S E D A R

Southeast Data, Assessment, and Review

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SEDAR 15A
Stock Assessment Report 3 (SAR 3)
South Atlantic and Gulf of Mexico Mutton Snapper

February 2008

SEDAR is a Cooperative Initiative of:

The Caribbean Fishery Management Council
The Gulf of Mexico Fishery Management Council
The South Atlantic Fishery Management Council
NOAA Fisheries Southeast Regional Office
NOAA Fisheries Southeast Fisheries Science Center
The Atlantic States Marine Fisheries Commission
The Gulf States Marine Fisheries Commission

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Stock Assessment Report 3
South Atlantic and Gulf of Mexico
Mutton Snapper

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Section I. Introduction

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1. SEDAR Overview

SEDAR (Southeast Data, Assessment and Review) was initially developed by the Southeast Fisheries Science Center and the South Atlantic Fishery Management Council to improve the quality and reliability of stock assessments and to ensure a robust and independent peer review of stock assessment products. SEDAR was expanded in 2003 to address the assessment needs of all three Fishery Management Council in the Southeast Region (South Atlantic, Gulf of Mexico, and Caribbean) and to provide a platform for reviewing assessments developed through the Atlantic and Gulf States Marine Fisheries Commissions and state agencies within the southeast.

SEDAR strives to improve the quality of assessment advice provided for managing fisheries resources in the Southeast US by increasing and expanding participation in the assessment process, ensuring the assessment process is transparent and open, and providing a robust and independent review of assessment products. SEDAR is overseen by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: the Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commissions: the Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products.

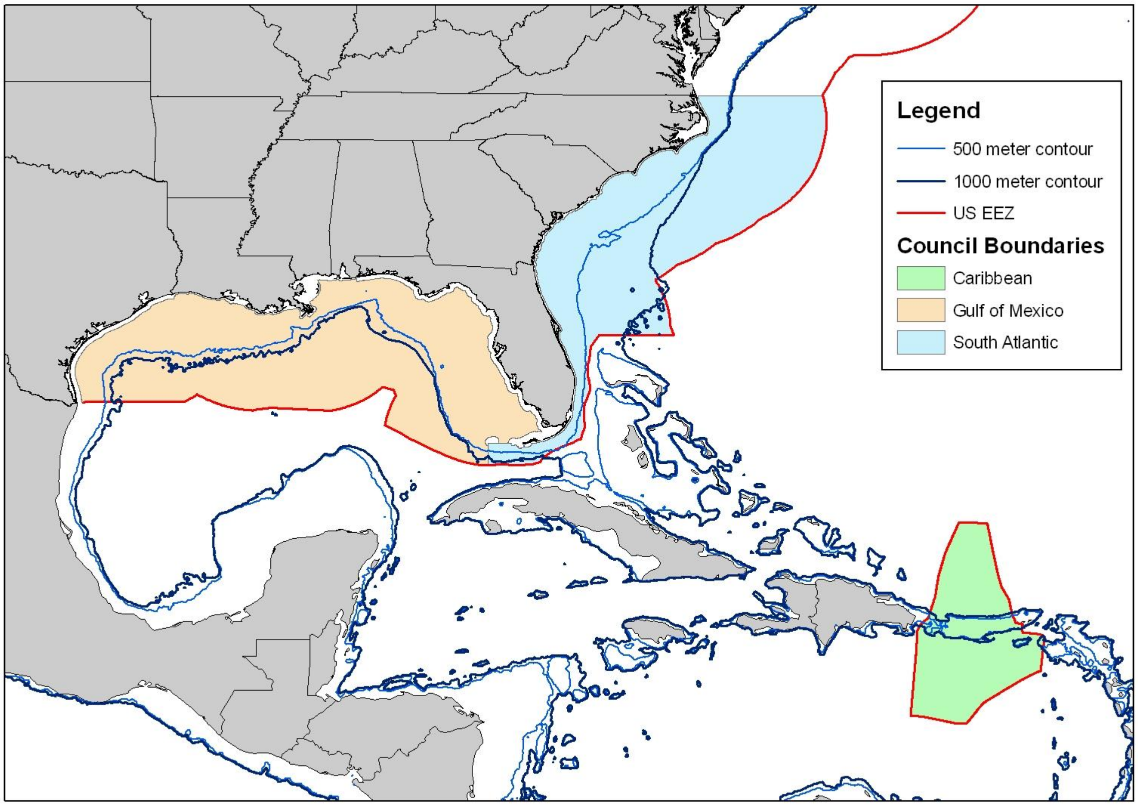
SEDAR workshops are organized by SEDAR staff and the lead Council. Data and Assessment Workshops are chaired by the SEDAR coordinator. Participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including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

SEDAR Review Workshop Panels consist of a chair, a reviewer appointed by the Council, and 3 reviewers appointed by the Center for Independent Experts (CIE), an independent organization that provides independent, expert reviews of stock assessments and related work. The Review Workshop Chair is appointed by the SEFSC director and is usually selected from a NOAA Fisheries regional science center. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers to the review workshop.

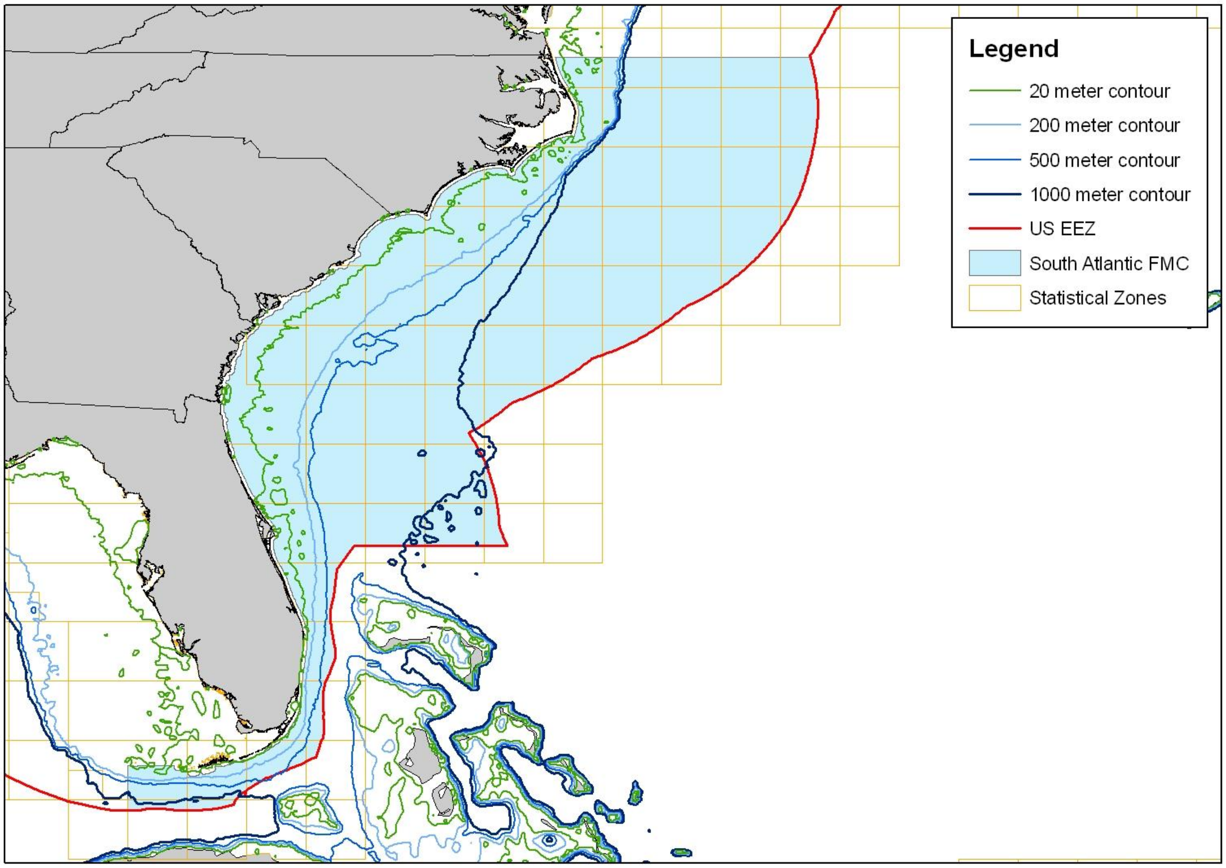
SEDAR 15A was charged with assessing mutton snapper in the US South Atlantic.

2. Southeast Region Maps

Southeast Region including Council and EEZ Boundaries



South Atlantic Council Boundaries, including contours, EEZ, and statistical area grid



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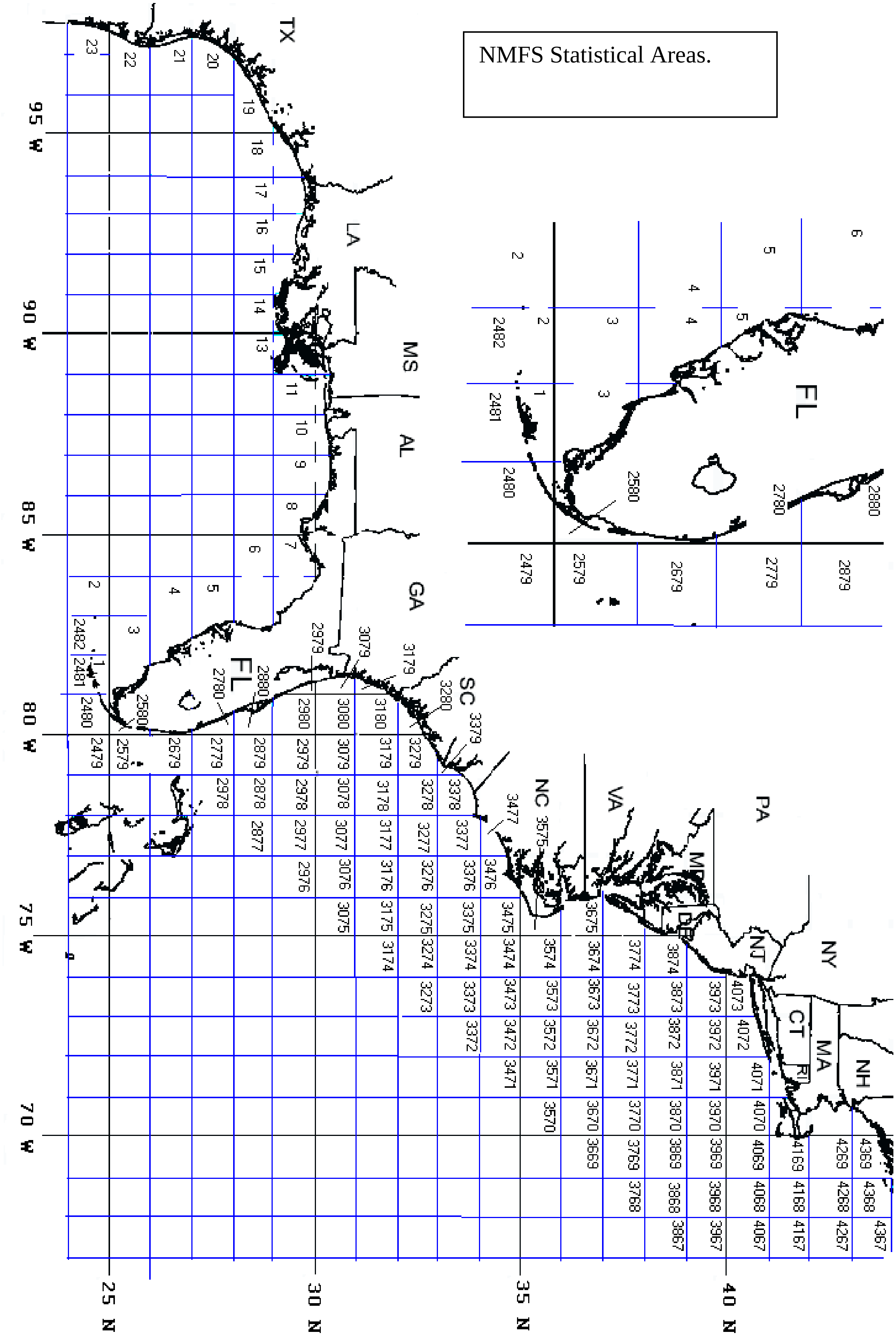


3. Summary Report

Stock Distribution and Identification

For this assessment, the SE US stock of mutton snapper was considered a single stock centered in South Florida and the Florida Keys.

Assessment Methods

A variety of models with different assumptions were used in this assessment including surplus production, a modified DeLury, catch curves, untuned virtual population analysis, stock reduction analysis, and a forward projecting statistical catch-at-age model (ASAP). The rationale for the different types of models was to examine the information content of catch and effort, the information in the catch-at-age, the influence of tuning, and the combination of all of these with the ideal of consistency across models. The assessment panel chose ASAP as the base model for determining the condition of the stock. The model was configured with five fleets, with discards being considered separately but linked to their appropriate fleet, and the model was tuned with 11 indices, six of which were fishery-independent indices and five were fishery-dependent. Two of the fishery-independent indices were associated with recruitment.

Assessment Data

Landings information and indices came from many sources. (Table 1 and Table 2)

Table 1. Fishery Dependent Assessment Data Availability

Fishery	Landings	Estimated Discards	Indices
Commercial Gears	1902 - 2006	2001 - 2006	1990 - 2006
Headboat (Survey)	1981 - 2006	2005 - 2006	1981-1991, 1995 - 2006
Recreational (MRFSS)	1981 - 2006	1981 - 2006	1981 - 2006

Table 2. Fishery Independent Assessment Data Availability

Survey	Indices
SEAMAP Video	1992 - 1997, 2002, 2004 - 2006
Florida Keys Visual	1999 - 2004, 2006
FWC Haul Seine	1999 - 2004, 2006
Riley's Hump Visual	2001 - 2006
NMFS/U Miami Reef Visual	1994 - 2005

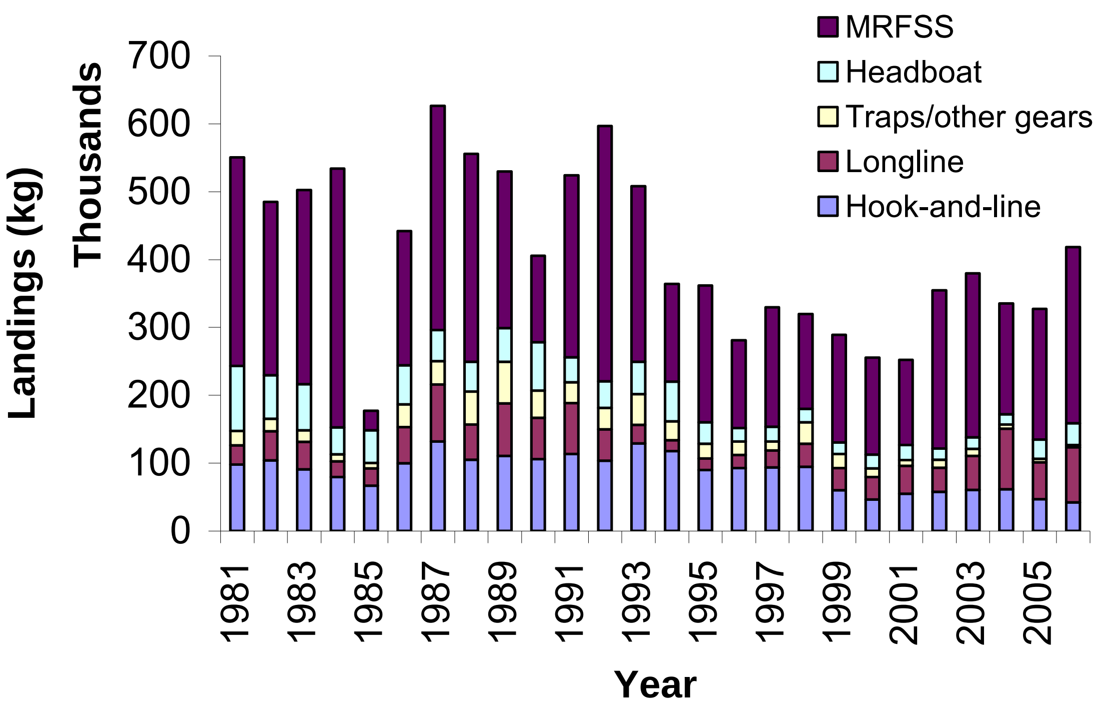


Figure 1. Landings by fishery sector.

Life history data are summarized in Table 3.

Table 3. Life History Data

Measure	Value
Natural Mortality (M)	0.11 per year
Maximum Age	40 years
Length at 50% Mature	402 mm Total Length
Age at 50% Mature	3.7 years
L_∞	874 mm Total Length
K	0.16
t_0	-1.32

Catch Trends

Recreational anglers land most of the mutton snapper, and anglers discard most of the mutton snapper that are discarded alive (Table 4, Fig. 1). The minimum size limit was raised to 16 inches (406 mm TL) from 12 inches in 1994, and the total landings decreased from an average of 490 mt to 330 mt. Commercial longline landings in recent years have offset the decrease in the other commercial gears. To estimate MRFSS landings in weight, the average weight by strata was used. For those strata lacking weight or length measurements because only Type B (unseen) fish were reported, a bootstrap procedure that drew from a pool of lengths from within the same mode and year was used. Commercial trips and headboat angler days have decreased over the time period while MRFSS effort has increased.

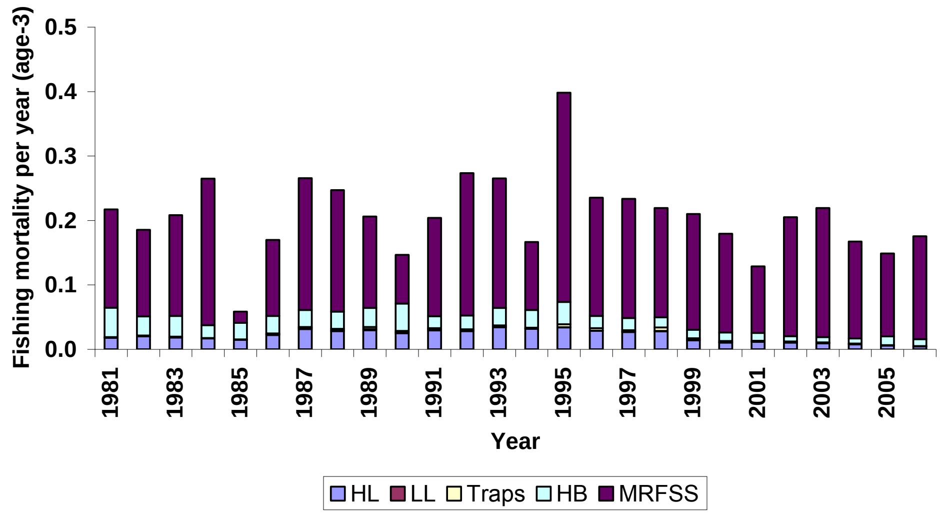
Fishing Mortality Trends

Since each fishery has a different selectivity, one cannot just compare the fishing mortality multipliers, but rather it is necessary to look at the breakdown of fishing mortality by fishery for a couple of ages. For example, when one looks at the mortality on age-3 fish, most of the mortality comes from MRFSS (average 77%), and if we look at age-7 fish, MRFSS still accounts for more of the fishing mortality, but the percentage is less (average 29%, Fig.2). Other than a spike in 1995, overall fishing mortality rates on age-3 fish averaged 0.20 per year while the fishing mortality rates on age-7 fish were slightly higher from 1987 through 1993 (0.23 per year) and then declined to 0.04 per year in 2005 and 2006.

Table 4. Landings and discards by fishery sector.

			Landings (kg)					Discards (kg)		
Year	Hook-and-line	Longline	Traps/other	Headboat	MRFSS	Hook-and-line	Longline	Traps/other	Headboat	MRFSS
1981	97861	28399	20872	96003	307268	8	0	1	58	0
1982	103771	43172	18174	64175	255266	8	0	1	39	95
1983	90633	40620	16981	67791	286203	7	0	1	37	864
1984	79392	23237	10121	39835	381396	6	0	1	23	4091
1985	66695	25313	8238	48061	28754	5	0	1	27	1415
1986	99472	53511	33422	57455	198024	8	0	2	26	1153
1987	131827	83655	34804	45484	330609	10	0	2	26	6284
1988	104645	51834	48911	43757	306497	8	0	3	31	3021
1989	110382	77454	61565	49374	230830	9	0	4	32	756
1990	105742	60741	40105	71373	127284	8	0	2	49	589
1991	113161	75170	30657	36937	267922	9	0	2	24	5671
1992	103518	46265	31627	38997	376152	8	0	2	26	5675
1993	129032	27278	45092	47593	258790	10	0	3	32	7925
1994	117482	15908	28188	58449	143820	9	0	2	30	5124
1995	89479	17249	21848	31294	201928	355	0	68	636	6277
1996	92602	19267	19970	19694	129289	367	0	62	351	6694
1997	93632	25025	13031	21870	175687	371	0	40	387	13068
1998	94431	33791	31663	19953	139720	375	0	98	287	14937
1999	60126	32603	20755	16662	158891	239	0	64	299	5240
2000	46168	32901	12974	20221	143274	183	0	40	328	7683
2001	54731	41171	8619	22031	125292	217	0	27	411	4907
2002	57357	35715	11773	16330	233099	326	0	0	317	8220
2003	60214	50196	10512	16829	241542	160	0	19	291	6909
2004	61181	89300	6379	15162	162881	402	0	13	297	7088
2005	46665	54539	4930	28165	192639	137	0	70	699	15792
2006	41836	81202	3423	31985	259849	47	0	8	392	15437

a.



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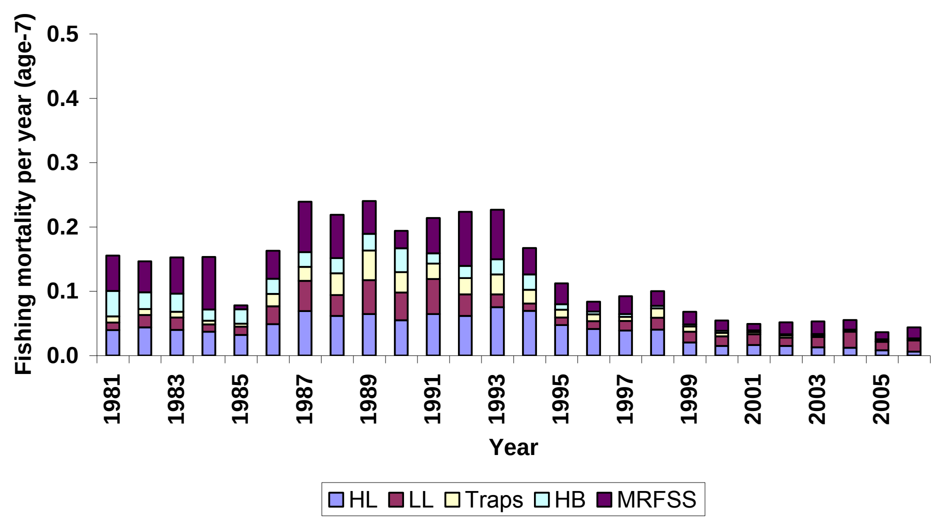

Figure 2. Fishing mortality rates by year and sectors for ages three (a) and seven (b) from the base run.

Stock Abundance and Biomass Trends

Population trends from the base run have been up in recent years (Table 5). The number of fish reached a low in 1985 and then has increased afterwards reaching 6.14 million fish in 2006. The biomass declined to a low in 1994 and then has increased to 9.57 million kg in 2006 (Fig. 3). Similarly, the spawning biomass reached a low in 1995 and has increased to 7.15 million kg in 2006. Recruitment was more variable, but the low was 462,000 fish in 1985, and the high was 2.40 million fish in 2005, reflecting the peak in the FWC FIM age 1+ recruitment index. Recruitment in 2006 was 1.58 million fish. The Beverton-Holt stock-recruit curve from the base run is shown in Fig. 4.

Table 5. Stock abundance, recruitment, biomass, and spawning stock biomass from base run.

	Population	Recruitment	Biomass	Spawning Biomass
Year	**Number**	**Number**	**kg**	**kg**
1981	2497436	579944	6326937	5517080
1982	2282802	477960	6101939	5219000
1983	2307693	622232	5932115	4983390
1984	2139113	495077	5473088	4718770
1985	1961510	462157	5242415	4398880
1986	2179827	610405	5286702	4392860
1987	2352898	760588	5062145	4181160
1988	2430850	813322	4718758	3801290
1989	2363530	724539	4471582	3543410
1990	2325322	688157	4291270	3361510
1991	2517999	818275	4348125	3351360
1992	2358457	622552	4228111	3287490
1993	2113994	512925	3988699	3149060
1994	2206956	779861	3806676	3003850
1995	2408167	801129	3882778	2997360
1996	2508368	780928	4005868	3035870
1997	2510065	642766	4235895	3202970
1998	2624831	764695	4434340	3403010
1999	3268991	1316870	4769035	3604630
2000	3660472	1192850	5290474	3885080
2001	3843587	1035820	5881601	4271750
2002	3662143	675971	6443473	4857510
2003	4211581	1410270	7004040	5484490
2004	4487359	1254940	7584769	6017020
2005	5894154	2402660	8533002	6491510
2006	6137546	1582160	9573187	7145870

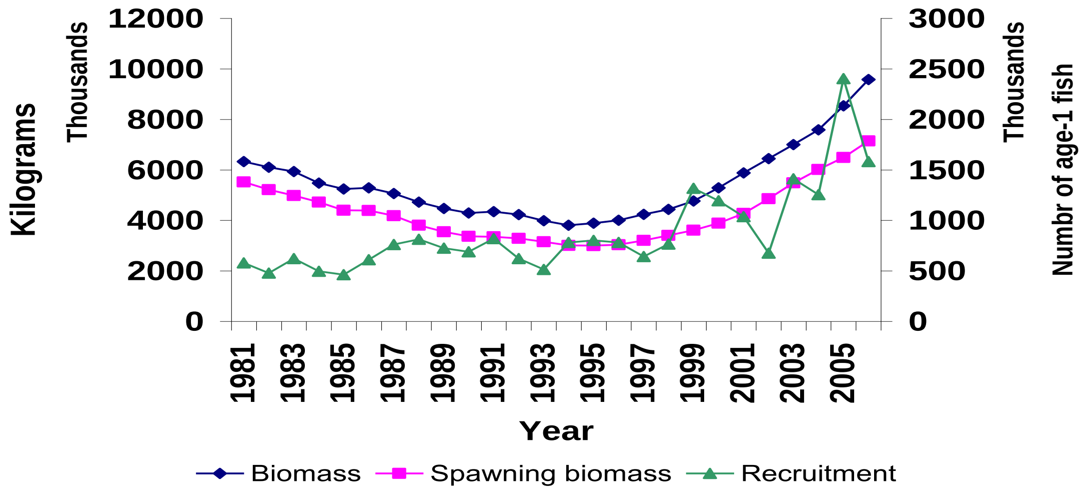

Figure 3. Stock biomass in kilograms showing both the immature portion and the spawning biomass by year from base run.

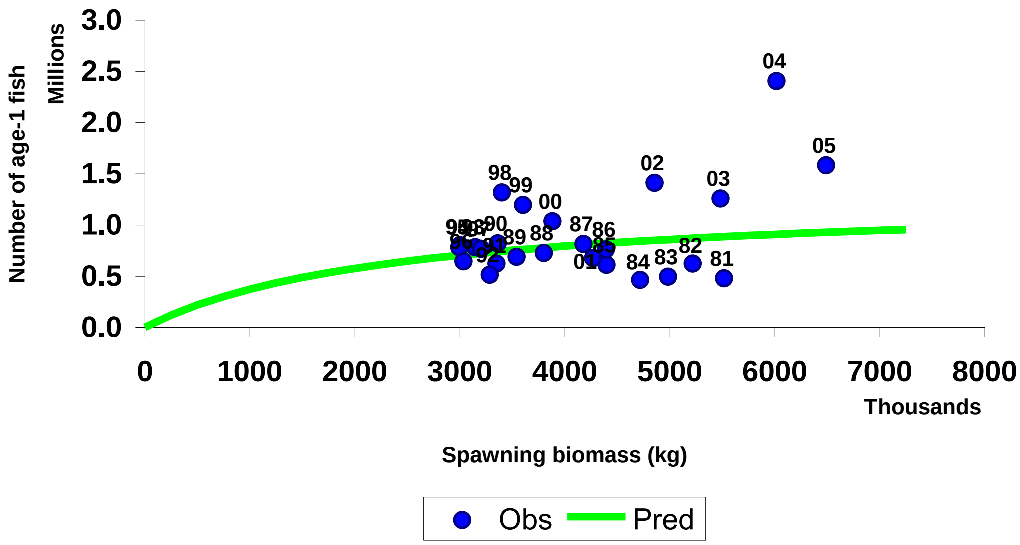

Figure 4. Spawning stock biomass and subsequent recruitment one year later. The steepness in the predicted curve was fixed at 0.75 in the base run.

Status Determination Criteria

In the management of mutton snapper in the Southeast US, the two Councils have adopted $F_{30\%}$ as a proxy for F_{MSY} and $F_{40\%}$ as a proxy for the fishing mortality rate at optimum yield, F_{OY} (Amendment 11, Snapper Grouper FMP, SAMFC 1998). Therefore, the MFMT would be $F_{30\%}$ or 0.34 per year, MSY would be the yield associated with $F_{30\%}$ or 688,000 kg, and SSB_{MSY} would be the spawning biomass at $F_{30\%}$ or 6.30 million kg. The MSST would be (1- constant) times the spawning biomass at $F_{30\%,}$ and the constant usually is the natural mortality. In the case of mutton snapper, the constant would be 0.11, and MSST would be 5.96 million kg (Table 6).

The control rule is shown in Fig. 5. The AW panel did not recommend changing any of the management criteria for mutton snapper.

Table 6. Stock status criteria

Parameter	Value	Units
Maximum sustainable yield (MSY, $Yield_{F30\%}$)	688000	Kg
Spawning biomass at MSY (SSB_{MSY}, $SSB_{F30\%}$)	6296000	Kg
Maximum Fishing Mortality Threshold (MFMT, $F_{30\%}$)	0.34	Per year
Minimum Spawning Stock Threshold (MSST, (1-0.11)*$SSB_{F30\%}$)	5603000	Kg
Fishing mortality at optimum yield ($F_{40\%}$)	0.26	Per year
Optimum yield (OY, $Yield_{F40\%}$)	524000	Kg
F_{2006}	0.18	Per year
$F_{2006}/F_{30\%}$	0.51	--
SSB_{2006}	7146000	Kg
$SSB_{2006}/SSB_{F30\%}$	1.14	--

Stock Status

The stock status ratios from the base run were $F_{2006}/F_{30\%} = 0.51$ and $SSB_{2006}/SSB_{F30\%} = 1.14$. Using the current status criteria, the base run indicates the stock was neither undergoing overfishing nor was the stock overfished in 2006, but sensitivity runs indicate that there is a moderate probability that the stock could be overfished. The general increase in the recreational fishing mortality rate adds to the concern.

Uncertainty

There were two aspects to uncertainty. The first estimated the standard errors of the parameters, and the second was explored through the use of different models and through sensitivity runs (Fig. 5). The standard errors of some key parameters such as virgin stock size were very narrow (on the order of CV = 0.2% or 0.4%) while their associated parameter estimates differed by 240%. While the sensitivity runs were not exhaustive, they were chosen to represent a range of plausible conditions. The sensitivity runs show that over many alternative configurations of steepness and natural mortality, the stock was not undergoing overfishing but the stock could be overfished. The uncertainty in virgin stock size complicates determining whether mutton snapper were overfished in 2006. The base run results indicate that the stock is in a healthy condition being neither over-fished nor undergoing overfishing. However, there is concern that, given the uncertainty in the results, the stock was overfished in 2006 and that the recreational fishing mortality rate could increase such that the stock could become overfished. The Review Panel thought that the way to address the uncertainty as to whether mutton snapper were overfished would be to have the stock re-assessed in a short time (3 years) using a different assessment method.

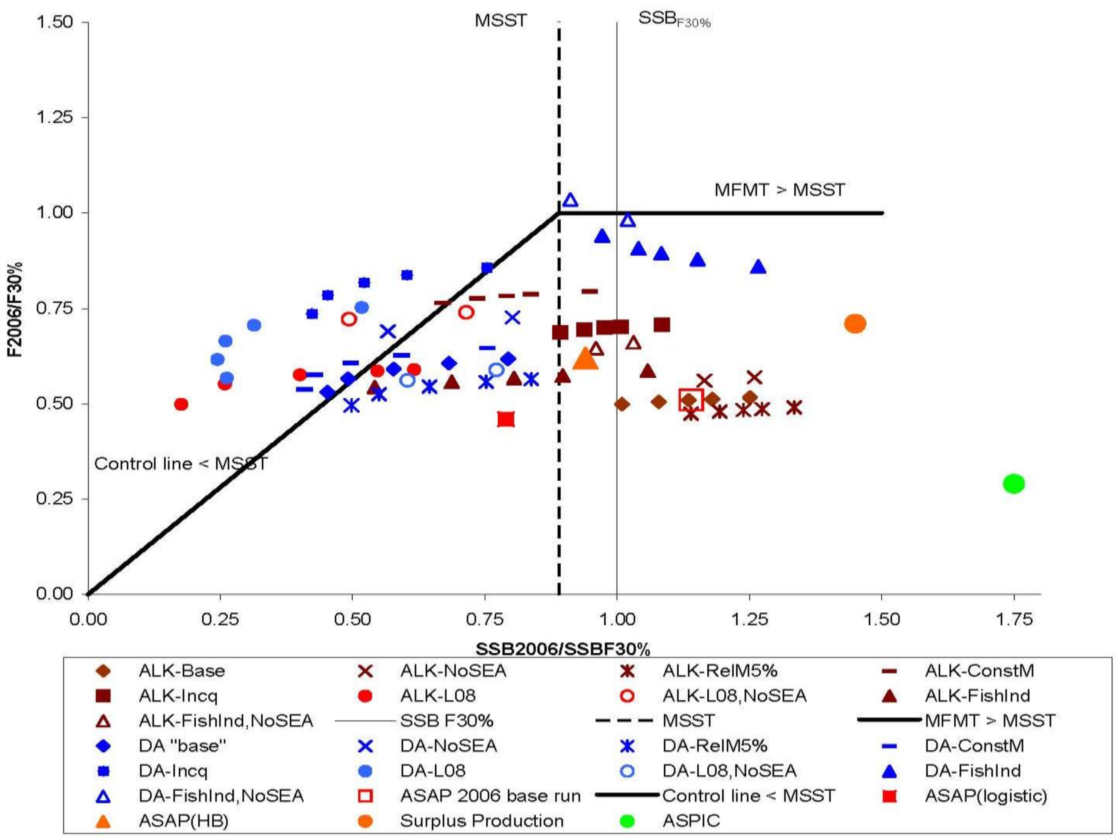

Figure 5. Control rule and results from ASAP sensitivity runs including two runs requested at the review and the surplus production model. The base run results are indicated by the square with the diamond in the center.

Projections

ASAP's projections were run using the base run, with natural mortality averaging 0.11 per year, and similar runs using the lower natural mortality averaging 0.08 per year. The fishing mortality options were: (a) F=0, (b) the Councils' OY fishing rate of $F_{40\%}$, (c) the Councils' MSY fishing rate of $F_{30\%}$, and (d) using the total harvest fishing mortality rate in 2006. Because of the longevity of mutton snapper, the projections were run out 50 years, 2007-2056 with the harvest in 2007 set equal to that in 2006 because any regulations could not be implemented prior to 2008. Projections using the base run of directed harvest through 2017 are shown in Table 7. The situation with mutton snapper is a bit unusual because the fishing mortality rate for the past several years has been less than either the MSY proxy or OY. Thus, if either of these benchmark fishing mortality rates is adopted, the harvest would be expected to increase which would reduce the spawning stock biomass. Another set of projections using the Lorezen natural mortality rates that averaged 0.08 per year also showed the spawning biomass increasing with fishing at $F_{30\%}$, $F_{40\%}$, or F_{2006}. Given a new assessment in three years, a better determination of stock status and whether stocks are continuing to increase can be made.

Table 7. Projected directed harvest from ASAP base run with age-specific natural mortality rates averaging 0.11 per year for three different fishing mortality rates.

	Directed Harvest (kg)		
Year	**MSY($F_{30\%}$)**	**OY ($F_{40\%}$)**	**F_{2006}**
2007	432600	432600	432600
2008	928851	708863	492672
2009	824689	646123	460589
2010	803414	643036	467920
2011	783622	639389	474006
2012	757327	629411	475015
2013	727479	614579	471269
2014	703190	602548	468454
2015	683254	592949	466694
2016	665965	584518	465103
2017	650941	577132	463696

Special Comments

No special comments are made.

Sources of Information

The source of results contained in summary report came from the Data Workshop and Stock Assessment Workshop reports and adjustments or corrections found after the reports were submitted.

4. SAIP Form (To be completed following the Review Workshop)

Stock Assessment Improvement Program
Assessment Summary Form

This form must be completed for each stock assessment once it has passed review or been rejected without anticipated revisions in the near future (<1 year). Please fill out all information to the best of your ability.

FMP Common Name: Snapper - Grouper (SAFMC) and Reef Fish (GMFMC)
Stock: Mutton snapper

Level of Input Data for

Abundance: 1
0 = none; 1 = fishery CPUE or imprecise survey with size composition; 2 = precise, frequent survey with age composition; 3 = survey with estimates of q; 4 = habitat-specific survey

Catch: 4
0 = none; 1 = landed catch; 2 = catch size composition; 3 = spatial patterns (logbooks); 4 = catch age composition; 5 = total catch by sector (observers)

Life History: 2
0 = none; 1 = size; 2 = basic demographic parameters; 3 = seasonal or spatial information (mixing, migration); 4 = food habits data

Assessment Details

Area: South Atlantic and Gulf of Mexico
e.g., Gulf of Mexico, South Atlantic, Caribbean, Atlantic.

Level: 4
0 = none; 1 = index only (commercial or research CPUE); 2 = simple life history equilibrium models; 3 = aggregated production models; 4 = size/age/stage-structured models; 5 = add ecosystem (multispecies, environment), spatial & seasonal analyses

Frequency: 1
0 = never; 1 = infrequent; 2 = frequent or recent (2-3 years); 3 = annual or more

Year Reviewed: 2008

Last Year of Data: 2006
Used in the assessment

Source: SEDAR 15
Citation

Review Result: Accept
Accept, Reject, Remand, or Not reviewed

Assessment Type: Benchmark
New, Benchmark, Update, or Carryover

Notes: ______

Stock Status

F/F_{target}: 0.69
F/F_{limit}: 0.51
B/B_{MSY}: 1.14
B/B_{limit}: 1.14
Overfished?: No
Overfishing?: No

Basis for

F_{target}: $F_{40\%}$
e.g., F_{OY}

F_{limit}: $F_{30\%}$
e.g., F_{MSY}

B_{MSY}: $SSB_{F30\%}$

B_{limit}: MSST
e.g., MSST

Next Scheduled Assessment

Year: Not scheduled
Month: ______

5. Abbreviations

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAC	SAFMC SSC Bioassessment sub-Committee
B_{MSY}	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
GMFMC	Gulf of Mexico Fishery Management Council
F	fishing mortality (instantaneous)
FSAP	GMFMC Finfish Assessment Panel
F_{MSY}	fishing mortality to produce MSY under equilibrium conditions
F_{OY}	fishing mortality rate to produce Optimum Yield under equilibrium
F_{XX}% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
F_{MAX}	fishing mortality that maximises the average weight yield per fish recruited to the fishery
F_0,	a fishing mortality close to, but slightly less than, Fmax
FWRI	(State of) Florida Fisheries and Wildlife Research Institute
GLM	general linear model
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
Lbar	mean length
M	natural mortality (instantaneous)
MFMT	maximum fishing mortality threshold, a value ofF above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
RVC	Reef Visual Census—a diver-operated survey of reef-fish numbers
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS corporation.
SEDAR	Southeast Data, Assessment, and Review
SEFSC	NOAA Fisheries Southeast Fisheries Science Center
SERO	NOAA Fisheries Southeast Regional Office
SFA	Sustainable Fisheries Act of 1996
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock

SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

Section II. Data Workshop Report

TABLE OF CONTENTS

1. Introduction

Workshop Time and Place

The SEDAR 15A data workshop was held April 16-18, 2007, in Marathon, Florida.

1.2 Terms of Reference

1. Characterize stock structure and develop a unit stock definition.
2. Tabulate available life history information:
   a.) Provide appropriate models to describe growth, sexual maturity, and fecundity by age, sex, or length, as applicable.
   b.) Provide estimates of natural mortality (age-specific, if feasible).
   c.) Provide estimates of recreational catch-and-release mortality as well as commercial discard mortality.
3. Provide measures of population abundance that are appropriate for stock assessment:
   a.) Document all data collection programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
   b.) Consider fishery-dependent and fishery-independent data sources; provide measures of abundance by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision.
4. Characterize commercial and recreational catch:
   a.) Provide landings and discard removals, in pounds and numbers.
   b.) Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector.
   c.) Provide length and age distributions of the catch and discards, if feasible.
5. Evaluate the adequacy of available data for estimating the impacts of past and current management actions.
6. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements.
7. Provide recommendations for future research and monitoring. Include specific guidance on sampling intensity and coverage where possible.
8. Prepare complete documentation of workshop actions and decisions, and write the SEDAR-15A Data Workshop Report. Provide final datasets in a format accessible to all participants. The final SEDAR-15A Data Workshop Report and all dataset are due no later than May 31, 2007.

1.3 List of Participants

Participant	Affiliation
Beaver, Rick	FWC, FWRI SFRL, Marathon
Gregory, Doug	UF-IFAS, Monroe Co. Extension Service, Key West
Tunnell, Janet	FWC, FWRI, St. Petersburg
Crabtree, Laura	FWC, FWRI, St. Petersburg
Faunce, Craig	FWC, FWRI, Tequesta
Colvocoresses, Jim	FWC, FWRI, St. Petersburg
Acosta, Alejandro	FWC, FWRI SFRL, Marathon
Ferguson, Karole	FWC, FWRI SFRL, Marathon
Feeley, Mike	FWC, FWRI SFRL, Marathon
Gledhill, Christopher	NOAA Fisheries, SEFSC, Pascagoula
Ingram, G. Walter	NOAA Fisheries, SEFSC, Pascagoula
Barbieri, Luiz	FWC, FWRI, St. Petersburg
Cummings, Nancie	NOAA Fisheries, SEFSC, Miami
Little, Ed	NOAA Fisheries, SEFSC, Key West
Burton, Michael	NOAA Fisheries, SEFSC, Beaufort
Sauls, Beverly	FWC, FWRI, St. Petersburg
Brown, Steve	FWC, FWRI, St. Petersburg
Zimmerman, Scott	Florida Keys Commercial Fishermen's Association, Director
O'Hern, Dennis	Fishing Rights Alliance, Director
Cavanaugh, Joe	REEF
Adamson, Alicia	FWC, FWRI SFRL, Marathon
Sullivan, Kelly	FWC, FWRI SFRL, Marathon
Tellier, Marie-Agnes	FWC, FWRI SFRL, Marathon
Muller, Robert	FWC, FWRI, St. Petersburg
O'Hop, Joe	FWC, FWRI, St. Petersburg
Hunt, John	FWC, FWRI SFRL, Marathon
McCarthy, Kevin	NOAA Fisheries, SEFSC, Miami

FWC – Florida Fish and Wildlife Conservation Commission
FWRI – Fish and Wildlife Research Institute
NOAA – National Oceanic and Atmospheric Administration
SEFSC – Southeastern Fisheries Science Center
SFRL – South Florida Regional Laboratory
UF-IFAS – University of Florida, Institute of Food and Agricultural Sciences

Appointed Panelists | Appointed by/Affiliation

<none>

Council Representative

Luiz Barbieri — Gulf of Mexico Fishery Management Council
Doug Gregory — South Atlantic Fishery Management Council

Staff

<none>

1.4 Supporting Documents

Working papers prepared for the data workshop:

Document#	Title	Authors
SEDAR15A-DW-01	SEAMAP Reef Fish Survey of Offshore Banks: Yearly Indices of Abundance for Mutton Snapper (*Lutjanus analis*)	Gledhill, C.T., Ingram, G.W.,Jr., Rademacher, K.R., Felts, P., Trigg, B.
SEDAR15A-DW-02	Annual Indices of Abundance of Mutton Snapper for Florida Keys. Stratified-random sampling (SRS) with Visual Point Counts.	Acosta, A., Muller, R.
SEDAR15A-DW-03	Annual Indices of Abundance of Mutton Snapper for Florida Keys. Juvenile Snapper Seining Program.	Ferguson, K.
SEDAR15A-DW-04	Nearshore Hard-Bottom Community Survey of the Florida Keys.	Tellier, M.
SEDAR15A-DW-05	Annual Indices of Abundance of Mutton Snapper of Florida Estuaries.	Ingram, W., Acosta, A., Colvocoresses, J., MacDonald, T., Barbieri, L.
SEDAR15A-DW-06-07	Baseline Data for Evaluating Reef Fish Populations in the Florida Keys, 1979-1998.	Bohnsack, J.A., McClellan, D.B., Harper, D.E., Davenport, G.S., Konoval, G.J., Eklund, A., Contillo, J.P., Bolden, S.K., Fischel, P.C., Sandorf, G.S., Javech, J.C., White, M.W., Pickett, M.H., Hulsbeck, M.W., Tobias, J.L., Ault, J.S., Meester, G.A., Smith, S.G., Luo, J.
SEDAR15A-DW-08	Fishery independent indices of abundance for mutton snapper, *Lutjanus analis*, from REEF fish surveys along Florida's Atlantic coast including the Dry Tortugas.	Muller, R.
SEDAR15A-DW-09	Revised standardized catch rates of mutton snapper from the United States Gulf of Mexico and South Atlantic handline and longline fisheries, 1990-2006.	McCarthy, K.
SEDAR15A-DW-10	Visual Census Surveys at Riley's Hump, Tortugas South Ecological Reserve.	Burton, M., Ingram, W.
SEDAR15A-DW-11-12	Recreational catch rates for mutton snapper, *Lutjanus analis*, in the Southeast United States from the Marine Recreational Fisheries Statistics Survey and the Headboat Logbook Program.	Muller, R.

Document#	Title	Authors
SEDAR15A-DW-13	Commercial Fishery	Brown, S., Beaver, R., Little, L.
SEDAR15A-DW-14	Recreational Fishery	Sauls, B.J., Cummings, N.
SEDAR15A-DW-15	Life History of *Lutjanus analis* inhabiting Florida waters.	Faunce, C., Tunnell, J., Burton, M., Ferguson, K., O'Hop, J., Muller, R., Feeley, M., Crabtree, L.
SEDAR15A-DW-16	Mortality estimates for mutton snapper, *Lutjanus analis* inhabiting Florida waters.	Faunce, C., Muller, R., O'Hop, J.
SEDAR15A-DW-17	Calibration and quality control of aging mutton snapper.	Tunnell, J, Crabtree, L., Burton, M., E. Ault
SEDAR15A-DW-18	Bottom longline fishery bycatch of mutton snapper from observer data.	Hale, L.

2. Life History Group Report

2.1 Overview (Group membership, Leader, Issues)

The life history group membership was comprised by Craig Faunce (leader), Janet Tunnell, Laura Crabtree, Karole Ferguson, Michael Feeley, Michael Burton. Robert Muller and Joe O'Hop provided some additional information during the working group's discussions and report writing.

Three species constitute the majority of snapper (Family Lutjanidae) targeted by fishermen in nearshore waters of Florida; the lane snapper (*Lutjanus griseus*), gray snapper (*Lutjanus griseus*) and the mutton snapper (*Lutjanus analis*). Mutton snapper achieve the largest body size of these snappers, and represent a valuable fishery resource. Users have conveyed concern that the abundance of this species has been in decline. These concerns prompted the Florida Fish and Wildlife Conservation Commission to initiate the Southeast Data Assessment and Review (SEDAR) process whereby available information on the biology and fishery of this species are assembled and reviewed. As part of this process, scientists and stakeholders were selected to participate in one of several working groups. This life history section report summarizes information from available sources that incorporate both fishery-dependent and -independent data (Table 2.1). Sections 2.3. and 2.4 draw upon (SEDAR 15A-DW-15, Faunce et al. 2007).

2.2 Stock Definition and Description

Online summaries of the taxonomy and biology of this species are available from Murray and Bester (2007) and Froese and Pauly (2007). *Lutjanus analis* were first described by Georges Cuvier in 1828 from a Hispanolan specimen, and is synonymous with *Mesoprion sobra* (Cuvier 1828), *Mesoprion isodon* (Valenciennes 1829) and *Mesoprion rosaceus* (Poey 1870). Common names in English include mutton snapper, mutton fish, king snapper, virgin snapper, snapper, and in Spanish include pargo, pargo cebado, pargo cebal, pargo colorado, pargo criollo (Cuba), pargo mulato, and sama.

Although mutton snapper are reportedly distributed within the Western Atlantic from Brazil north to Massachusetts, the majority of information on the biology of this species comes from a more limited geographic range. For example, spawning locations of mutton snapper are reported from the Turks and Caicos, Florida, the Bahamas, and Cuba (SCRFA 2007), and detailed information on the biology of this and other snappers is available from Cuba and Florida (Burton 2002; Barbieri and Colvocoresses 2003; Claro and Lindeman 2003; Burton et al. 2005). The strong Caribbean, loop, and Gulf stream currents of the region are sufficient to maintain a homogenous population at the genetic level (Shulzitski, et al. 2005). However, at ecologically meaningful scales (10-100 km), models that couple larval behaviors and hydrodynamics reveal that propagule emigration from Cuba (particularly from northeast and north central regions), to southeastern Florida occurs, but that their contribution is low in terms of the total number of advected larvae over the planktonic larval duration of ca. 30 days (Lindeman et al. 2001; Paris et al. 2005). For these reasons, the unit stock of mutton snapper for this SEDAR is considered at the functional population level, and is defined as the total number of individuals that use waters within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) and the Gulf of Mexico Fishery Management Council (GMFMC). Occurrence of this species in the nearshore bays of Florida confirm that juveniles of this species is limited to points south of Jupiter Inlet on the Atlantic coast, and Charlotte Harbor on the Gulf Coast (A. Acosta FIM data).

2.3 Natural Mortality

Prior to this assessment, the only published natural mortality estimate of *L. analis* was provided by Burton (2002) but the SAFMC Snapper Grouper Plan Development Team used a natural mortality rate of 0.2 per year based on only having otoliths from fish of ages 1-14 and they applied this rate to all ages (SAFMC 1990) . Although fish up to 29 years were observed by Burton (2002), an examination of the age-frequency distributions revealed that no fish were observed between 18 and 29 years of age. For this reason Burton (2002) calculated two natural mortality estimates; one for fishes up to 17 years, and one for fishes up to the maximum age of 29. This is significant, because age-frequencies from this SEDAR also show fewer fishes over 18 years; however, fish were observed in all age classes including 40 years (Table 2.2). From these data, it was concluded that the *L. analis* population consists of two portions; one of individuals up to 18 years that reside where fishermen regularly harvest (hypothesized to be the Florida shelf less than 30 meters), and older fishes that are found in comparatively lightly fished locations, such as deep (e.g., greater than 50 meters) or spatially remote locations (e.g., areas west of the Dry Tortugas and Pulley Ridge). This second portion of the population is believed to represent a relatively ligthly exploited portion of the population. The older fishes (Table 2.2; fish that were 25 years or older) were largely from areas west of the Dry Tortugas, and were caught at depths between 20 and 140 fathoms (36 to 256 meters) by commercial long line fishermen. As a result, because total mortality, Z, is equal to natural mortality (M) and fishing mortality (F) then an analysis of the proportion of fishes in age classes older than 18 years would provide an approximate estimate of natural mortality (M) and not F. As evidence, consider that the recreational fishery for mutton snapper operates nearshore and 95% of their landings are fish aged 7 years or less while the commercial fishery operates in deeper water and 95% of their landings are fish aged 21 years old or less (Figures 2.1 and 2.2).

Burton (2002) estimated natural mortality from equations derived from meta-analyses. For example, Hoenig (1983) who related total longevity (t_{max}) to natural mortality (M) according to an empirical relationship derived from an examination of fish with different life histories and longevities: $\ln(\hat{M}) = 1.44 - 0.982 * \ln(t_{max})$. According to this relationship, estimates of natural mortality from Burton (2002) became 0.26 per year for ages 1-17 and 0.14 per year for ages 1-29, and 0.11 per year for the t_{max}=40 yr in this assessment because fishes up to 40 years were observed (Table 2.2). By the nature of the equation, estimates of M will dramatically change with different t_{max} values. It is perhaps better then to estimate M based on multiple ages. For this reason we used a catch curve (Chapman and Robson 1960). To ensure that the data were as comparable as possible, we only included fish aged 18 years and older caught from the Dry Tortugas and southeast Florida shelf long line fishery. There were 162 mutton snapper that met these criteria. The Chapman-Robson catch curve estimated total mortality at 0.13 per year- similar to the estimate from Hoenig (1983). Instead of assuming that a single natural mortality rate applies to all ages, we derived age-specific M values using Lorenzen's (2005) method. His approach uses the relationship between age and length and is scaled to a "target" mortality rate. Based on the above, and the age-and-growth information from Faunce et al. (2007), we scaled the calculated age-specific rates (Table 2.3) for ages 3-40 to 0.11 per year, the estimate that we obtained from Hoenig's (1983) regression (Figure 2.3).

2.4 Discard Mortality

Discard mortality for mutton snapper has not been examined prior to this SEDAR, necessitating the inclusion and examination of alternative data. Data were obtained from two sources. First, the online search engine Cambridge Scientific Abstracts were culled for relevant articles from earliest to present within the default "Natural Resources" database using the following keywords: fishing mortality, grouper, snapper, mutton snapper, catch, release and mortality. Articles were deemed relevant if they focused on a species with similar body size to mutton snapper (< 1 m total length), with similar life history strategies (adults reside on marine reefs), collected with similar gear types (hook and line). Discard mortality from SEDAR 7 (Gulf of Mexico red snapper, *Lutjanus campechanus*, section 6.0) was selected as a second source (Table 2.4).

Discard mortality is influenced by the factors of hook type, hook placement, time of handling, and depth of capture (the latter being the result of barotrauma caused by the super-inflation of the swim bladder upon ascent). Of these factors, depth of capture is best represented in the available data. In order to identify general trends in the data, it was assumed that the average depth and mortality of fish captured could be adequately represented by the midpoint between the minimum and maximum reported values in each study (e.g., the data were normally distributed and that the mode=mean)- an assumption supported by Wilson et al. (2005). Two groups of data could be easily discerned from the data; those collected in less than 30 m depth, and those collected at greater depths. This division point of 30 m also has significance since a large proportion of the Florida shelf is near or below this depth (Figure 2.4). Therefore the shallow depth group can be considered a proxy for fishes collected nearshore and available to recreational anglers. This approximation is supported by a study using fish traps for snappers that was designed to collect specimens from recreational fishery locations, including *L. analis* made during 2000-2003 by the Florida Fish and Wildlife Conservation Commission (Barbieri & Colvocoresses 2003) on the Atlantic Florida shelf. The depths at which the traps were deployed averaged 22.6 meters, and 95% confidence intervals (1.96 * standard deviation) place approximate boundaries on the “typical” recreational fishing for reef species in that area between 14.5 and 30.7 m deep (n=485).

Mortality rates for red snapper (*L. campechanus*) and other reef species were drastically different between depth groups, and averaged 15% (range 1-58 %) for the shallow group and 66% (range 44 – 86%) for the second group (Table 2.3). These values were statistically different based on t-test comparison of means ($p<0.001$), and provide the first method to assign discard mortality rates to *L. analis*.

Limited data were available on *Lutjanus analis* release condition from head boat observations made in eastern and western Florida during 2005-06 (Beverly Sauls, FWC unpublished; Table 2.5). Comparing these limited data with *Lutjanus campechanus* data reveals that discard mortality rates were neither consistently greater or lower than red snapper mortality rates for the two depth classes (Figure 2.5). However, discard mortality for *L. analis* was lower than for *L. campechanus* in three of four instances, suggesting that discard mortality rates for *L. analis* may be lower than for *L. campechanus* at all depths. The high mortality of *L. analis* in shallow (< 60’ or ca. 20 m) depths on the east coast of Florida could be an artifact of the low sample size (four fish).

Because of these differences, a more attractive method to assigning release mortality would be to examine how rates change with depth as a continuous variable rather than within discrete depth bins. This type of data is only available for *L. campechanus*, and when available information was combined, it was revealed that discard rates could be effectively modeled using a logistic regression (Figure 2.6). The final form of this model was:

$$y = \frac{79.12}{1+\left(\frac{x}{34.10}\right)^{-5.55}}$$

where x is discard depth and y is the discard mortality rate (%). Examination of residuals and test results revealed that the model was adequate and statistically significant ($p<0.001$). Because this model can be used to estimate discard mortality for a variety of depths, it is the recommended as the preferable option to assign discard mortality rates for *L. analis*. An important assumption is that the relationship between mortality and depth for *Lutjanus campechanus* can be applied to *L. analis*. Examination of limited data from head boat at-sea surveys indicate that this assumption may not be correct, and that its acceptance adopts a more conservative approach to discard mortality rates for *L. analis*.

2.5 Age

Biological samples were examined from four sources (Table 2.1). Details pertaining to otolith processing, ageing and precision are found in (SEDAR 15a, DW-17, Tunnell et al. 2007). Ring deposition occurred once a year between the months of February and June. The observation of the last ring on the margin was minimal during these months, but the common occurrence of a small margin (less than 2/3 translucence) and the decrease in the frequency of a large margin (more than 2/3 translucence) in June and July confirms that rings are annuli and are formed by June (Figure 2.7). These data agree with similar findings presented by Burton (2002).

Substantial differences in the maximum age for mutton snapper were revealed. While the maximum age from Florida was previously estimated at 29 years by Burton (2002), the maximum age has been extended to 40 years in the current analysis (Table 2.2). Fishes aged from 0-10 were collected from Tequesta, ages 1-17 collected from the Keys, and ages 1-29 collected in the Burton (2002) data set. It should be noted however that the proportion of fish above age 17 in the data set of Burton (2002) is quite small, and a maximum age of 17 years was also observed among the two fishery independent data sets of FWRI. Despite differences in sampling gear and location, the age-structure of mutton snapper in Florida are remarkably similar among data sets (Figure 2.8). In total, 90% of the fish examined were less than eight years of age, or 20% of their maximum life span (Figure 2.9). Differences in size at age by sex were negligible (Table 2.5).

2.6 Growth

Age-length (total length with the tail compressed, TL_{max}) information was fitted to the von Bertalanffy (1938) growth function using a size-truncated model (PROC MODEL, SAS ver. 9.1.3)

$$L_t = L_{\inf}\left(1 - e^{-K(t-t_0)}\right)$$

where L_t is the size at age t (years), L_{inf} is the theoretical maximum size, K is the growth function or slope, and t_0 is the theoretical age when fish length is zero, or x-axis “fitting parameter”. Truncation of length data was based on the time of otolith collection and if it was collected from a fishery dependent or independent source. Fishery independent data had no length truncation, whereas dependent data collected from 1992 through 1994 was truncated due to a minimum size limit of 12 inches, and data collected from 1995 through the present was truncated due to a minimum size limit of 16 inches.

The Gaussian nonlinear maximum-likelihood estimator reached minimum tolerance of 0.001 after 146 runs with 7172 data points (Table 2.2; 1 missing length), and explained the majority of the variance in the data (adjusted r^2=0.84). Examination of residuals indicated no systematic trends with body size, and all parameters were statistically significant (Table 2.6). These data compare well to observed size at age estimates (Figure 2.10) and those from other studies (Table 2.7).

2.7 Reproduction

2.7.1 Timing

More is known about the age and growth of mutton snapper than its reproduction. This SEDAR contains new reproductive data for Florida. Fish were collected with Chevron traps, hook and line, and spearfishing gear during 1998-2002 from the mainland (Tequesta) and the Florida Keys (Marathon). This data set was first described by Barbieri and Colvocoresses (2003) and is hereafter termed the FWC dataset. The spawning season can be inferred from indices relating gonad weight to body weight (gonadosomatic index, or GSI) and directly assessed from examination of the gonads. Plots of GSI during each month showed elevated values during April-June (Figure 2.11). This trend closely matches newly available data from the “South Florida” (Fort Pierce South) dataset of Burton (2002) that show elevated values during March-July. These data also agree with trends in GSI from Cuba and Puerto Rico that demonstrate peak values during May-June (Claro 1981; Figuerola and Torres 2001).

Direct examination of the gonads revealed differences in gonad maturity stages (GMS) between FWC laboratories. The occurrence of stage 3 (presence of vitellogenic oocytes), and stage 4 (hydrated oocytes) spanned April-September in Tequesta and January-October in the Keys (Figure 2.12). Based on GSI and the presence of GMS 3 and 4 females, the reproductive season for this species spans March-July with a peak in activity during April-June (Figure 2.13).

2.7.2. Size at maturation

Following the recommendations of Hunter and Macewicz (1985, 2003) the reproductive stage of gonads for the peak spawning period (April-June) was evaluated using histological methods for the purposes of generating a size- and age- based maturation schedule for female *Lutjanus analis*. Gonad maturity stages (Table 2.9) were assigned a maturity value of 1 if greater than stage 1 (immature, primary oocytes only present or sex undetermined due to lack of development) and a value of zero if GMS=1. These data were fit to a logistic regression

$$y = \frac{1}{\left(1 + \left(e^{-R*\left(x - L_{50}\right)}\right)\right)}$$

where y is the proportion mature, L_{50} is the point at which 50% of individuals are mature, and x is equal to either size or age (PROC NLIN, SAS ver 9.1.3). To ensure accuracy of the data, analyses were restricted to fishes that were collected during the spawning season (i.e., if maturity were to occur, it would be observed). Both models were significant and explained the majority of variance in the data (Tables 2.10a,b).

Fifty percent of females achieved sexual maturity at 353 mm TL_{max} and 2.07 years of age (Figures 2.14 and 2.15 respectively). These values are very different from data (macroscopic determinations only, not histological) from Cuba, as Claro (1981) reported a L_{50} for this species to be 520 mm fork length (FL; ca. 574 mm TL_{max}) and 5-6 years of age. Similarly, Figuerola and Torres (2001), using histological criteria, reported a L_{50} of 414 mm FL (ca. 459 mm TL_{max}) for *L. analis* in Puerto Rico. A shift in cohort-specific maturity schedules over time is consistent with a genetic change at the population level, and a change towards smaller size at maturity is consistent with the expected life-history response to high rates of selective exploitation (Marshall and Browman 2007). If the data of prior estimates from Caribbean populations is indicative of fishes inhabiting Florida waters in the past, then current estimates of size-at-maturity are comparatively small and may indicate growth overfishing in the Florida population. However, we recommend further analyses of the maturity data from Tequesta and the Florida Keys, and if possible, maturity data from Puerto Rico before accepting the size- and age- at-maturity values from the regressions. There were some differences in the staging criteria and in the months included in the size-at-maturity curve in the Puerto Rico study (Figuerola and Torres 2001).

2.7.3. Timing and trends in reproduction

Available information on the timing of spawning comes from Garcia-Cagide et al. (2001) and Claro and Lindeman (2003), who place peak spawning 6-7 days after the full moon during May and June. Our best information on the spawning behavior of mutton snapper come from the area of the Dry Tortugas, Florida. M. Domeier observed an aggregation of mutton snapper during 1991 that had been heavily exploited and described these fishes as milling a few meters off the bottom yet exhibiting no clear behaviors related to spawning- suggesting these behaviors occur at night (Domeier and Colin 1997). Johannes et al. (1999) explain that fishes in spawning condition exhibit “spawning stupor” or a general ignorance to observation by divers. The longest data set relating to *L. analis* spawning comes from Burton et al. (2005), who conducted yearly observations of *Lutjanus analis* group size during the full and new moons of May-July during 1999-2004. Their observations revealed increases in the number of *Lutjanus analis* present over time. During 1999-2000 only solitary individuals were observed, during 2001 this number increased to 10, during 2002-2003 this number increased to 100 and during 2003-2004 over 200 individuals were observed (Burton et al. 2005). Because this normally solitary fish was observed in groups during suspected spawning periods and exhibited the stupor disposition, these authors concluded that they were witnessing fishes within a spawning aggregation.

Despite numerous attempts, spawning behaviors and courtship have yet to be documented for *Lutjanus analis*, however results offer indirect evidence that area closures where *L. analis* occurs during spawning months are correlated with an increase in numbers of this species during summer spawning months of subsequent years.

2.8 Movements and Migrations

Mutton snapper exhibit spatial separation of adult and juvenile members of the local population, and thus constitute a nursery species as defined by Beck et al. (2001). After a pelagic larval period of ca. 31 days, mutton snapper settle onto a suite of available habitats including, nearshore vegetated habitats such as seagrass beds < 10 m deep (Lindeman et al. 2000). Although data are limited, it is reasonable that mutton snapper undergo ontogenetic habitat shifts from shallow vegetated habitats to alternative structure including the reef tract in response to changing exposure to predation caused by increasing body size (e.g., Dahlgren and Eggleston 2000). Given that the number of individuals is expected to decline with size and age (i.e., the instantaneous mortality assumption of Ricker (1975)) supporting evidence comes from decreasing density of this species from seagrass beds, to mangroves, to coral reefs in the Netherland Antilles (Nagelkerken et al. 2000). However, *Lutjanus analis* is rarely observed within mangrove shorelines that are commonly used as secondary habitats for reef fishes such as members of the families Lutjanidae, suggesting perhaps hardbottom is used by this species as a secondary habitat (Serafy et al. 2003, Eggleston et al. 2004). The 1996 amendment to the Sustainable Fisheries Act requires fishery management plans to be amended to identify and describe essential fish habitat (EFH) for more than 700 federally managed fishery stocks (Schmitten 1999). The fishery management plan for the U.S. Caribbean summarized occurrence information for mutton snapper within various habitats during its ontogeny (Table 2.11). From this summary, two potential distribution bottlenecks can be identified; the distribution of larvae within the planktonic environment, and the distribution of spawning adults on coral reef and hardbottom habitats.

Little is documented regarding the seasonal migrations of mutton snapper along coastlines. Fishermen in Martin County (Atlantic Coast of Florida) note a spike in catch rates during the Fall (November) and Winter (February) that may be related to the latitudinal movement of fishes into the region (B. Hartig, B. Taylor pers. com). Perhaps the most significant movement patterns of mutton snapper occurs during the summer, when normally solitary individuals aggregate during days and weeks of travel time to specific locations that persist from days to two weeks throughout the Caribbean (Domeier and Colin 1997). In Florida, Lindeman et al. (2000) reported 22 locations identified by fishermen in the lower Keys that may serve as spawning aggregations for snapper; only three of which were particular to mutton snapper. Claro and Lindeman (2003) report nine snapper spawning locations in Cuba; four of which were used by mutton snapper. Although data on movement are limited, inference as to these migrations have been made from observations taken over almost 100 years. Fishermen in Key West noted that fish close to shore were caught year round with the exception of the summer months when this species undergoes migrations towards spawning sites (Schroeder 1924). More recently, Claro (1981) summarized the movement patterns of mutton snapper during the summer months in northwest Cuba. Fishes are depicted migrating from patch and reef crest habitats towards a specific point, the Corona de San Carlos for spawning, larvae are advected along shore, and then move shoreward for settlement in the surrounding embayment.

2.9 Meristics and Conversion Factors

A suite of length-length and length-weight conversions were calculated that facilitated comparisons between the data from other studies in the Caribbean and those reported here. Conversions incorporated a large range of possible values and were statistically significant (Table 2.12). Here we have added one length-length relationship; total length (relaxed) to/from total length (maximum). This relationship is provided to meet needs that may arise from new measurement rules set forth by the State of Florida whereby fishes are measured to maximum total length by extending the dorsal edge of the caudal fin to its horizontal (maximum) extension. Also, the total length (relaxed) from total length (max) relationship may be helpful in converting total lengths observed in visual (dive) surveys to their corresponding equivalents in total length (max).

2.10 Comments on the Adequacy of Data for Assessment Analyses

Ample data were gathered and analyzed for this portion of SEDAR 15a to support decisions regarding the status of the stock. We feel confident that the assessments of age and growth presented here represent the best data available. Ample data are available to confidently place boundaries on the spawning season and timing of spawning during the lunar period. Data on size and age at maturity was examined for the Florida population for the first time, and substantial differences were revealed between these estimates and the Caribbean. These differences could be due to differences in biology between populations or time periods rather than in the quality of data sources, but additional analyses are needed to adjust for methodological differences . However, histological samples of reproductively active (gonad maturity stage 4 and 5) fish remain rare, representing grounds for data improvement including fecundity. Estimates of mortality are based on the best methods and data available, however release mortality data on *L. analis* are relatively rare compared to other members of the family Lutjanidae.

2.11 Research Recommendations

The biology of *Lutjanus analis* during reproduction remains perhaps the greatest unknown in the life-history of this species. Despite its relatively large body size, exploited status, and gregarious nature during reproduction, the behaviors, location, and sources of individuals of spawning aggregations in Florida and the greater Caribbean remains elusive. Seasonal migration patterns are completely unknown and based on speculation. Primary habitats used by this species during various stages of its ontogeny are undefined. This information would reveal the dependence of the Florida population on various habitats and locations, e.g., a given spawning location; critical information since models have revealed that contributions to the Florida population of *L. analis* in the form of larvae from outside southern sources is minimal (Paris et al. 2005), and that the Florida population is biologically “on its own”. Because of the aforementioned difficulties and differences in staging criteria, we recommend further review of the maturity data from Tequesta and the Florida Keys, and Puerto Rico before accepting the size- and age- at-maturity values from the regressions reported here.

2.12 Itemized list of tasks for completion following workshop

Growth:
Models to describe length at age have been run and an error corrected by Craig Faunce, Joe O’Hop and Walter Ingram on April 24th. The number of otoliths used in the most recent growth model is 4056, however over 7000 otoliths have been aged (J. Tunnell). This gross discrepancy between the number of aged otoliths and those used in the model resulted from a mismatch in size and age data with collection information from samples obtained from NOAA Panama City. Correction of this data, in particular those fish older than 32 years is needed.

- **Janet Tunnell and Joe O’Hop have been tasked with correcting the data.**

Mortality:
Discussions with Bob Muller indicate that the choice of either a static or dynamic discard mortality rate will depend upon having adequate catch vs. depth information for mutton snapper.

- **These data are needed from Beverly Sauls**.

Age structure:

Age-structure of the mutton snapper population is completed and there are no immediate data needs.

- **Joe O'Hop is to provide data to Bob Muller for final estimation of natural mortality.**

Reporting:
Efforts are underway on two white papers; mortality of mutton snapper (Craig Faunce) and ageing methods and precision (Janet Tunnell). These papers are being written to streamline the final life-history section for the final SEDAR 15 report.

2.13 Literature Cited

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2.14 Tables

Table 2.1. Summary of data sets used in SEDAR 15a.

Parameter	Dependent Sampling*	M. Burton (2002)	FWRI Tequesta**	FWRI Keys**
Data type relative to fishery	dependent	dependent and independent	independent	independent
Duration	1979-2006	1992-2000	1998-2002	1998-2002
Chevron traps			x	
Hook and Line	x	x	x	x
Spearfishing	x	x	x	x
Port sampling	x	x	x	x
Otoliths	x	x	x	x
GSI		x	x	x
GMS			x	x
Fecundity			x	x

*NMFS Trip Interview Program, NMFS Southeast Head Boat Survey, and Fisheries Information Network (FIN) Biological Sampling
**Independent Study

Table 2.2. Observed age-frequency data for *Lutjanus analis*.

	N				
Age	FWRI St. Petersburg*	M. Burton	FWRI Tequesta Independent Study	FWRI Keys Independent Study	TOTAL
0	4		107		111
1	11	7	49	5	72
2	315	143	67	81	606
3	1346	326	245	98	2015
4	1147	295	91	54	1587
5	587	247	34	34	902
6	352	145	12	22	531
7	272	105	7	10	394
8	162	67	7	7	243
9	90	32	1	2	125
10	55	13	2	2	72
11	65	9		2	76
12	42	7			49
13	32	2			34
14	34	3		1	38
15	30	1		1	32
16	31	1			32
17	26	4		1	31
18	24				24
19	24				24
20	24				24
21	18	1			19
22	16				16
23	7	1			8
24	10	1			11
25	11	1			12
26	11				11
27	12				12
28	9				9
29	6	1			7
30	3				3
31	9	1			10
32	4				4
33	7				7
34	8				8
35	3				3
36	3				3
37	2				2
38	1				1
39	2				2
40	3				3
TOTAL	4818	1413	622	320	7173

* includes otoliths aged at FWRI and contributed from multiple sources, including NMFS Panama City Laboratory, FWRI, NMFS Beaufort Laboratory, NMFS Cooperative Research studies, and others.

Table 2.3. Age-specific natural mortality rates for *Lutjanus analis* following Lorenzen (2005) using the age and growth parameters in Table 4 and the mortality at t_{max} of 0.11 (Faunce et al. 2007). Total length (TL_{max}, tail compressed) is equivalent to the expected size at age from growth estimates.

Age	Length ($TL_{max,}$ mm)	M
0	166	0.399
1	271	0.273
2	360	0.216
3	436	0.184
4	501	0.163
5	556	0.148
6	603	0.138
7	643	0.130
8	677	0.124
9	706	0.120
10	731	0.116
11	752	0.113
12	770	0.111
13	786	0.109
14	799	0.107
15	810	0.106
16	819	0.105
17	827	0.104
18	834	0.103
19	840	0.102
20	845	0.102
21	849	0.101
22	853	0.101
23	856	0.100
24	859	0.100
25	861	0.100
26	863	0.100
27	865	0.099
28	866	0.099
29	867	0.099
30	868	0.099
31	869	0.099
32	870	0.099
33	870	0.099
34	871	0.099
35	871	0.099
36	872	0.099
37	872	0.099
38	872	0.099
39	873	0.099
40	873	0.099

Table 2.4. Discard mortality information from literature and SEDAR 7 sources. Depth bin 1 = < 30 m, depth bin 2 = > 30 m depth.

