucent and opaque band

increments on the dorsal side of the otolith (as described in Andrews et al. 2013).

3. An increase in dockside and other sampling programs to complete a more comprehensive and an updated reproductive study for the GOM to examine not only maturity but size and age of transition.

Lesser Amberjack

Additional research is needed to obtain estimates of all life history parameters for Lesser Amberjack in the GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following.

1. Increase in dockside and at-sea sampling for biological samples including age structures, reproductive tissues, and genetic material.
2. While age has been attempted, finding an appropriate aging methodology that includes a way to validate age using multiple hard structures is suggested.
3. Further research is needed for natural mortality estimates.
4. Need for reproductive tissue to examine maturity.

Almaco Jack

Additional research is needed to obtain estimates of all life history parameters for Lesser Amberjack in the GOM. This includes aging, reproduction and maturity, and estimation of growth parameters.

Primary research needs identified by the LHWG included the following.

1. Increase in dockside and at-sea sampling for biological samples including age structures, reproductive tissues, and genetic material.
2. While age has been attempted, finding an appropriate aging methodology that includes a way to validate age using multiple hard structures is suggested.
3. Further research is needed for natural mortality estimates.
4. Need for reproductive tissue to examine maturity.

1.2 COMMERCIAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

Further development of methods for calculating overall uncertainty when summing total removals from commercial, recreational, and other fisheries (e.g., shrimp and other trawl fisheries). Methods should account for differences in programs; e.g., some programs provide CVs while others produce ranges of uncertainty based upon expert opinion.

Develop more robust estimates of discard mortality for all SEDAR 49 species from each sector of the commercial fishery.

Develop methods to more appropriately estimate uncertainty of discard estimates from each sector of the commercial fishery.

Red Drum

Develop data collection methods to enable investigation of the magnitude of bycatch in the Gulf of Mexico menhaden fishery for Red Drum. Investigate the impact of menhaden fishery bycatch on stock assessments.

Lane Snapper

Develop appropriate sampling methods to determine the size composition of Lane Snapper caught as bycatch in Gulf of Mexico shrimp fisheries.

Wenchman

During the Data Workshop, a northern Gulf of Mexico finfish trawl fishery (likely targeting Butterfish) was identified as being the primary commercial fishery for Wenchman. That fishery was recommended as the representative fleet for Wenchman. Further investigation of that finfish trawl fishery is recommended. Data sources useful for accurately determining targeting, effort, and landings of the fishery should be identified.

Develop appropriate sampling methods to determine the size composition of Wenchman caught as bycatch in Gulf of Mexico shrimp fisheries.

Yellowmouth Grouper

Develop genetic markers for species identification and determine the frequency of misidentification of Yellowmouth Grouper.

Use port samplers to determine the frequency of Yellowmouth Grouper misidentification or misreporting.

Snowy Grouper

No research recommendations were suggested for Snowy Grouper.

Speckled Hind

No research recommendations were suggested for Speckled Hind.

Lesser Amberjack

Use port samplers to determine the frequency of Lesser Amberjack misidentification or misreporting.

Almaco Jack

Use port samplers to determine the frequency of Almaco Jack misidentification or misreporting.

1.3 RECREATIONAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

Red Drum

- Improve discard length and age data collection in the recreational fishery.
- Develop directed effort estimates.
- Investigate self-reported discards to determine if there is bias or misidentification in the data.
- Determine implications of gaps in the available recreational discard data.

Lane Snapper

- Improve discard length and age data collection in the recreational fishery.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

Wenchman

- Improve discard length and age data collection in the recreational fishery.
- Determine whether species identification issues (not commonly known in the recreational fishery) affect reported landings/discards.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

Yellowmouth Grouper

- Improve discard length and age data collection in the recreational fishery.

- Determine whether species is underreported and the percentage of landings/discards underreported due to species misidentification as Scamp or Black Grouper.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.
    - Species that are not typically targeted (ex: Yellowmouth Grouper) may benefit from a higher-level directed effort estimate (ex: shallow water grouper effort), as they are frequently caught in conjunction with associated species.

Snowy Grouper

- Improve discard length and age data collection in the recreational fishery.
- Determine whether species is underreported and the percentage of landings/discards underreported due to species misidentification as Black Grouper or Warsaw Grouper.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

Speckled Hind

- Improve discard length and age data collection in the recreational fishery.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.
- Investigate self-reported discards to determine if there is bias or misidentification in the data.
- Determine implications of gaps in the available recreational discard data.

Lesser Amberjack

- Improve discard length and age data collection in the recreational fishery.
- Determine effect of misreporting due to species misidentification as Banded Rudderfish or Greater Amberjack.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.

Almaco Jack

- Improve discard length and age data collection in the recreational fishery.
- Determine whether dead discards are underestimated in TX due to targeted bait fishery.
- Reliable estimates of discard mortality.
- Develop directed effort estimates.
    - In Texas there is a unique bait fishery which targets Almaco Jack. It was noted that b1 may be underestimated in Texas. It may be worth investigating the directed effort from this fishery.
- Investigate self-reported discards to determine if there is bias or misidentification in the data.

- Determine implications of gaps in the available recreational discard data

1.4 TOTAL REMOVALS RESEARCH RECOMMENDATIONS

See recommendations in Sections 3.6 and 4.6.

1.5 MEASURES OF FISHING EFFORT RESEARCH RECOMMENDATIONS

See recommendations in Sections 3.6 and 4.6.

1.6 INDICES OF POPULATION ABUNDANCE RESEARCH RECOMMENDATIONS

Red Drum

Given the importance of Red Drum to the recreational fishing interests of the Gulf Coast States, it was surprising to find that a survey designed to comprehensively sample both the near shore and offshore portions of the Gulf of Mexico stock does not exist. It is recommended that discussions be initiated into expanding an existing survey or developing a new survey to sample and characterize the composition and relative abundance of the Gulf of Mexico Red Drum stock, especially in federally managed waters where little data are available.

Lane Snapper

No research recommendations were suggested for Lane Snapper.

Wenchman

The small pelagics survey used as the index of abundance for SEDAR 49 is no longer in operation. The deep-water sampling of this survey provided the only data on a largely otherwise un-surveyed portion of the Gulf of Mexico Wenchman stock. Additional resources need to be put forward to promote and expand deep-water sampling efforts in the Gulf for species like Wenchman and numerous other deep-water species.

Yellowmouth Grouper

Additional information about Yellowmouth Grouper distribution and habitat utilization is needed to determine if low counts in the reef fish video survey are due to low abundance or survey habitat mismatch.

Snowy Grouper

Surveys designed to better cover deep-water habitat are needed to adequately sample the Snowy Grouper stock as well as many other reef fish managed under the reef fish FMP.

Speckled Hind

Surveys designed to better cover deep-water habitat are needed to adequately sample the Speckled Hind stock as well as many other reef fish managed under the reef fish FMP.

Lesser Amberjack

Species identification issues are of paramount concern for Lesser Amberjack, especially when dealing with fishery-dependent data sources. Efforts should be undertaken to determine whether port sampling data can be used to estimate the rate at which species like Lesser Amberjack are misidentified on an annual basis. This information could be used to adjust fishery-dependent landings data, allowing them to be used to construct indices of relative abundance.

Almaco Jack

Species identification issues are of paramount concern for Almaco Jack, especially when dealing with fishery-dependent data sources. Efforts should be undertaken to determine whether port sampling data can be used to estimate the rate at which species like Almaco Jack are misidentified on an annual basis. This information could be used to adjust fishery-dependent landings data, allowing them to be used to construct indices of relative abundance.

1.7 LENGTH FREQUENCY RESEARCH RECOMMENDATIONS

Red Drum

- Continue and expand fishery-independent collection efforts to collect length measurements at varying sizes, seasons or months, and locations, particularly for offshore Red Drum

Lane Snapper

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months
- Pursue statistical approaches to address sampling inconsistencies between random selection of small and large individuals in the SEAMAP groundfish survey, which could enable the use of length composition derived from the SEAMAP groundfish survey

Wenchman

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months

- Create sampling protocols to obtain lengths from NMFS Pascagoula small pelagic survey

Yellowmouth Grouper

- Expand collection efforts to collect genetic samples to ensure species identification along with length measurements at varying locations, seasons or months

Snowy Grouper

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months

Speckled Hind

- Continue and expand collection efforts to collect length measurements at varying locations, seasons or months

Lesser Amberjack

- Expand collection efforts to collect genetic samples to ensure species identification along with length measurements at varying locations, seasons or months

Almaco Jack

- Expand collection efforts to collect genetic samples to ensure species identification along with length measurements at varying locations, seasons or months

1.8 AGE FREQUENCY RESEARCH RECOMMENDATIONS

Red Drum

- Develop common practices for aging, interpreting edge, assigning annual or co-hort age, and calculating fractional age (or biological age) for Red Drum across federal and state agencies
- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations, particularly for offshore fish

Lane Snapper

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations

- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001)

Wenchman

- Increase collection of age samples at varying sizes, seasons or months, and locations
- Determination of the reproductive season to assist in determining when growth increments are deposited
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001)

Yellowmouth Grouper

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

Snowy Grouper

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

Speckled Hind

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

Lesser Amberjack

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Improvement of methods for aging *Seriola* sp. due to the difficulty in interpreting annuli marks

- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001)

Almaco Jack

- Expand collection efforts to collect age samples at varying sizes, seasons or months, and locations
- Improvement of methods for aging *Seriola* sp. due to the difficulty in interpreting annuli marks
- Validation of annual increments using methods such as tag and recapture, mark-recapture of chemically tagged fish, captive rearing from hatch, and radiochemical dating (Campana 2001).

2. ASSESSMENT WORKSHOP RESEARCH RECOMMENDATIONS

A number of research recommendations were identified throughout the SEDAR 49 stock evaluation and are described below. Research recommendations for improvements to input data, which were provided at the end of each relevant section in the Data Report, are also reiterated by the analysts.

1. Fine-tuning of the index-based and length-based methods reported herein to achieve target performance metrics (e.g. probability of not overfishing closest to 50% or the highest LTY).

2. Exploration of the cost or benefit of specifying an operating model incorrectly and how this influences method selection over a range of operating model input parameters.

3. Calculation and presentation of performance metrics in relation to the status quo rather than a reference method.

4. Simulation testing of the non-equilibrium mean length estimator and yield-per recruit approach to assess method performance in comparison to other available methods, as well as testing different assumptions inherent in the approach (e.g. whether to use a time series of recent total removals or the terminal year's total removals in catch recommendations).

5. Evaluation of the updated Hoenig equation (described in Then et al. 2014) for estimating natural mortality using maximum age. The updated equation tends to produce higher estimates of natural mortality, which can have important implications for applications such as the mean length estimator.

6. Region-specific estimates of correlation coefficients for growth parameters derived from growth curves specific to the Gulf of Mexico.

7. Investigation of more justifiable estimates of stock depletion such as through Productivity-Susceptibility Analysis (Cope et al. 2015).

8. Estimation of current stock abundance from tagging studies (e.g. Red Drum), which could be used in methods such as the Beddington and Kirkwood (2005) approach.

9. Identification of a reference period for catches for Red Drum.

10. Discussions regarding the appropriateness of the reference period selected for each species.

11. Evaluation of the appropriateness of target catch or index levels which could be used in conjunction with catch and index time series.

12. Evaluation of the appropriateness of target length levels which could be used in conjunction with catch and a length frequency series.

13. Incorporation of observation error into the application of index-based (Islope0, Itarget0) and length-based (Ltarget0, LstepCC0) methods.

14. Future data-limited assessments should ensure that the reliability scores for data inputs are agreed upon at the conclusion of the Data Workshop to provide a more quantitative means of weighting methods for catch recommendations.

Within the modeling framework used in SEDAR 49, many limitations are acknowledged within the MSE approach. Pragmatically, results are a product of the specific conditions of the simulation, which are assumed to be as simplistic as possible but contain sufficient complexity to reflect the system in a representative way. Thus, additional considerations towards confirmation of the stock and fleet subclass components of the operating models explored in SEDAR 49 are warranted. In addition, no implementation error was considered in the current analysis which employed the DLMtool Version 3.2.1.

Recommendations for enhancing the practical use of the DLMtool from the analytical team.

1. Revisions of the DLMtool software to enhance the model functionality to allow multiple fishing fleets.

2. Revision of the DLMtool software to allow age varying natural mortality.

3. Allow for implementation error of the harvest control rule (e.g. catch recommendation overages) within the implementation model in the MSE.

3. REVIEW PANEL RESEARCH RECOMMENDATIONS

- Sea sampling programs to better quantify discards and discard mortality for all the eight species.

- The choice of reference time period for Tier 3A and Tier 3B stocks needs to be re-visited given the new information available and possible changes in the ecosystems.

- The operating model simulates the population dynamics of a given species conditional on the assumed depletion level which is usually unknown. Although the base case scenario for depletion level was developed for each species based on the best available information and a sensitivity analysis was conducted for alternative depletion levels, a reality check may be necessary to help simulate a fishery that realistically reflects the dynamics of fishery of interests. Reliable information on the fishery and population (e.g., temporal trend of fishing efforts, fishery-dependent and fishery-independent abundance indices and biological information such as age- and length compositions) needs to be collected to help define possible depletion level. These data can be used to tune the operating model parameterization to improve the fishery simulation realism by the operating models. Further, a number of surveys were considered at the DW but not all of them were deemed appropriate to inform a stock assessment. It is important to revisit the design of the surveys to ascertain whether changes could be made to get more value out of those surveys. The Review Panel also recommends that more time is spent to identify the methodology and indicators that are best for the type of exploitation and species we have. Trying to calculate MSY and other conventional metrics might not be the most appropriate approach especially for species that are caught as bycatch. Similarly, collecting all the data that are needed to do a proper stock assessment is a very big task and it is important to identify some interim approaches such as using indicator species (to represent a complex of species) or maybe use the status of the targeted stock as a proxy for the status of the by-catch species.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 49

Gulf of Mexico Data-limited Species:

Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, Lesser Amberjack

SECTION V: Review Workshop Report

November 2016

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

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1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 49 Review Workshop was held November 1-3, 2016 in Miami, Florida.

1.2 TERMS OF REFERENCE

1. Review any changes in data following the Data/Assessment workshop and any analyses suggested by the workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data/Assessment Workshop recommendations.
2. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:
   a) Are data decisions made by the DW and AW sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
3. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:
   a) Are the data-limited methods scientifically sound and robust?
   b) Are the methods appropriate given the available data?
   c) Are the data-limited models configured properly and used in a manner consistent with standard practices?
   d) Are the quantitative estimates produced reliable? Does the method produce management metrics (e.g. OFL, ABC) or other indicators (e.g. trends in F or Z,

probability of overfishing) that may be used to inform managers about stock trends and conditions?

4. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
   - Ensure that the implications of uncertainty in technical conclusions are clearly stated.
5. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.
6. Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.
7. Provide guidance on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.
8. Prepare a Peer Review Summary summarizing the Panel’s evaluation of the stock assessment and addressing each Term of Reference.

1.3 LIST OF PARTICIPANTS

Workshop Panel

Luiz Barbieri, Chair .... Gulf SSC
Panayiota Apostolaki .... CIE Reviewer
Yong Chen .... CIE Reviewer
Jamie Gibson .... CIE Reviewer
Kai Lorenzen .... Gulf SSC
Joe Powers .... Gulf SSC

Analytic Representation

Skyler Sagarese .... SEFSC, Miami
Jeff Isely .... SEFSC, Miami
Shannon Cass-Calay .... SEFSC, Miami

Appointed Observers

Ben Blount .... Gulf SSC
Claudia Friess .... Gulf Appointee

Attendees

Shanae Allen ....FWRI
Jay Grove ....FWC
Bill Harford...Univ. of Miami
Matthew Johnson ....SEFSC
Mike Larkin .... SERO
Michelle Masi ....FWRI
Kevin McCarthy..SEFSC
Michael Schirripa..SEFSC
Matthew Smith..SEFSC
Beth Wrege ....SEFSC

Staff

Julie Neer .... SEDAR
Ryan Rindone...GMFMC Staff
Charlotte Schiaffo ....HMS

1.4 LIST OF REVIEW WORKSHOP WORKING PAPERS AND DOCUMENTS

Documents Prepared for the Review Workshop			
SEDAR49-RW-01	Revised Results for the Generic Implementation of Itarget0 and Ltarget0 for Lane Snapper, Wenchman, Lesser Amberjack, and Almaco Jack	Skyler R. Sagarese, J. Jeffery Isely, and Matthew W. Smith	21 October 2016

2. REVIEW PANEL REPORT

Executive Summary

The Review Workshop Panel was presented outputs and results of the SEDAR 49 stock assessment of Gulf of Mexico data-limited species: Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, and Lesser Amberjack. Multiple analytical models were used to conduct this assessment. The Data-Limited Methods Toolkit (DLMtool), a software program that allows evaluation of the performance of multiple data-limited assessment models in a simulation environment using management strategy evaluation (MSE), was the primary modeling platform used in this assessment to estimate reference or target catch levels. In addition to the DLMtool, a mean length estimator approach assuming non-equilibrium conditions was used to estimate total mortality from length-frequency data. Lastly, a catch curve analysis was employed where possible to estimate the total mortality rate (Red Drum only). Data used in the assessment include stock identification and life history information, fisheries catch and effort data, abundance indices, as well as assumptions about stock depletion and for some methods, choice of a reference period for indices or mean length information. In general, the assessment input data series are reliable and were applied properly given the data-limited assessment approach used. The data and information requirements for use of the DLMtool appear substantial relative to the information that is available for these specific stocks. Uncertainties in most data inputs were acknowledged and reported and most are within expected levels. Possible exceptions are uncertainties in inputs regarded as 'assumptions' rather than data, such as the depletion level or choice of index reference period. Although the Review Panel concluded that the SEDAR 49 assessments represent the best scientific information available it also recognized that the methods used only provide general guidance towards catch advice. Therefore, the outcomes of this analysis do not correspond to the traditional management estimates produced in data rich assessments (e.g., MSY or its proxy). Further, the DLMtool approach is still under development and adjustments to better fit Gulf of Mexico stocks are still required.

2.1 Statements Addressing Each ToR

1. *Review any changes in data following the Data/Assessment workshop and any analyses suggested by the workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data/Assessment Workshop recommendations.*

The data and analyses reviewed and initiated during the Data/Assessment workshops were examined during this Review Workshop. There were a number of additional tests that were requested to help guide the Review Panel in deliberations on the efficacy of the analyses. All of these may be categorized as either: (1) additional diagnostics for evaluating the methods used; or (2) additional sensitivity analyses to better understand the uncertainty of the methods as they were applied to the species/stocks of concern. All sensitivity analyses were conducted for all species except for alternative values of M for red drum.

The additional diagnostics that were requested were to include the interquartile range in the simulation trajectories instead of 5th and 95th percentiles; and to examine the trajectories of selected individual simulation runs. Both of these cases were desired since the trajectories expressed as simply a median and 5th and 95th percentiles for each year tends to mask the dynamic behavior that might occur in the simulation trajectories. Interquartile ranges narrow the interval and are probably more akin to risks addressed in most decision-making frames. Adding the interquartile range to the plots with the 5th and 95th percentiles would better display the distribution of the simulation results.

Examination of individual runs are useful for evaluating the variability exhibited by a simulated population from year to year and provides a qualitative method for evaluating the plausibility of the simulated population trajectories.

Additionally, simulation sensitivities were included. The first was to impose annual variability in growth parameters, specifically L_∞ of the von Bertalanffy growth equation. This was done because growth is known to vary through time for some species. Also, the panel wanted to look at potential differences in outcomes if there was plasticity in growth that responded to the environment. The variability imposed was approximately 15-20%. Results show an increased uncertainty in performance measures and the probability of achieving them.

The panel also wanted to better understand the performance of the methods when the index of abundance was of poorer quality. The original tests were conducted with a CV of 24%. Therefore, additional runs were done in which the CV of the observation error on the index was increased from the original tests to either 50% or 100%. Performance measure uncertainty increased, but not greatly so.

Ideally, one would do a stock assessment on a regular basis and then change catch recommendations based on the stock assessment. With data poor species this is not possible, so the methods being utilized are designed to provide a catch recommendation based on limited index information from a fixed decision interval. The initial tests used ten years. At the request of the Review Panel a three-year decision interval was conducted rather than the original 10-year interval. Results from these sensitivity analyses were not consistent for all species. Increasing the frequency of the assessment did increase the frequency at which catch recommendations could change, which for some species did change the longer term yield (e.g. Red Drum).

The methods utilizing an index are predicated on the index being proportional to abundance. But what happens if it is not? The beta parameter is a simple way to impose a nonlinear relationship between abundance and the index. This is done by making the index proportional to the abundance exponentiated by beta. Betas less than 1 imply hyper-stability in which large changes in biomass are not reflected by large changes in the index (the index is more stable than the biomass). In base model runs, a uniform distribution for beta was assumed with bounds of 0.33

and 3.0. At the request of the Review Panel betas values of 1.0 were examined. In general, the probability of not overfishing, the probability that the biomass was greater than 50% of Bmsy and yields all increased very slightly when beta was fixed at 1.0, although differences were negligible. .

The Panel wanted to see a run in which the steepness parameter is fixed at the lower bound of the range that was originally tested. As expected, in most, but not all cases (e.g. Lane Snapper, LstepCC0 model), the probability of not being overfished decreased relative to the base case. For some species, the number of operating models meeting the selection criteria changed when steepness was fixed at a lower value..

The base case red drum utilized a natural mortality rate, M, of 0.06. The panel felt that given that most of the fishery is inshore where natural mortality rates would be expected to be higher. Therefore, a sensitivity run in which M ranged from 0.16 to 0.184 was conducted.

In general, these analyses showed some sensitivity in the results to input variation. Nevertheless, key performance measures such as the probability of not being overfished were usually in an acceptable range (~80%), although in some cases the options for operating models did change. However, this is predicated on the specification of initial depletion related to the classification of species as specified by the Gulf Council's ABC Control Rule tiers 3-A or 3-B.

2. *Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:*
   a) *Are data decisions made by the DW and AW sound and robust?*

Data used in the assessment include stock identification and life history information, fisheries catch and effort data, abundance indices, as well as assumptions about stock depletion and for some methods, choice of a reference period.

Stock Identification

For all stocks, a single, separate, Gulf stock was assumed. For Red Drum, there is evidence of genetic divergence in the northern GOM, but specific populations have not been delineated. Some uncertainty was noted with respect to stock identification of Lane Snapper (some genetic evidence for separate Western and Eastern Gulf stocks, as well as for hybridization with Yellowtail Snapper). No genetic or other data suitable for stock identification were available for the remaining species considered in this assessment (Wenchman, Yellowmouth Grouper, Snowy Grouper, Speckled Hind, Lesser Amberjack, and Almaco Jack). Stock structure information for more extensively studied, related species was used to support the single stock assumption for the latter species and or Lane Snapper (SEDAR 2016). The stock identification decisions appear practical in the light of very limited data.

Life History Information

Growth: Body growth data were available for all stocks except Lesser Amberjack (growth information from the South Atlantic used) and Almaco Jack (no growth information at all, growth inferred from information about Greater Amberjack). Growth was described using a constant, standard von Bertalanffy growth function. This is the only growth modeling option offered by the DLMtool and is in line with common practice even in data-rich assessments in the Southeastern U.S. Growth in Red Drum has previously been shown to be better described by a bi-phasic model (Porch et al. 2002). Simulation testing during the Review Workshop of implications of temporal variation in growth for the performance of management procedures has shown that growth variation reduces the performance of procedures involving the use of mean length indices. Empirical analysis of temporal growth variation at the stock level could help identify stocks in which management procedures involving size indices may perform well (i.e. stocks with limited temporal growth variation).

Natural mortality: Natural mortality (*M*) was described by a constant rate for the exploited size/age groups, the only option available in DLMtool. Conversely, many data-rich assessments in the Southeastern region account for size/age-dependence in mortality rates. This is unlikely to be a major concern for the data-poor assessments, however. The only case where use of an age-dependent *M* could affect results is in the case of Red Drum since harvesting is largely restricted to juveniles which may have different natural mortality rates than the larger/older individuals in the spawning stock. No direct estimates of *M* were available for any stock except for Red Drum where, given closure of the fishery in federal waters, total mortality *Z* in the spawning stock may approximate *M*. Only one empirical estimator was used to generate *M* estimates: the revised Hoenig estimator of Then *et al*. 2014. Uncertainty in *M* was characterized as the range of point estimates obtained from the revised Hoenig estimator for plausible values of maximum age. The uncertainty generated in this way is likely to underestimate true uncertainty in *M* because the *M* estimator itself is associated with prediction uncertainty not reflected in the range of point estimates. Moreover, the use of only one empirical *M* predictor, as opposed to multiple predictors based on a suite of different life history characteristics, may underestimate uncertainty and represents a departure from previous practice. There is ongoing research about the most appropriate approach to estimation of *M* and best practices are expected to continue to evolve..

Maturity: Maturity (length at 50% maturity) information was available from biological sampling for all species except Wenchman, Lesser Amberjack and Almaco Jack. Information from related or similar species was used where information from direct sampling was not available. An alternative approach would have been to use life history invariants.

Steepness: No direct estimates for steepness (*h*) were available for the stocks considered. Plausible ranges for *h* were determined from reviews conducted as part of previous SEDAR assessments and from comparative information on related species.

Removals (Landings and Dead Discards)

Total removals (in weight) were calculated as the sum of commercial landings + commercial dead discards + recreational landings + recreational dead discards. Uncertainty in total removals was estimated by propagating uncertainty estimated for individual components.

Commercial landings were constructed using data housed in NOAA's Southeast Fisheries Science Center's Accumulated Landings System (ALS). The ALS includes landings data beginning in 1962, the terminal year for SEDAR 49 was 2014. Uncertainty estimates were provided for the landings of each species and accounted for species misidentification, landings reported by species group, and differences among states in the implementation of trip ticket programs. The workgroup used expert opinion to estimate landings uncertainty for each species. For most species, the commercial landings data were considered adequate for assessment analyses.

Recreational landings were obtained from multiple sampling programs including the Marine Recreational Fisheries Statistics Survey (MRFSS) and the Marine Recreational Information Program (MRIP), the Southeast Region Headboat Survey (SRHS), the Texas Parks and Wildlife Department (TPWD) and the Louisiana Creel Survey. The MRFSS/MRIP provided a long time series of estimated catch-per-unit effort, total effort, landings, and discards for six two-month periods (waves) each year, starting in 1981.

Annual removals associated with dead discards were obtained by multiplying annual numbers of discarded live fish with recommended discard mortality rates and average weights of discarded fish. Discard mortality rates were determined by consensus agreement among data workshop attendees. The recommended values were based on direct fisher input and review of relevant studies. For most of the species, field estimates of discard mortality rates were unavailable and mortality rates associated with similar species were discussed as proxies.

Fishing Effort

The fleet that accounted for the largest proportion of the total removals was selected as the representative fleet for each species. Fishing effort was summed by year for each of the representative fleets. The recreational fishery was recommended by the DW to be the most representative for Red Drum, Lane Snapper, Almaco Jack, and Yellowmouth Grouper. Commercial fisheries were recommended as the most representative for Speckled Hind (bottom longline), Snowy Grouper (bottom longline), Lesser Amberjack (vertical line), and Wenchman (finfish trawl). The effort time series was selected based on concurrent landings information from both the commercial and recreational fisheries. Effort data decisions are sound and well documented.

Abundance Indices

Abundance indices were potentially available from a variety of fisheries-independent and fisheries-dependent surveys. Fisheries-independent surveys considered included:

<u>SEAMAP Summer Groundfish Survey</u>: A collaborative effort between federal, state and university programs, designed to collect, manage and distribute fishery-independent data throughout the region. This semi-annual groundfish trawl survey provides a valuable source of fisheries-independent information on many commercially and recreationally important species throughout the northern Gulf of Mexico (GOM).

MSLABS Small Pelagics Survey: The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories (MSLABS) Small Pelagics Survey was initiated in October of 2002 as an outer shelf and upper slope survey (i.e., between 110 and 500 m station depth). The MSLABS Small Pelagics Survey was selected to provide an abundance index for Wenchman Snapper.

SEAMAP Reef Fish Video Survey: The SEAMAP reef fish video survey provides an index of the relative abundances of fish species associated with topographic features (e.g., reefs, banks, and ledges) located on the continental shelf of the Gulf of Mexico (GOM). SEAMAP Reef Fish Video Survey indices were produced for all SEDAR 49 species with the exception of Red Drum. The SEAMAP Reef Fish Video Survey was selected to provide abundance indices for Yellowmouth Grouper, Snowy Grouper, Lesser Amberjack and Almaco Jack.

NMFS Panama City Laboratory Trap and Camera Survey: Fishery-independent trap survey of natural reefs on the inner shelf of the eastern Gulf of Mexico off Panama City, FL. This survey provides and age-based annual index of abundance for pre-recruit (age 0-3) reef fish. No abundance indices based on this survey were recommended for the data-poor stocks in SEDAR 49.

DISL Bottom Longline Survey: Bottom longline survey operating monthly in the coastal waters of Alabama and Mississippi as well as federal offshore waters from May 2006 through the present by the Dauphin Island Sea Lab (DISL). This survey provides nominal catch per unit effort (CPUE) for Red Drum. The DISL survey was selected to provide an abundance index for Red Drum.

Fishery-dependent surveys included:

Headboat Survey: The Headboat Survey covers the Gulf of Mexico headboats starting in 1986. Total catch per trip is reported in logbooks provided to all headboats. The Headboat survey was selected to provide an abundance index for Lane Snapper.

Marine Recreational Fisheries Statistics Survey (MRFSS)/ Marine Recreational Information Program (MRIP): The MRFSS began in 1981 and provides information on participation, effort, and species-specific catch. No abundance indices based on this survey were recommended for the data-poor stocks in SEDAR 49.

Commercial Logbook: The NMFS Gulf of Mexico Reef Fish Logbook Program collects catch and effort data by trip for permitted vessels that participate in fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. No abundance indices based on this survey were recommended for the data-poor stocks in SEDAR 49.

Despite of consideration of the above, wide range of surveys, no abundance indices were recommended for Snowy Grouper and Speckled Hind. Potential abundance indices were constructed evaluated carefully and the decision process is well documented.

Size-Structure Indices

Some data-limited approaches in the DLMtool use length composition in conjunction with the mean length estimator to calculate current stock abundance or current stock depletion. Length samples were obtained from a variety of fishery-independent and fishery-dependent data sources for all eight species under assessment.

Size structure information was obtained from the NOAA Fisheries Trip Interview Program (TIP) for commercial landings. Length samples for recreational fisheries were obtained from the MRFSS/MRIP surveys, the Southeast Headboat Survey, the TPWD, the Florida Fish and Wildlife Conservation Commission (FWC), the Gulf States Marine Fisheries Commission FIN database (GFIN), and the TIP database.

Where available, length samples were also obtained from fishery-independent surveys including the NMFS small pelagics survey, SEAMAP groundfish survey, SEAMAP reef video survey, Panama City video survey, and Panama City trap survey. For all species except Red Drum and Wenchman, annual sample sizes were too small for analysis.

In addition to length composition data, the DLMtool and mean length estimator approach require information on the selectivity at length including the size at first capture (or size at first recruitment to the gear) and the size at full recruitment to the gear. Length frequency plots for each fleet and gear were used to inform decisions about the size at full recruitment for each species and gear since the assessment approach requires the characterization of a fleet considered most representative in terms of selectivity and exploitation pattern for the simulation.

Stock Depletion

The evaluation of management procedure in the DLMtool requires an estimate of current depletion of the stock. Estimates of current depletion were not available for the majority of the species under assessment during SEDAR 49. An estimate for Red Drum was available from the 2015 FWC assessment which assessed the stock status in Florida waters. For the remaining species under consideration for SEDAR 49, depletion estimates were derived by using ‘similar species/stocks’ that have been assessed using Stock Synthesis as proxies.

The rationale underlying the choice of proxy stocks for depletion estimates is stated only in general terms, selection criteria for the decision process are not well documented. Since the identification of proxies involves consideration of the fishery as well as biological characteristics, such decisions are potentially complex and should be guided by well-defined criteria. Moreover, since stocks assessed by Stock Synthesis tend to be strongly targeted and carefully managed, it is unclear how representative the depletion levels of such stocks are for the data limited, often non-targeted and barely managed stocks.

Reference Period

Some management procedures rely on comparison of abundance or mean length indices to index values derived for a reference period that essentially provides a baseline status associated with the index values during that time period. The choice of a reference period then becomes an important input. Reference periods specified in GMFMC (2011) for seven of the eight species were used, an approach that facilitated comparison of method performance between feasible methods considered during SEDAR 49 and the method currently being used. A reference period for the eighth species, Red Drum, was chosen at the Assessment Workshop. The analytical team explained that the periods were chosen to represent periods of approximately constant catch. The rationale for this criterion is not entirely clear. Indeed, different arguments have been advanced for this criterion, including that stable catches represent conditions associated with MSY, a sustainable catch level, or at least stability in exploitation. None of these arguments are necessarily true: stable yield and biomass can be achieved at any sustainable level of exploitations (not just MSY), including in a state of severe yet sustainable overfishing. Stable catches can also be associated with increasing exploitation levels in a declining stock, i.e. they are not even necessarily associated with stability in the fishery. It is important that the rationale for the setting of reference periods and the specific criteria and decision processes are more explicitly motivated and reported.

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Uncertainties in most data inputs have been acknowledged and reported and most are within expected levels. Possible exceptions are uncertainties in inputs regarded as ‘assumptions’ rather than data, such as the depletion level or choice of index reference period. These issues have been discussed in more detail above. Since such assumptions are important inputs to data-limited assessment, greater efforts should be made in future assessments to deal with uncertainty in ‘assumptions’ in the same rigorous and structured manner as is common practice with inputs regarded ‘data’.

The Data Workshop provided a particularly rigorous evaluation of the potential sources of life history. Sources of information were identified via a literature and a reliability rubric, based on sampling considerations, the quality of the data collection and analysis, and the overall reliability of the work, was used to score the work for providing life history parameters for use in the DLM tool. In this way, uncertainties in the life history information was fully acknowledged and clearly reported.

Similarly, the Workshops provided clear explanations of decisions about which surveys were most appropriate for each stock.

Uncertainties are broadly within expected levels. It should be noted that, due to the non-target nature of many of the fisheries and relatively low rates of encounter for many species, uncertainties are expected and found to be fairly large. The possibility of unquantified biases, e.g. due to misidentification of rare species, has been noted.

c) Are data applied properly within the assessment model?

The data are properly applied within the DLMtool, following guidance developed by the tool’s developers and other experts.

d) Are input data series reliable and sufficient to support the assessment approach and findings?

The input data series are generally reliable and sufficient to support the assessment approach and findings. However, the data and information requirements for use of the DLMtool are in fact quite variable and can be substantial for some of the more rigorous applications. The types of information available for the SEDAR 49 stocks shows that some of the Gulf stocks are too data poor for the more rigorous applications of data-poor methods. For stocks where data are sufficient to support use of the DLMtool, substantial efforts are required to prepare data inputs and arrive at well-founded assumptions.

3. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:

Overall, the methods used represent reasonable choices given paucity of data that limits the spectrum of quantitative approaches that could be used. The adoption of a simulation evaluation approach in the context of the DLMtool allows for a relatively abstract and high level consideration of management procedures which reflects the knowledge gaps and adds value to the assessment since it gives an indication of the procedures that might be fit for the nature of species and fisheries studied. However, the adopted approach does pose certain challenges both in terms of the way it is implemented/designed as well as its capabilities for simplifying assessment and development of catch recommendations for management. Furthermore, the Review Panel notes that this method is not meant to replace standard stock assessments and its use does not mean that data collection and knowledge should not be improved. More detailed analyses of this ToR is provided under each of the four questions below.

a) Are the data-limited methods scientifically sound and robust?

The DLMtool is the main package used in this analysis. The main equations in the population dynamics model are standard formulae that have been used extensively in the past and are scientifically sound. The management procedures (MSEs) considered have also been used in other studies and peer-reviewed as part of previous work (Geromont and Butterworth, 2014) so, the general concept is sound. However, those are empirical MSEs and their parameterization, as used in the DLMtool, has been adopted to support management of severely depleted stocks of medium productivity.

In addition to the DLMtool approaches, catch curve analysis was also employed to calculate total mortality. In principle, there is good understanding of the scientific basis and use of the operating model and MSEs in the DLMtool but there are still concerns about the implementation of the approach. Specifically:

- The translation of all the mathematical formulae into R code has not been checked by this Panel. Some parts of the code were discussed especially those involving internal boundaries and checks that are hardwired into the code and lead to diversions from the main formulae influencing the results. An example is the adjustment of the fishing mortality to avoid extinction that the model does automatically. Those need to be checked and documented in detail to ensure that the performance of tested MSEs is not artificially enhanced. In particular, the equations in Section 3.1 of the SEDAR 49 Addendum that include the catch recommendation smoothing parameter, *w*, should be checked to see if they are appropriate for values of *w* not equal to 0.5 (not that this would not affect results in SEDAR 49 where 0.5 was the only value used).

- The approach is still under development and requires a very good understanding of the underlying concepts and their translation into source code, and that takes a lot of time so, it is not a quick shortcut to assessing data-poor species.
- The scalars of the formulae used to describe the MSEs tested in this assessment were generally default values intended to provide a generic approach to help overexploited species to recover. Therefore, there is no evidence that the same values for the scalars represent the best option for the type of species assessed in this exercise (*see also comments below*).
- See comments under ToR 7 below for a discussion of the parametrization of the stock-recruitment function. Although the use of the steepness parameter (*h*) was considered acceptable here the Review Panel recommends the use of a different approach for the next application of the DLMtool approach.

b) Are the methods appropriate given the available data?

The methods proposed aim to address paucity of biological and other information in data limited species. All the species considered here, with the exception maybe of one, could be assigned to that category so, the use of DLMtool is generally appropriate. The volume and extend of data for red drum was relatively greater than for the other species and that warrants further consideration to decide whether this stock can be treated as data-moderate. This does not render the DLMtool inappropriate but suggests that consideration of additional quantitative approaches could be of value to identify those that are more suitable.

The Review Panel did consider the role of the species in the context of the fisheries that affect them (e.g., by-catch species) and their dynamics and it is not clear whether the current methods provide a flexible enough mechanism for capturing those characteristics.

For some species, several management approaches met the performance criteria, however, the Review Panel believed that the management approaches that made use of relative abundance information in the form of a CPUE index or mean length information to provide a signal about the population response to future exploitation would better safeguard populations than those that do not use relative abundance information.

In particular, the following points are made:

- The methods and parameterization of models has been designed for target species and at least half of the species considered in this assessment were not targeted species. So, the type of information available or of use for this assessment differs from that for targeted species. For example, effort patterns characterizing the target species in the relevant fishery in which the study species are caught is an alternative source of information in addition to indices for the study species. The former could be included into the model but the current configuration accepts only one data series for fisheries so, that is not possible.
- The MSEs are configured with overexploited species in mind and mainly to describe long-lived species. This does not fit well the dynamics of some of the species considered here so, further work is needed to identify smoothing parameters and scalars that are more appropriate for short-lived species or species that are not heavily fished or targeted.
- For the Red Drum, the von Bertalanffy growth model is not the most appropriate as it does not describe the gender-changing characteristic of that species and the effect it might have on growth so, that is a limitation.

c) Are the data-limited models configured properly and used in a manner consistent with standard practices?

The values of the model parameters reflects the recommendations of the data workshop and in that sense, it is properly configured but given concerns about parameter values selected by the data workshop there are recommendations for further work to address them. Those include:

- The choice of L_∞ is not supported by catch at age data that for most of the species considered appear to include considerably higher values for fish length.
- Similarly, the CV for the growth parameters are unrealistically small so, this part of the model configuration needs to be revisited.
- With the exception of Red Drum, all simulations used the reference periods adopted by the Gulf Council and used them to determine changes in future catches. However, there is very little information about the state of nature that reference period represents and no clear justification for the choice of that reference period. In conventional assessments the reference period is set at a much earlier time period and is assumed to either reflect the state of the population that led to optimum production or, in some cases, the state of the population at almost unexploited conditions. The interpretation of model predictions will be affected by those assumptions and, therefore, the choice of the reference period need to be substantiated and an explanation provided for what state of nature it is supposed to represent.
- Temperate species were included in the meta-analysis used to find plausible values for the length at age equation and that might have introduced bias in the range of plausible values. However, given that understanding of the dynamics of the 8 stocks is limited the approach applied is still considered reasonable.

- As pointed out in ToR 2 above, the Hoenig estimator was chosen to calculate *M* values and that does not reflect common practices that consider more than one methodology to find estimates of *M*. The latter provides a more thorough view of the plausible range of values for *M* and it is recommended.
- From the relevant documents and discussions during the review workshop, it transpired that more data than those used for red drum existed. This suggests that the model for red drum does not reflect best available knowledge. It is understandable that given the large number of species being assessed here compromises in the data compilation and hence model configuration were inevitable. However, that weakened the value of the analysis. It is recommended that future assessments allow enough time to identify and compile all available data to strengthen model configuration.

The timeframes for the MSE simulations do not reflect the dynamics of some of the stocks (e.g. 40 years for a species that live for 5 years). It is recommended that simulation time be calculated as a function of generation time or a similar constant to better reflect the biology of assessed stocks.

d) Are the quantitative estimates produced reliable? Does the method produce management metrics (e.g. OFL, ABC) or other indicators (e.g. trends in F or Z, probability of overfishing) that may be used to inform managers about stock trends and conditions?

Yes, within the context of data limited approaches it provides guidance on management approaches that can be effective and if those are adopted they can be used to guide the decision for ABC. However, the outcome of these analyses do not correspond to the traditional matrices produced in data rich assessments (e.g., MSY, OFL, or ABC). The estimates produced in this assessment mainly concerned metrics that described the performance of alternative management procedures. That included probability of the population and yield to be above a pre-specified reference point (MSY), probability of not overfishing, and probability that the biomass will fall below a pre-specified limit for each of the MPs considered. Although the assessment does provide catch estimates, it is not clear how they relate to management quantities (OFL, ABC, etc.), so, the metrics are useful to inform managers but the way in which they will be incorporated into the decision-making process has not been clarified yet and it is expected to require an adjustment in the current procedure for setting catch quotas. In that context the Panel has made the following points:

- This is a methodology to guide decisions and help avoid overexploitation while the knowledge is built to develop a robust assessment.
- The interpretation and use of these results requires a different management paradigm as the tested methodology does not produce the metrics that calculated in a conventional stock assessment (e.g., B_{MSY}).
- However, it is of value since it provides signals about stock status and exploitation levels in the absence of absolute estimates about stock size and exploitation.

Further, in terms of informing management decisions, the choice of the metrics does not reflect well the fact that most of the species are by-catch/no-target species. For example, it is questionable whether achieving MSY is a realistic or relevant objective in these fisheries, although knowledge of MSY would help ensure stocks are not overexploited. Hence, there is a need to define how the relevant metrics are expected to inform management decisions and whether all metrics that have been calculated should be given the same weight when one decides on the best management procedure to use. Therefore, the Panel recommends that performance metrics and additional criteria are revisited and possibly adjusted to reflect the fact that these stocks are bycatch species and because of that, certain objectives such as avoiding overexploitation could be more important or relevant than achieving MSY.

The evaluation outcomes were tested under a range of scenarios and uncertainty levels and the main conclusions were not affected. That provides some assurance about the robustness of the estimates and the reliability of the outcomes of the MSEs in terms of the management procedures that are more appropriate for the assessed stocks. However:

- The influence of the constraints of the model (see previous section about hardwired checks in the source code) on probability density functions reduces the reliability of the results.
- Combining probability density distributions for catches that come from different MSEs is an arbitrary choice that does not have a clear justification and leads to recommendations for catches that have not been tested in the simulation evaluation exercise. Therefore, the Panel did not agree with the proposed approach that combined catch results from two or more management procedures. Additionally, if the catch recommendation is a single value associated with a single procedure, testing of that value in a simulation evaluation would also be warranted, particularly if the probability density distribution is wide.
- Also, see comments in ToRs 4 and 7 below regarding the potential impact of covariance in life history parameters on the outcome of model results.

4. *Consider how uncertainties in the assessment, and their potential consequences, are addressed.*

Uncertainty associated with the population, data, and assessment models was addressed via Monte Carlo simulation and sensitivity analysis in the SEDAR 49 stock assessment.

   a) *Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.*

The SEDAR 49 assessment developed and employed a structured approach to systematically evaluate possible impacts of uncertainties associated with the parameters in the operating models and variables/data used in developing catch advice. This approach includes:

- Monte Carlo simulations were conducted to capture the uncertainties associated with the parameters used in the operating model to simulate the fisheries for evaluating the performance of 11 methods considered for developing catch advice. Uncertainties associated with some key life history parameters (e.g., von Bertalanffy growth parameters L_∞, K and t_0, with correlations of these three parameters being considered in random sampling; natural mortality rate (*M*); steepness (*h*); the beta parameter defining hyper-depletion/hyper-stability) and fishery parameters (i.e., total removals, length at first capture, and length at full capture) were quantified with lower and upper boundaries (or CVs) largely defined based on meta-analyses of existing data, previous studies and expert opinions. One thousand simulation runs were conducted with these model parameters being randomly drawn from the uniform distributions defined by these lower and upper boundaries.
- Uncertainty associated with the total removals for all the eight species was quantified with CVs defined in the Data Workshop based on the values defined for total commercial and recreational catches, and discard mortalities. The abundance indices from fishery-independent and/or fishery-dependent programs were also quantified for all the eight species based on the best information available at the Data Workshop.
- The quality of different data was quantified with reliability scoring systems at the Data Workshop based on source of the data, spatio-temporal coverages of sampling programs, sample sizes, likelihood of species misidentification, and other factors (e.g., changes in fishermen's fishing behaviors as a result of changes in management regulations). The semi-quantitative scores of data quality were used in the selection of feasible methods for catch advices.
- Sensitivity analyses were also conducted to evaluate the robustness of performance of feasible catch advice methods regarding uncertainties associated with scalars built in various methods. However, sensitivity analyses for the catch recommendation smoothing parameter *w*, which determines how the catch advice changes relative to the value of the abundance index, were not carried out. The AW did recommend additional tuning to meet specific performance criteria in future evaluations and this sensitivity could be carried out as part of this tuning. This parameter determines the catch rule.
- The simulation of fishery by the operating model is conditional on the assumed depletion level which is usually unknown. Possible impacts of violating the assumed depletion level were evaluated by running all three possible depletion scenarios (i.e., lightly, moderately, and heavily depleted) for each method identified as feasible for each species.
- All the methods for catch advice that were deemed feasible based on the data availability and quality were considered and evaluated for all the eight species in this study, indicating that variability associated with choices of catch advice methods were considered.

Although the coverage of uncertainty sources is very comprehensive for all the eight species in SEDAR 49, some extra analyses can be done to further improve our understanding of the impacts of uncertainties on the development of catch advice using the DLMtool:

- Evaluate all the default values and built-in constraints used for the methods included in the DLMtool software because these methods were developed for fisheries outside the Gulf of Mexico and their associated parameters are likely inappropriate. There is a need to carefully evaluate their suitability for Gulf of Mexico fisheries.
- Current simulations were run with uncertainty of all the sources being incorporated, which may make the identification of impacts of a single uncertainty source difficult, and a structured simulation design may be needed to isolate and identify impacts of an individual uncertainty source.
- Different levels/forms of uncertainty for some key parameters/data (e.g., annual variability in growth parameters, annual variability in total removals, different levels of variability in the index of abundance etc.) need to be considered to have a better understanding of impacts of these uncertainties.
- Possible correlations between the S-R parameter *h* versus *M*, and parameters quantifying reproductive potential may need to be considered in the simulations (see more detail on this topic under ToR 7 below).

b) Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The possible implications of uncertainty of various sources in technical conclusions are clearly stated in the selection of methods for developing catch advice, and the relevant mechanisms were discussed in the Review Report and at the Review Workshop.

5. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
a) Clearly denote research and monitoring that could improve the reliability of future assessments.
b) Provide recommendations on possible ways to improve the SEDAR process.

Sea sampling programs to better quantify discards and discard mortality for all the eight species.

The choice of reference time period for Tier 3A and Tier 3B stocks needs to be re-visited given the new information available and possible changes in the ecosystems.

The operating model simulates the population dynamics of a given species conditional on the assumed depletion level which is usually unknown. Although the base case scenario for depletion level was developed for each species based on the best available information and a sensitivity analysis was conducted for alternative depletion levels, a reality check may be necessary to help simulate a fishery that realistically reflects the dynamics of fishery of interests. Reliable information on the fishery and population (e.g., temporal trend of fishing efforts, fishery-dependent and fishery-independent abundance indices and biological information such as age- and length compositions) needs to be collected to help define possible depletion level. These data can be used to tune the operating model parameterization to improve the fishery simulation realism by the operating models. Further, a number of surveys were considered at the DW but not all of them were deemed appropriate to inform a stock assessment. It is important to revisit the design of the surveys to ascertain whether changes could be made to get more value out of those surveys. The Review Panel also recommends that more time is spent to identify the methodology and indicators that are best for the type of exploitation and species we have. Trying to calculate MSY and other conventional metrics might not be the most appropriate approach especially for species that are caught as bycatch. Similarly, collecting all the data that are needed to do a proper stock assessment is a very big task and it is important to identify some interim approaches such as using indicator species (to represent a complex of species) or maybe use the status of the targeted stock as a proxy for the status of the by-catch species.

6. *Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.*

The Review Panel considers that the SEDAR 49 assessment constitutes the best scientific information available, and fulfils the following criteria:

Relevance: application of the DLMtool to provide quantitatively-based catch advice (albeit data-limited in nature) to Gulf of Mexico stocks is a highly relevant step in the evolution of stock assessments in the region.

Inclusiveness: in general, analyses conducted during SEDAR 49 include all data that have been quality assured and proved adequate for use in the assessment. This includes data from State as well as Federal sampling schemes, where needed. Additionally, there are opportunities for stakeholders or the public to provide input into the process.

Objectivity: the DLMtool is a highly objective procedure based on well tested statistical modeling principles, and using data sets and principles that have been well documented and reviewed through the SEDAR data and assessment process. Possible exceptions are uncertainties in inputs regarded as ‘assumptions’ rather than data, such as the depletion level or choice of index reference period. .

Transparency: all outputs of the data, assessment and review workshops in SEDAR 49 are fully documented and publicly available. The discussions at the review workshop are also recorded for the administrative record. All data sets are thoroughly explored and the quality of data on which the assessment is based is documented and transparent, as are all decisions related to the choice of assessment model, how it is implemented, and the results of the different runs and sensitivity and uncertainty analyses.

Timeliness: The SEDAR process in general is arranged to provide timely fishery management advice where it is needed, and to ensure that assessments are benchmarked and reviewed at appropriate intervals.

Verification: The SEDAR 49 assessment was structured and conducted as to provide deliverables that comply with legal requirements under the Magnuson Stevens Act (2007) for developing and monitoring of fishery management plans and providing information on stock status. However, given the data-limited nature of the methodologies applied estimation of standard reference points for catch advice was not achieved.

Validation: The SEDAR 49 assessment process was implemented to meet the needs of fishery managers for peer-reviewed stock assessments and associated catch advice. The process is open and fully transparent to the fishery managers and to stakeholders from commercial and recreational fisheries, conservation groups or others with a stake in the outcomes and who have opportunity to give their views on record.

Peer review: The SEDAR 49 assessment process includes full peer-review by experts appointed from the Center for Independent Experts (CIE, University of Miami) and the GMFMC SSC. The review panel report and the independent CIE reviews are publicly available.

7. *Provide guidance on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.*

The eight species assessed during SEDAR 49 are all data poor and therefore improvements to the data for these species would be expected to improve their respective assessments. Opportunities for collecting samples to improve life history parameter estimates are outlined under ToR 5 above (Research Recommendations). In summary, these include increased dockside and/or at-sea sampling for most of the species, and development of sampling protocols for species encountered in existing surveys such as the NMFS Pascagoula Groundfish and Small Pelagic surveys.

With respect to removals by commercial, recreational and other fisheries, discard mortality and quantification of uncertainty in the discard estimates are two sources of uncertainty in the assessments. Because fishery removals play a key role in determining current abundance levels, improvements to the removal estimates would be expected to improve the catch recommendations. Additionally, improvements in the information about the size and age of fish removed by the fisheries should lead to better estimates of fisheries selectivity, thereby reducing uncertainty in the population-level effects of different catch levels.

Although the DLMtool does provide a mechanism for evaluating management procedures and operating models with very limited amount of data, it does not provide a real-world evaluation of whether the procedures and models are achieving the management objectives. Although metrics such as mean length can potentially be used as an abundance proxy, it is not clear, at least for some species, whether a change in mean length might be indicative of increased survival, a change in recruitment, or pulsed recruitment. Indices of relative abundance (particularly in combination with age or length data) would be expected to be most indicative about changes in abundance and whether management goals are being achieved. For species for which abundance indices are available, ensuring that relative abundance indices are indicative of abundance (by ensuring all habitat types are appropriately sampled, for example) would strengthen the assessments. Additionally, given both their within-year and among-year variability, evaluation of the precision of indices with respect to their utility for detecting changes in abundance would also be expected to improve the assessments.

As used for this assessment, the DLMtool was configured to primarily evaluate management procedures rather than to specifically provide catch advice. For this reason, the DLM tool produces very different outputs than traditional assessment models or the approaches currently used to provide catch recommendations for data-limited stocks. The long-term simulations are, in many ways, more like population viability analyses used in conservation biology than traditional fishery stock assessment models. The Review Panel suggested that some modifications and additions to the approach would be expected to significantly improve catch recommendations using the method.

The DLMtool does provide an evaluation of potential operating models based on a set of performance metrics. As applied in SEDAR 49, there was a constraint on the amount the catch could change, which limited the set of operating models deemed acceptable. For example, an extremely low constant catch would meet the three performance metrics used to choose potential operating models, but the constant catch scenario was not always considered appropriate likely due to this constraint. A broader range of catch recommendations for each operating model might increase the number of options available for operating models. Additionally, the effect of constraints on the catch recommendations from a single operating model was not fully explored during SEDAR 49, but is necessary to be able to interpret the probability distributions for the catch recommendations.

The model output includes a probability distribution for the catch recommendation associated with each potential operating model. However, because the tool is evaluating potential operating models, it is not evaluating whether a specific catch recommendation would meet the performance metrics (there is uncertainty associated with the catch recommendation). An additional step, involving feeding the specific catch recommendation back into the operating model would help ensure that performance metrics are met given the uncertainty in the operating model input parameters (use different random values). Sensitivity analyses to assumptions about depletion levels and other assumptions could also be carried out at this step.

As implemented in SEDAR 49, the probability of meeting the performance metrics was calculated across all years and simulations independently. However, each simulation is a potential realization of future conditions that either meets management objectives or does not. Performance metrics and standards, based on management goals, should be two tiered, including criteria that are applied to each individual simulation to determine whether it meets the metric or standard, as well as risk acceptance criteria applied across simulations based on the probability that the standard is met. For example, depending on management objectives, criteria applied within a single simulated trajectory could include: the proportion of the years during which the population is over-fished; the proportion of the years the population is in an over-fished state; the proportion of the years that the population is above or below some abundance threshold; or, in the case of rebuilding, whether a simulated population rebuilds within a specified timeframe. Each simulated population trajectory either meets the objective, or does not. The probability of meeting the objective can then be calculated as the proportion of simulated populations that meet the objective. This probability can then be compared with a risk tolerance criterion for that performance metric.

This application of the DLMtool provided much more information than was previously available for these species. For this reason, performance metrics could be developed that are situation specific (e.g. dependent on the depletion level, life history, whether fisheries are targeted or bycatch, distribution of fishing effort, trends in indices, etc.). Additionally, throughout the SEDAR 49 review meeting it was not clear how the catch recommendations should be used. The development of guidance on the interpretation of the catch recommendations from the tool as an OFL, ABC, ACL, ACT or some other value would aid in the utility of assessment results from the tool. Particularly given that a probability distribution is produced for the recommendation, the potential to use different percentiles from the distribution for different metrics could be explored. The interpretation of the output might also be situation-specific, and might differ among populations.

Life history parameter covariance is difficult to incorporate into the simulations and, if not fully specified, could result in parameters combinations that are biologically unrealistic. For example, the steepness parameter in the stock-recruitment (S-R) relationship depends on the slope at the origin of the S-R relationship, but also on the natural mortality rates, growth parameters, maturity parameters and length-weight conversion parameters, most of which were assumed uncorrelated in SEDAR 49. This individual issue would be addressed if the S-R relationship was parameterized in terms of the slope at the origin. More broadly, calculation of $SPR_{F=0}$, lifetime maximum reproductive rates or other similar metrics could provide a mechanism for filtering out combinations of parameter values that are biologically unrealistic, if limit values were included in the model.

For many of the operating models there are many control values that can be set which influence how the catch recommendation changes though time in each simulation. For example, in the case where abundance metrics or proxies (e.g. mean length), are available, there are options for choosing the index limits and smoothing parameter values that determine the harvest control rules. In SEDAR 49 sensitivity analyses were carried for many of these options, although the model performance metrics were applied using default settings. Optimization methods could be developed that would choose the most appropriate values (given management goals and performance metrics), including the catch recommendation and assessment frequency, reducing the need to run a potentially large number of sensitivity analyses separately to find the best values.

Overall, the Review Panel believes that the data synthesis that occurred as part of SEDAR 49, and the application of the methods in the DLMtool has provided a lot of information that was previously unavailable for these species. However, tailoring the approach used in SEDAR 49 specifically for the provision of catch advice, along the lines suggested above, would be a significant step prior to the next assessment for these species.

8. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference.

This report constitutes the Review Panel's summary evaluation of the stock assessment and discussion of the Terms of Reference. The Review Panel will complete edits to its report and submit a final document to the SEDAR program for inclusion in the full set of documents associated with SEDAR 49.

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 49

Gulf of Mexico Data-limited Species:

Red Drum, Lane Snapper, Wenchman, Yellowmouth Grouper, Speckled Hind, Snowy Grouper, Almaco Jack, Lesser Amberjack

SECTION VI: Post-Review Workshop Addendum Report

November 2016

SEDAR
4055 Faber Place Drive, Suite 201
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1 INTRODUCTION

The SEDAR 49 Review Workshop (RW) took place 1-3 November 2016. Results of applying the DLMtool were presented for eight species selected by the Gulf of Mexico Fishery Management Council. During the RW, the SEDAR 49 Review Panel requested additional analyses of the analytical team for the DLMtool application (detailed in next section). Requests were also made regarding graphical representation of the simulation results for individual simulations, interquartile ranges for trajectory plots, and alternative calculations of performance metrics for PNOF, B50, and Bbelow20 (i.e. calculated across years for each simulation and then across simulations). Revised results presented during the RW were for Wenchman, with the exception of the natural mortality sensitivity results presented for Red Drum. The sensitivity analyses for the remaining species were conducted after the RW and are documented herein. The structure of this report is as follows: (1) overview of requested analyses; (2) modified methodology where necessary; and (3) revised results by species.

2 SUMMARY OF ANALYSES REQUESTED BY REVIEW PANEL

Day 1 (Tuesday 1 November; all results presented were specific to Wenchman):

1. Assess the ***impact of the beta parameter (fixed at 1.0)*** on the results of the base MSE for Wenchman to determine whether this parameter is driving trends in biomass and catch related to the index of abundance. The beta parameter controls the relationship between the relative abundance index and biomass (i.e. hyper-depletion or hyperstability);

   Motivation: some of the trends in biomass (e.g. biomass is increasing) do not correspond to expected increases in the catch recommendations (e.g. catch is declining). Could the way the index is being treated in the simulation be driving this trend?

2. Assess the ***impact of the assessment interval (three year interval)*** on the results of the base MSE for Wenchman to determine whether this may change viability of methods and performance;

   Motivation: expect different (better) performance if the assessment process is able to re-assess the population more frequently.

3. Assess the ***impact of including interannual variability in the von Bertalanffy asymptotic length (Linf) parameter (15-20% interannual variability)*** on the results of the base MSE for Wenchman to determine whether this modification degrades the performance of the length-based indicator methods;

   Motivation: by excluding variability in the Linf, results may be overly optimistic for the length-based methods. Lorenzen (2016) identified ballpark figures for the level of plasticity in growth that can be commonly expected in wild populations, which is around 15% in length-at-age with extremes of 20%.

4. Analyze ***individual simulation behavior*** for model outputs (B/B_{MSY}, F/F_{MSY}, Biomass, Fishing Mortality, Total Removals (i.e. catch taken)) of the base MSE for Wenchman;

Motivation: difficult to interpret trajectory plots when all results are averaged across 1,000 simulations with 5th and 95th percentiles included. Trends are likely being masked by averaging everything together.

5. Explore the ***interquartile range*** in the trajectory plots for model outputs (B/B_{MSY}, F/F_{MSY}, Biomass, Fishing Mortality, Total Removals (i.e. catch taken)) of the base MSE for Wenchman;

    Motivation: difficult to interpret trajectory plots when all results are averaged across 1,000 simulations with 5th and 95th percentiles included.

6. Explore the trends in ***data inputs for the index of abundance and index of mean length*** between reference periods and recent periods for species where index-based and length-based methods were viable.

    Motivation: explore the relationship between the data inputs during the reference period and the recent period. Is it possible that the reference period is not reflective of a target level we want to achieve?

<u>Day 2 (Wednesday 2 November; all results presented were specific to Wenchman):</u>

1. Assess the ***impact of greater uncertainty in the observation error for the index of abundance (CV fixed at 0.5)*** on the results of the base MSE for Wenchman to determine whether this modification may degrade the performance of the index-based methods;

    Motivation: are the current base operating models underestimating the uncertainty in the index of abundance? If so, this would impact the performance of the index-based methods.

2. Assess the ***impact of greater uncertainty in the observation error for the index of abundance (CV fixed at 1.0)*** on the results of the base MSE for Wenchman to determine whether this modification may degrade the performance of the index-based methods;

    Motivation: are the current base operating models underestimating the uncertainty in the index of abundance? If so, this would impact the performance of the index-based methods.

3. Assess the impact of ***estimated natural mortality (fixed at 0.06)*** from the catch curve analysis on the results of the base MSE for Red Drum to determine whether this modification may change viability of methods and performance;

    Motivation: does using the M estimate of 0.06 result in the same viability of methods and performance if used instead of the base assumption of the M estimate derived from the updated Hoenig equation from Then et al. (2014)?

4. Assess the impact of ***lower assumed steepness (fixed steepness at lower bound; no other changes)*** on the results of the base MSE for Wenchman to determine whether this modification may change viability of methods and performance;

    Motivation: the steepness assumed in the operating model will determine the productivity of the stock and therefore play a critical role in the outcome of the

MSE. Does the viability of the methods and their performance change when assuming a less productive stock (i.e. fixed at lower steepness bound)?

5. Assess the ***impact of including interannual variability (15-20% interannual variability) and a gradient in the Linf parameter (range: ±5%)*** on the results of the base MSE for Wenchman to determine whether this modification may degrade the performance of the length-based methods;

   Motivation: by excluding variability in the Linf and assuming a constant gradient, results may be overly optimistic for the length-based methods. Lorenzen (2016) identified ballpark figures for the level of plasticity in growth that can be commonly expected in wild populations, which is around 15% in length-at-age with extremes of 20%.

6. Revisit the ***calculation of performance metrics PNOF, B50, and Bbelow20*** from a simulation perspective (i.e. across years for each simulation; obtain metric over simulations as opposed to over simulations * years). Note that this was not completed in time for in-person RW but is presented herein.

   Motivation: assessing the performance metrics on a simulation basis (i.e. threshold across years) may result in a different outcome.

Day 3 (Thursday 3 November; all results for remaining species as necessary):

1. Complete all analyses for the remaining species.

3 METHODS

3.1 IMPLEMENTATION OF ITARGET0 AND LTARGET0

Previous analyses were conducted using modified Itarget0 and Ltarget0 methods which were parameterized differently from the original equations documented in Geromont and Butterworth (2014). Analyses presented in the SEDAR 49 Assessment Report were based on a smoothing parameter of 1.0, which results in a doubling of average catch when the target levels are met. The generic formulation uses a smoothing parameter of 0.5, which results in a catch recommendation of average catch when the target index level is met. The revised methods are described below as defined in Geromont and Butterworth (2014) and Carruthers et al. (2015).

Itarget0:

If $I_y^{recent} > I^0$, $Catch\ Rec_{y+1} = w \times C^{AVE}\left[1 + \frac{(I_y^{recent} - I^0)}{(I^{target} - I^0)}\right]$

If $I_y^{recent} \leq I^0$, $Catch\ Rec_{y+1} = w \times C^{AVE}\left[\frac{I_y^{recent}}{I^0}\right]^2$

where:

w = the catch recommendation (termed the TAC) smoothing parameter (Assessment Report = 1.0; Revised Results = 0.5);
I_y^{recent} = mean CPUE for recent time period (2010-2014);
I^{AVE} = mean CPUE for reference period as specified in Table 3.1.2 of the Assessment Report for each species;
$I^0 = \mathbf{0.8}\ I^{AVE}$, where the scalar 0.8 may be modified during tuning;
$I^{target} = \mathbf{1.5}\ I^{AVE}$, where the scalar 1.5 may be modified during tuning; and
$C^{AVE} = \frac{\sum_{y=t_1}^{y=t_2} Cat_y}{1+t_2-t_1}$ where Cat_y is the catch during the reference period (defined by t_2 and t_1).

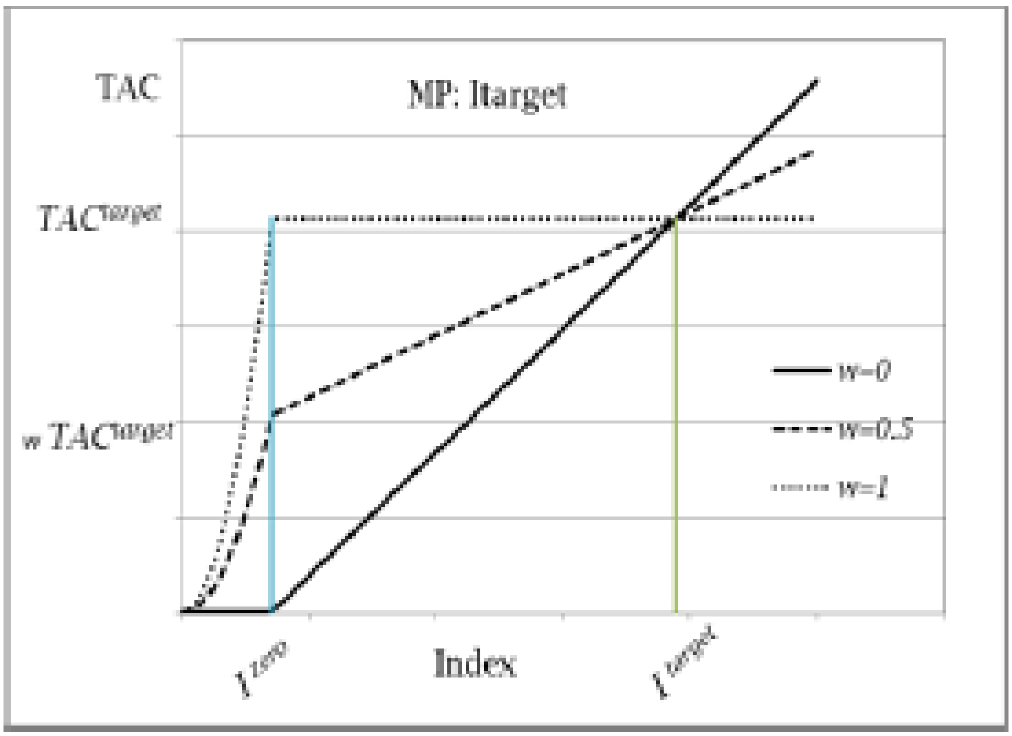

Figure 2 from Geromont and Butterworth (2014) supplementary material: Different forms of the Itarget0 method for three values of the control parameter w. Note that TAC is the terminology used for the catch recommendation in the source reference.

Ltarget0:

If $L_y^{recent} > L^0$, $Catch\ Rec_{y+1} = w \times C^{AVE}\left[1 + \frac{(L_y^{recent} - L^0)}{(L^{target} - L^0)}\right]$

If $L_y^{recent} \leq L^0$, $Catch\ Rec_{y+1} = w \times C^{AVE}\left[\frac{L_y^{recent}}{L^0}\right]^2$

where:

w = the catch recommendation (termed the TAC) smoothing parameter (Assessment Report = 1.0; Revised Results = 0.5);

L^{recent} = mean length for recent time period (2010-2014);
L^{AVE} = mean length for reference period as specified in Table 3.1.2 of the Assessment Report for each species;
L^{0} = **0.9** L^{AVE}, where the scalar 0.9 may be modified during tuning;
L^{target} = **1.05** L^{AVE}, where the scalar 1.05 may be modified during tuning; and
$C^{AVE} = \frac{\sum_{y=t_1}^{y=t_2} Cat_y}{1+t_2-t_1}$ where Cat_y is the catch during the reference period (defined by t_2 and t_1).

3.2 SENSITIVITIES CONDUCTED BY SPECIES

Requested analyses included sensitivity runs for:

1. 3YR = assessment interval of three years instead of the 10 years suggested by the Assessment Panel (AP);

2. Steep = Steepness fixed at the lower bound of the plausible range specified in the base operating model;

3. Beta = Beta parameter fixed at 1.0 to remove influence of hyper-stability or hyper-depletion in the index of abundance;

4. Linf = allow for interannual variability in Linf (15-20% based on Lorenzen (2016)) and a gradient in Linf (±5%);

5. IndCV0.5 = Increased observation error in the index of abundance (CV = 0.5);

6. IndCV1.0 = Increased observation error in the index of abundance (CV = 1.0); and

7. M = natural mortality as estimated by the catch curve analysis (Red Drum only).

Below is a summary of the sensitivities required for each species under assessment during SEDAR 49. – indicates sensitivities not necessary due to data limitations (e.g. no index of length available for Snowy Grouper). Note that the CV for Red Drum (CV = 1.18) already exceeded the sensitivity values.

Sensitivity Name	Method impacted	Red Drum	Lane Snapper	Wench-man	Snowy Grouper	Speckled Hind	Almaco Jack	Lesser Amber jack
M	All	X	-	-	-	-	-	-
3YR	All	X	X	X	X	X	X	X
Steep	All	X	X	X	X	X	X	X
Beta	Index	X	X	X	-	-	X	X
IndCV0.5	Index	-	X	X	-	-	X	X
IndCV1.0	Index	-	X	X	-	-	X	X
Linf	Length	-	X	X	-	-	X	-

3.3 ALTERNATIVE CALCULATION OF PERFORMANCE METRICS

The performance metrics for the probability of not overfishing (PNOF), the probability of the biomass being above 50% B_{MSY} (B50), and the probability of the biomass dropping below 20% B_{MSY} (Bbelow20) were recalculated based on trends across years for each simulation. For each simulation, the number of years where a given condition was met (e.g. $F/F_{MSY} < 1.0$) was summed and converted to a binomial result (= 1 if above 50%; = 0 if below or equal to 50%). The number of simulations equal to 1 was then used to determine each performance metric. Specific details and a simple example are provided to show how each performance metric was calculated.

<u>Probability of not overfishing evaluated across years for individual simulation, then across simulations (PNOF_sim)</u>

N Projection Year = 4

Nsim = 5

	ProYear1	ProYear2	ProYear3	ProYear4	Years Not Overfishing	PNOF_ sim > 50%?
Sim1	**F/FMSY<1**	**F/FMSY<1**	**F/FMSY<1**	F/FMSY>1	3 of 4 (75%)	1
Sim2	F/FMSY>1	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	2 of 4 (50%)	0
Sim3	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	**F/FMSY<1**	3 of 4 (75%)	1
Sim4	F/FMSY>1	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	2 of 4 (50%)	0
Sim5	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	F/FMSY>1	2 of 4 (50%)	0
Threshold	**F/FMSY<1 = 1**, F/FMSY≥1 = 0				**> 50% = 1**, ≤ 50% = 0	

$$PNOF\_sim = \frac{\sum simulations > 50\%}{Total\ simulations} = \frac{2}{5} \times 100 = 40\%$$

40% of the simulations show a greater than 50% probability of not overfishing across years

<u>Probability of the biomass being above 50% B_{MSY} evaluated across years for individual simulation, then across simulations (B50_sim)</u>

N Projection Year = 4

Nsim = 5

	ProYear1	ProYear2	ProYear3	ProYear4	Years above 50%BMSY	B50_sim > 50%?
Sim1	**B/BMSY>0.5**	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**	3 of 4 (75%)	**1**
Sim2	**B/BMSY>0.5**	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**	3 of 4 (75%)	1
Sim3	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**	4 of 4 (100%)	**1**
Sim4	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**	B/BMSY<0.5	2 of 4 (50%)	0
Sim5	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**	B/BMSY<0.5	3 of 4 (75%)	1
Thres hold	**B/BMSY>0.5 = 1**, B/BMSY≤0.5 = 0				**> 50% = 1**, ≤ 50% = 0	

$$B50\_sim = \frac{\sum simulations\ above\ 50\%}{Total\ simulations} = \frac{4}{5} \times 100 = 80\%$$

80% of the simulations shows a greater than 50% probability of the biomass remaining above 50% BMSY across years

<u>Probability of the biomass being below 20% B_{MSY} (evaluated across years for individual simulation, then across simulations)</u>

N Projection Year = 4

Nsim = 5

	ProYear1	ProYear2	ProYear3	ProYear4	Years below 20%BMSY	Bbelow20_sim > 50%?
Sim1	B/BMSY>0.2	B/BMSY>0.2	**B/BMSY<0.2**	B/BMSY>0.2	1 of 4 (25%)	**0**
Sim2	B/BMSY>0.2	B/BMSY>0.2	**B/BMSY<0.2**	**B/BMSY<0.2**	2 of 4 (50%)	0
Sim3	B/BMSY>0.2	B/BMSY>0.2	B/BMSY>0.2	B/BMSY>0.2	0 of 4 (0%)	**0**
Sim4	**B/BMSY<0.2**	**B/BMSY<0.2**	B/BMSY>0.2	**B/BMSY<0.2**	3 of 4 (75%)	1
Sim5	B/BMSY>0.2	B/BMSY>0.2	B/BMSY>0.2	**B/BMSY<0.2**	1 of 4 (25%)	0
Threshold	**B/BMSY<0.2 = 1**, B/BMSY≥0.2 = 0				**> 50% = 1**, ≤ 50% = 0	

$$Bbelow20\_sim = \frac{\sum simulations\ above\ 50\%}{Total\ simulations} = \frac{1}{5} \times 100 = 20\%$$

20% of the simulations shows a greater than 50% probability of dropping below 20% BMSY across years

4 RED DRUM

4.1 DATA

No reference period was available for the calculation of a target index value for Red Drum. The selected index of abundance from the Dauphin Island Sea Laboratory bottom longline survey spanned 2006 through 2014.

4.2 ALTERNATIVE PERFORMANCE METRICS FOR THE BASE OPERATING MODEL (ASSESSMENT WORKSHOP)

Performance metrics calculated across years for each simulation and then across simulations resulted in similar metrics as originally presented (range of difference: 0% [Bbelow20] to 0.2% [PNOF]; Table 4.1). The result does not change as Islope0 remains the only viable method, although this method is still not recommended for providing management advice as discussed in the Assessment Report.