Source	Species	Mean depth(m)	30m depth bins	Average M*
CSA				
Wilson and Burns, 1996[1]	*E. morio* and *M. phenax*	22.0	1	7.0
Wilson and Burns, 1996[2]	*E. morio* and *M. phenax*	59.5	2	67.0
St. John and Syers, 2005[3]	*Glaucosoma hebraicum*	7.0	1	21.0
St. John and Syers, 2005[4]	*Glaucosoma hebraicum*	52.0	2	86.0
Broadhurst et al., 2005[5]	*Pagrus auratus*	.	1	18.0
Wilson et al., 2005[6]	*Lutjanus campechanus*	46.0	2	69.0
SEDAR 7				
Parker, 1985	*Lutjanus campechanus*	22.0	1	21.0
Parker, 1985	*Lutjanus campechanus*	30.0	1	11.0
Gitschlag and Renaud, 1994[7]	*Lutjanus campechanus*	22.5	1	1.0
Gitschlag and Renaud, 1994[8]	*Lutjanus campechanus*	28.5	1	10.0
Gitschlag and Renaud, 1994[9]	*Lutjanus campechanus*	38.5	2	44.0
Render and Wilson, 1994	*Lutjanus campechanus*	21.0	1	20.0
Patterson et al., 2002	*Lutjanus campechanus*	21.0	1	9.0
Patterson et al., 2002	*Lutjanus campechanus*	27.0	1	14.0
Patterson et al., 2002	*Lutjanus campechanus*	32.0	1	18.0
Diamond et at., 2004[10]	*Lutjanus campechanus*	30.0	2	53.0
Diamond et at., 2004[11]	*Lutjanus campechanus*	40.0	2	71.0
Diamond et at., 2004[12]	*Lutjanus campechanus*	50.0	2	69.0
Wilson and Nieland, 2004[13]	*Lutjanus campechanus*	60.0	2	69.5

* estimated from mid-point in range of mortality estimates

(1) In-situ study 0-14% < 44 m
(2) In-situ study on depth and mortality 67% >44m
(3) Demersal reef fish hook catch and release condition 0-14 m
(4) Demersal reef fish hook catch and release condition 45-59 m
(5) Estuarine hook and line tournament
(6) Commercial Multi-hook gear -9 -85m (ave. = 46m)
(7) 21-24m -for fish <32 cm
(8) 27-30m – for fish <32 cm
(9) 37-40m – for fish <32 cm
(10) 30m - oil platform study (Texas)
(11) 40m - oil platform study (Texas)
(12) 50m - oil platform study (Texas)
(13) Commercial 30-90m

Table 2.5. 2005-06 At-sea head boat observer data for mutton snapper, *Lutjanus analis*; release conditions from east (EFL) and west (WFL) Florida.

		Release Condition					
Region	Median Depth	Good	Fair	Poor	Dead	Total	Proportion*
EFL	<60'	2	1	1		4	0.50
	>60'	50	10	13	3	76	0.38
WFL	<60'	37	1			38	0.03
	>60'	14	2	2		18	0.22

*assumes all fishes not in good condition suffer complete mortality following a precautionary approach.

Table 2.6. Observed age at length data for *Lutjanus analis* a) Females b) Males c) All data combined

a)

Females n = 1615				
Age	n	Mean TL_{max} (mm)	S.D.	Range (mm)
0	20	205	77.5	116-478
1	12	289	50.3	223-390
2	175	397	40.1	227-509
3	591	438	38.0	318-580
4	424	493	49.4	396-655
5	193	563	61.9	382-727
6	86	634	63.3	424-770
7	38	674	52.6	569-802
8	27	696	64.1	572-815
9	11	724	68.0	554-806
10	8	723	72.7	600-838
11	4	757	47.0	700-801
12	6	724	70.5	613-808
13	2	683	38.5	656-711
14	4	779	104.4	639-877
15	4	822	37.0	770-851
16	1	806		806
17	3	801	77.9	721-877
18	0			
19	1	690		690
20	2	729	86.9	667-790
21	0			
22	0			
23	2	738	3.1	736-740
24	0			
25	1	750		750

b)

Males n = 2006				
Age	n	Mean TL_{max} (mm)	S.D.	Range (mm)
0	10	232	31	195-281
1	22	299	58.5	210-409
2	211	400	41.5	279-562
3	755	439	44.0	231-672
4	517	496	48.3	360-654
5	280	565	62.0	405-730
6	105	628	63.9	420-754
7	47	661	72.5	463-774
8	18	677	92.9	399-810
9	9	699	51.4	609-782
10	3	729	72.2	646-779
11	6	736	78.6	629-860
12	3	757	59.4	689-798
13	0			
14	1	835		835
15	4	695	88.5	569-776
16	1	714		714
17	1	827		827
18	3	756	51.7	705-808
19	2	785	103.5	712-858
20	3	753	80.9	663-819
21	1	754		754
22	0			
23	0			
24	0			
25	1	667		667
26	1	835		835
27	1	800		800
28	0			
29	0			
30	0			
31	1	848		848

Table 2.6. Continued.

c)

All	n = 7173								
Age	n	Mean TL_{max} (mm)	S.D.	Range (mm)	Age	n	Mean TL_{max} (mm)	S.D.	Range (mm)
0	111	161	53.2	105-478	21	19	870	45.4	754-964
1	72	259	83.9	99-409	22	16	863	55.4	716-939
2	606	399	39.3	191-562	23	8	787	74.8	645-868
3	2015	438	40.9	231-672	24	11	845	40.1	795-915
4	1587	495	52.7	310-705	25	12	838	84.0	667-944
5	902	565	64.0	281-808	26	11	865	37.6	810-912
6	531	629	68.0	400-947	27	12	850	47.0	749-901
7	394	671	67.3	463-857	28	9	873	49.0	790-950
8	243	695	72.3	399-852	29	7	865	33.3	832-950
9	125	727	77.3	513-923	30	3	897	60.6	828-936
10	72	751	75.7	593-901	31	10	873	37.7	812-923
11	76	773	71.6	540-904	32	4	843	54.3	770-901
12	49	788	73.5	613-904	33	7	851	41.1	792-896
13	34	813	59.5	646-890	34	8	863	18.2	836-882
14	38	820	59.7	639-939	35	3	841	16.5	822-852
15	32	810	76.1	569-942	36	3	861	57.6	799-912
16	32	824	84.5	601-958	37	2	867	13.5	857-876
17	31	824	71.7	596-917	38	1	876		876
18	24	831	57.0	705-905	39	2	840	1.9	838-841
19	24	850	67.5	690-953	40	3	832	26.8	804-857
20	24	829	77.3	663-947					

Table 2.7. Nonlinear likelihood summary of von Bertalanffy (1938) growth parameter estimates.

Parameter	Estimate	Standard Error	P value
L_{∞} (TLmax, mm)	874.44	5.26	<0.0001
K	0.16	0.002	<0.0001
t_0	-1.32	0.024	<0.0001
CV	0.112	0.0009	<0.0001

Table 2.8. Compilation of von Bertalanffy (1938) growth equation estimates for *Lutjanus analis*.

	$-t_0$	**K**	**L_∞ (mm)**	**Obs. max. TL**	**Ages**	**Location**	**Method**	**n**	**MMMI***	**Source**
1a ♀♂	0.94	0.16	869	880	1-17,21, 23,29	FL Atlantic Coast	Otoliths – MIA**, TL	1395	May	Burton, 2002
1b ♂	0.94	0.17	860	834		FL Atlantic Coast	Otoliths – MIA, TL	339		Burton, 2002
1c ♀	1.41	0.14	929	902		FL Atlantic Coast	Otoliths – MIA, TL	272		Burton, 2002
2	0.58	0.153	862	860	1-14	FL Atlantic Coast	Otoliths – MIA, TL	1005	Mar-May	Mason & Manooch, 1985
3	0.62	0.17	1,028		1-8	Margarita Island, Venezuela	urohyral bones-MIA, FL	266	Nov	Palazon & Gonzalez, 1986
4	1.42	0.116	807.5		1-9	NE Cuban shelf	urohyral bones-MIA, FL	2587	Jan	Pozo, 1979
5a	0.35	0.15	880		1-9	SW Cuba	FL		May	Claro, 1981
5b	0.43	0.1	1,170		1-8	NW Cuba	FL		May	Claro, 1981
6				642		Jamaica	FL			Thompson & Munro, 1974
7	1.32	0.16	874	964	0-40	FL Atlantic Coast	Otoliths – MIA, TLmax	7172	June	SEDAR 15A (This study)

* MMMI=Month of Minimum Marginal Increment.
** MIA=Marginal Increment Analysis; TL=Total Length; TLmax=TL (tail compressed to maximum length); FL=Fork Length

Table 2.9. Histological staging criteria used in this study for determining the maturity stage of female specimens of *Lutjanus analis*.

Stage	Maturity description	Description
1 - Immature	Immature	Only primary growth oocytes present; no atresia; ovarian membrane thin; ovarian membrane should be free of any large folds (indicative of stretching due to previous spawning.
2 - Developing	Mature	Only primary growth, cortical alveoli and a few partially yolked oocytes may be present; there may be minor atresia
3- Fully developed / Partially spent / Redeveloping	Mature	Primary growth to advanced yolked oocytes present; may have some left over hydrated oocytes and POFs from previous spawning; might have atresia of advanced yolked oocytes, but no major atresia (only minor/moderate) of other oocytes
4 – Final oocyte maturation (FOM) / Hydrated	Mature	Primary growth to FOM/hydrated oocytes present; may have minor/moderate atresia of advanced yolked oocytes; germinal vessel migration (beginning of FOM); hydrated oocytes unovulated.
5 – Running ripe	Mature	Primary growth to ovulated, hydrated oocytes present; often minor/moderate atresia of advanced yolked oocytes; occasionally only hydrated and primary growth oocytes present; most of the hydrated oocytes will be concentrated in the lumen, giving the ovary cross-section the appearance of a jelly donut.
6 - Regressing	Mature	Primary growth and cortical alveoli oocytes present; yolked oocytes being resorbed; major atresia; may be remnant hydrated oocytes or degenerating POFs.
7 – Resting or Regenerating	Mature	Most oocytes (>90%) are primary growth; may have other oocytes in late stages of atresia; more follicular tissues than immature fish; presence of large folds on the ovarian membrane (indicative of stretching due to previous spawning).

Table 2.10. Logistic model fits for maturity related to (a) size and (b) age for *Lutjanus analis* during the peak spawning months of April-June residing in Florida. SE=standard error, SS=sum of squares for model F-tests.

A) Size

Parameter	Estimate	SE	
R	0.056	0.010	
L_{50} (TLmax, mm)	353.5	3.43	
Variance Source	DF	SS	P
Model	2	136.8	<0.001
Error	180	6.23	

B) Age

Parameter	Estimate	SE	
R	3.682	0.831	
A_{50} (Years)	2.072	0.054	
Variance Source	DF	SS	P
Model	2	126.1	<0.001
Error	168	6.87	

Table 2.11. Summary of occurrence and abundance patterns within various marine habitats for life-history stages of *Lutjanus analis* within the Caribbean (Table adapted from Essential Fish Habitat Generic Amendment to the Fishery Management Plans of the U.S. Caribbean Including a Draft Environmental Assessment. October 1998 accessed via the worldwide web). Table demonstrates population distribution bottlenecks during spawning until settlement.

	Life History Phase				
Habitat	Eggs	Larvae	Juvenile	Adult	Spawners
Planktonic	Present	Present			
Mangroves			Present	Present	
Seagrass			Present	Present	
Algae			Present	Present	Occasional
Plain			Present	Present	Present
Reef			Present	Present	Present
Reef/SAV interface			Present	Present	Occasional
Sand			Present	Present	Occasional
Hardbottom			Present	Present	Present
Mud			Occasional		Occasional

Table 2.12. Length-length (mm) and Length-weight relationships developed for Florida *Lutjanus analis*. Regressions are in the form Y = *a* + *b*X. SL: standard length (mm); FL: fork length (mm); TL: total length (mm); TW: total weight (kg), GW: gutted weight (kg).

LENGTH-LENGTH

Source	Y (mm)	*a*	*b*	X (mm)	*n*	Min X (mm)	Max X (mm)	Avg. X* (mm)	MSE*	Adj. r^2	Σx^2*	Σxy*	Σy^2*
SEDAR 15a	SL	-13.531	0.882	FL	1031	195	784	428.20	30.263	0.99	8578038.63	7567047.22	6706349.82
	$TL_{relaxed}$**	10.015	1.065	FL	1511	195	784	428.23	99.463	0.99	11062316.23	11777983.29	12690039.76
	TL_{max}***	28.956	1.222	SL	969	163	680	365.68	65.511	0.99	6600011.90	8068471.07	9927001.96
	TL_{max}	8.804	1.087	FL	951	195	768	428.40	16.165	0.99	7958892.75	8655554.36	9428537.15
	TL_{max}	6.179	1.015	$TL_{relaxed}$	957	208	831	462.02	37.030	0.99	9244272.70	9387564.91	9568442.07
Burton 2002	TL	8.91	1.08	FL	249					0.99			
	TL	20.53	1.21	SL	285					0.99			
Thompson and Munro (1983)	SL	-2.0	0.85	FL			220	450					
	TL	7.0	1.09	FL			220	450					

LENGTH-WEIGHT

Source	Ln (Y [kg])	Ln(a)	b	Ln (X[mm])	*n*	Min [mm]	Max [mm]	Avg. Ln(X [mm])	MSE	Adj. r^2	Σx^2	Σxy	Σy^2
SEDAR 15a	TW	-16.5739	2.8670	SL	492	209	680	5.9037	0.01094	0.97	18.1573	52.0576	154.6092
	TW	-18.0306	3.0275	FL	3232	215	829	6.0832	0.01642	0.96	132.2398	400.3635	1265.1756
	TW	-18.3791	3.0402	$TL_{relaxed}$	945	261	851	6.1438	0.02287	0.92	26.7678	81.3787	268.9721
	TW	-18.6469	3.0789	TL_{max}	459	270	858	6.1749	0.00645	0.98	15.3513	47.2642	148.4668
	GW	-18.1915	3.0487	FL	1101	270	877.5	6.4105	0.00597	0.99	56.3955	171.9311	530.7154
Burton 2002	TW	-18.42	3.05	TL	413	~300	~875			0.96			
	TW	-17.93	3.08	SL	282	~160	~710			0.98			
Bohnsack and Harper (1988)	TW	-4.8030	3.0112	FL	365	116	722			0.97			
Watanabe (2001)	TW	-18.4207	3.0499	TL									

*Avg. X, MSE, Σx^2, Σxy, Σy^2 - Mean of independent variable (X), mean square error and corrected sums of squares (CSS) for the independent variable (X), corrected sum of cross-products for XY, and CSS for the dependent variable (Y); used for generating prediction intervals and for analysis of covariance (Zar 1996), and MSE also used for bias corrections for the means of log-transformed data [e.g., Haddon (2001)]. Usually, lengths were measured to the nearest centimeter, and weight to the nearest 0.02 kg. However, some data may have been taken using length measurements to the nearest 0.5 cm or in fractions of inches and weight measurements to the nearest 0.1 or 0.01 pound. Estimates derived from the above equations should be rounded to the nearest centimeter and nearest 0.02 kg. The number of decimal places shown in the table were meant solely to reduce rounding errors for calculations of the prediction intervals and for generating sums of squares and cross-products needed for analysis of covariance.

$TL_{relaxed}$** - Tail flat, in its natural state

TL_{max}*** - Tail compressed to its maximum length

2.15 Figures

Figure 2.1. Proportion of *Lutjanus analis* captured by the recreational (pink line, squares) and commercial (blue line, diamonds) sectors.

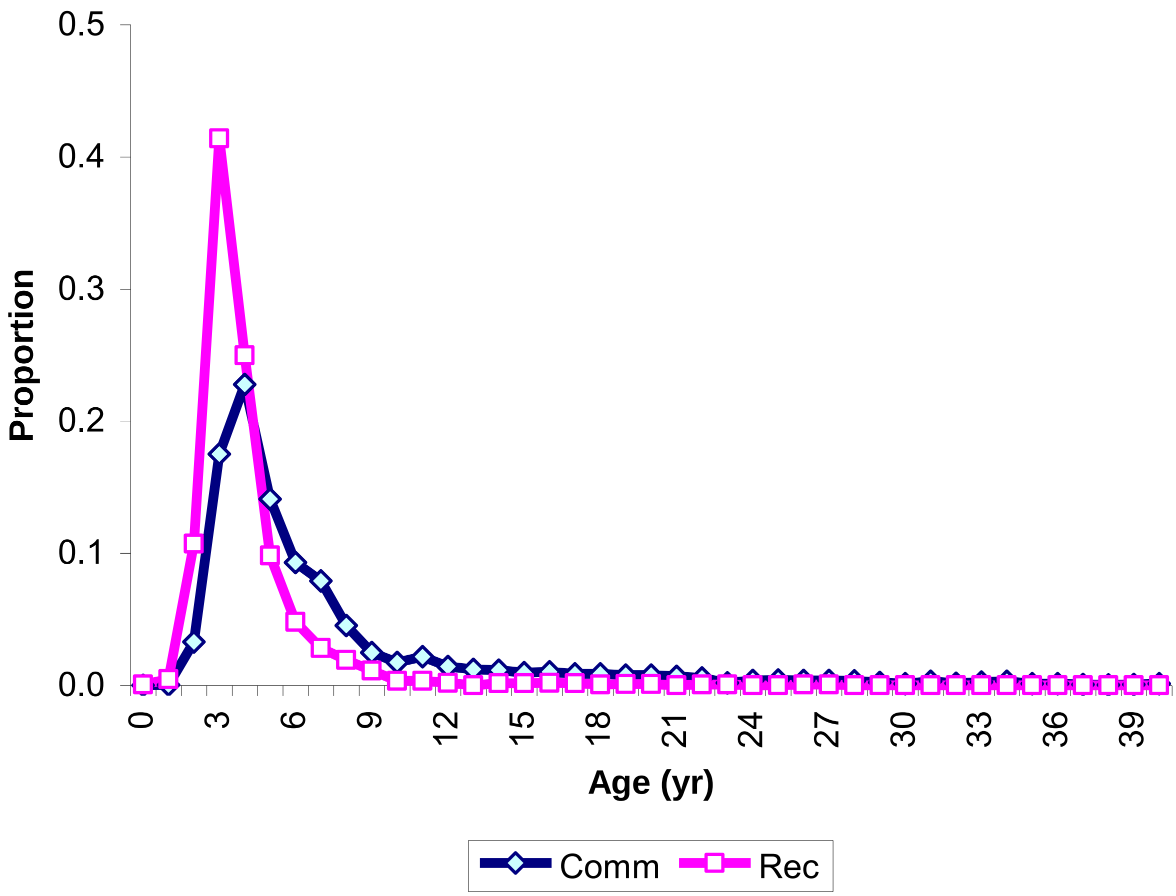


Figure 2.2. Cumulative distribution of *Lutjanus analis* catch by the recreational and commercial fishery sectors.

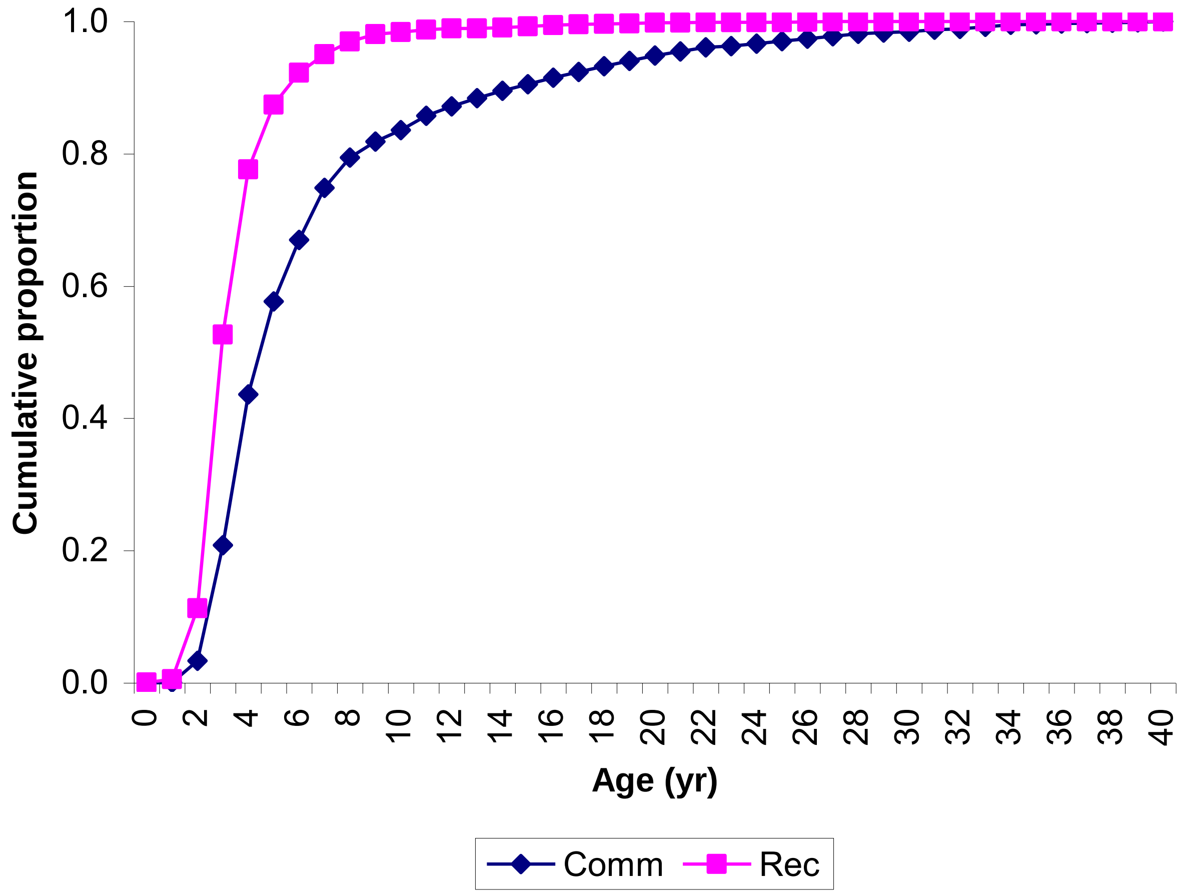


Figure 2.3. Age-specific natural mortality rates for *Lutjanus analis*.

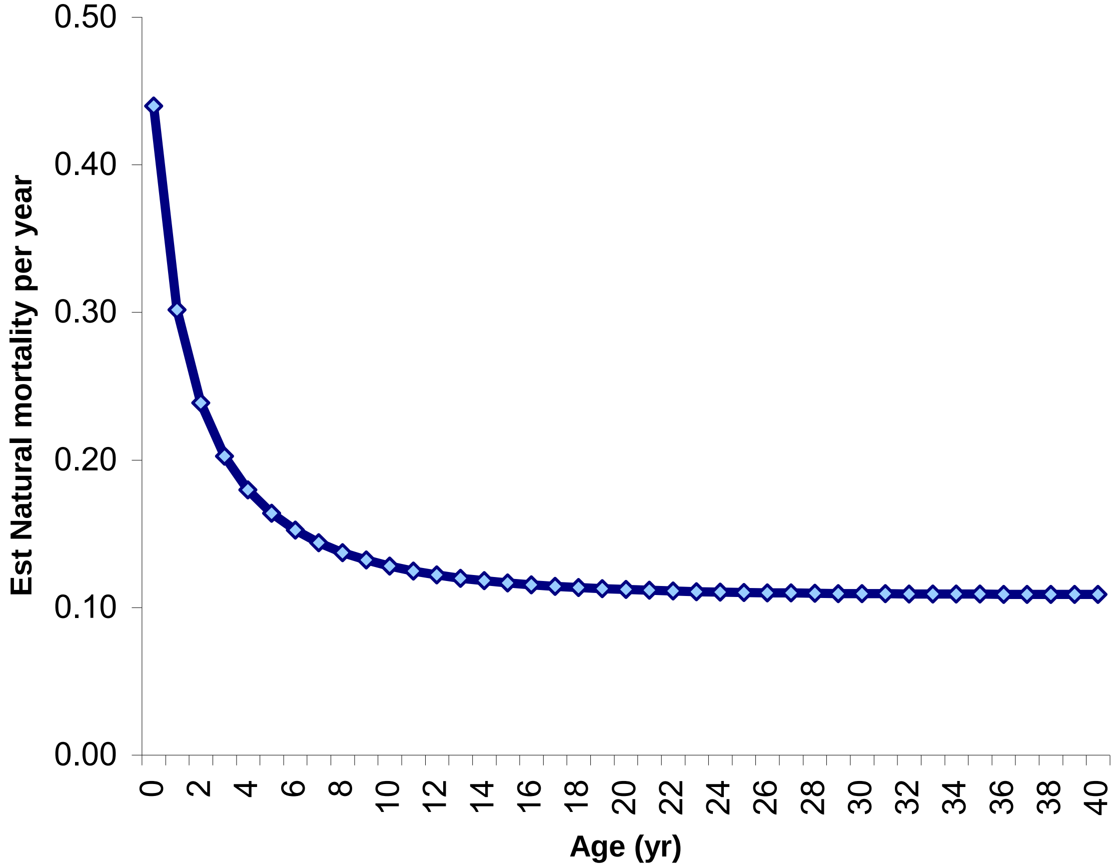


Figure 2.4. Satellite image and color enhancement of Florida bathymetry illustrating the preponderance of red and orange (depths less than 30 m) on the majority of the Florida shelf. Image courtesy of Google earth, while layer produced by USGS.

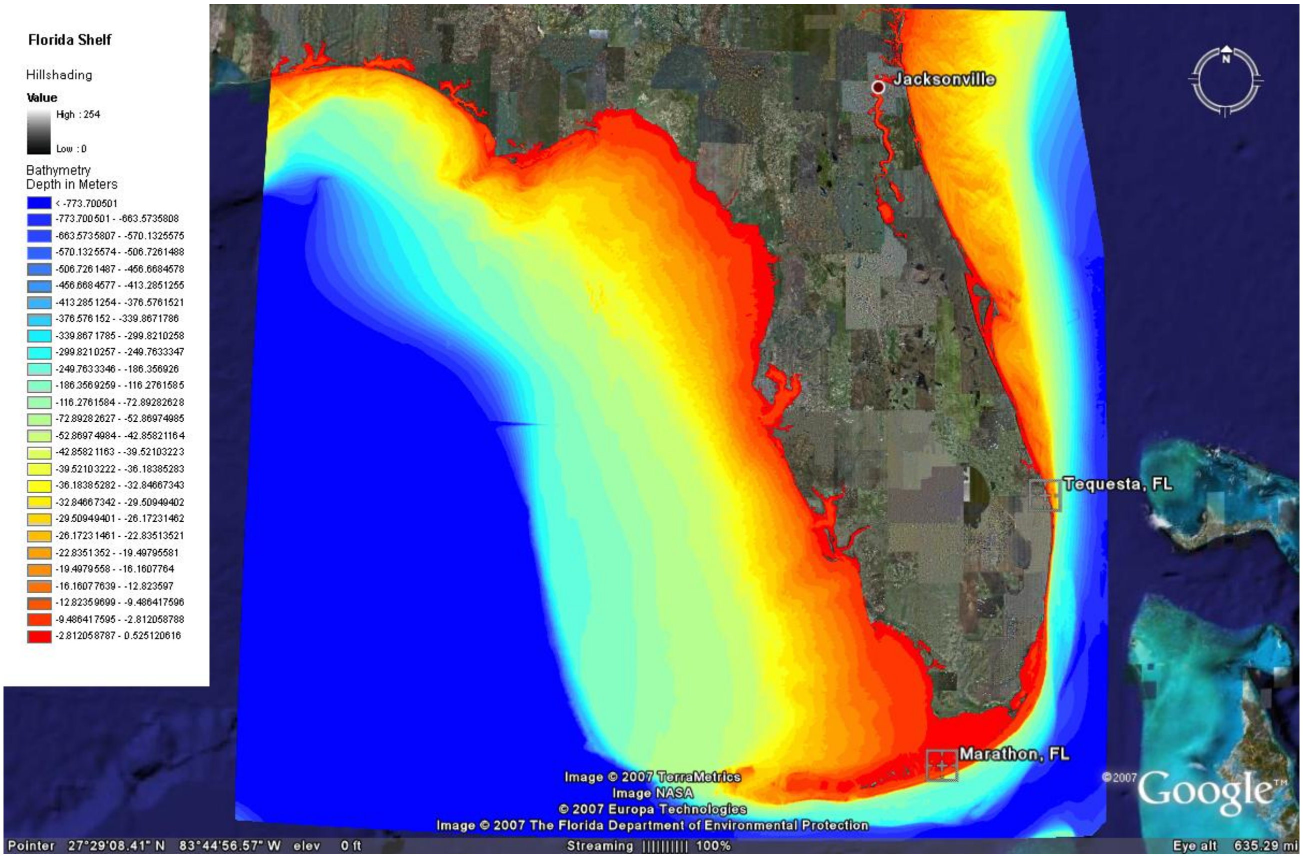


Figure 2.5. Discard mortality rates for two depth classes; <30m = depth class 1, and > 30 m = depth class 2.

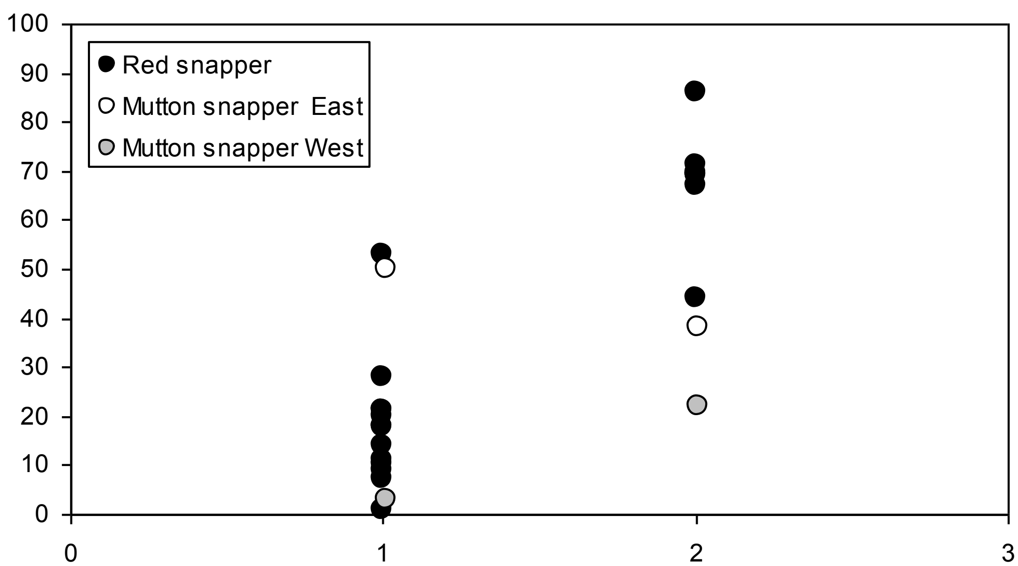
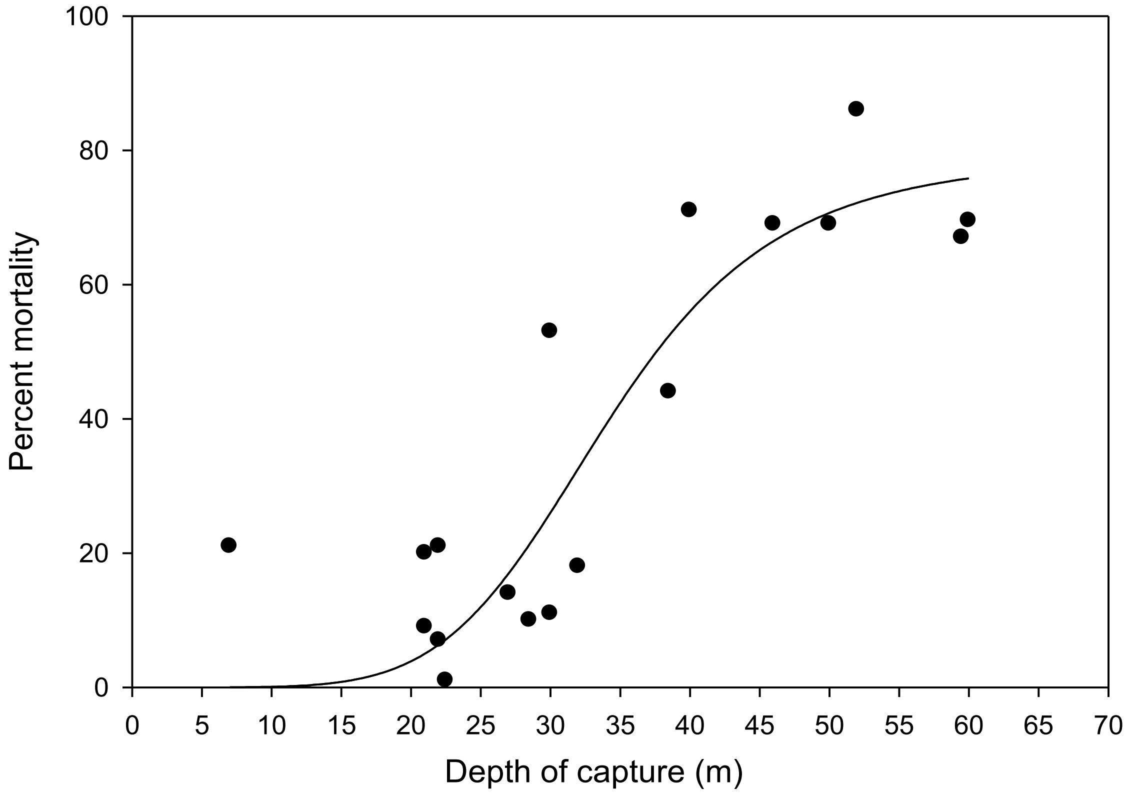


Figure 2.6. Discard mortality as a function of depth of capture (top figure) and associated residuals with fitted logistic curve (bottom).



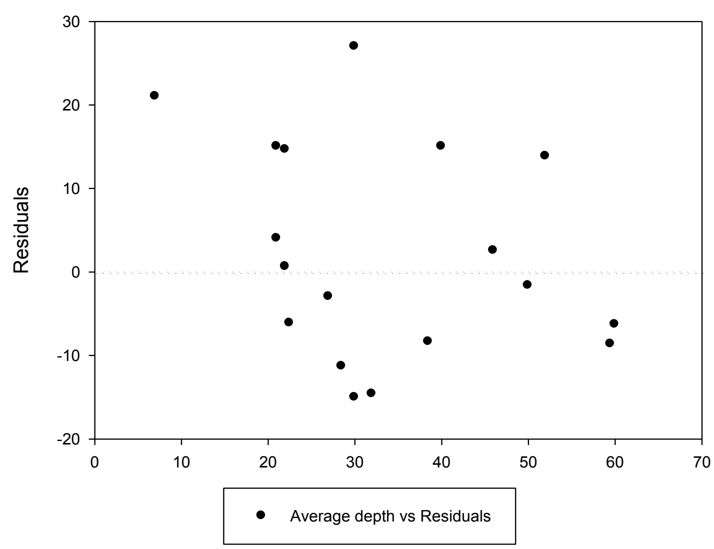


Figure 2.7. Percent frequency of edge type by month for the calibration set of *Lutjanus analis* otoliths.

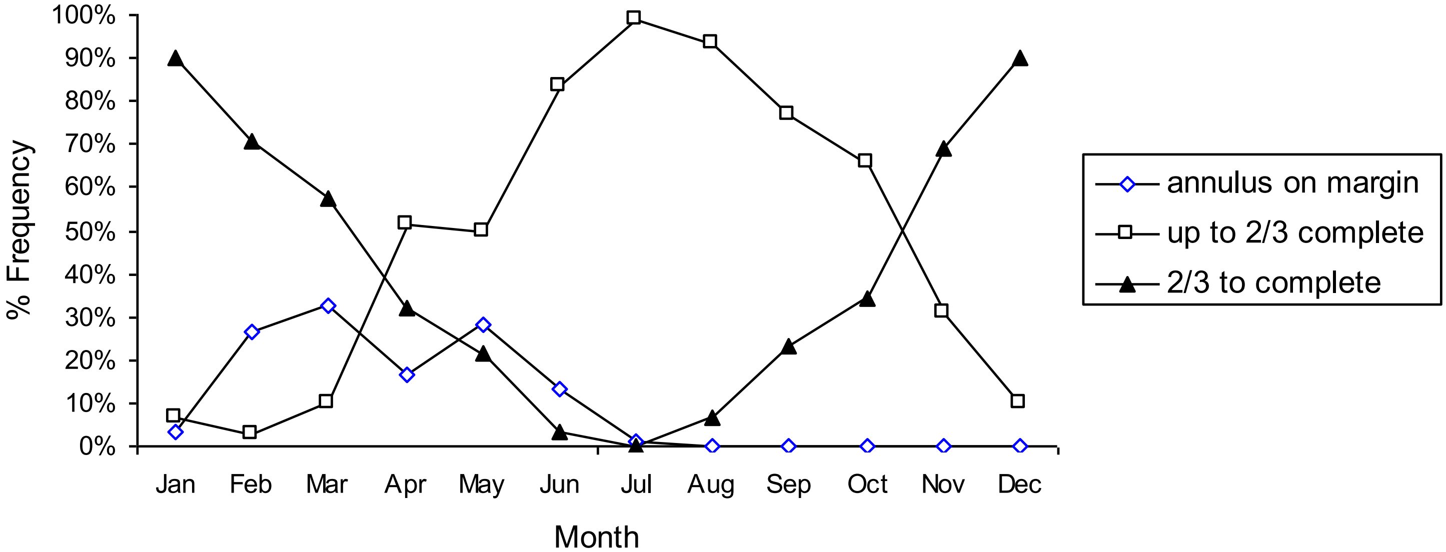


Figure 2.8. Age frequency (proportion) for *Lutjanus analis* by project.

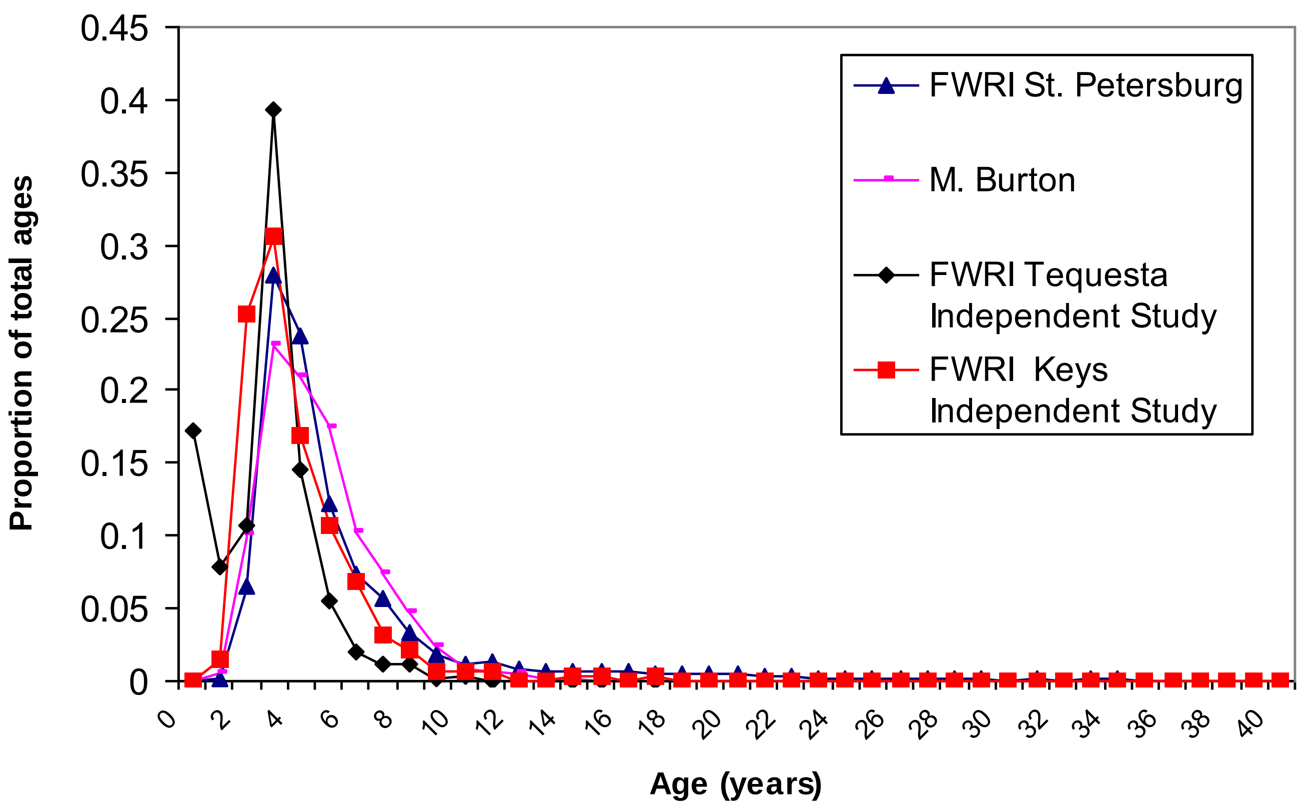


Figure 2.9. Cumulative percent age frequency of *Lutjanus analis*.

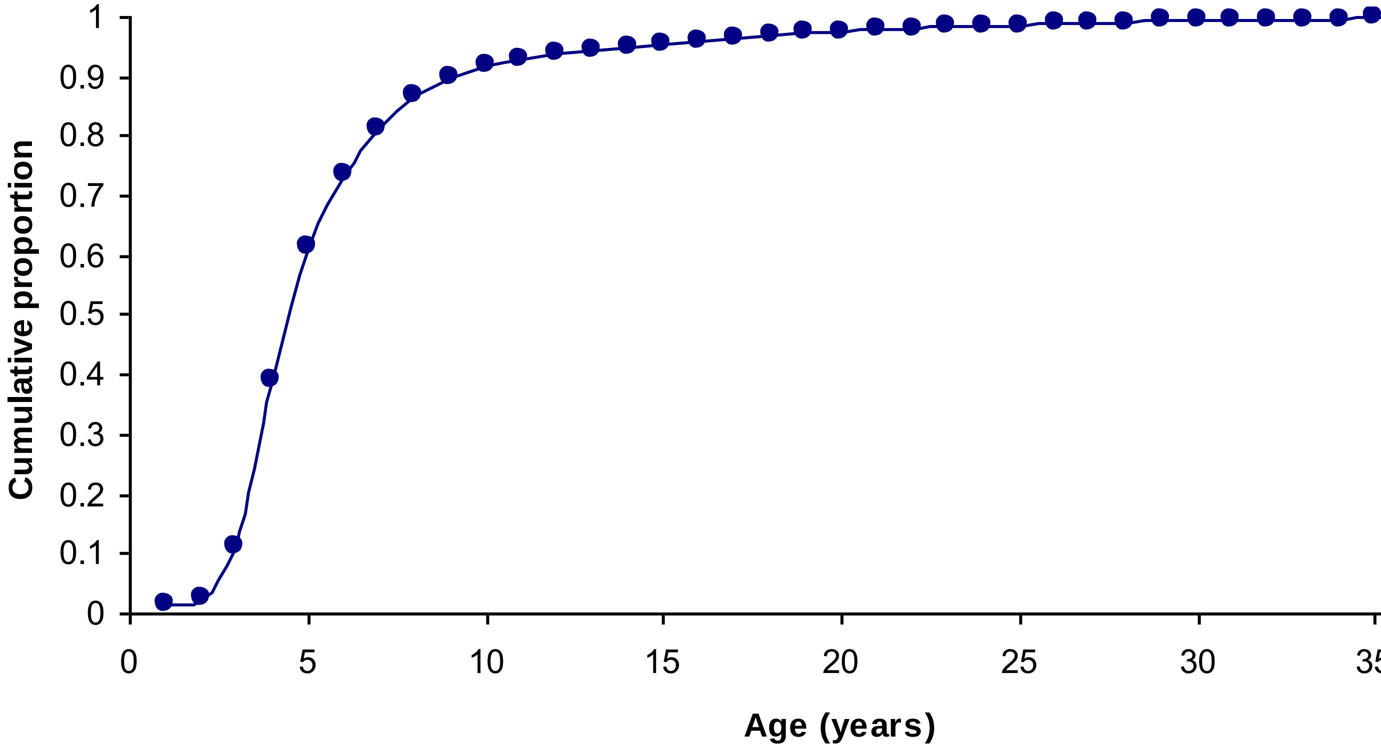


Figure 2.10. Total length (TL_{max}, mm) at age and estimated size at age from von Bertalanffy (1938) growth function of the current study.

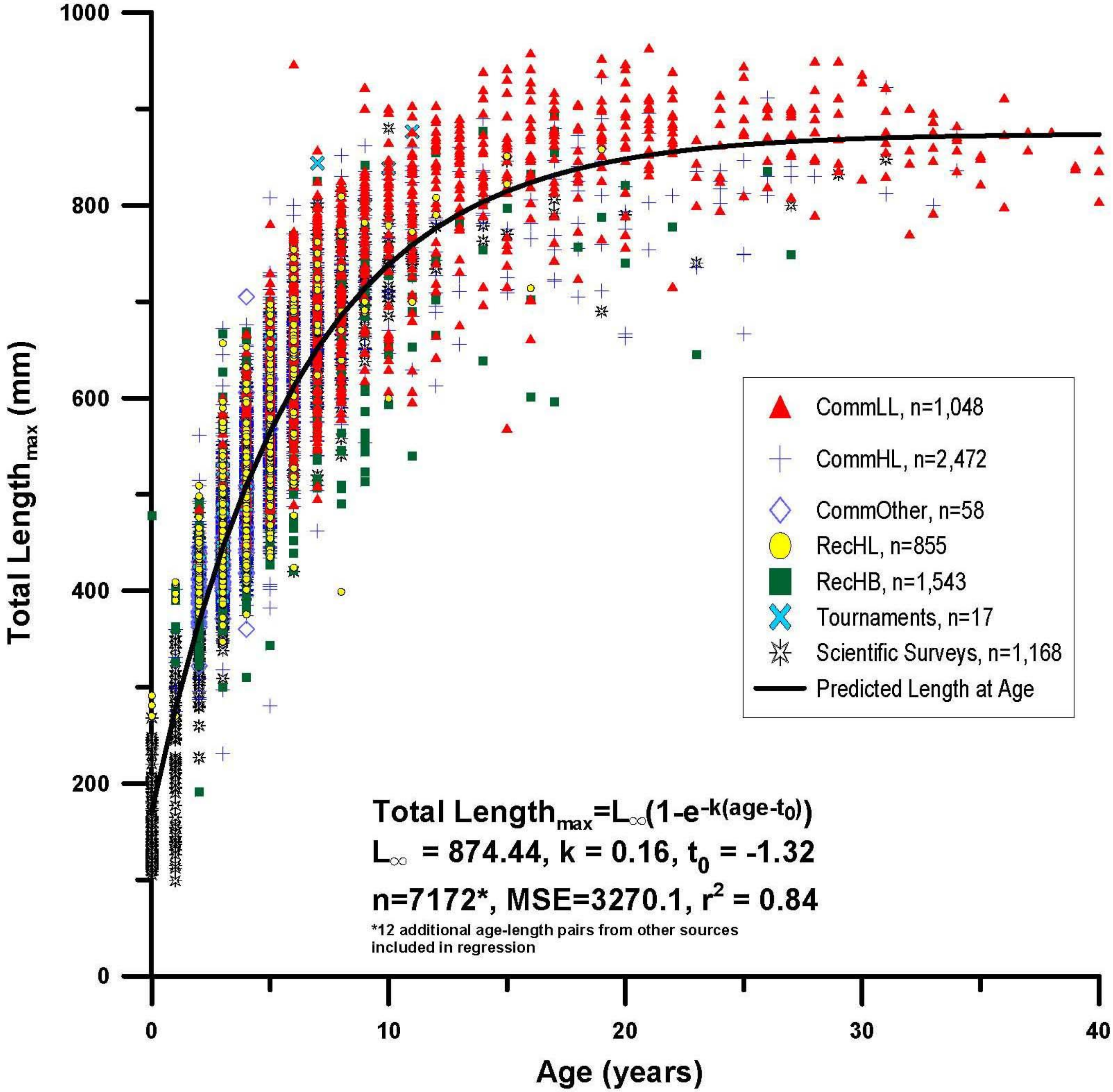


Figure 2.11. Female gonadosomatic index of *Lutjanus analis* (average ± 1 standard error) from two data sources. Horizontal lines indicate yearly averages. Reproductive seasonality is inferred during months of elevated GSI values.

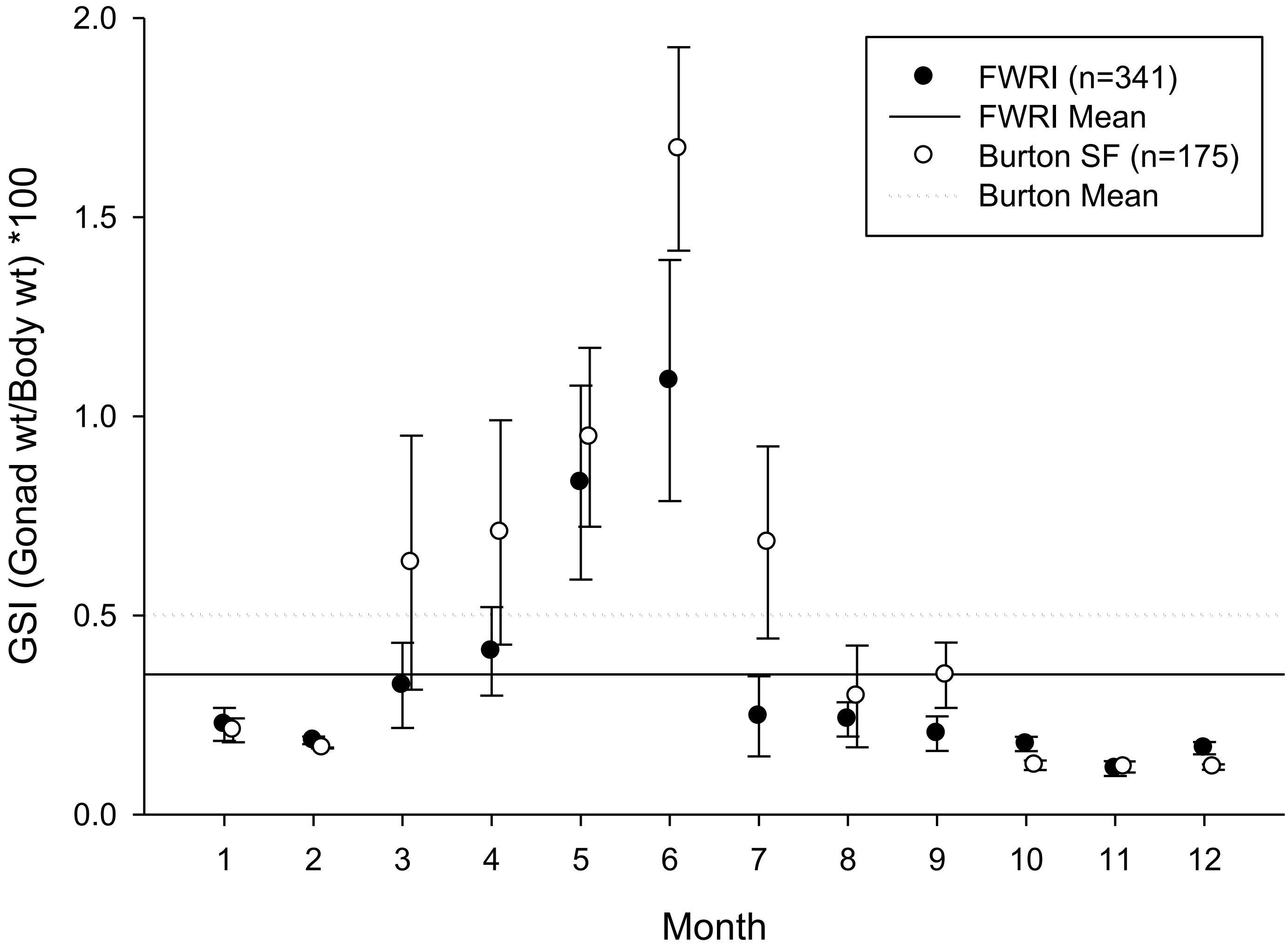


Figure 2.12. Gonad maturity stages for female *Lutjanus analis* observed as a proportion of all females from the two FWC laboratories during each month of the year. Stages: 2=developing, 3=vitellogenic oocytes dominate; 4=gravid (hydrated oocytes present); 6=regressing, 7=resting.

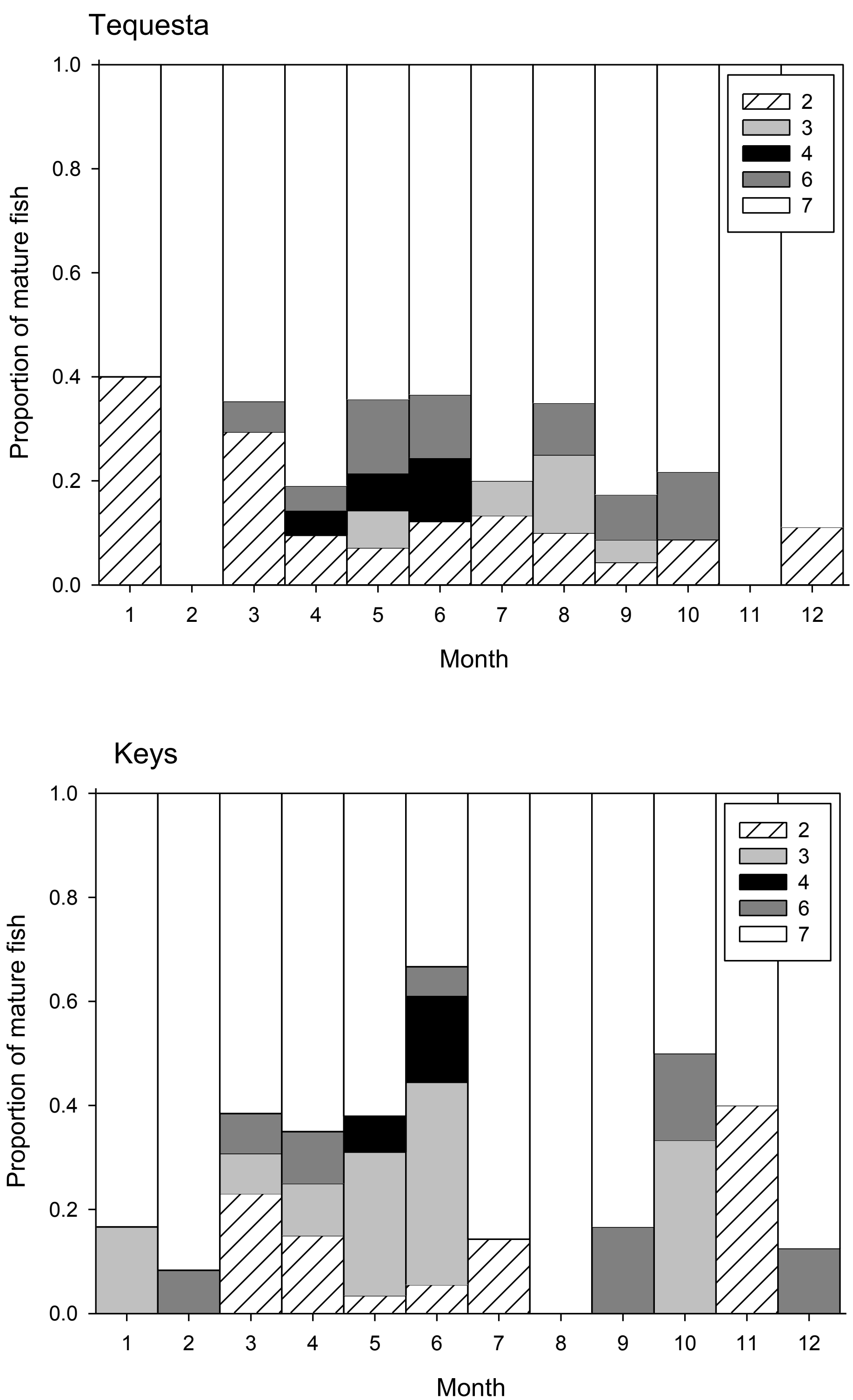
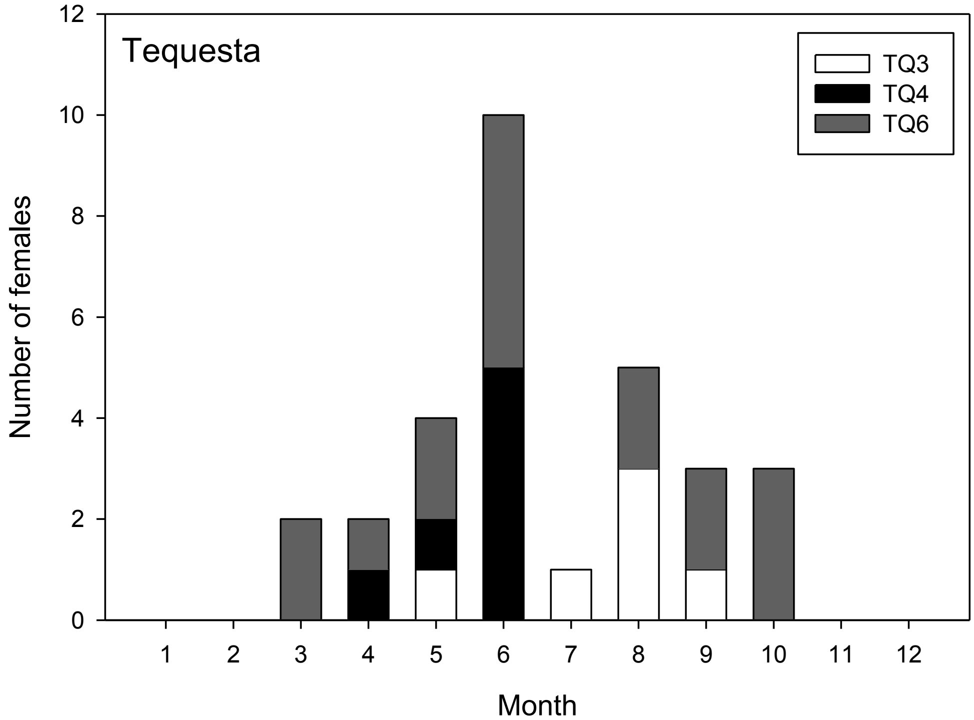


Figure 2.13. Gonad maturity stages 3-6 of female *Lutjanus analis* collected in Florida waters. Gonad maturity stages follow Figure 6.



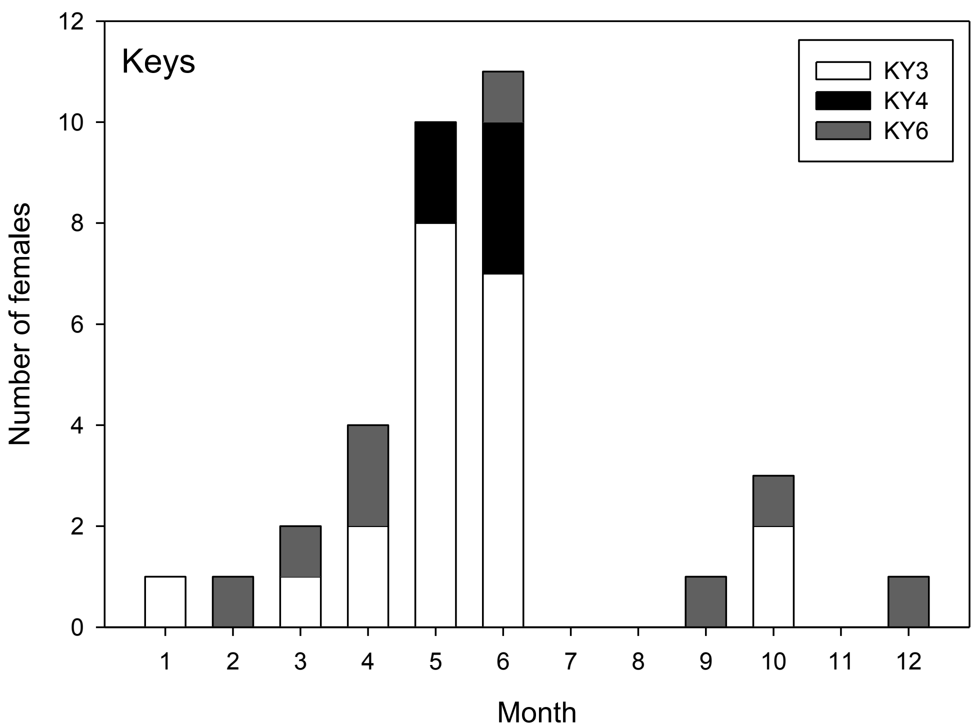


Figure 2.14. Maturity schedule for female *Lutjanus analis* residing in Florida waters in terms of size (TL_{max}, mm) compared to two Caribbean data sources. Black long dashed line indicates recreational 16" size limit.

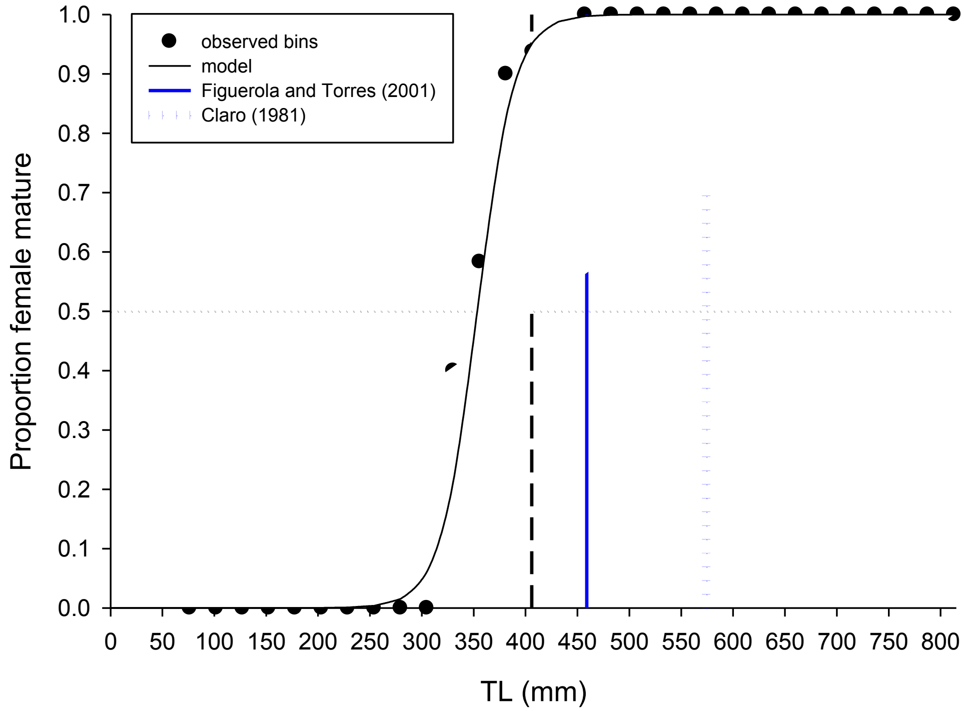
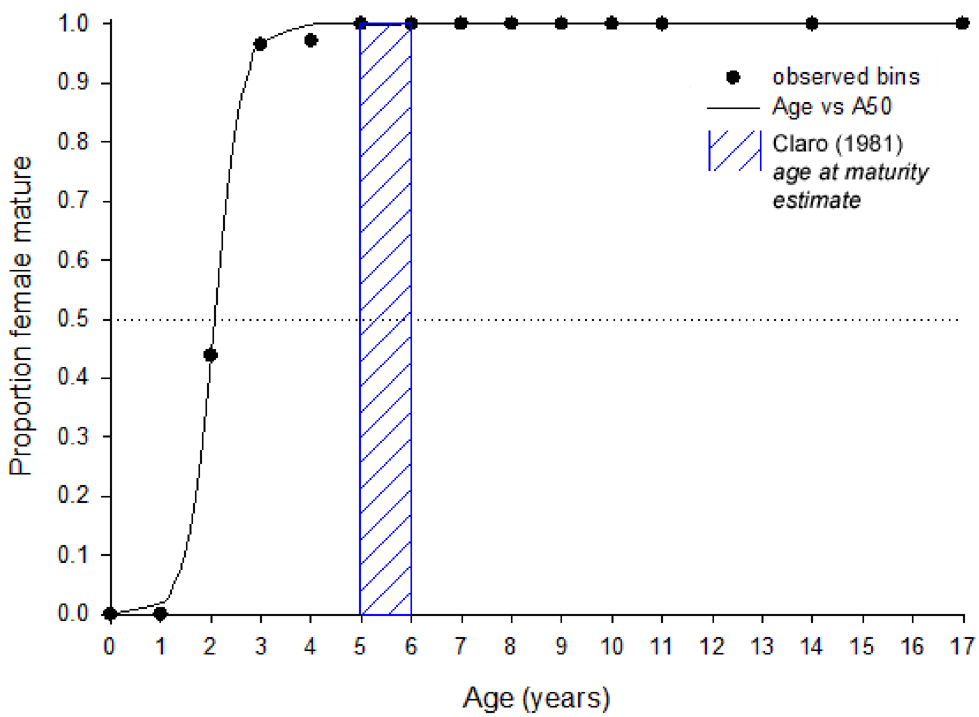


Figure 2.15. Maturity schedule for female *Lutjanus analis* residing in Florida waters in terms of age (years) compared to prior published results from Cuba.



3. Commercial Fishery Statistics

3.1 Overview (Group Membership, Leader, Issues)

The commercial workgroup consisted of two Florida Fish and Wildlife Conservation Commission (FWC) staff (Steve Brown and Rick Beaver), one field biologist (Ed Little) from the National Marine Fisheries Service (NMFS), and one industry representative associated with the Florida Keys Commercial Fisherman's Association (Scott Zimmerman). David Gloeckner, (NMFS Beaufort Laboratory) though not present at the Data Workshop meeting, provided valuable assistance with obtaining and using the NMFS Trip Interview Program data. Members of this work group lead by Steve Brown discussed issues such as what commercial mutton snapper data sets were available and how they were to be used, fisherman's concerns about regulations (such as FWC's elimination of trip limits on commercial trips, a need-to-know regarding future regulations which may be important with regard to fishing effort, and fisher's concerns about possible trip limits or quotas), and the selling of recreationally caught fish. It was noted that the majority of mutton snapper were probably harvested in Florida waters with little attributed to other states, and long line landings have increased in recent years in Gulf waters off South Florida and the Keys. There also seems to be a lack of commercial discard data, but members suggested that may not be an issue with long line gear since so few undersized fish are caught.

3.2 Commercial Landings

Available commercial landings data sources include historical data from the U.S. Fish Commission Report to Congress (1902-1937), the Florida Board of Conservation (1938-1962), NMFS Accumulated Landings System (ALS) (1950-2006; annual landings by state and gear), NMFS General Canvass (1962-2006; monthly dealer landings by water body and gear), NMFS logbook program (1990-2006; trip-level landings, mandatory vessel reporting), and the FWC marine fisheries trip ticket program (1986-2006; trip-level landings, mandatory dealer reporting). The U.S. Fish Commission Report data and Florida Board of Conservation data show historical landings by year and coast, but also have missing years until 1959 (Table 3.1). The NMFS General Canvass contain landings by year, water body, and gear from 1962-2006. Prior to 1997, the ALS utilized general canvass data collected monthly from seafood dealers. From 1997 to present, the ALS used FWC trip ticket data. However, there were unexplained differences (small in most years) in the total amount of reported commercial landings between the ALS and General Canvass in 1981-1985, and the ALS and FWC trip ticket data in 1986-2006 (compare Tables 3.1 and 3.2). Both the NMFS logbook data and the FWC trip ticket data contain trip level catch and effort. While the Florida trip ticket data are a longer time series, gear by trip was not required until late 1991, and area fished was not required until January of 1995, although area fished has been a data element on the trip ticket since the program began.

Commercial landings were stratified by year, month, region and gear for developing the commercial catch at age data for the assessment. It was recommended that commercial landings data from 1981-2006 be used for the assessment since older landings are not available from other sources being used for the assessment such as the NMFS Marine Recreational Fisheries Statistics Survey and Headboat Survey. It was also recommended that commercial landings from the Florida trip ticket be used for Florida over the NMFS logbook data because it is a longer time series and includes landings of mutton snapper from state waters not otherwise captured with logbooks. A comparison of FWC trip ticket data to NMFS logbook data show that commercial landings of mutton snapper by area fished compare well between the two programs (Fig. 3.1A), and that much of the state waters hook and line data reported on the trip ticket is missing from the logbook data (Fig. 3.1B). Trip ticket data were used from 1986-2006 and the NMFS General Canvass data from 1981-1985. The NMFS ALS and logbook data were used for compilation of landings from other states, although approximately 98% of mutton snapper harvest occurs in Florida waters (Table 3.2).

Prior to having gear information on every ticket beginning in 1991, gear related to trip tickets was retrieved from the Saltwater Products (SPL) or fisher's license record initially, but many license holders indicated more than one gear on their annual license application or renewal. Additionally, the SPL was prohibited from being retained on the trip ticket by the Florida legislature when then trip ticket program was initially approved in 1983. The prohibition was later removed in 1986 and SPL numbers were included on the trip ticket record. Beginning in late 1991, trip tickets included a series of check boxes for generic gear types and a single gear code for more specific gear information.

For trip tickets with missing gear from 1986-1992, gear was assigned from the commercial fishing license application database based on a species/gear hierarchy from later years where gear was reported by trip. Target species and species groups were identified on trips where gear was reported from 1991-1994. The species-gear associations from these data were ranked from most common to least common and applied to the trip ticket data from 1986-1992. Target species and species groups were then identified on trips where gear was not reported from 1986-1992. Gear was then assigned to each trip based on matching the species-license gear association with the species-ticket gear association from the 1991-1994 data. Region designations (Fig. 3.2) include NE Florida-North Carolina, SE Florida, the Florida Keys and Dry Tortugas, SW Florida, and NW Florida-Texas. Of particular interest in this fishery is the increase in longline and other commercial gears used in areas west of the Dry Tortugas and Pully Ridge (Fig. 3.3) where some of the oldest mutton snapper observed (otolith data; Life History Section II) in this study were caught. Commercial landings were stratified by the following fisheries or gear types: hook-and-line, longline, and traps and other gears. The majority of landings were categorized as one of these gear types. Landings from trip for which the gear used for harvest was unknown were prorated among the other gears.

Statewide, total commercial and recreational harvest of mutton snapper in Florida has gradually declined since the mid-1980's (Fig. 3.4), but in recent years, landings have increased. This can probably be attributed to increased landings of commercial longline-caught fish from vessels that have moved down from the Tampa area to fish Gulf waters off the Florida Keys and Dry Tortugas (Doug Gregory, pers. comm.). Longline landings have increased in recent years, primarily off the Florida Keys and Southwest Florida (Fig. 3.5). Prior to 2001, landings by all gear types were primarily from the Keys and Southeast Florida, but landings from Southwest Florida have increased in recent years.

Mutton snapper commercial harvest figures showed a strong seasonal trend with increased landings from May-July each year prior to 1996 (Fig. 3.6; monthly data by region and gear not available prior to 1986). After 1996, a more moderate seasonal trend existed with an overall decrease in landings annually. The 16-inch size limit implemented in state waters and South Atlantic federal waters in 1994, and Gulf of Mexico federal waters in 1999 was the likely explanation for the patterns seen in the annual landings and seasonality. Increased May-July harvest is most evident in the commercial hook-and-line fishery, even after the size limit went into effect (Fig. 3.7). Landings by longline were more evenly distributed throughout the year, but exhibit a considerable increase by month in recent years. In addition, during May and June in South Atlantic federal waters, commercial fishers are reduced to a 10-fish trip limit and so Florida East coast fishers may be shifting effort to the Gulf during that time. Burton (1997) noted that a May-June closure in 1994 on Riley's Hump west of the Dry Tortugas (Amendment 5, GMFMC 1994) caused effort to be shifted toward the months surrounding the closure, and that landings decreased during only one month of the closure period. Commercial landings by year and month for the region that included the Florida Keys and Dry Tortugas showed an increase in harvest during July with fluctuating May-June harvest in the years following the closure which agrees with earlier observations (Fig. 3.8). The increased landings in more recent years were due to increased longline harvest as hook-and-line harvest decreased after 2000. The establishment of the Tortugas South Ecological Reserve which includes Riley's Hump and waters south may have affected the overall level of commercial harvest of this species. Burton et al. (2005) noted an increase in the mutton snapper spawning aggregations within the reserve.

3.3 Commercial Discards

According to commercial data sources, the Federal logbook program is currently the only source of commercial discard data. Discard data have been collected through logbooks beginning in 2001. In that survey, there were few trips recording mutton discards. According to NMFS, only about 10-20% of logbook trips are sampled for discards. The data suggest that there were infrequent discards, but with so many trips not reporting discards, the data could be discard poor as well. It was noted by Ed Little, NMFS port sampler in lower Keys, that at least for longline vessels it may be a non-issue since they would not generally be fishing where smaller fish occur. Expert advice was given by industry (Eric Schmidt, Ft. Myers; Scott Zimmerman, Florida Keys) at the time of the data workshop that support Ed's statement, and the feeling is that mutton commercial discards have probably decreased over time. Because only a fraction of the logbooks required the reporting of discards, it may be possible to derive a ratio from the discard logbooks of the reported trips with discards of mutton snapper to the total number of trips on which the reporting of discards was required and on which mutton snapper had been caught. This ratio may be suitable for estimating the total discards of mutton snapper from all commercial reef fish trips. However, this task is left to the stock assessment scientists.

There have been some commercial fishing trips on which observers were onboard and directly observed catch and discards. Sutherland and Harper (1983) and Taylor and McMicheal (1983) observed catch and discards from the fish trap fishery of Dade and Broward Counties and Monroe and Collier Counties, respectively, from November 1979 to December 1980. Mutton snapper were among the targeted fish in this fishery and accounted for about 5.5% (by number) and 14.7% (by weight) of the observed catch in wire traps in the Dade and Broward area. Sutherland and Harper (1983) report that only 1 mutton snapper was observed to be discarded and it swam downward during the 2-minute observation period. Taylor and McMichael (1983) noted no discards of mutton snapper though they did not various trap-related injuries and death in mutton snapper either due to gas expansion, trap injury, or predation. In December 1993 through November 1994, a NMFS study (1995, report from MARFIN Grant No. 94MARFIN 17, supplement [Scott-Denton (1995)] from MARFIN Grant No. 95MFIH07, and addendum [Harper (1996)]) of the reef fish fishery observed catches from fish traps, longlines, and bandit rigs in the Gulf of Mexico and summarized Gulf Reef Fish Logbook data. Small numbers of mutton snapper were caught in the trips observed (1 from fish traps, 16 from bottom longlines, and fish from bandit rigs), and no discards of mutton snapper were recorded during this study. Recently, a study of the shark bottom longline fishery (Hale and Carlson 2007; Hale 2007 SEDAR15A-DW-xx) noted 22 mutton snapper caught on 4 out of 89 trips in South Atlantic and Gulf of Mexico waters, and 2 of those were discarded because they were cut-offs. There were no observed occurrences in the NMFS shrimp trawl characterization studies from 1992-2005 (Scott-Denton, personal communication).

3.4 Commercial Effort

Few measures of effort (number of vessels by port, number of industry personnel) were available prior to the implementation of Florida's marine fisheries trip ticket program in 1984. Fisheries can now be characterized by the number of species-specific fishers through the trip ticket program. The trip ticket includes the SPL, the wholesale or retail dealer number, date landed, county landed, time fished, days at sea, area fished, depth fished, gear used, species, size/market category, amount of catch, and unit price.

Since the early 1990's, the amount of effort in the commercial mutton snapper fishery has decreased similar to the decrease in reported commercial landings (Fig. 3.8). Both the number of trips and fishers decreased by region and by gear. Effort off the Florida Keys and Dry Tortugas accounted for 60-70% by region, and hook-and-line gear accounted for 80% of effort by gear. Conversely, statewide catch-per-trip has increased from a low of 47 pounds per trip in 1995 to 105 pounds per trip in 2006 statewide (Fig. 3.9). Statewide catch-per-trip was highly influenced by catch per trip in the Keys and Dry Tortugas with the majority of mutton snapper harvest occurring there. Catch-per-trip by longline gear has increased dramatically since 1999, but declined briefly in 2005. Catch-per-trip from trap gears has declined considerably, and has remained fairly consistent for hook-and-line gears.

3.5 Biological Sampling

3.5.1 Sampling Intensity/Age/Weight

Fishery-dependent biostatistical data from commercial catches is available through the NOAA Fisheries Trip Interview Program (TIP). Sampling of commercial catches is performed by both state and federal samplers in the Southeast region for this program. Data collected include length, weight, biological samples for aging, DNA and mercury testing, as well as catch and effort data. There were 21,242 length measurements for commercial mutton snapper available in the TIP data from 1983-2006 from the Southeast Atlantic and Gulf of Mexico regions (Table 3.4). Of those, 3,578 records included age samples which will be used with other available age-length data to estimate length at age. In addition, 1,101 records have a gutted weight and fork length associated with the sample. A regression analysis of mutton snapper measurements from commercial catches indicates a strong relationship for fork length and gutted weight (Fig. 3.11; see also Life History Section II, Table 2.12).

Some important effort variables from TIP include gear, water body, size, depth, time of year. Ninety-eight percent of trip interviews in TIP contain water body, gear and depth information. Lengths of fish landed commercially (Table 3.5) were used to compare sizes of fish landed by year, month, region, or gear and to convert landings from pounds to numbers of fish. Traditionally, mutton snapper harvested for sale by commercial fishermen are landed gutted, and a factor of 1.11 is used to convert gutted weights to whole weights for the commercial landings of snappers in the Southeastern Atlantic and Gulf of Mexico. Lacking data for a direct comparison of weight before and after gutting, we have used the same conversion factor in this report as is used by the NMFS and other southeastern states.

Length frequency data from commercial catches of mutton snapper indicate the size distribution ranged from 232.5 - 972.5 mm maximum total length for samples taken from the Gulf of Mexico, and 230.5 - 977.1 mm maximum total length for those taken from the South Atlantic from 1985-2006. Fig. 3.12 shows length frequency distributions by coast for the time periods before and after implementation of the 12 inch and 16 inch minimum size limits for mutton snapper. The beginning year of each of the 12 and 16 inch size limit histograms is the year of implementation. Undersized fish recorded during the implementation year could have been sampled prior to the actual implementation date. Mean total length in the Gulf increased during each period, but decreased slightly in the South Atlantic after implementation of the 12" minimum size. The majority of samples were taken in the Gulf. Generally, larger fish were taken in the longline fishery for both the Gulf and South Atlantic than in the hook-and-line and trap fisheries (Fig. 3.13). Seventy percent of samples taken in the Gulf came from the longline fishery. The majority of samples in the South Atlantic were from the hook-and-line fishery.

3.5.2 Length/Age Distributions

Size (by 25 mm size class) of mutton snapper measured from commercial catches by region and gear are presented in Table 3.5, and is taken from the measurements of mutton snapper from commercial fishing trips represented in the NMFS Trip Interview Program data base. There were very few records of discards from the commercial logbooks, and no size information for discarded fish. The conversion of catch-at-length to catch-at-age is left to the stock assessment workshop participants.

3.5.3 Adequacy for characterizing catch

The task of grouping commercial catches and size frequencies into catch-at-size and catch-at-age by gears and water bodies suitable for modeling was left to the stock assessment workshop participants

3.5.4 Alternatives for characterizing discard length/age

The task of developing suitable ways of characterizing discards was left to the stock assessment workshop participants.

3.6 Commercial Catch-at-Age/Length

The task of estimating catch-at-age is left to the stock assessment workshop participants.

3.7 Comments on Adequacy of Data for Assessment Workshop

The lack of size frequency, age, discard, trip-level, gear, and water body data in the earlier years of the time series may create serious problems for the stock assessment. Even in the later portions of the time series the number of lengths measured was barely adequate for expanding the annual catch by the observed size frequencies, and only for the major gear categories used in the fishery. If distinctions between gear types and methods (i.e., different hook types, depth of fishing, etc.) is important for future assessments, additional dockside sampling will be needed to collect information from more commercial reef fish trips.

3.8 Research Recommendations

Increasing the dockside sampling of commercial catches, particularly for the longline and bandit rig fisheries will be important to monitoring the size of fish, areas and depths fished, and fishing effort for this species and other reef fish. The scarcity of otoliths in the earlier portions of the sampling time series restricts the amount of age information that could be used for assessments, and we suggest placing more emphasis on sampling otoliths for this and other reef species to aid future age-structured stock assessments. There is also a need for increasing the amount of discard information (either at-sea or from logbooks) and discard mortality data in modern stock assessments, including this species. Few discards of mutton snapper were actually noted in commercial fishermen’s logbooks, and perhaps the number of fish discarded by commercial fishermen is really low. However, the relatively low frequency of discard logbooks assigned to fishermen may have also been a factor in the low number of discard records provided. Mutton snapper tend to be caught in low numbers with other reef fish species, and relatively few commercial fishing trips actually appear to target this species.

An examination of the conversion factors used to convert landed weight to whole weight should be undertaken. A comparison of the regressions in Life History Section II (Table 2.12) for gutted weight and whole weight would appear to suggest a lower percentage difference between gutted weight and whole weight at comparable sizes, perhaps as low as 2-5% rather than the 11% currently used for all snappers. However, at this time, there is not enough data to allow a direct comparison of gutted weight to whole weight and derive a suitable conversion factor and the differences suggested would be small and perhaps negligible for the stock assessment. Ultimately, if allocation between the various sectors of the fishery for mutton snapper and other reef fish are contemplated, conversion factors may become more of an issue.

There were differences noted in the commercial fisheries landings data between the ALS system, the General Canvass data, and the FWC trip ticket data. These differences should be reconciled so that each system will provide comparable numbers where appropriate.

3.9 Itemized List of Tasks for Completion Following Workshop

Commercial landings:
Provide commercial fishing effort data as number of trips and fishers by year, area and gear; also include catch per trip by gear.

- Steve Brown was given this task.

Length and age data (TIP):
Generate length frequencies by year, month, area, gear (in progress)

- Bob Muller and Joe O'Hop were given this task.

Apply length-weight regression to commercial landings to calculate numbers of fish landed

- Rick Beaver was given the task of producing length-weight regressions from the FWC Biological Sampling data and TIP length and weight data.
- Bob Muller and Joe O'Hop were given task of applying the length-weight regressions appropriately to the size-frequency data generated from the commercial sampling, and to produce catch-at-size matrices by year and gear.

Back-calculate missing weights (in progress)

- Bob Muller and Joe O'Hop were given this task.

Calculate length-at-age distributions (in progress)

- Bob Muller and Joe O'Hop were given the task of taking the catch-at-length matrices and producing catch-at-size matrices for the assessment models.

3.10 Literature Cited

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3.11 Tables

Table 3.1. Mutton snapper commercial landings (in kilograms, whole weight), 1902-2005 (U.S. Fish Commission Report to Congress, 1902-1937; Florida State Board of Conservation, 1938-1962; NOAA Fisheries Accumulated Landings System (ALS) 1950 – 2006; **in black**), and NMFS General Canvass (1962-2006). Landings for 1981-1985 (**in green**) were taken from the NMFS General Canvass data, and data for 1986-2006 (**in blue**) were from FWC marine fisheries trip tickets.

Year	Atlantic	Gulf	Total	Year	Atlantic	Gulf	Total
1900				1943			122,551
1901				1944			87,890
1902	2,150	12,837	14,987	1945			115,481
1903				1946			149,356
1904				1947			28,339
1905				1948			73,430
1906				1949			55,797
1907				1950	24,766	9,843	34,609
1908				1951			83,461
1909				1952	63,503	19,958	83,461
1910				1953	37,739	20,230	57,969
1911				1954			40,869
1912				1955	48,081	16,103	64,183
1913				1956	24,086	16,783	40,869
1914				1957			61,643
1915				1958			92,397
1916				1959	16,103	35,244	51,347
1917				1960	23,950	42,592	66,542
1918	109,351	6,396	115,747	1961	20,865	40,778	61,643
1919				1962	27,987	64,410	92,397
1920				1963	37,784	53,388	91,172
1921				1964	29,302	60,917	90,220
1922				1965	29,166	49,895	79,061
1923	55,837	12,803	68,640	1966	37,557	37,376	74,933
1924				1967	17,645	66,996	84,640
1925				1968	24,948	75,342	100,289
1926				1969	34,700	61,416	96,116
1927	58,468	14,686	73,154	1970	73,391	106,231	179,623
1928		15,694		1971	81,964	124,375	206,339
1929	82,047	20,298	102,345	1972	90,220	108,000	198,220
1930	69,869	32,207	102,076	1973	131,406	117,390	248,795
1931	10,886	5,291	16,177	1974	91,535	116,573	208,108
1932	88,716	3,425	92,140	1975	62,278	117,707	179,985
1933				1976	55,384	107,365	162,749
1934			90,220	1977	81,601	85,865	167,466
1935				1978	106,218	101,278	207,496
1936	65,544	9,525	75,070	1979	56,245	98,719	154,965
1937				1980	62,271	91,475	153,746
1938			176,121	1981	50,420	96,711	147,131
1939			105,501	1982	32,867	132,250	165,117
1940			77,050	1983	21,789	126,445	148,234
1941				1984	19,245	93,505	112,750
1942			70,445	1985	7,352	92,893	100,246

Table 3.1. (continued)

Year	Atlantic	Gulf	Total	Year	Atlantic	Gulf	Total
1986	71,602	114,803	186,405	1997	29,987	101,702	131,689
1987	81,713	168,573	250,286	1998	31,102	128,783	159,885
1988	75,106	130,284	205,390	1999	22,820	90,664	113,484
1989	84,646	164,754	249,400	2000	15,976	76,068	92,044
1990	64,833	141,755	206,588	2001	21,313	83,209	104,522
1991	59,434	159,554	218,988	2002	20,623	84,222	104,845
1992	31,780	149,630	181,410	2003	19,421	101,502	120,922
1993	51,836	149,566	201,402	2004	15,206	141,654	156,860
1994	35,028	126,550	161,578	2005	15,816	90,318	106,134
1995	28,249	100,327	128,576	2006	8,037	118,424	126,461
1996	27,178	104,660	131,838				

Table 3.2. Mutton snapper commercial landings (in pounds, whole weight) by state for the South Atlantic and Gulf of Mexico. Source: NOAA Fisheries Accumulated Landings System (ALS) 1981 – 2006).

Year	Florida East	Florida West	Georgia	Louisiana	No. Carolina	So. Carolina	Grand Total
1981	52,760	96,711					149,471
1982	33,713	132,250					165,963
1983	23,566	126,445					150,012
1984	33,800	93,505			234		127,539
1985	28,074	92,503			576		121,153
1986	75,442	109,742			504	515	186,202
1987	84,602	164,475			1,882	474	251,433
1988	77,180	124,633				522	202,335
1989	75,260	158,290			669	384	234,603
1990	67,967	137,117	59		433	236	205,813
1991	63,748	154,354			877	137	219,117
1992	32,171	139,324			755	250	172,500
1993	53,899	146,136			1,256	63	201,354
1994	36,833	123,818	569		918	83	162,222
1995	34,956	92,674			1,149		128,778
1996	31,665	99,251			860	72	131,849
1997	30,303	100,669			617	134	131,723
1998	34,990	124,248			644	821	160,703
1999	27,118	85,028		20	581	746	113,494
2000	15,647	75,194		36	307	899	92,083
2001	21,400	82,517			193	477	104,586
2002	21,603	82,206		138	192	868	105,008
2003	18,494	100,555		215	670	1,169	121,104
2004	13,342	141,370		42	730	1,505	156,988
2005	13,626	89,704			932	1,966	106,228
2006	8,517	118,066			682	2,059	129,324

Table 3.3. Commercial landings (kilograms) of mutton snapper by region and year, hook and line gears. Source data: NOAA Fisheries General Canvass (1981-1985), FWC trip ticket (1986-2006). Landings for which gear was unknown were prorated among all gears.

Hook and Line Gears

	Kilograms					
Year	Northeast	Southeast	Keys	Southwest	Northwest	Total
1981	10,292	33,010	37,509	9,153	7,897	97,861
1982	16,610	13,609	57,202	2,751	13,601	103,771
1983	4,955	12,455	55,680	11,542	6,002	90,633
1984	13,987	2,126	55,282	5,079	2,918	79,392
1985	4,859	947	53,456	2,559	4,874	66,695
1986	34,884	17,355	39,885	5,116	2,231	99,472
1987	35,587	18,969	67,978	6,029	3,264	131,827
1988	28,374	12,061	55,701	7,042	1,467	104,645
1989	12,950	18,455	68,891	7,621	2,464	110,382
1990	3,319	23,636	69,082	4,539	5,166	105,742
1991	3,918	30,120	66,600	7,948	4,574	113,161
1992	3,125	23,599	71,026	4,215	1,553	103,518
1993	5,017	43,152	69,658	7,903	3,301	129,032
1994	7,066	24,635	75,095	8,243	2,443	117,482
1995	8,130	16,155	58,890	3,818	2,486	89,479
1996	3,775	21,496	59,881	4,435	3,014	92,602
1997	4,862	23,254	60,267	3,861	1,388	93,632
1998	6,107	21,432	61,757	2,953	2,183	94,431
1999	7,274	13,253	34,641	3,097	1,861	60,126
2000	5,334	8,899	28,382	2,484	1,069	46,168
2001	4,138	14,073	32,259	3,533	728	54,731
2002	5,522	12,576	35,564	2,732	963	57,357
2003	4,803	12,157	40,533	1,607	1,115	60,214
2004	5,096	8,717	42,949	3,770	649	61,181
2005	6,385	8,437	28,357	2,996	490	46,665
2006	2,497	4,591	30,209	4,148	391	41,836

Table 3.3 continued. Commercial landings (kilograms) of mutton snapper by region and year, longline gear. Source data: NOAA Fisheries General Canvass (1981-1985), FWC trip ticket (1986-2006). Landings for which gear was unknown were prorated among all gears.

Longline Gear

	Kilograms					
Year	Northeast	Southeast	Keys	Southwest	Northwest	Total
1981	0	0	25,628	1,741	1,030	28,399
1982	0	0	40,790	507	1,875	43,172
1983	0	0	28,619	2,985	9,016	40,620
1984	158	0	14,358	5,342	3,380	23,237
1985	0	0	14,038	4,708	6,566	25,313
1986	2,406	8,256	25,885	5,396	11,567	53,511
1987	3,565	4,026	48,769	10,169	17,124	83,655
1988	31	3,460	22,786	10,803	14,755	51,834
1989	98	6,961	51,928	3,807	14,659	77,454
1990	3,755	5,370	31,749	9,931	9,936	60,741
1991	1,127	8,572	47,575	7,012	10,885	75,170
1992	1,265	1,782	25,672	7,237	10,309	46,265
1993	17	212	9,073	9,829	8,148	27,278
1994	45	47	4,274	4,866	6,676	15,908
1995	535	636	6,286	6,235	3,558	17,249
1996	269	0	5,920	7,710	5,368	19,267
1997	235	2	8,380	13,454	2,955	25,025
1998	744	229	13,983	8,763	10,072	33,791
1999	523	37	11,814	8,398	11,831	32,603
2000	467	147	10,466	9,956	11,865	32,901
2001	369	27	15,119	11,030	14,627	41,171
2002	45	15	12,337	15,014	8,304	35,715
2003	45	112	16,944	14,018	19,077	50,196
2004	9	186	53,914	21,273	13,918	89,300
2005	0	11	31,982	12,778	9,768	54,539
2006	0	230	47,937	28,342	4,693	81,202

Table 3.3 continued. Commercial landings (kilograms) of mutton snapper by region and year, fish trap gear. Source data: NOAA Fisheries General Canvass (1981-1985), FWC trip ticket (1986-2006). Landings for which gear was unknown were prorated among all gears.

Trap Gear

	Kilograms					
Year	Northeast	Southeast	Keys	Southwest	Northwest	Total
1981	0	7,094	12,271	0	0	19,365
1982	0	2,649	14,819	0	0	17,468
1983	0	4,379	10,891	0	0	15,270
1984	0	2,955	6,001	198	0	9,153
1985	0	1,539	5,205	128	0	6,872
1986	125	4,005	16,662	816	178	21,786
1987	159	13,738	8,851	462	64	23,275
1988	36	22,210	7,957	347	16	30,565
1989	49	44,038	10,254	434	53	54,829
1990	153	27,013	3,674	1,390	274	32,503
1991	97	14,611	11,286	347	48	26,388
1992	34	533	24,770	291	87	25,716
1993	3	1,037	39,555	225	0	40,820
1994	0	1,385	22,751	667	23	24,826
1995	0	1,592	16,369	936	10	18,906
1996	0	798	16,931	199	17	17,945
1997	0	897	10,162	131	75	11,265
1998	0	1,117	27,911	36	0	29,064
1999	0	478	18,270	4	0	18,752
2000	0	717	9,510	842	14	11,083
2001	0	1,823	3,667	81	142	5,713
2002	0	1,677	7,416	172	141	9,406
2003	0	1,603	7,133	3	57	8,796
2004	0	742	3,671	58	61	4,532
2005	0	304	1,627	204	8	2,143
2006	0	386	1,374	82	0	1,842

Table 3.3 continued. Commercial landings (kilograms) of mutton snapper by region and year, Other gears. Source data: NOAA Fisheries General Canvass (1981-1985), FWC trip ticket (1986-2006). Landings for which gear was unknown were prorated among all gears.

Other Gears

	Kilograms					
Year	Northeast	Southeast	Keys	Southwest	Northwest	Total
1981	24	0	972	510	0	1,507
1982	0	0	0	0	706	706
1983	0	0	1,663	48	0	1,711
1984	20	0	817	132	0	968
1985	7	0	845	514	0	1,366
1986	2,776	1,794	4,774	1,559	732	11,636
1987	4,802	866	3,138	1,904	821	11,530
1988	8,076	859	6,474	2,762	175	18,345
1989	867	1,228	2,972	1,508	161	6,736
1990	137	1,450	2,779	2,967	269	7,602
1991	198	792	2,190	736	354	4,269
1992	554	888	1,951	2,472	46	5,911
1993	374	2,025	1,162	496	215	4,272
1994	831	1,020	1,104	200	206	3,361
1995	449	753	1,598	116	25	2,941
1996	207	633	1,172	10	3	2,025
1997	134	603	1,019	9	0	1,766
1998	247	1,227	1,109	17	0	2,599
1999	192	1,063	693	0	55	2,003
2000	73	338	1,415	0	65	1,891
2001	333	550	1,898	17	109	2,906
2002	311	477	1,496	0	83	2,367
2003	304	397	914	0	101	1,716
2004	119	337	1,214	23	154	1,847
2005	162	517	2,029	0	79	2,787
2006	56	277	1,209	0	39	1,581

Table 3.4 Number of measurements (NMFS SEFSC Trip Interview Program) of mutton snapper by region and year for commercial gears, 1981-2006. Data marked in blue represent cells with fewer than 30 lengths measured.

	Commercial, Hook & Line			Commercial, Long Line			Commercial, Traps & Other Gears		
Region	Atlantic (Northeast & Southeast)	Florida Keys	Gulf (Northwest & Southwest)	Atlantic (Northeast & Southeast)	Florida Keys	Gulf (Northwest & Southwest)	Atlantic (Northeast & Southeast)	Florida Keys	Gulf (Northwest & Southwest)
1981	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0
1983	1	0	0	0	0	0	0	0	0
1984	7	0	0	7	0	0	0	0	0
1985	24	0	0	0	0	0	1	0	0
1986	17	0	0	0	9	5	0	12	0
1987	26	0	0	23	22	0	3	0	0
1988	29	44	0	49	11	0	9	2	0
1989	12	128	1	7	0	0	11	181	0
1990	42	122	3	111	73	9	2	481	0
1991	70	340	26	13	102	46	8	83	2
1992	303	272	8	0	323	24	60	155	0
1993	154	192	23	0	163	56	21	102	0
1994	171	126	8	1	231	118	43	142	0
1995	136	337	26	6	124	60	3	123	0
1996	151	54	77	0	66	54	0	196	0
1997	307	205	63	1	149	249	13	231	0
1998	448	125	39	1	739	523	14	217	15
1999	472	68	135	0	1165	654	57	163	0
2000	488	144	27	0	504	642	90	146	3
2001	517	90	74	0	561	278	57	76	31
2002	386	120	60	0	368	189	48	124	11
2003	341	66	14	0	582	196	21	178	0
2004	108	89	18	0	447	231	1	69	0
2005	135	52	11	0	213	318	7	17	0
2006	65	47	20	0	389	221	1	15	0

Table 3.5. Commercial Fisheries - Hook-and-line gears, Northwest Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)] Source: NMFS Trip Interview Program (TIP).

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
237.5														8											8
262.5														11											11
287.5														2											2
487.5											1		1								1		1		4
512.5											1														1
562.5											1					1									2
587.5							1				2		1												4
612.5											1		1												2
637.5													2				1			1				1	5
662.5											2							1					1		4
687.5											3														3
712.5											2		1			1									4
737.5											2											1			3
812.5											1														1
837.5											1				1				1						3
Total	0	0	0	0	0	0	1	0	0	0	17	0	6	21	1	2	1	1	1	1	1	1	2	1	57

Table 3.5 continued. Commercial Fisheries - Hook-and-line gears, Southwest Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
287.5									1																1
312.5									3																3
337.5									1																1
362.5									3				1												4
387.5															1										1
412.5													2		1		1		1						5
437.5														2		3			4			2			11
462.5												2	2	2	4		1	1	3	4					19
487.5											1	1		2	1		3		3	8		1	2		22
512.5								1		1				2	6	2	6	1	4	2		1	1	1	28
537.5									1					5	7	5	4	1	5	4		1	1	1	35
562.5									2	1		1		3	3	1	10	2	6	2					31
587.5													3	2	6	2	3	5	4	3			2	2	32
612.5											1	2	1	6	6	2	10	2	6	3	2			2	43
637.5									2				2	5	7	2	11	3	6	5	1	1	1	1	47
662.5										1	1			2	3	4	9		6	5	1	3	1	2	38
687.5								1	3	1	1		2	4	4	3	7	1	2	7	1	2	1	1	41
712.5									1	1		1		5	3	3	5		7	4	4			1	35
737.5													4	1	2		9	1	4	1	1	1		1	25
762.5												1	1	3	3		9	1	4	2				1	25
787.5														1	1	1	14	3	3	2	1	2			28
812.5									1	1			1	1	2	1	10	2	1	1				1	22
837.5									1	1				4		2	13	1	2	1	1	1		2	29
862.5									7		2		1	3	1	2	4		1	1				2	24
887.5								1		1				3	1	3	3	2	1	3		1			19
912.5																1	1				1	1			4
937.5																				1				1	2
1112.5																	1								1
Total	0	0	0	0	0	0	0	3	26	8	6	8	20	56	62	37	134	26	73	59	13	17	9	19	576

Table 3.5 continued. Commercial Fisheries - Hook-and-line gears, Florida Keys Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
262.5										2						1									3
287.5							4		3	3															10
312.5						1	14	1	7	17	1	6			1	1									49
337.5						4	17		13	15	10	5		1		1									66
362.5						4	15	4	33	12	10	3			3										84
387.5						2	16	8	33	9	10	4	80				3								165
412.5						2	14	6	15	1	11	5	76	1	7	3		3		2	2		6	3	157
437.5						1	9	3	8	5	11	6	34	3	8	5	5	4	4	4	9	3	1	4	127
462.5						2	6	7	12	13	8	2	22	5	6	7	1	5	7	9	3	5	1	2	123
487.5							6	2	12	18	7	8	22	1	7	3	1	7	3	6	2	5	1	3	114
512.5						1	5	6	12	18	7	7	12	2	5	3	1	3	5	8	4	3	3	2	107
537.5						1	1	7	12	13	14	6	9	2	4	5	3	9	7	11	5	6	2	4	121
562.5						3	1	11	20	18	13	3	8	2	13	3	1	6	7	7	4	2	2		124
587.5							4	9	6	11	9	7	5	3	11	5	3	4	6	12	1	2	2	1	101
612.5						5	1	7	21	17	7	8	3	5	21	8	4	5	8	8	9	4	3	3	147
637.5						4	5	15	18	16	8	8	4	4	24	15	3	17	9	7	3	4	2	5	171
662.5						3	4	12	41	5	16	12	1	8	32	11	8	13	6	12	6	4	7	2	203
687.5						6	3	9	25	17	11	9	6	3	22	17	9	20	8	6	6	18	5	5	205
712.5						2	2	3	13	17	15	6	6	3	14	16	6	11	4	8	5	15	4	7	157
737.5						1		6	12	15	5	9	7	4	15	4	4	15	5	9	2	10	4		127
762.5								4	8	21	9	4	11		5	8	7	8	6	2	1	5	3		102
787.5						1	1	2	8	4	3	5	9	5	6	4	2	9	2	5	2	2	3	3	76
812.5									4	5	2	2	11	1	1	2	3	2	1			1			35
837.5									3		4		8			1	3	1	1	1	2		1	3	28
862.5									1		1		3					1	1	1			2		10
887.5						1						1					1	1		2					6
912.5																1									1
937.5																1									1
962.5														1											1
Total	0	0	0	0	0	44	128	122	340	272	192	126	337	54	205	125	68	144	90	120	66	89	52	47	2621

Table 3.5 continued. Commercial Fisheries - Hook-and-line gears, Southeast Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
237.5																						1			1
262.5																			1			1			2
287.5										2							1	7	1	1					12
312.5						1				6						1		3	3						14
337.5										7	3					5		1	6		1	1			24
362.5								2		17	4	4			3	7	6	13	8	2		1			67
387.5								3		21	4	5	1		9	21	14	45	21	20	6	2	2		174
412.5								10	1	32	1	9	5	6	18	58	23	68	85	47	15	5	10	1	394
437.5								4		28	3	8	4	9	19	36	24	42	61	42	33	5	9	3	330
462.5								2	2	28	3	18	2	18	23	50	32	25	69	44	40	7	10	1	374
487.5								1	1	29	2	17	2	13	31	36	20	24	58	43	47		5		329
512.5								1	1	18	4	17	3	17	26	15	23	20	31	23	29	1	3	1	233
537.5										8	2	6	2	12	16	20	14	14	28	28	23	5	2		180
562.5						1				11	8	5	5	6	17	32	10	10	15	28	4		4		156
587.5						2				17	3	3	3	4	21	18	12	4	16	24	15		1		143
612.5									1	8	3	10	5	4	15	15	15	11	7	16	4	1	1		116
637.5										9	1	6	1	8	21	12	8	8	7	10	6		2		99
662.5						2				9	2	10		6	17	15	11	4	10	12	7	1	1		107
687.5						1				4	5	4	2	4	9	9	4	3	6	9	8				68
712.5						1				8	12	8		1	9	12	2	5	8	2	4		1		73
737.5										2	5	3		1	5	8	5	5	8	6	1				49
762.5						1				3	4	2	2		3	7	2	1	2	1		1			29
787.5						1					1					3	1	3	1		1				11
812.5									1	1		1		1	4	1	2	1	1	1					14
837.5															1		2	4		1					8
862.5										2								1		1					4
912.5																		1							1
962.5																		1							1
Total						10		23	7	270	70	136	37	110	267	381	231	324	453	361	244	32	51	6	3013

Table 3.5 continued. Commercial Fisheries - Hook-and-line gears, Northeast Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
237.5																					1				1
262.5																1	1								2
287.5																4	1								5
312.5										1						2	1								4
337.5																2									2
362.5																	1								1
387.5							1							1		1		2							5
412.5											1	2		1	1		2	6		1		1			15
437.5												3				1	1	4	1	1					11
462.5								1	1		1					1	1	3	1		2	1	2		14
487.5								1	1		1	3	4			5	1	1	1		2		1	1	22
512.5				1			2		3				4			3	2	3	1	2	3	1	3		28
537.5					1			2	7	2	1		4			1	7	2	5		4	1	2		39
562.5								1	9	5	1		11		1	2	5	5	7	3	3	1	7	1	62
587.5								1	8	2	4		4	1	1	1	6	9	1		4	5	5	2	54
612.5		1							7	2	5		6	1	1	1	7	6	1	1	6	4	5	4	58
637.5		2						2	7	6	8	1	5	1	5	2	8	15	1	2	9	7	3	4	88
662.5		1	2	1	1			1	3	3	11	4	8	3	5	8	9	6	4	3	8	1	6	4	92
687.5			1	1		2		2	1	2	8	1	10	3	5	5	15	17	4	2	3	6	2	2	92
712.5				3	6			1	4	3	13	5	8	7	3	4	22	15	4	2	6	4	7	4	121
737.5		1	1	1	6	1	1		3	2	10	4	7	3	3	4	19	9	8	4	7	5	8	7	114
762.5	1	1	2	4	7	7	1	2		1	10	1	13	4	5	4	38	17	7		4	5	6	6	146
787.5			6	1	3	5	4	2	1	2	2	5	4	8	5	2	31	15	4		9	9	4	8	130
812.5		1	8	3	2	2	2	1	3	2	6	5	8	3	4	8	32	15	8		13	11	9	7	153
837.5			2			2	1	1	1		1	1	2	2		3	22	6	3	4	4	8	9	7	79
862.5			1	2					3		1		1	2	1	2	6	7	3		5	5		1	40
887.5								1	1								3	1			1	1	3	1	12
912.5			1																		1		1		3
937.5																					2				2
962.5																							1		1
1012.5														1											1
Total	1	7	24	17	26	19	12	19	63	33	84	35	99	41	40	67	241	164	64	25	97	76	84	59	1397

Table 3.5 continued. Commercial Fisheries - Longline gear, Northwest Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
462.5												1				1									2
487.5																2					1				3
512.5																3			2				1		6
537.5												1		1		4	1			1			1	1	10
562.5														1		9	2			1		3		1	17
587.5														2	1	2	2		2			2	1	3	15
612.5												1	1			6						1	2	4	15
637.5													1		1	15	2	1	4					4	28
662.5															3	10			1				2	4	20
687.5													3	2		4	2		7				3		21
712.5										2				1		7	4		2	1			2	2	21
737.5											1			1	2	6	3	1	2	1	1		1		19
762.5													2	2		2	2		1		1		1	5	16
787.5								1					1	4		5	1		2			1	3	1	19
812.5								2		1			2	4		21			1		2		2	1	36
837.5								2		1				7		20	2		1	1	1		3	2	40
862.5								1						3		12		1	2	1			1	2	23
887.5													1			1		1	1				2		6
912.5								1								1	1		1				1	1	6
937.5																								1	1
Total	0	0	0	0	0	0	0	7	0	4	1	3	11	28	7	131	22	4	29	6	6	7	26	32	324

Table 3.5 continued. Commercial Fisheries - Longline gear, Southwest Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
387.5																1									1
437.5																2	1	1		2		1	1		8
462.5											1		1			1	9	2		1	1	5	4	6	31
487.5											1	1	1		2	6	13	10	3	3		4	9	6	59
512.5				1							2		1	1	3	10	20	12	5	7	2	9	10	6	89
537.5								1	2	1		3	3		8	13	34	19	5	5	8	9	19	7	137
562.5									5	1	1	1	2		9	13	34	34	6	11	4	10	29	11	171
587.5									1	2		3	2	1	6	18	36	31	8	11	4	5	22	13	163
612.5									1		7	5	7	2	6	13	36	28	9	9	8	17	22	11	181
637.5									1	1	1	1	2	2	13	15	38	41	12	16	8	16	24	15	206
662.5									3	2	4	8	8	1	17	23	51	53	21	15	11	15	21	14	267
687.5									4		8	6	6	2	20	20	33	54	16	12	9	10	24	11	235
712.5									2	3	7	5	1	2	32	22	41	49	28	6	15	14	17	10	254
737.5				2					4	1	5	5	3		22	23	40	47	18	12	18	20	19	11	250
762.5									5	2	6	14	1	3	26	33	30	35	24	7	11	13	23	10	243
787.5									4	1	1	14	4	3	29	27	44	42	25	11	21	15	12	10	263
812.5									4		3	13	4		21	38	50	56	27	9	15	13	5	11	269
837.5				2				1	6	3		14		3	16	42	46	47	15	16	17	12	6	10	256
862.5									3	1	3	14	2	3	8	40	46	44	16	15	15	17	5	10	242
887.5										1	4	6	1	1	3	26	19	18	7	7	13	12	9	12	139
912.5									1		1	1		1	1	4	6	13	2	4	5	4	7	4	54
937.5												1		1		2	4	2	1	2	5	3	4	1	26
962.5										1							1		1	1					4
1087.5																				1					1
Total	0	0	0	5	0	0	0	2	46	20	55	115	49	26	242	392	632	638	249	183	190	224	292	189	3549

Table 3.5 continued. Commercial Fisheries - Longline gear, Florida Keys Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
337.5									1																1
412.5				1				1	1						1	1		1							6
437.5								1							1	3	3	1			4	1			14
462.5									4	1	2	1	4			4	14	3	2	2	4	3		2	46
487.5				1					2	1	3	4	2	1	2	7	16	9	6	5	11	9	1	4	84
512.5					1				4	7	3	4	2		4	14	28	7	8	3	13	11	5	6	120
537.5									1	7	3	3	4	2	3	20	46	15	18	11	12	20	15	8	188
562.5								3	2	11	9	8	8	4	3	21	55	20	16	4	18	26	12	20	240
587.5						1		3	8	17	7	9	10	2	6	37	56	19	26	20	27	22	11	22	303
612.5						1		6	10	24	6	20	6	5	3	34	70	35	18	23	25	29	19	25	359
637.5					3			7	14	42	8	15	9	2	4	33	70	24	34	20	18	29	19	30	381
662.5				1	2			7	12	60	17	28	18	4	8	40	78	35	60	35	32	44	18	23	522
687.5				1	1			12	8	49	15	25	3	7	8	47	86	35	31	27	32	28	17	37	469
712.5					2			6	9	58	24	23	12	3	8	58	96	30	51	47	41	31	16	28	543
737.5					5			5	9	25	23	17	9	3	4	78	90	40	46	18	40	26	19	40	497
762.5					5	1		3	7	8	19	16	8	3	7	63	68	45	49	35	37	21	12	28	435
787.5					2	3		3	4	5	12	17	6	6	13	50	76	46	36	19	48	24	7	28	405
812.5					1	3		4	3	3	5	17	6	13	17	59	74	53	38	25	40	40	13	29	443
837.5				5		1		5	2		6	8	10	5	15	63	82	43	50	26	52	29	14	22	438
862.5						1		3	1	4		11	3	5	22	60	93	33	34	24	52	26	6	16	394
887.5								1		1		3	4	1	9	33	46	8	24	16	47	14	4	8	219
912.5								1			1	1			9	12	14		12	8	20	9	4	9	100
937.5								2				1			2	2	4	2	2		6	5		4	30
962.5																					2		1		3
1062.5																					1				1
Total	0	0	0	9	22	11	0	73	102	323	163	231	124	66	149	739	1165	504	561	368	582	447	213	389	6241

Table 3.5 continued. Commercial Fisheries - Longline gear, Southeast Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
<NONE>																									

Table 3.5 continued. Commercial Fisheries - Longline gear, Northeast Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
462.5								4					2												6
487.5								1					1												2
512.5								5								1									6
537.5								3																	3
562.5								13																	13
587.5								9	1																10
612.5							1	13	1						1										16
637.5								8																	8
662.5		1					1	11																	13
687.5					1	1	1	10																	13
712.5					4	3		17				1	1												26
737.5		2			4	4		6	1																17
762.5					8	16	2	3	3				1												33
787.5		1			3	14	1	2	3				1												25
812.5		1			2	5		2	3																13
837.5		2				3	1	2	1																9
862.5					1	3		1																	5
887.5								1																	1
Total	0	7	0	0	23	49	7	111	13	0	0	1	6	0	1	1									219

Table 3.5 continued. Commercial Fisheries –Traps and other gears, Northwest Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
<NONE>																									

Table 3.5 continued. Commercial Fisheries – Fish Trap and Other Gears, Southwest Region, dockside measurements (TIP) by year and 25 mm size class [converted to Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
412.5																			2						2
437.5																			1						1
462.5																			2						2
487.5																			3						3
512.5																			4						4
537.5																			2						2
562.5																			5						5
587.5																			4	2					6
612.5																			1	3					4
637.5																			3	2					5
662.5																			3	2					5
687.5																				1					1
762.5																			1	1					2
987.5									1																1
Total	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	31	11	0	0	0	0	43

Table 3.5 continued. Commercial Fisheries – Traps and other gears, Florida Keys Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
287.5																			1						1
312.5							1	2		1								1							5
337.5							28	27		1															56
362.5							21	42		1						3	2	6							75
387.5							21	55	4	6	3			4	1	5	2	14			2				117
412.5							19	59		11	1	5	1	14	7	14	3	15	3	1	17			6	176
437.5							11	47	4	10		14	1	17	10	14	2	10	1	2	9			2	154
462.5				1			6	34	7	13	1	6	4	12	6	10	5	8	1	1	6	1		2	124
487.5				1			2	18	7	6	6	6	5	8	12	9	2	7	4	3	2	2	2	1	103
512.5							7	19	9	13	3	3	3	8	6	6	4	7	3	7	9	1		1	109
537.5							4	13	6	6	4	1	3	14	7	5	3	8	1	7	4	1			87
562.5				1			2	11	6	12	8	4	4	9	4	7	3	4	4	4	5	3		2	93
587.5							8	16	8	2	4	5	2	16	11	4	4	4	2	8	11	3			108
612.5							9	15	9	4	5	7	4	6	13	12	6	7	6	5	11	2			121
637.5							9	18	9	5	3	12	4	9	17	12	14	4	4	12	12	6			150
662.5							7	13	5	3	6	16	7	16	16	17	17	4	6	12	15	2			162
687.5				1			11	18	2	10	13	18	13	20	23	32	36	7	5	20	13	4			246
712.5							10	12	1	5	15	14	37	11	21	21	24	6	9	5	13	6	1		211
737.5							2	14	3	6	9	9	15	16	25	23	25	4	5	10	16	7			189
762.5								14	2	4	11	6	7	5	13	12	8	1	3	9	7	10			112
787.5				2			1	15		13	6	8	6	3	17	7	1		5	5	10	8			107
812.5								8	1	11	4	2	5	2	4		1	1	2	5	7	4			57
837.5				3				4		2			1	2	5	2	1		4	4	2	7			37
862.5				2				1		6			1	2	3	1			5	1	3	1			26
887.5				1				1							2	1			1		3	1			10
912.5															1				1		1				3
962.5								1																	1
1012.5								1																	1
Total	0	0	0	12	0	0	179	478	83	151	102	136	123	194	224	217	163	118	76	121	178	69	3	14	2641

Table 3.5 continued. Commercial Fisheries – Traps and other gears, Southeast Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
<NONE>																									

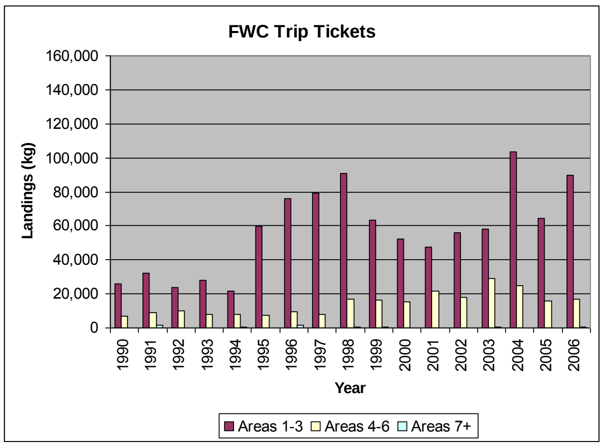
Table 3.5 continued. Commercial Fisheries – Traps and other gears, Northeast Region, dockside measurements (TIP) by year and 25 mm size class [Total Length (max.)]

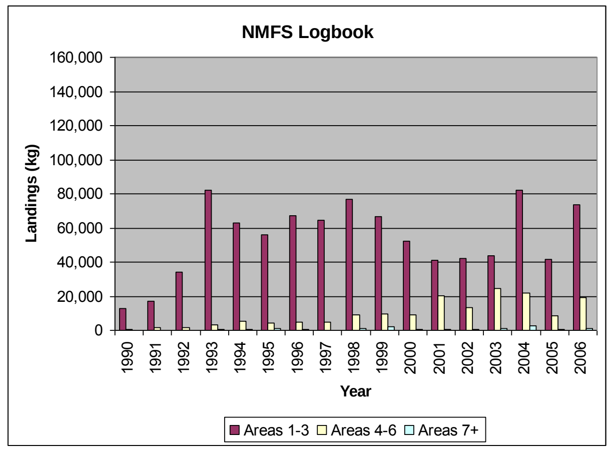
TL(max) class mid-points (mm)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
512.5																				1					1
637.5																				1					1
662.5									1																1
762.5									1																1
Total	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	4

3.12 Figures

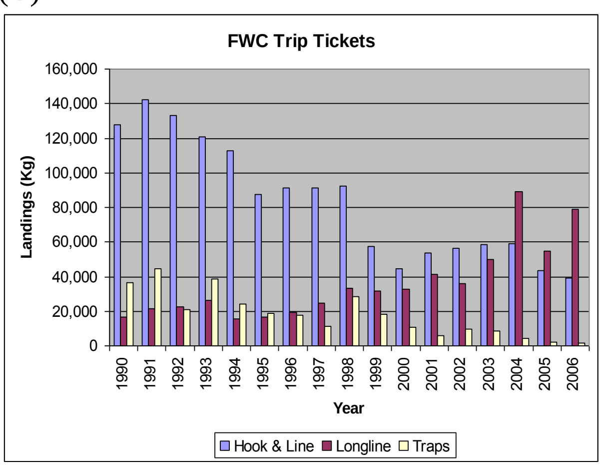
Figure 3.1. Comparison of FWC trip ticket and NMFS logbook commercial mutton snapper landings by (A) area fished and (B) gear used. Landings by area are less than landings by gear because area fished was not on every trip ticket and commercial landings from the NMFS statistical areas in the South Atlantic (areas 748 [Marathon] to 722 [Jacksonville]) were not included in part (A).

(A)





(B)



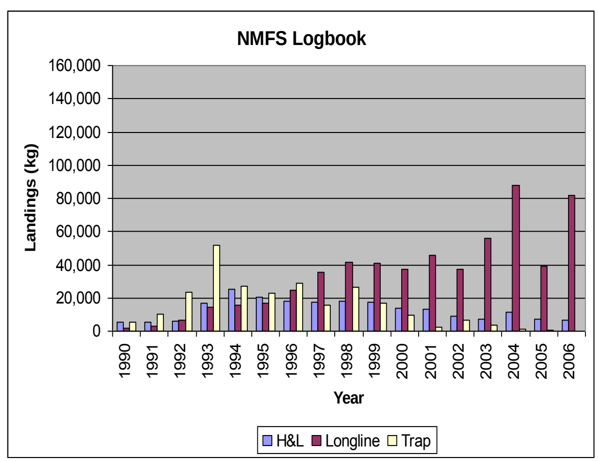


Figure 3.2. Map of Southeastern United States, South Atlantic Ocean, and Gulf of Mexico showing regional divisions used for SEDAR 15A.

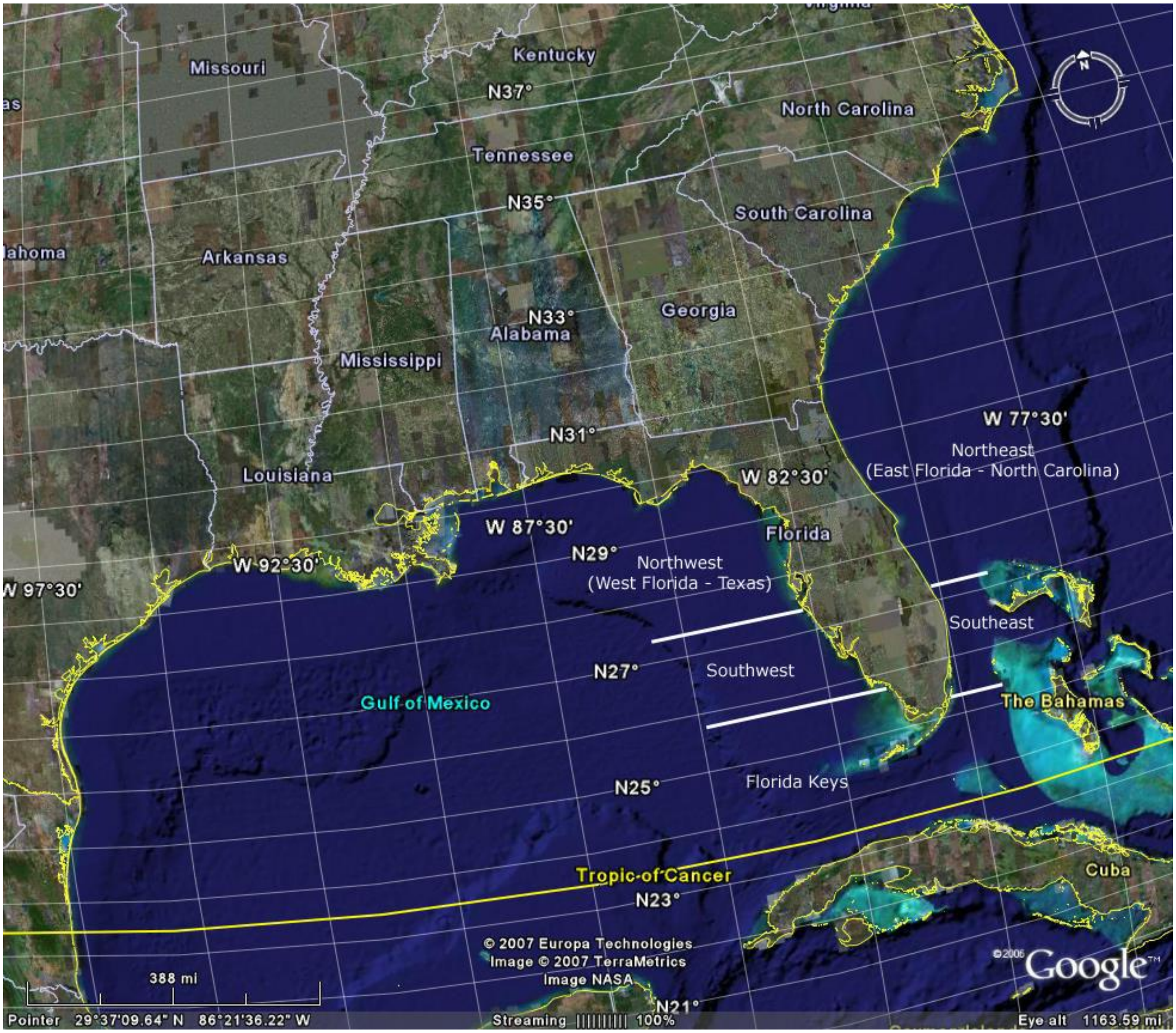


Figure 3.3 Location of Dry Tortugas, Pulley Ridge, and Florida Middle Grounds in relation to land features of the Florida Peninsula and depth contours.

Figure 3.4. Commercial and recreational harvest of mutton snapper in Florida. Source data: NMFS SEFSC General Canvass 1981-1985, FWC trip ticket 1986-2006, NMFS SEFSC Headboat Survey, NMFS Marine Recreational Fishery Statistics Survey (post-stratified, bootstrapped size frequencies and regressions of whole weight vs length)

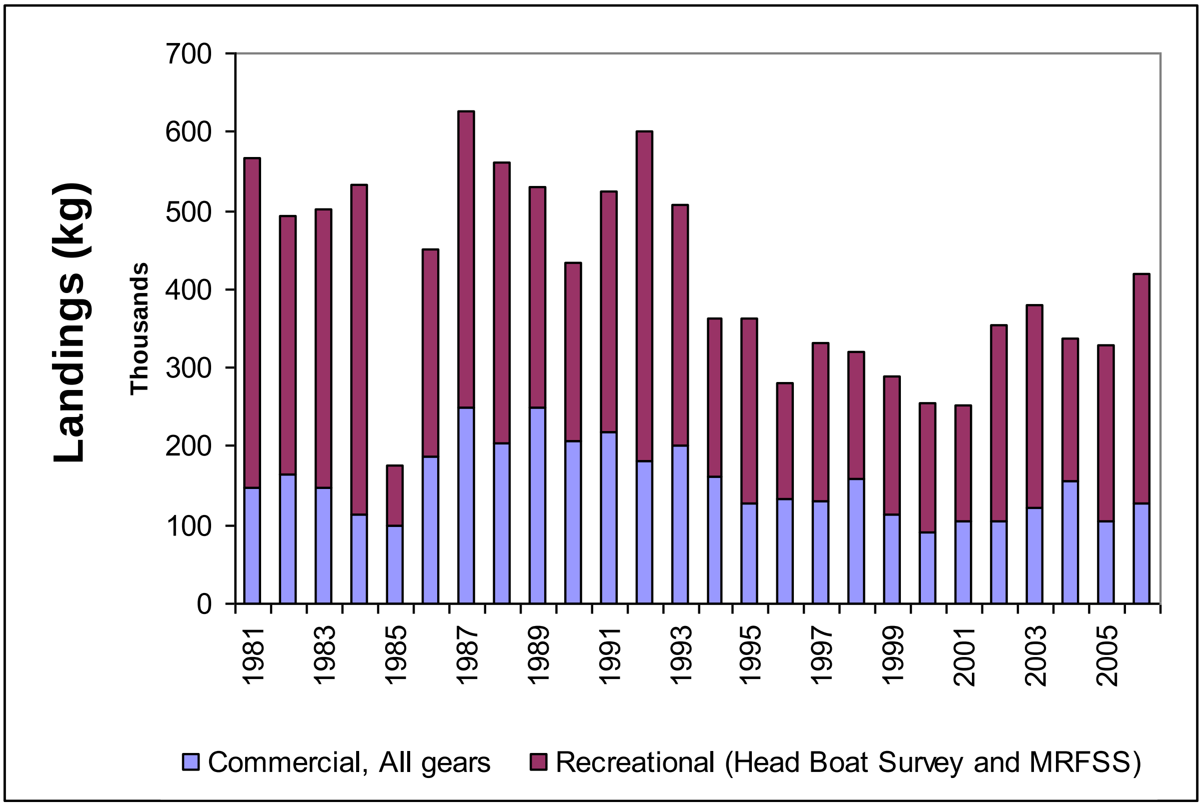


Figure 3.5. Florida commercial mutton snapper harvest by year, region, and gear.

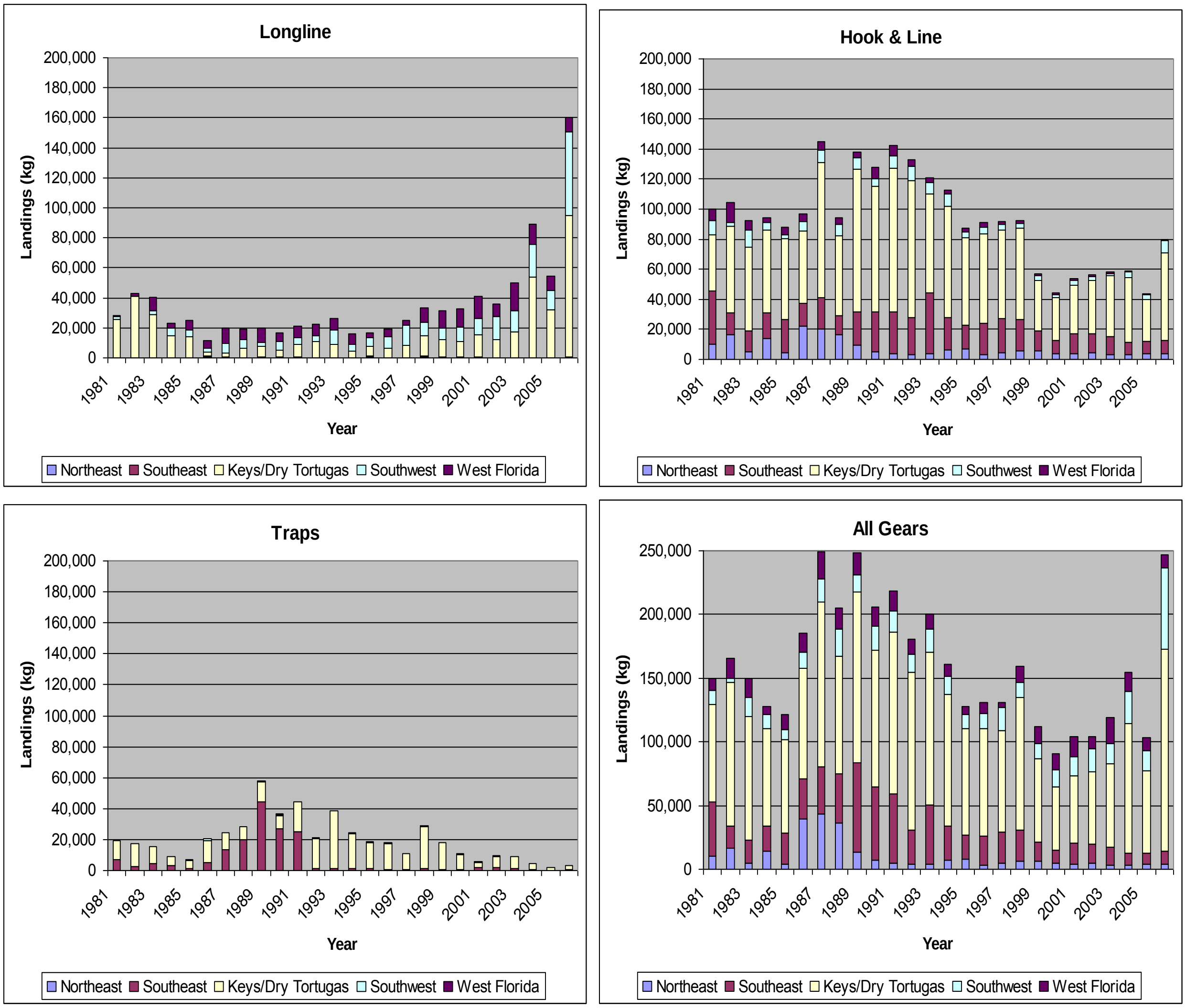


Figure 3.6. Statewide seasonality of commercial mutton snapper landings in Florida.

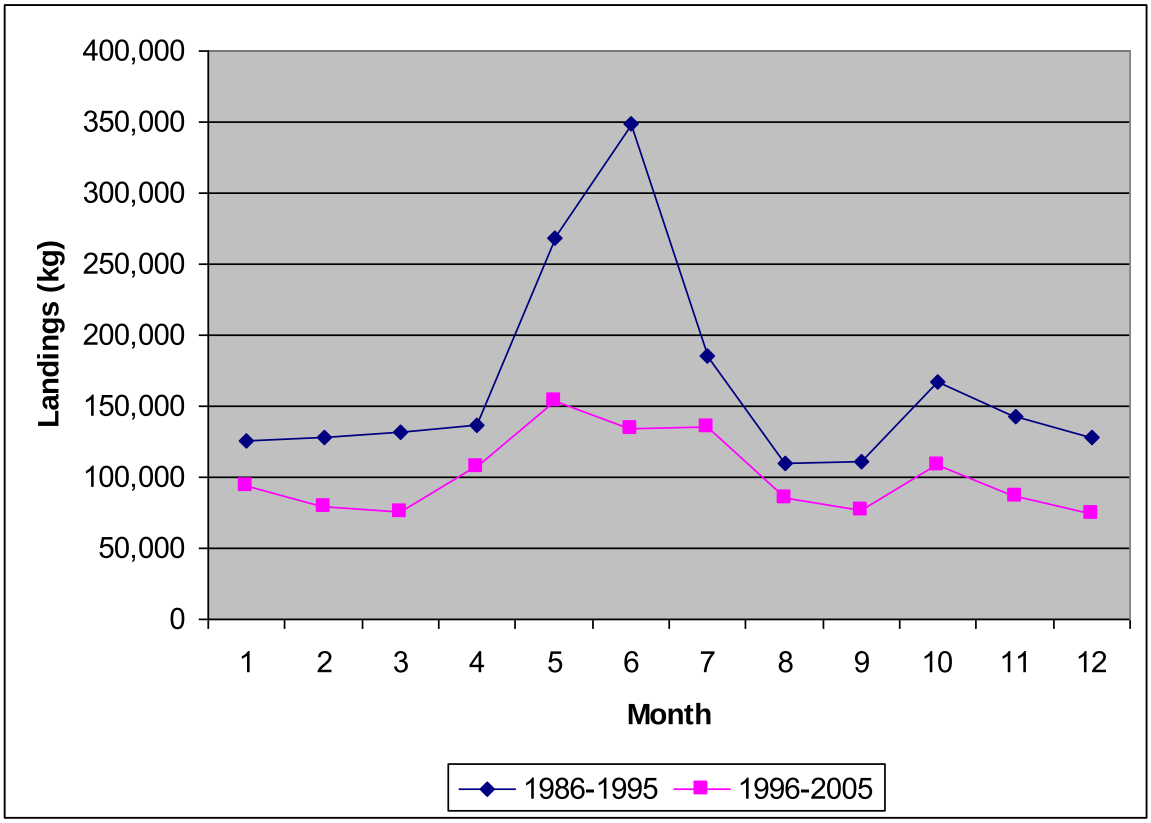
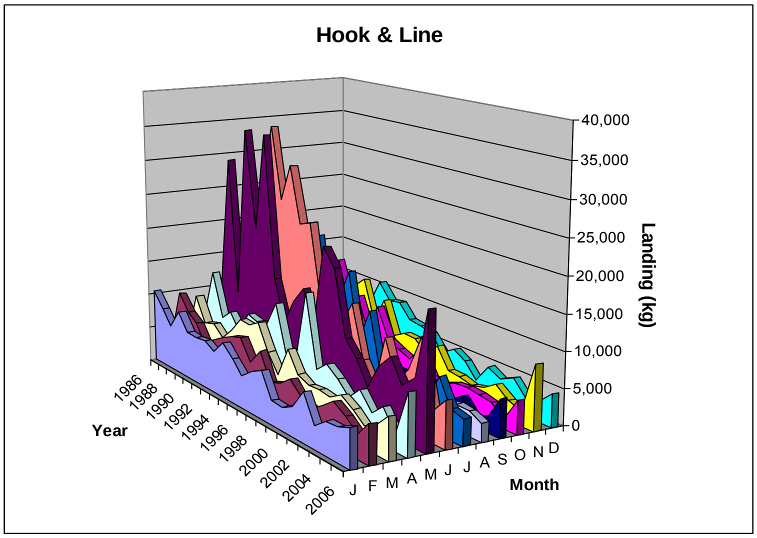


Figure 3.7. Commercial mutton snapper landings by year and month for hook and line, and longline fisheries.



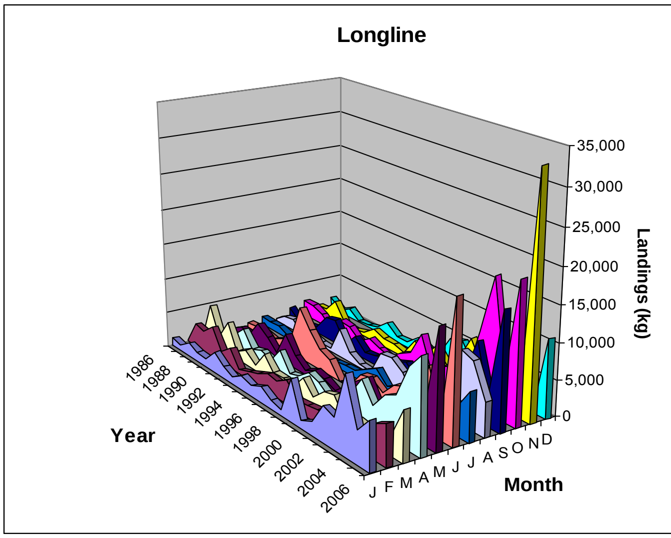


Figure 3.8. Mutton snapper commercial harvest by year and month from the Florida Keys and Dry Tortugas.

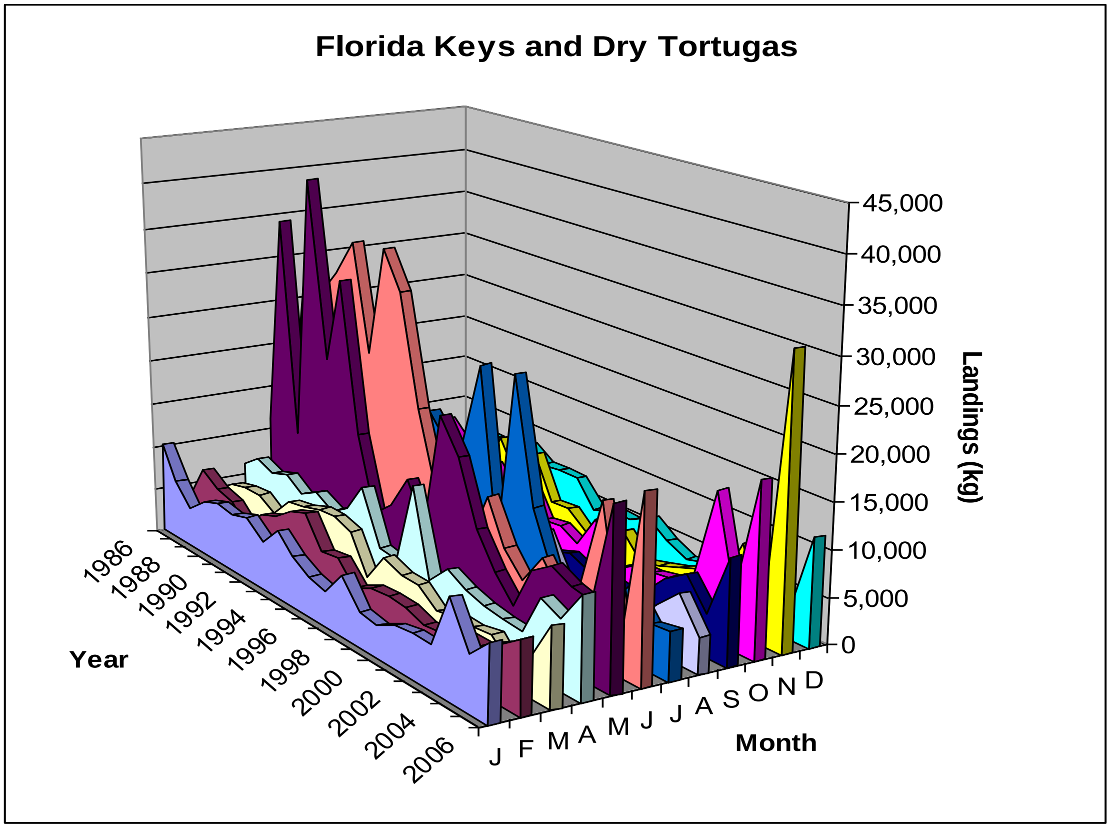


Figure 3.9. Effort as number of trips and fishers in the commercial mutton snapper fishery by region and by gear.

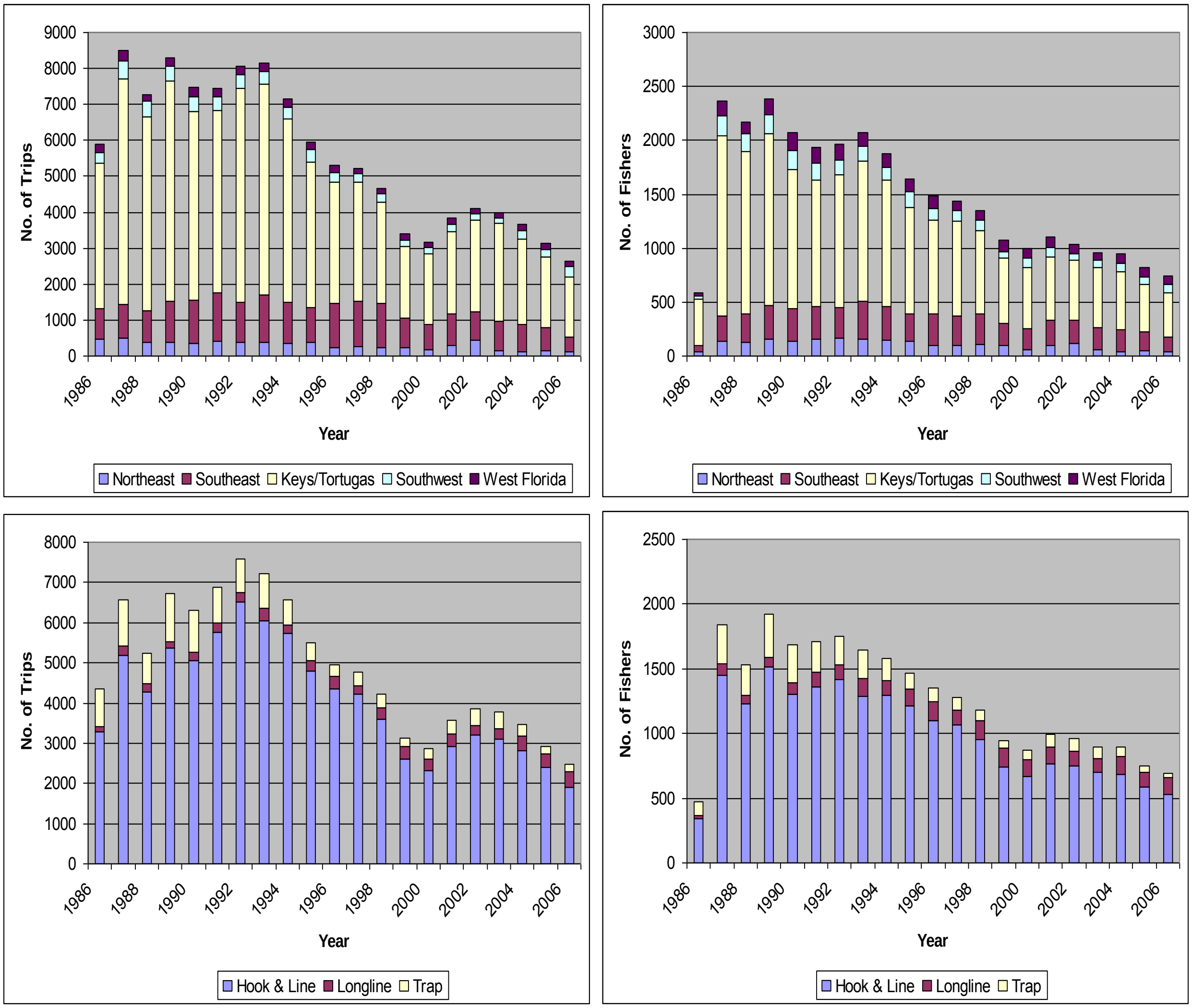


Figure 3.10. Catch per trip in the commercial mutton snapper fishery by region, and by gear.

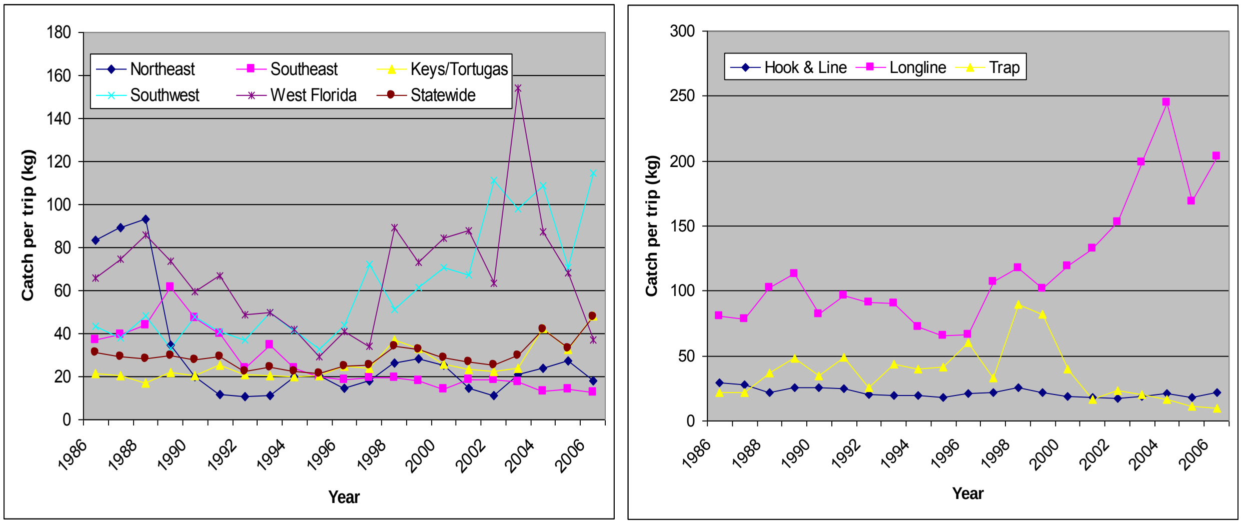


Figure 3.11. Regression of mutton snapper gutted weight-fork length data from commercial fishery samples (NMFS SEFSC Trip Interview Program), 1985-2006.

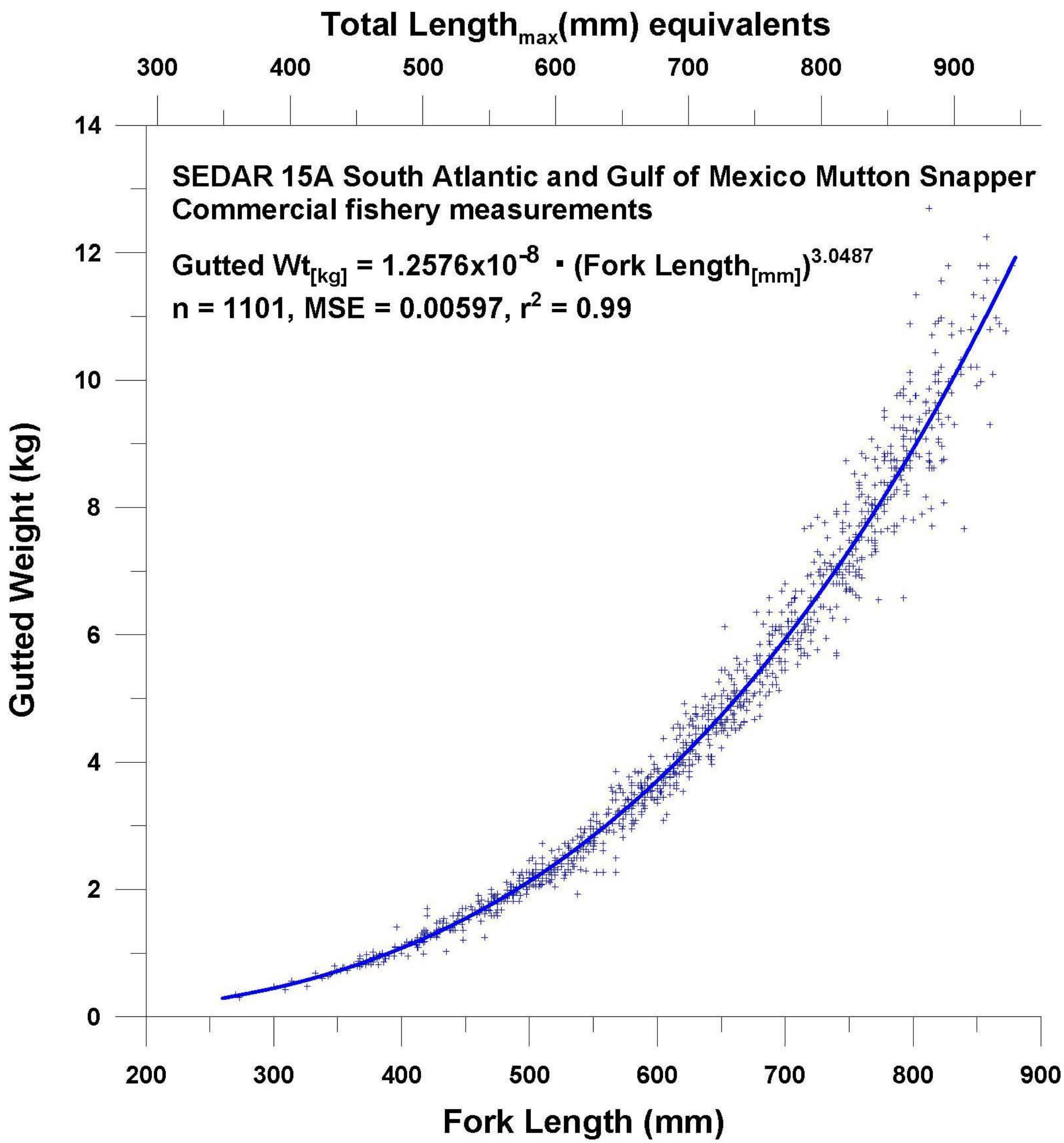


Figure 3.12. Commercial mutton snapper lengths in relation to size limit implementation by coast, 1985-2006.