4.3 SENSITIVITIES

4.3.1 Assessment interval

Islope0 remains the only viable method when assessing Red Drum every three years, with performance metrics identical across conservation metrics (PNOF, B50, Bbelow20; Table 4.2). When assessed every three years, large differences are evident for LTY which is reduced from 12.7% to 4.2% and VY15 which is increased from 54.3% to 68.4% (Table 4.2). During the simulation period, mean ratios of B/B_{MSY} and F/F_{MSY} remain above and below the 1.0 threshold, respectively, whereas total removals gradually decline over time (Figure 4.1). An example simulation is presented in Figure 4.2, which shows a conflicting trend in biomass and total removals during the first 10 years, where biomass is declining but the total catch is fairly high and increasing in some years.

4.3.2 Steepness

Similarly, Islope0 remains the only viable method when assuming a less productive stock (Table 4.3). Performance metrics are relatively similar (range of difference: 0% [Bbelow20] to 8.7% [STY]; Table 4.3). Trends in mean ratios of B/B_{MSY} and F/F_{MSY} remain above and below 1, respectively, for the entire simulation period (Figure 4.3). As above, total removals gradually decline over the simulation period. An example simulation is presented in Figure 4.4, which shows highly variable removals (range: 400 to 1600 pounds) throughout the simulation period. Note that these removals are relative in the simulation and are not comparable to actual removals as the simulation is conditioned on relative fishing effort, and not absolute catches.

4.3.3 Index of Abundance

Performance metrics for Islope0 were nearly identical when fixing the beta parameter (range of difference: 0% [Bbelow20] to 1.1% [VY15]; Table 4.4). Trends in mean simulated stock status outputs and catches were also similar (Figure 4.5). An example simulation for each sensitivity is shown in Figure 4.6, which does not show a corresponding increase in catch with increasing biomass for either operating model. No sensitivities were run for the observation error of the index of abundance since the base operating model assumed a CV of 1.18, which was the observed CV for the Dauphin Island Sea Laboratory bottom longline survey.

4.3.4 Natural Mortality

Islope0 did not meet the VY15 performance metric when assuming a lower estimate of M (Table 4.5). The remaining performance metrics were relatively similar to the metrics from the base operating model (range of difference: 0% [Bbelow20] to 13.1% [VY15]; Table 4.5).

4.4 TABLES

Table 4.1 Comparison of AW and RW performance metrics for methods that meet the performance criteria for the base AW MSE run for Red Drum. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing (PNOF_sim = calculated across simulations); B50 = Probability of the biomass being above 50% B_{MSY} (B50_sim = calculated across simulations); VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY} (Bbelow20_sim = calculated across simulations). Note that performance for Bbelow20 and Bbelow20_sim is reversed, where a low probability is preferable.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Islope0	99.5	99.8	54.3	12.7	30.4	0.0	99.7	99.8	0.0

Table 4.2 Performance metrics for methods meeting performance criteria assuming an assessment frequency of every three years for Red Drum. Performance metrics are as defined in Table 4.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Islope0	99.5	99.8	68.4	4.2	27.8	0.0	99.8	99.8	0.0

Table 4.3 Performance metrics for methods meeting performance criteria assuming a less productive stock (fixed steepness at 0.8, the lower bound of the plausible range) for Red Drum. Performance metrics are as defined in Table 4.1.

Method	SEDAR 49 AW Metrics							RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20		PNOF _sim	B50 _sim	Bbelow20 _sim
Islope0	99.2	99.9	52.9	21.2	39.1	0.0		99.5	99.9	0.0

Table 4.4 Performance metrics for index-based methods meeting performance criteria assuming a fixed beta parameter (1.0) for Red Drum. Performance metrics are as defined in Table 4.1.

Method	SEDAR 49 AW Metrics							RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20		PNOF _sim	B50 _sim	Bbelow20 _sim
Base: beta range: 0.33 (hyperstability) to 3.0 (hyper-depletion)										
Islope0	99.5	99.8	54.3	12.7	30.4	0.0		99.7	99.8	0.0
Beta = fixed at 1										
Islope0	99.7	100.0	53.2	13.0	31.0	0.0		99.9	100.0	0.0

Table 4.5 Performance metrics for methods meeting performance criteria assuming the natural mortality rate estimated from the Catch Curve Analysis for Red Drum (0.06 yr^{-1}). Performance metrics are as defined in Table 4.1. Note that Islope0 does not meet the VY15 criteria.

Method	SEDAR 49 AW Metrics							RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20		PNOF _sim	B50 _sim	Bbelow20 _sim
Islope0	99.3	99.8	41.2	13.6	33.8	0.0		99.5	99.8	0.0

4.5 FIGURES

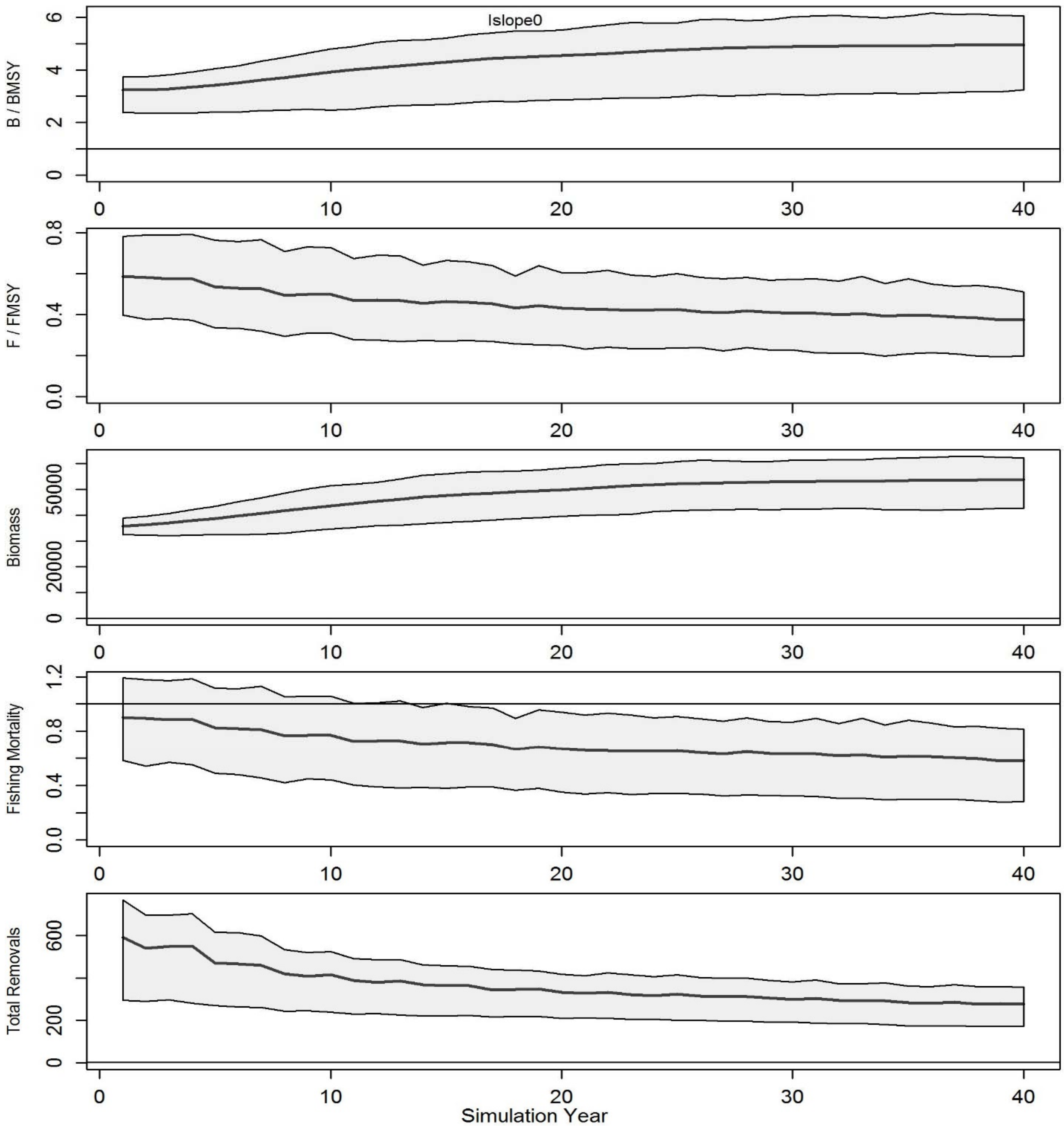

Figure 4.1 Comparison of stock status outputs and catches for Red Drum over the 40-year simulation period where an assessment is conducted every three years. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, and total removals (in pounds) for the viable method Islope0. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 25th and 75th percentiles.

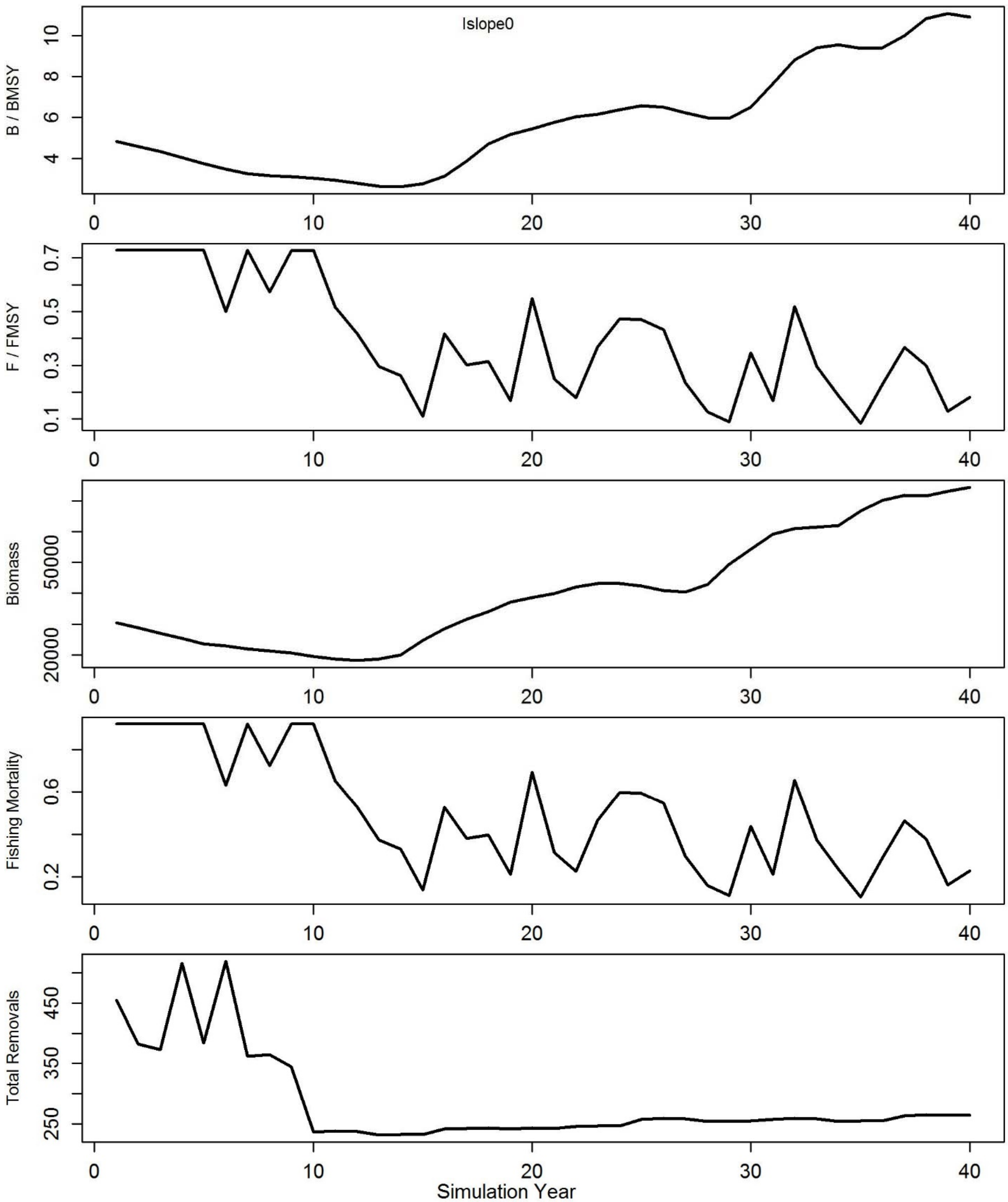

Figure 4.2 Comparison of stock status outputs and catches for Red Drum over the 40-year simulation period for a single simulation when an assessment is conducted every three years. Outputs are as defined in Figure 4.1.

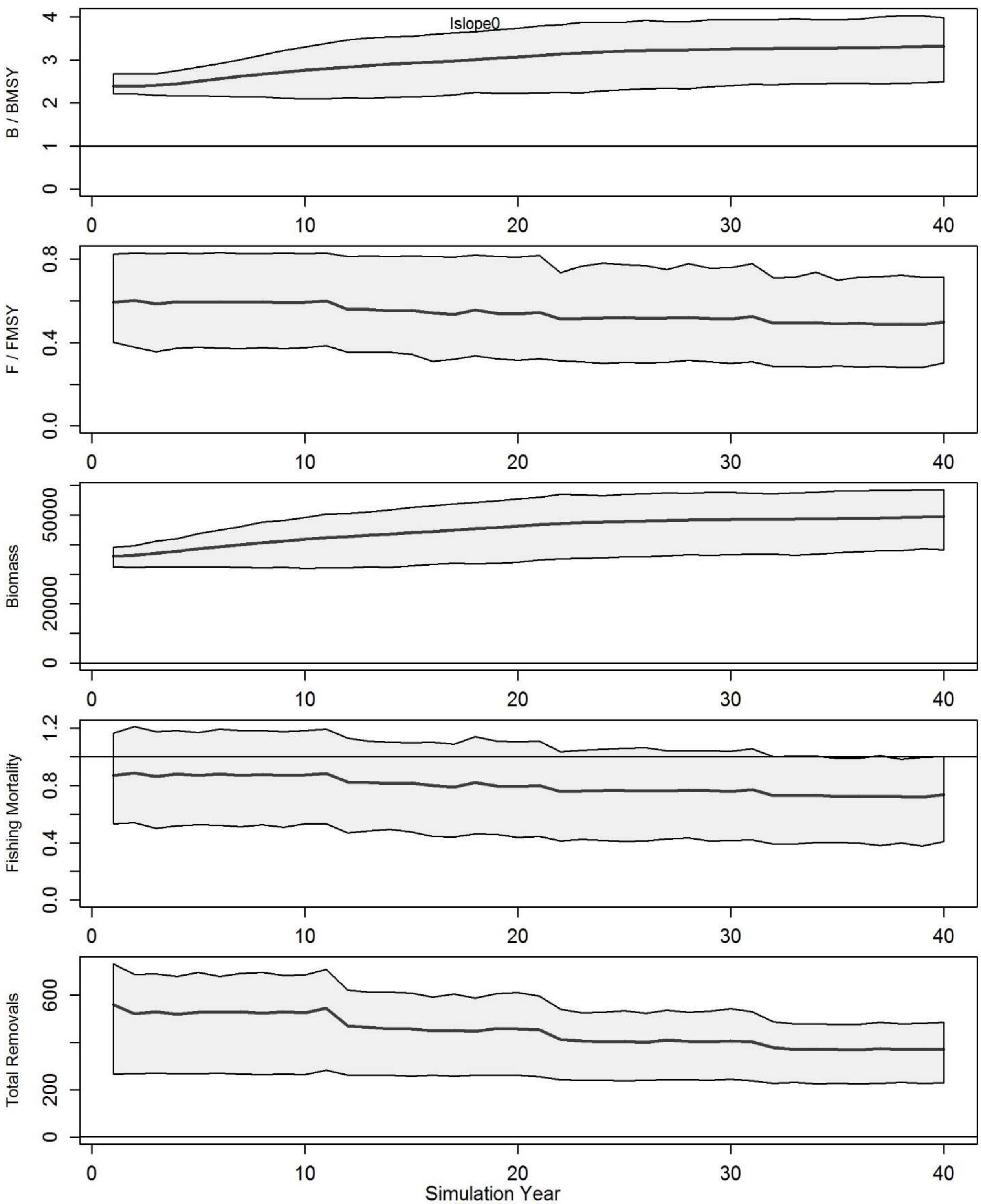

Figure 4.3 Comparison of stock status outputs and catches for Red Drum over the 40-year simulation period when a less productive stock is assumed (steepness fixed at 0.8). Outputs are as defined in Figure 4.1.

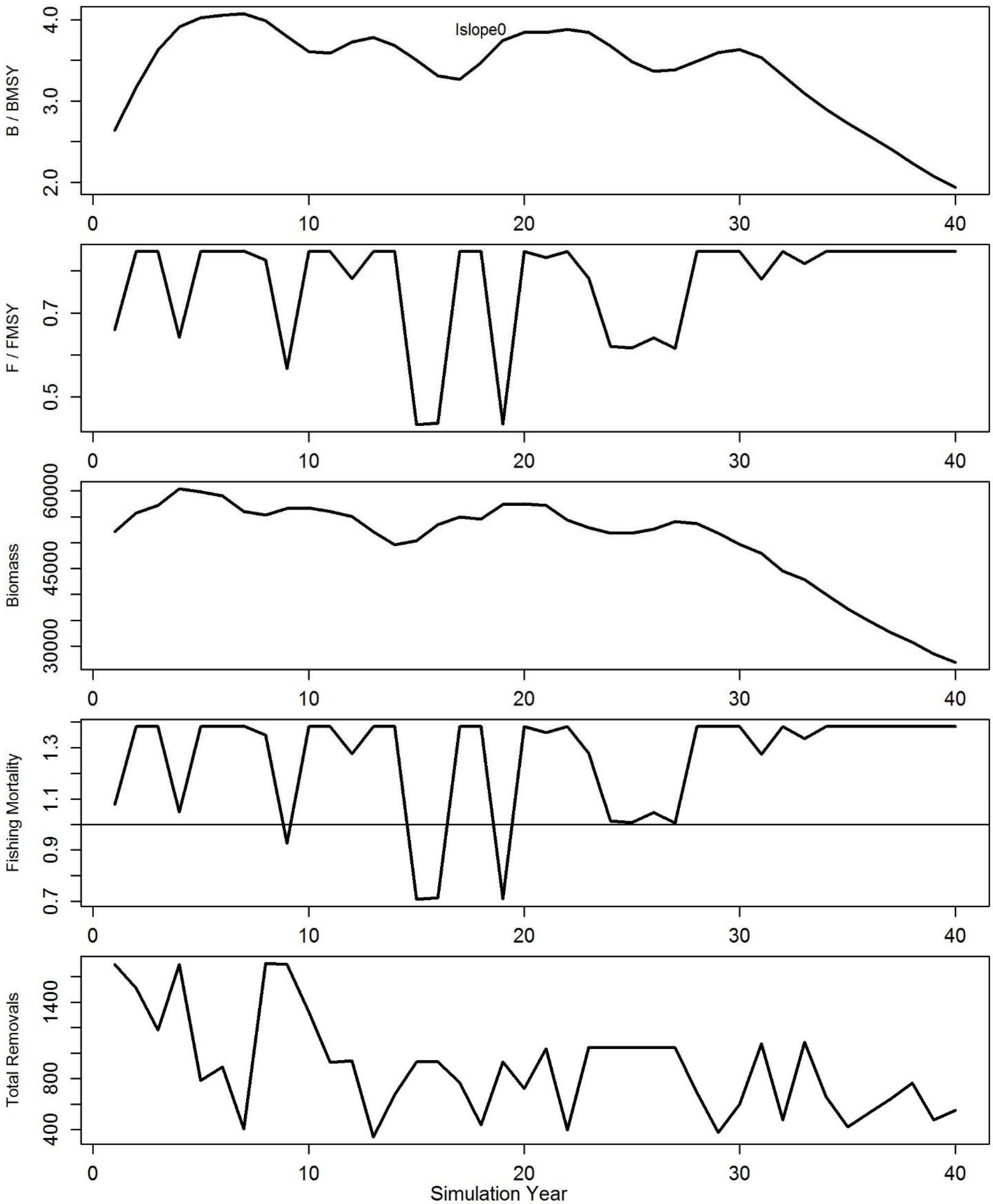

Figure 4.4 Comparison of stock status outputs and catches for Red Drum over the 40-year simulation period for a single simulation when a less productive stock is assumed (steepness fixed at 0.8) for Red Drum. Outputs are as defined in Figure 4.1.

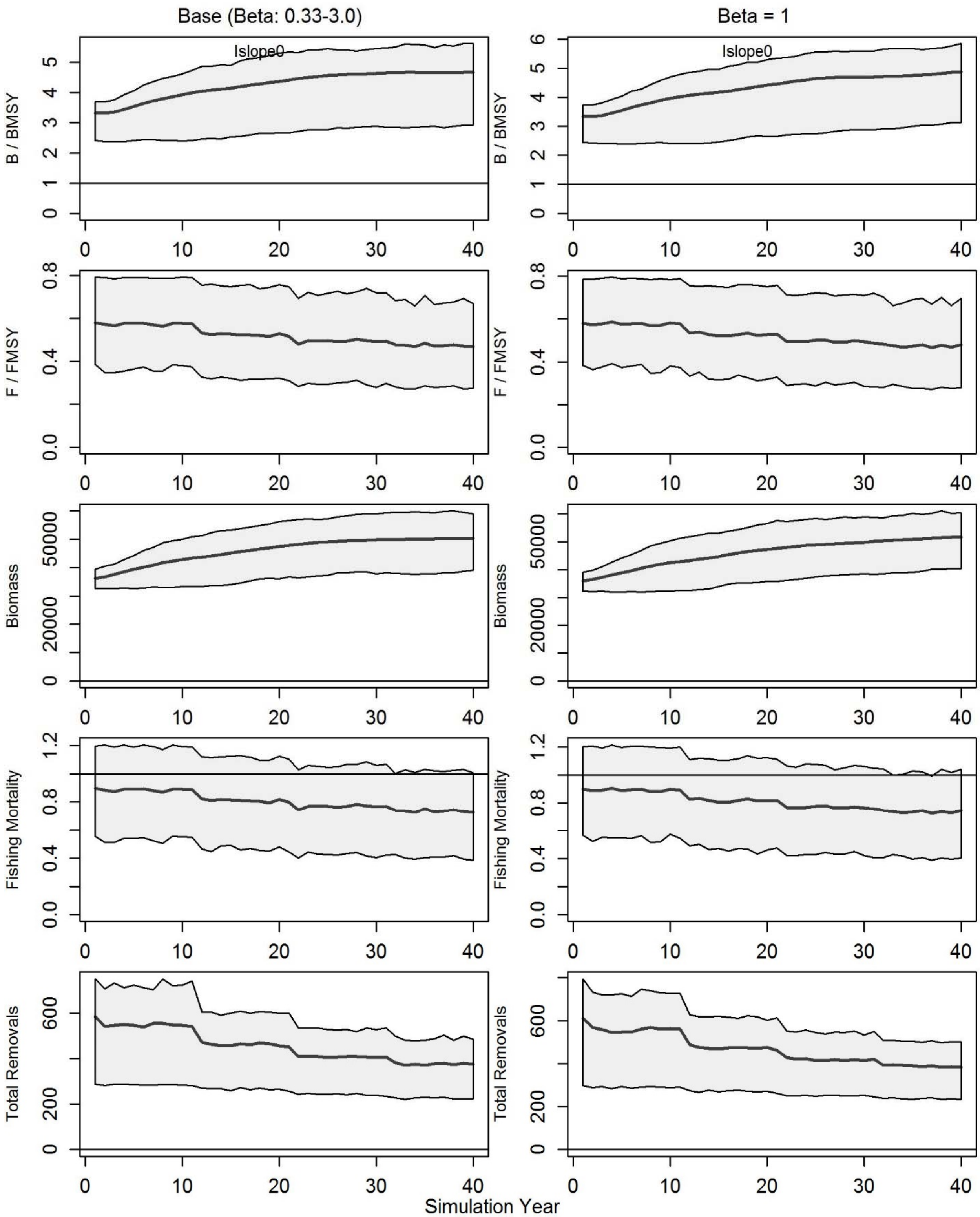

Figure 4.5 Comparison of stock status outputs and catches for Red Drum over the 40-year simulation period. Results are shown for the base model (beta range 0.33 – 0.30) and a beta sensitivity (beta fixed at 1.0). Outputs are as defined in Figure 4.1.

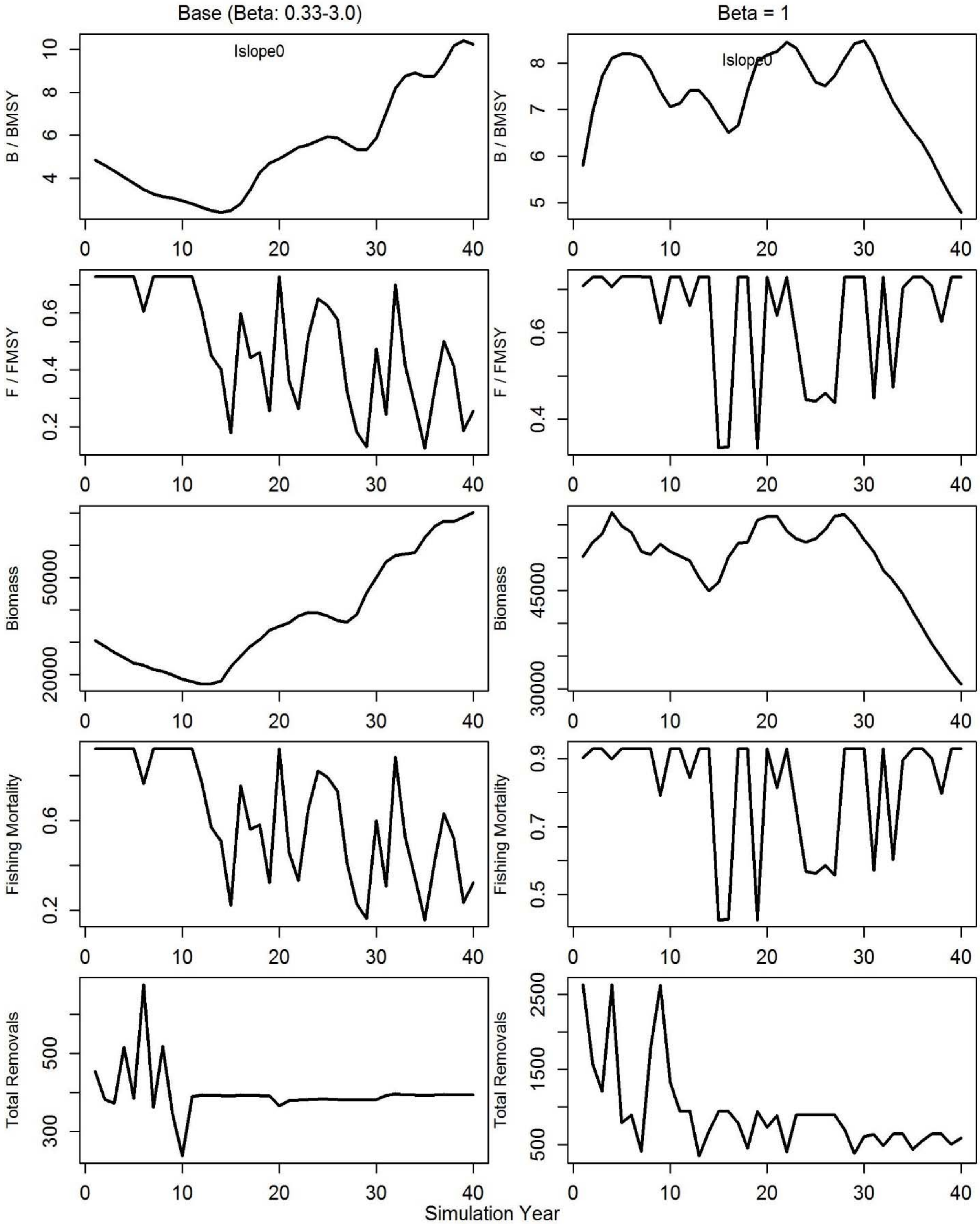

Figure 4.6 Comparison of stock status outputs and catches for Red Drum over the 40-year simulation period for a single simulation. Results are shown for the base model (beta range 0.33 – 0.30) and a beta sensitivity (beta fixed at 1.0). Outputs are as defined in Figure 4.1.

5 LANE SNAPPER

5.1 DATA

The trends observed between the recent index of abundance (Headboat survey) and the recent mean length (from the recreational private fishery) were similar (Figure 5.1). For both data inputs, the recent mean was slightly higher than the mean during the reference period (Figure 5.1).

5.2 ALTERNATIVE PERFORMANCE METRICS FOR THE BASE OPERATING MODEL (ASSESSMENT WORKSHOP)

Performance metrics calculated across years for each simulation and then across simulations resulted in similar metrics as originally presented (range of difference: 0% [Bbelow20] to 6.5% [PNOF]; Table 5.1). The overall viability of methods does not change, as four methods remain viable: Islope0, Itarget0, Ltarget0, and LstepCC0. The Tier3AStatusQuo_ABC method does not meet the performance criteria for either PNOF or B50.

5.3 SENSIVITIES

5.3.1 Assessment interval

Viable methods and their performance metrics are similar to the base case when assessing Lane Snapper every three years (Table 5.2). Absolute differences in performance metrics range from 0% (STY) to 12.8% (VY15). When the assessment frequency is increased, yields are generally less variable (i.e. higher VY15) and there is a slightly lower probability of dropping below 20% B_{MSY}. During the simulation period, the Tier3AStatusQuo_ABC method consistently results in mean B/B_{MSY} ratios below 1 and mean F/F_{MSY} ratios above 1 (Figure 5.2). Total removals throughout the simulation period gradually decrease for the remaining methods. An example simulation is presented in Figure 5.3, where the stabilization of the target methods is evident after the first 10 simulation years.

5.3.2 Steepness

If a less productive stock is assumed, Ltarget0 is no longer a viable method (Table 5.3). Large differences in performance metrics are evident for all metrics except for STY (range: 0.2% [STY] to 46.6% [LTY]; Table 5.3). In particular, the performance metrics are substantially reduced for Tier3AStatusQuo_ABC (range: 1.3% [STY] to 46.6% [LTY]), Islope0 (range: 0.7% [STY] to 24.1% [VY15]), and LstepCC0 (range: 0.2% [STY] to 22.5% [VY15]). The biomass for Tier3AStatusQuo_ABC approaches zero towards the end of the time series, with some simulations for both Islope0 and LstepCC0 also resulting in zero biomass (Figure 5.4). The separation of the mean trend from the 50% confidence interval indicates a highly skewed distribution for methods such as Tier3AStatusQuo_ABC and Itarget0. An example simulation is presented in Figure 5.5, which shows biomass levels as well as total removals approaching zero for all methods at some point in the simulation period.

5.3.3 Index of Abundance

Performance metrics were relatively similar across sensitivities concerning the beta parameter and observation error in the index of abundance (Table 5.4). Absolute differences in performance metrics ranged from 0.2% [B50] to 5.6% [LTY] for Islope0 and from 0.1% [Bbelow20] to 11.9% [LTY] for Itarget0. Trends in mean simulated stock status outputs and catches were also similar (Figure 5.6). An example simulation for each sensitivity is presented in Figure 5.7, where trends in total removals appear to mimic the trends in biomass for Islope0 throughout the simulation period. Total removals eventually stabilize for Itarget0, with the exception of a dramatic decline in biomass and total removals for the beta sensitivity run.

5.3.4 Mean Length

When allowing for interannual variability and a gradient in Linf, the performance metrics for Ltarget0 do not meet the criteria for VY15 (Table 5.5). Large differences in performance metrics were noted and ranged from 0.4% (PNOF) to 44.7% (VY15) for Ltarget0 and from 3.1% (B50) to 30.5% (VY15) for LstepCC0. Trends in biomass and total removals were more jagged when accounting for changes in growth (Figure 5.8). An example simulation is shown in Figure 5.9, which shows the stabilization of total removals for Ltarget0.

5.4 TABLES

Table 5.1 Comparison of AW and RW performance metrics for methods that meet the performance criteria for the base AW MSE run for Lane Snapper. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing (PNOF_sim = calculated across simulations); B50 = Probability of the biomass being above 50% B_{MSY} (B50_sim = calculated across simulations); VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY} (Bbelow20_sim = calculated across simulations). Note that performance for Bbelow20 and Bbelow20_sim is reversed, where a low probability is preferable.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3AStatus Quo_ABC	29.1	45.4	53.3	55.4	92.4	33.0	22.6	43.5	33.5
Islope0	69.0	75.5	87.9	49.2	73.6	14.4	69.3	78.3	13.9
Itarget0	84.9	87.6	94.3	52.3	59.3	6.1	85.5	89.8	5.4
Ltarget0	66.4	74.0	86.7	66.1	84.6	15.0	67.4	74.6	15.0
LstepCC0	70.4	76.3	88.1	46.3	73.7	14.0	70.3	78.7	14.0

Table 5.2 Performance metrics for methods meeting performance criteria assuming an assessment frequency of every three years for Lane Snapper. Performance metrics are as defined in Table 5.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF_sim	B50_sim	Bbelow20_sim
Tier3AStatus Quo_ABC	23.8	43.8	40.5	60.2	92.4	31.7	20.6	41.9	33.1
Islope0	73.4	79.2	95.3	60.1	77.1	10.3	77.3	82.6	8.2
Itarget0	84.7	87.7	93.3	53.6	60.2	5.6	84.6	89.4	5.2
Ltarget0	68.1	75.4	84.1	68.7	83.5	13.3	68.6	76.3	13.9
LstepCC0	77.7	81.5	95.8	39.0	76.2	9.0	82.2	84.8	7.2

Table 5.3 Performance metrics for methods meeting performance criteria assuming a less productive stock (fixed steepness at 0.5, the lower bound of the plausible range) for Lane Snapper. Performance metrics are as defined in Table 5.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF_sim	B50_sim	Bbelow20_sim
Tier3AStatus Quo_ABC	9.4	14.2	14.3	8.8	93.7	75.0	8.4	9.9	86.2
Islope0	52.7	56.1	63.8	33.4	74.3	33.4	52.0	54.6	38.5
Itarget0	80.7	79.7	87.5	40.9	56.9	11.9	81.9	80.7	12.9
LstepCC0	54.3	57.1	65.6	32.4	73.5	32.4	53.8	55.2	37.7

Table 5.4 Performance metrics for index-based methods meeting performance criteria assuming a greater amount of observation error in the index of abundance or a fixed beta parameter for Lane Snapper. Performance metrics are as defined in Table 5.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Base: beta range: 0.33 (hyperstability) to 3.0 (hyper-depletion), index observation error range: 0.06 to 0.30									
Islope0	69.0	75.5	87.9	49.2	73.6	14.4	69.3	78.3	13.9
Itarget0	84.9	87.6	94.3	52.3	59.3	6.1	85.5	89.8	5.4
Beta = fixed at 1									
Islope0	68.7	75.8	90.6	54.8	77.1	12.7	68.8	78.7	12.0
Itarget0	88.5	90.1	95.9	52.8	57.9	4.3	89.3	92.2	3.7
Index observation error = fixed at 0.5									
Islope0	68.6	75.7	90.3	53.6	76.7	12.7	67.8	78.1	11.9
Itarget0	84.2	87.4	92.0	45.1	54.4	6.0	84.5	89.2	5.3
Index observation error = fixed at 1.0									
Islope0	67.8	75.1	89.3	50.7	76.1	12.7	67.6	78.4	12.0
Itarget0	80.6	84.6	88.4	40.4	52.1	7.7	79.8	85.9	6.5

Table 5.5 Performance metrics for length-based methods meeting performance criteria assuming interannual variability (15-20%) and a gradient in Linf (range: ±5%) for Lane Snapper. Performance metrics are as defined in Table 5.1. Note that Ltarget0 does not meet the criteria for VY15 and is shown solely for comparison.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Base: no interannual variability or gradient in Linf									
Ltarget0	66.4	74.0	86.7	66.1	84.6	15.0	67.4	74.6	15.0
LstepCC0	70.4	76.3	88.1	46.3	73.7	14.0	70.3	78.7	14.0
Interannual variability in Linf (range: 15-20%) and gradient (±5%)									
Ltarget0	66.8	72.8	42.0	48.1	61.7	13.4	66.5	75.6	10.7
LstepCC0	78.5	79.4	57.6	26.1	48.0	9.7	82.2	82.9	7.3

5.5 FIGURES

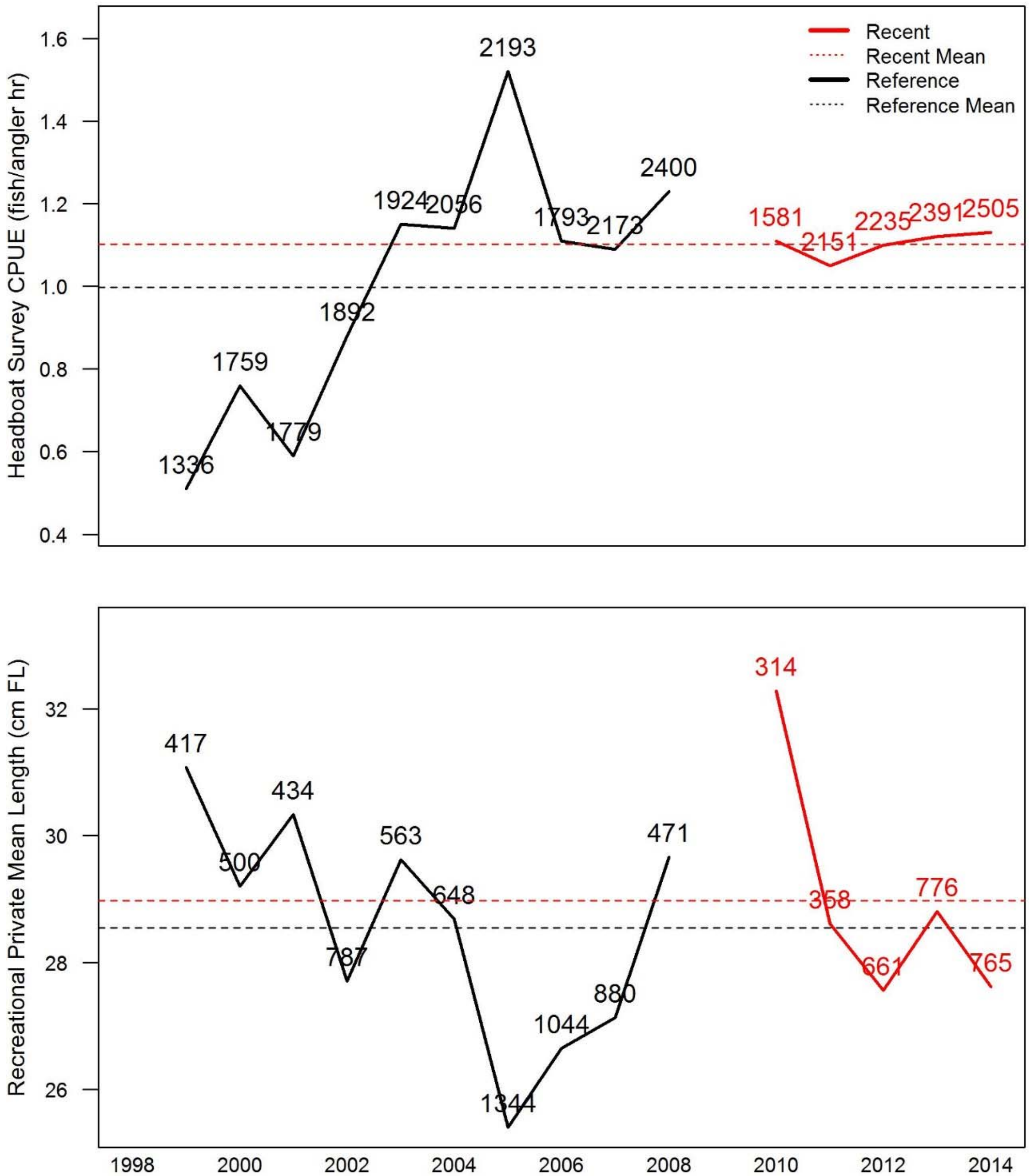

Figure 5.1 Comparison of trends in the Headboat index of abundance and the index of mean length derived from the recreational private fishery between the reference period (1999-2008) and the recent period (2010-2014) for Lane Snapper. Numbers correspond to the sample sizes for each data input.