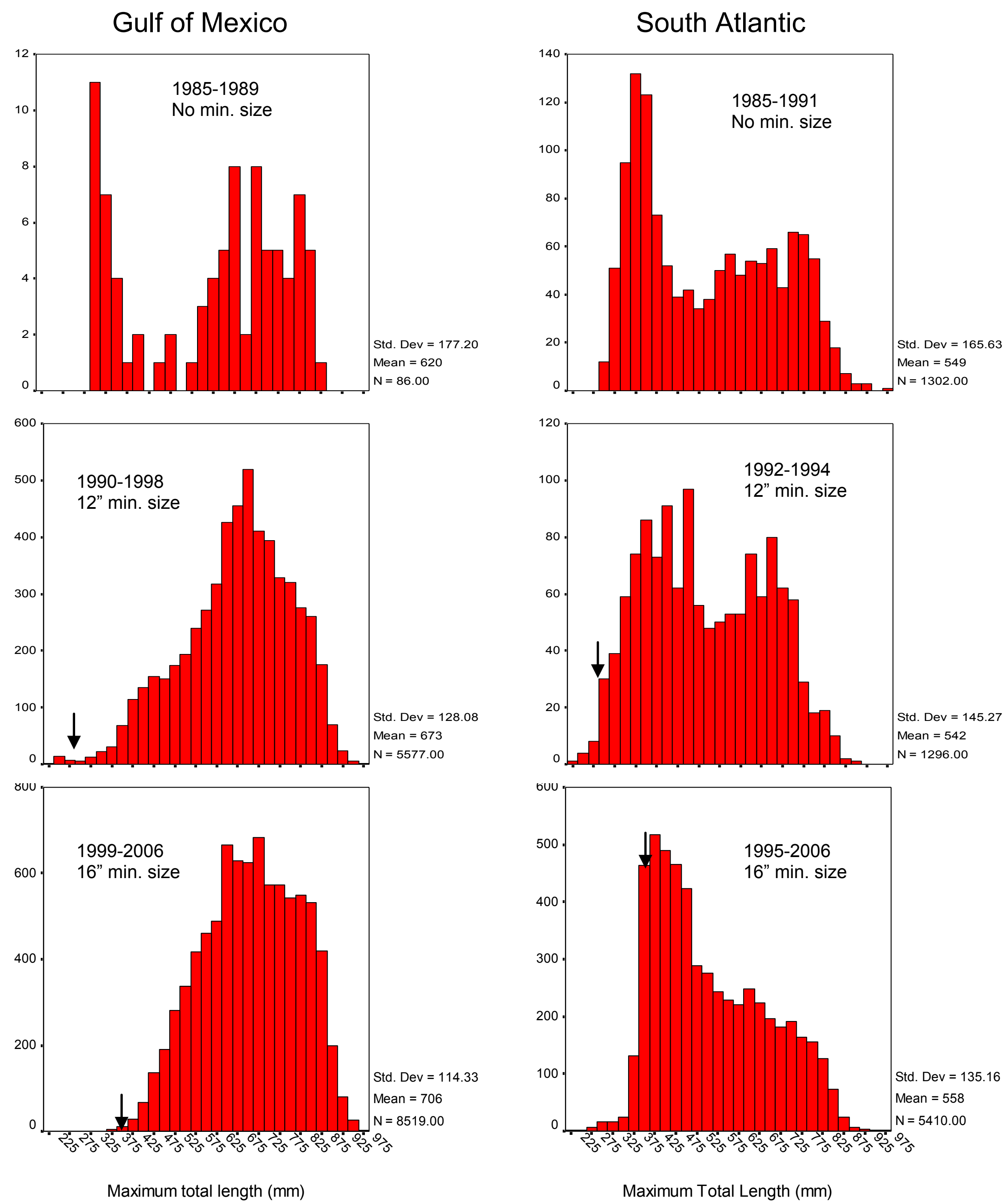
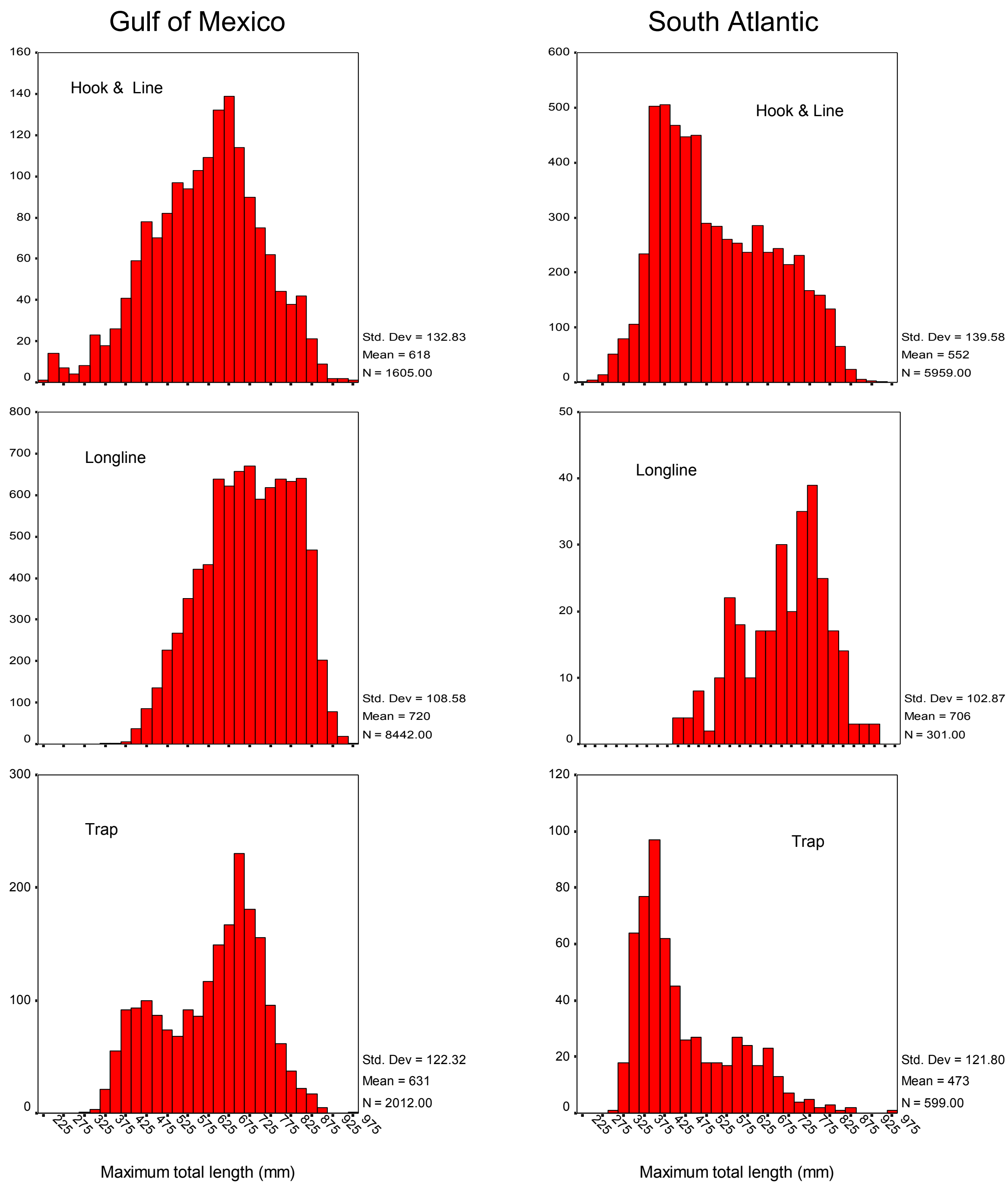


Figure 3.13. Commercial mutton snapper lengths by coast and gear, 1985-2006.



4. Recreational Fishery Statistics

4.1 Overview (Group Membership, Leader, Issues)

Members of the Recreational Fishery Working Group included Nancie Cummings, NMFS Southeast Fisheries Science Center, who also participating in the Carribbean SEDAR for mutton snapper; Douglas Gregory, County Extension Director for Florida Sea Grant in Monroe County; Dennis O'Hern, recreational fisher and Executive Director of the Fishing Rights Alliance; and the working group leader, Beverly Sauls, who supervises statewide recreational fishing surveys in Florida for FWC's Fish and Wildlife Research Institute. Also present for some of the discussions was Mike Burton, NMFS Beaufort Lab, who provided data from the Headboat Logbook Program; Kelly Sullivan, FWC, Marine Recreational Fisheries Statistics Survey (MRFSS) coordinator for the Florida Keys region; and Alecia Adamson, FWC, MRFSS sampler and coordinator of a pilot at-sea survey for headboats in the Keys. Ken Brennan, also of the NMFS Beaufort Lab, provided timely updates of the 2006 Headboat Survey data and answered numerous questions regarding the Headboat Survey sampling protocols and interpretation of the data. The group reviewed recreational fisheries landings from private anglers and for-hire sectors and concluded that the recreational fishery for mutton snapper primarily occurs on the Atlantic coast of southeast Florida and the Florida Keys, including the vicinity of the Dry Tortugas (Atlantic Ocean and Gulf of Mexico). Mutton snapper are recreationally harvested in the eastern Gulf of Mexico, as well as Georgia and South Carolina; however, the quantity of these landings is small and of little significance to the regional recreational fishery. Similarly, when we contacted Dr. Mark Fisher, Texas Parks and Wildlife, regarding recreational mutton snapper landings in Texas, he said that there were only three records of mutton snapper landings in their creel survey. Mutton snapper appear in recreational landings from shore-based fishing, private boats, charter and guide boats, and headboats. Recreational data sources for these fishing modes are described in this section.

4.2 Recreational Landings

4.2.1 Headboat Survey

The Headboat Survey, conducted by the NMFS Beaufort Lab, provides a time series of catch per unit effort, total effort, and estimated landings in number and weight (kg) from large-capacity headboats in the southeastern United States, including vessels operating in the Atlantic Ocean and Gulf of Mexico. For the east coast of Florida and Atlantic coast of the Florida Keys, the headboat logbook survey began in 1978 and effort and harvest estimates are available from 1981 to 2006. For the west coast of Florida and Gulf coast of the Florida Keys, the survey began in 1986 and estimates of effort and harvest are available from 1986 to 2006. Data on discarded catch was not requested on the logbook data sheet until 2005, when fields were added for number released alive and number released dead.

The Headboat Survey incorporates two components for estimating catch and effort:

1) Information about mean size of fishes landed are collected by port samplers during dockside sampling, where fish are measured to the nearest mm and weighed to the nearest 0.01 kg. These data are used to generate mean weights for all species by area and month. Port samplers also collect otoliths for ageing studies during dockside sampling events.

2) Information about total catch and effort are collected via the logbook, a form filled out by vessel personnel and containing total catch and effort data for individual trips.

Reporting is mandatory in this survey; however, compliance has been poorly enforced throughout the survey period and many vessels, particularly in southeast Florida, have lapsed into noncompliance (Table 4.1). Estimates of total effort and landings for non-reporting vessels are derived using data from comparable (geographically proximal, similar fishing characteristics) reporting vessels to estimate catch composition, and port agent summaries of total vessel activity information to estimate total effort by vessel by month. Correction factors derived from the ratio of total estimated effort/reported effort, on a by-month by-vessel basis, are applied to the reported landings to generate a total estimated landings, by species by vessel by month. The estimated total landings in number are multiplied by the mean weight from the dockside sampling component by species, Headboat Survey area, and month to estimate total landings in weight (kg). The Headboat Survey has operated continuously throughout 1981-2006 time frame for this assessment, and has collected fisheries data (including mutton snapper) in areas important to the recreational fishery (Southeast Florida, the Florida Keys, and the Dry Tortugas; Table 4.2, Fig. 1).

For the purposes of the assessment, and because of the distribution of landings of mutton snapper by area (Table 4.2), the numbers and weight of fish landed in the Headboat Survey areas were coalesced into five regions (Figure 2; Table 4.3). The estimated total effort (angler-days) on headboats was also summarized by these same five regions (Table 4.4). However, the amount of fishing effort directed towards fishing for mutton snapper was not calculated and probably cannot be estimated directly and was not attempted. Even with the grouping of headboat landings into the five regions, some regions had low numbers of mutton snapper landed (Table 4.3) and sometimes fewer than 30 measurements of landed fish (Table 4.5). Because mutton snapper were more likely to be landed in the Florida Keys, Southeast Atlantic, and Southwest Gulf regions (Table 4.3) across recreational and commercial fisheries (see Section 3, Commerial Fishery Statistics), landings were grouped of fish into an ‘Atlantic’, ‘Florida Keys’, and ‘Gulf of Mexico’ regions which sometimes improved the number of samples from which to calculate weight estimates. An attempt was made to re-sample the measured fish by the three region arrangement and time period (pre- and post- implementation of size limits) by bootstrapping methods to examine whether the bootstrapped samples and regressions of weight based upon lengths offered any significant changes to the calculated weights from the Headboat Survey (Table 4.6). However, the differences in most years when bootstrapped samples were drawn (see Table 4.6) tended to be small and therefore the original biomass estimates made by the Headboat Survey were recommended for assessment purposes. Table 4.7 contains the size-frequency data for mutton snapper measured by region grouped into 25 mm size classes for the 1981-2006 period. The number of otoliths collected from mutton snapper landed by headboat anglers has varied through the years (Table 4.8), but form an important component of the data used for the assessment. A majority of the otoliths were sampled from mutton snapper caught in the ‘Southeast Atlantic’ region used in this assessment which is where the majority of mutton snapper were usually landed and measured (Tables 4.3 and 4.5)

4.2.2 Marine Recreational Fishery Statistics Survey (MRFSS)

The Marine Recreational Fisheries Statistics Survey (MRFSS) provides a time series of estimated catch per unit effort, total effort, landings, and discards for six two-month periods (waves) each year. The survey provides estimates for three recreational fishing modes: shore-based fishing (SH), private and rental boat fishing (PR), and for-hire charter and guide fishing (also called party charter mode, PC). When the survey first began in 1979, headboats were included in the for-hire mode, but were excluded after 1986 to avoid overlap with the Headboat Survey.

The MRFSS surveys coastal saltwater recreational anglers from Maine to Louisiana. The state of Florida is sampled as two sub-regions. The east Florida sub-region includes counties adjacent to the Atlantic coast from Nassau County south through Dade County, and the west Florida sub-region includes Monroe County (Florida Keys) and counties adjacent to the Gulf of Mexico. Separate estimates are generated for each Florida subregion, and those estimates may be post-stratified into smaller regions based on proportional effort.

The MRFSS survey design incorporates two complementary survey methods for estimating catch and effort. Catch data are collected through angler interviews during dockside intercept surveys. Effort data are collected in a random digit dialing telephone survey of coastal households. Catch rates from dockside intercept surveys are combined with estimates of effort from telephone interviews to estimate total landings and discards by wave, mode, and area fished (inland, state, and federal waters). Catch estimates from early years of the survey are highly variable with high percent standard errors (PSE's; e.g., Table 4.9), and sample size in the dockside intercept portion have been increased over time to improve precision of catch estimates. Full survey documentation and ongoing efforts to review and improve survey methods are available on the MRFSS website at: http://www.st.nmfs.gov/st1/recreational.

Survey methods for the for-hire fishing mode have seen the most improvement over time. Catch data were improved through increased sample quotas (2x base quota in east Florida and 6x base quota in west Florida beginning in 1998). It was also recognized that the random household telephone survey was intercepting very few anglers in the for-hire fishing mode and the For-Hire Telephone Survey (FHS) was developed to estimate effort in the for-hire mode. The new method draws a random sample of known for-hire charter and guide vessels each week and vessel operators are called and asked directly to report their fishing activity. A pilot study for the FHS method was initiated in 1998 and adopted as the official survey method in 2000 in west Florida and the Keys. A similar pilot study for the FHS in east Florida began in 2000 and was officially adopted in 2003. A further improvement in the FHS method was the pre-stratification of Florida into five sub-regions for estimating effort, rather than the original two sub-regions. The five FHS subregions include northwestern Florida from Escambia through Dixie Counties (sub-region 1), the western peninsula from Levy through Collier Counties (sub-region 2), Monroe County (sub-region 3), southeast Florida from Dade through Indian River Counties (sub-region 4), and northeast Florida from Martin through Nassau Counties (sub-region 5). The coastal household telephone survey method for the for-hire fishing mode continued to run concurrently with new

FHS method through 2006, and the two data sets have been used to calibrate for-hire effort estimates from earlier years in the Gulf of Mexico (Diaz and Phares, 2004).

The incidence of mutton snapper in MRFSS angler intercepts indicate that the species is primarily encountered by the recreational fishery in southeast Florida and Monroe County (Table 4.10). . The Recreational Working Group discussed the need to separate Monroe County from the Gulf of Mexico (west Florida) landings, since the overwhelming majority of estimated Gulf recreational landings are from Monroe County. Post-stratified estimates for Monroe County were not much different than estimates for all of west Florida, and mutton snapper intercepts from outside Monroe County had little impact on overall west Florida landings in most years and modes (Table 4.11). Since west Florida landings and Monroe County landings are virtually the same, there was no need to consider Monroe County separately from west Florida unless it was important to the design of the assessment**.**

Annual estimates of harvest (A+B1) and percent standard errors (PSE) for east Florida and west Florida for for-hire, private boat, and shore modes from the MRFSS are provided in Table 4.9. The workgroup discussed the validity of shore landings for mutton snapper in the MRFSS. Springer and McErlean (1962) reported the presence of sub-adult mutton snapper from seine samples in shallow seagrass habitat in southeast Florida. Prior to July, 1985, there was no size limit for mutton snapper in state waters. Mutton snapper were reported to the workgroup to be caught from bridges in the Florida Keys and extreme southeast Florida around Miami (Ed Little, NMFS port sampler; Scott Zimmerman, FL Keys Comm. Fish. Assoc.; and Gerry Carr, FWC MRFSS sampler, all personal communication). Shore intercepts in the MRFSS are far fewer than in other modes (Table 4.10), and small numbers of shore intercepts within waves and years results in highly variable estimates and large PSE's. The workgroup decided to include the shore landings estimates as part of the recreational harvest, acknowledging that shore estimates are highly variable.

Post-stratified estimates from the MRFSS for the regions (Figure 2) used in this assessment show that the bulk of the recreational landings occur in the Southeast and Florida Keys regions (Table 4.12) and are similar to that shown by the Headboat Survey (Table 4.3). The number of released fish (MRFSS Type B2) is also highest in those two regions (Table 4.13).

The number of mutton snapper measured by the MRFSS has varied through the years and shows increases starting in 1999 (Table 4.5) coincident with an increase in sampling effort supported by the NMFS MRFSS, the Gulf States Marine Fisheries Commission Fisheries Information Network, and the Florida Fish and Wildlife Conservation Commission. However, even with these increases in sampling, the number of mutton snapper sampled through the MRFSS program remains relatively small and few were measured from the southwest and northwest regions of the Gulf of Mexico (Table 4.5). Because of the relatively small number of length measurements for this species, a re-sampling of measured fish by region and period (pre- and post- size limits) by bootstrapping and regression of body weight on size class was used to estimate the weight of recreationally caught mutton snapper to compare with the MRFSS when the number of mutton snapper measured was fewer than 30 individuals (Table 4.14). In several of the years particularly in the "Gulf (Northwest and Southwest regions)", the MRFSS estimate probably suffered from too few measurements of mutton snapper (Table 4.5) to adequately represent the weight of mutton snapper landed, and in other years the MRFSS estimate and the bootstrapped and regression-derived weight estimate were similar (Table 4.14; bootstrapped estimates are in blue). The bootstrapped and regression-derived weight estimates were recommended for use in the assessment over the MRFSS post-stratified estimates for these reasons.

Table 4.15 contains the size-frequency data for mutton snapper measured by region grouped into 25mm size classes for the 1981-2006 period. The number of otoliths collected from mutton snapper landed by recreational anglers intercepted by the MRFSS has been small, and MRFSS sampling protocols rarely permits otoliths to be taken from anglers' fish intercepted except during special collecting surveys. The GSMFC's FIN Biological Sampling program, beginning in 2002, has funded state partners to collect otoliths and other tissues from recreationally caught fish which have been very useful to the current assessment and hopefully to future ones. The number of otoliths available from this sector of the fishery is small, primarily from 2002 (Table 4.8), and the majority of the otoliths were sampled from mutton snapper caught in the 'Southeast Atlantic' region used in this assessment which is where the majority of mutton snapper were usually landed and measured (Tables 4.9 and 4.5)

4.2.3. Headboat At-Sea Survey

In 2005, an observer survey was launched in Florida to collect better information on recreational headboat catch, particularly discarded fish. The same survey was launched a year earlier in Alabama in 2004. Headboat vessels are randomly selected throughout the year in each of five sample regions (Table 4.16, sample regions same as the FHS described in the previous section). Biologists board selected vessels with permission from the captain and observe anglers as they fish on the recreational trip. Data collected include number and species of fish landed and discarded, size of landed and discarded fish, and the release condition of discarded fish. Data are also collected on the trip, including the length of the trip, area fished (inland, state, and federal waters), and minimum and maximum depth fished. In two sample regions, the Florida Keys (region 3) and western peninsula (region 2), some vessels that run multiple day trips are also sampled to collect information on trips that fish farther offshore and for longer durations, primarily in the vicinities of the Dry Tortugas and Florida Middle Grounds. While this data set is a short time series, it is the only available quantitative information on the size distribution and release condition of fish discarded in the recreational fishery.

4.3 <u>Recreational Discards</u>

Length statistics (in maximum total length, TL) for mutton snapper discards and harvested fish observed in the Headboat At-Sea Survey are presented in Table 4.17.

4.4 <u>Biological Sampling</u>

The number of measured fish for the NMFS Headboat Survey and the Marine Recreational Fishery Statistics Survey were discussed separately in the preceding sections. These data can be found in Tables 4.5, 4.7, and 4.15. The number of otoliths sampled from head boat anglers and other recreational anglers is presented in Table 4.8.

4.5 Comments on the Adequacy of data for assessment analyses

Due to low sample sizes, particularly in early years, MRFSS estimated landings in kilograms or pounds are not reliable. For private/rental boat mode in west Florida and for shore mode in both east and west Florida, low sample sizes occur in all years. B. Sauls reviewed mutton snapper landings by weight for missing cells and found east Florida shore mode landings in particular were lacking enough complete cells to adequately fill in the missing values**.**

The Recreational Working Group encourages the use of numbers of fish for estimated recreational landings for mutton snapper in place of weight wherever practicable. The decreased participation by headboat operators in the Headboat Survey over time is also cause for concern, and the Working Group recommends improved enforcement for reporting in this mandatory logbook program.

The Working Group also has requested data from NMFS in order to evaluate the necessity for calibrating MRFSS For-Hire estimates for the new For-Hire Survey method. When red snapper landings in the Gulf of Mexico were adjusted for the new method, the result was decreased landings in the For-Hire mode for many waves and areas (Diaz and Phares, 2004). A similar analysis for the east coast could not be completed in time for this assessment, but is expected to be available for the King Mackerel SEDAR Data Workshop in February, 2008.

A recommendation for consideration during the MRFSS redesign, which is currently being formulated, is the regional nature of many south Florida species, such as mutton snapper, and the need for finer resolution in regional sampling within the state. Regional fisheries, such as mutton snapper, can be poorly represented in time and space when sampled on a larger coastwide (e.g. west Florida or east Florida) scale.

4.6 Research Recommendations

Biological sampling of recreational landings in Florida has been funded on the West Coast of Florida, including Monroe County, since 2000, but continues to remain unfunded on the East Coast of Florida. Improved biological data collections are essential for making use of the best stock assessment models currently available, and the Recreational Data Working Group recommends funding and implementation of biological data collections in the shore, private boat, and for-hire modes on the east coast of Florida. The Recreational Data Working Group recommends continued funding for discard data collection and improved data collections on depth and area fished in the Headboat At-Sea Survey in Florida. Data on discarded catch is particularly important for size and bag regulate species, such as mutton snapper. The Working Group also recommends better data collection for area and depth fished in the MRFSS. Depth and area fished are particularly important for calculating depth and area-dependent discard mortality rates for reef fish species, such as mutton snapper, that are found in progressively deeper habitats throughout their life history.

4.7 Itemized list of tasks for completion following workshop

Obtain For-Hire effort estimates from NMFS Silver Spring for years where old and new estimation methods were in place in east Florida and updated years for west Florida.

Beverly Sauls; expected completion early May, 2007.

Obtain 2006 Headboat Survey Data (catch records, bioprofile data, and annual estimates) from NMFS Beaufort Laboratory.

Joe O'Hop requested and received 2006 Headboat data from Ken Brennan.

Generate calibration factors for For-Hire estimates for mutton snapper landings from east Florida and west Florida.

Beverly Sauls, expected completion May, 2007.

Generate post-stratified MRFSS landings estimates for Monroe County.

Beverly Sauls and Bob Muller, expected completion May, 2007.

Summarize headboat landings estimates for mutton snapper from logbook data and combine with MRFSS estimates for total recreational harvest.

Atlantic estimates provided by Mike Burton at the data workshop.
Gulf estimates need to be summarized. Beverly Sauls will ask Nicole Trapp to assist.

Summarize MRFSS landings and catch.

Doug Gregory.

Summarize MRFSS sampling intensity (number of mutton snapper interviews, number of lengths/weights) for west Florida and east Florida.

Nicole Trapp, expected completion 1st week of May.

Summarize headboat logbook sampling intensity (percent of vessels reporting, percent of estimated versus reported) for southeast Florida and Monroe County vessels.

Beverly Sauls will request from Ken Brennan, NMFS Beaufort.

Use MRFSS and pilot headboat survey discard data to summarize percent discards by mode.

MRFSS, Doug Gregory
Headboat, Beverly Sauls

Work with Bob Muller to summarize methods for generating CPUE's from MRFSS and Headboat logbook. Provide to Indices workgroup.

Beverly Sauls and Bob Muller

Provide supplementary data on release condition of red snapper in headboat pilot survey to Life History workgroup for comparing with discard mortality studies for this species in absence of studies for mutton snapper.

Beverly Sauls provided mutton snapper release condition data to Craig Faunce on 4/26/07.

4.8 Literature Cited

Diaz, G. and P. Phares. 2004. Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the Gulf of Mexico in 1981-1997 with For Hire Survey estimates with application to red snapper landings. NMFS, SE Fisheries Science Center, Sustainable Fisheries Division Contribution No SFD-2004-036.

Springer, V.G., and A.J. McErlean. 1962. Seasonality of fishes on a south Florida shore. Bull. Mar. Sci. 12(1):39-60.

4.9 Tables

Table 4.1. Compliance, calculated as a percent of total estimated trips that were reported in the Headboat Survey from 2004-2006 in southeast Florida and the Florida Keys. Note: Region in this survey is assigned as the area that vessels reported fishing in.

	2004 Trips			2005 Trips			2006 Trips		
Region	Reported	Estimated	Compliance	Reported	Estimated	Compliance	Reported	Estimated	Compliance
Keys/Dry Tortugas	1,320	3,156	42%	1,431	3,374	42%	1,476	3,047	48%
Southeast Florida	557	6,970	8%	602	6,921	9%	468	7038	7%

Table 4.2. Numbers of mutton snapper landed by headboat anglers by Headboat Survey area (source: NMFS Headboat Survey).

	Northeast Region							Southeast Region	Florida Keys			Southwest Region	Northwest Region					
	NC	NC	NC	SC	GA	NE FL 1	NE FL 2	SE FL	Keys	Tortugas (vessels from Key West)	Tortugas (vessels from SW FL)	SW FL	FL Middle Grounds	NW FL and AL	LA	NE TX	Port Aransas, TX	SE TX
Area	10	3	4	5	6	7	8	11	12	17	18	21	22	23	24	25	26	27
Year																		
1981-2006	24	71	90	145	1	825	7,351	248,271	115,001	105,700	1,607	1,863	1,247	44	166	629	1,442	33
1981	0	0	0	0	0	26	70	23,997	10,110	11,687	no data							
1982	0	0	0	9	0	26	24	17,707	6,977	6,393								
1983	1	0	0	85	0	6	19	10,667	9,715	8,291								
1984	0	0	85	0	0	19	38	6,456	6,198	4,714								
1985	0	0	0	0	0	0	44	10,151	5,842	5,455								
1986	0	0	0	0	0	5	163	8,482	4,311	7,769	44	29	7	0	0	255	0	0
1987	0	0	0	1	0	248	145	9,830	4,369	5,571	0	224	0	4	0	90	100	0
1988	0	0	0	1	0	12	583	16,648	3,426	3,024	0	128	0	1	0	86	1,073	2
1989	0	0	0	0	0	24	298	18,419	3,569	3,638	53	91	0	9	0	19	13	1
1990	0	0	2	4	0	23	346	23,913	4,837	9,916	251	164	36	5	3	75	10	0
1991	0	0	0	0	0	30	462	12,883	3,546	2,203	119	188	26	2	115	3	0	0
1992	0	0	1	1	0	30	663	10,376	6,190	3,259	118	49	11	2	22	4	0	0
1993	3	0	1	1	0	28	410	15,476	5,796	3,033	281	258	145	10	17	2	0	2
1994	4	0	0	4	1	27	808	12,417	6,299	4,230	336	175	25	0	5	8	0	0
1995	0	0	0	1	0	32	508	8,598	4,239	2,143	336	38	11	6	1	1	13	0
1996	0	0	0	4	0	9	209	3,591	3,143	1,797	0	36	0	1	3	5	3	0
1997	8	60	0	0	0	14	398	4,366	2,892	1,936	0	1	5	0	0	3	4	0
1998	2	1	0	12	0	19	337	2,638	2,643	1,466	0	24	0	0	0	0	43	0
1999	0	6	1	0	0	7	432	4,027	1,544	1,072	0	128	173	0	0	0	103	0
2000	1	0	0	0	0	18	294	2,900	1,885	2,926	0	136	61	1	0	0	6	0
2001	0	0	0	1	0	19	196	4,336	4,618	881	69	40	85	1	0	5	41	0
2002	2	0	0	5	0	76	582	3,215	2,066	1,959	0	7	7	1	0	0	19	0
2003	3	0	0	2	0	15	150	2,383	3,175	954	0	6	588	0	0	0	4	0
2004	0	0	0	1	0	12	45	3,450	2,565	1,195	0	131	22	0	0	2	10	1
2005	0	4	0	11	0	43	89	9,581	3,169	3,507	0	6	45	1	0	43	0	1
2006	0	0	0	2	0	57	38	1,764	1,877	6,681	0	4	0	0	0	28	0	26

Table 4.3. Numbers and kilograms of mutton snapper landed by head boat anglers by region (source: NMFS Headboat Survey).

	Number of mutton snapper kept					Kilograms of mutton snapper kept				
Year	Northeast	Southeast	Florida Keys	Southwest	Northwest	Northeast	Southeast	Florida Keys	Southwest	Northwest
1981	96	23,997	21,797			166	31,825	20,840		
1982	59	17,707	13,370			89	23,175	39,344		
1983	111	10,667	18,006	No data		176	16,615	49,434	No data	
1984	142	6,456	10,912			259	11,076	26,934		
1985	44	10,151	11,297			65	15,075	31,355		
1986	168	8,482	12,124	29	262	291	14,673	40,019	313	2,159
1987	394	9,830	9,940	224	194	564	14,124	29,298	802	695
1988	596	16,648	6,450	128	1,162	1,059	23,544	18,424	100	631
1989	322	18,419	7,260	91	42	501	28,081	20,430	268	94
1990	375	23,913	15,004	164	129	673	24,888	45,096	212	503
1991	492	12,883	5,868	188	146	711	17,545	18,380	172	130
1992	695	10,376	9,567	49	39	947	10,187	27,662	132	70
1993	443	15,476	9,110	258	176	1,024	22,695	22,609	760	506
1994	844	12,417	10,865	175	38	1,470	21,541	34,599	725	115
1995	541	8,598	6,718	38	32	1,100	11,624	18,358	112	99
1996	222	3,591	4,940	36	12	444	4,918	14,142	142	48
1997	480	4,366	4,828	1	12	1,660	5,977	14,191	3	39
1998	371	2,638	4,109	24	43	985	4,515	14,169	98	187
1999	446	4,027	2,616	128	276	877	6,196	8,065	484	1,039
2000	313	2,900	4,811	136	68	411	3,483	15,548	519	260
2001	216	4,336	5,568	40	132	312	6,233	14,742	170	574
2002	665	3,215	4,025	7	27	1,391	4,723	10,116	20	79
2003	170	2,383	4,129	6	592	423	4,030	10,284	22	2,070
2004	58	3,450	3,760	131	35	111	5,135	9,408	404	105
2005	147	9,581	6,676	6	90	203	12,466	15,230	18	249
2006	97	1,764	8,558	4	54	140	2,112	29,512	15	206

Table 4.4. Number of head boat angler days by region (source: NMFS Headboat Survey).

Year	Northeast	Southeast	Florida Keys	Southwest	Northwest	Total
1981	150,831	154,747	71,709			377,287
1982	161,439	154,558	71,614			387,611
1983	173,062	129,643	64,721	No data		367,426
1984	191,413	122,446	71,314			385,173
1985	191,834	119,169	67,227			378,230
1986	211,515	128,513	76,218	107,478	194,284	718,008
1987	228,211	136,723	82,174	127,125	159,649	733,882
1988	228,045	115,978	76,641	116,008	158,027	694,699
1989	204,306	132,944	81,586	135,135	138,860	692,831
1990	198,628	147,006	81,182	139,930	135,485	702,231
1991	194,029	127,765	68,468	99,442	139,890	629,594
1992	193,776	107,043	68,002	104,799	164,740	638,360
1993	181,737	91,020	74,698	109,284	187,535	644,274
1994	165,667	113,326	64,656	117,573	199,472	660,694
1995	161,140	94,293	57,613	104,661	177,765	595,472
1996	137,310	93,797	58,821	90,577	167,176	547,681
1997	150,103	64,450	56,059	79,624	161,033	511,269
1998	150,531	53,946	49,605	107,261	163,574	524,917
1999	144,105	65,261	41,781	105,707	136,671	493,525
2000	131,413	76,250	46,228	94,670	128,008	476,569
2001	136,841	62,271	45,888	91,195	127,064	463,259
2002	118,979	54,731	47,904	76,578	138,426	436,618
2003	112,349	49,672	42,544	73,742	151,537	429,844
2004	129,959	74,838	48,319	89,137	134,283	476,536
2005	115,148	72,515	50,785	70,482	119,608	428,538
2006	130,718	73,936	52,678	49,222	150,621	457,175

Table 4.5. Number of mutton snapper measured by the NMFS Headboat Survey and the NMFS Marine Recreational Fishery Statistics Survey (MRFSS) by region and year. Data marked in blue represent cells with fewer than 30 lengths measured annually.

Year	Head Boat Survey			NMFS MRFSS		
	Atlantic (Northeast & Southeast)	Florida Keys	Gulf (Northwest & Southwest)	Atlantic (Northeast & Southeast)	Florida Keys	Gulf (Northwest & Southwest)
1981	641	360	No data	15	17	0
1982	316	463		45	18	5
1983	462	448		9	4	0
1984	344	576		24	4	10
1985	530	492		6	6	0
1986	389	606	2	33	20	0
1987	287	491	0	20	33	0
1988	230	418	0	17	14	3
1989	440	575	7	29	5	0
1990	138	251	0	9	6	0
1991	114	108	1	9	26	0
1992	88	120	9	35	45	2
1993	160	130	0	58	44	0
1994	88	93	0	25	33	0
1995	128	77	0	26	44	0
1996	12	79	2	15	19	0
1997	305	110	0	21	45	4
1998	406	119	0	46	50	4
1999	240	92	3	61	75	0
2000	236	79	0	92	85	0
2001	367	109	0	134	54	0
2002	398	69	0	152	82	1
2003	404	82	3	182	94	3
2004	352	62	1	178	55	3
2005	398	69	0	275	16	0
2006	428	84	1	101	25	2

Table 4.6. Kilograms of mutton snapper landed by headboat anglers estimated by the Headboat Survey ("actual"), and estimated from the length measurements taken by the Headboat Survey binned in 25 mm size classes and regressions of length and weight (see Life History Section II, Table 2.12) with bootstrapped samples (**noted in blue**) if the numbers of fish measured in a region and year were below 30 individuals. The Headboat Survey estimates (green shaded portion of the table) were used in the assessment models.

Head Boat Survey, kg (actual)				Bootstrapped, regression			
Year	Atlantic (Northeast &Southeast)	Florida Keys	Gulf (Northwest &Southwest)	Year	Atlantic (Northeast &Southeast)	Florida Keys	Gulf (Northwest &Southwest)
1981	31,991	62,445	No data*	1981	30,890	62,176	No data
1982	23,264	39,344		1982	22,942	36,896	
1983	16,791	49,434		1983	17,265	46,590	
1984	11,334	26,934		1984	11,285	26,579	
1985	15,140	31,354		1985	14,480	30,715	
1986	14,964	40,019	2,472	1986	13,966	36,008	**1,008**
1987	14,689	29,298	1,497	1987	13,251	28,509	**1,451**
1988	24,602	18,424	730	1988	22,690	17,753	**3,992**
1989	28,582	20,430	363	1989	21,897	18,230	**410**
1990	25,561	45,096	716	1990	25,999	43,287	**993**
1991	18,256	18,380	301	1991	17,340	17,575	**1,449**
1992	11,134	27,662	202	1992	11,803	27,673	**344**
1993	23,719	22,608	1,266	1993	24,155	22,527	**1,269**
1994	23,011	34,599	839	1994	24,376	34,313	**951**
1995	12,725	18,357	212	1995	12,532	17,955	**243**
1996	5,362	14,143	189	1996	**4,910**	14,095	**201**
1997	7,637	14,191	42	1997	6,539	14,389	**51**
1998	5,499	14,169	285	1998	4,571	13,561	**292**
1999	7,073	8,066	1,523	1999	6,485	8,236	**1,572**
2000	3,893	15,548	779	2000	3,855	16,667	**811**
2001	6,545	14,742	745	2001	6,369	14,772	**683**
2002	6,115	10,116	99	2002	5,852	10,193	**103**
2003	4,452	10,284	2,092	2003	4,298	10,384	**1,949**
2004	5,246	9,408	508	2004	5,334	9,340	**528**
2005	12,669	15,230	266	2005	13,562	15,780	**285**
2006	2,252	29,512	222	2006	2,324	29,629	**228**

*No data: Headboat Survey expanded to the Gulf of Mexico beginning in 1986.

Table 4.7. NMFS Headboat Survey – Dockside measurements [Total Length (max.)] by region, year, and 25 mm size class.

Northwest Region

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
487.5	No data				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
562.5					0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
637.5					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
687.5					0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
737.5					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
837.5					0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
862.5					0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
887.5					0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Total					0	2	0	0	4	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	10

Southwest Region

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
337.5	No data					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
362.5						0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
387.5						0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
412.5						0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
437.5						0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
537.5						0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
562.5						0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	3
587.5						0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
637.5						0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
662.5						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
712.5						0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
787.5						0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
812.5						0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
837.5						0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total						0	0	0	3	0	1	9	0	0	0	2	0	0	2	0	0	0	0	1	0	1	19

Table 4.7 Continued. NMFS Headboat Survey – Dockside measurements [Total Length (max.)] by region, year, and 25 mm size class.

Florida Keys Region

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
212.5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
262.5	1	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
287.5	0	0	2	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
312.5	4	5	6	4	0	2	5	7	4	4	3	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	48
337.5	4	4	10	7	4	4	5	2	8	14	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	66
362.5	12	11	9	15	18	6	8	6	20	7	5	3	2	1	0	1	1	1	0	0	0	1	0	0	0	0	127
387.5	42	24	16	39	23	20	15	11	15	15	4	6	8	4	4	4	2	4	0	0	0	0	4	1	0	2	263
412.5	28	29	28	28	18	28	19	23	37	19	4	7	10	13	7	8	18	10	8	5	6	4	4	7	8	13	389
437.5	16	43	26	17	24	26	26	18	27	10	3	9	7	7	9	6	12	10	4	6	13	6	6	8	14	13	366
462.5	12	34	36	43	34	37	34	30	32	34	5	4	9	6	10	12	5	2	4	3	13	15	12	4	7	6	443
487.5	21	29	44	65	40	42	46	40	67	19	8	6	10	5	1	7	3	4	4	7	11	7	3	5	6	6	506
512.5	25	29	41	64	55	68	56	46	76	38	19	12	14	11	7	5	6	6	9	6	7	4	7	2	7	3	623
537.5	24	29	52	76	54	58	51	33	55	18	13	9	12	1	1	5	1	5	5	1	1	4	7	3	10	6	534
562.5	25	23	35	41	29	57	31	26	38	8	5	8	8	3	2	6	9	2	12	5	5	6	7	6	4	5	406
587.5	21	28	28	34	21	36	34	17	24	14	1	0	7	3	4	2	5	5	5	5	1	2	5	6	4	3	315
612.5	21	27	14	23	39	45	33	20	19	4	1	2	2	4	9	4	5	7	3	3	4	2	1	7	1	6	306
637.5	19	20	12	27	31	24	18	18	28	6	7	9	10	6	2	3	7	16	11	5	8	2	6	2	0	1	298
662.5	22	37	29	24	27	44	31	29	30	10	2	10	6	2	4	3	10	11	2	9	18	10	8	3	1	1	383
687.5	20	31	17	20	17	24	17	17	18	6	3	2	6	3	4	3	4	7	6	7	7	3	3	2	2	3	252
712.5	8	26	11	21	25	25	19	18	22	9	4	7	7	12	4	3	6	6	6	8	4	1	5	1	2	1	261
737.5	14	18	14	13	17	25	11	21	13	5	3	9	4	5	5	1	5	10	3	4	6	0	1	1	2	2	212
762.5	9	10	10	4	10	23	14	19	20	6	5	1	4	5	3	5	3	6	5	2	0	2	2	2	2	3	175
787.5	9	5	4	7	4	11	13	9	13	2	8	4	1	1	1	0	6	5	3	0	4	0	0	2	0	4	116
812.5	2	0	1	1	1	1	4	7	7	2	2	5	1	0	0	1	1	1	1	2	1	0	1	0	0	3	45
837.5	0	1	0	1	0	0	1	0	1	1	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	3	12
862.5	1	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6
887.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Total	360	463	448	576	492	606	491	418	575	251	108	120	130	93	77	79	110	119	92	79	109	69	82	62	70	84	6163

Table 4.7 Continued. NMFS Headboat Survey – Dockside measurements [Total Length (max.)] by region, year, and 25 mm size class.

Southeast Region

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
212.5	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
237.5	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	5
262.5	0	0	0	0	0	0	2	1	0	1	0	1	1	0	0	0	2	2	0	0	0	0	0	0	0	0	10
287.5	1	0	1	0	0	0	0	2	2	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	10
312.5	1	0	2	2	0	9	2	1	3	4	3	0	1	0	0	0	0	2	1	1	0	0	0	1	0	0	33
337.5	5	0	1	2	11	7	23	13	12	4	1	5	7	1	0	0	0	2	1	1	0	0	0	0	0	0	96
362.5	41	9	7	9	22	18	42	21	51	19	8	15	12	1	0	0	4	11	14	4	0	0	1	4	2	3	318
387.5	95	29	16	21	64	37	57	28	78	22	9	16	18	2	7	1	27	32	19	43	26	25	14	23	40	33	782
412.5	122	54	47	36	87	46	36	42	72	20	19	9	23	12	29	1	70	63	39	68	68	66	58	52	102	100	1341
437.5	109	84	59	40	81	46	17	27	82	18	19	5	27	6	17	1	67	74	37	37	77	80	74	59	81	115	1339
462.5	83	51	78	44	84	67	16	20	55	7	17	6	12	16	19	2	28	63	37	21	78	30	79	55	56	71	1095
487.5	60	35	79	38	56	37	22	19	27	9	9	7	9	11	10	3	31	36	19	26	39	40	42	59	43	41	807
512.5	26	17	66	44	33	38	16	12	14	2	6	2	6	6	7	1	22	29	10	9	26	27	50	30	19	23	541
537.5	20	10	42	35	23	17	13	6	18	2	0	3	6	4	4	0	14	13	16	5	13	21	18	24	15	13	355
562.5	14	3	18	22	21	15	12	5	3	5	1	1	4	3	2	0	11	14	6	10	13	24	16	16	12	7	258
587.5	16	4	18	16	13	8	7	2	3	3	1	0	2	0	1	0	5	9	8	3	6	8	7	9	5	5	159
612.5	10	3	10	15	15	6	7	3	2	0	1	0	4	1	2	0	3	11	4	3	7	8	3	3	6	2	129
637.5	6	6	6	5	5	10	2	4	2	0	1	0	2	0	2	0	2	5	3	0	2	1	7	7	5	2	85
662.5	5	3	5	9	3	4	2	5	1	1	1	1	3	3	0	0	3	6	2	1	3	6	4	3	3	1	78
687.5	5	1	2	2	6	6	3	4	5	0	1	0	4	2	0	0	1	7	4	0	1	1	9	5	2	2	73
712.5	2	0	4	1	3	4	0	2	0	1	0	0	1	1	2	0	0	1	0	0	1	3	1	0	3	0	30
737.5	1	0	1	1	1	1	2	1	2	0	1	1	1	0	0	0	0	3	1	0	0	0	2	0	0	0	19
762.5	1	0	0	1	2	2	3	0	1	0	0	0	0	1	0	0	0	4	0	1	0	0	2	0	3	0	21
787.5	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	3	0	1	1	10
812.5	0	0	0	0	1	2	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	2	0	0	10
837.5	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	1	0	6
862.5	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	5
887.5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3
937.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
987.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	624	309	462	344	531	384	287	219	435	120	100	72	146	72	102	9	295	388	222	233	362	342	394	352	399	419	7622

Table 4.7 Continued. NMFS Headboat Survey – Dockside measurements [Total Length (max.)] by region, year, and 25 mm size class.

Northeast Region

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
287.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
312.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
337.5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	3
362.5	0	0	0	0	0	0	0	1	0	0	0	2	0	2	0	0	0	1	0	0	1	0	0	0	0	0	7
387.5	3	0	0	0	1	1	1	2	1	2	1	5	4	0	0	0	1	1	1	0	0	2	0	0	0	0	26
412.5	3	0	0	0	0	1	0	3	2	1	0	0	1	1	2	0	1	2	2	1	2	3	1	0	0	0	26
437.5	4	2	0	0	1	1	1	1	0	0	1	0	0	2	3	0	1	0	0	0	1	7	0	0	0	0	25
462.5	1	0	0	2	0	0	1	2	1	1	2	0	0	3	4	0	0	0	1	0	0	8	0	0	0	2	28
487.5	0	2	0	0	0	0	0	1	0	3	3	0	1	1	3	0	0	1	3	2	0	6	0	0	0	0	26
512.5	1	0	2	0	0	0	0	0	0	0	1	1	2	1	3	1	0	1	3	1	1	11	0	0	0	0	29
537.5	0	1	1	1	2	3	0	0	0	3	0	2	0	1	2	0	1	0	0	0	1	3	2	0	0	0	23
562.5	0	0	0	0	0	0	0	2	0	1	3	2	0	0	0	0	1	0	0	0	1	8	2	0	0	0	20
587.5	0	0	1	2	0	2	0	2	0	4	1	0	1	1	1	1	1	0	5	0	0	4	1	0	0	0	27
612.5	2	1	1	0	2	0	0	0	0	1	1	1	0	0	2	0	0	3	1	1	0	4	4	0	0	1	25
637.5	0	0	0	0	0	0	1	0	0	0	1	1	0	1	2	0	3	2	0	0	0	1	1	0	0	1	14
662.5	1	0	0	0	0	0	1	0	0	0	0	1	1	0	2	0	0	1	2	0	0	1	1	0	0	0	11
687.5	0	0	0	0	0	0	0	1	0	1	0	1	1	2	0	0	0	1	0	0	0	2	0	1	0	0	10
712.5	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	1	8
737.5	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	6
762.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
787.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
812.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2
837.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Total	17	7	5	5	6	9	5	15	5	18	14	16	14	16	26	3	10	18	18	5	7	62	12	3	0	6	322

Table 4.8. Total number of mutton snapper otoliths collected by recreational fishing mode.

Year	Headboat	For-Hire	Private/Rental Boat	Mode Unknown
1979	1			
1980	17			
1981	150			
1982	169			
1983	4			
1984	20			
1985	76			
1986	33			
1987	14			
1988	33			
1989	2			
1990	6			
1991	11			
1992	10			
1993	52			
1994	51			
1995	122			
1996	24			
1997	19			
1998	0			
1999	0			
2000	3	0	0	1
2001	13	3	0	33
2002	2	109	3	6
2003	146	209	27	1
2004	135	124	5	2
2005	242	261	3	0
2006	204	65	3	0

Table 4.9. Recreational harvest (A + B1) and released catch (B2) estimates, percent standard errors (PSE), and percent of total catch that was released (% B2). Source: Marine Recreational Fisheries Statistics Survey (MRFSS).

		For-Hire (includes head boats 1981-85)					Private Boat					Shore				
Year	Subregion	A + B1	PSE	B2	PSE	% B2	A + B1	PSE	B2	PSE	% B2	A + B1	PSE	B2	PSE	% B2
1981**	East FL	8,614	67.0	0	0.0	0.0%	24,131	38.4	0	0.0	0.0%	31,374	55.6	0	0.0	0.0%
1982	East FL	31,731	38.6	0	0.0	0.0%	38,568	30.2	0	0.0	0.0%	67,461	49.5	987	100.0	1.4%
1983	East FL	7,512	31.7	0	0.0	0.0%	42,807	26.7	20,019	71.8	31.9%	38,503	57.7	0	0.0	0.0%
1984	East FL	4,944	33.1	1,287	100.0	20.7%	87,306	31.7	2,218	100.0	2.5%	0	0.0	2,121	100.0	100.0%
1985	East FL	1,753	52.1	0	0.0	0.0%	15,634	55.2	20,273	67.2	56.5%	0	0.0	11,411	100.0	100.0%
1986	East FL	553	99.9	0	0.0	0.0%	40,905	22.5	11,893	49.2	22.5%	0	0.0	7,893	72.8	100.0%
1987	East FL						74,537	27.4	126,386	84.0	62.9%	8,253	100.0	0	0.0	0.0%
1988	East FL	1,299	74.9	0	0.0	0.0%	59,423	18.5	9,778	46.7	14.1%	3,821	100.0	1,851	100.0	32.6%
1989	East FL	2,433	85.1	0	0.0	0.0%	60,926	30.4	15,520	40.8	20.3%	10,050	74.5	0	0.0	0.0%
1990	East FL	861	81.0	0	0.0	0.0%	51,128	21.9	2,650	70.7	4.9%					
1991	East FL	316	100.1	0	0.0	0.0%	59,328	21.7	17,481	31.9	22.8%	7,745	57.8	0	0.0	0.0%
1992	East FL	4,234	39.6	525	74.9	11.0%	61,236	13.5	73,295	35.9	54.5%	24,620	44.9	3,803	100.0	13.4%
1993	East FL	525	100.0	0	0.0	0.0%	94,767	13.3	75,398	25.9	44.3%	19,632	25.3	4,870	51.2	19.9%
1994	East FL	4,914	38.0	0	0.0	0.0%	57,721	15.0	58,056	23.4	50.1%	8,172	38.5	9,479	36.7	53.7%
1995	East FL	2,337	60.9	1,066	70.7	31.3%	44,300	23.8	21,263	32.3	32.4%	1,270	70.7	16,332	36.7	92.8%
1996	East FL	1,402	70.0	8,476	58.0	85.8%	28,133	21.3	27,673	25.9	49.6%	2,541	70.7	2,614	100.0	50.7%
1997	East FL	1,814	51.0	0	0.0	0.0%	33,117	23.5	63,647	20.0	65.8%	1,269	100.0	1,138	100.0	47.3%
1998	East FL	8,077	59.8	1,619	53.2	16.7%	40,485	18.4	82,399	18.5	67.1%	4,465	62.2	8,491	48.2	65.5%
1999	East FL	1,659	36.9	1,382	66.4	45.4%	29,742	18.9	38,965	17.9	56.7%	7,149	42.7	7,243	89.9	50.3%
2000	East FL	13,730	27.3	16,353	22.8	54.4%	51,648	15.3	62,310	20.0	54.7%	1,934	99.4	7,892	80.9	80.3%
2001	East FL	17,563	15.5	8,007	23.4	31.3%	39,741	16.8	41,279	20.7	50.9%	3,486	58.4	7,105	53.6	67.1%
2002	East FL	18,337	11.8	4,927	23.9	21.2%	71,669	11.9	70,291	19.3	49.5%	4,330	43.9	22,731	53.4	84.0%
2003	East FL	15,085	14.0	5,329	25.4	26.1%	58,263	15.9	41,338	16.8	41.5%	5,026	42.0	16,407	27.9	76.6%
2004	East FL	13,183	12.3	2,394	31.2	15.4%	60,696	14.9	59,676	15.2	49.6%	6,625	38.1	15,155	53.1	69.6%
2005	East FL	25,775	11.6	11,600	24.8	31.0%	99,291	11.8	131,037	14.2	56.9%	7,551	38.6	18,835	49.4	71.4%
2006*	East FL	9,186	12.9	8,940	17.7	49.3%	92,357	11.5	129,259	11.1	58.3%	6,851	44.6	16,137	37.9	70.2%

Table 4.9. Continued. Recreational harvest (A + B1) and released catch (B2) estimates, percent standard errors (PSE), and percent of total catch that was released (% B2). Source: Marine Recreational Fisheries Statistics Survey (MRFSS).

		For-Hire (includes head boats 1981-85)					Private Boat					Shore				
Year	Subregion	A + B1	PSE	B2	PSE	% B2	A + B1	PSE	B2	PSE	% B2	A + B1	PSE	B2	PSE	% B2
1981**	West	270	99.9	1,924	79.2	12.3%	259,585	50.1	0	0.0	0.0%	3,305	57.3	0	0.0	0.0%
1982	West	26,155	45.9	0	0.0	100.0%	58,510	35.1	0	0.0	0.0%	1,176	100.0	1,184	100.0	50.2%
1983	West	9,737	32.7	0	0.0	100.0%	13,454	43.0	0	0.0	0.0%	96,762	100.0	0	0.0	0.0%
1984	West	69,678	33.9	0	0.0	100.0%	135,005	53.2	90,413	58.7	40.1%	12,172	71.5	0	0.0	0.0%
1985	West	7,818	31.9	0	0.0	100.0%						2,299	51.7	1,199	100.0	34.3%
1986	West	10,793	30.5	5,141	62.8	32.3%	32,640	33.8	1,777	100.0	5.2%	12,693	100.0	0	0.0	0.0%
1987	West	11,797	31.4	0	0.0	0.0%	68,982	38.1	19,148	67.0	21.7%	20,211	94.5	0	0.0	0.0%
1988	West	4,726	48.6	87	99.6	1.8%	78,276	54.2	32,055	60.5	29.1%	3,417	100.0	26,183	72.9	88.5%
1989	West	3,002	50.4	0	0.0	0.0%	41,892	41.9	1,976	100.0	4.5%	4,154	100.0	0	0.0	0.0%
1990	West	18,900	34.5	0	0.0	0.0%	23,687	43.3	10,989	64.2	31.7%					
1991	West	5,780	43.9	0	0.0	0.0%	46,528	24.3	106,054	33.4	69.5%	16,303	100.0	7,795	71.3	32.3%
1992	West	17,221	21.1	5,648	54.2	24.7%	57,194	29.8	44,570	38.3	43.8%	3,583	100.0	3,583	100.0	50.0%
1993	West	15,970	25.6	3,631	51.4	18.5%	41,245	24.5	89,464	28.3	68.4%	18,518	33.7	10,180	68.7	35.5%
1994	West	7,678	36.4	3,827	38.4	33.3%	16,961	18.1	39,816	29.9	70.1%	11,271	29.6	7,486	48.5	39.9%
1995	West	14,915	34.5	0	0.0	0.0%	24,659	30.5	38,487	41.3	60.9%	5,964	42.1	659	99.9	10.0%
1996	West	7,152	31.1	2,280	59.9	24.2%	19,773	38.7	40,777	21.8	67.3%	1,691	73.3	1,154	100.0	40.6%
1997	West	11,457	24.1	13,002	43.4	53.2%	4,599	40.8	84,203	29.1	94.8%	2,910	70.8	0	0.0	0.0%
1998	West	8,173	19.3	3,148	34.0	27.8%	8,950	34.2	80,405	24.9	90.0%	1,002	100.1	9,096	66.0	90.1%
1999	West	7,826	16.7	1,724	38.8	18.1%	14,762	41.6	10,203	52.1	40.9%	3,934	82.4	5,437	56.2	58.0%
2000	West	2,765	12.9	291	36.7	9.5%	3,147	77.4	6,568	71.0	67.6%	0	0.0	1,383	100.0	100.0%
2001	West	2,575	11.8	221	44.0	7.9%	600	99.8	3,980	72.5	86.9%	1,604	100.0	0	0.0	0.0%
2002	West	6,215	11.8	4,755	45.5	43.3%	10,463	36.4	1,226	70.7	10.5%	980	100.0	0	0.0	0.0%
2003	West	6,923	11.4	2,261	35.2	24.6%	15,892	31.4	14,084	35.9	47.0%	8,840	55.8	5,230	72.6	37.2%
2004	West	9,104	18.6	3,843	40.3	29.7%	4,983	47.7	8,707	38.0	63.6%	1,041	99.8	7,287	52.0	87.5%
2005	West	2,322	11.6	872	31.6	27.3%	1,288	70.5	20,365	53.3	94.1%	2,369	99.8	11,845	72.8	83.3%
2006*	West	5,908	15.1	2,322	30.2	28.2%	22,544	44.5	14,303	35.2	38.8%					

* 2006 data were preliminary at the time of the data workshop

** No Wave 1 sampling

Table 4.10. Prevalence of mutton snapper interviews (interviews where anglers caught and/or targeted mutton snapper) calculated as a percent of total interviews in the MRFSS from 1982 to 2005. Regions are defined as the five sample regions used in the For-Hire Telephone Survey.

	For-Hire Mode			**Private/Rental Boat Mode**			**Shore Mode**		
Sub-Region	**Total Intercepts**	**Mutton Intercepts**	**Prevalence**	**Total Intercepts**	**Mutton Intercepts**	**Prevalence**	**Total Intercepts**	**Mutton Intercepts**	**Prevalence**
NW Florida	36,860	78	0.21	28,084	68	0.24	23,062	7	0.03
West Peninsula	18,216	107	0.59	140,617	347	0.25	64,430	16	0.02
Keys	**32,704**	**8,896**	**27.20**	**12,955**	**1,890**	**14.59**	**7,482**	**612**	**8.18**
SE Florida	**23,050**	**5,192**	**22.52**	**75,096**	**18,050**	**24.04**	**45,367**	**2,993**	**6.60**
NE Florida	4,963	208	4.19	75,465	1,502	1.99	49,520	97	0.20

Table 4.11. MRFSS estimated mutton snapper harvest (A+B1) and total catch (A+B1+B2) in numbers of fish.

	For-Hire Mode				Private/Rental Boat Mode				Shore Mode			
	West Florida (including Monroe Co.)		Monroe County Only		West Florida (including Monroe Co.)		Monroe County Only		West Florida (including Monroe Co.)		Monroe County Only	
YEAR	A+B1	A+B1+B2	A+B1	A+B1+B2	A+B1	A+B1+B2	A+B1	A+B1+B2	A+B1	A+B1+B2	A+B1	A+B1+B2
1981	270	2,193	275	2,199	259,585	259,585	160,352	160,352	3,305	3,305	2,866	2,866
1982	26,155	26,155	26,841	26,841	58,510	58,510	53,099	53,099	1,176	2,361	1,143	2,327
1983	9,737	9,737	8,748	8,748	13,454	13,454	13,647	13,647	96,762	96,762	96,762	96,762
1984	69,678	69,678	68,197	68,197	135,005	225,417	133,958	224,371	24,868	24,868	12,369	12,369
1985	7,818	7,818	7,763	7,763					2,299	3,498	1,159	3,017
1986	10,793	15,934	6,802	8,384	32,640	34,417	32,188	33,965	12,693	12,693	13,077	13,077
1987	11,797	11,797			68,982	88,130			20,211	20,211		
1988	4,726	4,812			78,276	110,331	1,726	18,899	3,417	29,599		
1989	3,002	3,002	3,437	3,437	41,892	43,868	42,558	44,534	4,154	4,154	4,154	4,154
1990	18,900	18,900	3,046	3,046	37,801	52,187	22,663	33,652				
1991	5,780	7,318	6,013	6,013	46,528	152,582	47,331	153,385	16,303	24,098	16,303	24,098
1992	17,221	22,869	16,009	21,657	57,194	101,764	30,334	74,904	3,583	7,167	3,583	7,167
1993	15,970	19,601	16,827	20,457	41,245	130,709	41,307	130,772	18,518	28,698	18,541	28,721
1994	7,678	11,504	8,132	11,958	16,961	56,777	16,905	49,987	11,271	18,757	11,274	18,761
1995	14,915	14,915	16,268	16,268	24,659	63,146	24,193	62,679	5,964	6,623	5,957	6,615
1996	7,152	9,432	7,479	9,759	19,773	61,423	16,597	44,233	1,691	2,845	1,723	2,877
1997	11,457	24,459	12,404	20,620	4,599	89,576	3,689	87,892	2,910	2,910	2,910	2,910
1998	8,173	11,321	8,721	11,790	8,950	90,194	7,748	81,950	1,002	10,099	1,002	10,099
1999	7,826	9,550	8,085	9,809	14,762	24,966	14,208	24,411	3,934	9,371	3,889	9,326
2000	2,765	3,055	2,381	2,631	3,147	9,715	3,169	3,169	0	1,383	0	1,383
2001	2,575	2,796	2,575	2,796	600	4,580	601	3,785	1,604	1,604	1,617	1,617
2002	6,215	10,971	6,215	10,971	10,463	11,690	9,423	10,649	980	980	951	951
2003	6,923	9,184	6,766	9,012	15,892	29,975	15,241	29,324	8,840	14,070	8,840	14,070
2004	9,104	12,948	9,071	12,777	4,983	13,690	3,159	7,269				
2005	2,322	3,194	2,724	4,271	1,288	21,653	1,260	20,621	1,041	8,328	1,049	8,335

Table 4.12. Numbers of mutton snapper (Type A+B1; numbers of fish) landed by recreational anglers (source: NMFS Marine Recreational Fishery Statistics Survey, post-stratified). [Note: Regions defined in Figure 2.]

MRFSS post-stratified landings (Type A + B1; numbers of fish)

Year	Northeast	Southeast	Florida Keys	Southwest	Northwest	Total
1981	8,730	42,385	203,651	3,477	8,670	266,913
1982	6,150	103,215	55,137	0	830	165,332
1983	7,173	74,448	110,413	0	0	192,034
1984	0	88,549	146,271	0	12,696	247,516
1985	0	15,634	2,259	0	0	17,893
1986	6,845	34,586	53,577	0	4,436	99,444
1987	50,544	31,981	100,383	0	0	182,908
1988	0	64,634	82,642	2,582	0	149,858
1989	25,209	48,565	50,009	0	0	123,783
1990	0	51,971	25,958	0	27,403	105,332
1991	1,167	66,103	69,758	0	0	137,028
1992	2,769	87,336	76,872	0	1,402	168,379
1993	14,599	100,337	76,457	0	0	191,393
1994	2,589	68,011	36,345	0	0	106,945
1995	12,038	35,817	46,485	0	0	94,340
1996	4,804	28,841	28,985	0	0	62,630
1997	16,036	25,926	19,960	0	970	62,892
1998	21,437	31,404	18,278	716	0	71,835
1999	14,161	23,671	26,505	0	0	64,337
2000	6,425	60,666	9,289	0	0	76,380
2001	4,444	56,842	8,254	0	0	69,540
2002	6,120	91,000	20,406	0	0	117,526
2003	3,229	77,103	34,206	47	35	114,620
2004	6,715	77,801	11,672	0	451	96,639
2005	5,462	135,889	6,884	0	129	148,364
2006	5,027	108,296	32,990	0	91	146,404

Table 4.13. Number of mutton snapper (Type B2; numbers of fish) released alive by recreational anglers (source: NMFS Marine Recreational Fishery Statistics Survey, post-stratified). [Note: Regions defined in Figure 2.]

MRFSS post-stratified released alive fish (Type B2; numbers of fish)

Year	Northeast	Southeast	Florida Keys	Southwest	Northwest	Total
1981	0	0	0	0	0	0
1982	0	1,020	1,184	0	0	2,204
1983	0	20,019	0	0	0	20,019
1984	0	4,339	90,413	0	0	94,752
1985	11,411	20,273	1,076	0	0	32,760
1986	0	19,786	3,359	0	3,559	26,704
1987	105,726	20,659	19,148	0	0	145,533
1988	0	11,629	50,293	8,032	0	69,954
1989	1,806	13,715	1,976	0	0	17,497
1990	0	2,650	10,989	0	3,397	17,036
1991	157	17,481	113,849	0	1,538	133,025
1992	1,308	76,315	53,801	0	0	131,424
1993	8,359	71,909	103,275	0	0	183,543
1994	25,302	42,233	51,129	0	0	118,664
1995	15,719	22,941	39,145	0	0	77,805
1996	9,118	29,644	44,210	0	873	83,845
1997	25,833	38,952	92,419	0	5,560	162,764
1998	38,654	53,855	86,447	6,203	839	185,998
1999	24,051	23,539	17,365	0	0	64,955
2000	19,371	67,184	2,111	6,568	0	95,234
2001	8,431	47,960	4,441	0	0	60,832
2002	21,237	77,326	3,334	0	0	101,897
2003	11,656	51,704	22,287	0	0	85,647
2004	5,003	72,441	5,801	0	4,615	87,860
2005	16,809	148,593	30,356	0	0	195,758
2006	37,519	123,508	27,141	0	3,183	191,351

Table 4.14. Kilograms of mutton snapper landed by recreational anglers estimated by the NMFS Marine Recreational Fishery Statistics Survey [MRFSS; post-stratified](“actual”), and estimated from the length measurements taken by the MRFSS binned in 25 mm size classes and regressions of length and weight (see Life History Section II, Table 2.12) with bootstrapped samples (**noted in blue**) if the numbers of fish measured in a region and year were below 30 individuals. The regression estimates of biomass from lengths and bootstrapped length estimates (green shaded portion of the table) were used in the assessment models.

Post-stratified MRFSS kg (“actual”), Type A+B1 Landings			
Year	Atlantic (Northeast +Southeast)	Florida Keys	Gulf (Northwest +Southwest)
1981	64,807	236,405	4,055
1982	74,567	172,287	1,889
1983	113,722	164,335	0
1984	109,258	262,025	0
1985	22,167	5,877	0
1986	57,816	134,091	2,069
1987	139,307	182,035	0
1988	124,901	171,727	1,087
1989	125,839	98,578	0
1990	77,068	47,167	7,541
1991	85,304	174,208	0
1992	107,743	255,219	934
1993	113,677	139,613	0
1994	83,583	57,513	0
1995	95,905	99,918	0
1996	45,030	80,419	0
1997	121,543	45,908	871
1998	84,495	51,277	608
1999	60,181	93,266	0
2000	110,012	29,741	0
2001	91,318	31,037	0
2002	167,945	59,118	0
2003	130,353	104,362	116
2004	122,597	36,770	339
2005	172,278	17,907	127
2006	167,221	86,799	0

Post-stratified MRFSS kg (bootstrapped), Type A+B1 Landings			
Year	Atlantic (Northeast +Southeast)	Florida Keys	Gulf (Northwest +Southwest)
1981	**65,857**	**241,412**	**15,247.2**
1982	75,436	**179,830**	**9,605.4**
1983	**116,967**	**169,235**	**0.0**
1984	**111,091**	**270,305**	**0.0**
1985	**22,639**	**6,115**	**0.0**
1986	58,820	**139,204**	**8,459.5**
1987	**143,580**	187,029	**0.0**
1988	**128,475**	**178,022**	**4,665.9**
1989	**128,756**	**102,074**	**0.0**
1990	**78,562**	**48,722**	**29,614.1**
1991	**86,876**	**181,046**	**0.0**
1992	109,844	266,308	**3,287.0**
1993	114,932	143,858	**0.0**
1994	**84,781**	59,040	**0.0**
1995	**98,943**	102,985	**0.0**
1996	**45,872**	**83,417**	**0.0**
1997	**128,296**	47,391	**2,564.9**
1998	86,553	53,167	**1,975.6**
1999	61,611	97,280	**0.0**
2000	112,367	30,907	**0.0**
2001	92,909	32,383	**0.0**
2002	171,785	61,314	**0.0**
2003	133,114	108,428	**261.7**
2004	124,675	38,207	**1,689.0**
2005	174,147	**18,492**	**423.8**
2006	170,180	**89,669**	**0.0**

Table 4.15. NMFS Marine Recreational Fishery Statistics Survey – Dockside measurements [Total Length (max.)] by year and 25 mm size class.

Gulf of Mexico Region

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
237.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
262.5	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
287.5	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	4
312.5	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	2	0	0	8
337.5	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	4
362.5	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	4
387.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
412.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	3
437.5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
462.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2
487.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
587.5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
787.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Total	0	5	0	10	0	0	0	3	0	0	0	2	0	0	0	0	4	4	0	0	0	1	3	3	0	2	37

Table 4.15. Continued. NMFS Marine Recreational Fishery Statistics Survey – Ddockside measurements [Total Length (max.)] by year and 25 mm size class.

Florida Keys region.

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
137.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
187.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
237.5	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
262.5	4	0	0	0	1	0	2	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	9
287.5	1	1	0	1	0	0	0	1	0	0	1	0	2	2	2	0	0	0	2	0	1	0	0	0	0	0	14
312.5	1	2	1	0	3	2	2	1	0	0	3	1	3	1	1	1	0	1	2	0	0	0	1	0	0	0	26
337.5	1	0	0	0	1	2	0	1	0	0	2	2	4	2	1	0	0	0	1	0	0	0	0	0	0	0	17
362.5	1	1	0	0	0	1	3	3	0	0	2	2	5	4	2	0	1	0	0	1	1	0	1	0	0	0	28
387.5	2	1	1	0	0	1	0	1	0	0	3	1	2	3	2	0	2	0	0	0	0	0	5	0	0	1	25
412.5	2	0	0	1	0	1	3	1	1	0	0	2	7	4	2	0	7	2	1	1	2	5	2	5	0	0	49
437.5	2	0	0	0	1	2	4	0	1	1	0	6	2	5	3	0	2	5	1	4	0	7	5	5	2	2	60
462.5	1	0	0	0	0	0	4	0	1	1	0	4	2	2	0	3	5	5	2	6	1	9	6	2	1	1	56
487.5	0	1	0	0	0	0	3	0	0	1	1	1	1	0	8	2	6	5	6	3	2	5	5	3	1	1	55
512.5	1	0	0	1	0	0	3	0	0	2	2	1	1	1	3	3	2	4	3	9	3	6	8	4	4	0	61
537.5	0	0	0	0	0	3	0	2	1	0	1	0	2	2	2	1	4	4	3	6	3	6	8	1	0	6	55
562.5	0	0	0	0	0	0	2	0	0	0	0	1	2	0	7	2	0	2	7	5	3	4	4	3	0	3	45
587.5	0	0	0	1	0	1	0	0	0	0	0	1	1	0	1	0	1	3	4	9	1	4	4	3	0	2	36
612.5	0	0	0	0	0	0	1	1	0	0	2	0	0	0	1	2	4	0	5	6	4	8	7	3	3	1	48
637.5	0	0	0	0	0	2	1	0	0	0	0	1	2	1	2	0	2	4	4	2	6	2	4	1	1	3	38
662.5	0	2	0	0	0	0	1	0	1	0	2	2	4	2	3	1	4	3	5	10	6	4	8	7	0	1	66
687.5	0	0	1	0	0	1	2	1	0	0	0	1	1	0	0	2	2	2	5	5	2	3	4	6	2	1	41
712.5	0	2	0	0	0	1	0	1	0	0	1	3	0	1	1	0	0	3	4	3	4	6	5	2	1	1	39
737.5	0	3	0	0	0	0	1	1	0	0	0	5	0	0	0	0	1	1	3	4	4	3	5	3	1	2	37
762.5	0	1	0	0	0	0	0	0	0	0	3	4	1	1	1	0	0	1	3	4	4	5	4	2	0	0	34
787.5	0	2	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	3	4	2	0	0	1	2	0	0	19
812.5	0	1	0	0	0	3	1	0	0	0	2	2	1	1	1	0	1	0	5	2	4	4	5	3	0	0	36
837.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	2	3	1	2	1	1	0	0	0	13
862.5	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	3
887.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3
912.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	3
937.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
962.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
987.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	17	18	4	4	6	20	33	14	5	6	26	45	44	33	44	19	45	50	75	85	54	82	94	55	16	25	919

Table 4.15. Continued. NMFS Marine Recreational Fishery Statistics Survey – Ddockside measurements [Total Length (max.)] by year and 25 mm size class.

Atlantic (Northeast and Southeast) Region.

TL(max) class mid-points (mm)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
137.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
162.5	0	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	6
187.5	0	6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7
212.5	0	4	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6
237.5	0	3	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	9
262.5	0	3	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0	4	5	0	0	0	0	2	0	1	22
287.5	3	5	2	0	0	3	1	0	0	0	1	0	1	2	0	0	0	0	2	1	2	0	0	0	0	1	24
312.5	1	5	1	4	0	0	1	0	0	0	1	6	7	2	2	2	2	3	1	1	0	5	1	1	1	1	48
337.5	2	3	1	5	0	1	4	0	0	0	0	4	8	1	0	0	1	1	2	4	0	0	3	0	5	2	47
362.5	3	2	0	4	0	0	0	2	1	0	0	8	3	4	1	2	2	1	2	0	2	1	1	0	2	2	43
387.5	0	0	0	1	0	0	2	3	9	1	2	6	7	1	0	2	2	1	6	2	0	5	5	13	16	4	88
412.5	3	0	0	0	0	2	0	0	2	0	1	3	4	5	6	0	1	11	7	15	30	22	35	30	81	18	276
437.5	0	0	0	0	0	1	0	0	0	0	0	0	5	4	0	1	0	5	4	15	32	33	33	28	68	16	245
462.5	0	1	0	2	0	5	3	3	3	3	2	2	3	1	4	1	0	2	6	14	19	14	25	31	42	14	200
487.5	0	1	0	1	0	5	2	0	0	1	0	0	2	0	4	0	2	4	3	12	12	17	25	24	18	9	142
512.5	1	4	0	2	0	4	0	1	3	1	0	0	3	1	2	0	0	3	4	8	9	8	12	25	22	15	128
537.5	1	2	1	1	0	1	0	3	3	0	0	0	2	0	0	1	1	2	5	1	8	6	11	5	4	1	59
562.5	1	0	0	0	5	5	1	3	1	0	0	1	1	1	0	1	0	1	2	2	5	16	8	7	6	3	70
587.5	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	5	4	8	6	3	2	5	38
612.5	0	0	0	0	0	0	2	0	3	0	0	1	2	0	0	1	3	1	2	3	5	5	4	0	4	1	37
637.5	0	0	0	2	0	2	0	0	2	0	1	0	2	1	0	2	4	1	2	2	3	0	2	4	1	4	35
662.5	0	1	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	1	1	1	0	0	4	1	0	0	12
687.5	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	1	1	1	3	3	0	2	1	1	0	1	18
712.5	0	1	1	0	0	0	0	2	1	0	0	0	0	0	1	0	0	1	1	1	1	2	1	1	1	1	16
737.5	0	0	0	0	1	0	1	0	0	0	0	1	0	0	2	0	0	3	2	1	1	6	1	1	0	1	21
762.5	0	0	0	0	0	0	2	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	2	0	0	0	8
787.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	1	1	0	0	0	0	0	5
812.5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
837.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
862.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
887.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
912.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
937.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
962.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
987.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Total	15	45	9	24	6	33	20	17	29	9	9	35	58	25	26	15	21	46	61	92	134	152	182	178	275	101	1617

Table 4.16. Number of trips sampled in Headboat At-Sea Observer Surveys in Florida. Region for this survey refers to the area the vessel is located. Some vessels sampled from the western peninsula region do multi-day fishing trips to the Keys.

Region	2005 Day Trips	2006 Day Trips	2005 Multi-Day Trips	2006 Multi-Day Trips
Western Peninsula (2)	61	80	19	23
Keys (3)	34	52	1	4
Southeast Florida (4)	95	71	n/a	n/a
Northeast Florida (5)	43	38	n/a	n/a

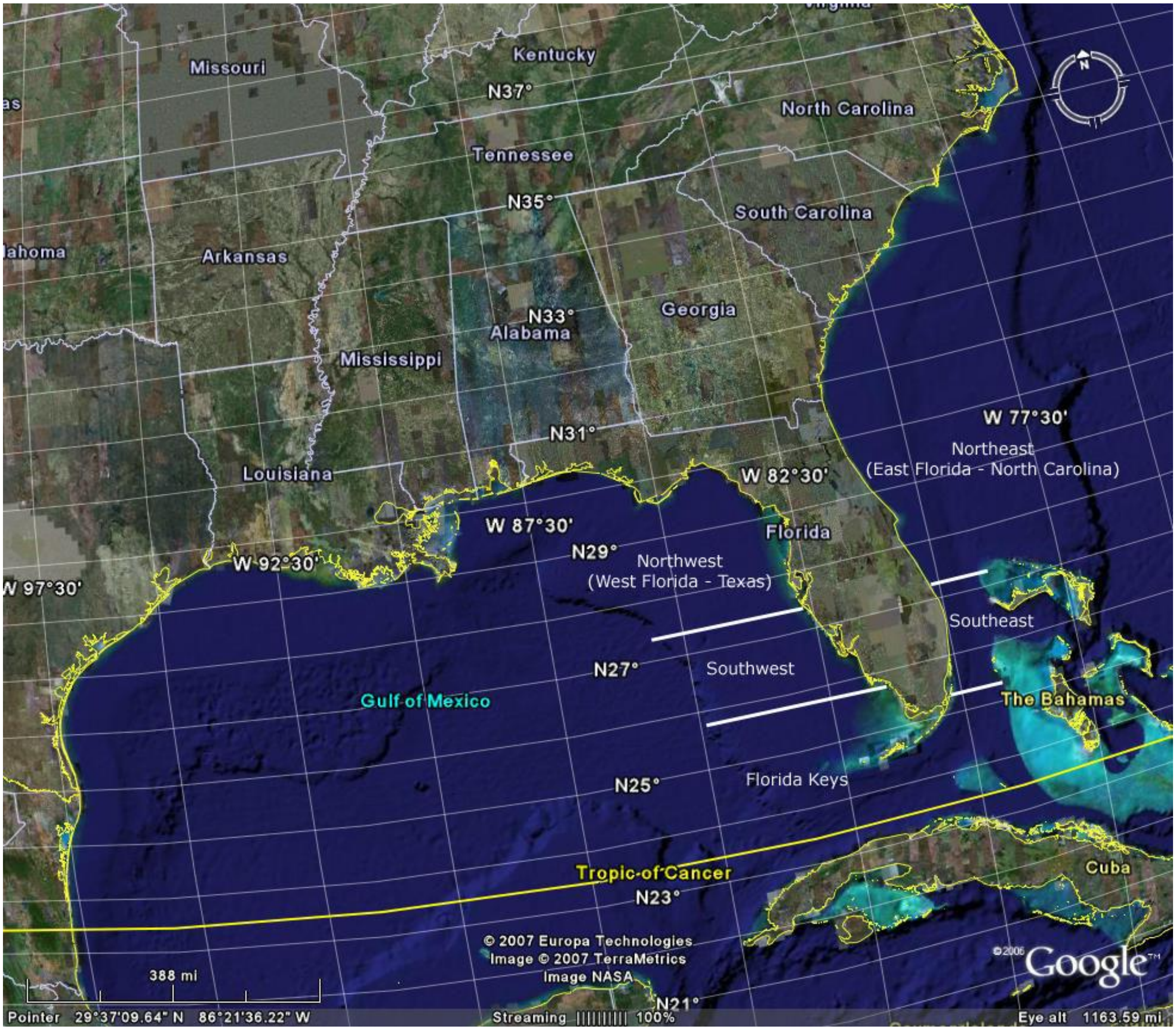
Table 4.17. Length statistics (in maximum total length, TL) for mutton snapper discards and harvested fish observed in at-sea surveys.

		Discarded Fish						Harvested Fish					
Region	Year	n	Mean	S.D.	Max	Median	Min	n	Mean	S.D.	Max	Median	Min
East FL	2005	53	366.56	36.81	522.12	371.0	270.90	145	453.14	61.89	658.06	438.38	368.78
East FL	2006	23	366.32	23.52	397.05	377.5	324.19	41	439.76	31.87	525.38	435.12	381.83
West FL	2005	19	346.68	35.57	399.23	353.6	292.65	44	575.95	116.04	833.15	540.61	415.54
West FL	2006	39	348.37	40.95	437.29	351.4	269.81	126	596.75	128.64	876.66	577.04	301.35

4.10 Figures

Fig. 1. Location of Dry Tortugas, Pulley Ridge, and Florida Middle Grounds in relation to land features of the Florida Peninsula and depth contours.

Fig. 2. Map of Southeastern United States, South Atlantic Ocean, and Gulf of Mexico showing regional divisions used for SEDAR 15A.



5. Measures of Population Abundance

5.1 Overview (Group Membership, Leader, Issues)

The Population Abundance Index group was comprised of Alejandro Acosta, Joe Cavanaugh, Mike Feeley, Karole Ferguson, Christopher Gledhill, Walter Ingram, Kevin McCarthy, and Marie-Agnes Tellier. There were several scientifically based fishery independent surveys and fishery dependent programs (NMFS SEFSC Reef Fish logbooks, Head Boat Survey logbooks) and surveys (NMFS Marine Recreational Fishery Statistics Survey) from which to develop or evaluate indices that might be suitable as indices of abundance useful for stock assessments. The task of this group, led by Alejandro Acosta, was to make recommendations on the indices that could be chosen to lend guidance to the models, and to develop appropriate parameters (i.e., ages) over which the indices should apply in the models.

5.2 Fishery Independent Surveys

5.2.1 SEAMAP Offshore Reef Fish Survey [SEDAR15A-DW-01]

Christopher T. Gledhill, G. Walter Ingram, Jr. , Kevin R. Rademacher,
Paul Felts, and Brandi Trigg
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Mississippi Laboratories, Pascagoula, MS

5.2.1.1 INTRODUCTION

The objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) offshore reef fish survey is to provide an index of the relative abundances of fish species associated with topographic features (banks, ledges) located on the continental shelf of the Gulf of Mexico (Gulf) in the area from Brownsville, TX to the Dry Tortugas, FL (Figure 5.1). The total reef area surveyed is approximately 1771 km²; 1244 km² in the eastern and 527 km² in the western Gulf. The offshore reef fish survey was initiated in 1992, with sampling conducted during the months of May to August from 1992-1997, and in 2001-2006. No surveys were conducted from 1998 to 2000 and in 2003. The 2001 survey was abbreviated due to ship scheduling and did not sample the Dry Tortugas. Mutton snapper were observed only near the Dry Tortugas and only data from the area around Fort Jefferson, Tortugas Bank and the southern most part of Pulley Ridge are included for the abundance index.

5.2.1.2 SAMPLING DESIGN

The survey area is large. Therefore, a two-stage sampling design is used to minimize travel times between sample stations. The first-stage or primary sampling units (PSUs) are blocks 10 minutes of latitude by 10 minutes of longitude (Figures 5.1 and 5.2). The first-stage units are selected by stratified random sampling. The blocks were stratified, with strata defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and SouthTexas), and by reef habitat area (Blocks ≤ 20 km² reef, Block > 20 km² reef). For the mutton snapper index, only the blocks near the Tortugas were used. The sample design was two-stage cluster sampling.

5.2.1.3 GEAR

The SEAMAP reef fish survey currently employs four Sony VX2000 DCR digital camcorders mounted in Gates PD150M underwater housings. The housings are rated to a maximum depth of 150 meters. The four Sony VX2000 camcorders are mounted orthogonally and a height of 30 cm above the bottom of the pod. A chevron (or arrow) fish trap with 1.5-inch vinyl-clad mesh is used to capture fish for biological samples. In its greatest dimensions, the trap is 1.76 m in length, 1.52 m in width and 0.61 m in depth. A 0.4 m by 0.29 m blow out panel is placed on one side and kept closed using 7-day magnesium releases. The magnesium releases are examined after each soak and replaced as needed. The trap is deployed at a randomly selected subset of video stations. Both the camera pod and fish trap are baited with squid.

5.2.1.4 VIDEO TAPE VIEWING PROCEDURES

One video tape from each station is selected out of the four for viewing. If all four video cameras face reef fish habitat and are in focus, the viewed tape is selected randomly. Tape viewers examine 20 minutes of the selected video tape, identify, and enumerate all species for the duration of the tape. Identifications are made to the lowest taxonomic level and the time when each fish enters and leaves the field of view is recorded. This is referred as a time in - time out procedure (TITO).

Tapes are viewed from the time when the view clears from any silt plume raised by the gear when it landed. Less than 20 minutes may be viewed if the duration when water is not clear enough to count fish is less than 20 minutes, or if the camera array is dragged. If a tape contains a large amount of fish, it is sub-sampled. There are four cases for sub-sampling:

1) when there is generally a large number of fish of a given species present throughout the tape so that following individual fish is difficult;
2) large number of fish occur in pulses periodically during the tape;
3) a single school of fish; and,
4) multiple schools of fish. The estimator of relative abundance we use from the video data is a minimum count (i.e., mincount: the greatest number of a taxon that appears on screen at one time).

5.2.1.4 STATISTICS

Design-based Estimator

The design-based estimator of abundance employed is a ratio estimate for two-stage sampling with unequal cluster size (Cochran, 1977).

1. Cluster mean

$$\bar{x} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}}{\sum_{i}^{n} m_i},$$ is a ratio estimate of the number of mutton snapper where x_{ij} is the number of fish observed at the j-th site in the i-th block, and m_i in the number of sites sampled in the i-th block.

2. Variance of the ratio estimate of the cluster mean ($V(\bar{x})$), ignoring finite population correction

$$V_{\bar{x}} = \frac{1}{\bar{m}^2}\left[s_x^2 + \bar{x}^2 s_m^2 + 2\bar{x}COV_{x,m}\right],$$

where s^2_x and s^2_m are the variances of the number of mutton snapper and number of units sampled in a cluster, $COV_{x,m}$ is the covariance between number of mutton snapper and number of units sampled in a cluster and $\bar{m}$ is the average number of sites sampled within a block.

Model-based Index

In addition to the calculations of cluster means, a delta-lognormal modeling approach (Lo *et al*., 1992) was employed in order to develop standardized indices of annual average mincount for mutton snapper in the region near the Tortugas. This index is a mathematical combination of yearly mincount estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive mincounts (i.e., presence/absence) and lognormal model which describes variability in only the nonzero mincount data. The GLMMIX and MIXED procedures in SAS were employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. The parameters tested for inclusion in each sub-model were region, year, block nested within year, and station depth (scaled to a mean of one). All variables were considered fixed except for block nested within station, which was considered random. Also, separate covariance structures were developed for each survey year. For the binomial sub-models, a logistic-type mixed model was employed. Model selection was based upon the AICc statistic (i.e. the Akaike's Information Criterion corrected for sample size). This statistic considers both the likelihood of the model and the number of parameters (Burnham and Anderson, 1992); the smaller the statistic – the more appropriate the model. Initially, several sub-model types were used to describe the nonzero mincount data. These included lognormal, Poisson and negative binomial. Based on analyses of residual scatter and QQ plots, the lognormal sub-model was more fitting than the others in describing the variability in the nonzero data.

Fish Sizes

The size of mutton observed during the SEAMAP survey comes from fish measured on video tape using laser reference points, which were first introduced in 1995.

5.2.1.5 RESULTS

Design-based Results and Conclusions

Abundance data from all blocks sampled around the Dry Tortugas were included for analysis during all years. Few sites were sampled in 1992 – 1994. Sampling effort increased is subsequent surveys. The index of mutton snapper abundance has increased since 1992 (Table 5.1, Figure 5.3). No mutton snapper were hit by lasers until the 2005 survey. Two fish were measured in 2005 and three fish in 2006. Fork length ranged from 439 mm FL to 517 mm FL (Table 5.2).

Model-based Results and Conclusions

Due to issues of model convergence and index calculation, we dropped data during the 1994 survey year for both sub-models, due to zero catch at all site sites that year. Table 5.3 summarizes the parameters of the resulting binomial sub-model with the lowest AICc = 1405.2. The lognormal sub-model would neither converge while using separate covariance structures for each year, nor while including block nested within year as a random variable. Therefore, a similar covariance structure was used for all years, and block was included as a fixed variable in the sub-model. Table 5.4 summarizes the parameters of the resulting lognormal sub-model with the lowest AICc = 76.6. Table 5.5 and Figure 5.4 summarize the index values for mutton snapper from the Dry Tortugas area. There is an increasing trend early in the time series, with the trend reaching a plateau in 1997. This differs from the design-based index in that it peaks in 2002. Also, the design-based index has lower CV values. Point estimates between indices were very similar during the early years of the time series, and during later years, the greatest difference occurred in 2002. Usually, the advantages of a model-based approach, used to standardize annual abundance indices and based on the variables described herein, would result in a recommendation for its use over a design-based approach. However, due the small difference between point estimates of both approaches and due to the lower CV values, we recommend the use of the design-based indices (Table 5.5).

5.2.1.6 COMMENTS ON ADEQUACY FOR ASSESSMENT

Use the size based estimator as an index for 2 to 5 year old, as a base for stock assessment.

5.2.2 Annual Indices of Abundance of Mutton Snapper for Florida Keys: Stratified-random sampling (SRS) with visual point counts [SEDAR15A-DW-02].

Alejandro Acosta and Robert Muller
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5.2.2.1 INTRODUCTION

Survey geographic range

The survey is conducted in the open-waters of the Florida Keys National Marine Sanctuary (FKNMS). For the purposes of the Fisheries Research, Fisheries Independent program, the sampling universe in the FKNMS was divided into six geographical zones, designated A through F, four of which were sampled during the present study; (Figure 5.5). Zone A includes all of the waters surrounding Key Largo, the northernmost and largest island in the chain. Zone B extends from the southwestern end of Key Largo along the rest of the Upper Keys to Long Key. Zone C encompasses the Middle Keys from Long Key to Big Pine Key, while Zone D surrounds the Lower Keys (Big Pine Key to Key West) (Figure 5.5). Visual sampling was only conducted on the Atlantic side of the Keys.

5.2.2.2 SAMPLING METHODS

Visual Census

The Finfish program currently uses the stationary point count method for its visual surveys. In this method, a stationary diver records the number of individuals of each target species that are observed within an imaginary five-meter radius cylinder and assign length intervals to each. Two divers conduct a total of four point counts at each site. During the visual survey, each diver lays out a 25 meter tape in a pre-determined direction opposite from the other diver. The tapes are laid as straight as possible within the same habitat type, with at least a 15 meter distance between each point count. The first count is conducted at the 10 meter mark, and a second count is conducted at 25 meters. If suitable habitat is not present at the designated mark then the distance is adjusted accordingly. At each survey point, the diver stops and remains still for two minutes, allowing for a settling period. During this time period, the diver records depth, substrate, habitat type, relief, complexity, percent and type of biotic coverage within the area to be surveyed, which is the cylindrical area extending out 5 m from the center point and extending from the substrate to the surface. After the settling period, the diver records the time and begins estimating the number of fish in each five-centimeter size class for all the target species present. The diver has three minutes to allow the fish to naturally redistribute themselves and to list the target species present within the survey cylinder. This time period also allows for cryptic species to reveal themselves for counting.

A habitat-based, random-stratified site selection procedure, based upon the "Benthic Habitats of the Florida Keys" GIS system, was used to select 39 sample sites each month. Sampling sites were randomly selected using a one longitudinal by one latitudinal minute grid (approximately 1nm^2) system. One mile square grids containing areas defined as "Patch Reefs" and "Platform Margin Reefs" were included in the sampling universe, with further random selection of one of 100 " micro-grids" within each selected sampling grid (Figure 5.6). Within each grid chosen for sampling, a second random selection of one of one hundred 0.1′ x 0.1′ "micro-grids" (~ 0.01 nautical mile) determined the nominal location within the grid, providing that micro-grid contained reef or patch reef habitat adequate for sampling purposes (Figure 5.6). If this was not the case, a randomization procedure was used to relocate the sample to a nearby micro-grid with the desired habitat.

Species sampled

These surveys sampled fifty-four species of commercial and recreational importance members of the following families: Haemulidae (thirteen species); Serranidae (thirteen species); Lutjanidae (nine species); Chaetodontidae (seven species); Balistidae (three species); Labridae (three species); Pomacanthidae (two species) and Priacanthidae (two species).

Unit measure of abundance

Density (# fish/100 m^2) was used as an index of relative abundance. Density estimates by year, season, strata, and zone were used for spatial comparisons.

Temporal and spatial resolution

The surveys are conducted from April to October, Thirty nine randomly select 39 sites (13 in Zone A, 10 in Zone B, 6 in Zone C and 10 in Zone D) are conducted each month.

Series period

From 1999 and 2000, we used to sampling gears transects and point counts. Since 2001- 2004 and 2006, we sampled with visual point counts.

5.2.2.3 RESULTS

Indices

The FWC visual survey index (VS) used the dives conducted from 1999 through 2006. While each dive is frequently considered a cluster sample and the response variable is the combined total number of fish observed by both divers; in this survey, the spatial extent of a single dive can encompass multiple bottom habitat reliefs and so we used the combined number of fish by species by bottom habitat relief observed by divers as the response variable. There were a total of 2198 unique dive/habitat combinations. However, mutton snapper were not found in all of them. Therefore, the number of dive/habitat combinations used to develop the index were all of those that saw mutton snapper (539) plus some additional dives (248) that possibly could have seen mutton snapper. The additional dives were identified through a logistical regression technique (Stephens and MacCall 2004) that used the presence or absence of other species seen to estimate the probability that a dive potentially could have seen mutton snapper. When compared to the dive/habitat combinations that observed mutton snapper, the logistic regression used sixteen species of fish to determine the probability that a trip could have seen mutton snapper. To determine which dives to include in the analyses, the number of false positive dives (the dive's probability based on the logistic regression was at least the critical value but mutton snapper were not observed on that dive) and number of false negative dives (the dive's probability was less than the critical value but mutton snapper were observed on the dive) were tallied for each possible critical value. The curves of the predicted false positive dives and false negative dives crossed at a critical value of 0.345 (Fig. 5.7).

Once the individual dive/combinations were identified, we estimated the mean number of mutton snapper per dive per habitat by year with a generalized linear model in SAS (PROC GENMOD) that used a Poisson distribution with a log link. The potential explanatory variables were year, month (May-October), zone, bottom habitat relief, secchi distance, and depth. Secchi was categorized by two meter intervals from six or less meters to 26 or more meters. Depth was categorized by 10 feet intervals with all depths greater than 60 feet combined. Variables to include in the model were selected in a stepwise manner using the percent change in mean deviance (deviance/df, 0.5% minimum based on recommendation from SEDAR 3) and that the variable was significant at the 0.05 level. Neither month nor depth was significant in the final model.

The VS index showed lower levels for 2001-2003 and then followed by an increase back to the earlier levels (Fig 5.8). Similarly, lower VS index were observed in the Middle Keys (zone C) (Fig 5.9).

Because the visual survey estimates the total length of fish as well as the number of fish observed, we were able to re-run the catch rate analyses separating mutton snapper into juveniles (TL < 375 mm, the upper 95 percentile for sexes combined) and adults. As before, additional dive/habitats were identified using the Stephens and MacCall approach and the catch rates were calculated using generalized linear models with the same potential explanatory variables with the addition of the bottom habitat type (edge, intermittent reef, or continuous reef). Table 5.6 lists the species associated with mutton snapper juveniles and adults. Only four species out of 22 were statistically significant for both life stages.

Divers observed juvenile mutton snappers on 181 dive/habitats with another 131 dive/habitats (critical value = 0.201, Fig. 5.10) that potentially could have caught mutton snapper. Significant variables reducing the mean deviance in juvenile catch rates included year, zone, secchi distance, bottom habitat type, month, and bottom habitat relief. Juvenile mutton snappers showed a large increase in numbers per dive/habitats observed in 2004 and 2006 (Fig. 5.11). On average, more juvenile mutton snappers per dive/habitat were observed in the Lower Keys (Zone D, Fig. 5.12). Divers observed adult mutton snappers on 412 dive/habitats and there were 262 additional dive/habitats that potentially could have caught mutton snappers (critical value = 0.272, Fig. 5.13). There was no temporal trend with adult mutton snappers (X^2 = 6.93, *df* = 6, *P* = 0.33) because only zone and secchi distance reduced the mean deviance in adult catch rates more than 0.5%. The overall mean value was 0.75 mutton snapper per dive per habitat. More adult mutton snappers per dive were observed in the Upper Keys (Fig. 5.14).

Examining the visual survey data by life stage (juvenile or adult) provides some insights into mutton snapper dynamics. For example, the increase in catch rates in 2004 and 2005 (Fig. 5.8) was due to divers seeing higher numbers of juveniles (Fig. 5.11). Conversely, overall there were more mutton snappers in the Upper (Zone A) and Lower Keys (Zone D) than in the Middle Keys (Zone C) (Fig. 5.9) but that results from the more juveniles being observed per dive in the Lower Keys (Fig. 5.12) and more adults in the Upper Keys (Fig. 5.14).

5.2.2.4 COMMENTS ON ADEQUACY FOR ASSESSMENT

Potential advantages

Relatively low-cost and scientifically valid fisheries independent monitoring methods are continually being sought and the use of visual census survey methods to conduct assessment of coral reef ecosystems is an example of a non-destructive and low cost sampling tool. The principal goal of our visual census survey was to evaluate the relative abundance, size structure, and habitat utilization of the reef fish species that comprise local, commercial and recreational fisheries in the Florida Keys reef ecosystem. We feel that the primary attainable criteria for a successful fishery monitoring program using a visual census sampling approach is to establish and maintain a consistent sampling methodology which will track relative changes in abundance and which generate sample sizes adequate to allow meaningful statistical comparisons within the observed range of abundance levels. We feel that our sampling protocol had produced robust density estimates and enough information to meet those two criteria.

Potential problems/limitations

Length frequency information is an essential component for any visual-based monitoring program; estimating fish lengths underwater is not an easy task and there are many possible sources of error, however, we feel that our estimates of fish lengths are very robust due to the rigorous training and testing undertaken by our observers. Some of the main limitations of visual censuses are those inherited with the methodology. We considered that we under sampled the deeper reef habitats of the Florida Keys and as a consequence we are probably missing the larger and more reproductive fishes for some species such as grouper.

5.2.2.5 GENERAL RECOMMENDATIONS

- Recommend using a design based estimator for an index for 0 to 20 year old.
- Do not recommend a modified Stevens & MacCall procedure for station selection.
- Leave up to stock assessment workgroup for decision about partitioning life history/age groups. ALEJANDRO: size maturity around 2 year old; and we have the size info, so WE should do the split ourselves.
- Incorporate use of stereo-video camera. Increase the depth range of the survey.

5.2.3 Annual Indices of Abundance of Mutton Snapper for Florida Keys: Juvenile Snapper Seining Program [SEDAR15A-DW-03].

Karole Ferguson
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5.2.3.1 INTRODUCTION

The intent of this program is to describe the distribution and abundance, species composition, size structure, and habitat usage of juvenile snapper species in the middle Florida Keys and to establish recruitment signals, which may be used as tuning indices for stock assessment and management of these economically important snappers in the Keys.

5.2.3.2 SAMPLING DESIGN

Sampling Intensity-Time Series

From 1994-1997 a bonefish life history study was conducted using seines at six fixed stations in the middle and lower Keys. During this study, a total of 433 juvenile snapper were also collected, 11 of which were *Lutjanus analis* (mutton snapper). Based on the promising number of snapper collected during this study we conducted a six-month pilot project from June through November 2003 in order to determine the feasibility of collecting early life stages of snappers in shallow mixed-species seagrass beds adjacent to sandy beaches. Sampling was conducted in the middle Keys from Long Key to Bahia Honda Key. Twelve randomly selected sites were sampled each month. During this pilot study, we were successful in collecting relatively high numbers of snappers during 72 hauls.

Due to the encouraging results of the initial pilot project, we conducted a year-round study in the middle Keys from April 2005 through April 2006. A total of 30 randomly selected sites were sampled each month for a total of 342 hauls. Seines were not conducted during October 2005 due to damage to facilities and logistical constraints following Hurricane Wilma.

In June 2006 we began a long-term seine monitoring project that continues to this day. Sampling is conducted in the middle Keys from Grassy Key to Boot Key. Monitoring locations were chosen based on the sites with the highest snapper abundance from the previous two studies. Ten randomly selected sites are sampled each month, for a total of 90 hauls as of February 2007.

Methods

Sampling is conducted on the Atlantic side of the Middle Keys in shallow (<1.3m deep) mixed-species seagrass beds consisting of *Halodule wrightii*, *Thalassia testudinum*, *Syringodium filiforme*, and mixed algae. Sites are selected by a habitat-based, stratified-random-sampling procedure based upon the "Benthic Habitats of the Florida Keys" Geographical Information System (GIS) (FDEP and NOAA, 1998) (Figure 5.15). One seine haul is conducted at each site during daylight hours using a 21.3m center-bag drag offshore seine, constructed of knotless 3.2mm #35 Delta nylon-mesh and a 183cm x 183cm x 183cm bag. The net coverage area is approximately 140 m^2/haul. All snappers collected are counted and measured to the nearest mm (with the exception of snapper collected during the first two seine projects which were only measured if < 100mm). Young juvenile snapper are defined as ≤ 100mm standard length (SL), settlement-stage snapper as ≤ 40mm SL, early-stage juveniles as > 20mm to ≤ 40mm SL, and new recruits as ≤ 20mm SL.

5.2.3.3 RESULTS

Since seine sampling began in 2003, we have collected a total of 1,291 snapper and measured a total of 1,224 snapper. Mutton snapper constitute 12% (n=161) of the total number of snapper species collected (Table 5.7). During 2003, a total of 363 snapper were caught and 313 were measured in 72 seines from June through November. The most abundant snapper was the gray snapper, *Lutjanus griseus* (n=156). A total of 62 mutton snapper were collected, with a mean size of 36mm SL. The majority of these (68%) were settlement-stage individuals. During 2005-06 a total of 630 snapper were collected and 613 were measured in 342 seines from April 2005 through April 2006. *Lutjanus griseus* was the most abundant snapper measured (n = 248). A total of 51 mutton snapper were measured with a mean size of 30mm SL, 82% of which were settlement stage individuals. During June 2006 we began a long-term seine monitoring project in the middle Keys. A total of 298 snapper have been collected and measured in 90 seines through February 2007. *Lutjanus griseus* has been the most abundant snapper collected to date (n = 86). A total of 48 mutton snapper have been collected, with a mean size of 42mm SL. Of these, 58% are settlement stage individuals.

Mutton snapper mean density varies between sampling years. Annual mean density was highest during the 2003 project with 0.6 snapper/100m^2, and lowest during the 2005-06 sampling period with only 0.1 snapper/100m^2 (Figure 5.16). The majority of mutton snapper were collected from June through November, but the peak months varied between years. During 2003, the highest number of mutton snapper was collected during the month of August followed by a second peak in October. The majority (85%) of the August snapper were split evenly between new recruits ($\leq$ 20mm SL), and young juveniles (41-100mm SL), while 47% of the October snapper were early juveniles (21-40mm SL) (Figure 5.17). During the 2005-06 sampling project, mutton snapper numbers were highest during September followed by a second peak in November. The majority (78%) of the September snapper were early juveniles, while 64% of the November snapper were new recruits (Figure 3). During the 2006-07 monitoring project, mutton snapper numbers were highest in June followed by a second peak in November. Early juveniles were the most abundant snapper collected during both months at 80% and 64%, respectively (Figure 5.17).

Mutton snapper length frequencies were fairly consistent from year to year, with 70% of the snapper collected being settlement stage individuals (Figure 5.18). During 2003, 68% of the mutton collected were settlement stage, during 2005-06, 82% of the mutton collected were settlement stage, and during 2006-07, 58% were settlement stage. Greater numbers of new recruits were collected during 2003 than during 2005-06, and there were no new recruits collected during 2006-07.

5.2.3.4 COMMENTS ON ADEQUACY FOR ASSESSMENT

None.

5.2.3.5 RESEARCH RECOMMENDATIONS

Recommend continuing this project because in the future it might provide a good juvenile index

5.2.4 Nearshore Hard-Bottom Community Survey of the Florida Keys [SEDAR15A-DW-04].

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5.2.4.1 INTRODUCTION and SAMPLING METHODS

This study examines and quantifies sessile structure, motile invertebrates, and fishes in the nearshore hard-bottom habitats throughout the Florida Keys (from Key Largo to the Marquesas Keys). Thirty-two permanent sites, stratified by species richness and structural complexity of sessile invertebrates, are repetitively visually surveyed to monitor any regional declines or improvements in habitat quality and fish/invertebrate communities. Two types of surveys are done: a sessile invertebrate survey and a motile survey. Sessile surveys are used to characterize the habitat; in addition patch sizes and height of algae and seagrasses are recorded. Motile surveys are used to characterize the diversity and distribution of the motile invertebrates and fish community; concurrently, benthic macroalgae and seagrass surveys were conducted. Size distributions of fish and spiny lobster are also recorded as part of the motile surveys.

5.2.4.2 RESULTS

We observed 30,951 fish among 176 different taxa. The most abundant species of fish we recorded was the white grunt, *Haemulon plumierii* (4,766 fish), which represented 15.40% of all fish recorded during visual surveys from fall 2003 to fall 2006 (Table 5.8). The most abundant snapper was the gray snapper, *Lutjanus griseus*, with 3,275 fish, representing 10.58% of all fish recorded. The gray snappers represented more than 75% of all snappers, whereas only 19 mutton snappers, *Lutjanus analis*, were counted, representing 0.06% of all fish surveyed or 0.44% of all snappers (Table 5.9).

The size distribution of mutton snapper was highly skewed to the left (Figure 5.19). Sixty-three percent of all mutton snappers were less than 15 centimeters in total length, and 47.4% were less than six centimeters in total length. Throughout this study, the nearshore hard-bottom habitat was found to be a nursery habitat for many fish species. However, because of the small number of mutton snapper recorded and the proximity of seagrass beds and mangrove from a large number of the sampling sites, we cannot definitively conclude that the nearshore hard-bottom is a mutton snapper nursery habitat. We observed no seasonal variation in size from fall 2003 to fall 2006, but we counted on average twice as many mutton snapper in fall as in winter or spring. No relationship between mutton snapper abundance and water temperature or salinity could be documented to this point.

Among the 19 mutton snappers found in the nearshore hard-bottom habitat, 21% were found in channels, 31.6% in the Gulf, 36.8% in Florida Bay, and 10.5% on the ocean side of the peninsula. Almost 70% of the snappers were found in the gulf-bay region. Almost 80% of the mutton snapper recorded during this study were found at sites with low structural indices, and 89.5% of the mutton snappers were found in locations with medium species richness of sessile invertebrates. No mutton snappers were found at locations with low species richness.

5.2.4.3 COMMENTS ON ADEQUACY FOR ASSESSMENT

None.

5.2.4.4 RESEARCH RECOMMENDATIONS

- Recommend continuing this project because in the future it might provide a good juvenile index.
- Incorporate use of stereo-video camera.

5.2.5 Annual Indices of Abundance of Mutton Snapper for Florida Estuaries [SEDAR15A-DW-05].

Walter Ingram[1], Alejandro Acosta[2], Jim Colvocoresses[2], Tim MacDonald[2], and Luiz Barbieri[2]
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2. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute

5.4.5.1 INTRODUCTION AND SAMPLING METHODS

Mutton snapper abundance and habitat data collected throughout Florida estuaries [i.e., Apalachicola Bay, Cedar Key, Tampa Bay, Charlotte Harbor, Southern Indian River Lagoon, Northern Indian River Lagoon, and Northeast Florida (St. Johns, Nassau, and St. Marks Rivers)] by the Florida Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute's Fisheries-Independent Monitoring program from 1996 to 2004 were analyzed to develop annual indices of abundance. Monthly stratified-random sampling was conducted during the day by using three different seines. The estuaries was divided into 1 x 1 nautical-mile cartographic grids (1 nm^2), and grids with appropriate water depths for each seine were selected as the sampling universe. Samples were stratified by depth and habitat type depending on gear. Due to the extremely low occurrence of mutton snapper in other gears only the data from samples collected with the 183-m center-bag haul seine (183 m x 3 m, 37.5-mm stretch mesh) were used for analyses. These sampling stations were stratified based on the presence or absence of overhanging shoreline vegetation (e.g., fringing mangroves). The seine was deployed by boat, in a rectangular shape (40 m x 103 m) along shorelines and on offshore flats inside the estuary and retrieved by hand. All fishes were identified to the lowest possible taxon, enumerated, and measured to the nearest millimeter (SL), and all juvenile mutton snapper were released alive in the field. For each sample, bottom type, seagrass species, shoreline vegetation species, and coverage of each were qualitatively measured by visual survey. Water-quality data such as salinity (ppt), dissolved oxygen (mg/l^{-1}), and temperature (°C) were recorded using a hand-held data sonde.

5.4.5.2 RESULTS

In order to develop standardized indices of annual average CPUE (catch per haul) for mutton snapper from Florida estuaries in the Gulf of Mexico and Atlantic, a zero-inflated delta-lognormal model, as described by Ingram et al. (1992), was employed. This index is a mathematical combination of yearly CPUE estimates from two distinct generalized linear models: a zero-inflated binomial model (ZIB) which describes proportion of positive CPUEs (i.e., presence/absence) and lognormal model which describes variability in only the nonzero CPUE data. The NLMIXED and MIXED procedures in SAS were employed to provide yearly index values for both the ZIB and lognormal sub-models, respectively. A backward stepwise selection procedure was employed to develop both sub-models. Type 3 and parameter significance analyses were used to test each parameter for inclusion or exclusion into the sub-model. Both variable inclusion and exclusion significance level was set at an $\alpha = 0.05$. The parameters tested for inclusion in each sub-model were categorical variables of year, estuary, shoreline vegetation type, and the continuous variables of station depth, salinity and temperature, which were normalized to a mean of one. The fit of each model was evaluated using the fit statistics provided by the NLMIXED macro.

Mutton snapper was only collected in Indian River and Tequesta Estuaries, with very few collected in other estuaries. Length frequency histograms of mutton snapper collected from these estuaries (Figures 5.20 and 5.21) show that age-0 fish (those ≤ 80 mm SL) were observed only in Indian River. Therefore, an age-0 index was developed with those age-0 fish collected from the Indian River Estuary, while age-1+ fish (mostly juvenile) were collected from both Indian River and Tequesta Estuaries, and the age-1+ index was developed from these data. Figures 5.22 and 5.23 illustrate age-0 and age-1+ mutton snapper collected during this survey. Age-0 mutton snapper had a mean standard length (± standard error) of 43 (± 2) mm (N = 112). Age-1+ mutton snapper had a mean standard length (± standard error) of 141 (± 1) mm (N = 813).

The separate models for age-0 and age-1+ and mutton snapper from Indian River and Tequesta Estuaries converged. For the age-0 mutton snapper, which only occurred in the Indian River Estuary during 1998 through 2006 survey years, the year, depth, temperature and salinity variables were retained in the ZIB, and the year and salinity variables were retained in the lognormal sub-model. Figure 5.24 summarizes the index values for age-0 mutton snapper. For the age-0 dataset, all years but one had frequencies of occurrence of less than 1 %, resulting in very high CVs. However, an oscillating but generally increasing trend was observed.

For the age-1+ mutton snapper, which occurred in both the Indian River and Tequesta Estuaries during 1999 through 2006 survey years, the year and salinity variables were retained in the ZIB, and the year, bottom vegetation and depth variables were retained in the lognormal sub-model. Figure 5.25 summarizes the index values for age-1+ mutton snapper. For the age-1+ dataset, all years had frequencies of occurrence of less than 5 %, resulting in very high CVs. Higher index values were observed in later survey years.

5.4.5.3 COMMENTS ON ADEQUACY FOR ASSESSMENT

Recommend it to calculate a base juvenile and YOY indices.
NOTE: The table lists gears employed by the survey, however, only the beach seine data were used to develop the age-0 index.

5.4.6 Baseline Data for Evaluating Reef Fish Populations in the Florida Keys, 1979-1998 [SEDAR15A-DW-06-07].

James A. Bohnsack, David B. McClellan, Douglas E. Harper, Guy S. Davenport, George J. Konoval, Anne-Marie Eklund, Joseph P. Contillo, Stephania K. Bolden, Peter C. Fischel, G. Scott Sandorf, Joaquin C. Javech, Michael W. White, Matthew H. Pickett, Mark W. Hulsbeck, and James L. Tobias
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
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Jerald S. Ault, Geoffrey A. Meester, Steven G. Smith, and Jiangang Luo
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Miami, FL 33149
September 1999
This group provided NOAA Technical Memorandum NMFS-SEFSC-427, September 1999.

5.2.6.1 OVERVIEW

Reef fishes are an essential and conspicuous component of the South Florida Marine Ecosystem that support important commercial, recreational, and aesthetic fisheries. Fishes are the ultimate downstream integrators of environmental conditions and human activities. Factors that increase mortality, such as fishing, loss of habitat, and pollution are eventually reflected in adult population abundance, individual size and condition. Over the last two decades, the Florida reef tract ecosystems and Florida Bay undergone dramatic environmental changes from human and natural forces. These changes are a general concern and the of an intensive effort to restore the ecosystem by altering the hydrology to a more natural condition. Fishes are a direct public concern and obvious measure of restoration success. Success of restoration and management changes should be reflected in fish communities in terms of the species composition, the size/age structure of fishes, in fisheries. Fishery resources are regulated by several state and federal agencies different levels of spatial protection. Understanding and modeling the dynamics of physical and biological processes of Florida and the Florida reef tract requires a good database on fish composition by habitat.

The Florida Keys National Marine Sanctuary (FKNMS) final management plan became effective on 1 July 1997 creating the planned network of 'no-take' marine reserves in North America. These reserves included 18 'no-take' Sanctuary Protected (SPAs) and one large 'no-take' ecological reserve. This action provides a unique research opportunity to examine the processes and effects of reserve protection at replicated sites of different size. An important goal of the FKNMS management is to evaluate changes resulting from establishing no-take marine reserves five years after they became established. In addition, new ecological reserves are being proposed for the Tortugas region.

5.2.6.2 SAMPLING DESIGN AND METHODS

Biological data on reef fish biodiversity have been collected continuously since 1979 by highly trained and experienced divers using open circuit SCUBA and visual methods. Visual methods are ideal for assessing reef fishes in the Florida Keys because of prevailing good visibility and management concerns requiring the use of nondestructive assessment methods. Data were collected from randomly selected 7.5 m radius plots using a standard fishery independent, stationary plot method (Bohnsack and Bannerot 1986). Data collected show reef fish species composition, abundance (density per plot), frequency-of occurrence, and individual sizes of fishes at reef sites extending from Miami through the Tortugas. These data can be used to assess changes in reef fish communities in the Florida Keys as the result of changes in zoning, regional fishery management practices, and restoration efforts in Florida Bay.

5.2.6.3 RESULTS

This report provides a summary of a 20 year historical data base that will form the baseline for assessing future changes in reef fish communities in the FKNMS. A total of 263 fish taxa from 54 families were observed from 118 sites in the Florida Keys from 6,673 visual stationary plot samples from 1979 through 1998. The ten most abundant species accounted for 59% of all individuals observed. Ten species had a frequency-of occurrence in samples greater than 50% and only ten species accounted for 55% of the total observed biomass.

Bray-Curtis similarity analysis of 90 reef sites was conducted to analyze spatial distribution patterns. The analysis showed that reef sites clustered primarily between inshore patch reefs and offshore reefs irrespective of region. Within offshore reefs, Tortugas deeper reefs were distinguished from sites in the rest of the Florida Keys. In the main Keys, offshore reefs clustered into high relief forereef and low relief hard bottom habitats. Within habitat types, reef sites clustered primarily by geographical region.

Trophic composition of fishes differed greatly in terms of number of individuals and total biomass. Fishes were numerically dominated by planktivores (44%) followed by macroinvertivores (26%), herbivores (17%), piscivores (8%), microinvertivores (3%), and browsers (1%). In terms of biomass, piscivores (42%) dominated, followed by macroinvertivores (25%), herbivores (21%), planktivores (5%), browsers (4%), and microinvertivores (3%). Data collected from 1994-1997 form a baseline for assessing changes at study sites during the first five years of protection under the FKNMS management plan. Annual mean density (number of fish observed per plot sample) with 95% confidence intervals were calculated for selected species and projected through 2002 as a prediction of future performance based on the assumption of no changes in population parameters over time.

5.2.6.4 COMMENTS ON ADEQUACY FOR ASSESSMENT

Since only one full year of data were available following the establishment of notake zones, it is premature to make conclusion about the impacts of marine reserves on changes in abundance or sizes of multispecies reef fish stocks. It is encouraging, however, that after only one year of no-take protection, the annual mean densities of exploited species in no-take sites were the highest observed for yellowtail snapper, combined grouper, and hogfish and the second highest for gray snapper compared to the baseline period. In comparison, similar uniform responses were not observed for the same species at fished sites nor for two species without direct economic importance (striped and stoplight parrotfish).

Sizes of reef fishes are also being monitored to assess population changes. Mean fish size in exploitable and nonexploitable phases for stocks of economically important species were examined as baseline statistics for evaluating future community changes in response to management actions. Because adult growth rates are relatively slow, size changes were unlikely to change much after only one year of protection and may lag other parameters.

[Note: Tables 5.10 and 5.11, and Figures 5.26 and 5.27 were supplied with this report, but without further explanation. These tables and figures are the density index values for 1994-2005 and average lengths for mutton snapper from the 177 m^2 point counts.]

General recommendations

- Recommend to update the times series with more recent data,
- Calculate two separate indices for protected and non-protected areas.
- Incorporate use of stereo-video camera.
- Increase the depth range.
- Add data from the Tortugas survey.

5.2.7 Fishery independent indices of abundance for mutton snapper, Lutjanus analis, from REEF fish surveys along Florida's Atlantic Coast including the Dry Tortugas [SEDAR15A-DW-08].

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5.2.7.1 INTRODUCTION

As essential part of Reef Environmental Education Foundation's (REEF) program is their Fish Survey Project. In this project, divers record their observations on marine populations. The program is quite wide spread with divers from Western Atlantic and Caribbean, Pacific U.S. and Canada, Hawaiian Islands, and the Eastern Tropical Pacific having participated in this program. REEF volunteer divers use a Roving Diver Technique and record their observations on a standard form for the particular region. An advantage of diver observations is that they are independent of size and bag limits. The changes in the number or frequency of occurrence of a particular species, say mutton snapper, are assumed to reflect the changes in the underlying abundance; thus, the dive records can be used to develop a fishery independent indices. An index based on REEF dive surveys was used in the goliath grouper stock assessment (SEDAR6 2004). In addition to recording the numbers of fish seen on a dive, divers also record basic environmental information about the dive site.

5.2.7.2 METHODS

The information that divers provide REEF about their dives includes the experience level of the diver, the survey type, the geographic code of the dive site, the dive date, the surface and bottom temperature, the dive's bottom time, the start time, visibility, average depth of the dive, current, habitat, species and abundance of fish seen (REEF 2007). Divers report the abundance of species as single, few (2-10), many (11-100), and abundant (100+).

REEF provided FWC with an extract from their database of all the dive records from Florida's Atlantic coast including those off the Dry Tortugas for a total of 24,541 dive surveys. The resulting database had records from 1993 to 2007; however, some of the records were eliminated for being incomplete and others because they were from 2007 and the dives from 1993 were eliminated as because they only came from the northern Keys and mostly from July. The working database contained records from 1994 through 2006 with no missing information for habitat, visibility, current, or average depth (22,668 dives). The dive sites were grouped geographically to the Northeast (St. Mary's River - Jupiter Inlet; geo codes 3101, 3200, 3201), Southeast (Jupiter Inlet - Biscayne National Park; geo codes 3300, 3301, 3302), Florida Keys (Key Largo - Key West; 3400, 3403, 3404, 3405, 3406, 3407, 3408), and West of Key West (Marquesas Keys - Dry Tortugas; 3409, 3410). Some of the associated data were sparse towards the ends and were aggregated into plus groups. For example, any dives with average depths greater than 100 feet were combined into a he 100 feet plus group, bottom times were rounded to 10 minute categories and any exceeding 120 minutes were combined into a 120 min plus group. Most of the dives that observed mutton snapper came from only a few habitat types (mixed, high profile reef, low profile reef, ledge, and artificial include wrecks) and so the other habitats were grouped into an 'Other' category.

Three indices were calculated with different subsets of the REEF dive surveys: an index based on all dives on Florida's Atlantic coast; an index based on sites that were visited by divers on at least seven of the 13 years, i.e. more than half, and at which mutton snapper were observed more than once; an index that used a logistic regression of presence or absence of species on the dives to calculate the probability that a dive would observe mutton snapper (Stephens and MacCall 2004). This method is straight-forward -- it uses the presence or absence of every species recorded to calculate a probability of observing a mutton snapper on the dive. The method uses maximum likelihood to determine a critical value that minimizes the false positive and false negative conditions. The final data set consists of all of the dives that observed mutton snapper plus trips with probabilities that exceeded the critical value. These additional trips were the dives that could have seen a mutton snapper but for some reason did not.

As with other indices of abundance, the relationship between the index and the abundance may change. All of the indices were standardized in the attempt to minimize those changes. The REEF indices calculated here used generalized linear models (PROC GENMOD) in SAS version 9.1.3 (SAS Institute, Cary NC) to identify which factors significantly affected the catch rates and to adjust the catch rates accordingly. Generalized linear models were used because they allowed the calculation of catch rates with error distributions in addition to the normal distribution. In the case of the REEF diver information, one measure that REEF recommends is the percent sighting frequency (C. Semmens, REEF, personal communication) and thus the binomial distribution with a logit link function is the appropriate configuration. The potential list of explanatory variables included year, month, zone, experience, visibility, habitat, current, average depth, bottom time, and starting time. Temperature was not included on many dives and including it would have reduced the working dataset. Confidence intervals were estimated with Monte Carlo simulations generating 1000 estimates of the annual proportion of positive dives from the logit least square means and their standard errors.

5.2.7.3 RESULTS

Of the 22,668 dives in the working dataset, mutton snapper were reported on 3,137 dives. On those dives that recorded mutton snapper, fifty-three percent of the dives reported seeing a single mutton snapper and another 41% reported seeing from 2-10 mutton snapper, i.e. 94% of the dives saw 10 or fewer mutton snapper. Thus, the annual probability of seeing one or more mutton snapper on a dive is reasonable as a suitable fishery independent index of abundance.

While year was significant in the model according to the Type III Sum of Squares, year only accounted for 0.15% of the reduction in mean deviance due to the extensive overlap of the confidence intervals (Table 5.12). The other variables that were included in the final reduced model were diver experience, habitat, and average depth. While all of the potential variables were statistically significant except current, none of the other variables achieved the 0.5% reduction in mean deviance criterion. The proportion of positive dives was higher in the earlier years and then has been flat since 2000 (Figure 5.28).

The second model used only dive sites that mutton snapper had been observed on two or more occasions and these sites were visited on at least seven of the 13 years in the time series, i.e. more than half of the years (14,370 dives with mutton snapper recorded on 2,032 dives). The variables included in this final model zone, bottom time, and start time were different from those in the model using all of the records. Year was more important in this model that in the above model (0.42% vs. 0.15%, Table 5.13) but there still was a lot of overlap in the confidence limits (Figure 5.29).

The last model used the Stephens and MacCall (2004) logistical regression based on the observed species per dive to reduce the number of zero dives. Divers recorded 521 species on the 22647 dives (21 dives did not have species records) along Florida's Atlantic coast including the Dry Tortugas. Of those species, there were 213 species occurred on at least 1% of the dives and the presence or absence of these species were used in the logistic regression. Many of the species coefficients were not significant at the 0.05 level and the reduced model used 85 species. The critical value for the REEF dives was 0.21 (Figure 5.30a) and that added 2974 zero dives to the 3137 dives with mutton snapper for a total of 6111 dives. These dives were then used in a generalized linear model to estimate the annual proportion of positive dives. The potential variables were the same as in the above models. Year reduced the mean deviance only 0.3% but year was statistically significant (Table 5.14). Only average depth met the 0.5% criterion; however, all of the variables were statistically significant except visibility. The annual proportion of positive dives decreased reaching a low in 2000 and then has generally increased afterwards (Figure 5.30b).

5.2.7.4 RESEARCH RECOMMENDATIONS

- Provide data to SEDAR committee panel for analysis.
- Incorporate use of stereo-video camera.
- Increase the depth range.

5.2.8 Visual Census Surveys at Riley's Hump, Tortugas South Ecological Reserve [SEDAR15A-DW-10].

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5.2.8.1 INTRODUCTION

Visual census transects were begun in 2001 on Riley's Hump to enumerate snapper-grouper species and determine the effect of enactment of the Ecological Reserve on what were perceived to be overexploited stocks of snapper-grouper species. Our primary concern was mutton snapper, since Riley's Hump was the site of a historically large spawning aggregation, and anecdotal accounts from fishermen of harvest of mutton snapper from Riley's Hump during the summer spawning months were of catches in excess of 10,000 lbs of fish per vessel for a four-day trip in the heyday of the aggregation (late 1970s/early 1980s).

5.2.8.2 SAMPLING METHODS

We selected 10 initial stations on Riley's Hump, an approximately 2 x 2 mile area in the northeast corner of the Tortugas South Ecological Reserve, by transiting the immediate area in a NOAA vessel and identifying hard bottom areas of diveable depth using the ship's depth recorder and color scope. Four more stations were added in 2002 with input provided from the commercial fisherman whose vessel we chartered for our dive work.

Sampling procedure consists of dropping a diver descent line on the GPS numbers for the station. Certainty of starting at the same point each time is good, since we have deployed temperature loggers at three different stations, and have been able to retrieve them from year to year with little difficulty. Once the dive team of two divers reach the bottom, they swim a pre-determined random number of fin kicks on a predetermined compass course, and then start from there to swim out a 30 m transect tape another random compass course, identifying and counting all snapper-grouper species they see. After completing the transect they swim the tape back in the starting point, obtaining a measure of visibility on the way. They then swim a second random number of fin kicks on another random compass course, from which point they will deploy the tape on a random compass transect course. This is done until bottom time is up. Dive teams are usually able to complete between two and four replicate transects per dive (average probably 3).

All stations are sampled within the course of a given summer, and most if not all of the stations are able to be sampled multiple times.

5.2.8.3. RESULTS

A delta-lognormal modeling approach (Lo *et al*., 1992) was employed in order to develop standardized indices of annual average CPUE (number per area surveyed) for mutton snapper. This index is a mathematical combination of yearly CPUE estimates from two distinct generalized linear models: a binomial (logistic) model, which describes proportion of positive CPUEs (i.e., presence/absence) and lognormal model, which describes variability in only the nonzero CPUE data. The GLMMIX and MIXED procedures in SAS were employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. The parameters tested for inclusion in each sub-model were survey year, station nested within month, and replicate nested within station. The year variable was considered fixed, while the nested variables (i.e., station nested within month and replicate nested within station) were considered random. Also, separate covariance structures were developed for each survey year. For the binomial sub-models, a logistic-type mixed model was employed. Both sub-models converged. The binomial converged while including all variables, and the lognormal sub-model converged while including year and station nested within month variables. Residual analyses indicated that the models sufficiently fit the data (Figures 5.32 – 5.33). The annual indices show a general increase over time (Figure 5.34).

5.2.8.4. COMMENTS ON ADEQUACY FOR ASSESSMENT

This index, though the time series is short, is suitable for consideration to include in the stock assessment models.

5.3 Fishery Dependent Surveys

5.3.1 Revised standardized catch rates of mutton snapper from the United States Gulf of Mexico and South Atlantic handline and longline fisheries, 1990-2006 [SEDAR15A-DW-09].

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Sustainable Fisheries Division Contribution SFD-2007-024

5.3.1.1. INTRODUCTION

Initial mutton snapper indices of abundance were constructed for the SEDAR 15A data workshop and are described in SEDAR 15A-DW-09 (McCarthy, 2007). The indices working group recommended the construction of revised indices that included the years 1990-1993 along with the examination of affects that changes in minimum size regulations may have had on mutton snapper cpue.

Handline and longline catch and fishing effort data from commercial vessels operating under federal fishing permits in the Gulf of Mexico and south Atlantic were available through the National Marine Fisheries Service coastal logbook program. No size information is available in the coastal logbook data, however, size frequency data of mutton snapper in commercial landings were available through the Trip Interview Program (TIP). Port agents attempt to randomly sample vessels and the landings from those vessels and record lengths of individual fish in the course of sampling the commercial landings. The TIP data were used to assess the potential affect that minimum size regulations may have had on mutton snapper cpue.

5.3.1.2. METHODS

The available TIP data were examined for changes among years in the size of mutton snapper landed by handline/rod and reel fishers and by longline fishers. Scatter plots of total lengths of individual fish and the mean total length of measured fish were compared among years. Changes in the size composition of the landings following changes in minimum size regulations would suggest that regulations could have affected the cpue of mutton snapper.

Construction of the mutton snapper indices of abundance followed the methods described in SEDAR 15A-DW-09 (McCarthy, 2007). For the revised indices, the time series was expanded to include the years 1990-1993. The 17 year time series, 1990-2006, includes all the available data from the coastal logbook database. As in the initial construction of commercial mutton snapper indices, data from May and June for all years beginning in 1993 were excluded from the analyses because the commercial fishery was closed during those periods.

For each fishing trip, the logbook database includes a unique trip identifier, the landing date, fishing gear deployed, areas fished (equivalent to NMFS shrimp statistical grids, Figure 5.32), number of days at sea, number of crew, gear specific fishing effort (e.g. number of lines fished, number of hooks per line and estimated total fishing time), species caught and whole weight of the landings. Multiple areas fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations was not possible; therefore, only trips in which one area fished was reported were included in these analyses. Prior to 2001, handline and electric reel (bandit rigs) gears were reported as a single gear type. Data from trips using those gear types were combined in these analyses.

Handline catch rate was calculated in weight of fish per hook-hour. For each trip, catch per unit effort was calculated as:

CPUE = landings of mutton snapper/(number of lines fished*hooks per line*total hours fished)

Longline catch rate was calculated in weight of fish per hook fished. For each trip, catch per unit effort was calculated as:

CPUE = total pounds of mutton snapper/(number of longline sets*number of hooks per set)

The data for number of hours fished while using longline gear is unreliable in the coastal logbook program due to misreporting. Calculating CPUE by hook-hour could not be done for the longline data.

Data were restricted geographically to Areas 1 – 7 in the Gulf and Areas 2479-3477 (Figure 5.35) in the south Atlantic for handlines. Longline data were restricted to Areas 1-6 in the Gulf of Mexico. Landings reported from longline vessels in the south Atlantic were insufficient to be included in the analysis.

Mutton snapper trips were identified using a modified Stephens and MacCall (2004) approach, where trips are subset based upon the reported species composition of the landings. This method is intended to identify trips that fished in locations containing mutton snapper habitat and, therefore, had the potential of catching mutton snapper. For the initial indices of abundance (McCarthy, 2007), all trips with mutton snapper landings were included as mutton snapper trips in addition to trips identified by the Stephens and MacCall method. In the construction of the revised indices, only those trips identified by the Stephens and MacCall method were included in the analysis. Including trips not identified by the Stephens and MacCall method is an *ad hoc* approach to constructing a data set, increases the proportion of positive trips substantially without adequate justification, and is ultimately unnecessary, at least in this case, because the initial and revised indices differed little.

Once trips were identified, restrictions were made by eliminating trips with reported data for days at sea, number of lines fished (or longline sets), number of hooks per line, or hours fished that fell beyond the 99.5 percentile of the data as a whole. For example, handline vessel trips with more than 10 hooks per line reported were eliminated from the dataset. The data were also filtered by eliminating longline trips that reported fishing fewer than 100 hooks per set (the lowest 1% of the range of hooks/set) and longline trips that reported more than 24 sets per day. Finally, data from handline trips that reported fishing more than 24 hours per day were removed from the data set.

Index Development

Handline

For the handline index, five factors were considered as possible influences on the proportion of trips that landed mutton snapper and the cpue of trips that landed mutton snapper. The factors are summarized below:

Factor	Levels	Value
YEAR	17	1990-2006
AREA	10	Figure 1 areas: 1, 2, 3-7, 2479-2480, 2481, 2482, 2579-2580, 2679-2580, 2779-3081, 3100-3477
DAYS	4	1=1 day at sea, 2=2-3 days at sea, 4= 4-6 days at sea, 7=7-12 days at sea
MONTH	10	Month of the year, May and June excluded
CREW	3	1, 2, 3 or more crew members

The delta lognormal model approach (Lo et al. 1992) was used to develop standardized indices of abundance for the handline data. This method combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed mutton snapper) and the catch rates on successful trips to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA).

For each GLM procedure of proportion positive trips, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. During the analysis of catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. The linking function selected was "normal", and the response variable was ln(CPUE). The response variable was calculated as: ln(CPUE) = ln(pounds of mutton snapper/hook hour). All 2-way interactions among significant main effects were examined.

A stepwise approach was used to quantify the relative importance of the factors. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ($p<0.05$), and the reduction in deviance per degree of freedom was ≥1%. This model then became the base model, and the process was repeated, adding factors and interactions individually until no factor or interaction met the criteria for incorporation into the final model. Higher order interaction terms were not examined.

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

Longline

In developing the longline index, the same factors considered for the handline index were also examined.

Factor	Levels	Value
YEAR	17	1990-2006
AREA	3	Figure 1 areas: 1-2, 3, 4-6
DAYS	4	1-8, 9-12, 13-21 days at sea
MONTH	10	Month of the year, May and June excluded
CREW	3	1-2, 3, 4 or more crew members

The delta lognormal model approach (Lo et al. 1992) was again used to develop standardized indices of abundance for the longline data using the methods described above for the handline index.

5.3.1.3. RESULTS AND DISCUSSION

Size frequency data

Scatter plots of individual total lengths of mutton snapper landed by commercial vessels and measured by TIP port agents are shown in Figure 5.36. Sample sizes were low, ranging from 3 to 245 fish per year and are provided in Table 5.16. The average number of fish sampled per year was 138 in the Atlantic and 26 in the Gulf of Mexico. The handline/rod and reel data (Figure 5.36 A and B) indicates no clear relationship between minimum size regulations and the total length of landed mutton snapper. Most of the measured fish were above even the largest minimum size of 406.4 mm (16 inches) established in 1994. The mean size landed was always well above the 406.4 mm minimum size (the lowest was for Atlantic handline vessels in 1989 when the mean size of measured fish was 429.2 mm) and there were no apparent changes in mean length of landed mutton snapper coincident with changes in minimum size regulations. No effect on cpue due to changes in minimum size regulations was assumed for the construction of handline standardized indices of abundance.

All mutton snappers measured from longline vessels were larger than the largest minimum size of 406.4 mm established in 1994 (Figure 5.36 C and D). Sample sizes were often small, ranging from 2 to 802 individuals (Table 5.16). The average number of samples per year in the Gulf of Mexico was 132 and 262 average samples per year in the Atlantic. Provided there was no sampling bias, those data suggest that longline vessels since 1990 have landed mutton snapper larger than the largest minimum size implemented and that minimum size regulations have had little or no effect on longline mutton snapper cpue. A single sample from a longline vessel in the Gulf of Mexico was recorded as 70 mm, but this is likely a data entry error. Construction of longline standardized indices of abundance assumed no effect from changes in minimum size regulations.

Handline index of abundance

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

PPT = AREA + DAYS at SEA + YEAR + AREA*YEAR

LN(CPUE) = DAYS at SEA + AREA + CREW + YEAR + AREA*YEAR + AREA*CREW

Binomial models that included either of the interaction terms AREA*DAYS at SEA or DAYS at SEA*YEAR failed to converge, therefore, those interaction terms were excluded from the analysis. The linear regression statistics of the final models are summarized in Table 5.17. Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indices are provided in Table 5.18 for the mutton snapper handline data. Sample sizes were 76 to 2,264 trips per year with the fewest trips in the period 1990-1992. During those years only a 20% random sample of commercial fishers in Florida were selected to report catch and effort data to the coastal logbook program. Positive trips ranged from 29 to 45%, much lower than the initial handline index that included all positive trips in addition to those trips identified by the Stephens and MacCall method as mutton snapper trips.

The delta-lognormal handline abundance indices, with 95% confidence intervals, are shown in Figure 5.37. Standardized catch rates developed from mutton snapper handline data were generally increasing over the time series. CPUE was highly variable from 1990-1994 and had higher CVs than in later years, perhaps due to small sample size. During the period 1996-1999, cpue was relatively unchanged. Catch rates decreased during 2000, but increased through 2003 and changed little since then. QQ plots of residuals for successful catch rates, frequency distributions of ln(CPUE) for positive catches, plots of residuals for lognormal models on successful catch rates by each main effect, and plots of chi-square residuals for the delta lognormal model on proportion successful trips by each main effect are shown in Figure 5.38. These data appear to have met the assumptions for the analysis.

Longline index of abundance

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

PPT = AREA + YEAR + DAYS at SEA

LN(CPUE) = AREA + YEAR + DAYS at SEA + AREA*YEAR

The linear regression statistics of the final model are summarized in Table 5.19. Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indices, 95% confidence intervals, and coefficients of variation are provided in Table 5.20 for the mutton snapper longline data. Sample sizes ranged from approximately 19 trips per year to 266 trips per year. Low sample sizes in the initial years of the time series were due to the 20% random sampling in Florida prior to 1993. Positive trips made up 39 to 64% of all mutton snapper trips per year. As with the handline data, the proportion positive trips was lower in this analysis than in the initial mutton snapper longline index of abundance (McCarthy, 2007) because only those trips identified by the Stephens-MacCall method as mutton snapper trips were used in the analysis.

The delta-lognormal longline abundance indices developed, with 95% confidence intervals, are shown in Figure 5.39. Mutton snapper standardized catch rates developed from longline data increased gradually over the first half of the time series. After 1999, however, yearly mean CPUEs increased more substantially except for lower mean CPUE in 2001 and 2005. Confidence intervals became broader as the time series progressed for these data. Coefficients of variation, however, were largest in the first several years of the series. QQ plots of residuals for successful catch rates, frequency distributions of ln(CPUE) for positive catches, plots of residuals for lognormal models on successful catch rates by each main effect, and plots of chi-square residuals for the delta lognormal model on proportion successful trips by each main effect are shown in Figure 5.40. These data appear to have met the assumptions for the analysis.

The longline index had a greater increase in CPUE over time than did the handline index. Sample sizes were lower and coefficients of variation were greater for the longline index than the handline index. In addition, the effort measure used in the handline index (hook-hours) is a better effort measure than was the available effort measure used in the longline index (total hooks fished per trip). The longline index is also limited in spatial coverage compared to the range of the mutton snapper fishery and the spatial coverage of the handline data. In spite of those differences, the CPUE trends are in general agreement between the two indices with higher mean CPUEs late in the time series of both indices. The initial indices of abundance constructed from commercial handline and longline data differ little from the indices presented here, aside from the longer time series in the revised indices (Figures 5.41 and 5.42).

5.3.1.4. COMMENTS ON ADEQUACY FOR ASSESSMENT

(See discussion above)

- Use the trip interview program samples (TIP) to determine an approximate size/age distribution.
- Work with the life history group to assign ages to the length data.

5.3.2. Recreational catch rates for mutton snapper, Lutjanus analis in the Southeast United States from the Marine Recreational Fisheries Statistics Survey and the Headboat Logbook Program. [SEDAR15A-DW-11-12]

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5.3.2.1. INTRODUCTION

Maunder and Punt (2004) recently reviewed the literature on standardizing catch rates. Traditionally, catch rates are considered to reflect the underlying trends in abundance; in other words, catchability is assumed to be constant relating the catch rate to the underlying abundance. Simply put

$$C = F\overline{N} \qquad (1)$$

and

$$F = qE \qquad (2)$$

substituting Eq. 2 into Eq. 1 gives

$$C = qE\overline{N} \qquad (3)$$

dividing Eq. 3 by E gives

$$\frac{C}{E} = q\overline{N} \qquad (4)$$

where C is catch, F is fishing mortality, $\overline{N}$, is the average abundance, q is the catchability and E is effort. However, catchability may vary with season, location, life stage, fishing methods, etc. and so catch rates are standardized in the attempt to remove or reduce the factors influencing catchability. The recreational indices calculated here used generalized linear models (GLIM) in SAS version 9.1.3 (SAS Institute, Cary NC) to identify which factors significantly affected the catch rates and to adjust the catch rates accordingly. Generalized linear models were used because they allowed the calculation of catch rates with error distributions in addition to the normal distribution. In the case of the recreational catch rates, I chose the Poisson distribution because the catches were in numbers of fish.

5.3.2.2. METHODS

The National Marine Fisheries Service has two programs that collect catch rate information on the recreational fisheries in the Southeast US. These programs are the Marine Recreational Fisheries Statistics Survey (MRFSS) and the Headboat Logbook Program (HB). The MRFSS uses a two-stage, stratified sampling approach to estimate what anglers catch and discard. One stage uses a telephone survey to estimate the number of angling trips by stratum and in the other stage interviewers intercept anglers at docks, bridges, beaches, boat ramps, etc. to characterize what anglers catch. The HB is a log of the number of trips, anglers, and catches that the headboat captains submit monthly to NMFS's Beaufort Laboratory. For both sources of recreational information, I only included trips from the core region of the recreational mutton snapper fishery which is in Southeast Florida from Martin through Monroe counties for MRFSS and areas headboat 11 and 12.

Marine Recreational Fisheries Statistics Survey

FWC Fishery Dependent Monitoring program downloaded MRFSS databases from the MRFSS ftp site, ftp://cusk.nmfs.noaa.gov/mrfss/intercept/ag/. The MRFSS interview sites for sampling are drawn randomly by stratum (sub-region, state, year, two-month wave, fishing mode (shore, charterboat, and private/rental boats), and area (estuary or bay, state waters three miles or less offshore, or federal waters three miles or more on the Atlantic coast)). Samplers visit these sites, intercept anglers, examine their catch, and inquire as to whether there were any other fish that the angler caught that were not available to the sampler. MRFSS categorizes the catch in three ways: the fish that the sampler could examine and measure (Type A fish), the fish that were unavailable but were not discarded alive (Type B1 fish) and the fish that were discarded alive (Type B2). This breakdown is useful for determining the efficacy of regulations; however, the total number of fish per interview is the appropriate measure for catch rate because it is less sensitive to regulatory changes. Although MRFSS began in 1979, there was a change beginning in 1981 such that the data from the first two years do not have the same variables for estimating the catch as do the later years and so the recreational time series begins in 1981. Beginning in 1991, MRFSS included a party code to link the ancillary interviews from multiple anglers on the same trip into a single interview. Another addition at that time was the field for the number of anglers fishing on that trip.

Interviews were selected for analysis if anglers reported catching mutton snapper on the trip or if the anglers told the interviewers that they were targeting mutton snapper. Prior to 1986, there were usually less than 10 interviews per year that caught or targeted mutton snapper and so the interviews from these early years were excluded.

Catch rates were calculated two ways from the MRFSS data: an index using data from 1986 to 2006 using trips with a single angler. The data from 2006 is considered preliminary at this time. Another index was developed using data from 1991 to 2006 with the associated interviews collapsed using the party code. The response variable for catch rates was the total number of fish caught, including discards, per trip and these were standardized with a GLIM. Because catch is reported in numbers of fish, I used a Poisson distribution for the error structure of the catch rates with a log link function. Potential explanatory variables in the GLIM were year, two-month wave, fishing mode, area, county, hours fished, number of anglers (only in the second index), and avidity (number of trips in the past 60 days). All of these variables were treated as categorical and hours fished , number of anglers, and avidity had plus groups (8+, 4+, and 10+ respectively based on their catch rates). The stepwise process compared the change in mean deviance (deviance/degrees of freedom) for each of the variables against the mean deviance of the null model. The variable that accounted for the greatest reduction in mean deviance was selected provided that the variable was statistically significant in the model based on its log-likelihood. Typically, all of the variables are statistically significant because the numbers of observations are so large. Maunder and Punt (2004) recommend selecting a cutoff value for the change in mean deviance reduction before the analysis begins. In this case I chose 0.5% based on the recommendation of a CIE reviewer for yellowtail snapper (SEDAR 03). After the first variable had been selected, GLIM runs of this first variable with each of remaining variables were run and these results were checked for the amount of mean deviance reduced and whether the variable was significant. The process was repeated until the remaining variables no longer reduced the mean deviance by at least 0.5% or were not statistically significant at the 0.05 level. To determine the annual values and the variability surrounding the index, the annual least-square means on the link scale were estimated and a Monte Carlo simulation used those least-square means and their standard errors together with random normal deviates to calculate 1000 new estimates in the log scale which were back-transformed.

Headboat logbook

In 1974, the Headboat logbook program began in North Carolina and expanded into Florida's Atlantic coast in June 1978. In this program, headboat captains send in logbook forms that list the vessel, trips, date of the trips, the type of trip (half day morning, half day night, three-quarter day trips, and full day trips), the area fished (I only used Ft. Pierce - Miami (Area 11) and Key Largo - Key West (Area 12)), the fish caught on each trip by species, the weight of the catch by species, and the number of anglers. Beginning in 2005, headboat operators began supplying the number of fish discarded alive or dead. Multi-day trips accounted for less than 1% of the headboat trips and they mostly came from the Dry Tortugas area and these trips were excluded from further analyses. Similarly, the lat-long field was subset to those trips from Southeast Florida: 2480, 2481, 2482, 2580,2680, 2679, and 2780. The number of anglers was treated as categorical data and in 10-angler bins. Rarely were there more than 69 anglers on a trip (0.5% of the trips) and so the 60-69 category became the 60 + category.