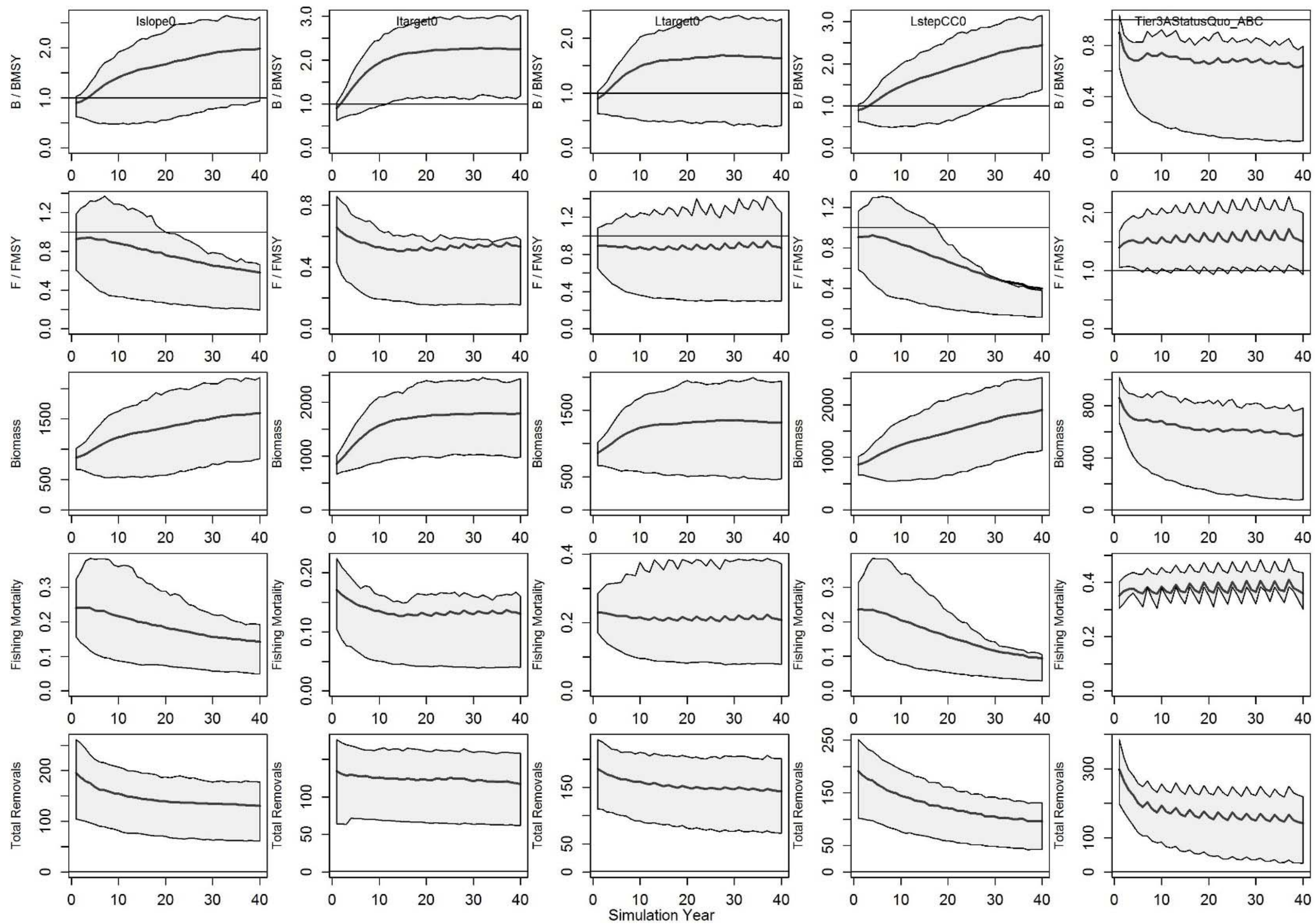

Figure 5.2 Comparison of stock status outputs and catches for Lane Snapper over the 40-year simulation period where an assessment is conducted every three years. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, and total removals (in pounds) for the viable methods and the status quo. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 25th and 75th percentiles. Note that the y-axes differ between panels.

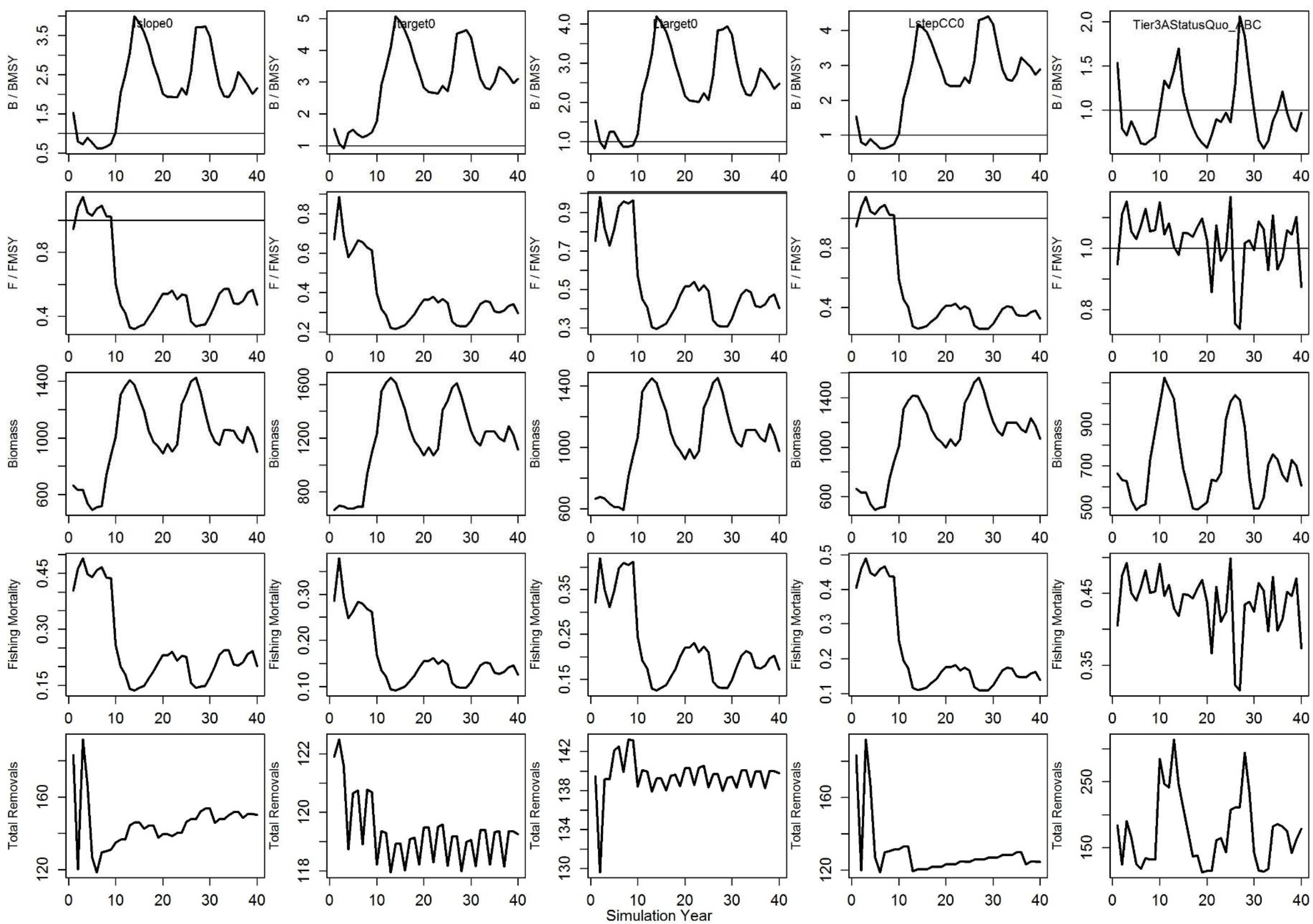

Figure 5.3 Comparison of stock status outputs and catches for Lane Snapper over the 40-year simulation period for a single simulation when an assessment is conducted every three years. Outputs are as defined in Figure 5.2. Note that the y-axes differ between panels.

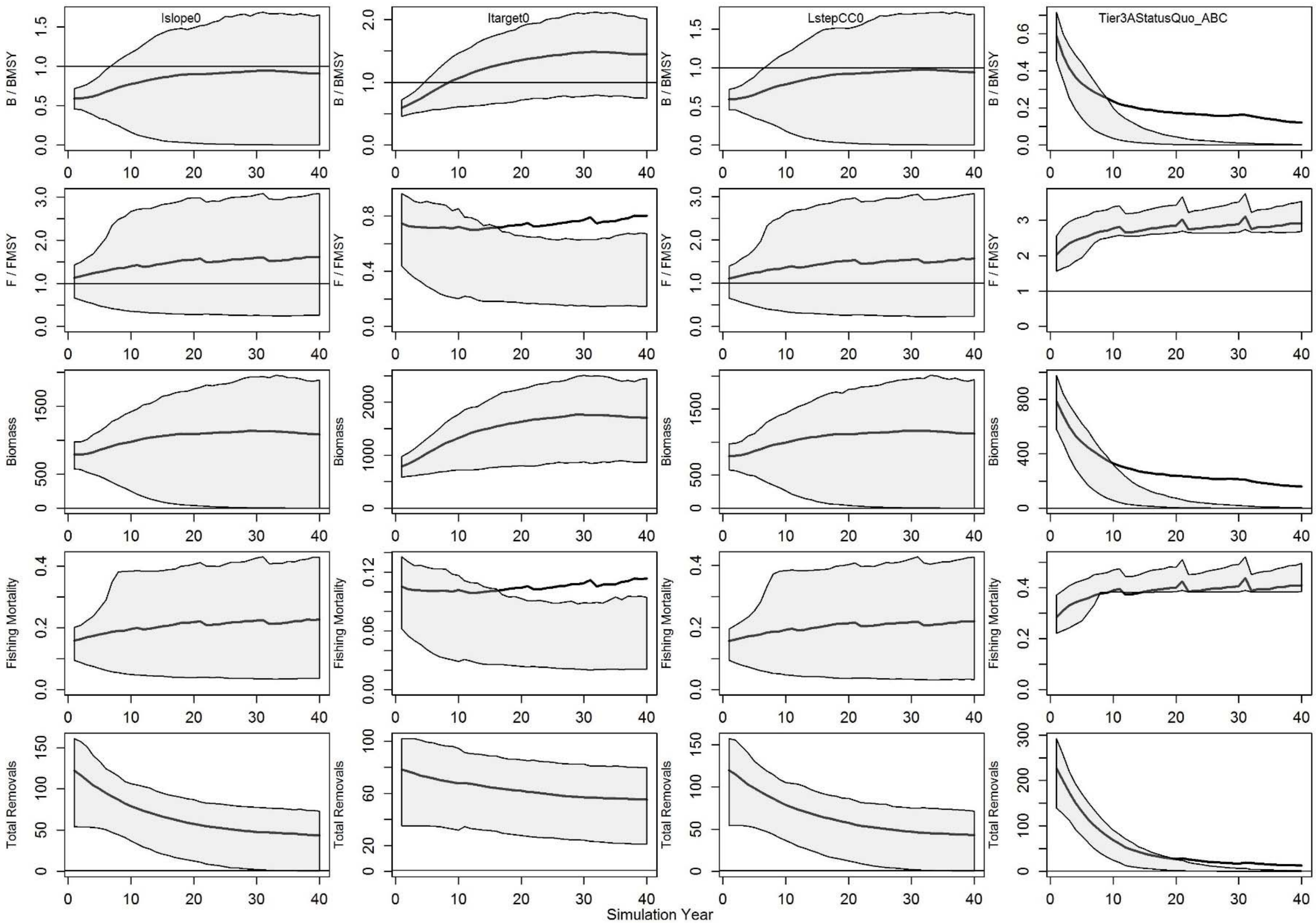

Figure 5.4 Comparison of stock status outputs and catches for Lane Snapper over the 40-year simulation period when a less productive stock is assumed (steepness fixed at 0.5). Outputs are as defined in Figure 5.2. Note that the y-axes differ between panels.

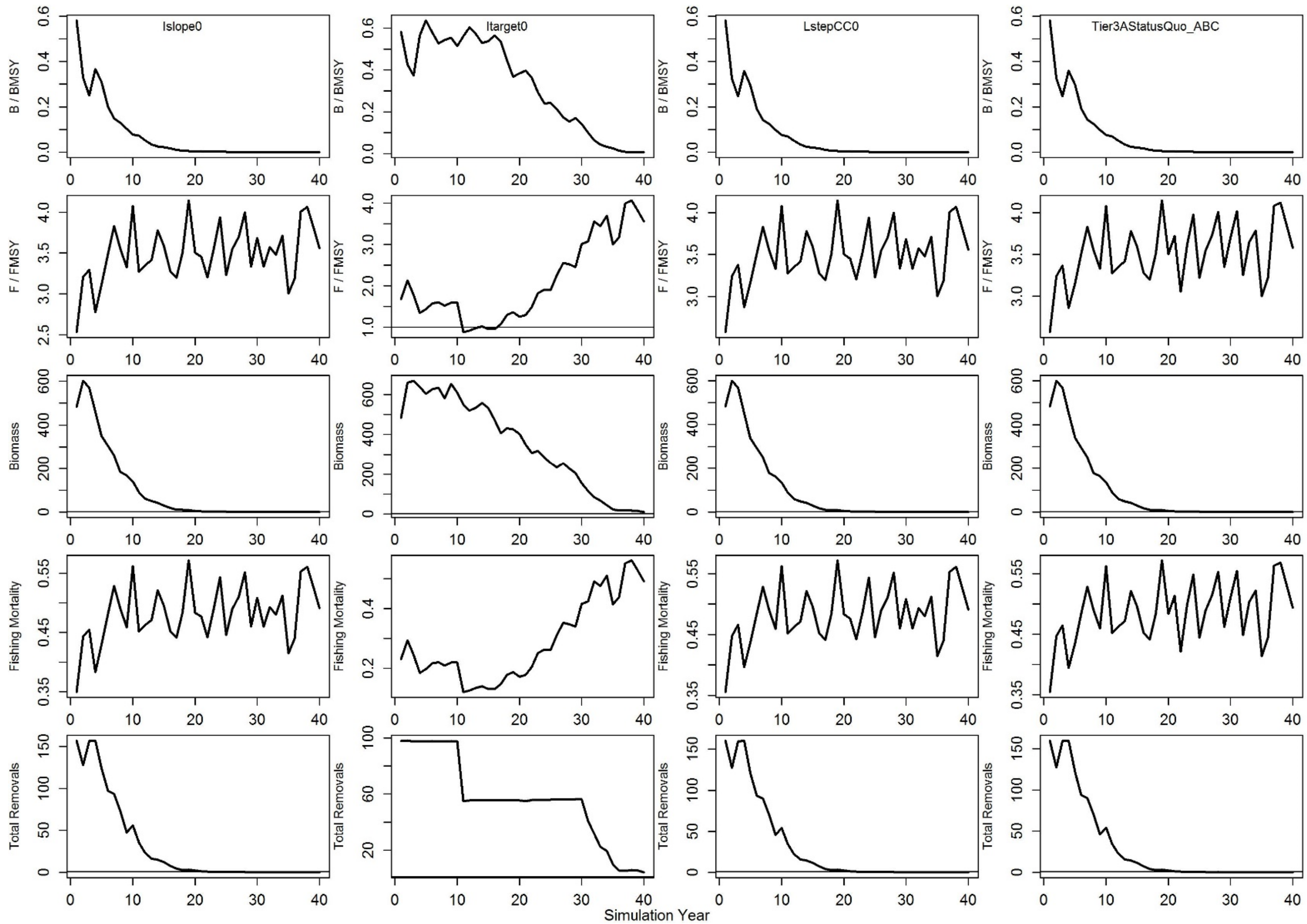

Figure 5.5 Comparison of stock status outputs and catches for Lane Snapper over the 40-year simulation period for a single simulation when a less productive stock is assumed (steepness fixed at 0.5). Outputs are as defined in Figure 5.2. Note that the y-axes differ between panels.

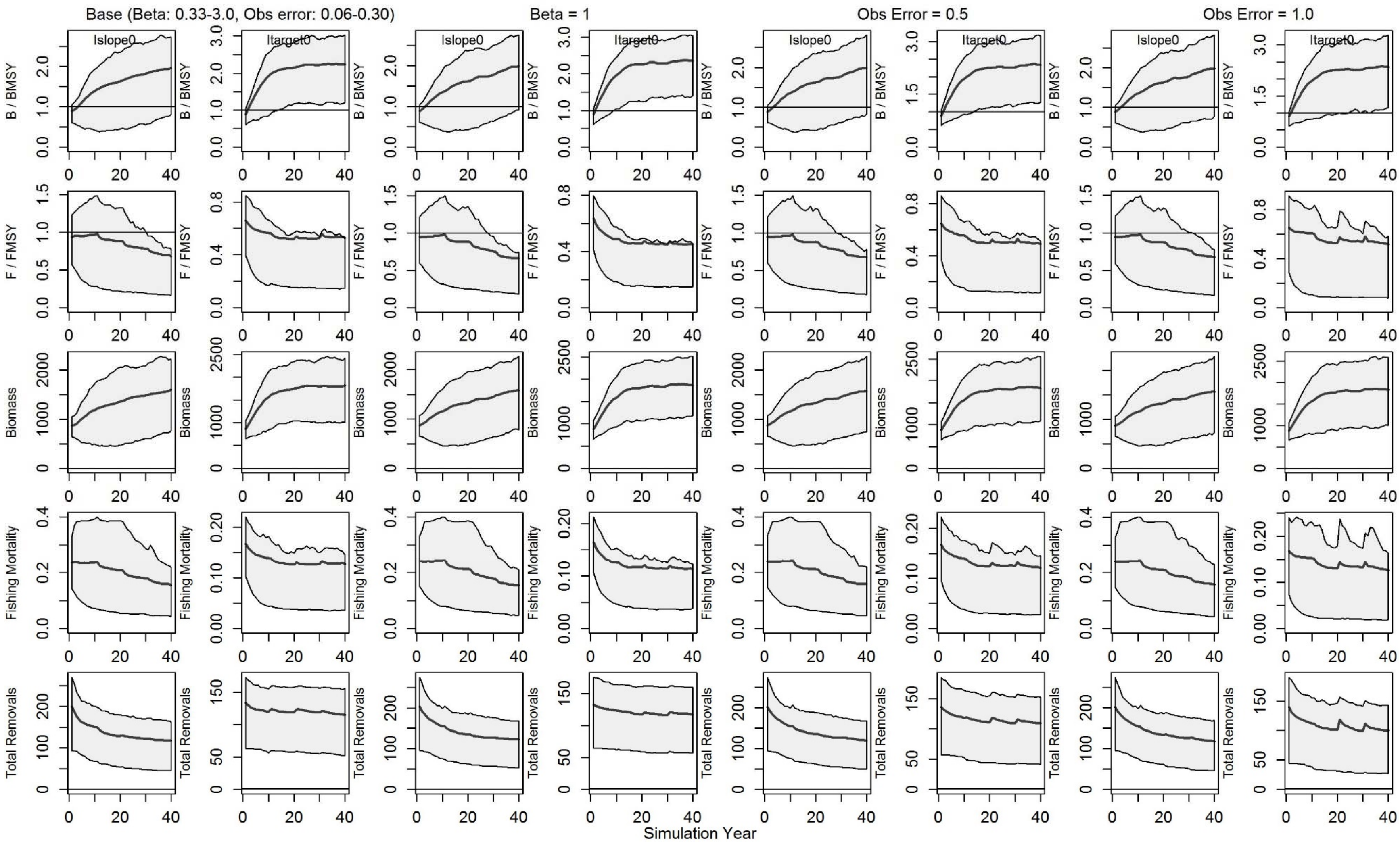

Figure 5.6 Comparison of stock status outputs and catches from the index-based methods for Lane Snapper over the 40-year simulation period. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.064 – 0.30), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 5.2. Note that the y-axes differ between panels.

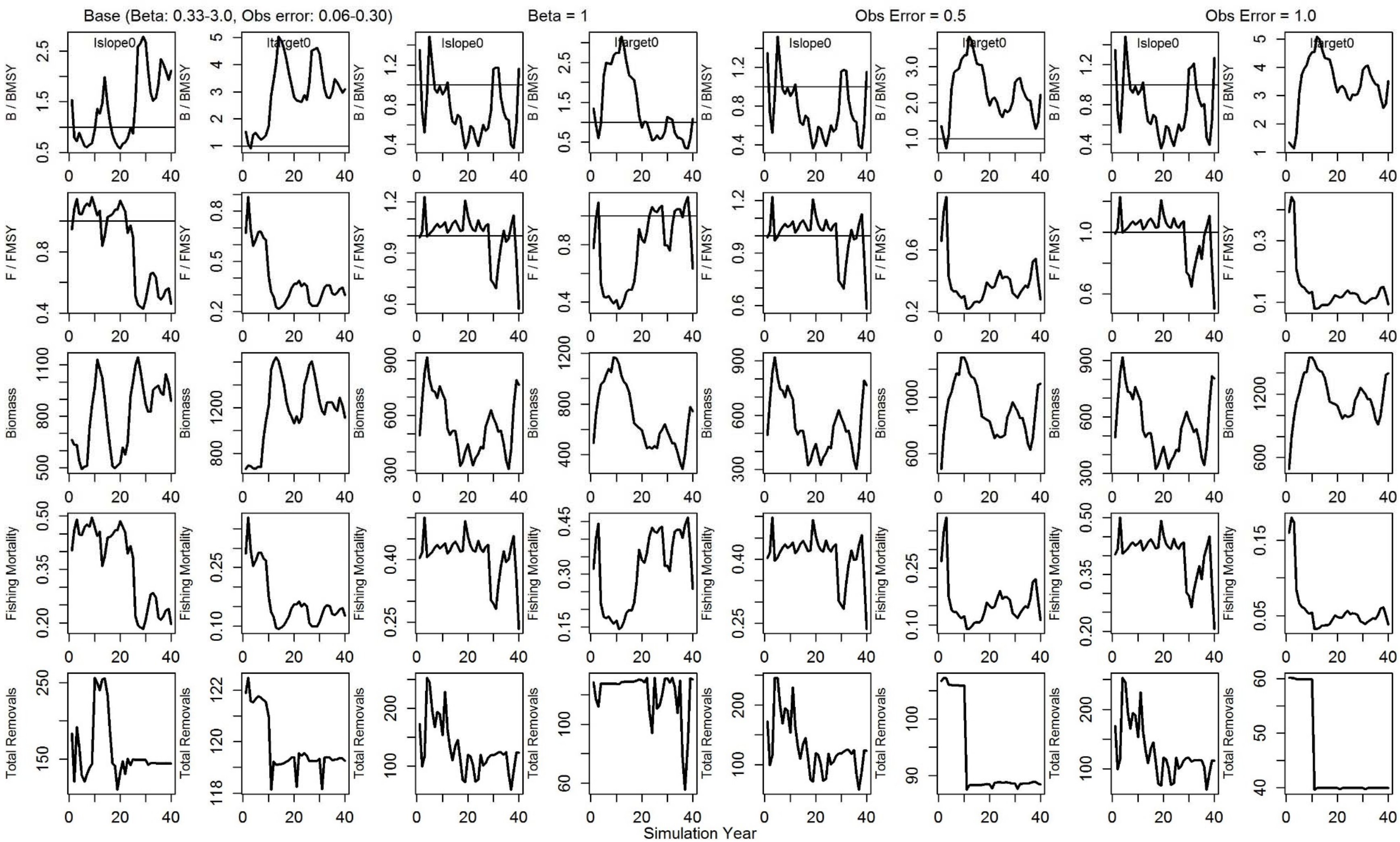

Figure 5.7 Comparison of stock status outputs and catches from the index-based methods for Lane Snapper over the 40-year simulation period for a single simulation. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.064 – 0.30), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 5.2. Note that the y-axes differ between panels.

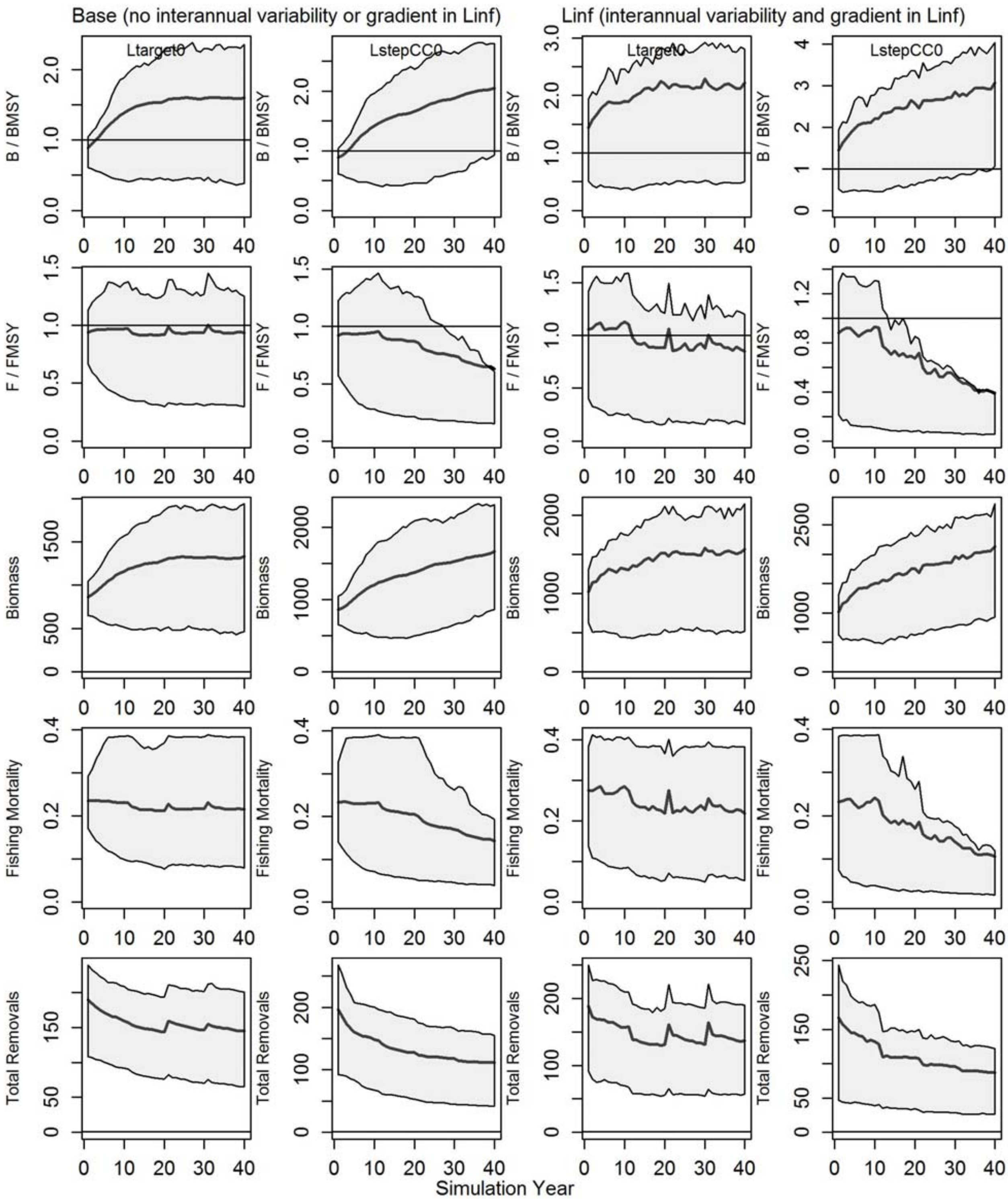

Figure 5.8 Comparison of stock status outputs and catches from the length-based methods for Lane Snapper over the 40-year simulation period. Results are shown for the base model (no interannual variability of gradient in Linf) and a Linf sensitivity (15-20% interannual variability and a gradient of ±5% in Linf). Outputs are as defined in Figure 5.2. Note that the y-axes differ between panels.

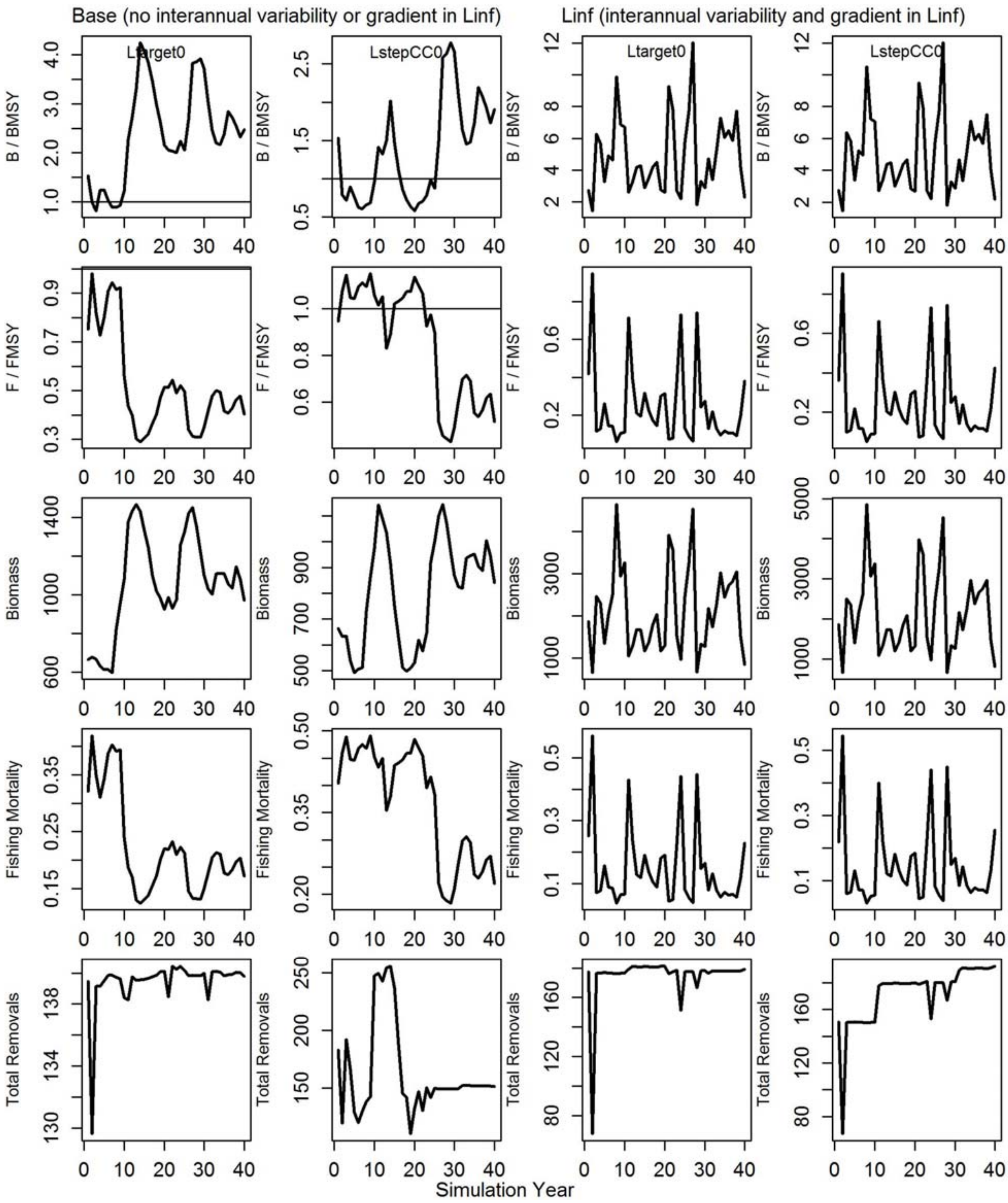

Figure 5.9 Comparison of stock status outputs and catches from the length-based methods for Lane Snapper over the 40-year simulation period for a single simulation. Results are shown for the base model (no interannual variability of gradient in Linf) and a Linf sensitivity (15-20% interannual variability and a gradient of ±5% in Linf). Outputs are as defined in Figure 5.2. Note that the y-axes differ between panels.

6 WENCHMAN

6.1 DATA

A conflicting trend was noted between the index of abundance and index of mean length derived from the SEAMAP small pelagics survey (Figure 6.1). The mean of the recent index of abundance is slightly higher than the mean index during the reference period. In contrast, the mean length from the SEAMAP small pelagics survey has declined by roughly 3 cm compared to the reference period. The DLM tool assumes changes in mean length or CPUE are the result of fishing pressure. Thus, a decrease in mean length indicates an increase in F, and an increase in CPUE indicates a decrease in F. As the small pelagic survey is an index of recruitment before fishing has occurred, the DLM tool interpretation of mean length is not appropriate. The observed decrease in mean length accompanied by an increase in CPUE suggests either an increase in recruitment or the sampling of younger fish with a reduced accumulated impact of natural mortality.

6.2 ALTERNATIVE PERFORMANCE METRICS FOR THE BASE OPERATING MODEL (ASSESSMENT WORKSHOP)

Performance metrics calculated across years for each simulation and then across simulations resulted in similar metrics as originally presented (range of difference: 0.1% [PNOF] to 5.4% [PNOF]; Table 6.1). The overall viability of methods does not change, as all feasible methods remain viable including the Tier3AStatusQuo_ABC.

6.3 SENSITIVITIES

6.3.1 Assessment interval

Viable methods and their performance metrics are similar to the base case when assessing Wenchman every three years (Table 6.2). Absolute differences in performance metrics range from 0% (B50, Bbelow20) to 11.6% (LTY). During the simulation period, all methods including the Tier3AStatusQuo_ABC consistently result in mean B/B_{MSY} ratios above 1 and mean F/F_{MSY} ratios below 1 (Figure 6.2). Total removals eventually stabilize over the simulation period, with the exception of LstepCC0 where removals gradually decline. An example simulation is presented in Figure 6.3, which shows similar removals for catch-based methods and Ltarget0 but more variable catches for Islope0, Itarget0, and LstepCC0 over the simulation period.

6.3.2 Steepness

If a less productive stock is assumed, Tier3AStatusQuo_ABC no longer meets the performance criteria for PNOF, B50, or VY15 (Table 6.3). Large differences in performance metrics are evident for all metrics except for STY (range: 1.2% [STY] to 46.3% [LTY]; Table 6.3). The performance metrics for Tier3AStatusQuo_ABC are especially worse (range: 1.2% [STY] to 46.3% [LTY]). The biomass for Tier3AStatusQuo_ABC approaches zero towards the end of the simulation period

(Figure 6.4). The mean ratios of B/B_{MSY} and F/F_{MSY} for most methods throughout the simulation period remain above and below 1, respectively, although total removals gradually decline for all methods. An example simulation is presented in Figure 6.5, which shows a similar pattern in biomass and total removals for the index-based methods and relatively stable catches for the catch-based methods and Ltarget0.