Because headboat discards were not reported until 2005 and the index is sensitive to changes in minimum size, the Data Workshop recommended developing two indices with these data: one for the period prior to the implementation of the 12-inch minimum size in the South Atlantic, 1979-1991 and another for the period after the 16-inch minimum size was implemented in January 1995. Because of the brevity of the time period with the 12-inch minimum size limit, 1992-1994, a separate index for that time period was not developed.

Estimating total headboat effort for mutton snapper is a challenge because mutton snapper are frequently taken with other species and there could easily be trips that were in an appropriate area for mutton snapper but no angler on the headboat caught one (this a zero trip that should be included in the analysis even though no mutton snapper were caught). A zero trip could also occur if the headboat was fishing in areas where there was no possibility of catching mutton snapper but these zero trips should be excluded from the analyses. Stephens and MacCall (2004) developed a logistic regression method to distinguish between these two types of zero trips based on the species composition of the catches. They recommend using presence/absence data to avoid any abundance trends in the other species. To narrow the analyses a little, I excluded any species which did not occur on at least 1% of the trips. This was the working species list. For each of the headboat trips, I determined the presence or absence of each species on the working species list including mutton snapper. The logistic regression then used mutton snapper as the dependent variable and the other species as the independent variables as the full model. Any species with a coefficient that was not statistically significant at the 0.05 level was excluded from the analyses. Sometimes the regression was repeated because a species was significant but not significant after the regression was rerun with just the subset of significant species. Using the equation from the final logistic regression, I calculated a probability of each trip being a mutton snapper trip. Stephens and MacCall gave a maximum likelihood method to select a critical value that minimized the number of false-positive trips and the false-negative trips. Thus, trips included in the catch rate analyses were the trips that caught mutton snapper plus the trips that met or exceeded the critical value from the regression. Some people have argued for only using the trips identified by the regression but that excludes many trips that actually had mutton snapper. The intent of this step was to attempt to more fully identify the mutton snapper effort and it did not seem reasonable to exclude many trips that caught mutton snapper.

Once the headboat trips were identified, the catch rates were calculated in a stepwise GLIM similar to the MRFSS catch rates. The response variable was the number of fish caught per trip using a Poisson distribution and a log link function. The potential explanatory variables that could have an impact on catchability were year, month, trip category, number of anglers, area, and lat-long. The hours fished were not explicitly included in the model because they depended on the trip type.

5.3.2.3. RESULTS

Marine Recreational Fisheries Statistics Survey

The MRFSS users manual (VanVorhees and Kline 1993) recommends calculating catch rates using only interviews with a single angler to avoid treating ancillary interviews as independent interviews. There were 1,998 interviews from the time period 1986 to 2006 with a single angler. The variable, year, reduced the mean deviance by 10.4% and the final model reduced the mean deviance by 17.0% (Table 5.21). The catch rate of mutton snapper was less than one fish per interview (trip) from 1986 until 1990 and then there was what appears to be an abnormally high cluster of years, 1991 through 1993, followed by a drop in 1994 and then a general, albeit variable, increase afterwards (Figure 5.43, Table 5.22). However, the medians for the period, 1991-2006 varied without trend (t-test for slope equal zero, $t = 0.61$, $df = 14$, $P = 0.55$).

The second index used data from 1991-2006 and the ancillary interviews were combined by the party code. There were 3,489 combined interviews. In this analysis, year also reduced the mean deviance the most followed the number of anglers, area, and so on but the final model explained only 8.3% of the total deviance (Table 5.23). As with the catch rates from the longer time series, the catch rates have been increasing since 1994 (Figure 5.44, Table 5.22). Since these two indices were correlated ($r = 0.69$, $df = 14$, $P < 0.05$) in the years that they overlapped, the recommendation is to go with the longer time series. As with the other MRFSS index, the medians from the MRFSS data for the time period, 1991-2006, also varied without trend (t-test for slope equal zero, $t = 1.54$, $df = 14$, $P = 0.14$).

Headboat logbook

For the 1979-91 time period prior to the implementation of the 12-inch minimum size (305 mm TL), there were 94,335 unique headboat trips and 38,160 of those trips caught mutton snapper. The question was should all 56,175 zero trips be included in calculating catch rates with the underlying assumption that the headboats were always fishing in areas that could have caught mutton snapper or should some of them be excluded because the headboats were fishing at location where mutton snapper did not occur? Anglers on headboats caught 222 species but only 52 species occurred on at least 1% of the trips. Thirty-seven species had coefficients in the logistic regression that were statistically significant at the 0.05 level (Figure 5.45)and this final equation was used to calculate the probability of each trip being a mutton snapper trip. The maximum likelihood profile indicated that the critical value was 0.467 (Figure 5.46). The Stephens and MacCall's method for distinguishing zero trips reduced the number of zero trips from 56,175 to 14,099 trips and with the 38,160 mutton snapper trips there was a total of 52,259 trips used to calculate the catch rates. If only the critical value was used and the actual catch of mutton snapper was ignored, then the analyses would have used a total of 35,088 trips of which 20,988 trips would have caught mutton snapper. Doing so would have excluded 17,181 headboat trips (45%) with mutton snapper reported.

As with MRFSS, the GLIM identified year as the variable that reduced the mean deviance the most followed by month and trip type. The model reduced the mean deviance by 6.6% (Table 5.24). The catch rates (Table 5.22) look like a wave with the crests at 1980 and 1990 and the trough in 1983-87 with narrow error bars because of the large sample size each year (Figure 5.47). Like the MRFSS index, there was no trend in the catch rates (t-test for slope equal zero, $t = -0.18$, $df = 11$, $P = 0.86$).

In the latter period with the 16-inch minimum size (406 mm TL), 1995-2006, there were 25,748 headboat trips and the captains reported that anglers had caught mutton snapper on 7,630 trips. Anglers caught a total of 155 species but only 55 species were caught on 1% or more of the trips. Thirty-two species had coefficients in the logistic regression on mutton snapper that were statistically significant at the 0.05 level (Figure 5.48). The maximum likelihood profile indicated that the critical value was 0.373 (Figure 5.49). Therefore the catch rate analysis included the 7,630 trips that caught mutton snapper during this period and another 3,513 trips that could have caught mutton snapper for a total of 11,143 trips. Again, if we had just used the critical value to select trips, then we would have only used 6590 trips of which 3028 trips would have caught mutton snapper.

The GLIM model reduced the mean deviance by 10.6% and the selected variables were year, month, trip type, and number of anglers (Table 5.25). The shape of the catch rates (Table 5.22) was sigmoid with high sections at 1995 and 2001-2003 (Figure 5.50). The lowest value was in 1999 and the highest was in 2005; however, 2006 was down. As with the earlier period, the overall trend was flat (t-test for slope equal zero, $t = 1.16$, $df = 10$, $P = 0.27$).

All of the indices are plotted together in Figure 5.51 for comparison. The 1986-1990 values from MRFSS seem abnormally low as if there was a change in sampling.

5.3.2.4. <u>COMMENTS ON ADEQUACY FOR ASSESSMENT</u>

(See discussion above)

NOAA/NMFS MRFSS – SEDAR15-DW-11

- Add earlier data; we have data as early as 1981 available, we should use them to calculate the index.
- Recommend to increase the number of intercepts.
-

NOAA Headboat – SEDAR15-DW-12

- Add earlier data; we have data as early as 1981 available, we should use them to calculate the index.
- More validation of captain reports,
- increase size sampling.

5.4 Consensus Recommendations and Survey Evaluations

Participants involved in the Indices Working Groups presented a summary table (Table 5.26) at the Data Workshop which provided their overall consensus recommendations on the use of the various indices for the assessment models.

GENERAL recommendations:

- Mutton tends to occur in aggregation of one, so we cannot use a delta-log normal for analysis (break normal assumptions) – probably could use the proportion positive for the index.
- Do not use trip ticket data, because of the uncertainty of assigning gear type to the data for analysis.
- Take the data from 1981 for MRFSS and Headboats to calculate the indices

5.5 Research Recommendations

GENERAL recommendations:

- Explore night fish data! No data taken at night by anyone!

5.6 Itemized List of Tasks for Completion Following Workshop

- Get info from Miami (Ault/Bohnsack):
  - Need date of change of protocol,
  - Confirm if the data include the Tortugas or not; if not include the Tortugas data
  - get different indices for no take and take zones,
  - Get the more recent data since they sampled until 2006.
  - Need to get a reference paper from Ault (SEDAR15A-DW-7)
- Get the Reef data for the index (Bob and get it to Walter)
- Coastal log program (MacCarthy):
  - use the TIP info
  - Incorporate the life history/age info to recalculate index.
  - Needs to take in account that size changed in November 1999.
  - Reference paper
- FIM Visual: partitioning the data into life history group and/or age (Alejandro).
- Include data from 1981 for both MRFSS and headboat surveys to calculate the indices (Bob & MRFSS). [They will send it by email once the analysis is finalized.]
- Get reference paper from MRFSS for each of the datasets (one for recreational – SEDAR15A-DW-11 and one for headboats – SEDAR15A-DW-12) (Bob and Beverly).

5.7 Literature Cited

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5.8 Tables

Table 5.1. Ratio estimate of the number of mutton snapper (CV=SE/Mean) observed near the Dry Tortugas.

YEAR	Number of blocks	Number of sample units	Nominal Index	Scaled Index	V(Index)	SE(Index)	CV
1992	2	11	0.182	0.623	0.107	0.231	1.273
1993	2	14	0.143	0.489	0.003	0.041	0.286
1994	2	14	0.000	0.000	0.000	0.000	
1995	3	44	0.023	0.078	0.002	0.025	1.080
1996	4	28	0.321	1.101	0.088	0.148	0.462
1997	4	33	0.364	1.246	0.069	0.131	0.361
2002	4	34	0.559	1.914	0.085	0.146	0.261
2004	4	26	0.462	1.581	0.119	0.172	0.373
2005	6	48	0.375	1.285	0.155	0.161	0.429
2006	6	57	0.491	1.683	0.131	0.148	0.300

Table 5.2. Mutton snapper fork length measured with lasers from video tapes. No fi were hit by lasers prior to 2005.

Year	Station	Fork Length (mm)
2005	457	500
2005	459	517
2006	42	475
2006	42	439
2006	42	463

Table 5.3. The parameters of the resulting binomial sub-model.

5.3a. *Solution for Fixed Effects*

Effect	*season*	*YEAR*	*Estimate*	*Standard Error*	*DF*	*t Value*	*Pr > |t|*
Intercept			-0.6700	0.4615	17.7	-1.45	0.1640
YEAR		1992	-0.8953	1.0077	16.3	-0.89	0.3872
YEAR		1993	-1.1038	1.0056	18.5	-1.10	0.2864
YEAR		1995	-3.1173	1.1026	45.9	-2.83	0.0069
YEAR		1996	-0.2651	0.6782	21.2	-0.39	0.6998
YEAR		1997	-0.3385	0.6631	19.5	-0.51	0.6155
YEAR		2002	-0.05993	0.7539	19.2	-0.08	0.9375
YEAR		2004	0.2375	0.7705	21.4	0.31	0.7609
YEAR		2005	-0.5558	0.6205	20.7	-0.90	0.3807
YEAR		2006	0	.	.	.	.
season	spring		0.1326	0.7457	22.8	0.18	0.8604
season	summer		0	.	.	.	.

5.3b. *Solution for Random Effects*

Effect	*YEAR*	*blockno*	*Estimate*	*Std Err Pred*	*DF*	*t Value*	*Pr > |t|*
blockno(YEAR)	1992	30	0.1870	0.5743	3.02	0.33	0.7659
blockno(YEAR)	1992	50	-0.1870	0.5743	3.02	-0.33	0.7659
blockno(YEAR)	1993	29	-0.06835	0.5703	3.03	-0.12	0.9121
blockno(YEAR)	1993	30	0.06835	0.5703	3.03	0.12	0.9121
blockno(YEAR)	1995	29	-0.09621	0.5711	2.88	-0.17	0.8774
blockno(YEAR)	1995	30	0.1991	0.5713	2.97	0.35	0.7506
blockno(YEAR)	1995	45	-0.1029	0.5712	2.89	-0.18	0.8689
blockno(YEAR)	1996	29	-0.4740	0.5620	4.01	-0.84	0.4463
blockno(YEAR)	1996	30	0.07465	0.5583	4.13	0.13	0.8999
blockno(YEAR)	1996	44	0.4561	0.5500	4.38	0.83	0.4498
blockno(YEAR)	1996	50	-0.05671	0.5514	4.34	-0.10	0.9227
blockno(YEAR)	1997	29	0.1256	0.5410	4.52	0.23	0.8266
blockno(YEAR)	1997	44	-0.03089	0.5477	4.35	-0.06	0.9575
blockno(YEAR)	1997	45	0.4027	0.5417	4.5	0.74	0.4942
blockno(YEAR)	1997	46	-0.4974	0.5567	4.1	-0.89	0.4209
blockno(YEAR)	2002	29	0.2289	0.5371	4.44	0.43	0.6899
blockno(YEAR)	2002	30	0.2289	0.5371	4.44	0.43	0.6899
blockno(YEAR)	2002	45	-0.2888	0.5345	4.5	-0.54	0.6147
blockno(YEAR)	2002	46	-0.1690	0.5415	4.34	-0.31	0.7693
blockno(YEAR)	2004	29	-0.03014	0.5599	4.07	-0.05	0.9596
blockno(YEAR)	2004	30	0.4243	0.5485	4.41	0.77	0.4785
blockno(YEAR)	2004	45	0.09926	0.5537	4.26	0.18	0.8659
blockno(YEAR)	2004	46	-0.4934	0.5490	4.39	-0.90	0.4153
blockno(YEAR)	2005	29	-0.1871	0.5530	4.3	-0.34	0.7510
blockno(YEAR)	2005	30	-0.1399	0.5566	4.16	-0.25	0.8135
blockno(YEAR)	2005	44	0.3237	0.5480	4.48	0.59	0.5832
blockno(YEAR)	2005	45	-0.03455	0.5643	3.84	-0.06	0.9542
blockno(YEAR)	2005	46	-0.3123	0.5435	4.63	-0.57	0.5924

5.3b. *Solution for Random Effects*

Effect	*YEAR*	*blockno*	*Estimate*	*Std Err Pred*	*DF*	*t Value*	*Pr > |t|*
blockno(YEAR)	2005	50	0.3501	0.5320	5.01	0.66	0.5395
blockno(YEAR)	2006	29	-0.2055	0.5391	4.51	-0.38	0.7203
blockno(YEAR)	2006	30	0.1827	0.5342	4.63	0.34	0.7473
blockno(YEAR)	2006	44	-0.2055	0.5391	4.51	-0.38	0.7203
blockno(YEAR)	2006	45	0.5448	0.5252	5.2	1.04	0.3454
blockno(YEAR)	2006	46	-0.06107	0.5472	3.87	-0.11	0.9167
blockno(YEAR)	2006	50	-0.2554	0.5477	3.85	-0.47	0.6661

Table 5.4. The parameters of the resulting lognormal sub-model.

Solution for Fixed Effects

Effect	*season*	*YEAR*	*blockno*	*Estimate*	*Standard Error*	*DF*	*t Value*	*Pr > |t|*	*Alpha*	*Lower*	*Upper*
Intercept				0.04712	0.2317	60	0.20	0.8395	0.05	-0.4163	0.5106
YEAR	1992			0.1091	0.3432	60	0.32	0.7517	0.05	-0.5774	0.7956
YEAR	1993			0.1034	0.3375	60	0.31	0.7604	0.05	-0.5717	0.7785
YEAR	1995			0.1091	0.4601	60	0.24	0.8134	0.05	-0.8114	1.0295
YEAR	1996			-0.05541	0.2176	60	-0.25	0.7999	0.05	-0.4907	0.3799
YEAR	1997			0.1615	0.1964	60	0.82	0.4144	0.05	-0.2315	0.5544
YEAR	2002			-0.05680	0.2292	60	-0.25	0.8051	0.05	-0.5152	0.4016
YEAR	2004			-0.2716	0.2353	60	-1.15	0.2529	0.05	-0.7422	0.1990
YEAR	2005			0.2365	0.2015	60	1.17	0.2451	0.05	-0.1665	0.6394
YEAR	2006			0	.	.	.	.	.	.	.
blockno		29		-0.1448	0.2335	60	-0.62	0.5375	0.05	-0.6118	0.3222
blockno		30		-0.1562	0.2214	60	-0.71	0.4832	0.05	-0.5990	0.2866
blockno		44		0.2680	0.2148	60	1.25	0.2170	0.05	-0.1617	0.6976
blockno		45		-0.04676	0.2199	60	-0.21	0.8324	0.05	-0.4867	0.3932
blockno		46		-0.3976	0.2438	60	-1.63	0.1081	0.05	-0.8852	0.08998
blockno		50		0	.	.	.	.	.	.	.
season			spring	0.4337	0.2351	60	1.84	0.0700	0.05	-0.03660	0.9040
season			summer	0	.	.	.	.	.	.	.

Table 5.5. Index values for mutton snapper from the Dry Tortugas area.

Survey Year	*Nominal Frequency*	*N*	*Index (in mincount units)*	*Scaled Index (to a mean of one)*	*CV*	*LCL (for Scaled Index)*	*UCL (for Scaled Index)*
1992	0.18182	11	0.24522	0.77260	1.14304	0.12414	4.80850
1993	0.14286	14	0.20542	0.64718	1.21104	0.09676	4.32858
1994	0	14					
1995	0.02273	44	0.03029	0.09544	3.07720	0.00445	2.04563
1996	0.28571	28	0.34866	1.09848	0.60358	0.36031	3.34897
1997	0.27273	33	0.41260	1.29994	0.56709	0.45213	3.73751
2002	0.35294	34	0.40055	1.26200	0.54335	0.45633	3.49006
2004	0.42308	26	0.38867	1.22454	0.52440	0.45693	3.28168
2005	0.22917	48	0.37819	1.19152	0.57011	0.41240	3.44262
2006	0.36842	57	0.44699	1.40829	0.32102	0.75278	2.63460

Table 5.6. Logistic regression coefficients for species associated with mutton snapper juveniles and adults.

NODC Code	Scientific name	Common name	Juveniles	Adults
8835020408	Epinephelus morio	red grouper	0.69	
8835020438	Epinephelus fulvus	coney		0.56
8835020439	Epinephelus cruentatus	graysby	-0.80	
8835360102	Lutjanus griseus	gray snapper	0.47	
8835360109	Lutjanus jocu	dog snapper		1.04
8835360112	Lutjanus synagris	lane snapper		0.82
8835360401	Ocyurus chrysurus	yellowtail snapper		-0.33
8835400103	Haemulon album	margate		1.02
8835400110	Haemulon macrostomum	Spanish grunt		-1.10
8835400111	Haemulon melanurum	cottonwick	0.61	
8835400113	Haemulon sciurus	bluestriped grunt		-0.67
8835400116	Haemulon striatum	striped grunt		1.07
8835550101	Chaetodon ocellatus	spotfin butterflyfish	0.41	-0.31
8835550103	Chaetodon capistratus	foureye butterflyfish	-0.53	
8835550107	Chaetodon sedentarius	reef butterflyfish		0.29
8835550301	Holacanthus ciliaris	queen angelfish		0.47
8835550401	Pomacanthus arcuatus	gray angelfish		0.50
8835550402	Pomacanthus paru	French angelfish	0.62	
8839010301	Bodianus pulchellus	spotfin hogfish		-1.99
8839010302	Bodianus rufus	Spanish hogfish	0.51	0.30
8839010901	Lachnolaimus maximus	hogfish	0.86	0.53
8860020202	Balistes vetula	queen triggerfish	0.68	0.76

Table 5.7. Total number of mutton snapper collected during study period.

	Total number of mutton snapper collected			
	<20mm	**21-40mm**	**>40mm**	**Total**
2003	20	22	20	**62**
2005-06	12	30	9	**51**
2006-07	0	28	20	**48**
				161

Table 5.8. Relative abundance of the five most abundant fish species recorded during visual surveys in the nearshore hard-bottom habitat of the Florida Keys from fall 2003 to fall 2006.

Scientific Names	Common Names	Relative abundance
Haemulon plumierii	White grunt	15.40%
Lagodon rhomboides	Pinfish	13.58%
Lutjanus griseus	**Gray snapper**	**10.58%**
Eucinostomus spp.	Mojarras	8.27%
Haemulon aurolineatum	Tomtate	4.93%
Others		47.24%

Table 5.9. Total and relative abundance for all snapper species recorded during visual surveys of the nearshore hard-bottom habitat of the Florida Keys from fall 2003 to fall 2006.

Scientific Names	Common Names	Total abundance	Relative abundance
Lutjanus griseus	Gray snapper	3275	10.58%
Lutjanus synagris	Lane snapper	906	2.93%
Ocyurus chrysurus	Yellowtail snapper	111	0.36%
Lutjanus spp.	Unidentified snappers	21	0.07%
Lutjanus analis	**Mutton snapper**	**19**	**0.06%**
Lutjanus apodus	Schoolmaster	6	0.02%
Lutjanus mahogoni	Mahogany snapper	3	0.01%
TOTAL		**4341**	

Table 5.10. Mutton snapper density index (1994-2005) and upper and lower 95% Confidence intervals.

Species:	mutton snapper
Life stage	exploited phase, >=40 cm
n:	primary units sampled (200 m x 200 m, 40,000 m2)
nm:	second-stage units sampled (177 m2)
avdns:	domain-wide mean density, number per 177 m2 (2-stage stratified random design)

year	nstrat	n	nm	avdns	se_dns	lw_95ci	up_95ci
1994	5	33	141	0.022	0.0117	0.0232	0.0232
1995	5	55	283	0.036	0.0152	0.0298	0.0298
1996	5	46	198	0.006	0.0042	0.0083	0.0083
1997	5	68	404	0.015	0.0057	0.0111	0.0111
1998	10	78	462	0.007	0.0034	0.0067	0.0067
1999	10	159	438	0.014	0.0077	0.0152	0.0152
2000	10	208	473	0.034	0.0105	0.0205	0.0205
2001	10	277	689	0.067	0.0162	0.0319	0.0319
2002	10	315	583	0.054	0.0108	0.0213	0.0213
2003	10	213	411	0.069	0.0196	0.0386	0.0386
2004	10	121	229	0.097	0.0378	0.0745	0.0745
2005	10	224	375	0.032	0.0095	0.0186	0.0186

Table 5.11. Mutton snapper mean length (mm) estimation (1994-2005) and upper and lower 95% Confidence intervals.

Species:	mutton snapper
Life stage:	exploited phase, >=40 cm
lbar:	mean length in exploited phase
note 1:	n is statistical sample size, based on average number of fish observed >=400 mm per 177 m2 point count, usually by a buddy pair of divers; actual number of fish observed is approximately double the n.
note 2:	lower and upper SEs are somewhat asymmetrical due to log-transformation (and back-transformation) for estimation of lbar

Year	n	lbar (mm)	lw_se	up_se	lw_95ci	up_95ci
1994	3.0	500.2	64.2	73.7	204.4	144.8
1995	5.7	502.1	29.0	30.8	74.6	60.5
1996	1.0	600.0	0.0	0.0	0.0	0.0
1997	5.0	421.8	20.2	21.2	51.9	41.7
1998	4.0	479.1	58.3	66.4	161.8	130.4
1999	3.5	462.1	27.8	29.5	88.4	58.1
2000	16.8	459.7	18.8	19.6	39.8	38.4
2001	48.0	481.0	15.8	16.4	31.8	32.2
2002	100.2	504.5	7.8	7.9	15.5	15.6
2003	46.8	518.6	17.1	17.7	34.5	34.8
2004	34.0	491.4	18.4	19.1	37.5	37.6
2005	43.5	474.5	10.2	10.5	20.6	20.5
	Mean	**491.2**				

Table 5.12. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the all of REEF's dives in terms of proportion of positive dives, **1994-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	22667	18222.69	0.8039				-9111.34				
Year	22655	18185.30	0.8027	0.0012	0.15%	0.15%	-9092.65	-18.69	37.39	12	0.0002
With Year											
Month	22644	18160.06	0.8020	0.0007	0.09%		-9080.03	-12.62	25.24	11	0.0084
Zone	22652	18062.73	0.7974	0.0053	0.66%		-9031.37	-61.28	122.57	3	0.0000
Experience	22654	18026.80	0.7957	0.0070	0.87%	1.02%	-9013.40	-79.25	158.50	1	0.0000
Visibility	22649	18022.01	0.7957	0.0070	0.87%		-9011.01	-81.64	163.29	6	0.0000
Habitat	22650	18022.43	0.7957	0.0070	0.87%		-9011.21	-81.44	162.87	5	0.0000
Current	22653	18178.58	0.8025	0.0002	0.02%		-9089.29	-3.36	6.72	2	0.0347
Ave depth	22644	18052.96	0.7973	0.0054	0.67%		-9026.48	-66.17	132.34	11	0.0000
Bottom time	22643	18110.57	0.7998	0.0029	0.36%		-9055.28	-37.37	74.73	12	0.0000
Start time	22653	18090.16	0.7986	0.0041	0.51%		-9045.08	-47.57	95.14	2	0.0000
With Year and Experience											
Month	22643	17995.10	0.7947	0.0010	0.12%		-8997.55	-15.85	31.71	11	0.0008
Zone	22651	17936.09	0.7918	0.0039	0.49%		-8968.04	-45.36	90.72	3	0.0000
Visibility	22648	17890.93	0.7900	0.0057	0.71%		-8945.47	-67.94	135.87	6	0.0000
Habitat	22649	17877.97	0.7893	0.0064	0.80%	1.82%	-8938.98	-74.42	148.83	5	0.0000
Current	22652	18024.51	0.7957	0.0000	0.00%		-9012.26	-1.14	2.29	2	0.3186
Ave depth	22643	17904.60	0.7907	0.0050	0.62%		-8952.30	-61.10	122.20	11	0.0000
Bottom time	22642	17976.80	0.7940	0.0017	0.21%		-8988.40	-25.00	50.00	12	0.0000
Start time	22652	17933.76	0.7917	0.0040	0.50%		-8966.88	-46.52	93.04	2	0.0000
With Year, Experience, and Habitat											
Month	22638	17842.96	0.7882	0.0011	0.14%		-8921.48	-17.50	35.01	11	0.0002
Zone	22646	17801.66	0.7861	0.0032	0.40%		-8900.83	-38.16	76.31	3	0.0000
Visibility	22643	17746.24	0.7837	0.0056	0.70%		-8873.12	-65.86	131.73	6	0.0000
Current	22647	17876.48	0.7894	-0.0001	-0.01%		-8938.24	-0.75	1.49	2	0.4739
Ave depth	22638	17728.87	0.7831	0.0062	0.77%	2.59%	-8864.44	-74.55	149.10	11	0.0000
Bottom time	22637	17835.47	0.7879	0.0014	0.17%		-8917.74	-21.25	42.50	12	0.0000
Start time	22647	17790.73	0.7856	0.0037	0.46%		-8895.37	-43.62	87.24	2	0.0000

Table 5.13. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for only REEF dives from sites that were visited in seven of the 13 years and mutton snapper were observed more than once in terms of proportion of positive dives, **1994-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	14369	11711.75	0.8151				-5855.88				
Year	14357	11652.98	0.8117	0.0034	0.42%	0.42%	-5826.49	-29.39	58.77	12	0.0000
With year											
Month	14346	11641.42	0.8115	0.0002	0.02%		-5820.71	-5.78	11.56	11	0.3974
Zone	14354	11499.69	0.8011	0.0106	1.30%	1.72%	-5749.85	-76.64	153.29	3	0.0000
Experience	14356	11586.05	0.8071	0.0046	0.56%		-5793.02	-33.47	66.93	1	0.0000
Visibility	14351	11582.16	0.8071	0.0046	0.56%		-5791.08	-35.41	70.83	6	0.0000
Habitat	14352	11595.61	0.8079	0.0038	0.47%		-5797.81	-28.68	57.37	5	0.0000
Current	14355	11645.77	0.8113	0.0004	0.05%		-5822.89	-3.60	7.21	2	0.0272
Ave depth	14346	11602.61	0.8088	0.0029	0.36%		-5801.31	-25.18	50.37	11	0.0000
Bottom time	14345	11578.39	0.8071	0.0046	0.56%		-5789.20	-37.30	74.59	12	0.0000
Start time	14355	11560.11	0.8053	0.0064	0.79%		-5780.06	-46.43	92.87	2	0.0000
With year and zone											
Month	14343	11487.06	0.8009	0.0002	0.02%		-5743.53	-6.32	12.63	11	0.3179
Experience	14353	11464.57	0.7988	0.0023	0.28%		-5732.28	-17.56	35.13	1	0.0000
Visibility	14348	11452.67	0.7982	0.0029	0.36%		-5726.33	-23.51	47.02	6	0.0000
Habitat	14349	11439.73	0.7972	0.0039	0.48%		-5719.86	-29.98	59.97	5	0.0000
Current	14352	11495.93	0.8010	0.0001	0.01%		-5747.96	-1.88	3.77	2	0.1521
Ave depth	14343	11464.45	0.7993	0.0018	0.22%		-5732.23	-17.62	35.24	11	0.0002
Bottom time	14342	11401.41	0.7950	0.0061	0.75%	2.47%	-5700.70	-49.14	98.28	12	0.0000
Start time	14352	11412.94	0.7952	0.0059	0.72%		-5706.47	-43.38	86.75	2	0.0000
With year, zone, and bottom time											
Month	14331	11381.78	0.7942	0.0008	0.10%		-5690.89	-9.81	19.63	11	0.0508
Experience	14341	11381.74	0.7937	0.0013	0.16%		-5690.87	-9.83	19.67	1	0.0000
Visibility	14336	11355.46	0.7921	0.0029	0.36%		-5677.73	-22.98	45.95	6	0.0000
Habitat	14337	11349.99	0.7917	0.0033	0.40%		-5674.99	-25.71	51.42	5	0.0000
Current	14340	11400.57	0.7950	0.0000	0.00%		-5700.29	-0.42	0.84	2	0.6586
Ave depth	14331	11355.95	0.7924	0.0026	0.32%		-5677.97	-22.73	45.46	11	0.0000
Start time	14340	11312.65	0.7889	0.0061	0.75%	3.21%	-5656.33	-44.38	88.76	2	0.0000

Table 5.14. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for only REEF dives that observed mutton snapper or from dives that were identified by Stephens and MacCall's logistic regression as dives that could have had mutton snapper in terms of proportion of positive dives, **1994-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	6110	8467.30	1.3858				-4233.65				
Year	6098	8425.72	1.3817	0.0041	0.30%	0.30%	-4212.86	-20.79	41.57	12	0.0000
With Year											
Month	6087	8386.05	1.3777	0.0040	0.29%		-4193.03	-19.83	39.67	11	0.0000
Zone	6095	8399.01	1.3780	0.0037	0.27%		-4199.50	-13.36	26.72	3	0.0000
Experience	6097	8401.72	1.3780	0.0037	0.27%		-4200.86	-12.00	24.01	1	0.0000
Visibility	6092	8422.94	1.3826	-0.0009	-0.06%		-4211.47	-1.39	2.78	6	0.8358
Habitat	6093	8402.95	1.3791	0.0026	0.19%		-4201.47	-11.39	22.77	5	0.0004
Current	6096	8420.69	1.3813	0.0004	0.03%		-4210.34	-2.52	5.04	2	0.0806
Ave depth	6087	8349.25	1.3717	0.0100	0.72%	1.02%	-4174.62	-38.24	76.48	11	0.0000
Bottom time	6086	8412.20	1.3822	-0.0005	-0.04%		-4206.10	-6.76	13.52	12	0.3323
Start time	6096	8415.66	1.3805	0.0012	0.09%		-4207.83	-5.03	10.06	2	0.0065

Table 5.15. Fishery independent indices from REEF dive surveys in terms of the proportion of positive dives by year for Florida's Atlantic coast including the Dry Tortugas.

	Proportion positive dives			Scaled to mean		
Year	All records	Visited at least 7 years out of 13 years mutton observed more than once	Dives with mutton snapper or identified from regression	All records	Visited at least 7 years out of 13 years mutton observed more than once	Dives with mutton snapper or identified from regression
1994	0.20	0.06	0.54	1.22	1.07	1.04
1995	0.19	0.07	0.62	1.20	1.19	1.18
1996	0.18	0.06	0.59	1.10	1.02	1.13
1997	0.17	0.06	0.43	1.02	1.12	0.84
1998	0.17	0.06	0.56	1.06	1.13	1.08
1999	0.17	0.07	0.49	1.05	1.22	0.95
2000	0.15	0.05	0.44	0.92	0.87	0.84
2001	0.14	0.05	0.54	0.88	0.90	1.04
2002	0.15	0.04	0.50	0.90	0.73	0.96
2003	0.15	0.05	0.50	0.91	0.93	0.96
2004	0.15	0.05	0.49	0.92	0.94	0.94
2005	0.15	0.05	0.52	0.92	0.88	1.00
2006	0.15	0.05	0.53	0.91	0.99	1.03
Mean	0.16	0.055	0.52			

Table 5.16.

Table 1. Sample sizes of measured mutton snapper from Atlantic and Gulf of Mexico commercial handline and longline vessel landings.

Year	Atlantic		Gulf of Mexico	
	handline	longline	handline	longline
1990	74	71	3	22
1991	202	66	13	37
1992	216	190	9	31
1993	152	30	14	110
1994	89	102	22	117
1995	245	26	18	89
1996	58	2	57	84
1997	161	55	60	183
1998	145	262	34	587
1999	182	424	20	802
2000	171	367	37	366
2001	90	75	59	480
2002	117	42	36	336
2003	99	105	9	423
2004	163	170	11	199
2005	94	121	21	157
2006	87	130	19	433
Total	2,345	2,238	442	4,456

Tables 5.17 and 5.18.

Table 2. Linear regression statistics for the final GLM models on proportion positive trips (a) and catch rates on positive trips (b) for mutton snapper in the Gulf of Mexico for vessels reporting handline landings 1990-2006.

a.

source	df	% reduction dev/df	chi square	p>chi square
Area	9	4.28	1418.33	<0.0001
Days at sea	11	2.64	847.83	<0.0001
Year	16	0.18	43.28	0.0003
Area*Year	132	1.10	491.13	<0.0001

b.

source	df	% reduction dev/df	chi square	p>chi square
Days at sea	3	22.72	837.34	<0.0001
Area	9	10.09	274.79	<0.0001
Crew	2	2.89	77.44	<0.0001
Year	16	0.88	75.63	<0.0001
Area*Year	130	2.82	358.79	<0.0001
Area*Crew	18	1.25	127.44	<0.0001

Table 3. Handline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for mutton snapper (1990-2005) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1990	0.529062	76	0.447368	0.821502	0.4168	1.61916	0.349265
1991	0.803914	99	0.363636	1.289936	0.663679	2.507139	0.341661
1992	0.970832	578	0.403114	0.962631	0.682128	1.358481	0.173511
1993	1.219914	1,830	0.392896	1.146831	0.843629	1.559004	0.154431
1994	1.092995	2,022	0.361029	0.775275	0.566887	1.060267	0.157493
1995	0.977261	2,181	0.332875	0.858692	0.634176	1.162691	0.152416
1996	1.216038	2,264	0.33083	0.994414	0.734991	1.345404	0.152015
1997	1.158785	2,200	0.347727	0.914474	0.676691	1.235812	0.151425
1998	0.996354	1,755	0.321368	0.986621	0.725125	1.342419	0.154888
1999	0.798362	1,607	0.29496	0.868927	0.630908	1.196743	0.16108
2000	0.601347	1,644	0.316302	0.725607	0.530787	0.991934	0.157284
2001	0.927845	1,662	0.304452	0.961591	0.702406	1.316414	0.158012
2002	1.339774	1,859	0.351802	1.110981	0.820042	1.505141	0.152701
2003	1.31301	1,714	0.332555	1.198829	0.878252	1.636422	0.15653
2004	0.9824	1,759	0.324048	1.084486	0.795971	1.477577	0.155578
2005	1.031263	1,379	0.340827	1.11366	0.814868	1.522012	0.157148
2006	1.040845	1,156	0.32872	1.185543	0.854678	1.644494	0.164717

Tables 5.19 and 5.20.

Table 4. Linear regression statistics for the final GLM models on proportion positive trips (a) and catch rates on positive trips (b) for mutton snapper in the Gulf of Mexico for vessels reporting longline landings 1990-2006.

a.

source	df	% reduction dev/df	chi square	p>chi square
Area	2	16.18	695.56	<0.0001
Year	16	1.72	97.41	<0.0001
Days at sea	2	1.91	65.16	<0.0001

b.

source	df	% reduction dev/df	chi square	p>chi square
Area	2	21.87	267.72	<0.0001
Year	16	9.10	157.51	<0.0001
Days at sea	2	3.47	58.23	<0.0001
Area*Year	31	3.62	89.30	<0.0001

Table 5. Longline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for mutton snapper (1990-2005) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1990	0.226114	19	0.473684	0.105271	0.026216	0.422717	0.788132
1991	0.251342	44	0.477273	0.40158	0.147444	1.093747	0.53412
1992	0.343107	45	0.4	0.470005	0.165736	1.332868	0.558649
1993	0.289495	135	0.392593	0.377013	0.163173	0.871094	0.437778
1994	0.803849	132	0.492424	0.65007	0.293857	1.438088	0.413162
1995	0.438806	144	0.506944	0.590953	0.27161	1.285757	0.403836
1996	0.378318	242	0.454545	0.398491	0.188417	0.842788	0.388039
1997	1.334329	253	0.565217	0.758331	0.368223	1.561733	0.373325
1998	1.358057	266	0.578947	0.737159	0.363056	1.496748	0.365521
1999	1.270027	182	0.478022	0.850902	0.396195	1.827472	0.396587
2000	1.719245	161	0.546584	1.317985	0.623833	2.784537	0.387455
2001	1.102011	176	0.596591	1.006202	0.48764	2.07621	0.374389
2002	1.01522	152	0.5	1.32654	0.619615	2.839999	0.394825
2003	1.766106	237	0.493671	1.483123	0.716454	3.070198	0.376171
2004	1.830992	239	0.58159	2.586274	1.280449	5.223804	0.362646
2005	1.177602	227	0.599119	1.475298	0.733762	2.966226	0.360138
2006	1.69538	263	0.642586	2.464802	1.23878	4.904218	0.354424

Table 5.21. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, **1986-2006**, from interviews with a single angler. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	1997	4784.252	2.3957				-1741.81				
Year	1977	4245.603	2.1475	0.2482	10.36%	10.36%	-1472.49	-269.32	538.65	20	0.0000
Wave	1992	4743.179	2.3811	0.0146	0.61%		-1721.28	-20.54	41.07	5	0.0000
Mode_fx	1996	4763.109	2.3863	0.0094	0.39%		-1731.24	-10.57	21.14	1	0.0000
Area_x	1995	4761.015	2.3865	0.0092	0.38%		-1730.19	-11.62	23.24	2	0.0000
Cnty	1993	4532.680	2.2743	0.1214	5.07%		-1616.03	-125.79	251.57	4	0.0000
Num_hrsf	1990	4695.940	2.3598	0.0359	1.50%		-1697.66	-44.16	88.31	7	0.0000
Avidity	1987	4644.522	2.3375	0.0582	2.43%		-1671.95	-69.86	139.73	10	0.0000
With year											
Wave	1972	4220.877	2.1404	0.0071	0.30%		-1460.12	-12.36	24.73	5	0.0002
Mode_fx	1976	4244.867	2.1482	-0.0007	-0.03%		-1472.12	-0.37	0.74	1	0.3908
Area_x	1975	4229.191	2.1414	0.0061	0.25%		-1464.28	-8.21	16.41	2	0.0003
Cnty	1973	4101.256	2.0787	0.0688	2.87%	13.23%	-1400.31	-72.17	144.35	4	0.0000
Num_hrsf	1970	4160.604	2.1120	0.0355	1.48%		-1429.99	-42.50	85.00	7	0.0000
Avidity	1967	4148.126	2.1089	0.0386	1.61%		-1423.75	-48.74	97.48	10	0.0000
With year and cnty											
Wave	1968	4078.153	2.0722	0.0065	0.27%		-1388.76	-11.55	23.10	5	0.0003
Mode_fx	1972	4068.643	2.0632	0.0155	0.65%		-1384.01	-16.31	32.61	1	0.0000
Area_x	1971	4051.287	2.0554	0.0233	0.97%		-1375.33	-24.98	49.97	2	0.0000
Num_hrsf	1966	4026.217	2.0479	0.0308	1.29%		-1362.79	-37.52	75.04	7	0.0000
Avidity	1963	4005.306	2.0404	0.0383	1.60%	14.83%	-1352.34	-47.98	95.95	10	0.0000

Table 5.21. continued. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, **1986-2006**, from interviews with a single angler . The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
With year, cnty, and avidity											
Wave	1958	3982.986	2.0342	0.0062	0.26%		-1341.18	-11.16	22.32	5	0.0005
Mode_fx	1962	3987.158	2.0322	0.0082	0.34%		-1343.26	-9.07	18.15	1	0.0000
Area_x	1961	3957.679	2.0182	0.0222	0.93%		-1328.53	-23.81	47.63	2	0.0000
Num_hrsf	1956	3934.746	2.0116	0.0288	1.20%	16.03%	-1317.06	-35.28	70.56	7	0.0000
With year, cnty, avidity, and num_hrsf											
Wave	1951	3913.314	2.0058	0.0058	0.24%		-1306.34	-10.72	21.43	5	0.0007
Mode_fx	1955	3915.179	2.0026	0.0090	0.38%		-1307.28	-9.78	19.57	1	0.0000
Area_x	1954	3884.776	1.9881	0.0235	0.98%	17.01%	-1292.07	-24.99	49.97	2	0.0000
With year, cnty, avidity, num_hrsf, and area_x											
Wave	1949	3865.148	1.9831	0.0050	0.21%		-1282.26	-9.81	19.63	5	0.0015
Mode_fx	1953	3867.995	1.9805	0.0076	0.32%		-1283.68	-8.39	16.78	1	0.0000

Table 5.22. Recreational fishery catch per unit effort indices from the Marine Recreational Fisheries Statistics Survey and the headboat logbook. The longer time series, 1986-2006, of MRFSS data only includes trips with a single angler and the shorter time series, 1991-2006, where the ancillary interviews can be linked back to a primary interview for the trip. Because headboat entries are only successful trips, the index was broken where the minimum size changed. The first headboat time series, 1979-1991, preceded the 12-inch minimum size and the second time series was after the 16-inch minimum size was implemented in Southeast Florida. The second set of indices in the table are the indices scaled to their means to facilitate comparisons.

	Number of fish per trip				Scaled to mean			
Year	MRFSS 1986-2006	MRFSS 1991-2006	Headboat 1979-91	Headboat 1995-2006	MRFSS 1986-2006	MRFSS 1991-2006	Headboat 1979-1991	Headboat 1995-2006
1979			2.00				0.87	
1980			2.97				1.30	
1981			3.21				1.41	
1982			2.25				0.99	
1983			1.96				0.86	
1984			1.59				0.70	
1985			2.12				0.93	
1986	0.72		1.73		0.43		0.76	
1987	0.91		1.83		0.54		0.80	
1988	0.94		2.32		0.56		1.01	
1989	0.74		2.50		0.44		1.09	
1990	0.55		3.09		0.33		1.35	
1991	1.85	1.25	2.13		1.10	0.84	0.93	
1992	2.22	1.63			1.32	1.09		
1993	2.39	1.87			1.43	1.25		
1994	1.72	1.17			1.03	0.78		
1995	1.39	1.29		2.20	0.83	0.86		1.09
1996	1.59	0.93		1.80	0.95	0.62		0.89
1997	1.88	1.40		1.67	1.12	0.93		0.83
1998	2.19	1.73		1.96	1.31	1.15		0.97
1999	1.33	1.48		1.36	0.79	0.99		0.67
2000	2.04	1.47		1.45	1.22	0.98		0.72
2001	2.52	1.71		2.54	1.51	1.14		1.26
2002	1.94	1.32		2.22	1.16	0.88		1.10
2003	1.93	1.58		2.46	1.15	1.06		1.22
2004	1.74	1.43		1.97	1.04	0.95		0.98
2005	2.90	1.94		2.89	1.73	1.29		1.43
2006	1.70	1.78		1.70	1.01	1.19		0.84

Table 5.23. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, **1991-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	3488	7754.462	2.2232				-2021.33				
Year	3473	7542.912	2.1719	0.0513	2.31%	2.31%	-1915.55	-105.77	211.55	15	0.0000
Wave	3483	7665.030	2.2007	0.0225	1.01%		-1976.61	-44.72	89.43	5	0.0000
Mode_fx	3486	7632.296	2.1894	0.0338	1.52%		-1960.25	-61.08	122.17	2	0.0000
Area_x	3484	7666.760	2.2006	0.0226	1.02%		-1977.48	-43.85	87.70	4	0.0000
Cnty	3484	7678.773	2.2040	0.0192	0.86%		-1983.49	-37.84	75.69	4	0.0000
Num_hrsf	3481	7626.495	2.1909	0.0323	1.45%		-1957.35	-63.98	127.97	7	0.0000
Party	3483	7567.472	2.1727	0.0505	2.27%		-1927.83	-93.50	186.99	5	0.0000
Avidity	3478	7686.421	2.2100	0.0132	0.59%		-1987.31	-34.02	68.04	10	0.0000
With year											
Wave	3468	7474.251	2.1552	0.0167	0.75%		-1881.22	-34.33	68.66	5	0.0000
Mode_fx	3471	7433.030	2.1415	0.0304	1.37%		-1860.61	-54.94	109.88	2	0.0000
Area_x	3469	7420.910	2.1392	0.0327	1.47%		-1854.55	-61.00	122.00	4	0.0000
Cnty	3469	7474.483	2.1547	0.0172	0.77%		-1881.34	-34.21	68.43	4	0.0000
Num_hrsf	3466	7430.786	2.1439	0.0280	1.26%		-1859.49	-56.06	112.13	7	0.0000
Party	3468	7389.858	2.1309	0.0410	1.84%	4.15%	-1839.03	-76.53	153.05	5	0.0000
Avidity	3463	7480.070	2.1600	0.0119	0.54%		-1884.13	-31.42	62.84	10	0.0000
With year and party											
Wave	3463	7329.762	2.1166	0.0143	0.64%		-1808.98	-30.05	60.10	5	0.0000
Mode_fx	3466	7354.627	2.1219	0.0090	0.40%		-1821.41	-17.62	35.23	2	0.0000
Area_x	3464	7267.485	2.0980	0.0329	1.48%	5.63%	-1777.84	-61.19	122.37	4	0.0000
Cnty	3464	7343.400	2.1199	0.0110	0.49%		-1815.80	-23.23	46.46	4	0.0000
Num_hrsf	3461	7296.334	2.1082	0.0227	1.02%		-1792.27	-46.76	93.52	7	0.0000
Avidity	3458	7332.020	2.1203	0.0106	0.48%		-1810.11	-28.92	57.84	10	0.0000

Table 5.23. continued. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, 1991-2006. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
With year, party, and area_x											
Wave	3459	7209.320	2.0842	0.0138	0.62%		-1748.76	-29.08	58.16	5	0.0000
Mode_fx	3462	7229.463	2.0882	0.0098	0.44%		-1758.83	-19.01	38.02	2	0.0000
Cnty	3460	7242.262	2.0931	0.0049	0.22%		-1765.23	-12.61	25.22	4	0.0000
Num_hrsf	3457	7177.421	2.0762	0.0218	0.98%	6.61%	-1732.81	-45.03	90.06	7	0.0000
Avidity	3454	7208.709	2.0871	0.0109	0.49%		-1748.45	-29.39	58.78	10	0.0000
With year, party, area_x, and num_hrsf											
Wave	3452	7115.427	2.0612	0.0150	0.67%	7.29%	-1701.81	-31.00	61.99	5	0.0000
Mode_fx	3455	7134.290	2.0649	0.0113	0.51%		-1711.24	-21.57	43.13	2	0.0000
Cnty	3453	7156.613	2.0726	0.0036	0.16%		-1722.41	-10.40	20.81	4	0.0003
Avidity	3447	7119.458	2.0654	0.0108	0.49%		-1703.83	-28.98	57.96	10	0.0000
With year, party, area_x, num_hrsf, and wave											
Mode_fx	3450	7071.116	2.0496	0.0116	0.52%	7.81%	-1679.66	-22.16	44.31	2	0.0000
Cnty	3448	7098.373	2.0587	0.0025	0.11%		-1693.29	-8.53	17.05	4	0.0019
Avidity	3442	7054.034	2.0494	0.0118	0.53%		-1671.12	-30.70	61.39	10	0.0000
With year, party, area_x, num_hrsf, wave, and mode_fx											
Cnty	3446	7055.017	2.0473	0.0023	0.10%		-1671.61	-8.05	16.10	4	0.0029
Avidity	3440	7010.623	2.0380	0.0116	0.52%	8.33%	-1649.41	-30.25	60.49	10	0.0000
With year, party, area_x, num_hrsf, wave, mode_fx, and avidity											
Cnty	3436	6995.522	2.0359	0.0021	0.09%		-1641.86	-7.55	15.10	4	0.0045

Table 5.24. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the headboat's catch rates in terms of number of fish caught per trip for the period: **1979-1991**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	52258	167125.7	3.1981				-24369.73				
Year	52246	162103.2	3.1027	0.0954	2.98%	2.98%	-21858.45	-2511.27	5022.54	12	0.0000
Month	52247	163037.4	3.1205	0.0776	2.43%		-22325.54	-2044.18	4088.37	11	0.0000
Num_angl	52252	166745.4	3.1912	0.0069	0.22%		-24179.58	-190.15	380.29	6	0.0000
Trip type	52254	165707.3	3.1712	0.0269	0.84%		-23660.51	-709.22	1418.44	4	0.0000
Area	52257	166981.6	3.1954	0.0027	0.08%		-24297.66	-72.07	144.13	1	0.0000
Lat-Long	52252	166489.3	3.1863	0.0118	0.37%		-24051.49	-318.24	636.47	6	0.0000
With year											
Month	52235	157850.9	3.0219	0.0808	2.53%	5.51%	-19732.32	-2126.13	4252.26	11	0.0000
Num_angl	52240	161740.3	3.0961	0.0066	0.21%		-21677.03	-181.42	362.85	6	0.0000
Trip type	52242	160392.9	3.0702	0.0325	1.02%		-21003.31	-855.15	1710.30	4	0.0000
Area	52245	161951.2	3.0998	0.0029	0.09%		-21782.49	-75.97	151.93	1	0.0000
Lat-Long	52240	161515.3	3.0918	0.0109	0.34%		-21564.51	-293.94	587.89	6	0.0000
With year and month											
Num_angl	52229	157264.9	3.0111	0.0108	0.34%		-19439.30	-293.02	586.05	6	0.0000
Trip type	52231	156077.9	2.9882	0.0337	1.05%	6.56%	-18845.83	-886.49	1772.97	4	0.0000
Area	52234	157628.9	3.0177	0.0042	0.13%		-19621.30	-111.02	222.04	1	0.0000
Lat-Long	52229	157159.2	3.0090	0.0129	0.40%		-19386.47	-345.85	691.69	6	0.0000
With year, month, and trip type											
Num_angl	52225	155482.8	2.9772	0.0110	0.34%		-18548.27	-297.57	595.13	6	0.0000
Area	52230	156074.9	2.9882	0.0000	0.00%		-18844.34	-1.50	2.99	1	0.0835
Lat-Long	52225	155683.1	2.9810	0.0072	0.23%		-18648.42	-197.42	394.83	6	0.0000

Table 5.25. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the headboat's catch rates in terms of number of fish caught per trip for the period: **1995-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	11143	37389.15	3.3557				-8893.00				
Year	11132	36758.78	3.3024	0.0533	1.59%		-8577.81	-315.19	630.37	11	0.0000
Month	11132	36352.15	3.2658	0.0899	2.68%		-8374.50	-518.50	1037.01	11	0.0000
Num_angl	11137	37106.72	3.3321	0.0236	0.70%		-8751.79	-141.21	282.43	6	0.0000
Trip type	11139	36100.60	3.2412	0.1145	3.41%	3.41%	-8248.73	-644.28	1288.55	4	0.0000
Area	11142	37358.03	3.3532	0.0025	0.07%		-8877.44	-15.56	31.13	1	0.0000
Lat-Long	11137	36932.69	3.3165	0.0392	1.17%		-8664.77	-228.23	456.47	6	0.0000
With trip type											
Year	11128	35379.31	3.1796	0.0616	1.84%		-7888.08	-360.65	721.29	11	0.0000
Month	11128	35244.81	3.1675	0.0737	2.20%		-7820.83	-427.90	855.80	11	0.0000
Num_angl	11133	35717.37	3.2085	0.0327	0.97%		-8057.11	-191.62	383.23	6	0.0000
Area	11138	36076.68	3.2394	0.0018	0.05%		-8236.76	-11.96	23.92	1	0.0000
Lat-Long	11133	35176.06	3.1599	0.0813	2.42%	5.83%	-7786.45	-462.27	924.55	6	0.0000
With trip type and lat-long											
Year	11122	34586.82	3.1100	0.0499	1.49%		-7491.84	-294.62	589.23	11	0.0000
Month	11122	34305.56	3.0848	0.0751	2.24%	8.07%	-7351.20	-435.25	870.50	11	0.0000
Num_angl	11127	34784.03	3.1264	0.0335	1.00%		-7590.44	-196.01	392.02	6	0.0000
Area	11132	35175.42	3.1601	-0.0002	-0.01%		-7786.13	-0.32	0.64	1	0.4239
With trip type, lat-long, and month											
Year	11111	33741.17	3.0370	0.0478	1.42%	9.50%	-7069.01	-282.20	564.39	11	0.0000
Num_angl	11116	33854.54	3.0458	0.0390	1.16%		-7125.69	-225.51	451.03	6	0.0000
Area	11121	34305.40	3.0850	-0.0002	-0.01%		-7351.12	-0.08	0.16	1	0.6859
With trip type, lat-long, month, and year											
Num_angl	11105	33320.72	3.0008	0.0362	1.08%	10.58%	-6858.78	-210.22	420.45	6	0.0000
Area	11110	33740.32	3.0372	-0.0002	-0.01%		-7068.58	-0.43	0.86	1	0.3549

Table 5.26. Summarized fishery independent and fishery dependent data collection programs with recommendations for the mutton snapper assessment.

Series	*Author*	*Reference*	*Data Source*	*Area*	*Years*	*Season*	*Biomass /Number*	*Fishery Type*	*Standardized*	*Selectivity Info*	*Age Range*	*Positive Aspects*	*Negative Aspects*	*Utility for Assessment*
SEAMAP Video	Gledhill et al.	SEDAR15A-DW-01	SEAMAP Video Survey of Shelf Edge Banks	Dry Tortugas, South Pulley Ridge	1992-1997, 2002, 2004-2006	Spring-Summer	Number/Index only	Independent	Design-based, delta-lognormal	Limited Size Info	2-5 year old	Permanent record, Deeper water.	Very limited size, can only use as an index	Base
FWC Visual	Acosta. A	SEDAR15-DW-02	Visual point counts	Florida Keys	1999-2004 2006	April-October	Number/ 100m^2 Number of fish	Independent	SRS	Size info	0-20 year old	Non-disruptive, low cost	Limited Depth range	Base
FWC Seine	Ferguson, K.	SEDAR15-DW-03	Beach seines 21.3m	Middle Florida keys	2003-6months 2005-present	June-November Year around	Number/ 100m^2 Number of fish	Independent	SRS	Size info	0 and 1 year old	Juvenile and YOY	Limited spatial cover, selective gear, depth range	No Base
FWC NSHB	Tellier, M.	SEDAR15-DW-04	FWC Nearshore Hard-Bottom Community Visual Survey	Florida Keys	2003-now	Quarterly (2003-2004), biannually (2005 - now)	Number/100m^2 Number/minute Size	Independent	Design-based, fixed stations	Limited Size info	0 – 20 year old	Juvenile and YOY, habitat and species association, non-disruptive	Few fish, only three years of data	No Base
FWC-FIM Age 0	Ingram et al.	SEDAR15-DW-05	FIM Age 0, 21.3m beach seine, haul seine	Indian River estuary	1998-2006	Monthly	Number/seine	Independent	SRS, ZIDL	Size info	0 – 20 year old	YOY index	N/A	Base
FWC-FIM Age 1	Ingram et al.	SEDAR15-DW-05	FIM Age 1, Haul seine	Indian River and Tequesta estuaries	1999-2006	Monthly	Number/seine	Independent	SRS, ZIDL	Size info	0 – 20 year old	Age 1 index	N/A	Base
NMFS-UM - Early	Bohnsack/ Harper	SEDAR15-DW-06	Visual point counts	Florida Keys-	1979-1993	Summer	Frequency Occurrence Density	Independent	Nominal density	Size info	TBD	Non-disruptive	Depth range	Sensitivity, revisit (see discussion)
NMFS-UM - Late	Ault/ Bohnsack	SEDAR15-DW-07	Visual point counts	Florida Keys-	1994-2002	Once a year	Presence-absence Density	Independent	SRS, Nominal density	Size info	TBD	Non-disruptive	Depth range	Revisit (see discussion)
REEF	Muller, R	SEDAR15-DW-08	Roving Diver Surveys	East Coast Florida – Dry Tortugas	1993-2007	Random	Presence-absence, Multinomial	Independent	Nominal multinomial	N/A	N/A	Large geographical area, species associations	Categorical data, lack of size info, little data in grass beds and sand, depth range	TBD

Table 5.26. Continued.

Series	*Author*	*Reference*	*Data Source*	*Area*	*Years*	*Season*	*Biomass /Number*	*Fishery Type*	*Standardized*	*Selectivity Info*	*Age Range*	*Positive Aspects*	*Negative Aspects*	*Utility for Assessment*
NOAA/NMFS - CLP	McCarthy, K	SEDAR15-DW-09	Coastal Logbook Program	West coast FL to NC	1994-2006	Year around	Landings in pounds	Dependent	Modified Stevens & MacCall, Delta-log normal	N/A	N/A	Broad spatial coverage, relative long time series, many observations	Landing data, no size or age info, self-reported dataset	Base
NOAA/ NMFS - Railey's	Burton, M	SEDAR15-DW-10	Reef fish visual census surveys	Dry Tortugas	2001-2006	Summer	Density	Independent	Delta-log normal	Fish behavior (avoidance/ attraction)	N/A	Monitoring of spawning aggregation	Limited spatially and temporally	Base
NOAA/ NMFS - MFRSS	Muller, R	SEDAR15-DW-11	MFRSS	From NC to TX	1991-2005	Year around	Number per trips	Dependent	GML Poisson	TBD	TBD	Long time series, large geographical coverage, estimate of discard magnitude	Low intercept rate	Base
NOAA/ NMFS Headboat	Muller, R	SEDAR15-DW-12	NMFS Headboat survey	From NC to TX	1981-1993, 1995-2005	Year around	Number per trip	Dependent	Modified Stevens & MacCall, GLM Poisson	TBD	TBD	Long time series, large geographical area, mandatory, near census	Captain reporting (bias), annual estimate reported by large strata	Base

5.9 Figures

Figure 5.1. Gulf of Mexico shelf-edge banks sampled during SEAMAP offshore reef fish survey with sample blocks.

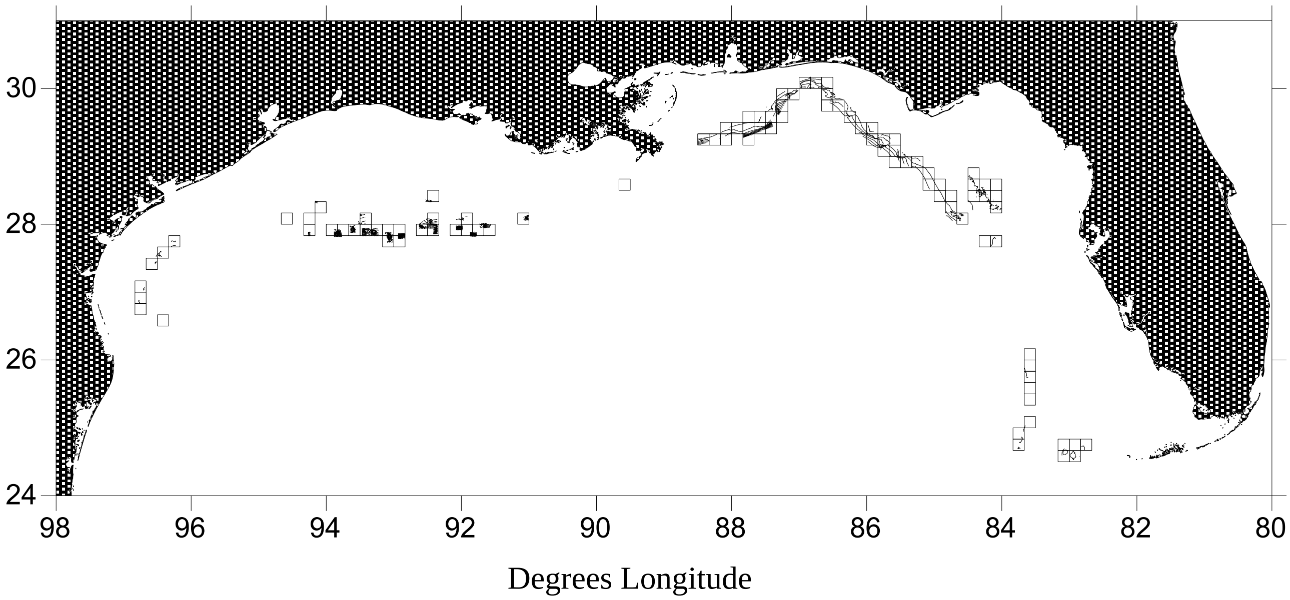


Figure 5.2. SEAMAP offshore reef fish survey sample blocks in the eastern Gulf of Mexico. The mutton snapper index was developed from sample blocks 29, 30, 44, 45, 46, and 50).

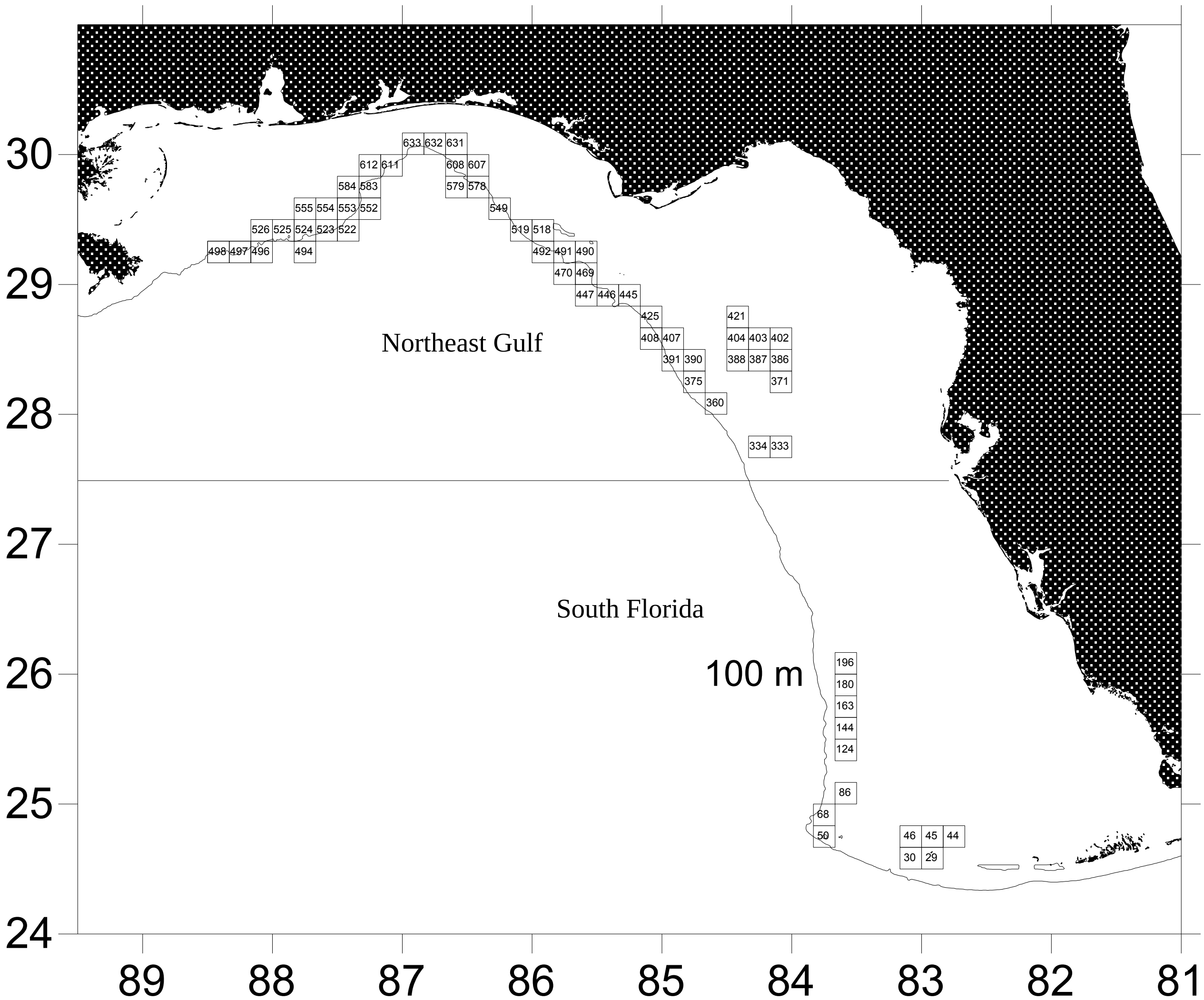


Figure 5.3. Design-based nominal index of abundance ± SE from SEAMAP video survey blocks located near the Dry Tortugas.

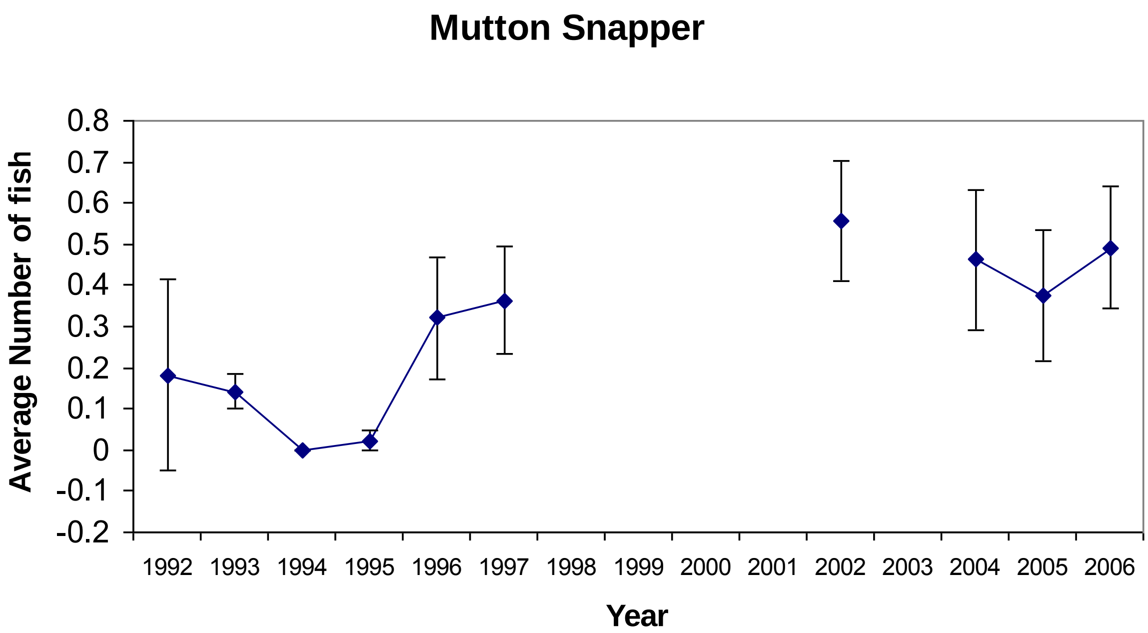


Figure 5.4. Scaled design-based and scaled delta-lognormal indices of abundance ± SE from SEAMAP video survey blocks located near the Dry Tortugas.

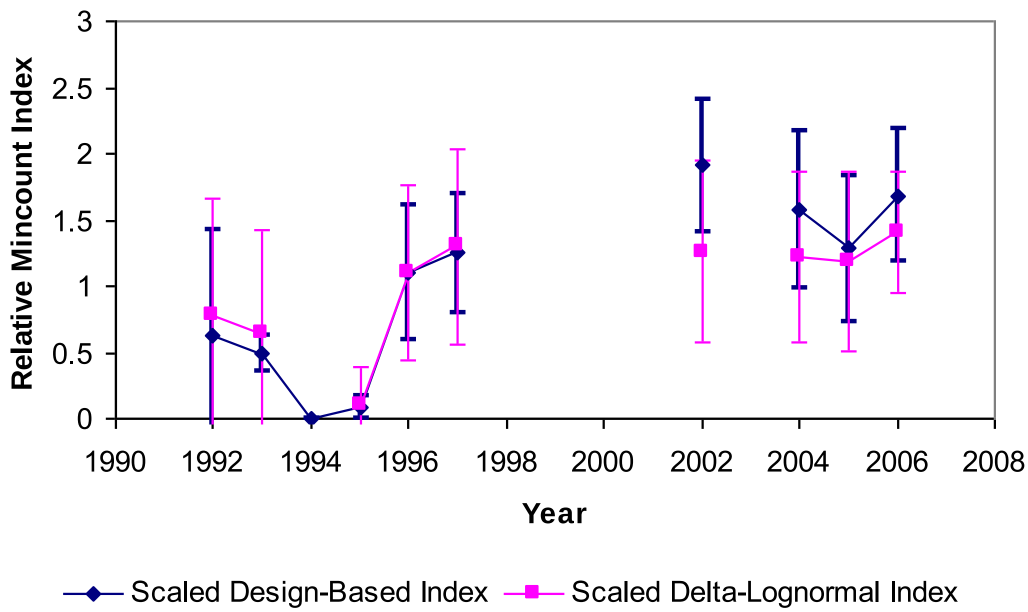
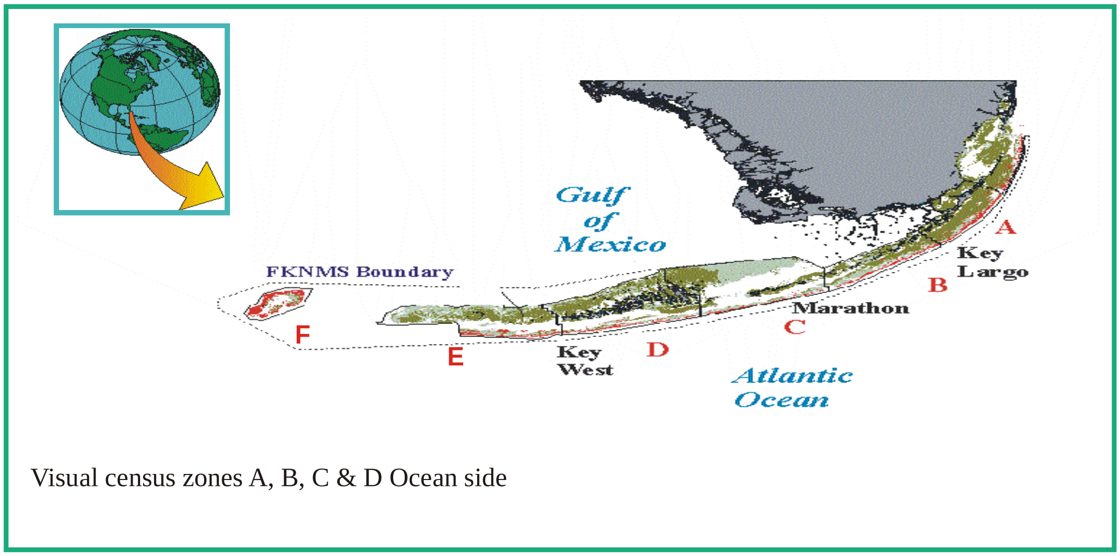


Figure 5.5. Map of Fisheries-Independent Monitoring Program sampling areas, divided into 4 zones (A-D), in the Florida Keys National Marine Sanctuary (FKNMS).



*** Sampling conducted on the Atlantic side of the Keys only.***

Figure 5.6 . A habitat-based, random-stratified site selection procedure, based upon the "Benthic Habitats of the Florida Keys" GIS system.

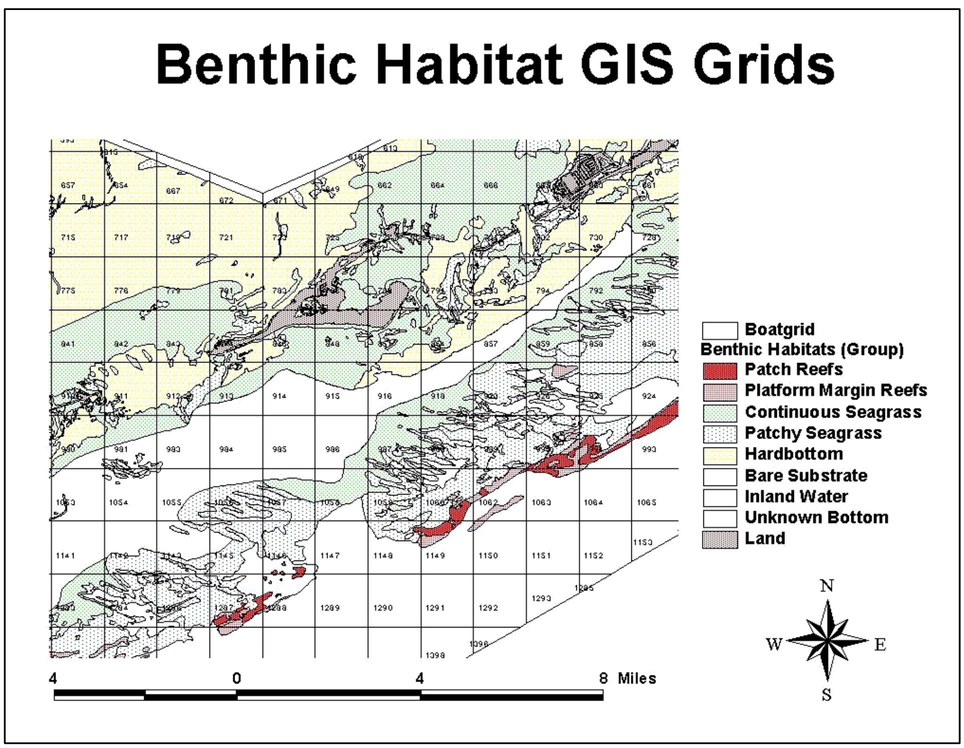


Figure 5.7. The absolute differences between false positive and false negative dives per habitat for juvenile mutton snapper for each critical value from Stephens and MacCall method.

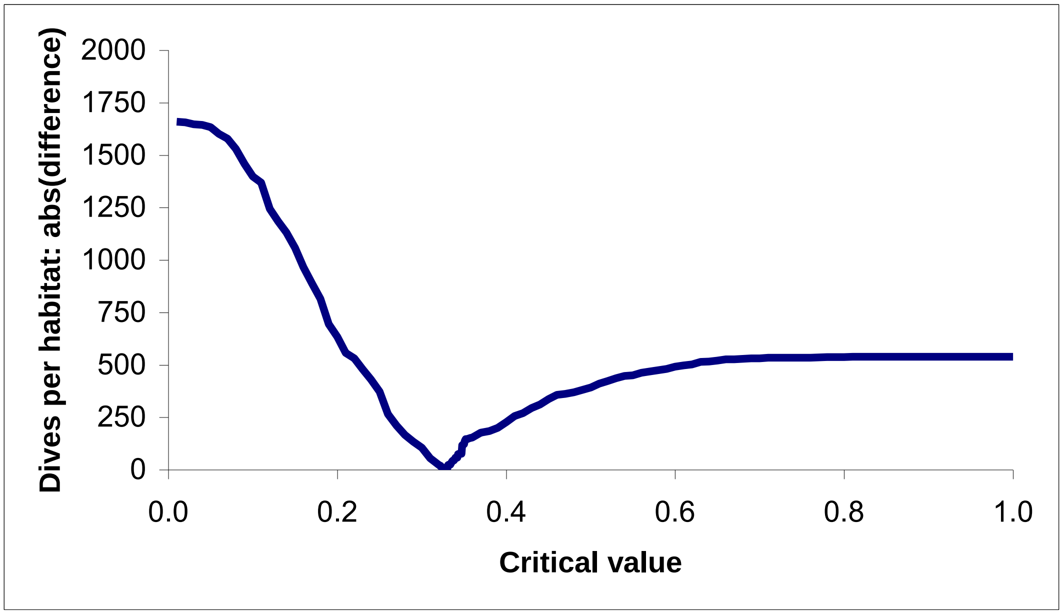


Figure 5.8. Number of mutton snapper per dive per bottom habitat by year observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

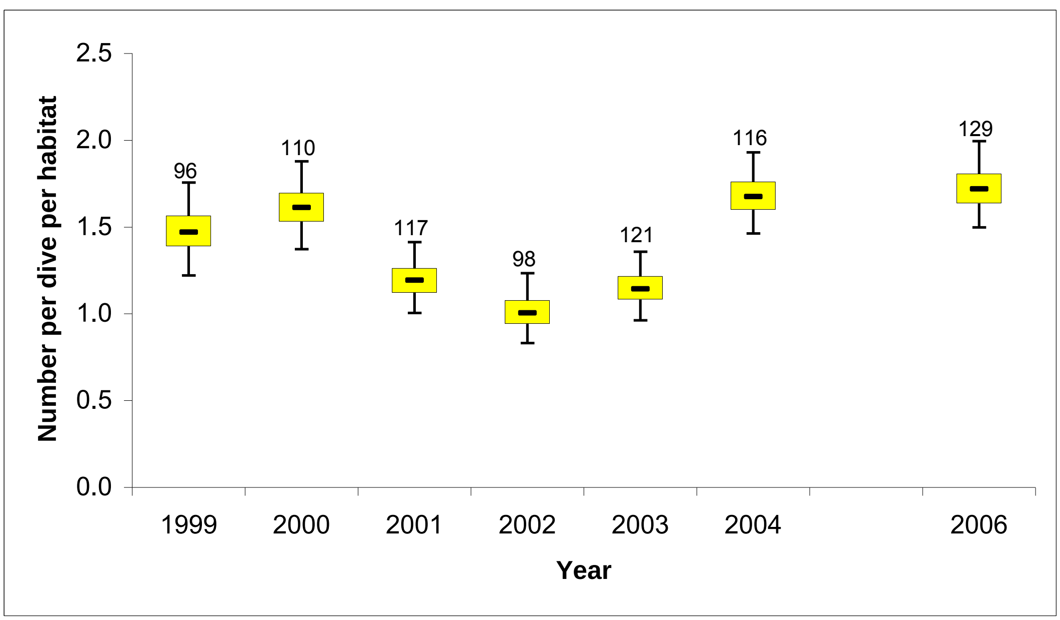


Figure 5.9. Number of mutton snapper per dive per bottom habitat by zone observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

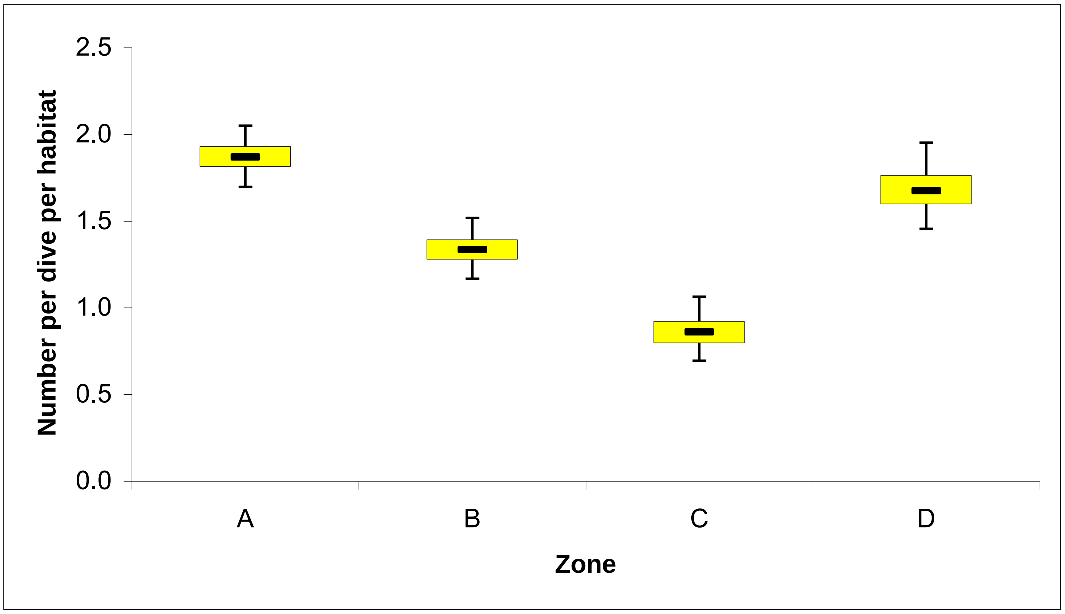


Figure 5.10. The absolute differences between false positive and false negative dives per habitat for juvenile mutton snapper for each critical value.

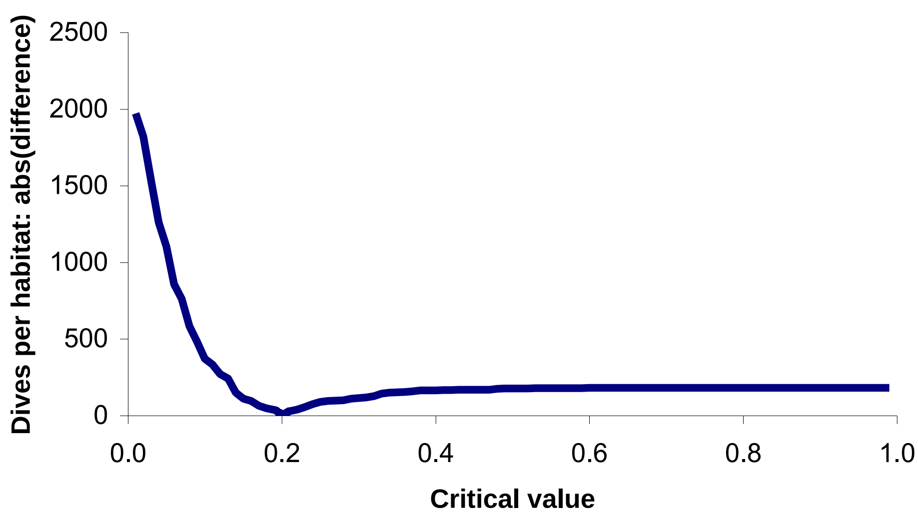


Figure 5.11. Number of juvenile mutton snapper per dive per bottom habitat by year observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats

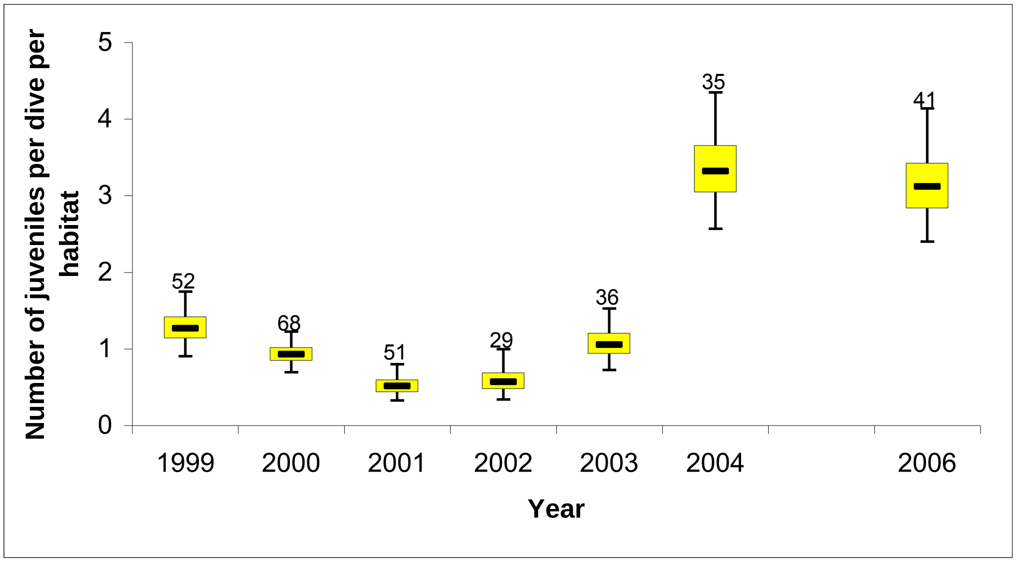


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Figure 5.12. Number of juvenile mutton snapper per dive per bottom habitat by zone observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

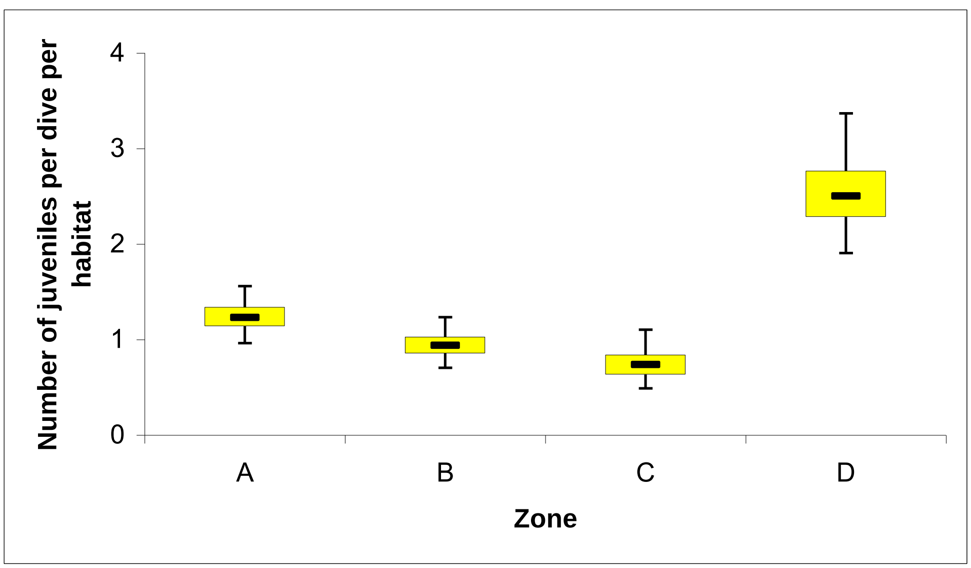

Figure 5.13. The absolute differences between false positive and false negative dives per habitat for juvenile mutton snapper for each critical value from the Stephens and MAcCAll method.

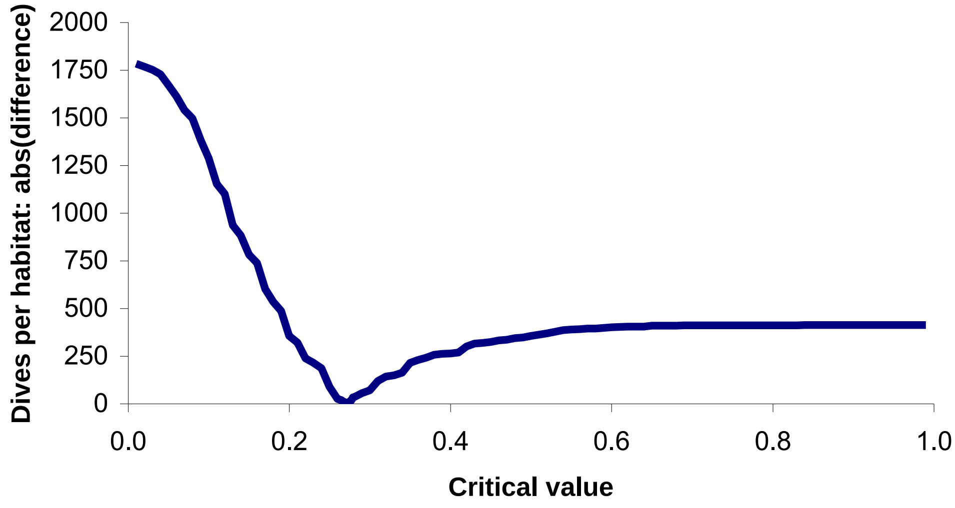

Figure 5.14. Number of juvenile mutton snapper per dive per bottom habitat by zone observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

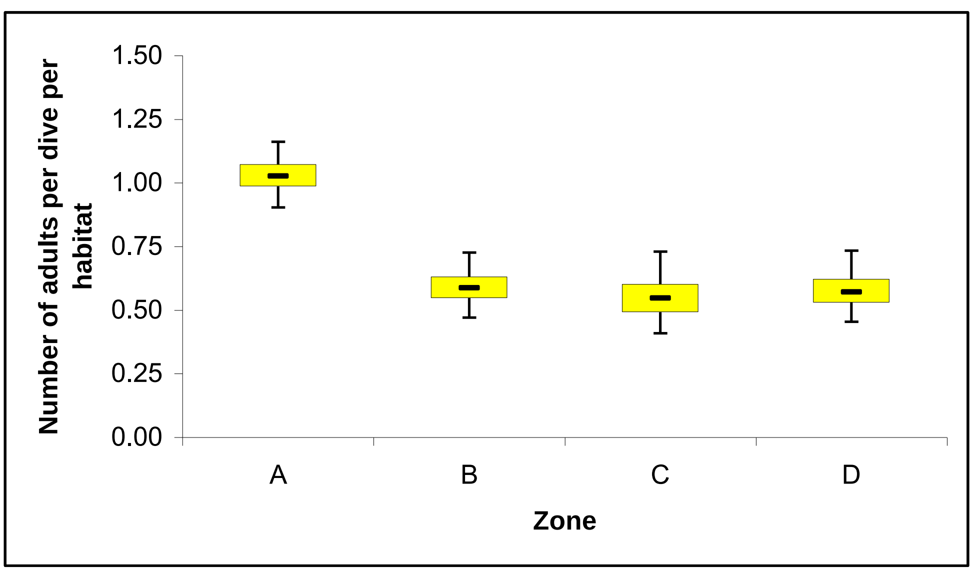

Figure 5.15. Map of sampling area in the middle Florida Keys showing location of sampling microgrids.

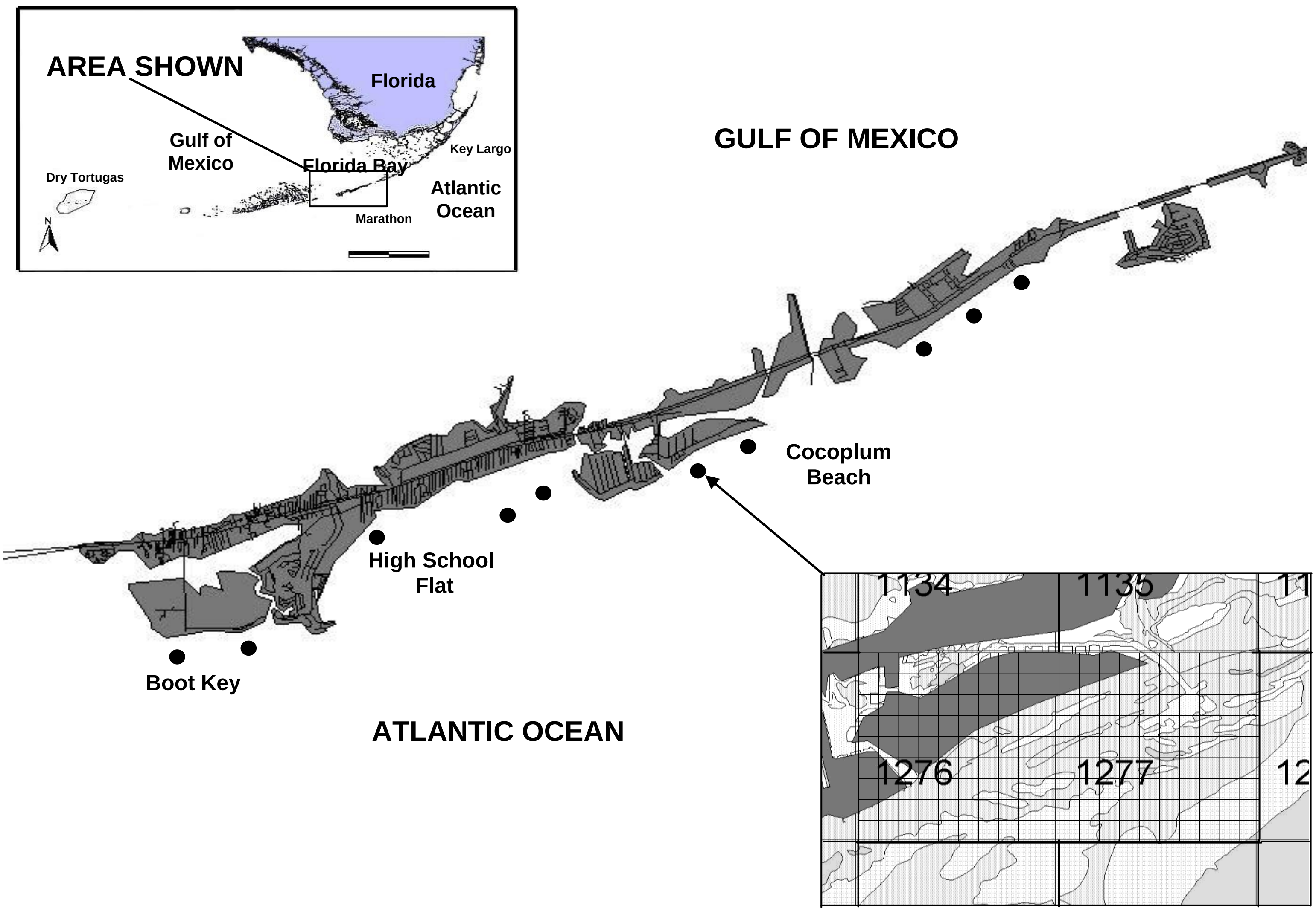

Figure 5.16. Mutton snapper mean density (# snapper/100m^2) by year.

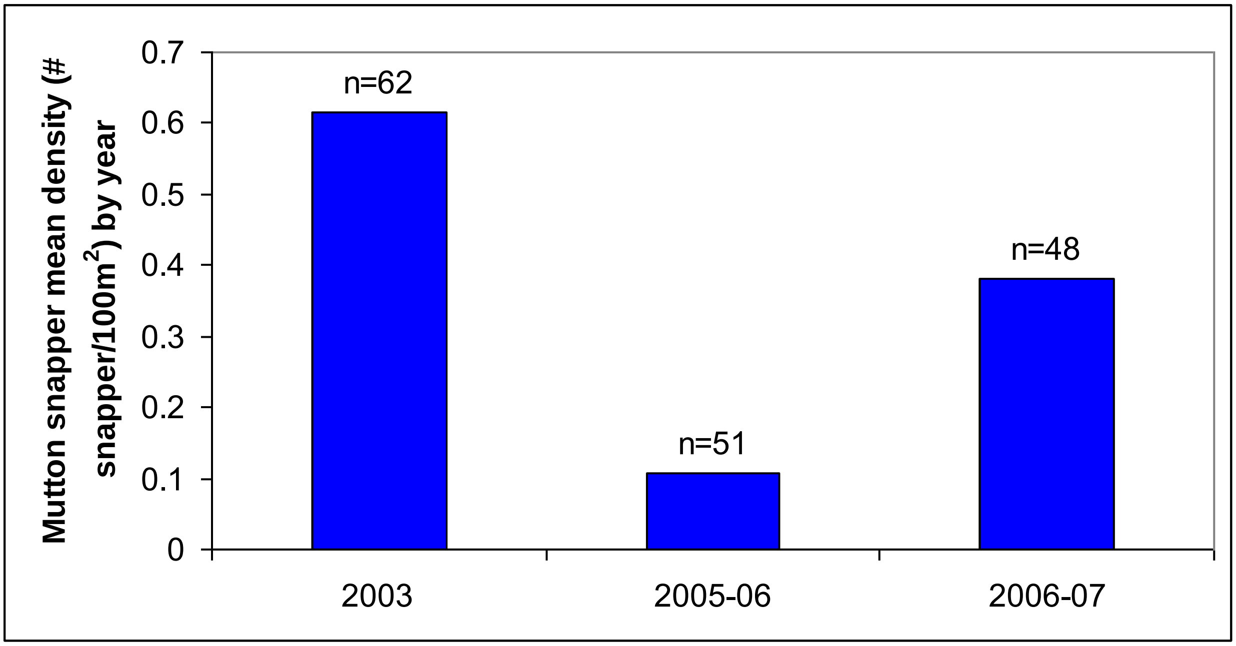

Figure 5.17. Number of mutton snapper collected per month.

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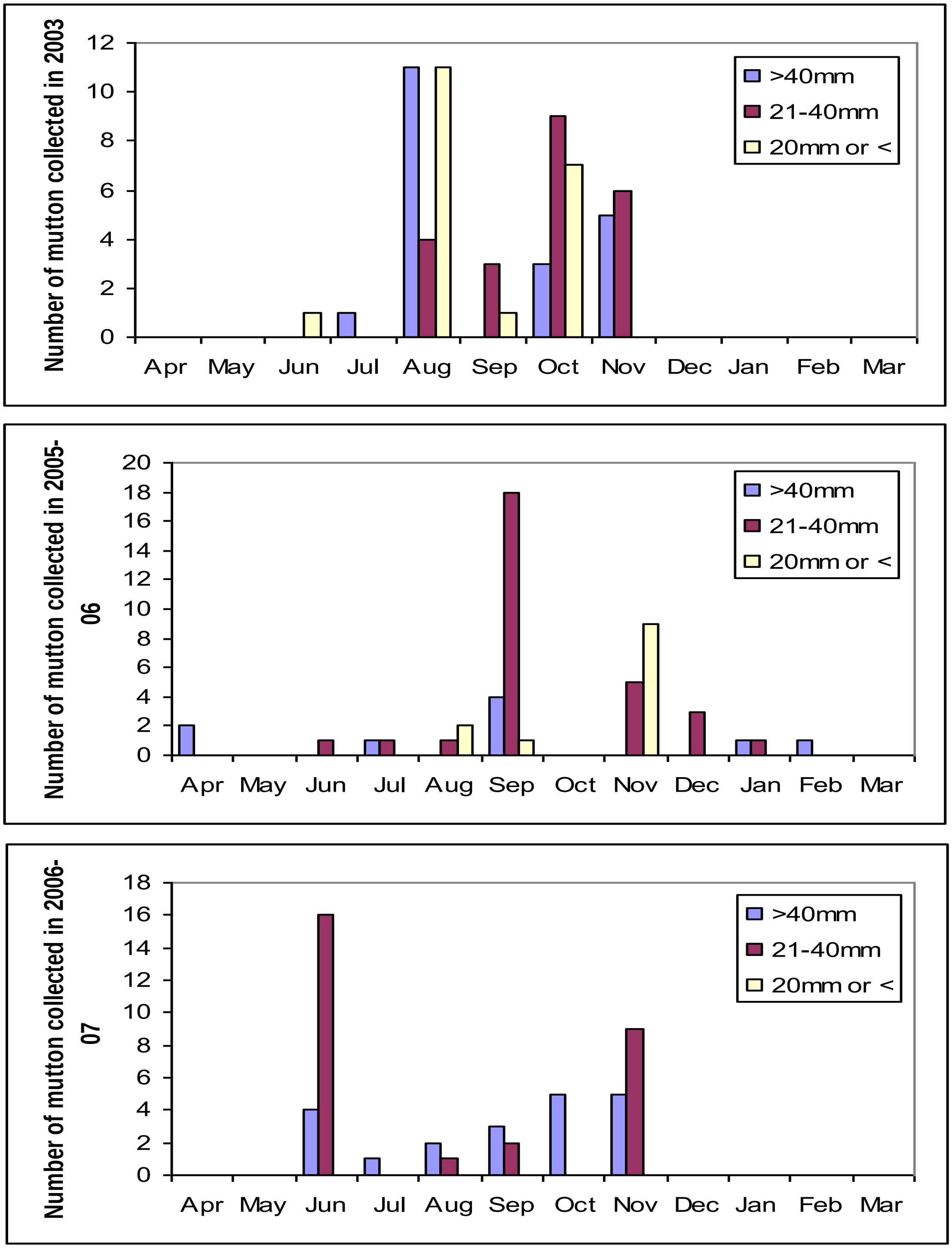


Figure 5.18. Mutton snapper length frequencies, all years combined. Dashed line indicated settlement stage individuals

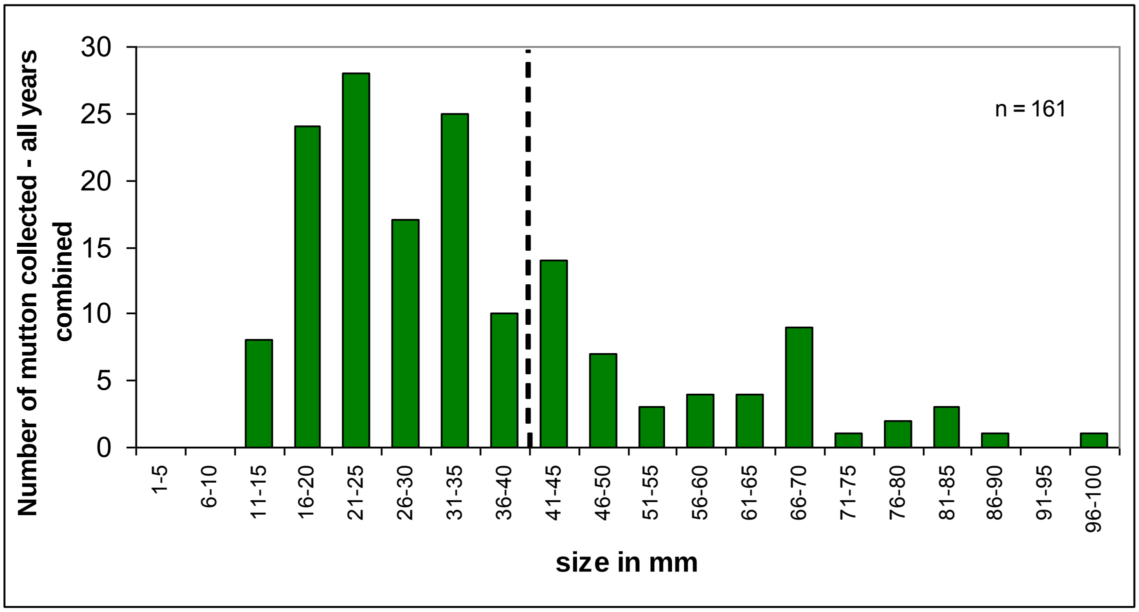


Figure 5.19. Size distribution of mutton snapper, *Lutjanus analis*, in the nearshore hard-bottom habitat of the Florida Keys.

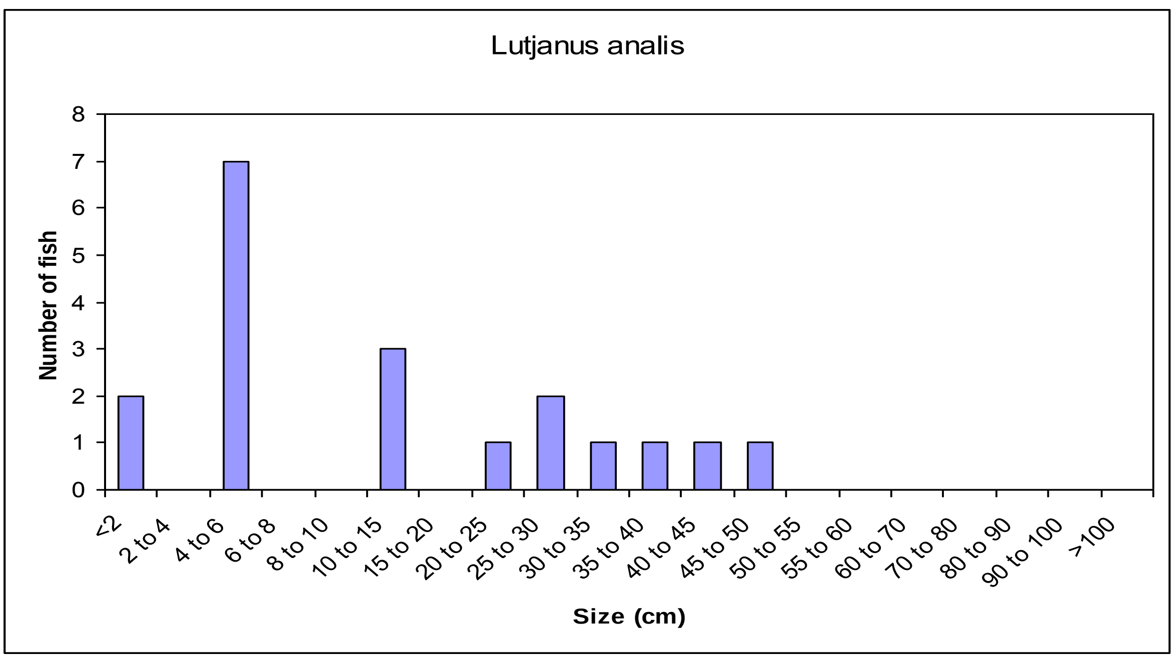


Figure 5.20. Standard length (mm) frequency histograms for mutton snapper collected from the Indian River Estuary [Mean (SE) = 85 (4) mm; N = 201].

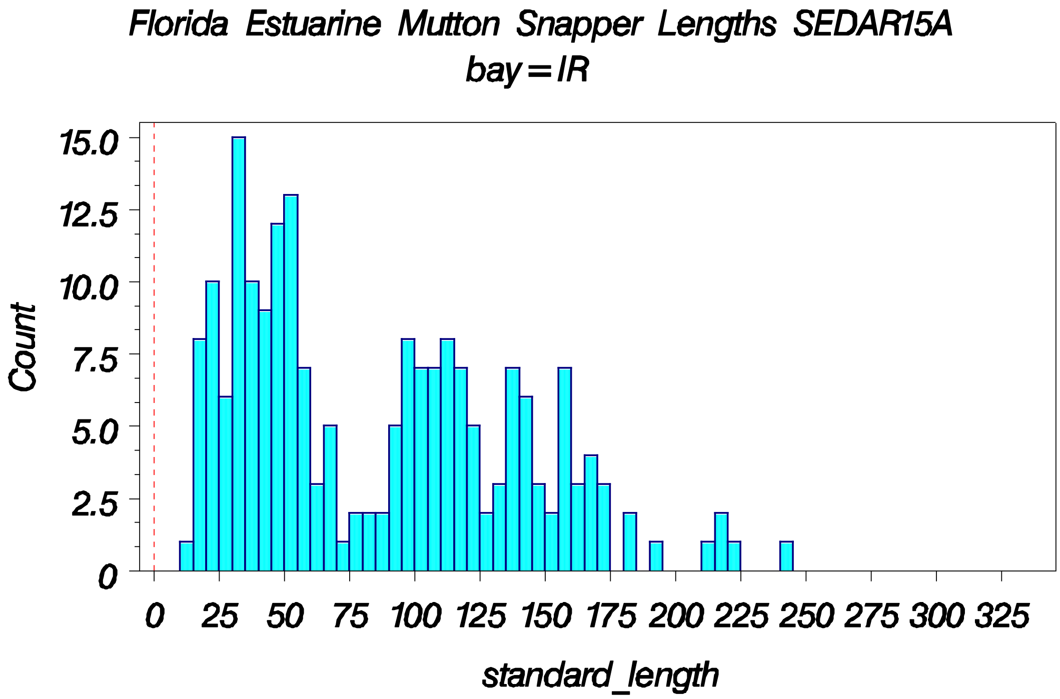


Figure 5.21. Standard length (mm) frequency histograms for mutton snapper collected from the Tequesta Estuary [Mean (SE) = 142 (2) mm; N = 724].

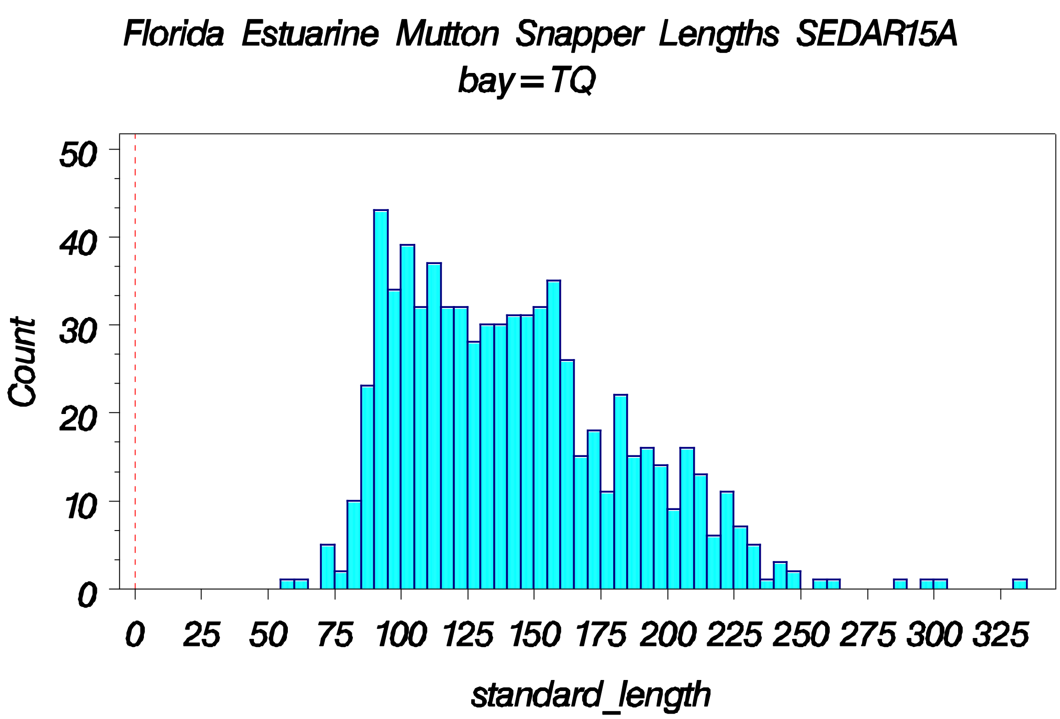


Figure 5.22. Standard length (mm) frequency histograms for age-0 mutton snapper collected from the Indian River Estuary [Mean (SE) = 43 (2) mm; N = 112].

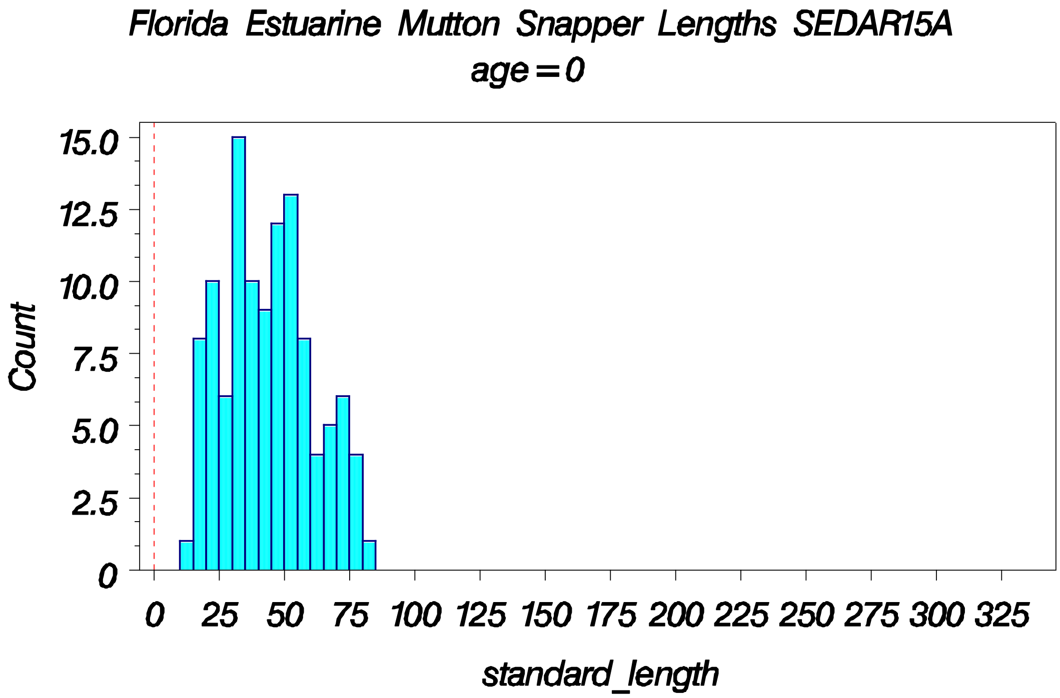


Figure 5.23. Standard length (mm) frequency histograms for age-1+ mutton snapper collected from the Tequesta and Indian River Estuaries [Mean (SE) = 141 (1) mm; N = 813].

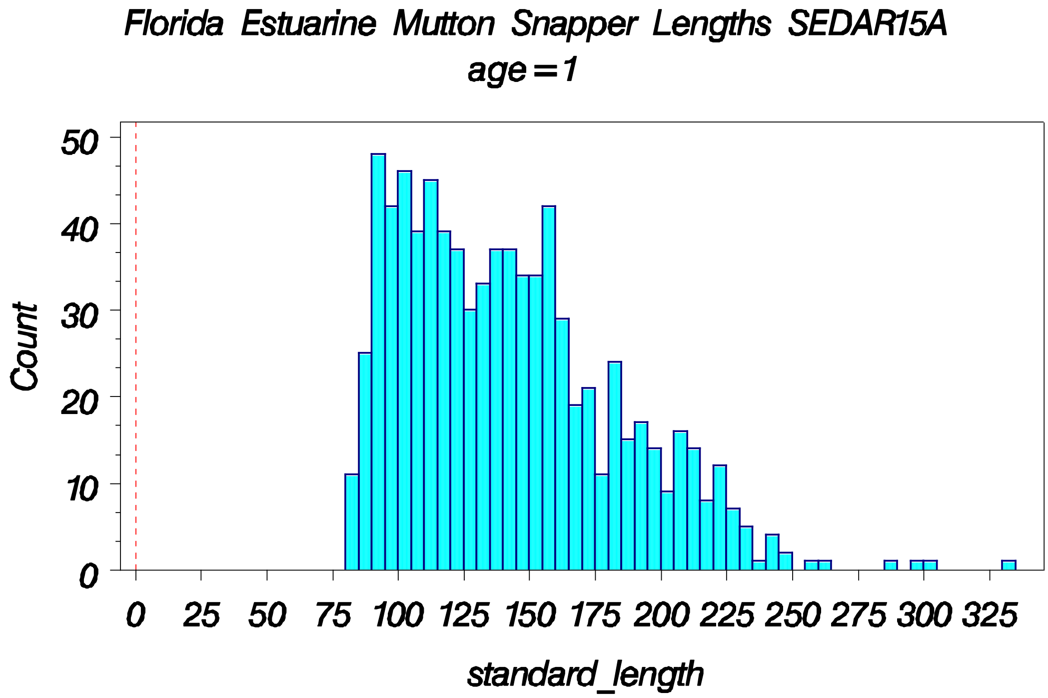
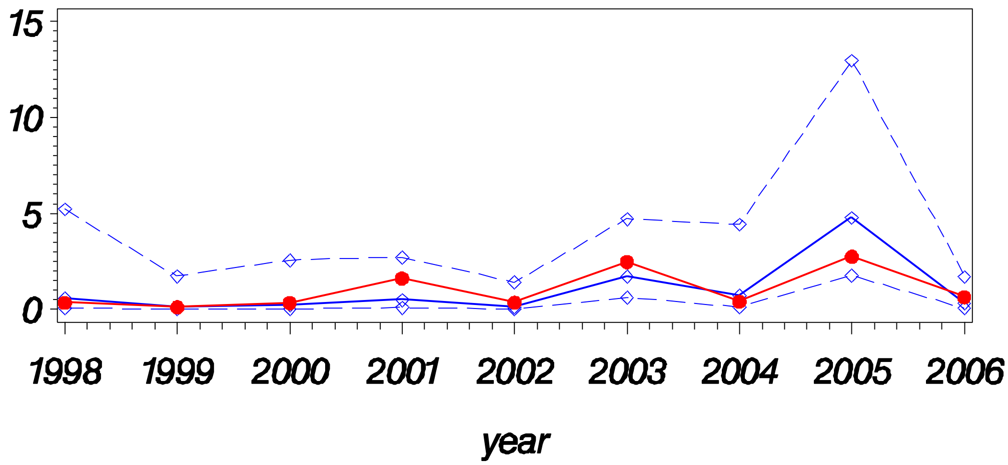
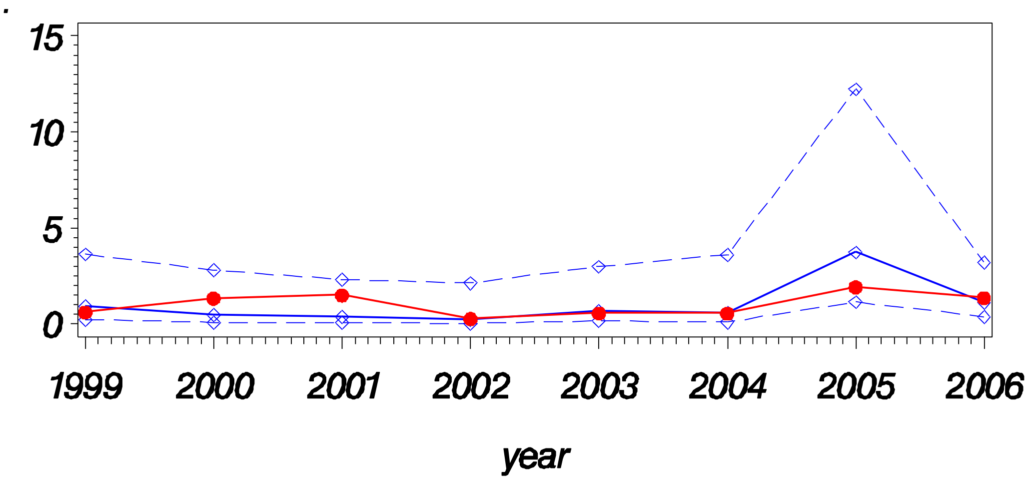

Florida Estuarine Mutton Snapper Lengths SEDAR15A
age=1
Count
0
10
20
30
40
50
0 25 50 75 100 125 150 175 200 225 250 275 300 325
standard_length

Figure 5.24. Index values for age-0 mutton snapper collected from the Indian River Estuary. N is the number of stations, Index is the index in CPUE units, Scaled Index is that same index normalized to a mean of one, CV is the coefficient of variation on the mean, and LCL and UCL are lower and upper 95% confidence limits for the scaled index (blue lines and symbols). Nominal scaled CPUE values are shown in red.



Survey Year	Nominal Frequency	N	Index	Scaled Index	CV	LCL	UCL
1998	0.002101	476	0.04733	0.56667	1.55762	0.06158	5.2144
1999	0.002114	473	0.00882	0.10564	2.46140	0.00645	1.7301
2000	0.002024	494	0.01642	0.19665	2.05187	0.01506	2.5682
2001	0.006383	470	0.04049	0.48481	1.04990	0.08647	2.7182
2002	0.004329	462	0.01112	0.13311	1.75289	0.01244	1.4240
2003	0.023981	417	0.14209	1.70138	0.54428	0.61426	4.7124
2004	0.004975	402	0.06047	0.72403	1.12603	0.11851	4.4234
2005	0.017766	394	0.39799	4.76537	0.53386	1.75041	12.9734
2006	0.007828	511	0.02692	0.32235	0.99171	0.06159	1.6871

Figure 5.25. Index values for age-1+ mutton snapper collected from the Tequesta and Indian River Estuaries. N is the number of stations, Index is the index in CPUE units, Scaled Index is that same index normalized to a mean of one, CV is the coefficient of variation on the mean, and LCL and UCL are lower and upper 95% confidence limits for the scaled index (blue lines and symbols). Nominal scaled CPUE values are shown in red.



Survey Year	*Nominal Frequency*	*N*	*Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
1999	0.020576	243	0.02515	0.90626	0.78604	0.22635	3.6284
2000	0.016949	236	0.01281	0.46163	1.11766	0.07626	2.7944
2001	0.022321	224	0.01003	0.36142	1.16720	0.05658	2.3086
2002	0.012766	235	0.00573	0.20657	1.69880	0.02010	2.1234
2003	0.021930	228	0.01858	0.66946	0.86476	0.15020	2.9837
2004	0.013043	230	0.01564	0.56370	1.16609	0.08835	3.5964
2005	0.017544	228	0.10340	3.72666	0.65027	1.13634	12.2218
2006	0.040486	247	0.03064	1.10431	0.57336	0.38020	3.2075

Figure 5.26. Annual density (Number of Fish / 177 m^2) and 95% C.I for mutton snapper.

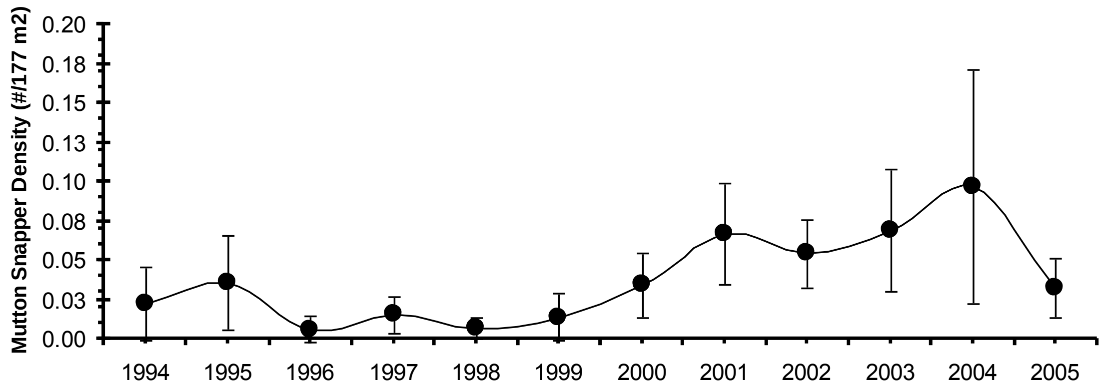


Figure 5.27. Mutton snapper mean length (mm) and 95% C.I by year.

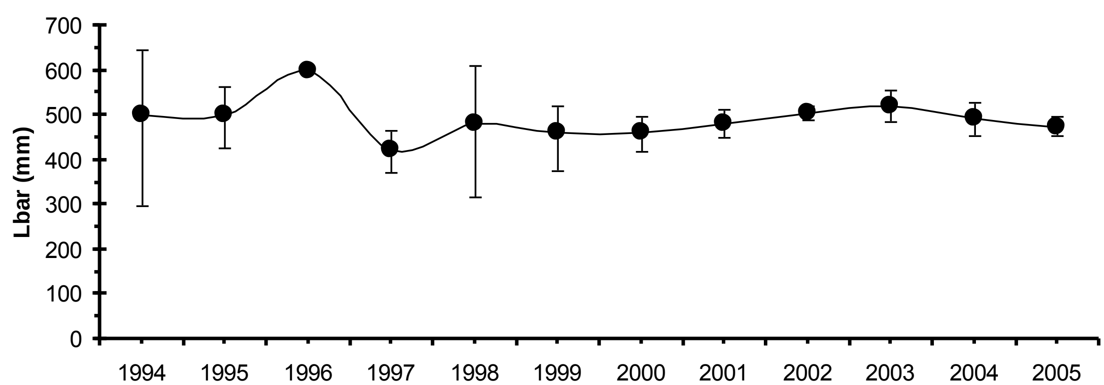


Figure 5.28. The proportion of positive dives by year from all REEF dive surveys for mutton snapper along the Atlantic coast of Florida including the Dry Tortugas. The variability was simulated with Monte Carlo technique that generated 1000 estimates per year. The vertical line is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes were in the box), the horizontal line is the median, and the number above the symbol is the number of dives during that year.

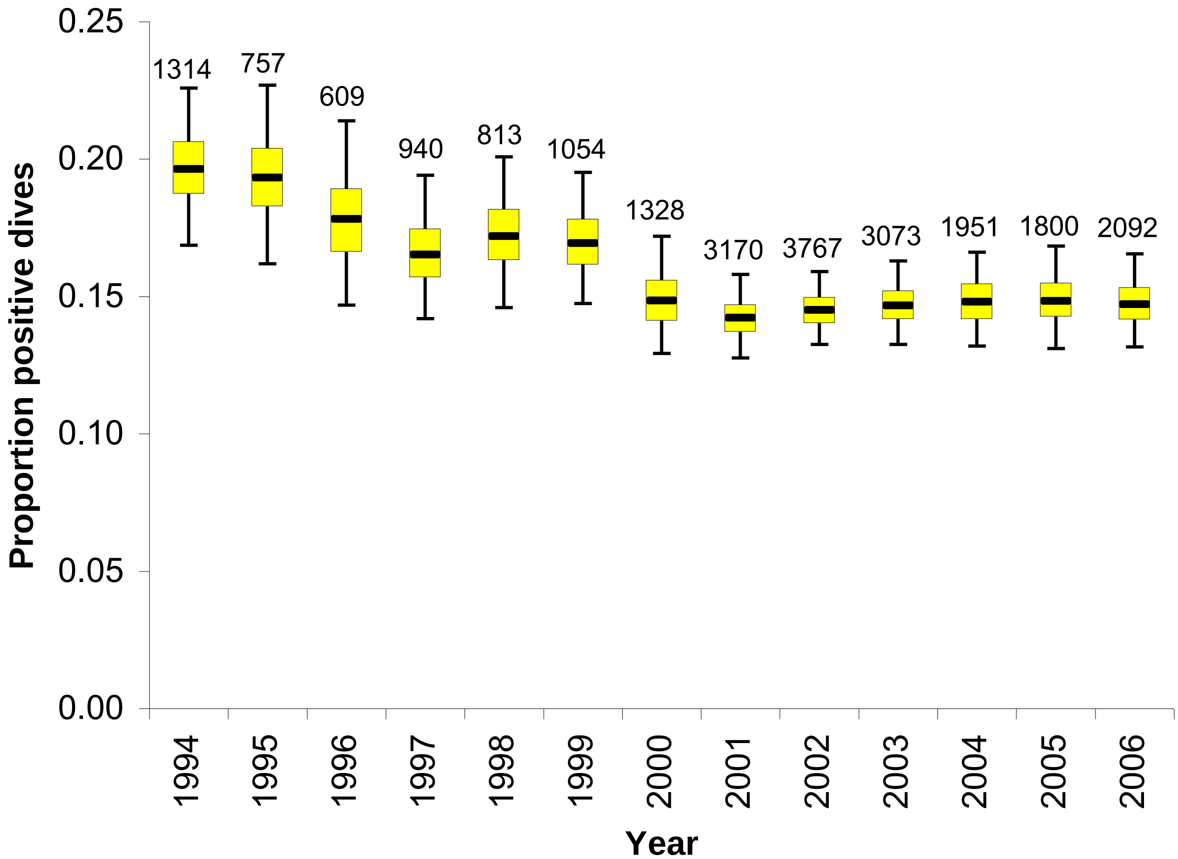


Figure 5.29. The proportion of positive dives by year from REEF dive surveys for mutton snapper along the Atlantic coast of Florida including the Dry Tortugas using only those sites that had been visited by divers in seven of the 13 years and mutton snapper had been reported on more than one occasion. The variability was simulated with Monte Carlo technique that generated 1000 estimates per year. The vertical line is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes were in the box), the horizontal line is the median, and the number above the symbol is the number of dives during that year.

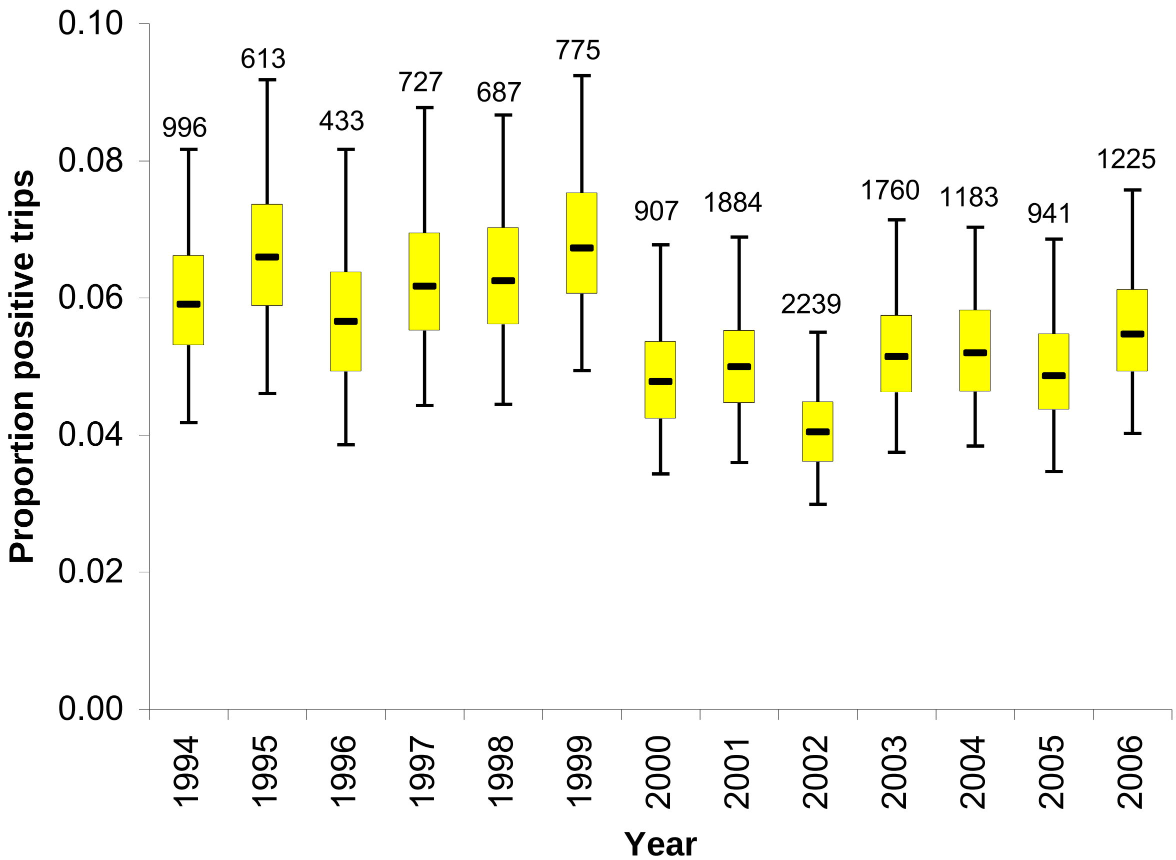
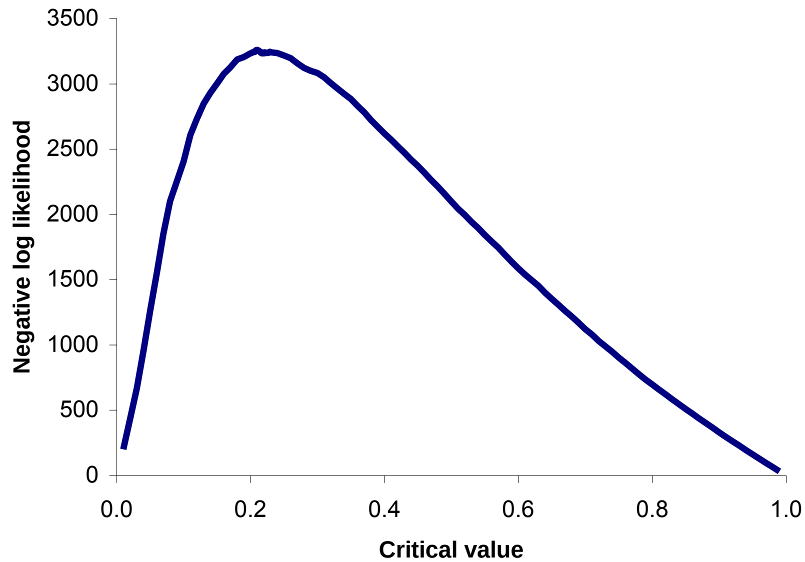


Figure 5.30. Negative log likelihoods associated with different critical values from the Stephens and MacCall logistic regression method of selecting REEF dives that could have caught mutton snapper (a) and the proportion of positive dives by year. The variability was simulated with Monte Carlo technique that generated 1000 estimates per year. The vertical line is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes were in the box), the horizontal line is the median, and the number above the symbol is the number of dives during that year.

a.



b.

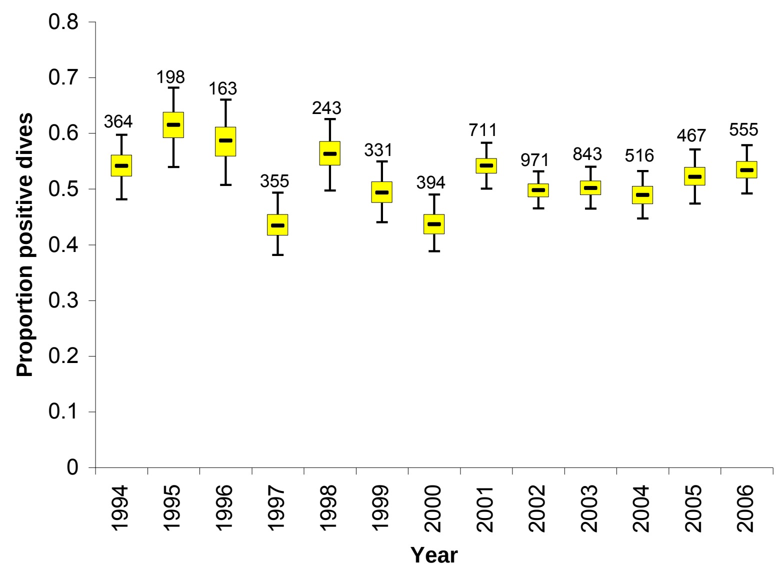


Figure 5.31. Comparison of the proportion of positive dives by year from three groupings of REEF dive surveys for mutton snapper along the Atlantic coast of Florida including the Dry Tortugas. The indices have been scaled to their respective means.

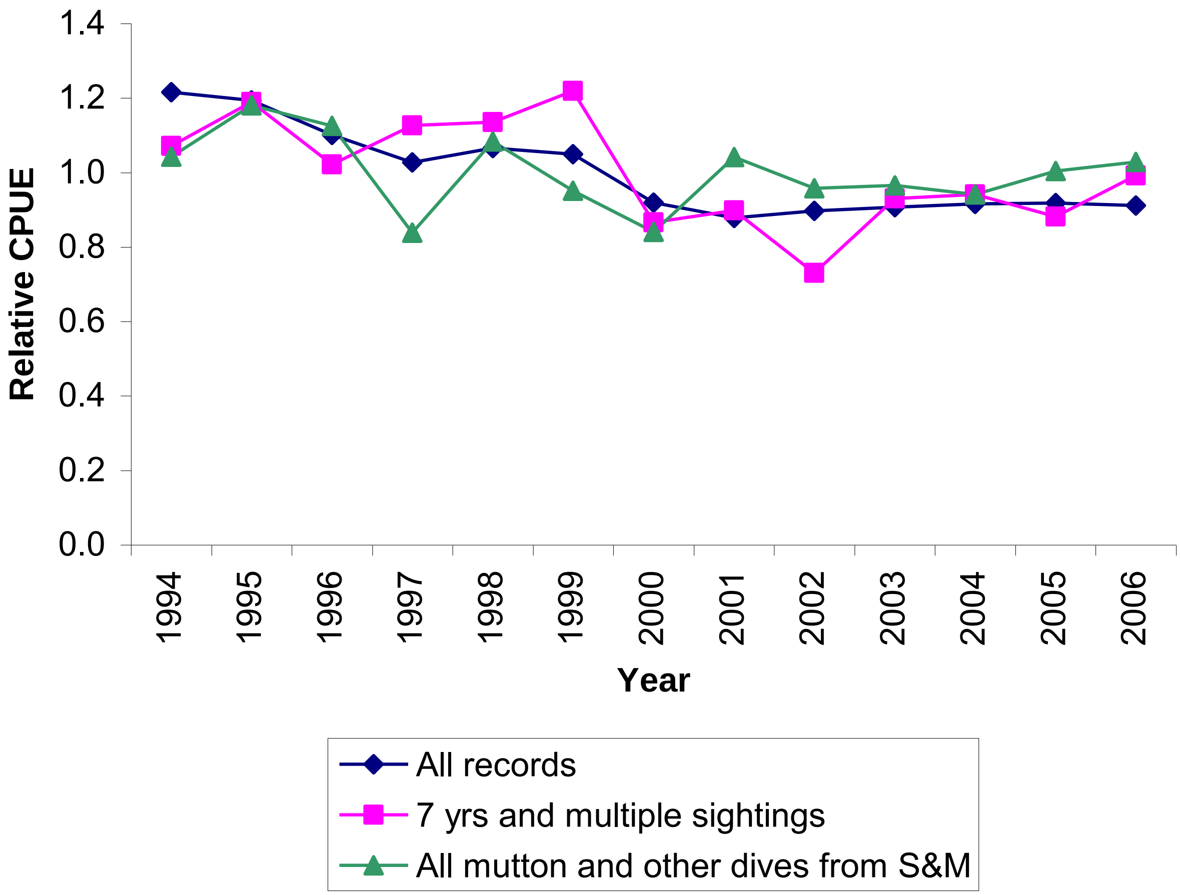


Figure 5.32. Residual plot for binomial sub-model.

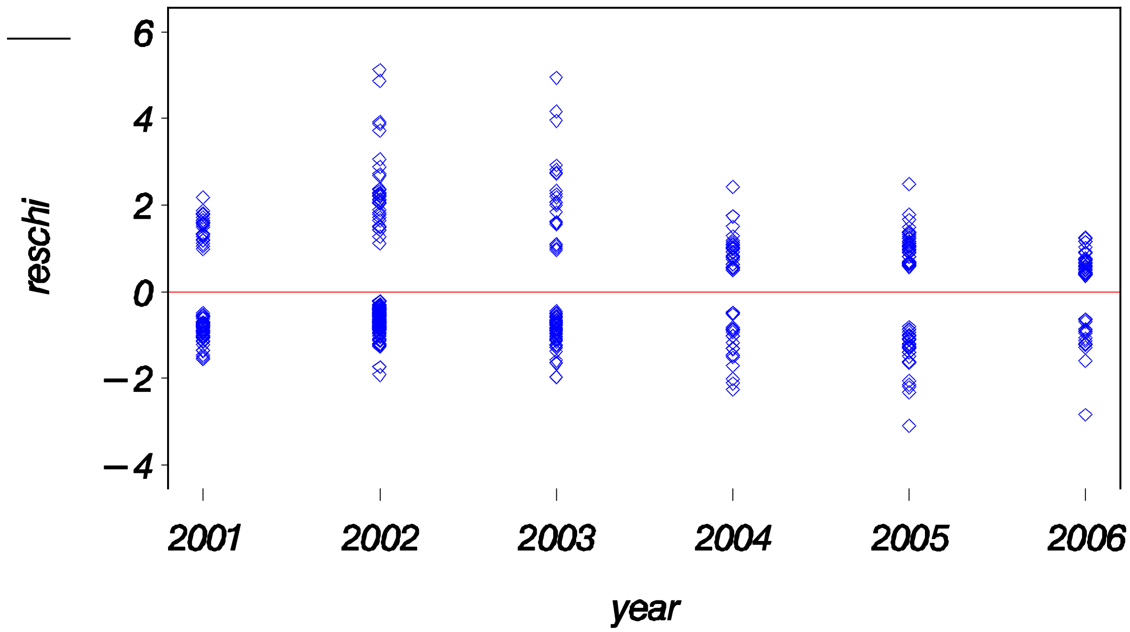


Figure 5.33. Residual plot for lognormal sub-model.

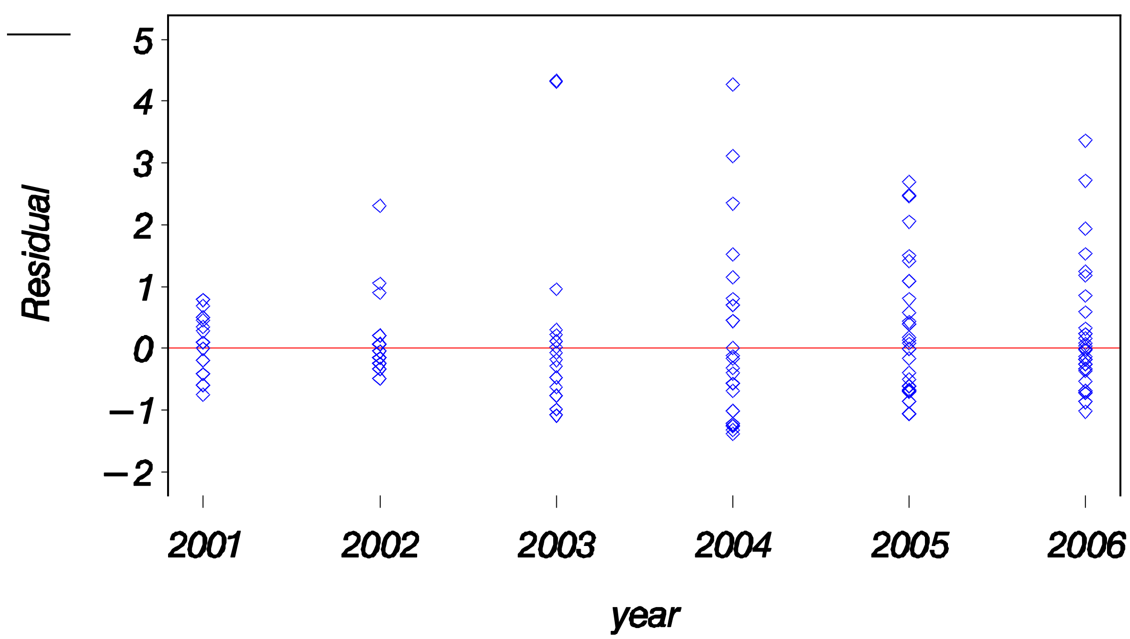
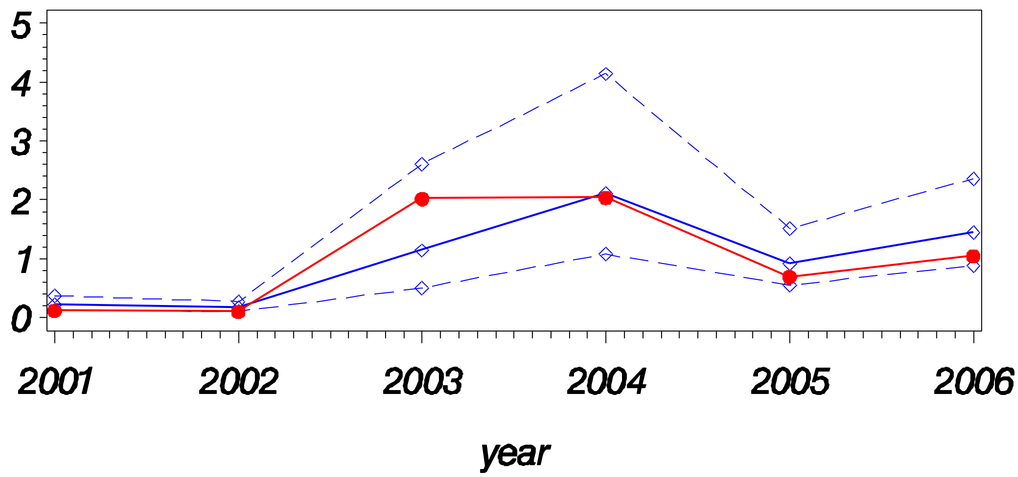


Figure 5.34. Annual abundance indices for mutton snapper. Delta-lognormal model results and 95% C.I. in blue. Nominal means in red.



Survey Year	Nominal Frequency	N	Delta-lognormal Index	Scaled Index	CV	Scaled LCL	Scaled UCL
2001	0.36508	63	0.35060	0.21974	0.27170	0.12885	0.37472
2002	0.21212	165	0.26678	0.16720	0.24783	0.10261	0.27246
2003	0.31884	69	1.82359	1.14291	0.43112	0.50048	2.60998
2004	0.56000	50	3.37482	2.11513	0.34560	1.08039	4.14089
2005	0.57813	64	1.45573	0.91236	0.25603	0.55119	1.51020
2006	0.67308	52	2.30187	1.44267	0.25024	0.88126	2.36171

Figure 5.35. Gulf of Mexico and South Atlantic Coastal Logbook defined fishing areas.