6.3.3 Index of Abundance

Performance metrics were relatively similar across sensitivities concerning the beta parameter and observation error in the index of abundance (Table 6.4). Absolute differences in performance metrics ranged from 0% [VY15] to 3.1% [LTY] for Islope0 and from 0.1% [Bbelow20] to 7.2% [STY] for Itarget0. Trends in mean simulated stock status outputs and catches were also similar (Figure 6.6). An example simulation for each sensitivity is presented in Figure 6.7, which shows conflicting trends in biomass and total removals for Islope0 across the sensitivity runs.

6.3.4 Mean Length

When allowing for interannual variability and a gradient in Linf, the performance metrics were relatively similar to the base operating model (Table 6.5). Absolute differences in metrics ranged from 0.4% (PNOF) to 15.6% (VY15). Mean trends in biomass and total removals were more variable when accounting for changes in growth (Figure 6.8). An example simulation is shown in Figure 6.9, where total removals are relatively consistent throughout the simulation period for the Linf sensitivity run.

6.4 TABLES

Table 6.1 Comparison of AW and RW performance metrics for methods that meet the performance criteria for the base AW MSE run for Wenchman. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing (PNOF_sim = calculated across simulations); B50 = Probability of the biomass being above 50% B_{MSY} (B50_sim = calculated across simulations); VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY} (Bbelow20_sim = calculated across simulations). Note that performance for Bbelow20 and Bbelow20_sim is reversed, where a low probability is preferable.

Method	SEDAR 49 AW Metrics							RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20		PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3AStatus Quo_ABC	66.9	76.7	60.8	70.5	82.3	9.8		61.5	78.5	7.6
CC1_Ref	83.9	87.4	85.5	59.6	65.2	5.4		83.5	89.5	4.0
Islope0	88.8	90.9	92.5	43.4	50.1	3.6		89.4	94.1	2.6
Itarget0	81.9	86.6	85.2	58.6	62.7	5.4		81.5	89.0	3.8
Ltarget0	87.7	90.2	87.6	49.6	55.1	4.2		87.6	91.6	3.4
LstepCC0	89.2	91.2	93.3	40.0	50.6	3.4		89.7	94.5	2.5

Table 6.2 Performance metrics for methods meeting performance criteria assuming an assessment frequency of every three years for Wenchman. Performance metrics are as defined in Table 6.1.

Method	SEDAR 49 AW Metrics							RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20		PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3AStatus Quo_ABC	63.9	75.8	56.8	73.1	81.0	10.4		60.3	78.0	8.7
CC1_Ref	83.6	87.4	83.9	60.9	64.7	5.4		84.5	90.1	5.1
Islope0	89.9	91.5	98.0	50.2	52.1	3.2		93.1	94.6	2.2
Itarget0	82.7	87.0	84.4	61.4	64.4	4.9		82.8	89.1	3.8
Ltarget0	85.0	88.6	85.4	55.3	58.7	5.0		84.8	90.6	4.2
LstepCC0	91.9	92.7	98.6	28.4	52.6	2.9		94.8	95.4	2.0

Table 6.3 Performance metrics for methods meeting performance criteria assuming a less productive stock (fixed steepness at 0.5, the lower bound of the plausible range) for Wenchman. Performance metrics are as defined in Table 6.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3AStatus Quo_ABC	32.5	35.0	43.6	24.2	81.1	49.1	27.4	30.0	53.4
CC1_Ref	62.8	63.5	73.6	33.4	63.4	25.3	61.1	63.4	27.5
Islope0	76.1	74.8	85.2	26.8	48.4	16.5	74.6	74.5	17.1
Itarget0	68.0	67.9	78.0	36.3	58.6	21.1	66.9	68.5	22.0
Ltarget0	66.8	66.8	76.7	29.7	56.7	23.0	65.1	66.1	24.9
LstepCC0	77.8	76.1	85.9	22.2	46.9	15.4	76.7	75.6	15.7

Table 6.4 Performance metrics for index-based methods meeting performance criteria assuming a greater amount of observation error in the index of abundance or a fixed beta parameter for Wenchman. Performance metrics are as defined in Table 6.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Base: beta range: 0.33 (hyperstability) to 3.0 (hyper-depletion), index observation error range: 0.18 to 0.26									
Islope0	88.8	90.9	92.5	43.4	50.1	3.6	89.4	94.1	2.6
Itarget0	81.9	86.6	85.2	58.6	62.7	5.4	81.5	89.0	3.8
Beta = fixed at 1									
Islope0	88.3	90.2	92.5	46.5	53.0	4.0	89.7	93.3	2.9
Itarget0	82.7	86.9	86.3	61.6	66.5	5.5	82.5	90.1	4.2
Index observation error = fixed at 0.5									
Islope0	88.1	90.1	92.2	45.9	52.7	3.9	89.2	93.6	2.9
Itarget0	82.7	86.9	84.1	57.0	60.5	5.5	82.0	89.2	4.0
Index observation error = fixed at 1.0									
Islope0	87.4	89.8	90.8	44.8	52.2	3.9	88.9	92.7	2.8
Itarget0	82.6	87.2	81.5	51.8	55.5	5.5	81.8	89.0	3.8

Table 6.5 Performance metrics for length-based methods meeting performance criteria assuming interannual variability (15-20%) and a gradient in Linf (range: ±5%) for Wenchman. Performance metrics are as defined in Table 6.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Base: no interannual variability or gradient in Linf									
Ltarget0	87.7	90.2	87.6	49.6	55.1	4.2	87.6	91.6	3.4
LstepCC0	89.2	91.2	93.3	40.0	50.6	3.4	89.7	94.5	2.5
Interannual variability in Linf (range: 15-20%) and gradient (range: ±5%)									
Ltarget0	88.1	84.7	74.4	39.4	45.3	6.0	89.7	89.8	2.9
LstepCC0	89.9	86.2	77.7	28.1	41.5	5.8	91.8	90.9	3.4

6.5 FIGURES

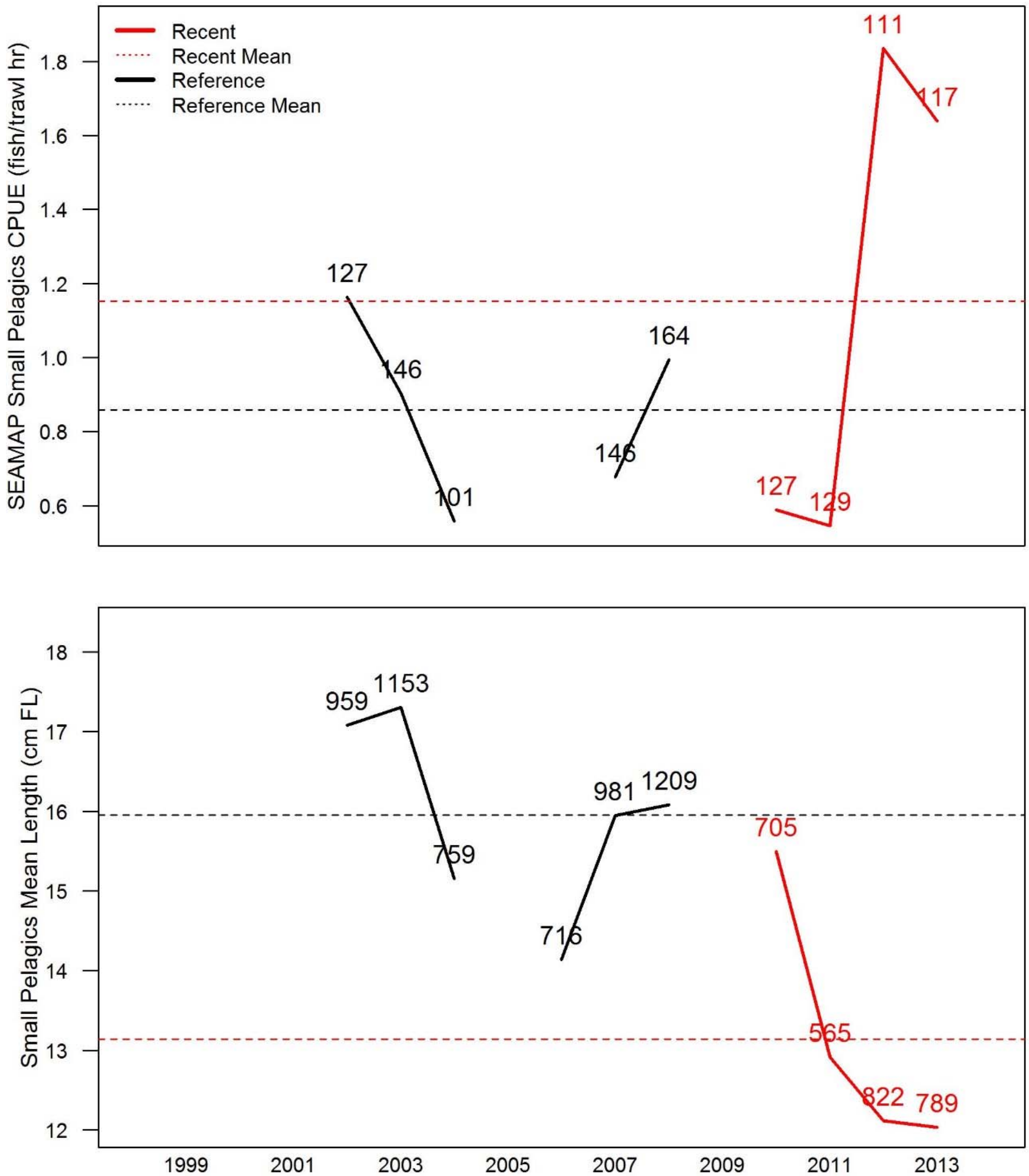

Figure 6.1 Comparison of trends from the index of abundance and index of mean length both derived from the SEAMAP small pelagics survey between the reference period (1999-2008) and the recent period (2010-2014) for Wenchman. Numbers correspond to the sample sizes for each data input.

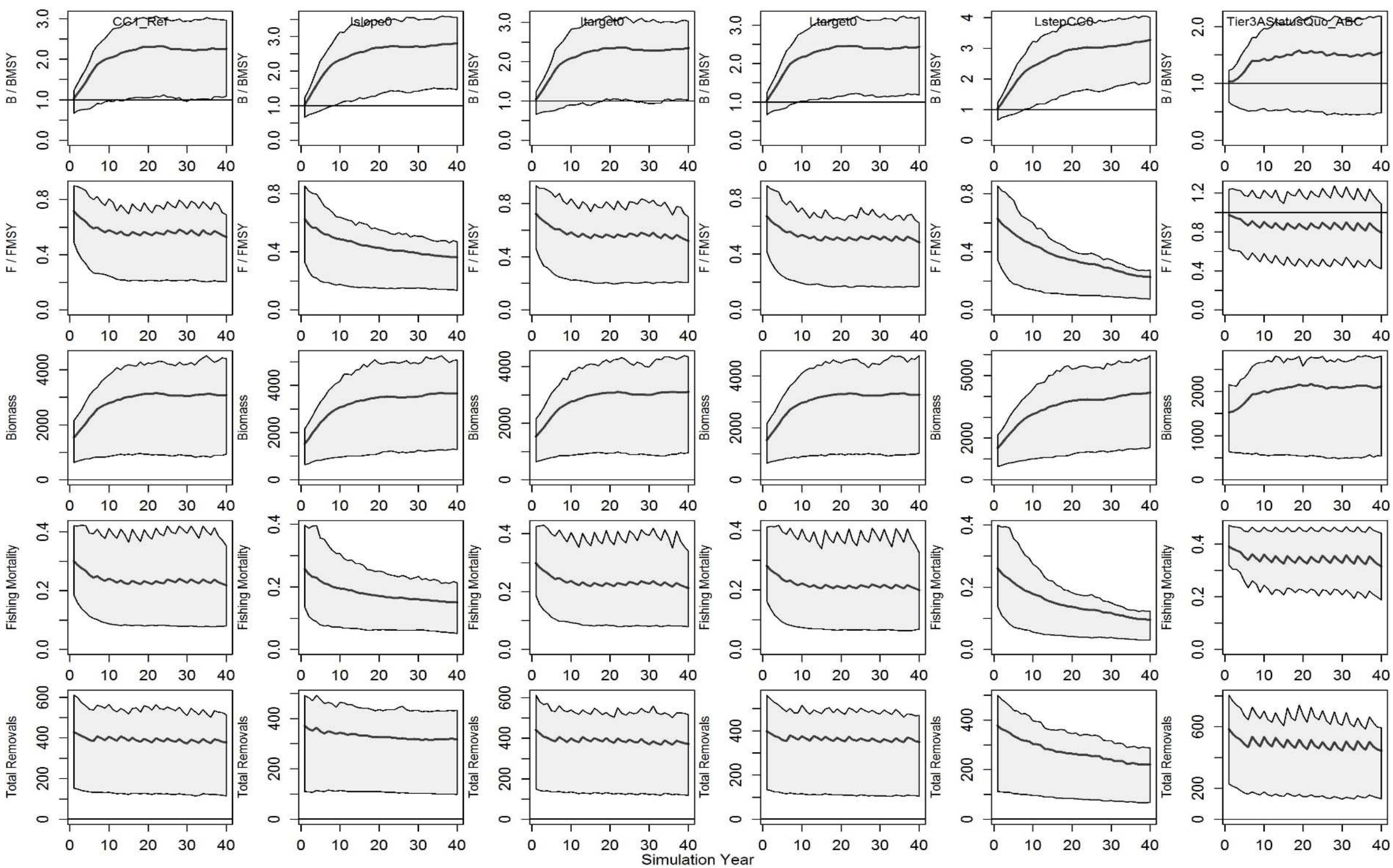

Figure 6.2 Comparison of stock status outputs and catches for Wenchman over the 40-year simulation period where an assessment is conducted every three years. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, and total removals (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 25th and 75th percentiles. Note that the y-axes differ between panels.

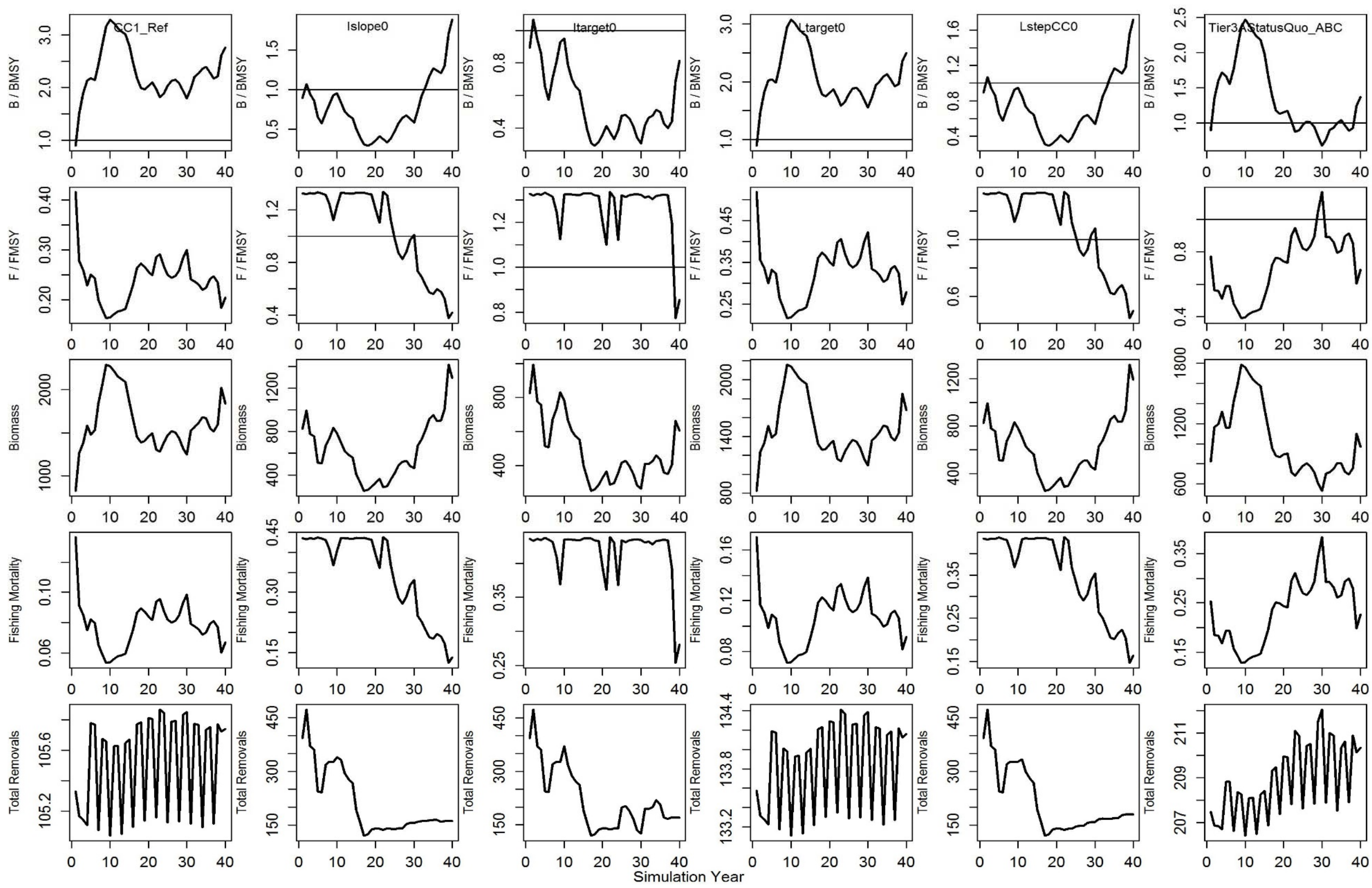

Figure 6.3 Comparison of stock status outputs and catches for Wenchman over the 40-year simulation period for a single simulation when an assessment is conducted every three years. Outputs are as defined in Figure 6.2. Note that the y-axes differ between panels.

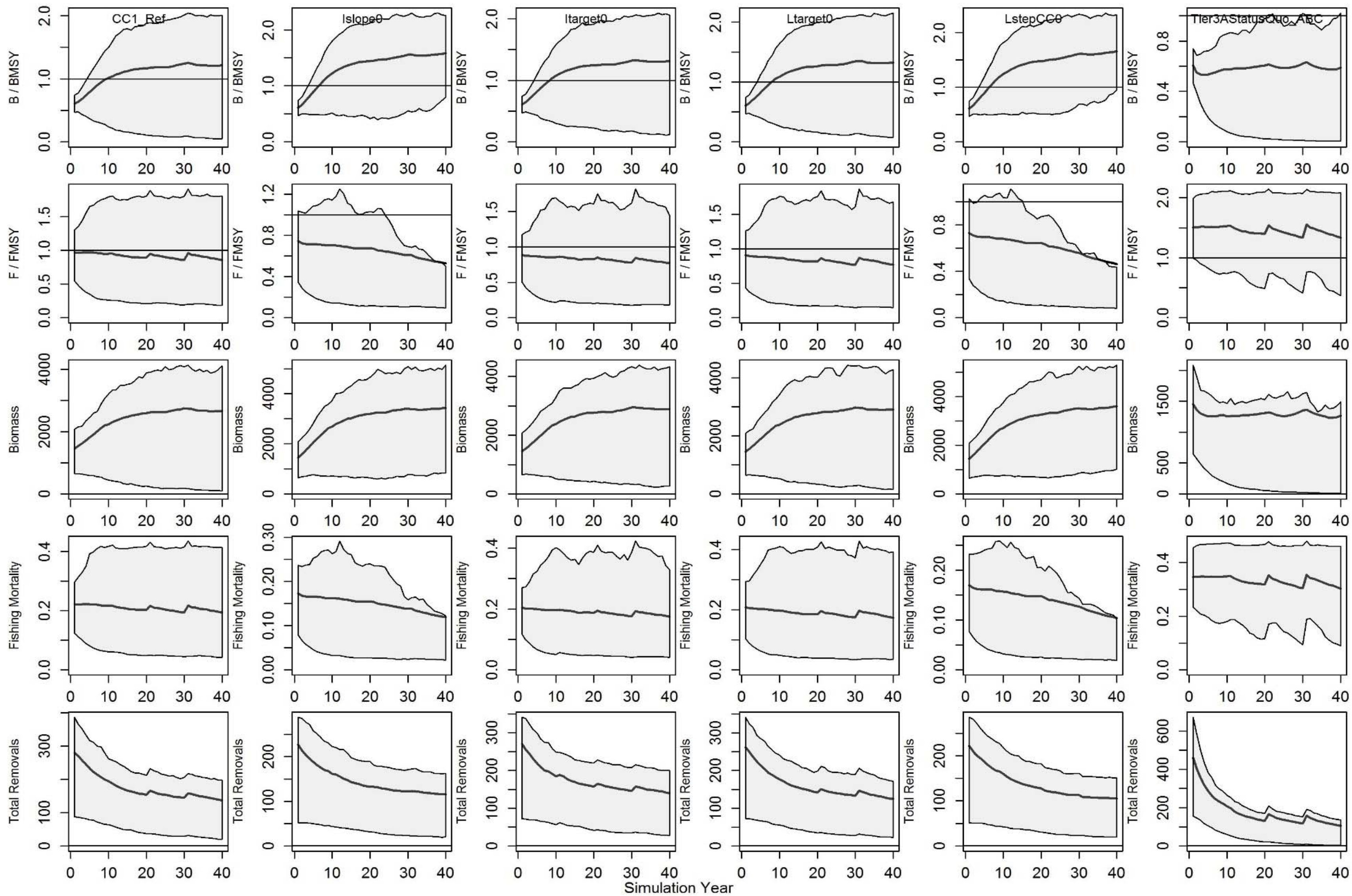

Figure 6.4 Comparison of stock status outputs and catches for Wenchman over the 40-year simulation period when a less productive stock is assumed (steepness fixed at 0.5). Outputs are as defined in Figure 6.2. Note that the y-axes differ between panels.

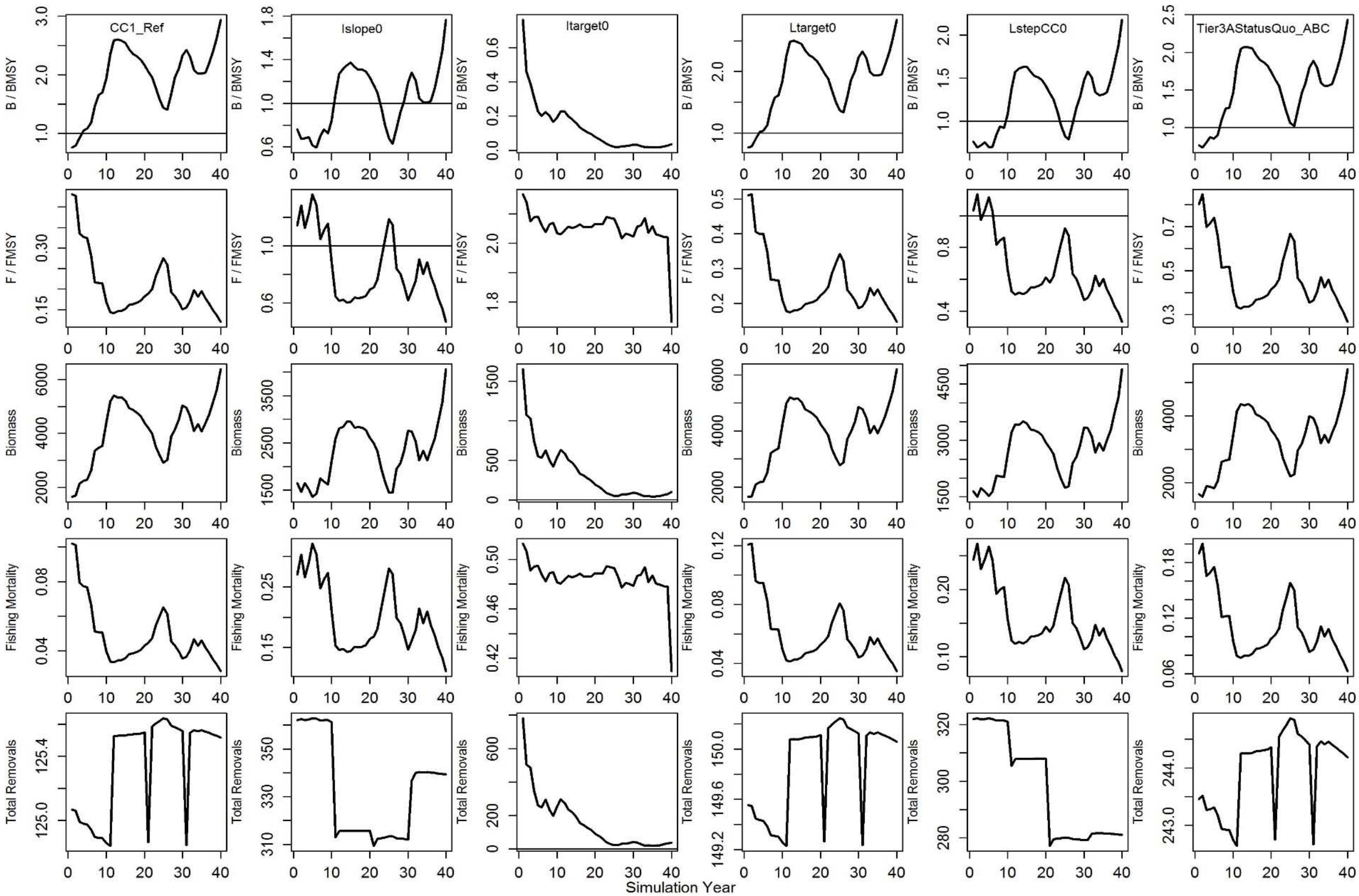

Figure 6.5 Comparison of stock status outputs and catches for Wenchman over the 40-year simulation period for a single simulation when a less productive stock is assumed (steepness fixed at 0.5). Outputs are as defined in Figure 6.2. Note that the y-axes differ between panels.

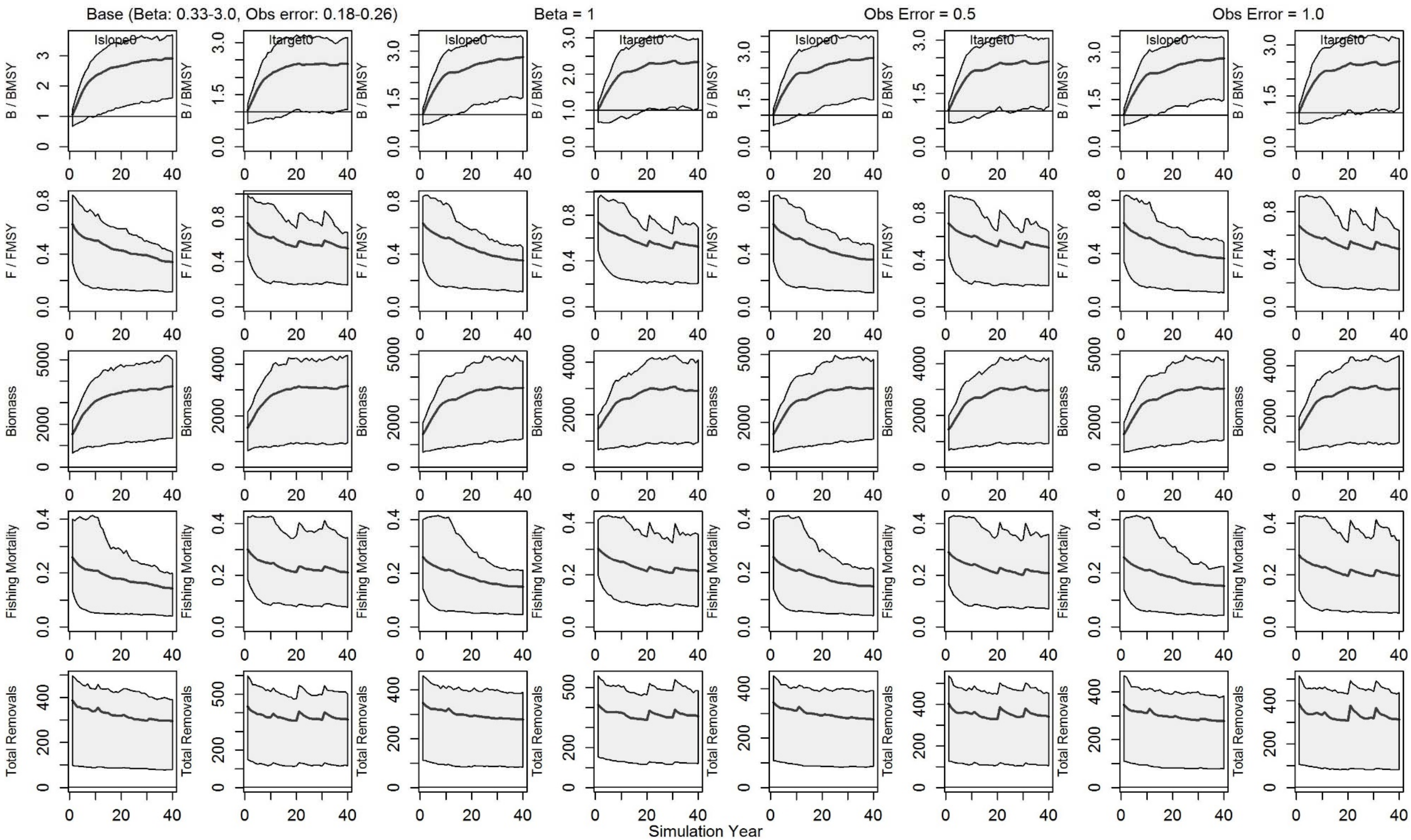

Figure 6.6 Comparison of stock status outputs and catches from the index-based methods for Wenchman over the 40-year simulation period. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.18 – 0.26), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 6.2. Note that the y-axes differ between panels.

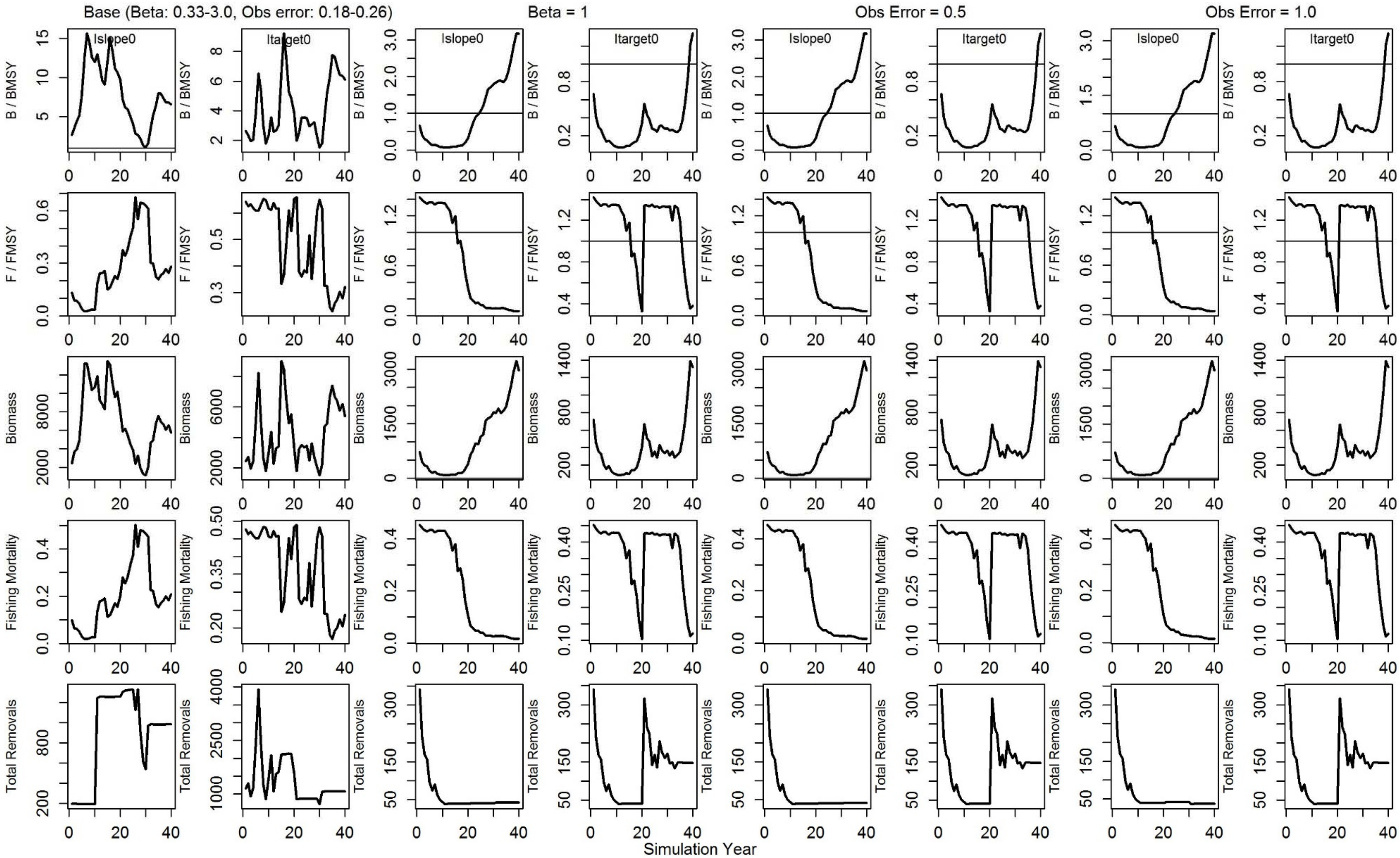

Figure 6.7 Comparison of stock status outputs and catches from the index-based methods for Wenchman over the 40-year simulation period for a single simulation. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.18 – 0.26), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 6.2. Note that the y-axes differ between panels.

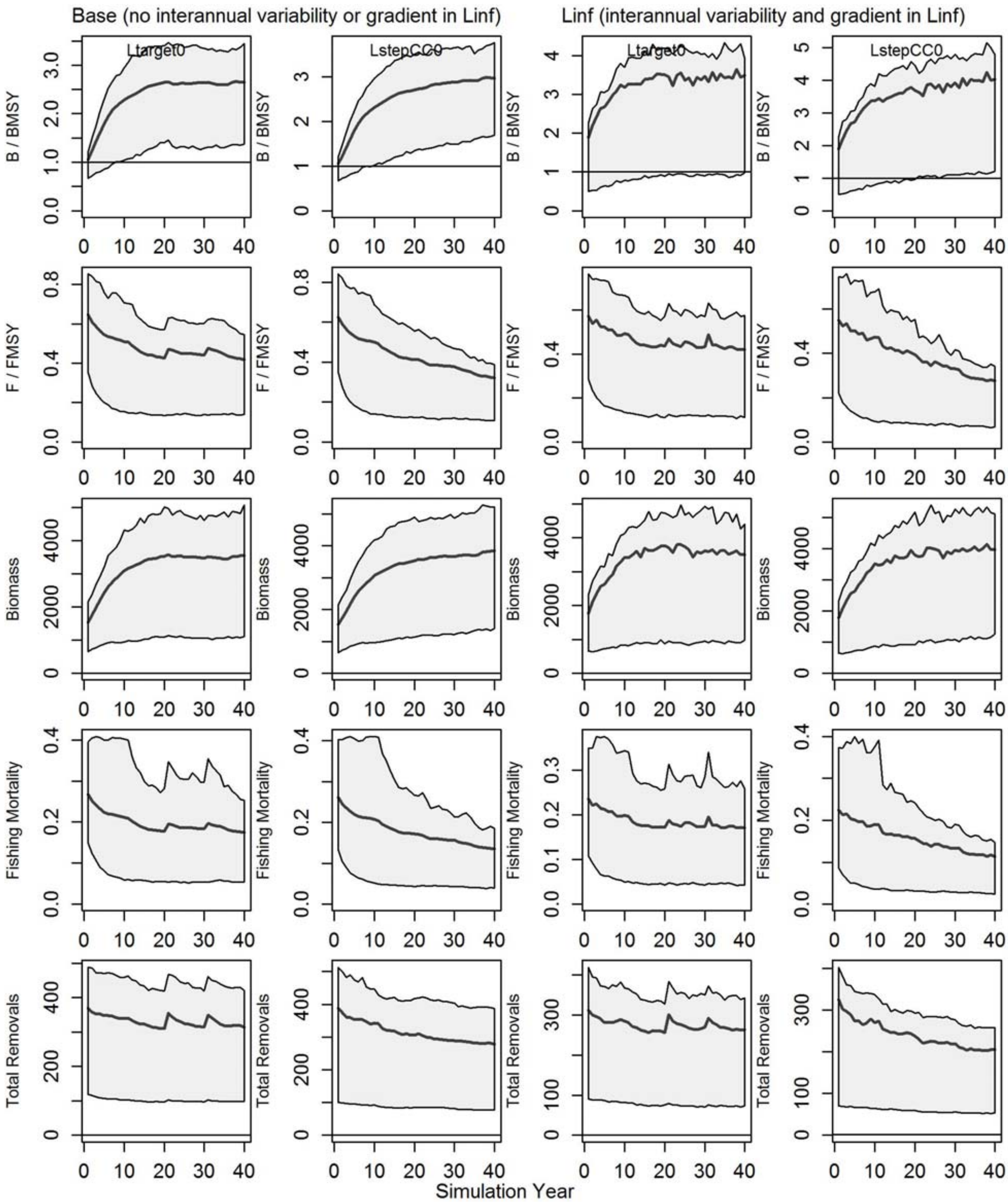

Figure 6.8 Comparison of stock status outputs and catches from the length-based methods for Wenchman over the 40-year simulation period. Results are shown for the base model (no interannual variability of gradient in Linf) and a Linf sensitivity (15-20% interannual variability and a gradient of ±5% in Linf). Outputs are as defined in Figure 6.2. Note that the y-axes differ between panels.

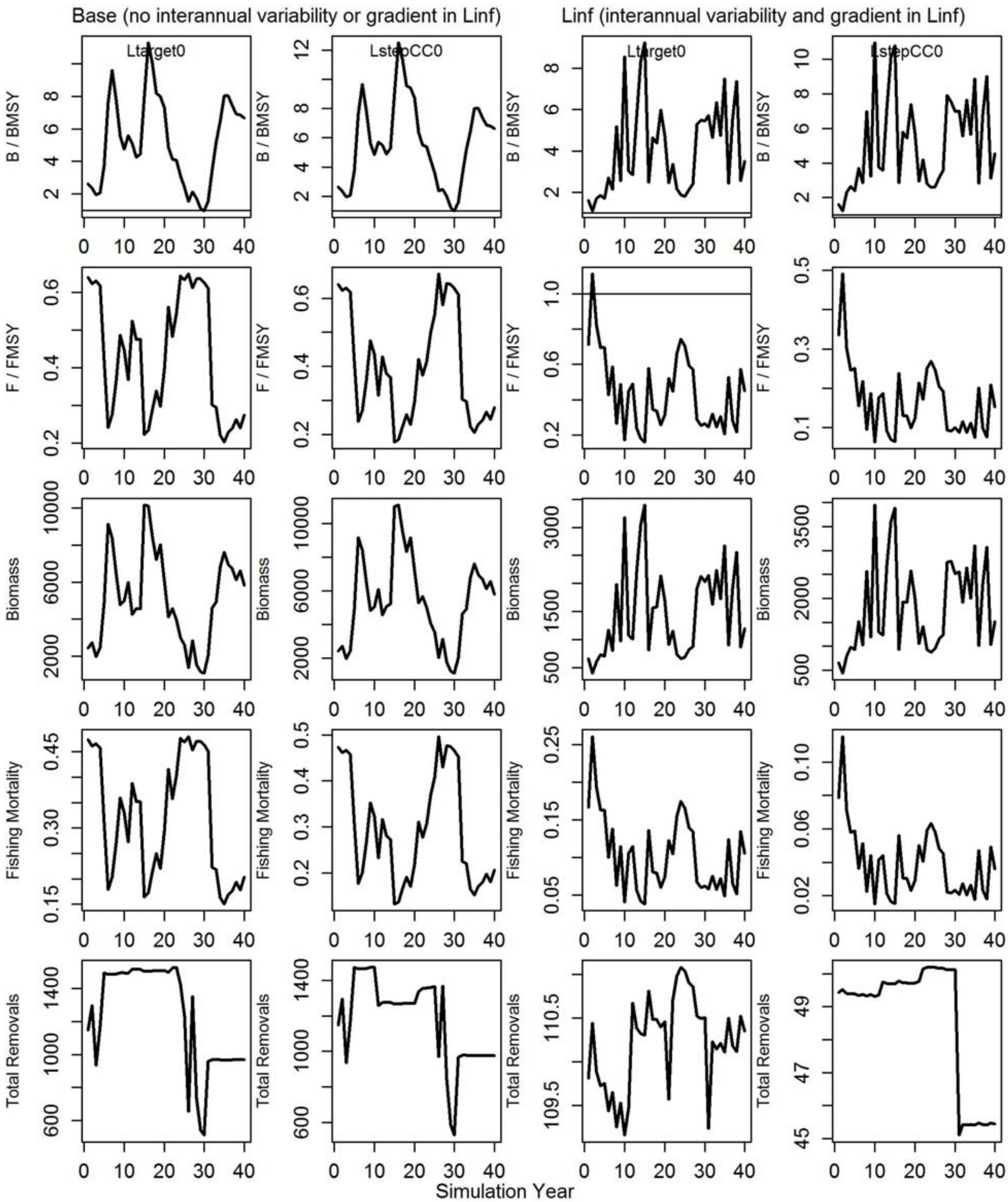

Figure 6.9 Comparison of stock status outputs and catches from the length-based methods for Wenchman over the 40-year simulation period for a single simulation. Results are shown for the base model (no interannual variability of gradient in Linf) and a Linf sensitivity (15-20% interannual variability and a gradient of ±5% in Linf). Outputs are as defined in Figure 6.2. Note that the y-axes differ between panels.

7 SNOWY GROUPER

7.1 DATA

No indices of abundance or mean length were included in this assessment for Snowy Grouper.

7.2 ALTERNATIVE PERFORMANCE METRICS FOR THE BASE OPERATING MODEL (ASSESSMENT WORKSHOP)

Performance metrics calculated across years for each simulation and then across simulations resulted in similar metrics as originally presented (range: 2.5% [PNOF] to 10.5% [B50]; Table 7.1). The overall result does not change as CC1 remains the only viable method, although this method is still not recommended for providing management advice.

7.3 SENSITIVITIES

7.3.1 Assessment interval

When the frequency of assessment is increased, CC1 no longer meets the performance criteria (Table 7.2). This result cautions the consideration of catch-only methods, and adds further support for not recommending the catch-only methods tested herein.

7.3.2 Steepness

When assuming a less productive stock, the performance metrics for the only viable method CC1 are similar for most performance metrics (range: 1.7% [LTY] to 8.5% [VY15]; Table 7.3). Performance metrics for Tier3BStatusQuo_ABC are more variable with absolute differences ranging from 0.2% (STY) to 26.3% (VY15). The status quo method resulted in some simulations which approached zero or very low biomass estimates during the last 20 years (Figure 7.1). Trends in B/B_{MSY} and F/F_{MSY} tended towards mean ratios below 1 and above 1, respectively, towards the end of the simulation period (Figure 7.1). An example simulation is presented in Figure 7.2, where both methods lead to zero biomass by the end of the 40-year simulation period.

7.4 TABLES

Table 7.1 Comparison of AW and RW performance metrics for methods that meet the performance criteria for the base AW MSE run for Snowy Grouper. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing (PNOF_sim = calculated across simulations); B50 = Probability of the biomass being above 50% B_{MSY} (B50_sim = calculated across simulations); VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY} (Bbelow20_sim = calculated across simulations). Note that performance for Bbelow20 and Bbelow20_sim is reversed, where a low probability is preferable.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3BStatus Quo_ABC	23.9	46.7	72.5	37.0	99.6	42.2	21.4	36.2	48.9
CC1	58.6	73.5	91.8	57.0	86.1	20.8	52.5	76.9	13.8

Table 7.2 Performance metrics for methods meeting performance criteria assuming an assessment frequency of every three years for Snowy Grouper. Performance metrics are as defined in Table 7.1. Note that no methods met the performance criteria.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3BStatus Quo_ABC	26.5	50.2	57.8	41.2	99.9	39.5	23.1	41.3	45.8

Table 7.3 Performance metrics for methods meeting performance criteria assuming a less productive stock (fixed steepness at 0.74, the lower bound of the plausible range) for Snowy Grouper. Performance metrics are as defined in Table 7.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3BStatus Quo_ABC	14.0	40.9	46.2	25.9	99.4	47.8	12.0	31.5	56.5
CC1	61.7	77.8	83.3	58.7	82.0	17.3	57.1	81.7	11.3

7.5 FIGURES

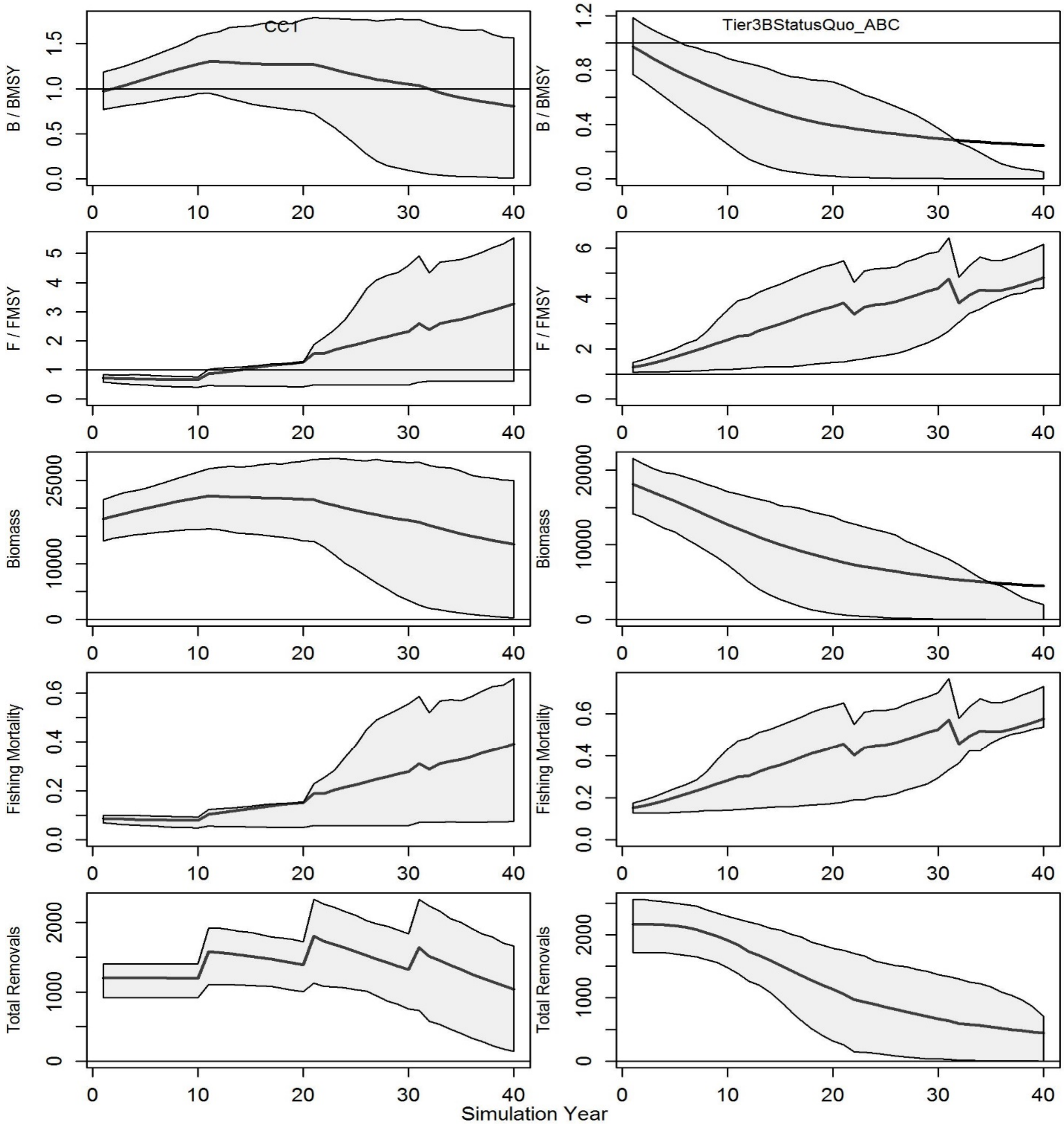

Figure 7.1 Comparison of stock status outputs and catches for Snowy Grouper over the 40-year simulation period when a less productive stock is assumed (steepness fixed at 0.74). Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, and total removals (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 25th and 75th percentiles. Note that the y-axes differ between panels.

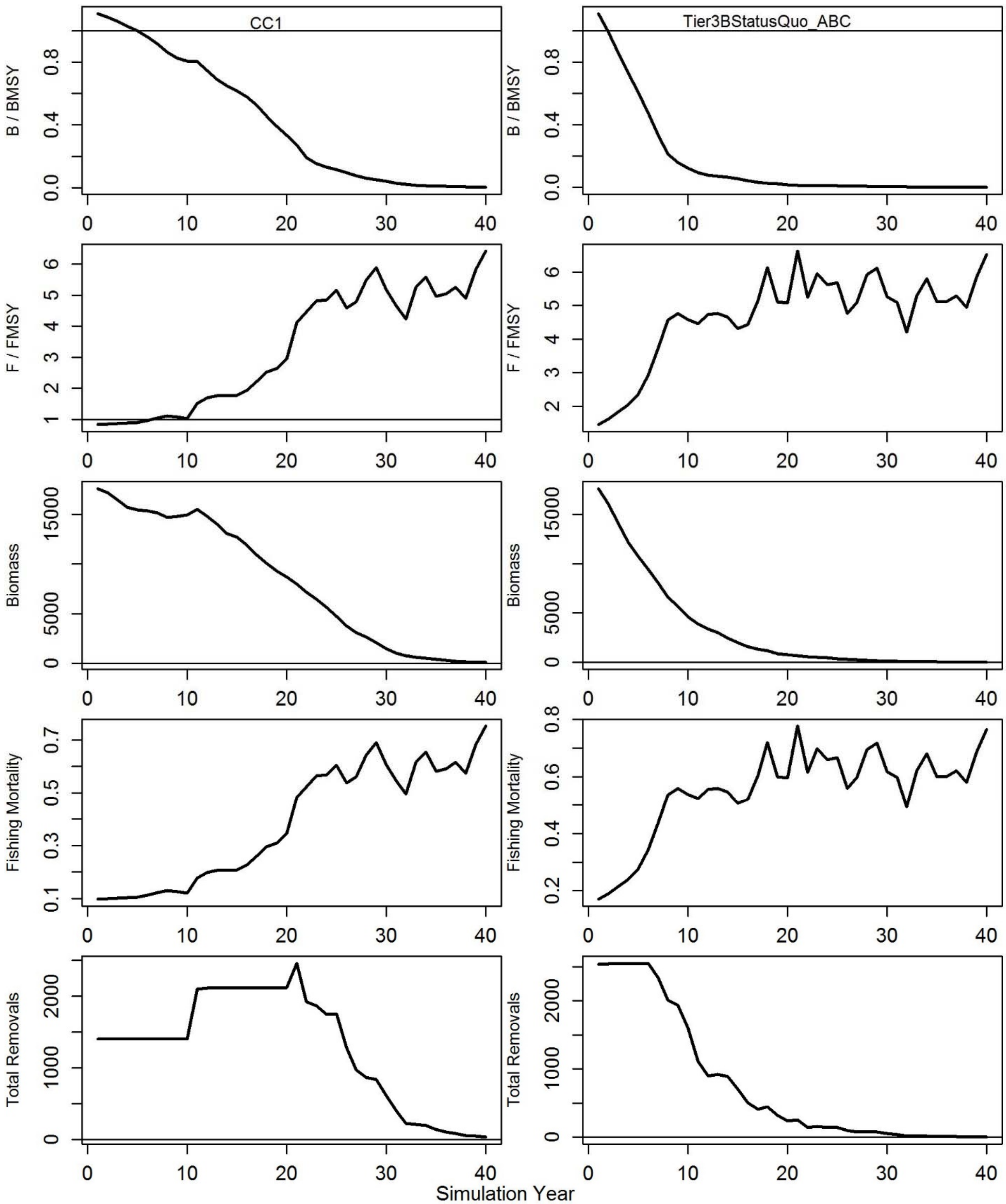

Figure 7.2 Comparison of stock status outputs and catches for snowy Grouper over the 40-year simulation period for a single simulation when a less productive stock is assumed (steepness fixed at 0.74) for Snowy Grouper. Outputs are as defined in Figure 7.1. Note that the y-axes differ between panels.

8 SPECKLED HIND

8.1 DATA

No indices of abundance or mean length were included in this assessment for Speckled Hind.

8.2 ALTERNATIVE PERFORMANCE METRICS FOR THE BASE OPERATING MODEL (ASSESSMENT WORKSHOP)

Performance metrics calculated across years for each simulation and then across simulations resulted in similar metrics as originally presented (range: 0.3% [PNOF] to 5.3% [Bbelow20]; Table 8.1). The overall result does not change as CC1 remains the only viable method, although this method is still not recommended for providing management advice.

8.3 SENSITIVITIES

8.3.1 Assessment interval

When the frequency of assessment is increased, CC1 remains a viable method (Table 8.2). However, the performance metrics are less optimistic for CC1, with differences in metrics ranging from 0.5% (STY) to 29.4% (VY15). The probability of dropping below 20% B_{MSY} doubles whereas the PNOF remains just above the 50% threshold. For CC1, trends in mean B/B_{MSY} and F/F_{MSY} remain above 1 and below 1, respectively, for the majority of the simulation period (Figure 8.1). Total removals decline gradually over the simulation period. An example simulation is presented in Figure 8.2, which shows a decline in biomass and total removals for CC1.

8.3.2 Steepness

When assuming a less productive stock, performance metrics are similar for CC1 (range: 0.7% [PNOF] to 9.4% [STY]; Table 8.3). Larger differences are evident for Tier3BStatusQuo_ABC, which ranged from 5.1% (STY) to 26.1% (VY15). Simulations for Tier3BStatusQuo_ABC tend towards zero biomass for much of the simulation period (Figure 8.3). For CC1, trends in mean F/F_{MSY} remain above 1 for the second half of the simulation period (Figure 8.3). An example simulation is presented in Figure 8.4, which shows a drop in biomass and total removals for Tier3BStatusQuo_ABC. Although biomass increases for CC1, there is a reduction in catch during the second decade of the simulation period.

8.4 TABLES

Table 8.1 Comparison of AW and RW performance metrics for methods that meet the performance criteria for the base AW MSE run for Speckled Hind. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing (PNOF_sim = calculated across simulations); B50 = Probability of the biomass being above 50% B_{MSY} (B50_sim = calculated across simulations); VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY} (Bbelow20_sim = calculated across simulations). Note that performance for Bbelow20 and Bbelow20_sim is reversed, where a low probability is preferable.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3BStatus Quo_ABC	33.1	45.1	60.6	37.4	89.3	43.8	33.4	41.4	49.1
CC1	73.0	77.2	87.9	41.3	50.9	14.8	70.3	80.7	11.6

Table 8.2 Performance metrics for methods meeting performance criteria assuming an assessment frequency of every three years for Speckled Hind. Performance metrics are as defined in Table 8.1. Note that no methods met the performance criteria.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3BStatus Quo_ABC	33.4	45.5	56.7	39.4	91.2	43.6	34.4	41.7	49.0
CC1	55.3	60.5	58.5	20.9	50.4	31.6	50.3	57.5	35.3

Table 8.3 Performance metrics for methods meeting performance criteria assuming a less productive stock (fixed steepness at 0.65, the lower bound of the plausible range) for Speckled Hind. Performance metrics are as defined in Table 8.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3BStatus Quo_ABC	17.3	28.6	34.5	24.3	94.4	56.2	18.2	24.6	64.4
CC1	73.7	75.7	82.7	38.1	41.5	13.0	71.2	80.8	10.8

8.5 FIGURES

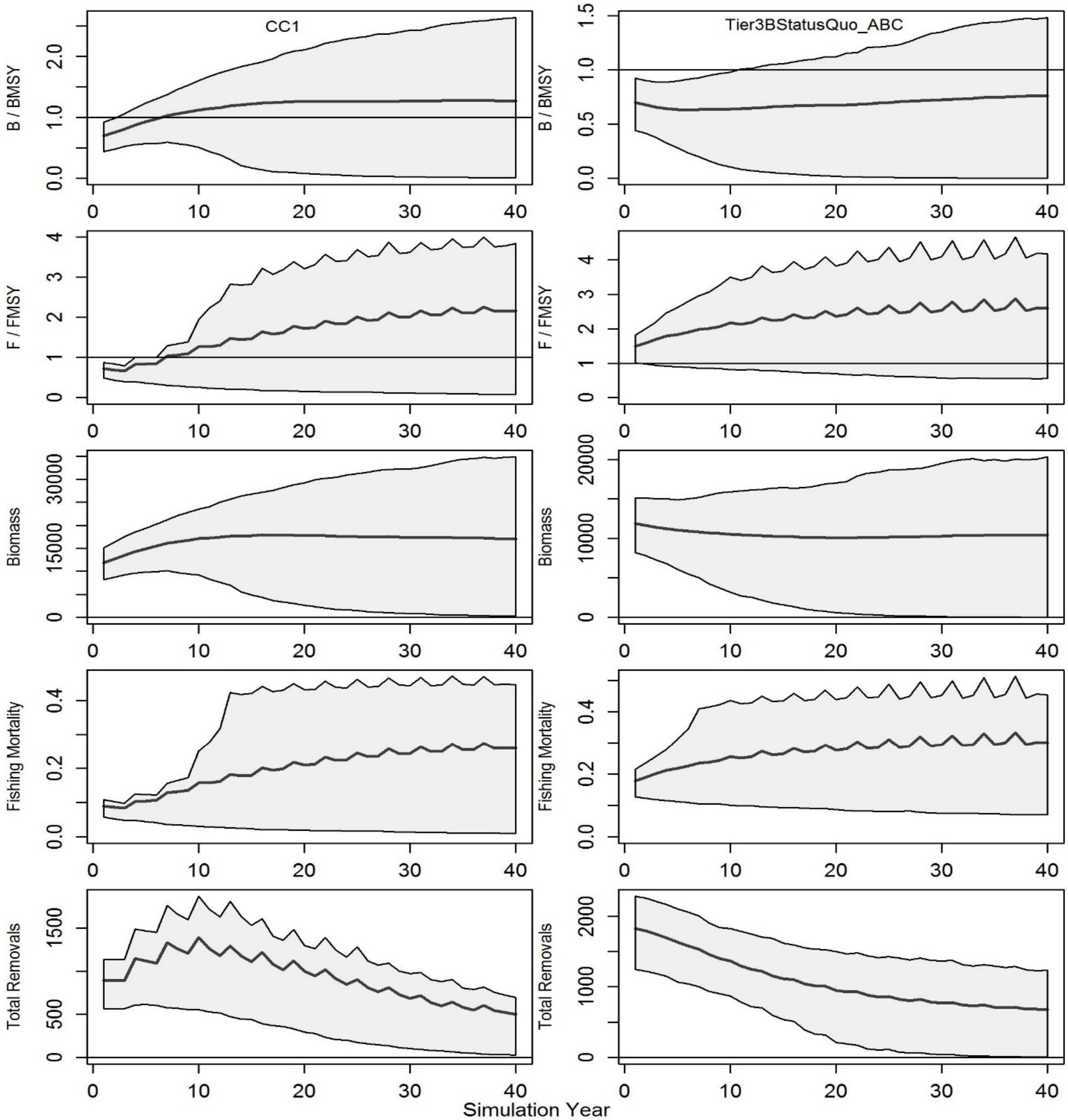

Figure 8.1 Comparison of stock status outputs and catches for Speckled Hind over the 40-year simulation period where an assessment is conducted every three years. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, and total removals (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 25th and 75th percentiles. Note that the y-axes differ between panels.

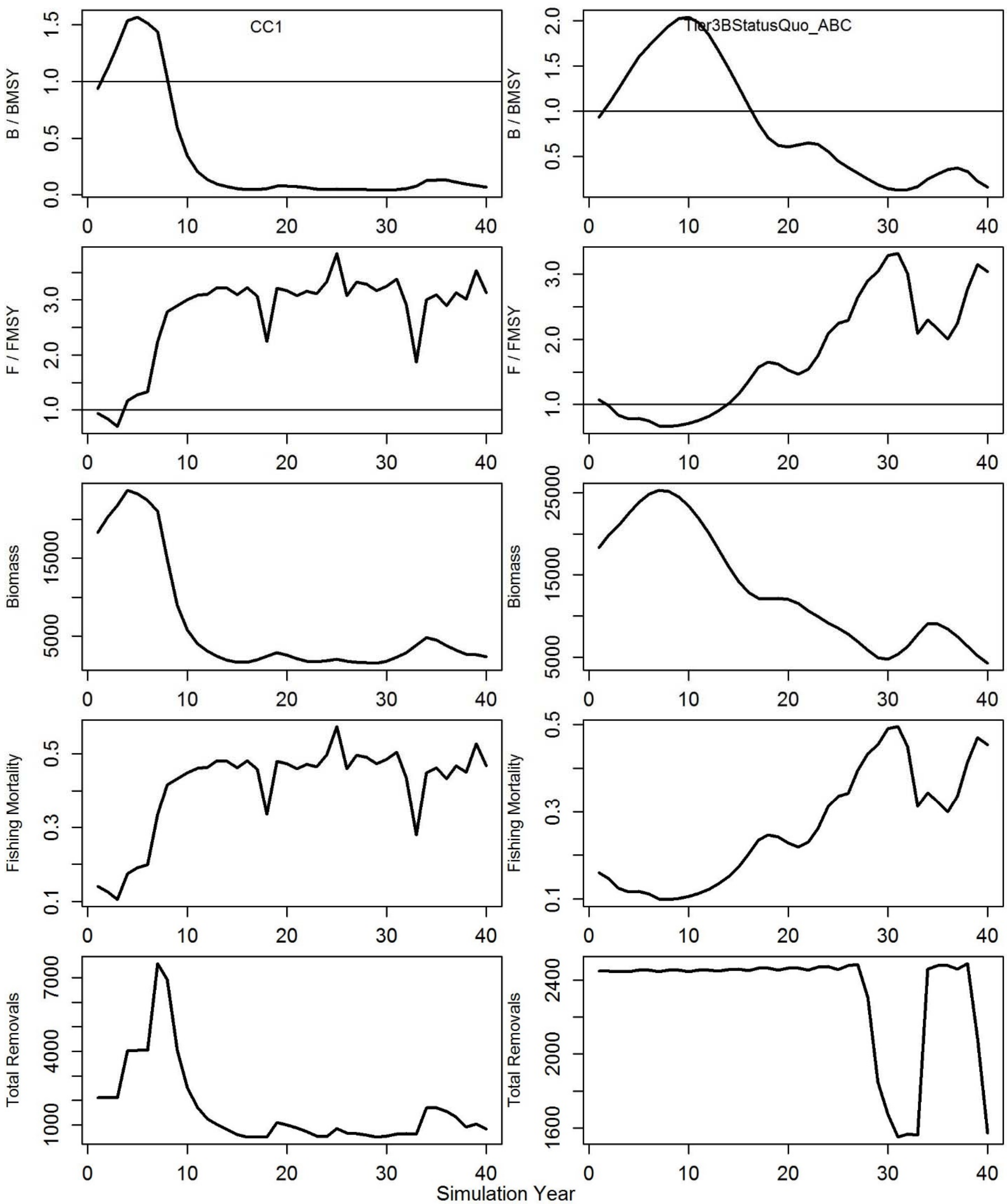

Figure 8.2 Comparison of stock status outputs and catches for Speckled Hind over the 40-year simulation period for a single simulation when an assessment is conducted every three years. Outputs are as defined in Figure 8.1. Note that the y-axes differ between panels.

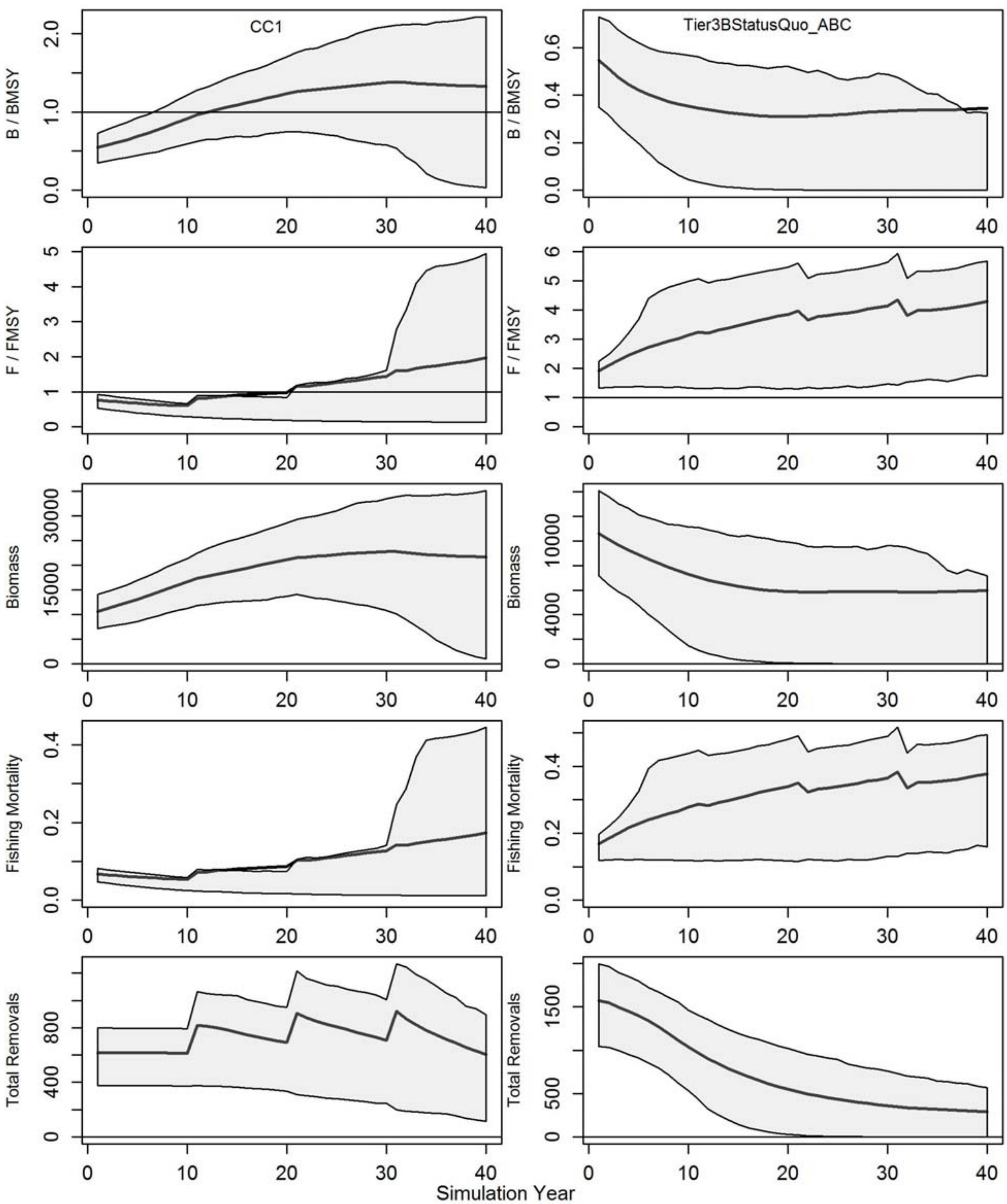

Figure 8.3 Comparison of stock status outputs and catches for Speckled Hind over the 40-year simulation period when a less productive stock is assumed (steepness fixed at 0.65). Outputs are as defined in Figure 8.1. Note that the y-axes differ between panels.

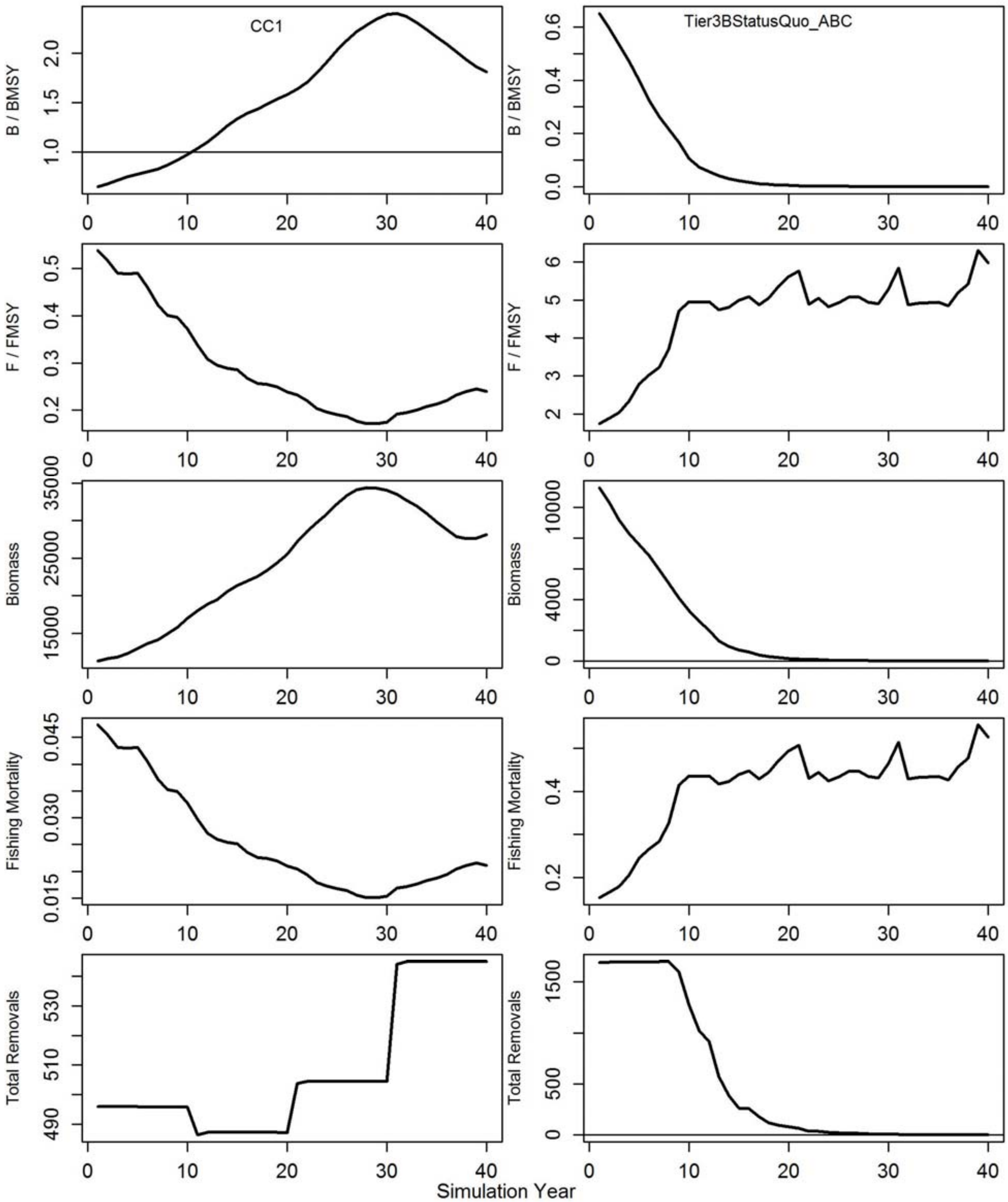

Figure 8.4 Comparison of stock status outputs and catches for Speckled Hind over the 40-year simulation period for a single simulation when a less productive stock is assumed (steepness fixed at 0.65). Outputs are as defined in Figure 8.1. Note that the y-axes differ between panels.

9 LESSER AMBERJACK

9.1 DATA

The mean of the recent index of abundance derived from the SEAMAP Video survey is slightly higher than the mean index during the reference period, although it important to note the overlap between the reference period and recent period (Figure 9.1). The mean index with 2014 as the terminal year is substantially larger than the mean index during the reference period or recent period (2005-2009) selected for the base run.

9.2 ALTERNATIVE PERFORMANCE METRICS FOR THE BASE OPERATING MODEL (ASSESSMENT WORKSHOP)

Performance metrics calculated across years for each simulation and then across simulations resulted in similar metrics as originally presented (range: 0.3% [PNOF] to 6.1% [PNOF]; Table 9.1). However, Tier3AStatusQuo_ABC no longer meets the PNOF metric, resulting in three methods considered viable: Islope0, Itarget0, and CC1_Ref.

9.3 SENSITIVITIES

9.3.1 Assessment interval

Viable methods and their performance metrics are similar to the base case when assessing Lesser Amberjack every three years, with the exception that the Tier3AStatusQuo_ABC no longer meets the PNOF metric (Table 9.2). Changes in performance metrics range from 0% (B50) to 11% (VY15). During the simulation period, the Tier3AStatusQuo_ABC method consistently results in mean F/F_{MSY} ratios above 1 whereas these ratios remain below 1 for the remaining methods (Figure 9.2). An example simulation is presented in Figure 9.3, which shows relatively little change in the total removals across the simulation period (small y-axes for total removals).

9.3.2 Steepness

If a less productive stock is assumed, Islope0 and Tier3AStatusQuo_ABC no longer meet the performance metrics for B50 (Table 9.3). Large differences in performance metrics (> 10%) are evident for all metrics except for PNOF, where differences range from 1.6% (Itarget0) to 3.3% (CC1_Ref). The performance metrics for Itarget0 and CC1_Ref are degraded slightly, particularly the yield metrics and the probability of dropping below 20% B_{MSY}. Trends in mean B/B_{MSY} ratios remain above 1 for the last 30 years of the simulation period, whereas mean F/F_{MSY} ratios remain below 1 for CC1_Ref and Itarget0 (Figure 9.4). An example simulation is presented in Figure 9.5, which reveals biomass being driven to zero under Tier3AStatusQuo_ABC and consistently low total removals throughout the simulation period for CC1_Ref and Itarget0.

9.3.3 Index of Abundance

Performance metrics were relatively similar across sensitivities concerning the beta parameter and observation error in the index of abundance (Table 9.4). Differences in performance metrics ranged from 0% (Bbelow20) to 4.4% (LTY) for Islope0 and from 0.6% (B50) to 10.9% (LTY) for Itarget0. Trends in mean simulated stock status outputs and catches were also similar (Figure 9.6). An example simulation for each sensitivity is presented in Figure 9.7, where trends in total removals appear to contrast the trends in biomass for Islope0. Total removals eventually stabilize for Itarget0.

9.4 TABLES

Table 9.1 Comparison of AW and RW performance metrics for methods that meet the performance criteria for the base AW MSE run for Lesser Amberjack. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing (PNOF_sim = calculated across simulations); B50 = Probability of the biomass being above 50% B_{MSY} (B50_sim = calculated across simulations); VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY} (Bbelow20_sim = calculated across simulations). Note that performance for Bbelow20 and Bbelow20_sim is reversed, where a low probability is preferable.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3AStatus Quo_ABC	52.4	59.4	67.3	56.2	72.2	21.0	46.3	58.2	19.2
Itarget0	70.7	73.5	85.8	51.0	58.4	13.0	70.1	76.3	10.8
CC1_Ref	76.5	78.8	88.7	47.3	53.0	9.8	76.0	81.1	8.2
Islope0	61.5	64.1	84.9	42.9	67.4	20.2	61.2	68.5	17.5

Table 9.2 Performance metrics for methods meeting performance criteria assuming an assessment frequency of every three years for Lesser Amberjack. Performance metrics are as defined in Table 9.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3AStatus Quo_ABC	46.0	54.0	56.3	54.1	72.0	25.6	43.4	53.1	25.2
Itarget0	70.1	73.5	79.4	48.3	57.2	13.6	70.7	76.0	13.0
CC1_Ref	72.5	75.5	81.6	44.4	53.3	12.8	72.4	78.2	12.6
Islope0	70.2	71.2	92.7	51.5	65.5	15.1	76.7	77.3	11.1

Table 9.3 Performance metrics for methods meeting performance criteria assuming a less productive stock (fixed steepness at 0.7, the lower bound of the plausible range) for Lesser Amberjack. Performance metrics are as defined in Table 9.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Tier3AStatus Quo_ABC	49.5	47.6	56.3	26.3	61.1	40.3	47.8	49.0	43.3
Itarget0	69.1	66.2	76.6	27.9	47.0	23.2	70.5	69.7	24.0
CC1_Ref	73.2	70.3	80.2	25.6	42.7	19.8	73.3	73.8	21.3

Table 9.4 Performance metrics for index-based methods meeting performance criteria assuming higher observation error in the index of abundance or a fixed beta parameter for Lesser Amberjack. Performance metrics are as defined in Table 9.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Base: beta range: 0.33 (hyperstability) to 3.0 (hyper-depletion), index observation error range: 0.15 to 0.30									
Islope0	61.5	64.1	84.9	42.9	67.4	20.2	61.2	68.5	17.5
Itarget0	70.7	73.5	85.8	51.0	58.4	13.0	70.1	76.3	10.8
Beta = fixed at 1									
Islope0	61.2	63.6	85.3	39.9	65.5	21.1	61.2	66.2	17.4
Itarget0	73.5	75.9	87.2	48.7	57.2	11.9	71.8	77.7	10.4
Index observation error = fixed at 0.5									
Islope0	60.8	63.4	84.0	39.9	66.6	21.2	60.7	66.6	17.5
Itarget0	71.6	74.2	84.5	44.2	54.7	13.6	70.4	76.3	12.0
Index observation error = fixed at 1.0									
Islope0	61.4	64.2	83.0	38.5	65.2	20.2	62.3	67.6	16.1
Itarget0	71.3	74.1	81.4	40.1	49.8	13.7	69.7	76.3	12.1

9.5 FIGURES

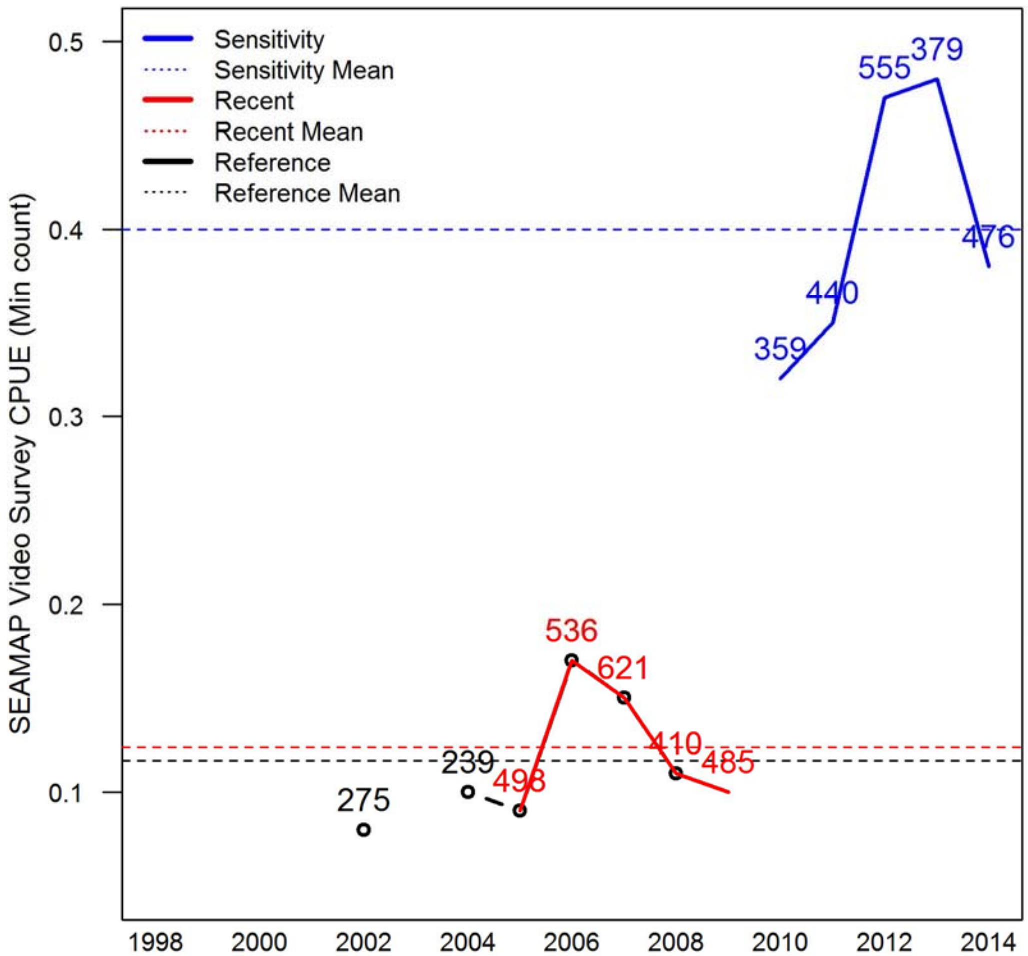

Figure 9.1 Comparison of the trends in the SEAMAP video survey index of abundance between the reference period (2000-2008) and the recent period (2005-2009) for Lesser Amberjack. Numbers correspond to the sample sizes. Note that the overlap in years is due to the terminal year of 2009 as recommended by the Total Removals Working Group at the Data workshop. The range of recent years tested as a sensitivity (2010 – 2014) is also shown for comparison.

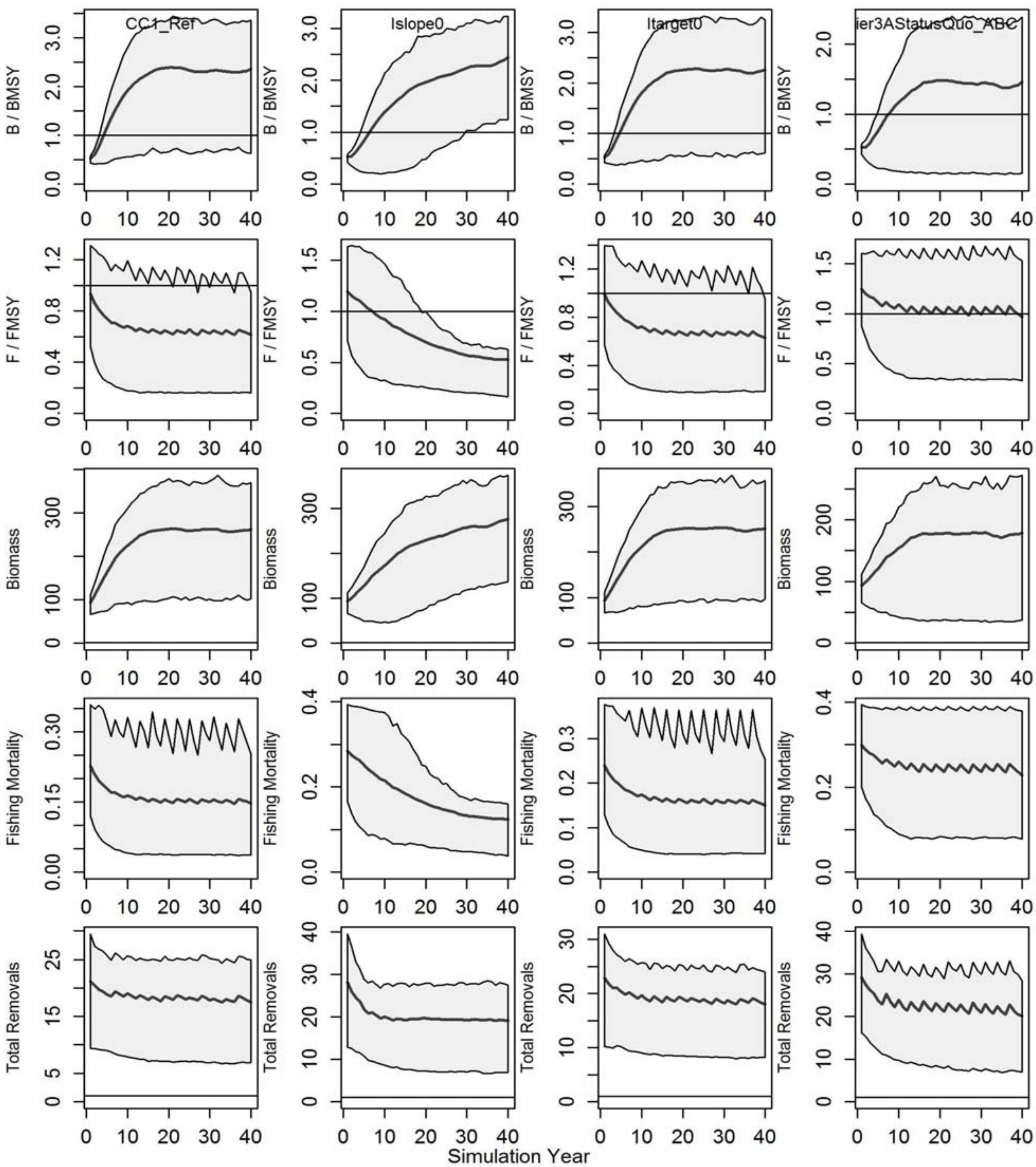

Figure 9.2 Comparison of stock status outputs and catches for Lesser Amberjack over the 40-year simulation period when an assessment is conducted every three years. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, and total removals (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 25th and 75th percentiles. Note that the y-axes differ between panels.

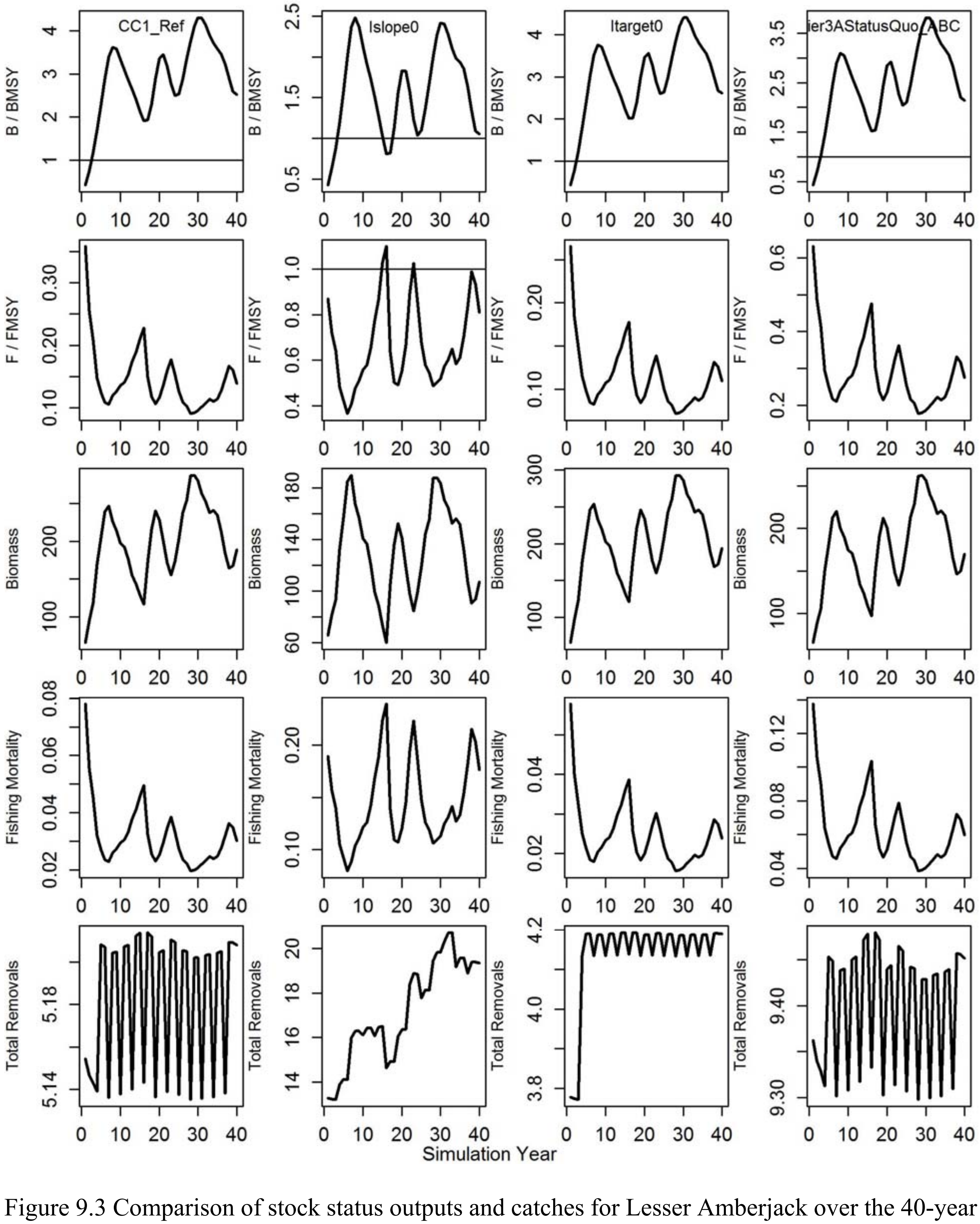

Figure 9.3 Comparison of stock status outputs and catches for Lesser Amberjack over the 40-year simulation period for a single simulation when an assessment is conducted every three years for Lesser Amberjack. Outputs are as defined in Figure 9.2. Note that the y-axes differ between panels.

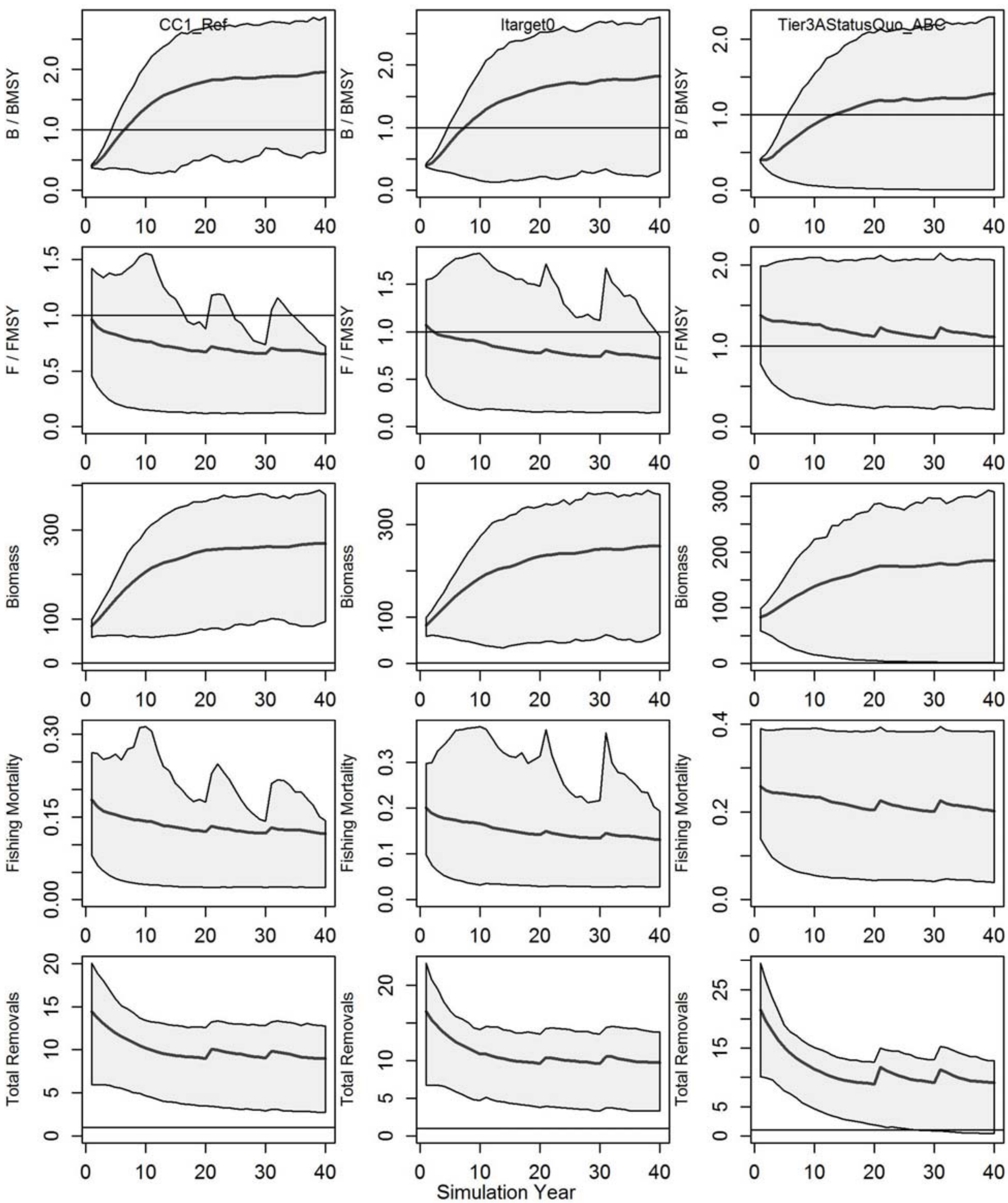

Figure 9.4 Comparison of stock status outputs and catches for Lesser Amberjack over the 40-year simulation period when a less productive stock is assumed (steepness fixed at 0.7). Outputs are as defined in Figure 9.2. Note that the y-axes differ between panels.

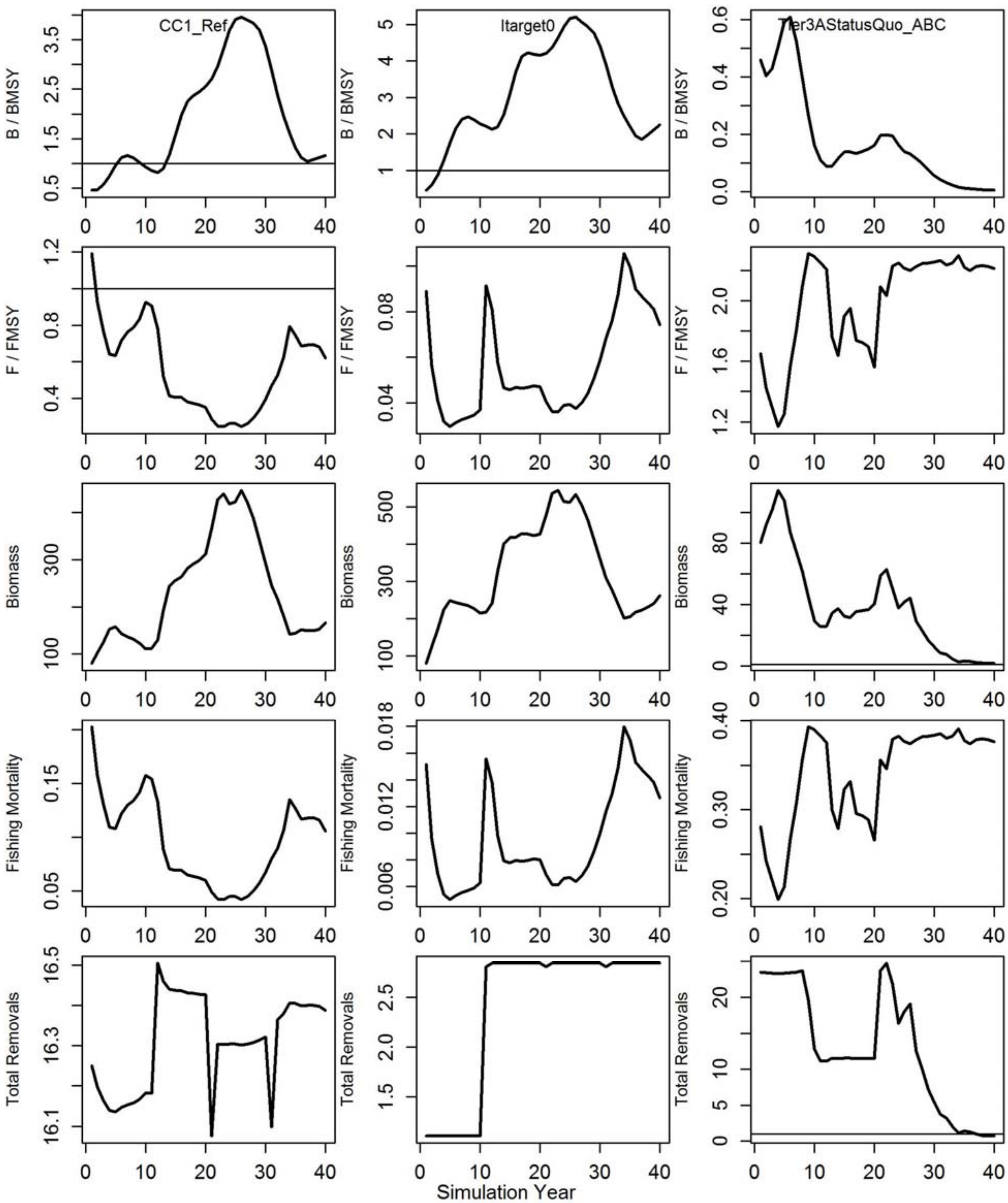

Figure 9.5 Comparison of stock status outputs and catches for Lesser Amberjack over the 40-year simulation period for a single simulation where a less productive stock is assumed (steepness fixed at 0.7). Outputs are as defined in Figure 9.2. Note that the y-axes differ between panels.

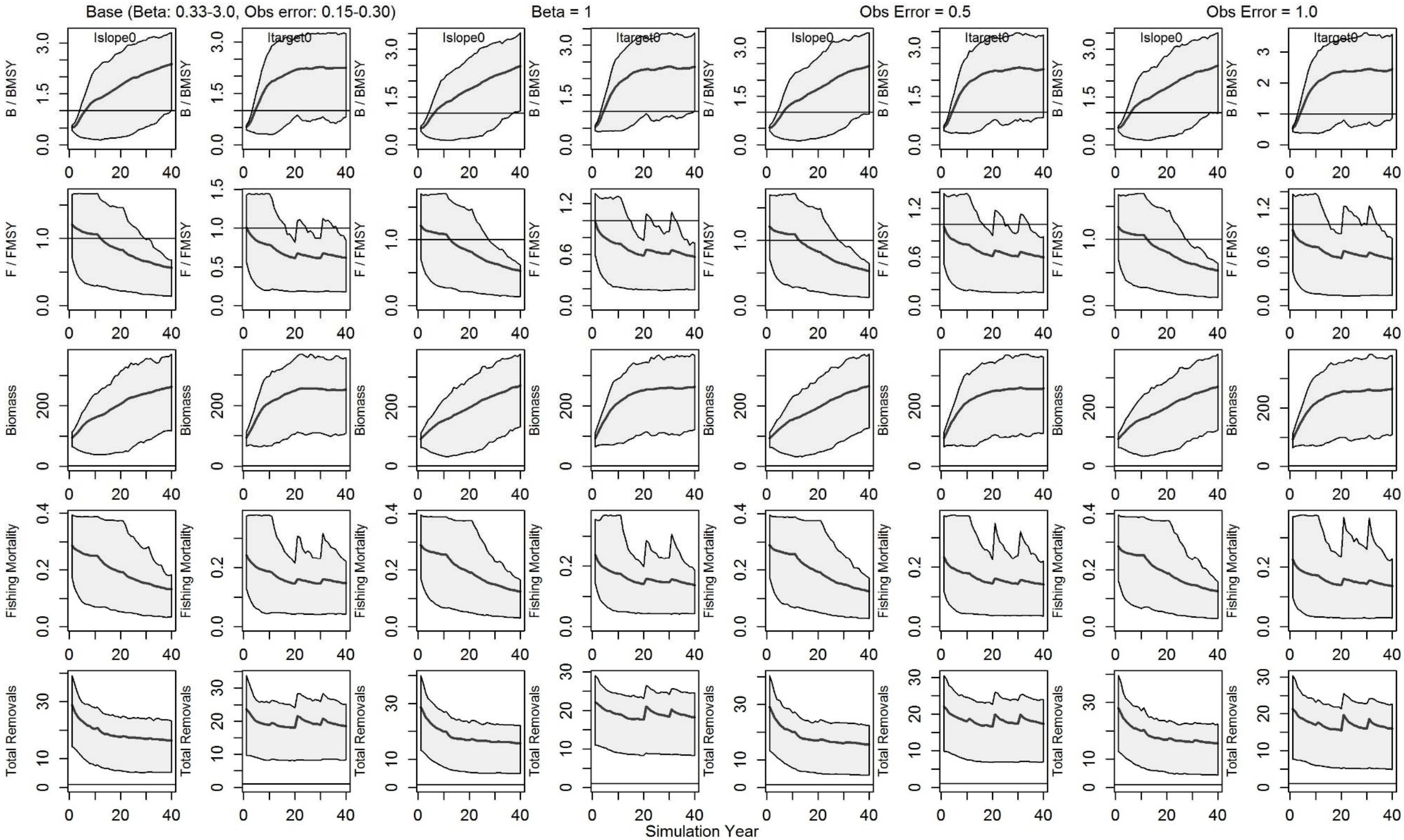

Figure 9.6 Comparison of stock status outputs and catches from the index-based methods for Lesser Amberjack over the 40-year simulation period. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.15 – 0.30), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 9.2. Note that the y-axes differ between panels.

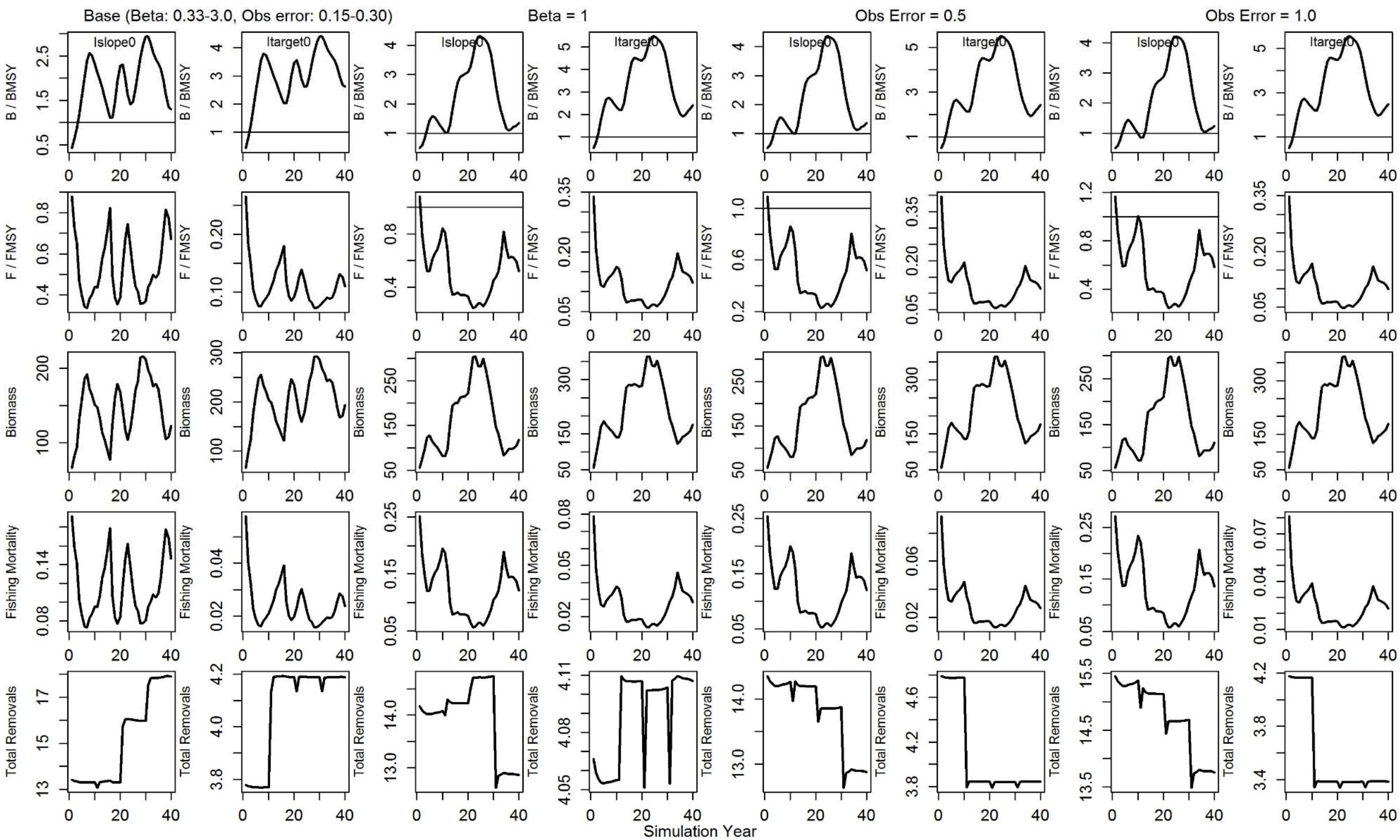

Figure 9.7 Comparison of stock status outputs and catches from the index-based methods for Lesser Amberjack over the 40-year projection period for a single simulation. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.15 – 0.30), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 9.2. Note that the y-axes differ between panels.

10 ALMACO JACK

10.1 DATA

A conflicting trend was observed between the recent index of abundance derived from the SEAMAP video survey and the recent mean length from the recreational (charterboat, headboat, private) fishery (Figure 10.1). The mean of the recent index of abundance derived from the SEAMAP Video survey is nearly half the mean index during the reference period. In contrast, the mean length from the combined recreational fishery is roughly 3 cm larger in recent years compared to the reference period.

10.2 ALTERNATIVE PERFORMANCE METRICS FOR THE BASE OPERATING MODEL (ASSESSMENT WORKSHOP)

Performance metrics calculated across years for each simulation and then across simulations resulted in similar metrics as originally presented (range: 0.1% [PNOF, B50] to 8.3% [B50]; Table 10.1). The overall result does not change as three methods remain viable: Islope0, Itarget0, and LstepCC0.

10.3 SENSITIVITIES

10.3.1 Assessment interval

Viable methods and their performance metrics are similar to the base case when assessing Almaco Jack every three years (Table 10.2). Differences in performance metrics range from 0.1% (PNOF, Bbelow20) to 13.9% (LTY). During the simulation period, the Tier3AStatusQuo_ABC method consistently results in mean B/B_{MSY} ratios below 1 and mean F/F_{MSY} ratios above 1 (Figure 10.2). This method also drives some simulated biomass trajectories to zero during the last 20 years of the simulation period. Although biomass trajectories for the remaining viable methods increase on average throughout the simulation period, the total removals gradually decline. An example simulation is presented in Figure 10.3, which shows a similar trend in biomass and total removals for Islope0 as well as a stabilization of total removals for Itarget0. Tier3AStatusQuo_ABC results in biomass and total removals of zero by the end of the simulation period.

10.3.2 Steepness

If a less productive stock is assumed, the performance metrics for the viable methods degrade slightly, with differences in performance metrics ranging from 0.2% (STY) to 15.8% (VY15). Larger reductions are evident for the Tier3AStatusQuo_ABC, which ranged from 1.2% (STY) to 24.6% (VY15) (Table 10.3). The biomass for Tier3AStatusQuo_ABC approaches zero by the middle of the simulation period, whereas some simulations for both Islope0 and LstepCC0 also result in zero biomass (Figure 10.4). An example simulation is presented in Figure 10.5, which shows a conflicting trend between the biomass trajectory and the total removals. This may be a result of the maximum F constraint built into the current version of DLMtool, which caps F when a recommended catch recommendation is too high.

10.3.3 Index of Abundance

Performance metrics were relatively similar across sensitivities concerning the beta parameter and observation error in the index of abundance (Table 10.4). Differences in performance metrics ranged from 0.2% (B50, VY15, and Bbelow20) to 2.4% (LTY) for Islope0 and from 1.1% (PNOF) to 10.7% (LTY) for Itarget0. Trends in mean simulated stock status outputs and catches were also similar (Figure 10.6). An example simulation for each sensitivity is presented in Figure 10.7, which shows a similar pattern between biomass and total removals for Islope0 and consistent removals across the last 30 years of the simulation period for Itarget0.

10.3.4 Mean Length

When allowing for interannual variability and a gradient in Linf, the performance metrics for the conservation metrics were similar to the base operating model (Table 10.5). Differences in metrics were evident for the yield metrics, which ranged from 12.9% (STY) to 16.8% (VY15 and LTY). Mean trends in biomass were more jagged when accounting for changes in growth (Figure 10.8). An example simulation is presented in Figure 10.9, which shows relatively consistent total removals throughout the simulation period.

10.4 TABLES

Table 10.1 Comparison of AW and RW performance metrics for methods that meet the performance criteria for the base AW MSE run for Almaco Jack. Colors reflect poor performance (red), fair performance (yellow), and good performance (green). Performance metrics include PNOF = Probability of not overfishing (PNOF_sim = calculated across simulations); B50 = Probability of the biomass being above 50% B_{MSY} (B50_sim = calculated across simulations); VY15 = Probability of the inter-annual variability in yield remaining within 15%; LTY and STY = long and short-term yields; and Bbelow20 = Probability of the biomass being below 20% B_{MSY} (Bbelow20_sim = calculated across simulations). Note that performance for Bbelow20 and Bbelow20_sim is reversed, where a low probability is preferable.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Islope0	69.0	72.8	85.5	45.3	68.7	19.9	70.0	72.9	19.7
Itarget0	82.1	84.5	91.9	43.2	56.6	10.6	82.2	85.5	10.8
LstepCC0	68.9	72.9	84.6	42.2	69.1	20.2	69.2	72.7	19.8
Tier3AStatus Quo_ABC	16.2	24.1	34.4	30.9	93.1	62.4	11.1	15.8	67.3

Table 10.2 Performance metrics for methods meeting performance criteria assuming an assessment frequency of every three years for Almaco Jack. Performance metrics are as defined in Table 10.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Islope0	69.8	73.9	87.8	48.1	70.0	19.0	70.3	74.6	17.4
Itarget0	82.2	84.7	89.7	42.9	55.5	10.7	83.7	85.5	11.7
LstepCC0	72.7	75.9	88.3	28.3	69.3	17.7	74.0	77.1	16.2
Tier3AStatus Quo_ABC	10.3	18.7	26.7	27.3	94.1	69.0	9.2	12.9	76.6

Table 10.3 Performance metrics for methods meeting performance criteria assuming a less productive stock (fixed steepness at 0.7, the lower bound of the plausible range) for Almaco Jack. Performance metrics are as defined in Table 10.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Islope0	63.3	67.1	69.7	37.6	68.5	26.4	64.7	66.8	30.2
Itarget0	79.6	81.3	84.7	35.6	51.6	13.0	80.7	82.7	15.1
LstepCC0	64.2	67.9	71.1	35.9	66.8	25.1	65.3	68.0	28.4
Tier3AStatus Quo_ABC	6.9	13.5	9.8	7.1	91.9	79.9	6.7	8.6	89.5

Table 10.4 Performance metrics for index-based methods meeting performance criteria assuming a greater amount of observation error in the index of abundance or a fixed beta parameter for Almaco Jack. Performance metrics are as defined in Table 10.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Base: beta range: 0.33 (hyperstability) to 3.0 (hyper-depletion), index observation error range: 0.24 to 0.36									
Islope0	69.0	72.8	85.5	45.3	68.7	19.9	70.0	72.9	19.7
Itarget0	82.1	84.5	91.9	43.2	56.6	10.6	82.2	85.5	10.8
Beta = fixed at 1									
Islope0	69.4	73.6	86.1	45.9	70.4	19.6	69.8	73.5	20.2
Itarget0	84.9	87.6	94.2	46.0	55.4	8.1	85.4	88.0	8.4
Index observation error = fixed at 0.5									
Islope0	68.6	73.0	85.7	44.1	70.4	20.1	68.8	72.7	21.1
Itarget0	80.4	83.3	89.8	38.7	55.0	11.7	81.1	83.3	12.5
Index observation error = fixed at 1.0									
Islope0	67.9	72.5	84.6	42.9	70.4	20.4	68.3	72.0	21.2
Itarget0	76.2	78.9	85.8	32.5	52.7	16.0	76.2	77.7	17.4

Table 10.5 Performance metrics for length-based methods meeting performance criteria assuming interannual variability (15-20%) and a gradient in Linf (±5%) for Almaco Jack. Performance metrics are as defined in Table 10.1.

Method	SEDAR 49 AW Metrics						RW Requested metrics		
	PNOF	B50	VY15	LTY	STY	Bbelow20	PNOF _sim	B50 _sim	Bbelow20 _sim
Base: no interannual variability or gradient in Linf									
LstepCC0	68.9	72.9	84.6	42.2	69.1	20.2	69.2	72.7	19.8
Interannual variability in Linf (range: 15-20%) and gradient (±5%)									
LstepCC0	70.3	68.9	67.8	25.4	56.2	21.8	70.5	70.2	21.5

10.5 FIGURES

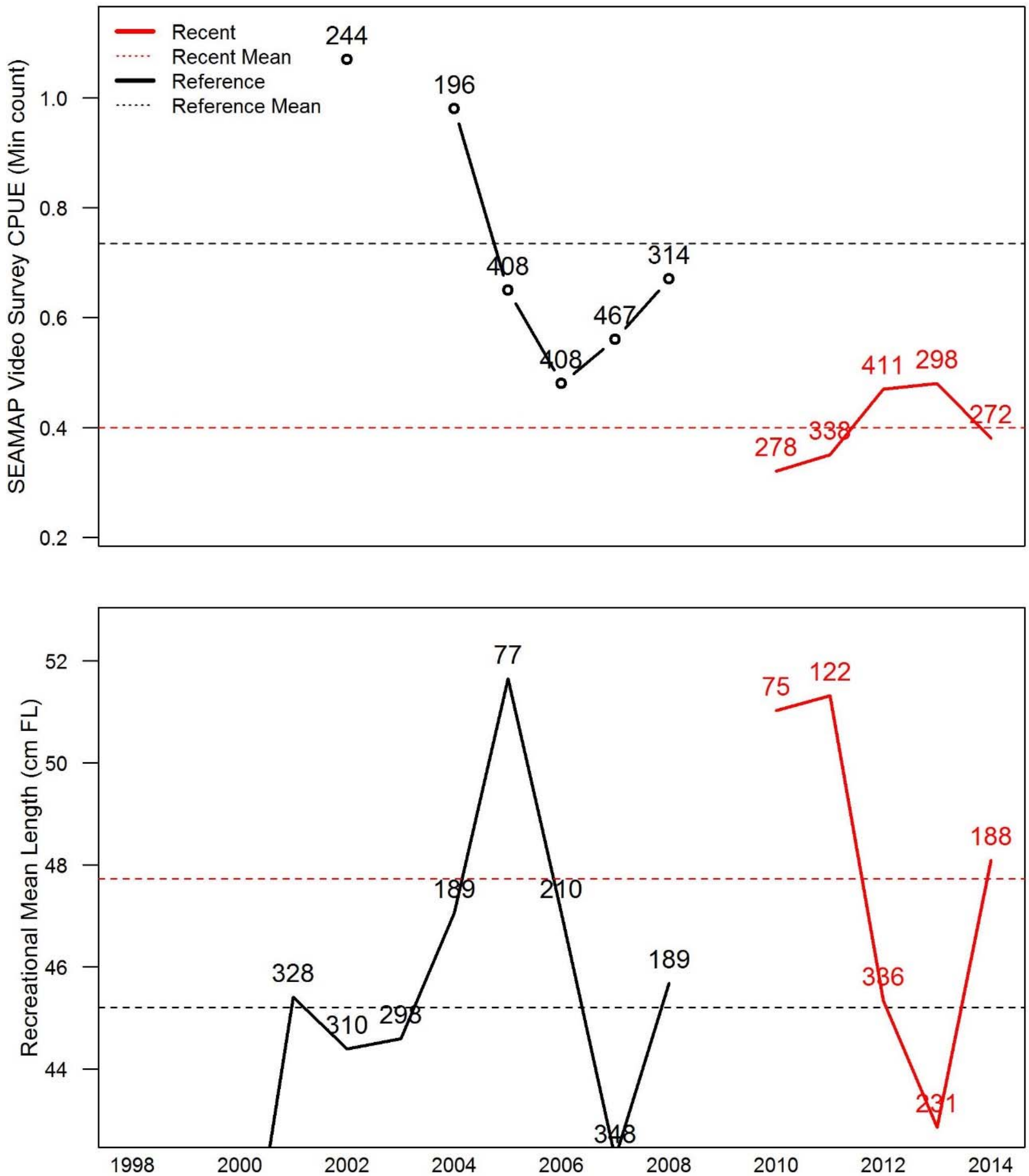

Figure 10.1 Comparison of the trends in the SEAMAP Video index of abundance and the index of mean length derived from the combined recreational fishery between the reference period (2000-2008) and the recent period (2010-2014) for Almaco Jack. Numbers correspond to the sample sizes for each data input.

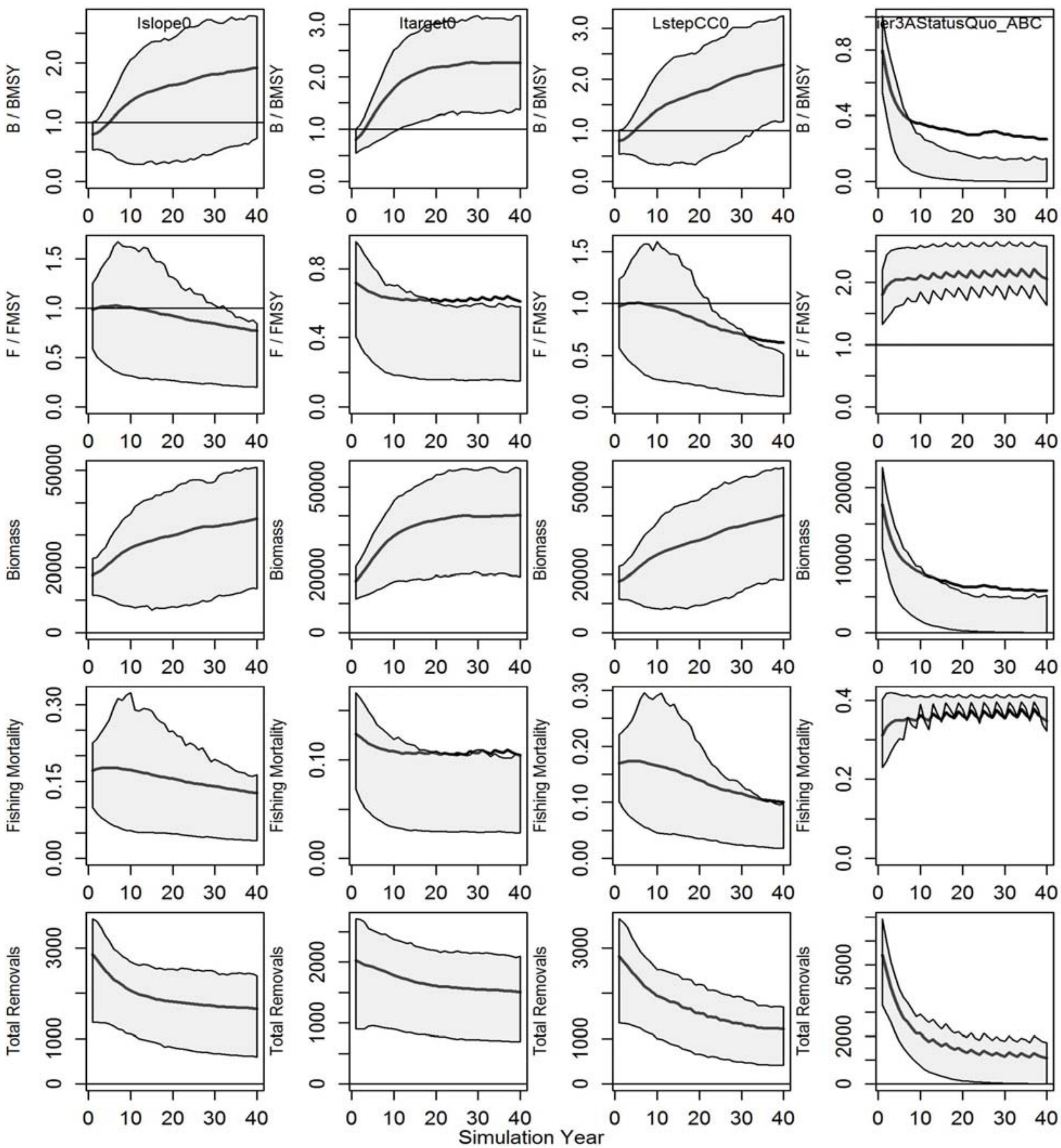

Figure 10.2 Comparison of stock status outputs and catches for Almaco Jack over the 40-year simulation period when an assessment is conducted every three years. Outputs include the ratio of biomass to biomass at maximum sustainable yield (B/B_{MSY}), the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F/F_{MSY}), biomass (in pounds), fishing mortality, and total removals (in pounds) for the viable methods. Solid black lines identify the mean across 1,000 simulations whereas the shaded area bounds the 25th and 75th percentiles. Note that the y-axes differ between panels.

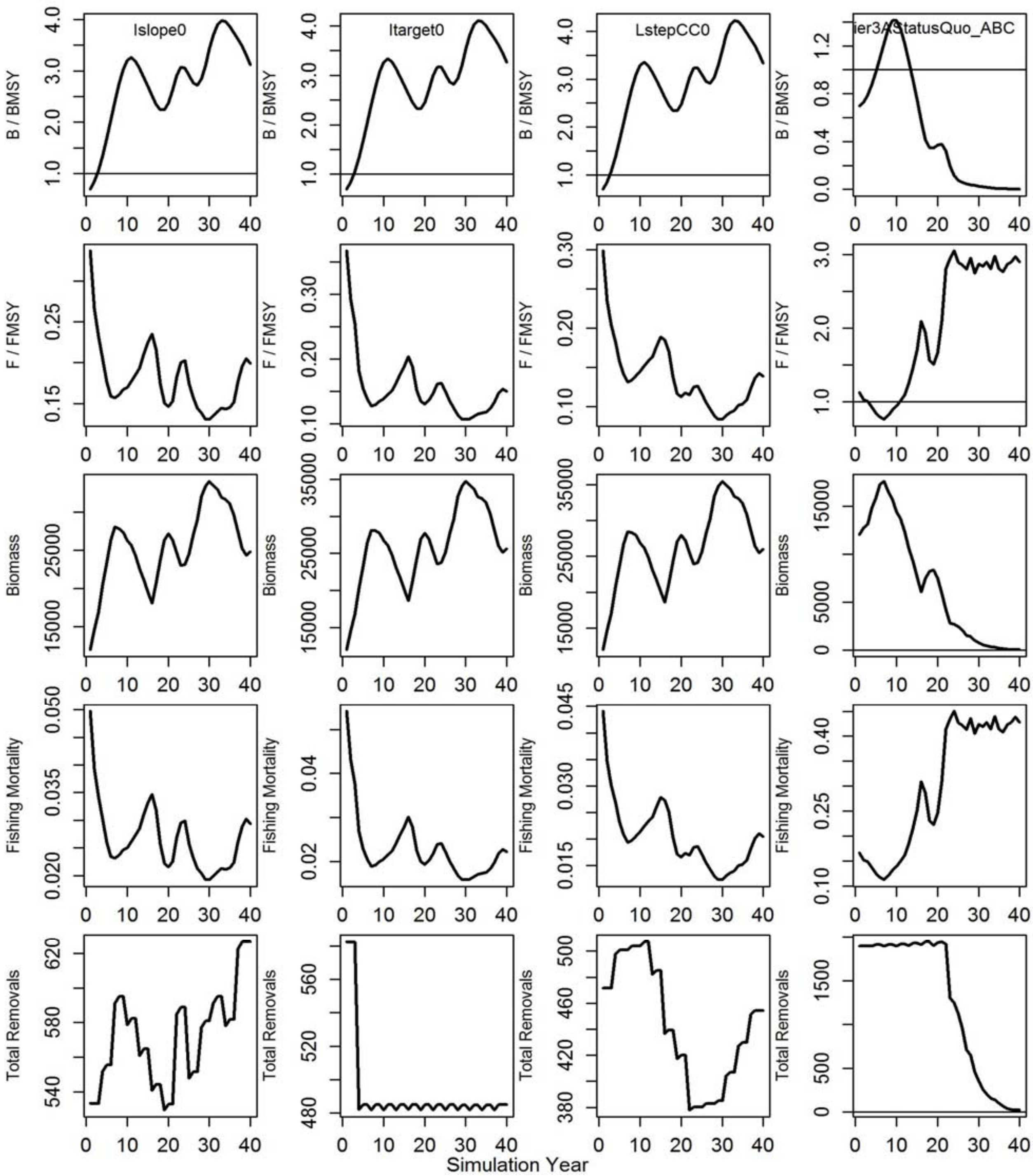

Figure 10.3 Comparison of stock status outputs and catches for Almaco Jack over the 40-year simulation period for a single simulation when an assessment is conducted every three years. Outputs are as defined in Figure 10.2. Note that the y-axes differ between panels.

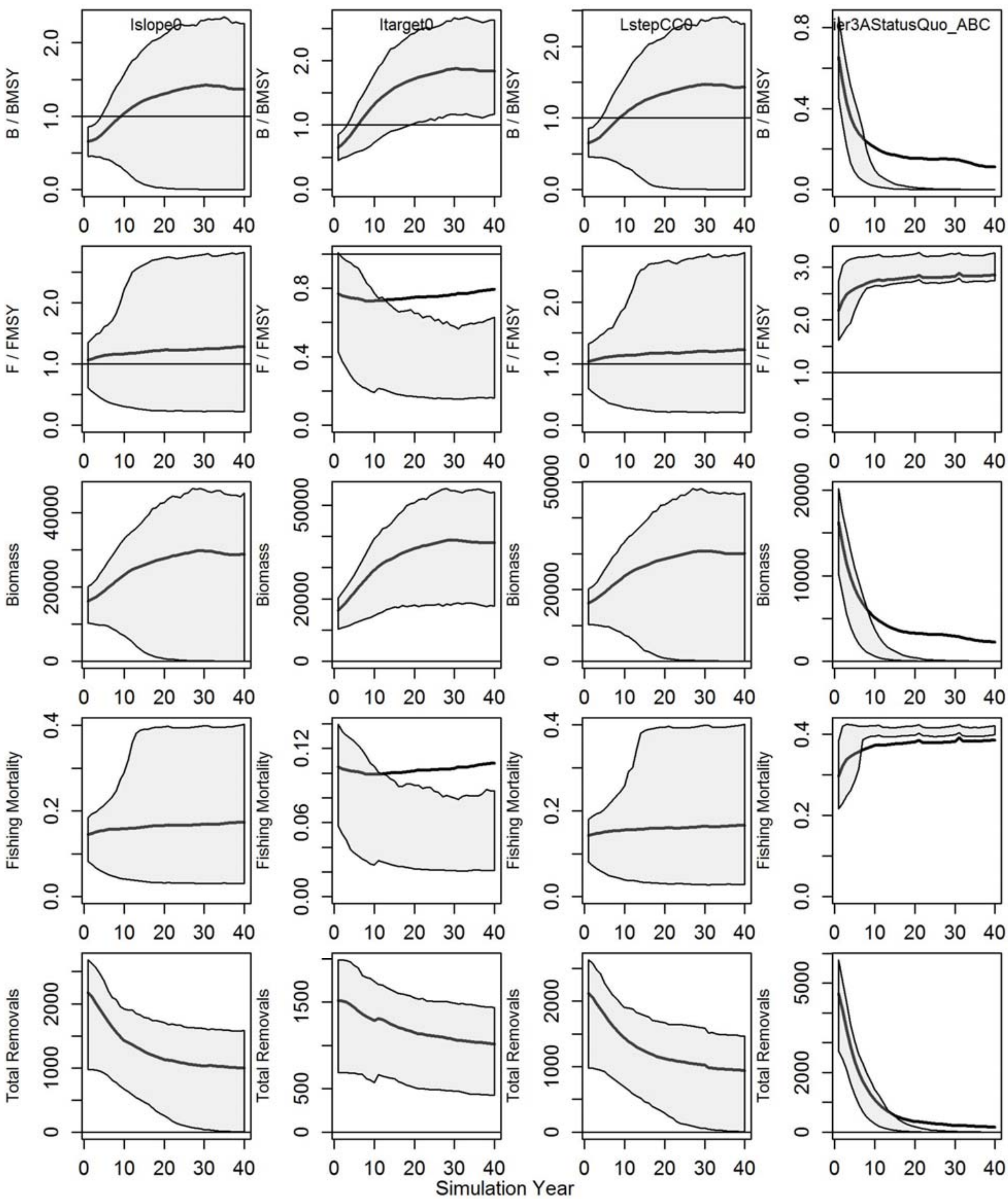

Figure 10.4 Comparison of stock status outputs and catches for Almaco Jack over the 40-year simulation period when a less productive stock is assumed (steepness fixed at 0.7). Outputs are as defined in Figure 10.2. Note that the y-axes differ between panels.

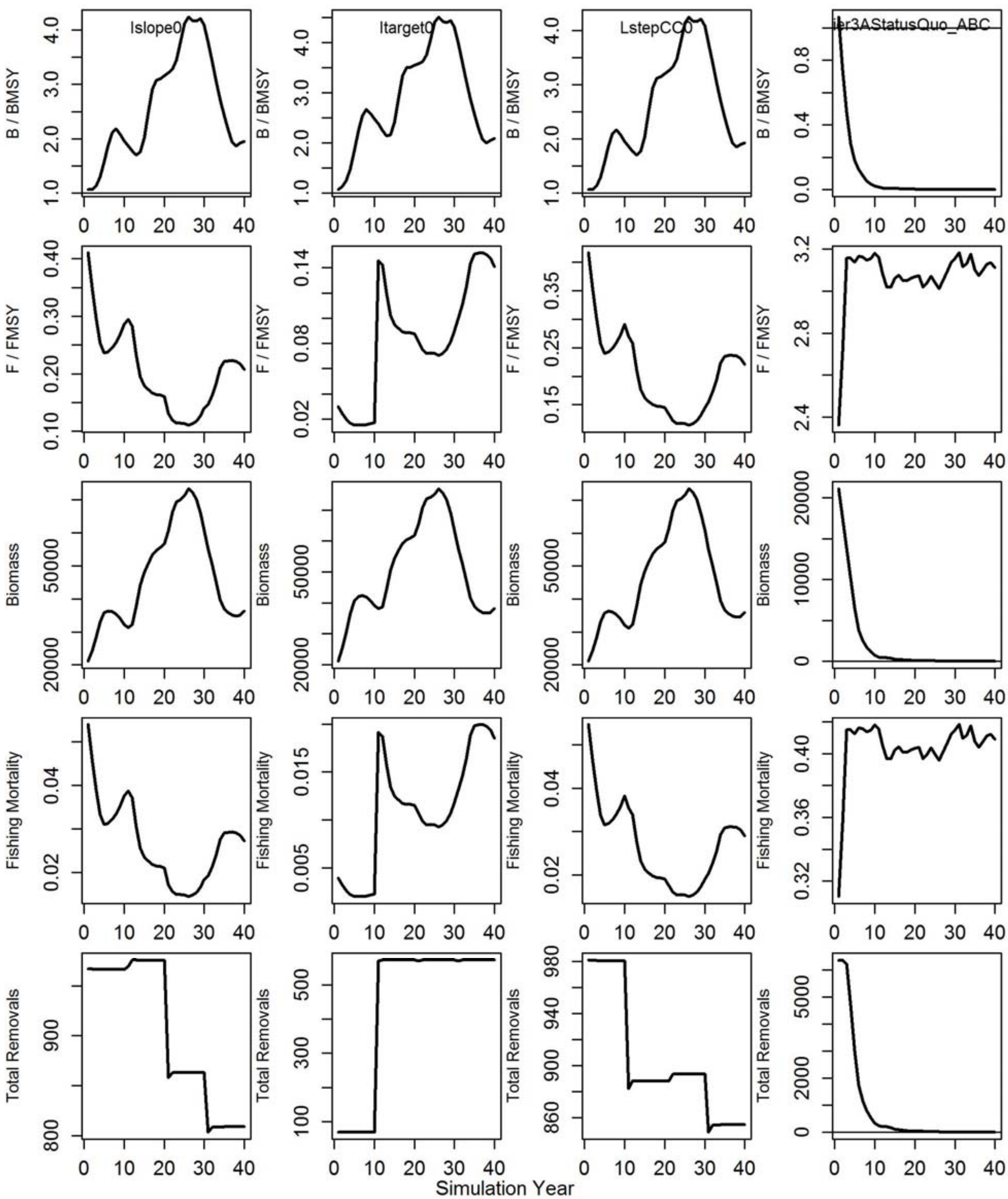

Figure 10.5 Comparison of stock status outputs and catches for Almaco Jack over the 40-year simulation period for a single simulation when a less productive stock is assumed (steepness fixed at 0.7). Outputs are as defined in Figure 10.2. Note that the y-axes differ between panels.

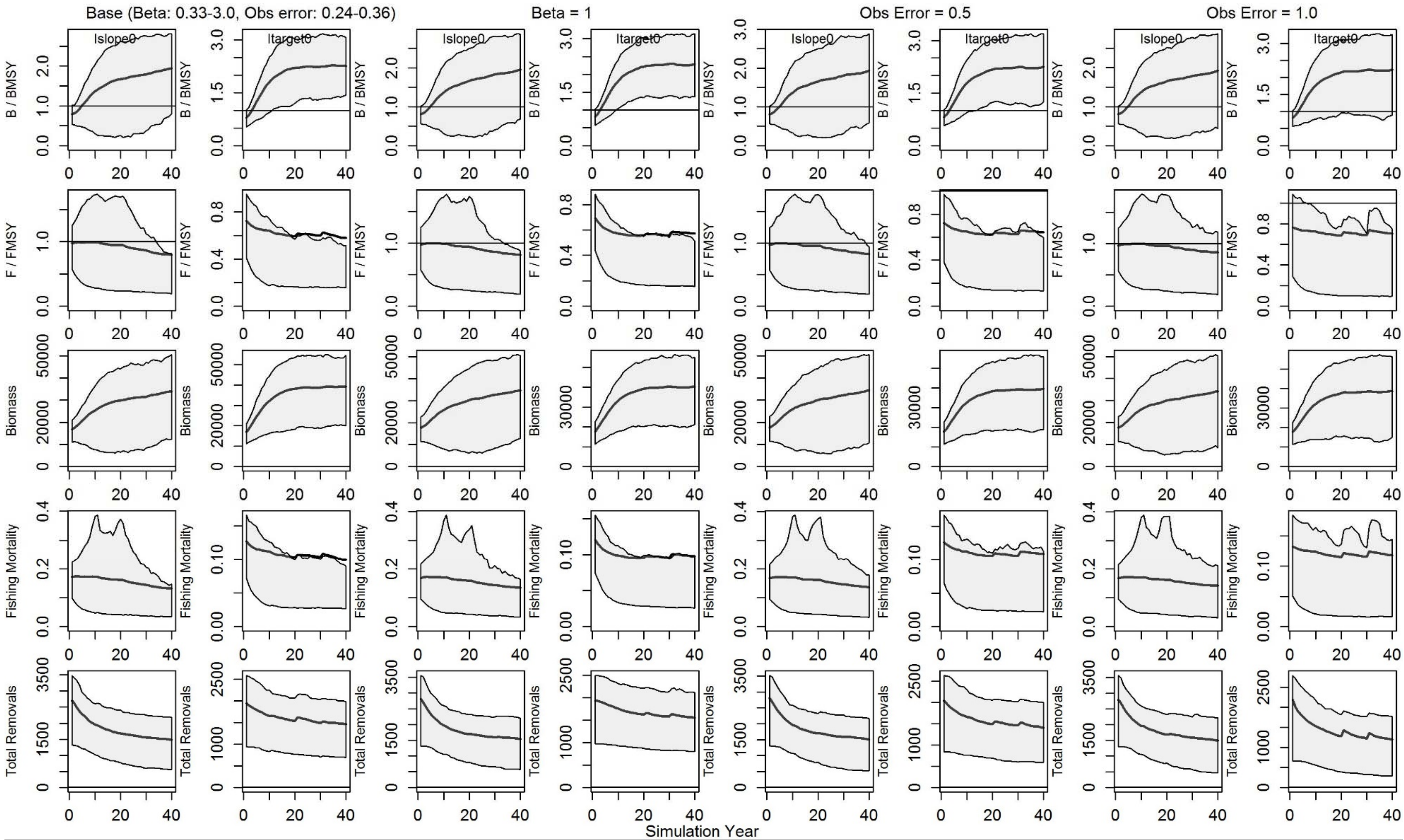

Figure 10.6 Comparison of stock status outputs and catches from the index-based methods for Almaco Jack over the 40-year projection period. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.24 – 0.36), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 10.2. Note that the y-axes differ between panels.

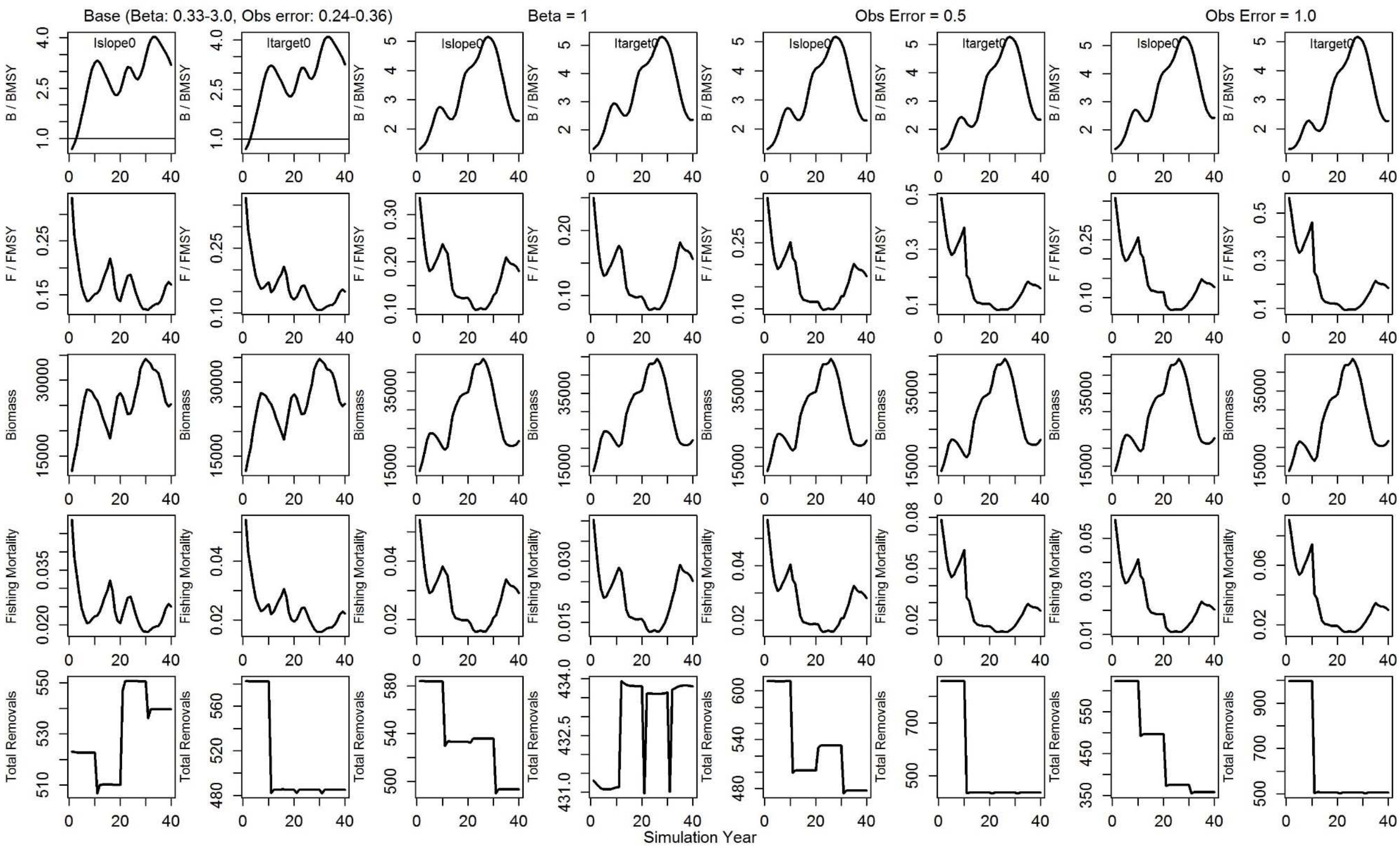

Figure 10.7 Comparison of stock status outputs and catches from the index-based methods for Almaco Jack over the 40-year simulation period for a single simulation. Results are shown for the base model (beta range 0.33 – 0.30, index observation error range 0.24 – 0.36), a beta sensitivity (beta fixed at 1.0), an index observation error of 0.5, and an index observation error of 1.0. Outputs are as defined in Figure 10.2. Note that the y-axes differ between panels.

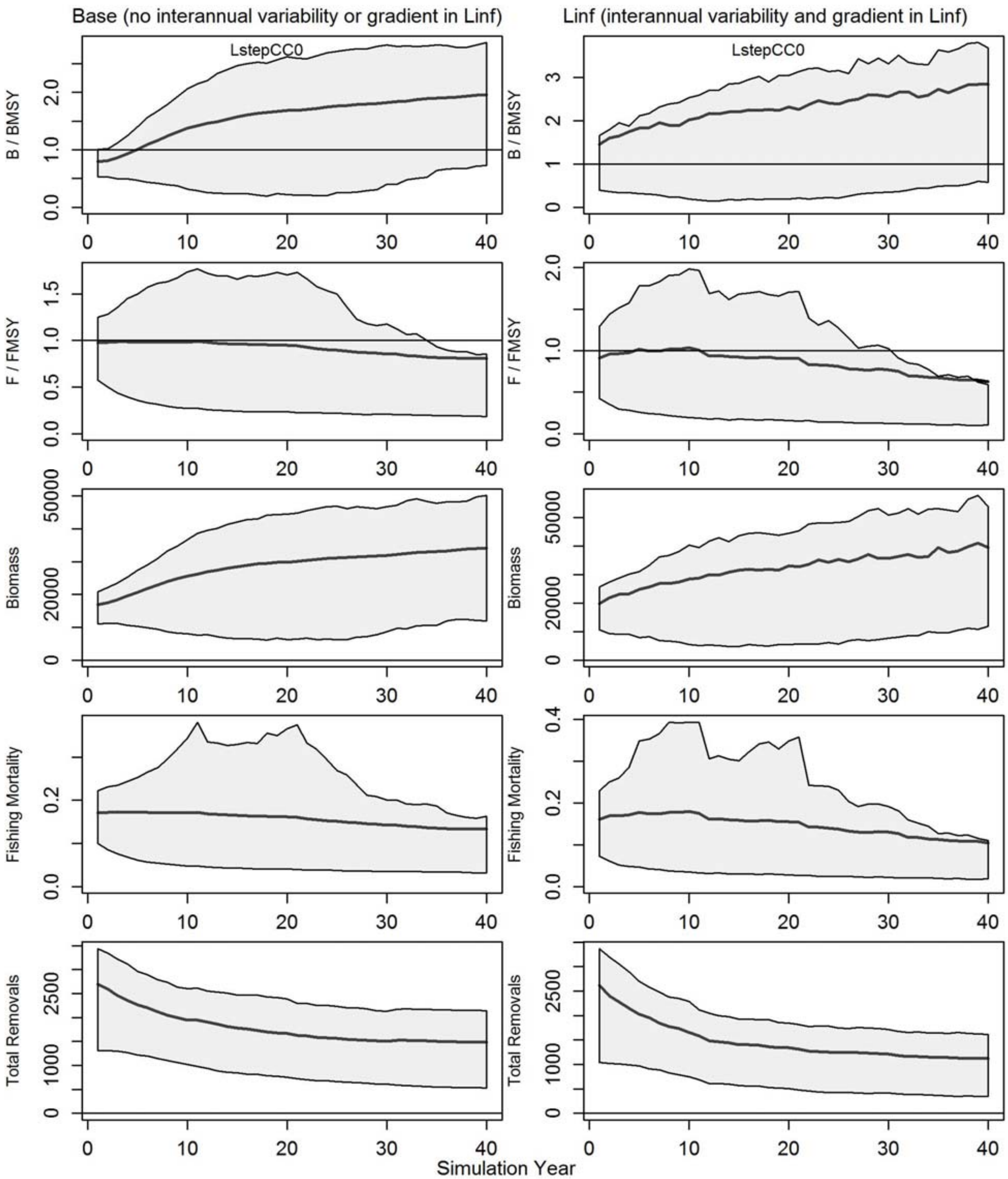

Figure 10.8 Comparison of stock status outputs and catches from the length-based methods for Almaco Jack over the 40-year projection period. Results are shown for the base model (no interannual variability of gradient in Linf) and a Linf sensitivity (15-20% interannual variability in Linf and a gradient of ±5%). Outputs are as defined in Figure 10.2. Note that the y-axes differ between panels and Ltarget0 did not meet the performance metrics for the base operating model.

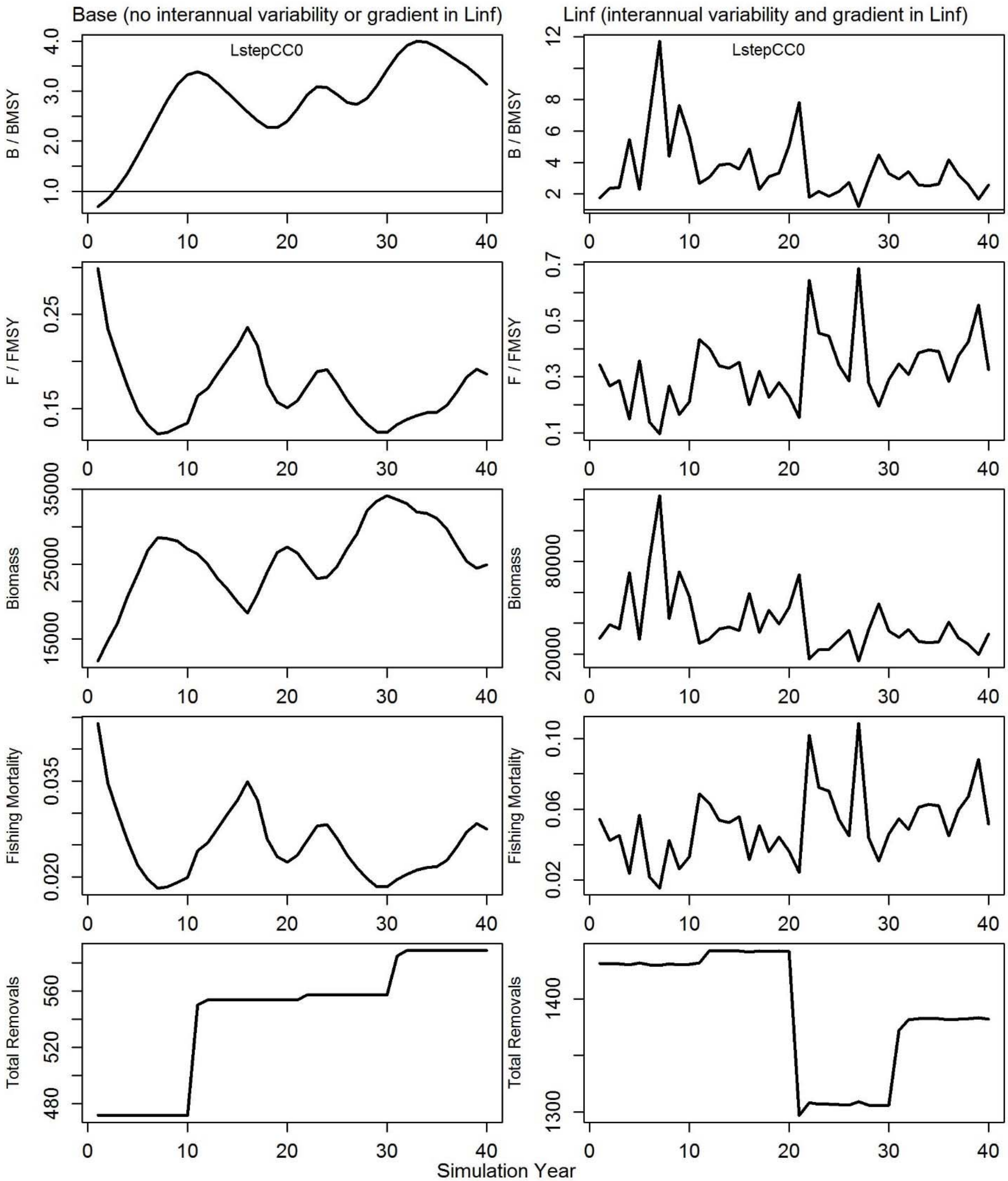

Figure 10.9 Comparison of stock status outputs and catches from the length-based methods for Almaco Jack over the 40-year projection period for a single simulation. Results are shown for the base model (no interannual variability of gradient in Linf) and a Linf sensitivity (15-20% interannual variability in Linf and a gradient of ±5% in Linf). Outputs are as defined in Figure 10.2. Note that the y-axes differ between panels.

11 STATUS QUO TRENDS IN THE BIOMASS DROPPING BELOW 20% BIOMASS AT MAXIMUM SUSTAINABLE YIELD

Table 11.1 Summary of depletion ranges tested and the probability of the biomass dropping below 20% B_{MSY} for the status quo method. NA indicates that more than 100 attempts at matching the depletion level at the end of the historical period in DLMtool crashed.

Species	Tier	Depletion Assumed	Bbelow20 for Status Quo (ABC)
Wenchman	Tier 3A	0.12 - 0.31 (Base)	9.8
		0.05 - 0.2	12.3
		0.2 - 0.6	10.7
		0.6 - 0.9	NA
Lane Snapper	Tier 3A	0.12 - 0.31 (Base)	33
		0.05 - 0.2	35.5
		0.2 - 0.6	23.7
		0.6 - 0.9	NA
Lesser Amberjack	Tier 3A	0.10 - 0.13 (Base)	21
		0.05 - 0.2	23.1
		0.2 - 0.6	20.3
		0.6 - 0.9	NA
Almaco Jack	Tier 3A	0.07 - 0.32 (Base)	62.4
		0.05 - 0.2	67.7
		0.2 - 0.6	43.6
		0.6 - 0.9	NA
Snowy Grouper	Tier 3B	0.15 - 0.40 (Base)	42.2
		0.05 - 0.2	58.6
		0.2 - 0.6	24
		0.6 - 0.9	0.3
Speckled Hind	Tier 3B	0.05 - 0.3 (Base)	43.8
		0.05 - 0.2	45.5
		0.2 - 0.6	21.5
		0.6 - 0.9	NA

12 LITERATURE CITED

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