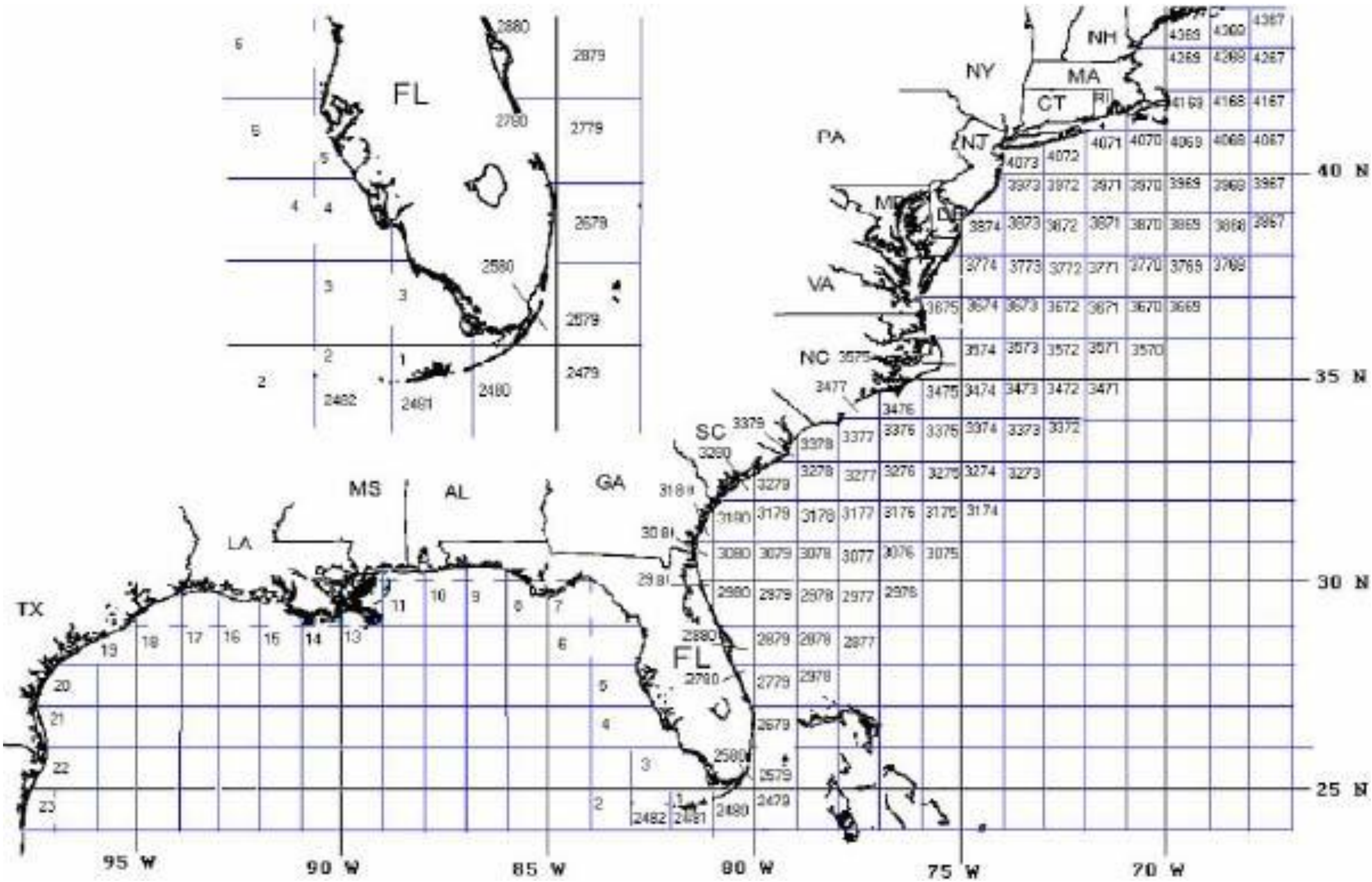
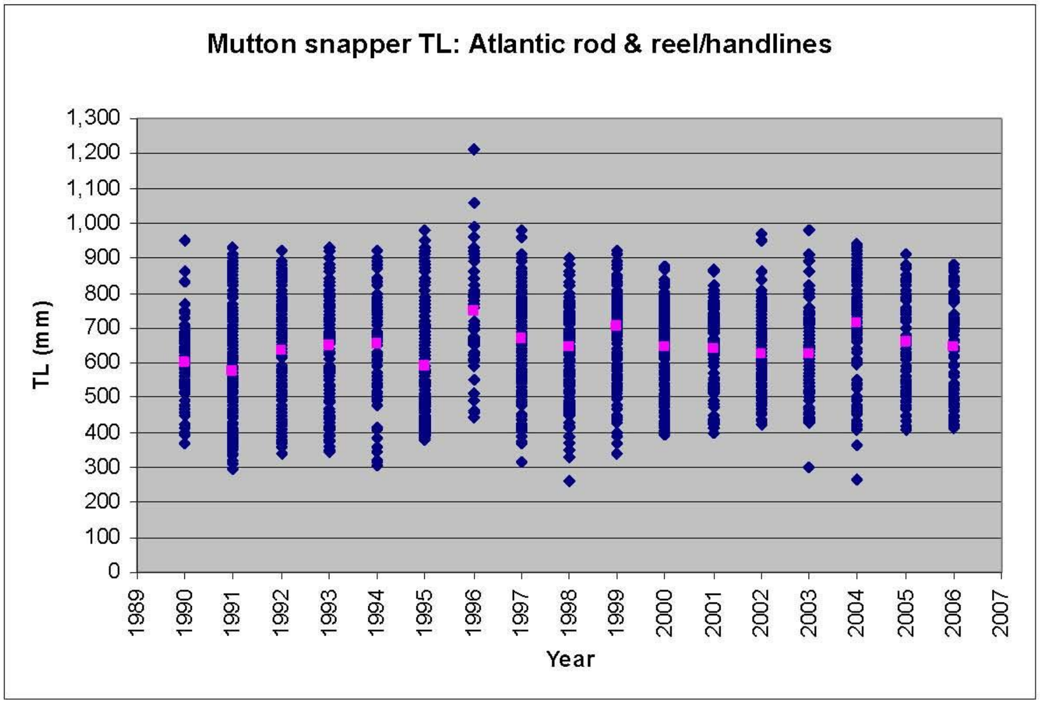


Figure 5.36.

Figure 2. Total lengths of mutton snapper measured from commercial landings by the TIP; A. Atlantic handline vessel landings, B. Gulf of Mexico handline vessel landings, C. Atlantic longline vessel landings, D. Gulf of Mexico longline vessel landings.

A.



B.

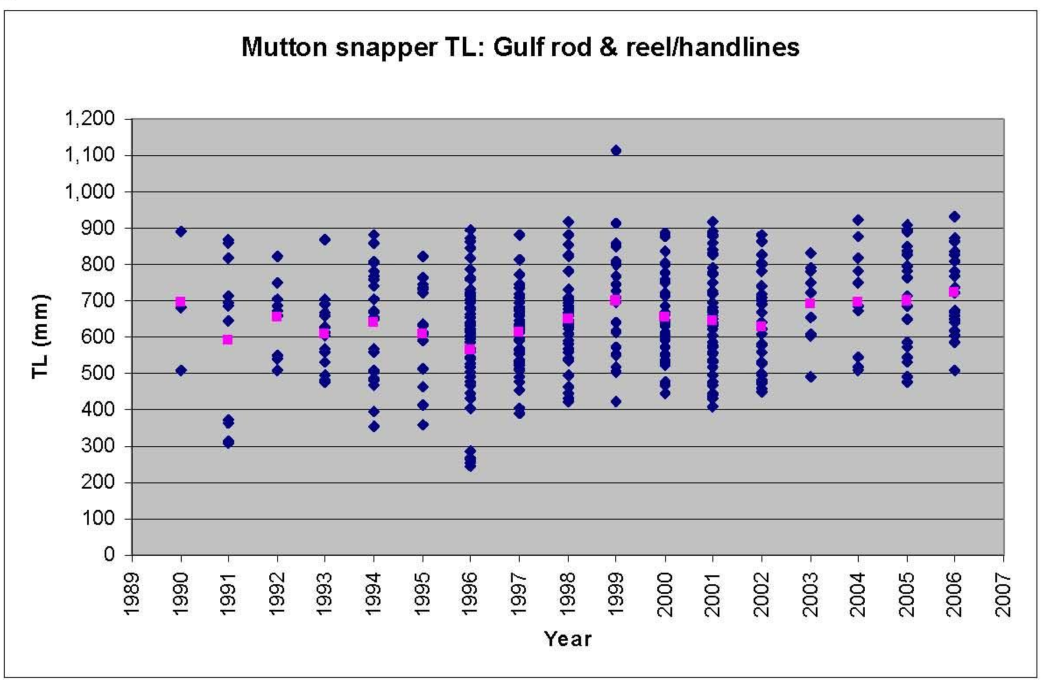
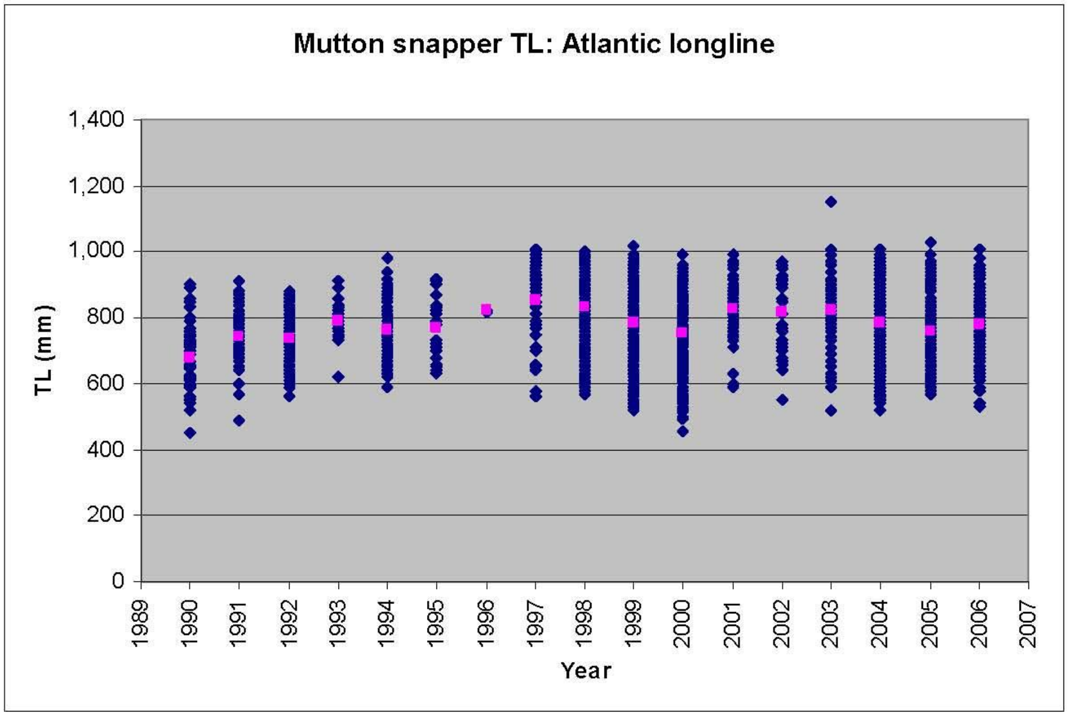


Figure 5.36. Continued.

Figure 2. Continued.

C.



D.

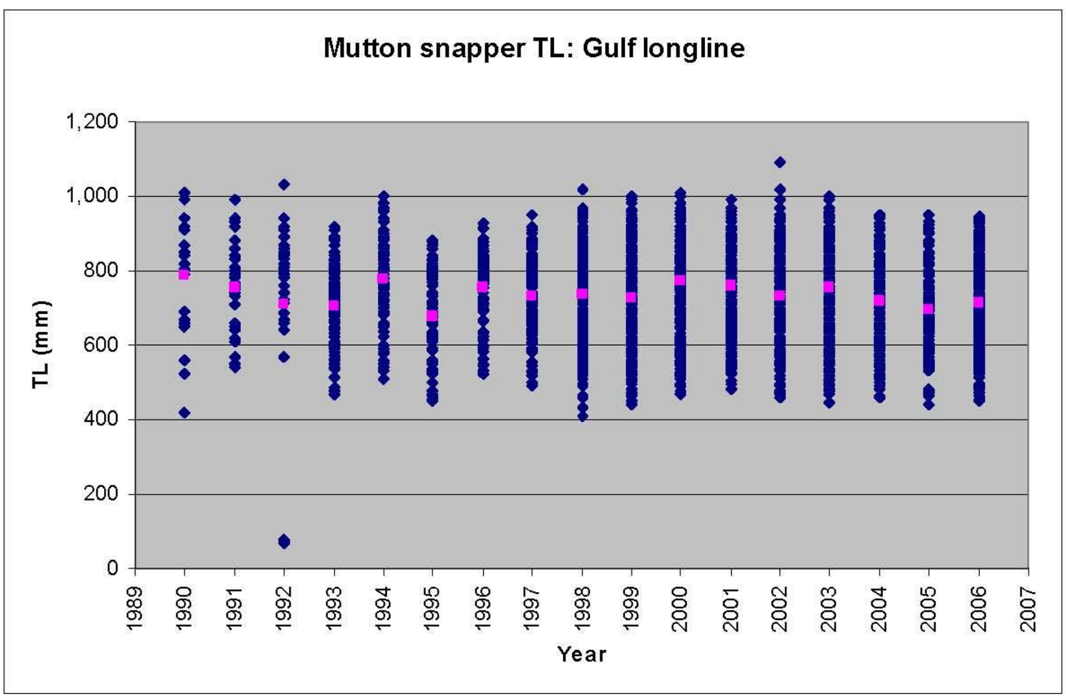


Figure 5.37.

Figure 3. Mutton snapper (1990-2006) nominal CPUE (squares), standardized CPUE (diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dotted) for vessels fishing handlines in the Gulf of Mexico and South Atlantic.

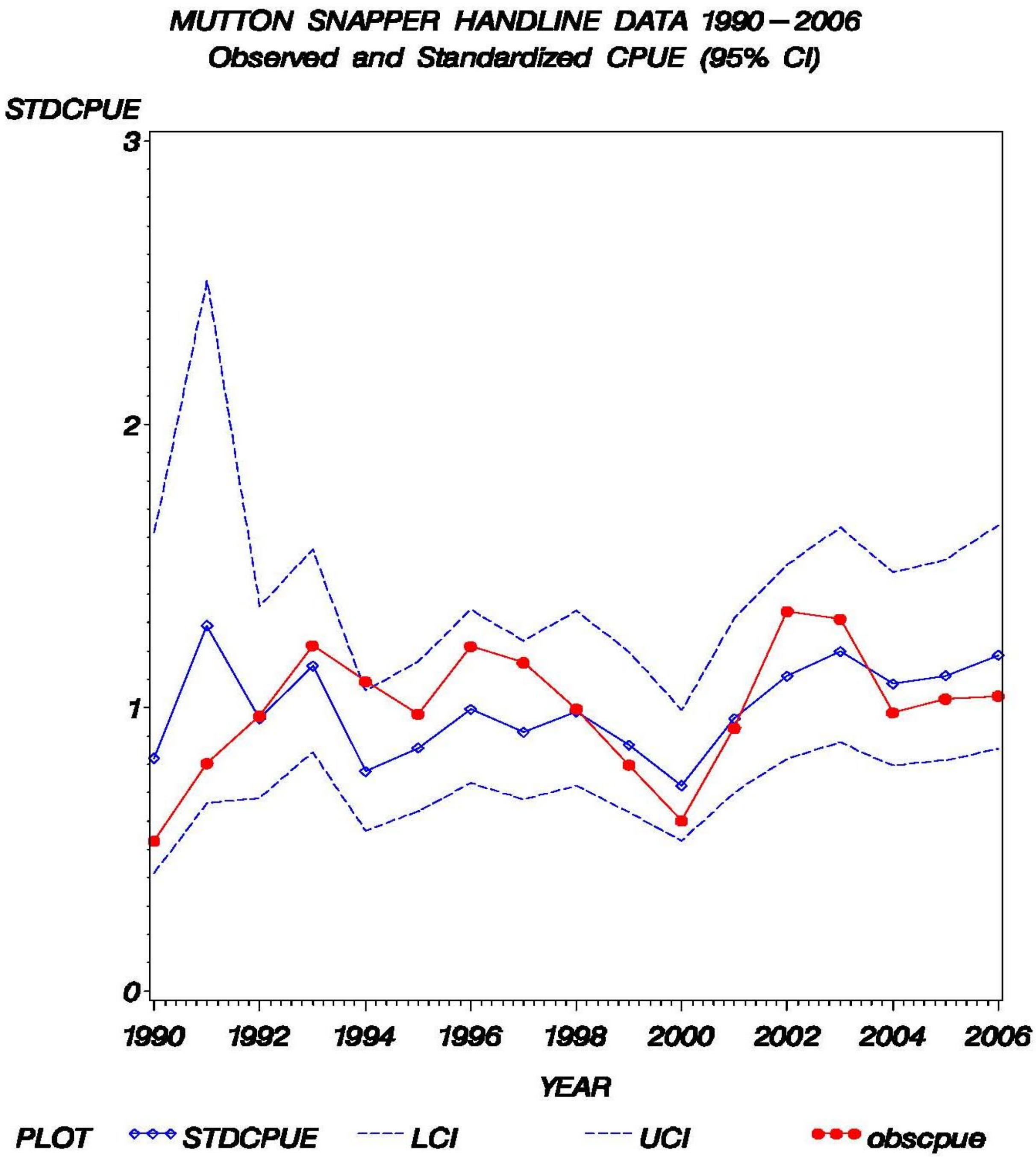
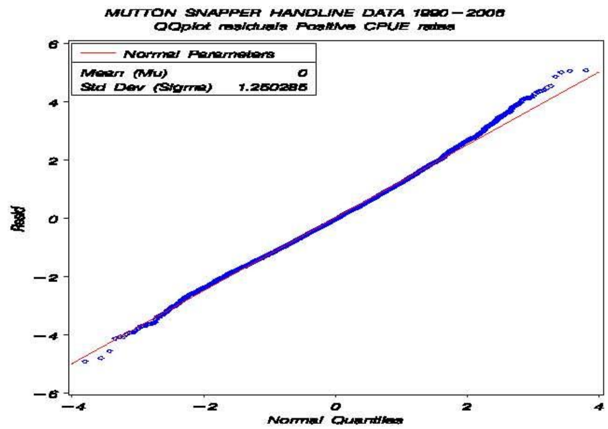


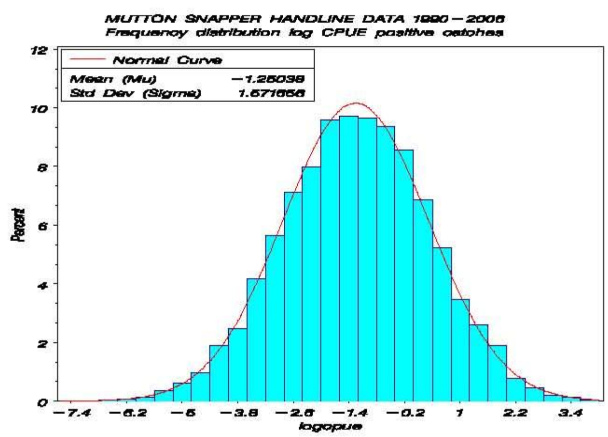
Figure 5.38.

Figure 4. QQ plots of residuals (a), error distribution ln(CPUE) (b), residuals (c-f) of the final delta-lognormal model of successful catch rates, and residuals (g-i) of the final delta-lognormal of proportion positive catches for handline vessels landing mutton snapper, 1990-2006.

a.



b.



c.

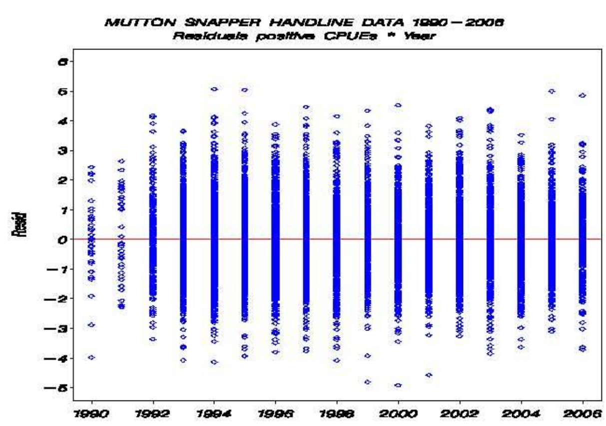
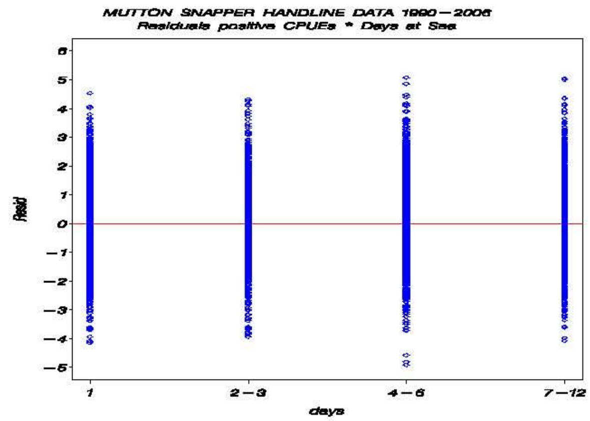


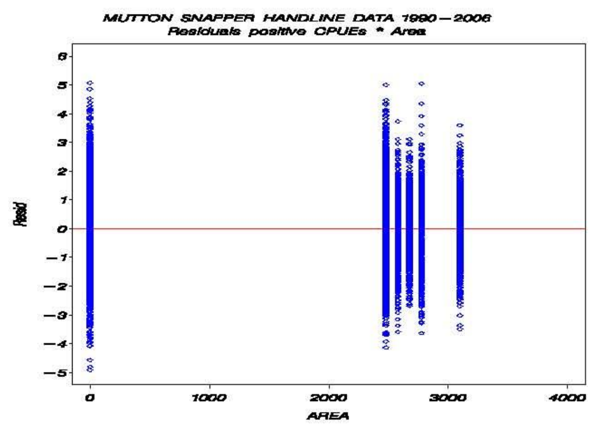
Figure 5.38. Continued.

Figure 4. continued.

d.



e.



f.

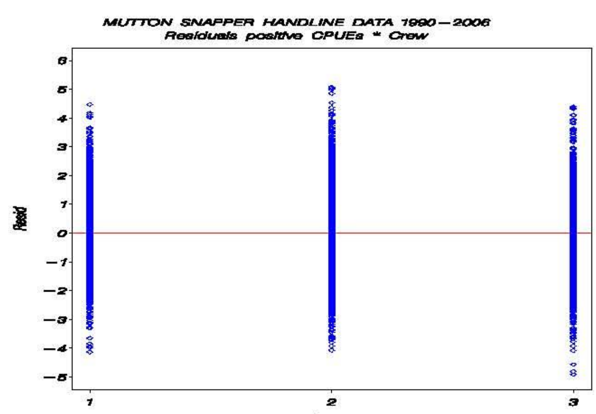
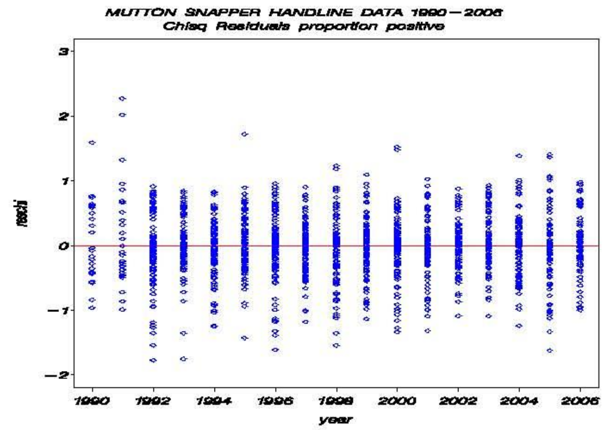


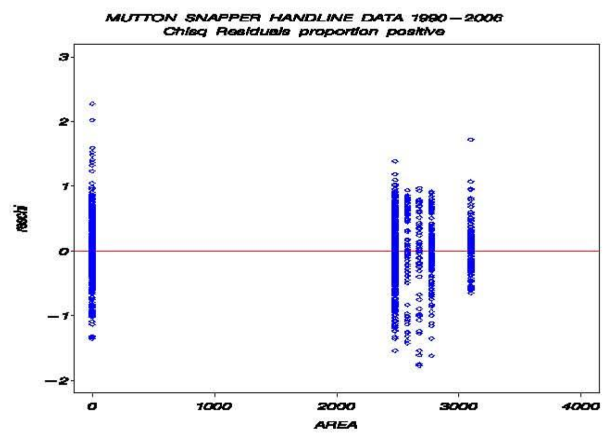
Figure 5.38. Continued.

Figure 4. continued.

g.



h.



i.

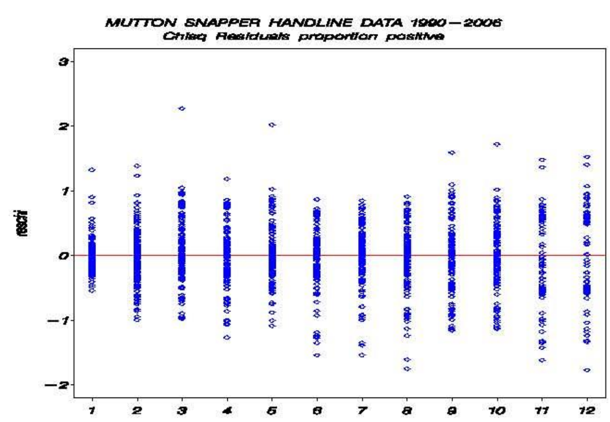


Figure 5.39.

Figure 5. Mutton snapper (1990-2006) nominal CPUE (squares), standardized CPUE (diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dotted) for vessels fishing longlines in the Gulf of Mexico.

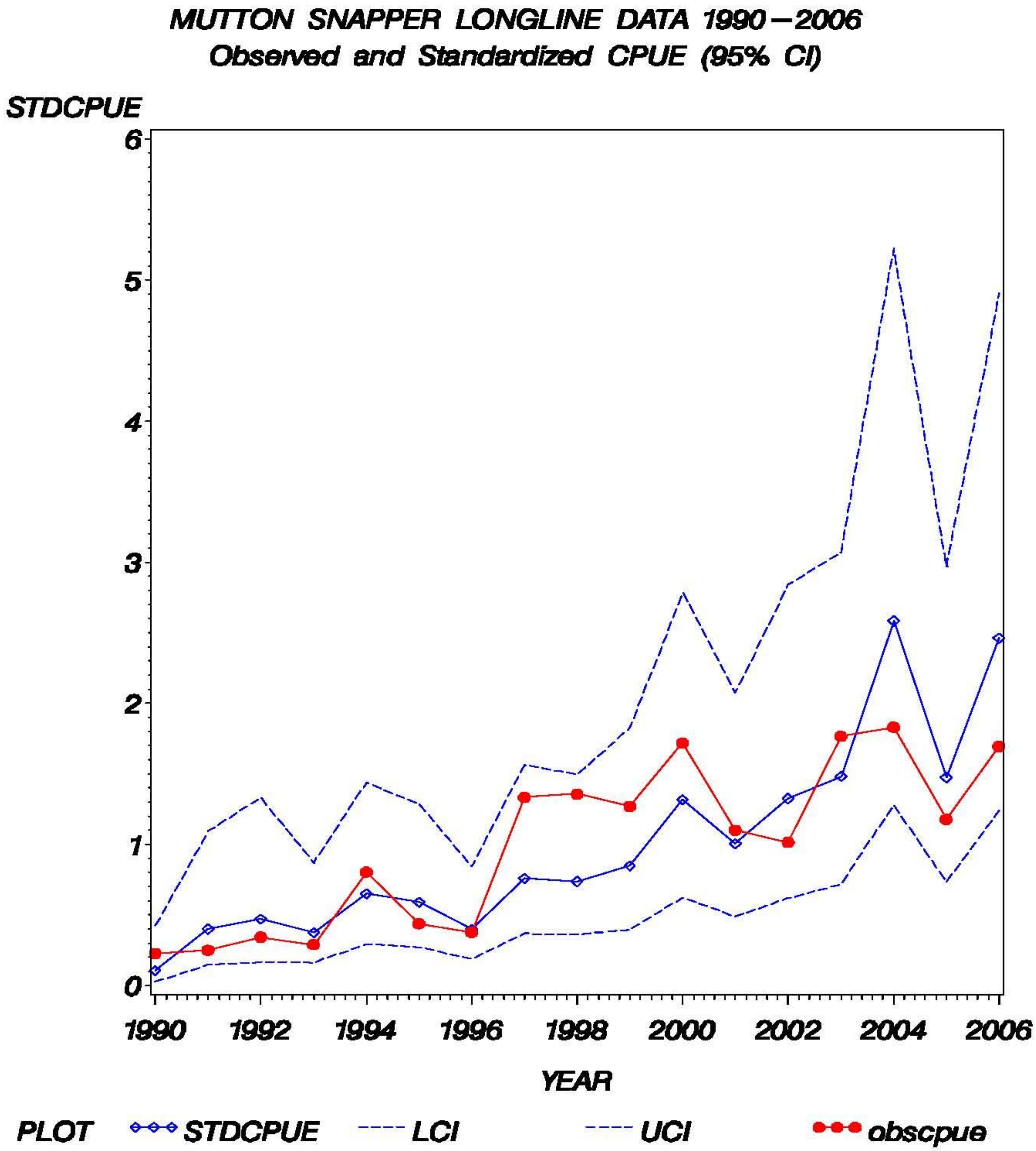
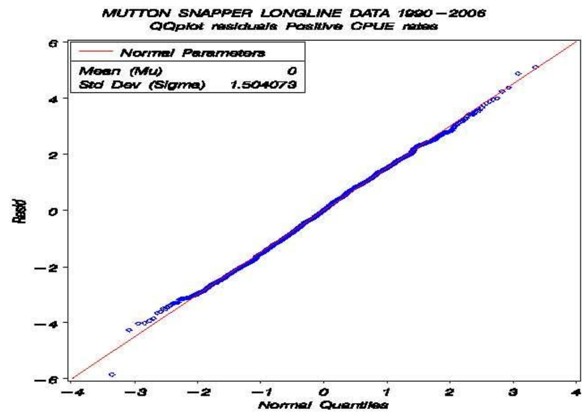


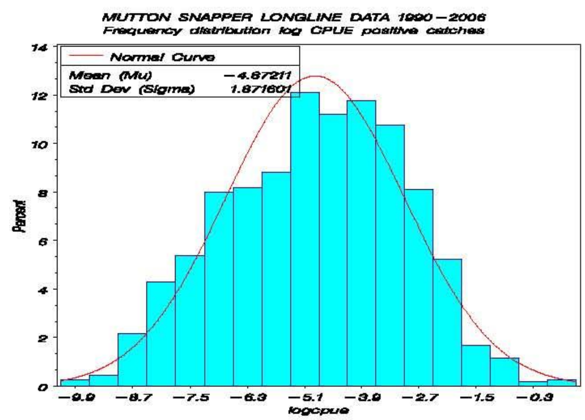
Figure 5.40.

Figure 6. QQ plots of residuals (a), error distribution ln(CPUE) (b), residuals (c-e) of the final delta-lognormal model of successful catch rates, and residuals (f-h) of the final delta-lognormal of proportion positive catches for longline vessels landing mutton snapper, 1990-2006.

a.



b.



c.

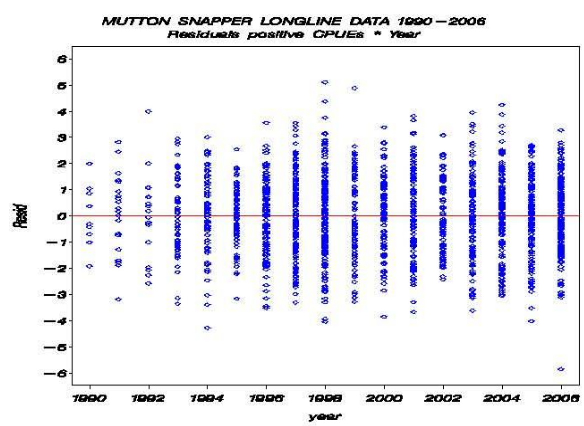
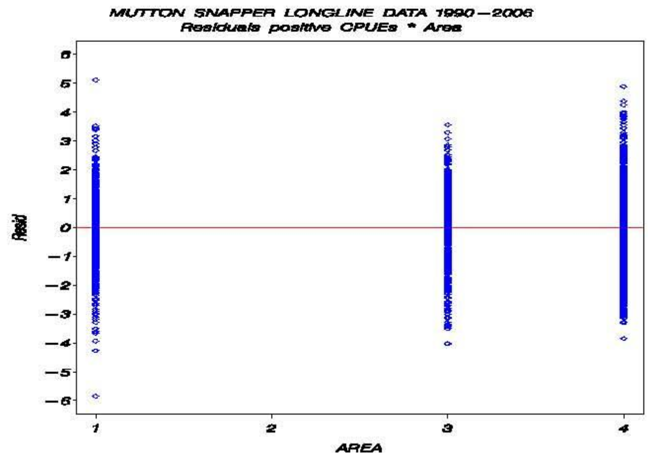


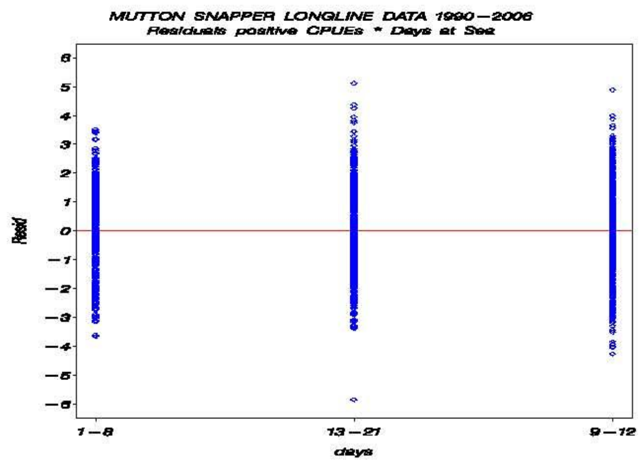
Figure 5.40. Continued.

Figure 6. continued.

d.



e.



f.

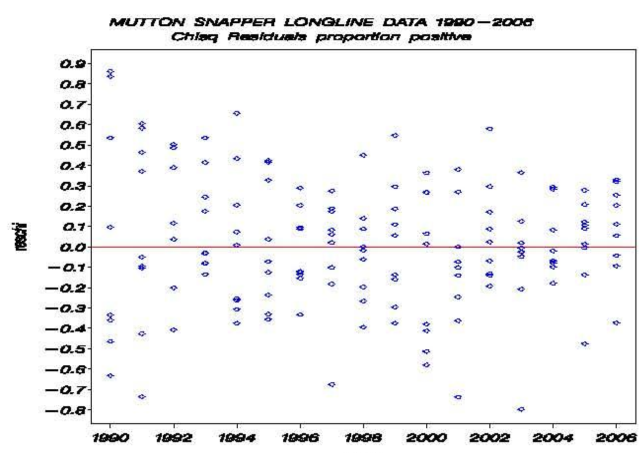
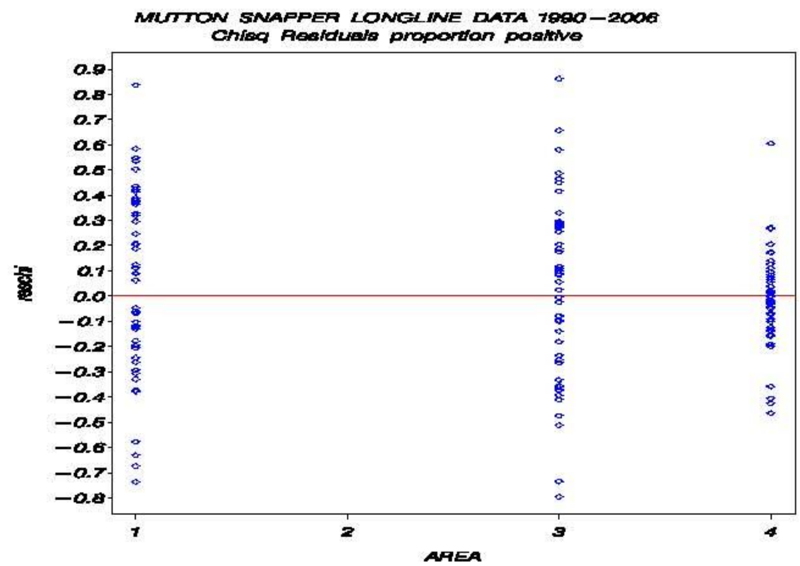


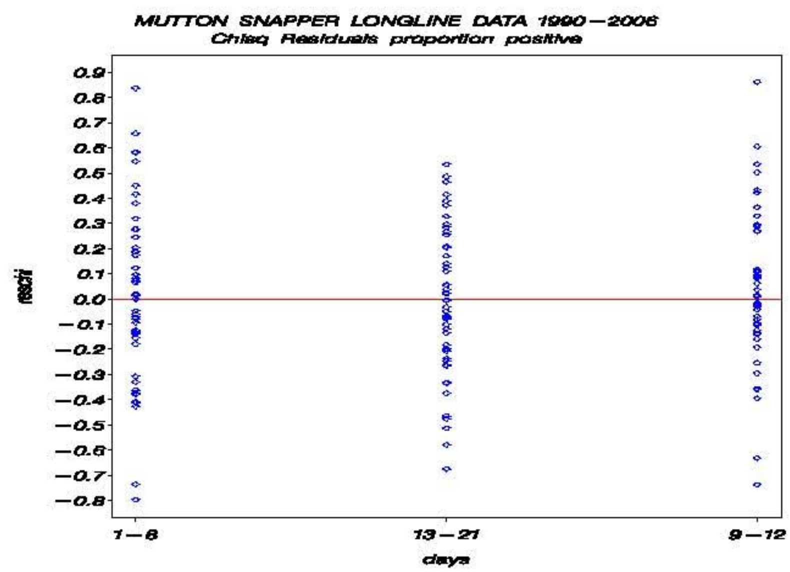
Figure 5.40. Continued.

Figure 6. continued.

g.



h.



Figures 5.41 and 5.42.

Figure 7. Initial and revised mutton snapper indices of abundance constructed from commercial handline data.

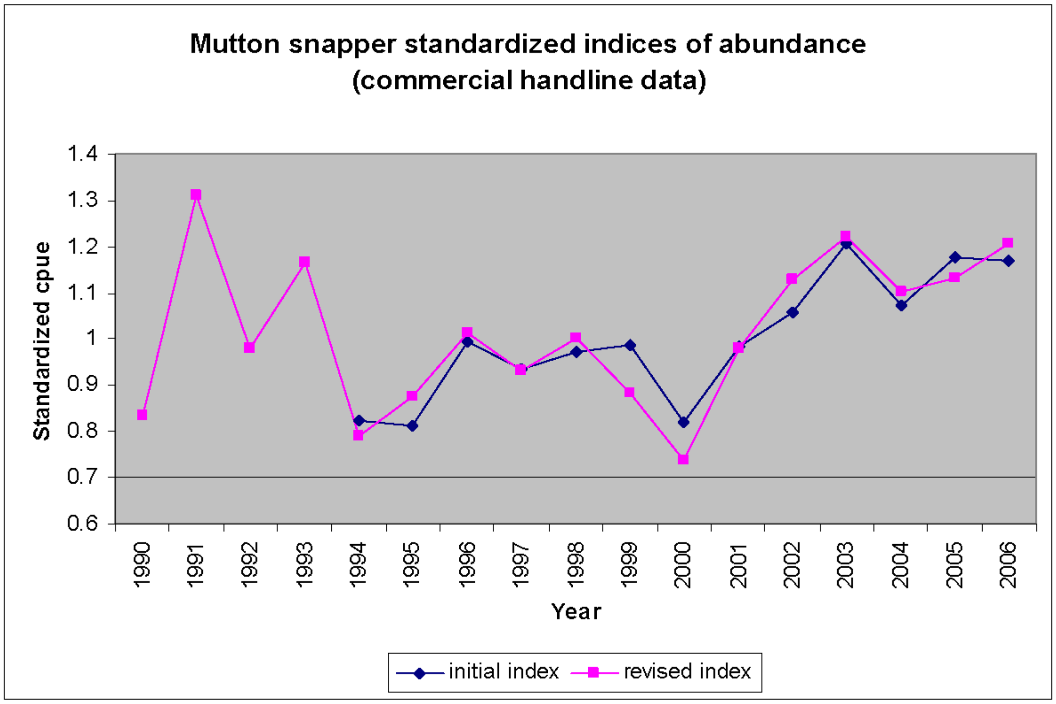


Figure 8. Initial and revised mutton snapper indices of abundance constructed from commercial longline data.

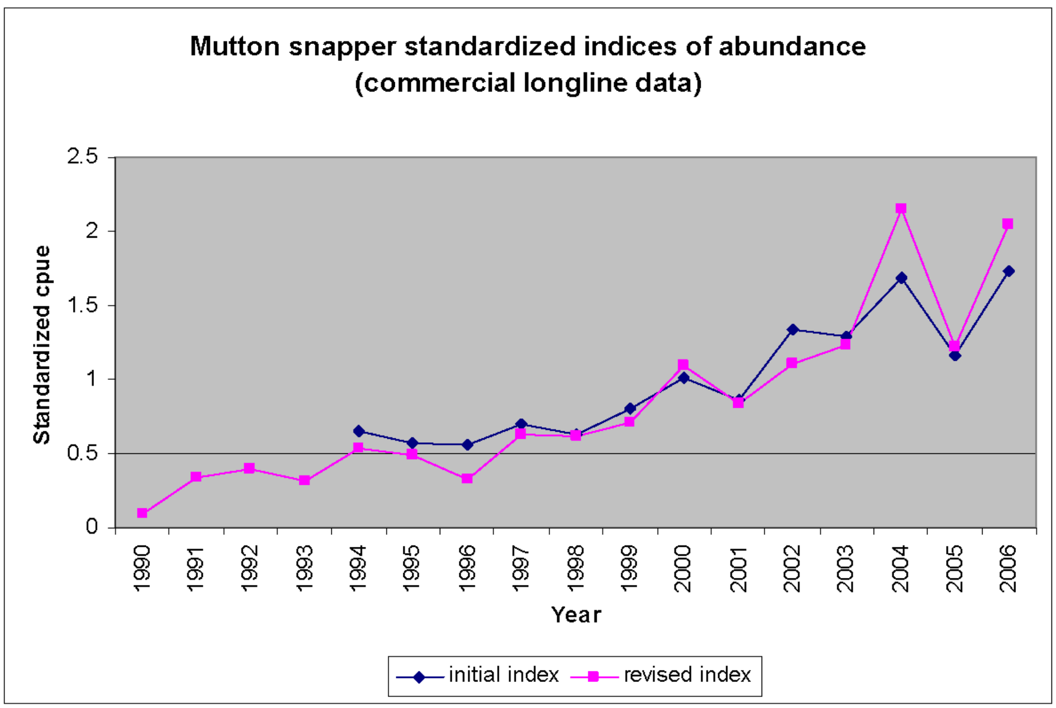


Figure 5.43. The Marine Recreational Fisheries Statistics Survey's standardized annual catch rates of mutton snapper in the total number of fish per interview including discards from those trips with a single angler in southeast Florida. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

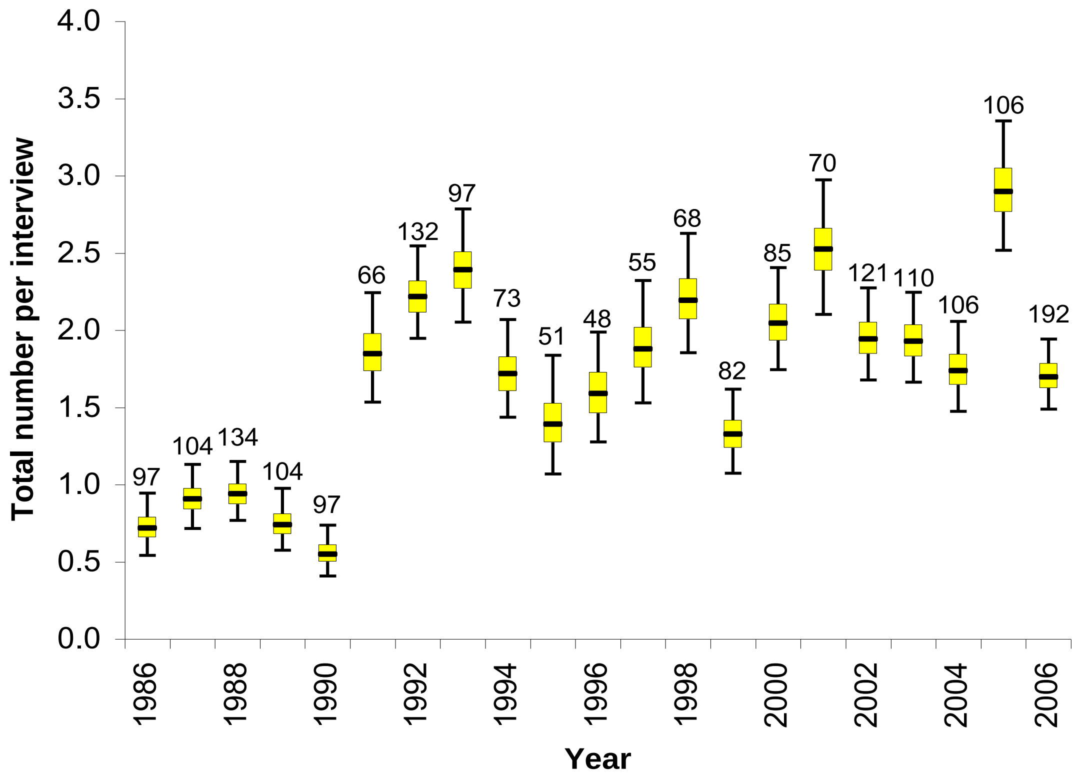


Figure 5.44. The Marine Recreational Fisheries Statistics Survey's standardized annual catch rates in the total number of fish per interview including discards from those trips that caught or targeted mutton snapper in southeast Florida.. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

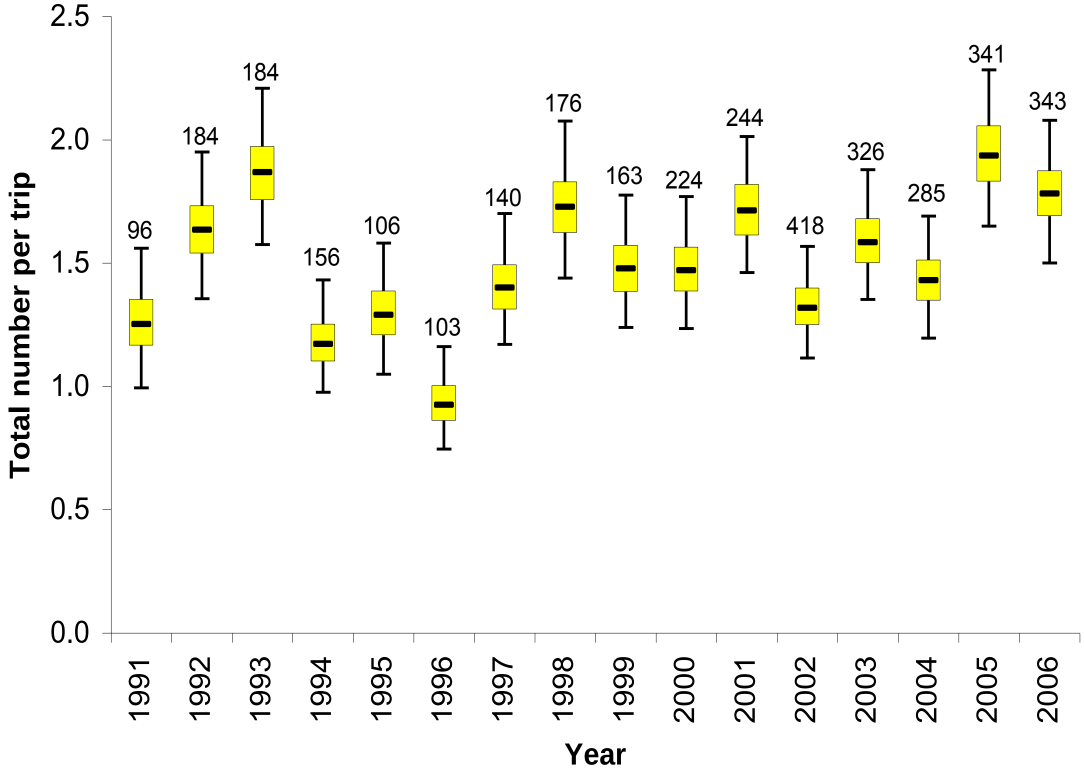


Figure 5.45. The species and their coefficients that were statistically significant in determining whether a trip should be considered a mutton snapper trip in the 1979-1991 time period.

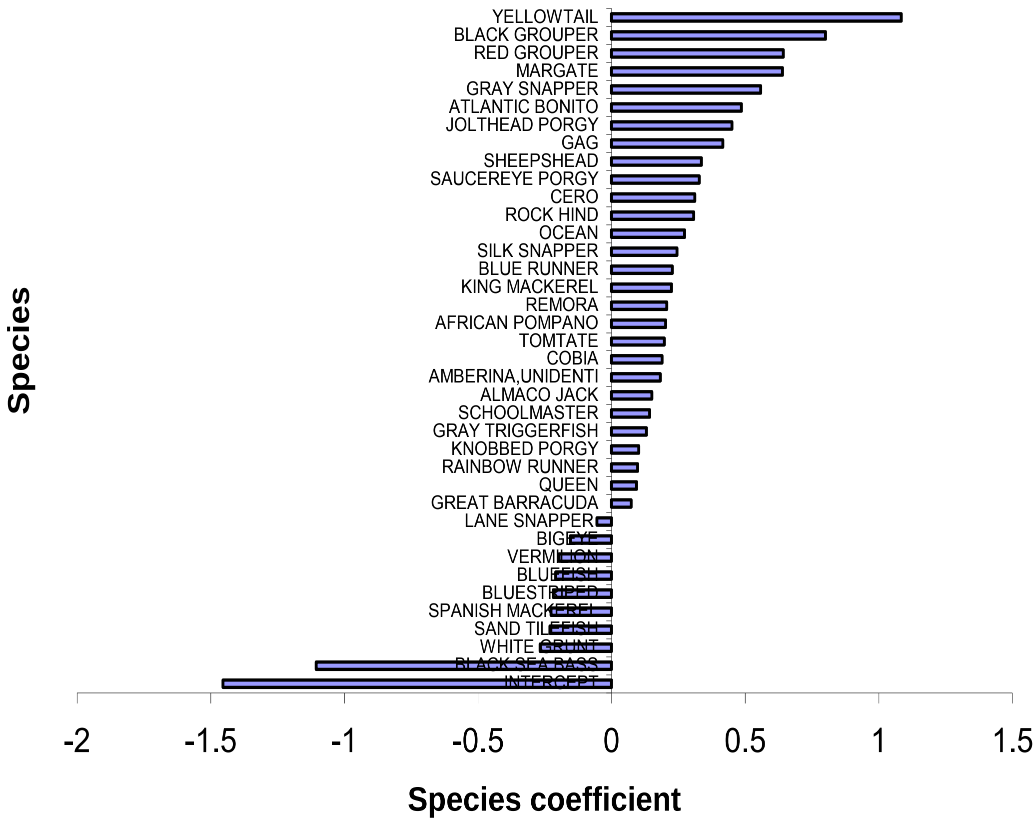


Figure 5.46. Negative log-likelihood profile for the critical value to identify which trips to include in the mutton snapper catch rate analyses for the 1979-91 time period.

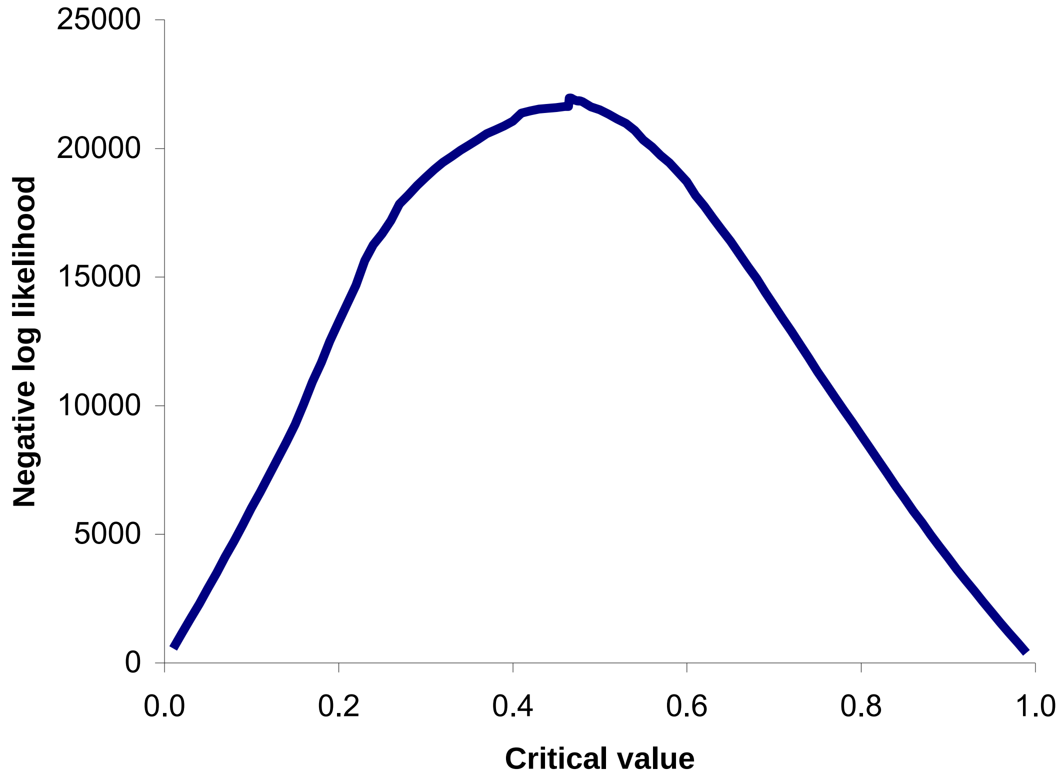


Figure 5.47. The headboat logbook's standardized annual catch rates for 1979-1991 from southeast Florida in the number of fish caught per trip from those trips that caught mutton snapper or had probability of catching mutton snapper greater or equal to the critical value of 0.467. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

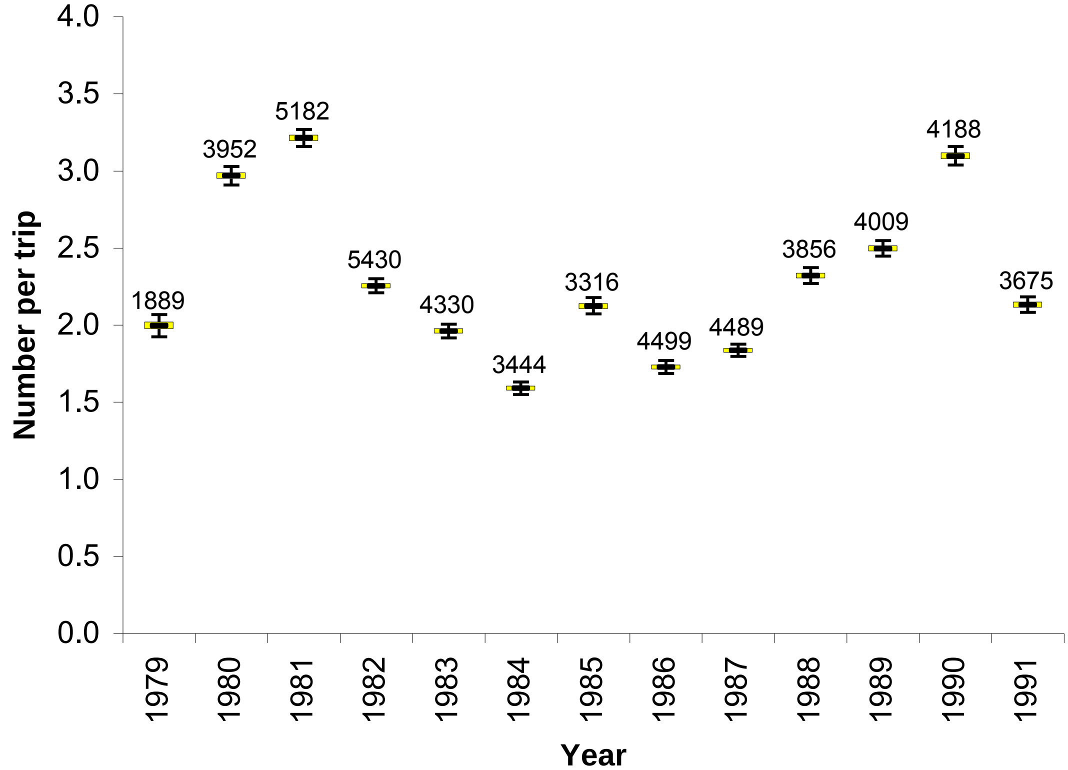


Figure 5.48. The species and their coefficients that were statistically significant in determining whether a trip should be considered a mutton snapper trip in the 1995-2006 time period.

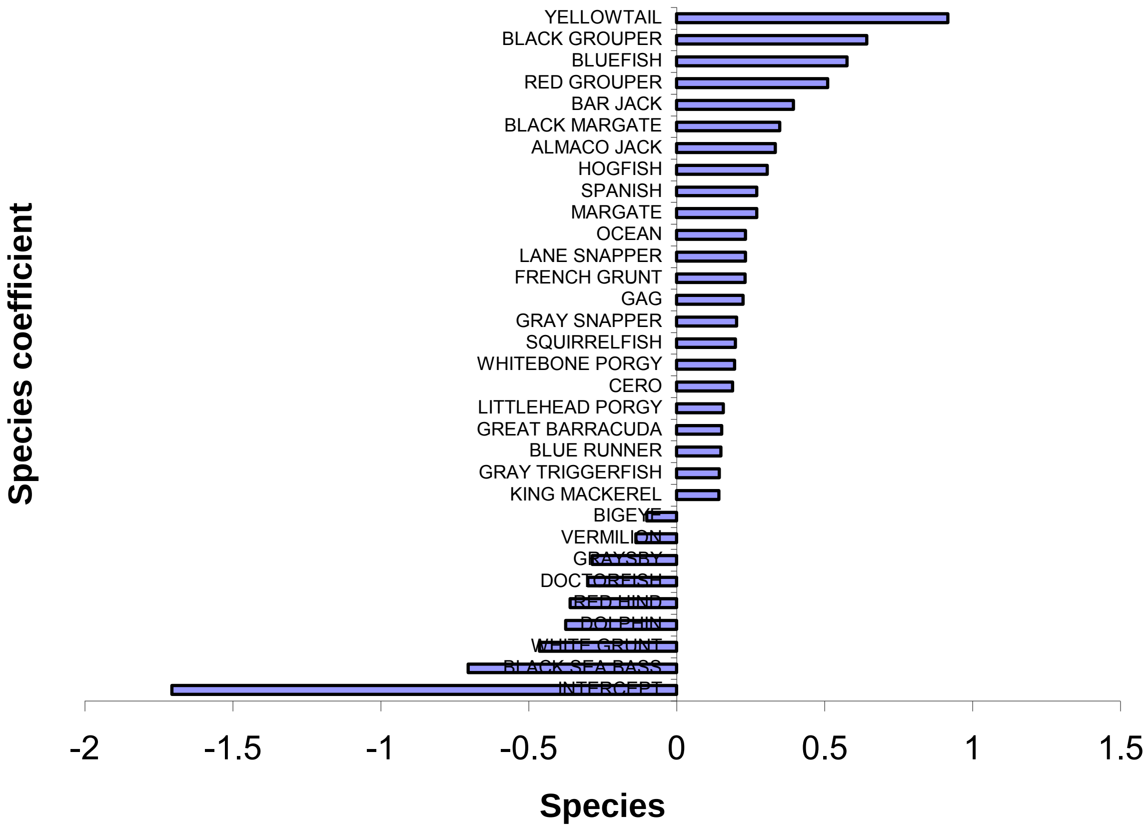


Figure 5.49. Negative log-likelihood profile for the critical value to identify which trips to include in the mutton snapper catch rate analyses for the 1995-2006 time period.

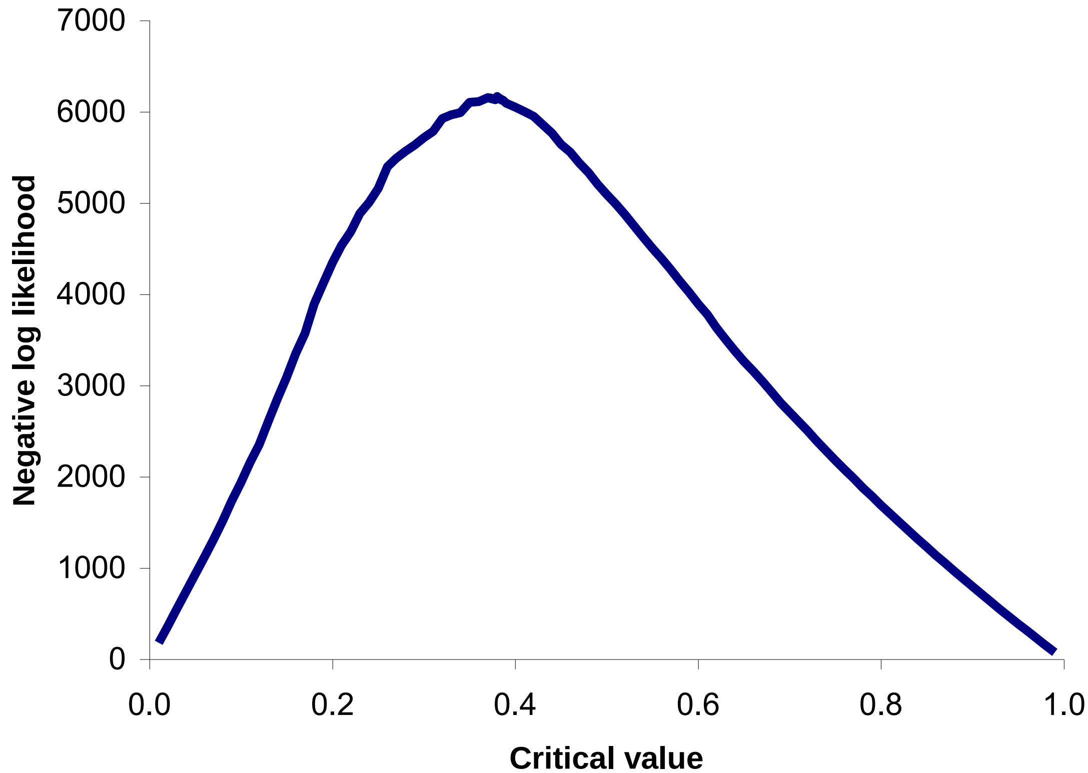


Figure 5.50. The headboat logbook's standardized annual catch rates for 1995-2006 from southeast Florida in the number of fish caught per trip from those trips that caught mutton snapper or had probability of catching mutton snapper greater or equal to the critical value of 0.373. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

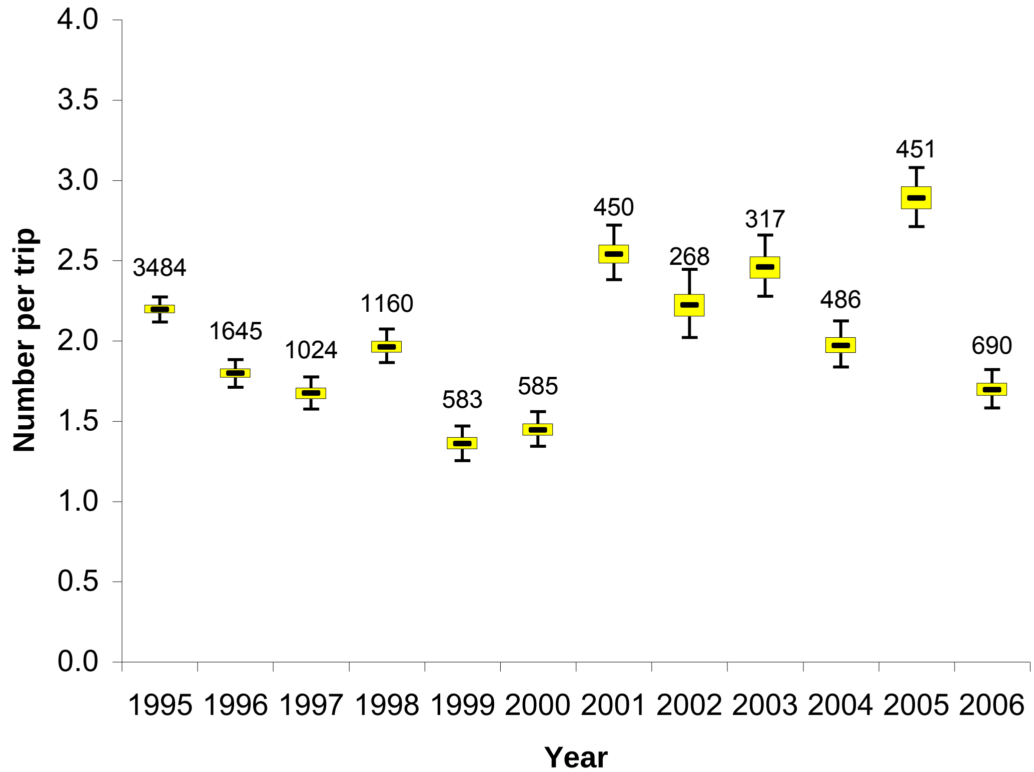
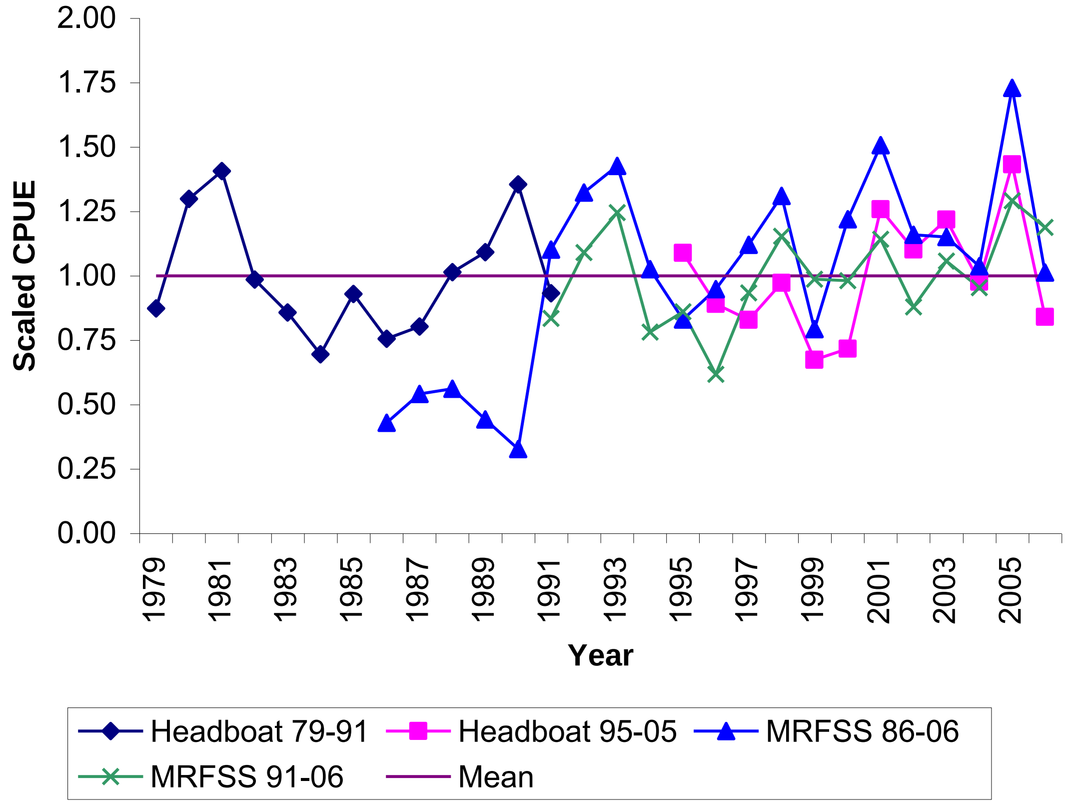


Figure 5.51. A comparison of the different recreational indices using the values that were scaled to their respective means.



6. Submitted Comment

(written comments or opinion statements submitted by participants or observers)

<None thus far.>

Section III. Assessment Workshop Report

Contents

1. Introduction

1.1. Workshop Time and Place

The SEDAR 15 Assessment Workshop was split into two meetings both of which were held at the FWC-Fish and Wildlife Research Institute in St. Petersburg, Florida. The first workshop (AW1) was held August 21-23, 2007 and the second (AW2) was held October 16-18.

1.2. Terms of Reference

The following terms of reference (TOR) were not formally announced before the first assessment workshop but were borrowed partially from the Caribbean mutton snapper SEDAR 14 Assessment Workshop and the SEDAR Generic Assessment Workshop TORs. These were used for the second and final assessment workshop.

1. Review any changes in data following the data workshop and any analysis suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

2. Develop population assessment models that are compatible with available data and recommend which model and configuration is considered most reliable or useful for providing advice. Document all input data, assumptions, and equations.

3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.

4. Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.

5. Provide yield-per-recruit, spawning biomass-per-recruit, and stock-recruitment evaluations, values, and figures.

6. Provide complete SFA criteria that are compatible with applicable FMPs and Acts. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT); recommend proxy values where necessary; provide stock control rules.

7. Provide declarations of stock status relative to existing and, if appropriate, recommended SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT.

8. Provide an Allowable Biological Catch (ABC) range that is consistent with FMP requirements.

9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following guidelines.
A) If stock is overfished:
   F=0, F=current, F=Fmsy, Ftarget (OY),
   F=Frebuild (max that rebuild in allowed time)
B) If stock is overfishing:
   F=Fcurrent, F=Fmsy, F= Ftarget (OY)
C) If stock is neither overfished nor overfishing:
   F=Fcurrent, F=Fmsy, F=Ftarget (OY)

10. Evaluate the results of past management actions and, if appropriate, probable impacts of current management actions with emphasis on determining progress toward stated management goals.

11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity.

12. Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report) and prepare a first draft of the Assessment Advisory Report.

1.3. Workshop Participants

Assessment Workshop I, August 21-23, 2007

NAME	**Affiliation**
	Workshop Panel
Robert Muller	Florida FWC
Behzad Mahmoudi	Florida FWC
Walter Ingram	NMFS SEFSC
David Chagaris	Florida FWC
Michael Murphy	Florida FWC
Joseph Munyandorero	Florida FWC
Luiz Barbieri	Florida FWC
Joseph O'Hop	Florida FWC
Nancie Cummings	NMFS SEFSC
Doug Gregory	Florida Sea Grant
Dennis O'Hearn	Fishing Rights Alliance
Council Representative	
George Geiger	SAFMC

Staff
None.

Assessment Workshop II, October 16-18, 2007

NAME	Affiliation
Workshop Panel	
Nancie Cummings	NMFS SEFSC
Steven Turner	NMFS SEFSC
Robert Muller	Florida FWC
Behzad Mahmoudi	Florida FWC
David Chagaris	Florida FWC
Michael Murphy	Florida FWC
Joseph Munyandorero	Florida FWC
Luiz Barbieri	Florida FWC
Joseph O'Hop	Florida FWC
Council Representative	
George Geiger	SAFMC
William Teehan	GMFMC
Staff	
Stu Kennedy	GMFMC

1.4. Workshop Documents

Working Papers
None

2. Panel Recommendations and Comments

2.1. Discussion and Recommendations Regarding Data Modifications

The draft of the report on the data workshop held April 17-19, 2007, in Marathon, FL, was still being compiled at the time of the first assessment workshop (AW1) and was unavailable for review. A number of the AW panelists had participated in the Data Workshop and either had access to the incomplete draft report or had personal knowledge of the issues brought up at that workshop. The AW Panel agreed that it was necessary to go over the available input data and Data Workshop decisions before presenting several "straw man" assessment model runs.

2.1.1. Life History

2.1.1.1. *Stock identification*

The AW1 Panel reviewed the available information on the stock structure of mutton. Genetic studies indicated little discernable difference among western Caribbean, Puerto Rican, U.S. Gulf of Mexico or U.S. South Atlantic populations. The greatest genetic diversity seemed to occur within samples taken from around Puerto Rico. Although it is possible, given the length of the pelagic larval stage (approximately a month) and the speed of the currents, that larvae from the Caribbean could recruit to U.S. mainland waters, it appears likely that the U.S. mutton snapper population is mostly self-contained given current gyres that would facilitate entrainment of locally spawned Caribbean larvae, the presence of spawning aggregations in U.S. waters near likely areas of entrainment (high relief) and the relatively short (compared to Caribbean spiny lobster) larval stage. The AW Panel agreed that the spatial extent of the population to consider for this assessment should include only the waters adjacent to the U.S. mainland which is primarily the waters off South Florida.

2.1.1.2. *Natural Mortality*

Natural mortality rates were discussed and the AW Panel agreed with the general Hoenig (1983)-based level of 0.11 yr^{-1} for the maximum age of 40 years but thought that the age-specific rates using the Lorenzen (1996, 2005) relationship of length to natural mortality were appropriate and that those rates should be scaled such that the average across ages 3 through 40 was still 0.11 per year. The Panel agreed that this should be used in the base run of any analysis but that the following sensitivities should be investigated: starting ages for the Lorenzen curve of 5, 6, or 7 years and another run using a Lorenzen relationship for natural mortality that averaged 0.08 per year with the 0.08 per year coming from the 'Rule of Thumb M = 3/max age' even though Hewitt and Hoenig (2005) argue against using the 3/max age rule. At the assessment workshop, a comparison of the age-specific natural mortality rates with starting ages of one through seven years (Fig. 2.1.1.2) showed that the largest differences were with starting ages of one or two and the difference between starting at age-3 or age-7 was less than 0.01 per year for ages three and higher. The panel agreed with using ages 3-40 for scaling the natural mortality curve to an average of 0.11 per year. The age-specific natural mortality rates averaging 0.11 per year and 0.08 per year are listed in Table 2.1.1.

The original assessment for mutton snapper (PDT, SAFMC 1990) used a natural mortality rate of 0.2 per year but at that time the only otoliths available for aging came from fish aged 1-14 years. The more extensive sampling in recent years has sampled fish from all the fishery sectors and now the age information contains fish of ages 0-40 years. A catch curve was developed from ages of fish sampled in the longline fishery in the Florida Keys and Dry Tortugas that estimated a total mortality for ages 18 to 40 of 0.13 per year which we considered an upper limit to natural mortality. Consequently, we are using a lower natural mortality rate than the 0.2 per year used in the early assessment. Also for comparison, the recent assessment of red snapper, *Lutjanus campechanus*, used a natural mortality rate of 0.1 per year for ages 1+ and its maximum age exceeds 50 years (SEDAR 8, 2005).

2.1.1.3. *Release Mortality Rate*

In the absence of release mortality rates for mutton snappers, Faunce et al. (SEDAR 15a, DW Report Sect. 2.4) reviewed the literature on release mortality rates for other snappers and groupers and noted that release rates averaged 15% in shallow water of less than 30 m and averaged 66% in deeper waters. They also fit a logistic regression of release mortality on depth; however, we chose to use the shallow-deep water dichotomy instead of the logistic regression of release mortality because most of the discards come from the recreational fisheries (headboat and MRFSS) and depth information is lacking for those sectors other than the general belief that they operate in shallow water. Based on the depth information from trip tickets, the hook-and-line and the traps/other gear also operate in shallow water (83% of the hook-and-line trips and 92% of the traps/other gear trips were from less than 30 m). The release mortality rate for the longline fishery which operates in deeper water was 66%; however, the longline rate was moot because the best available information indicated that there were no live mutton snapper released from the longline fishery. Some attendees suggested that the release mortality rate should be very low for the recreational fisheries because many of the mutton snapper that are released alive (likely due to the minimum size limit) are small fish caught in shallow waters. The AW Panel agreed that sensitivity runs for any of the chosen analyses should include a run using a 5% release mortality rate for the inshore recreational fisheries.

2.1.1.4. *Aging Mutton Snapper*

The AW Panel reviewed the mutton snapper life history information highlighted at the Data Workshop. There was good agreement among multiple readers on the ages of mutton snapper using either sectioned or whole otoliths with an average percent error of less than 5%. A population level growth curve was fit to both fishery dependent data and fishery independent data using a truncated normal likelihood function for the fishery dependent data to account for the minimum size limit ($L\infty$ = 874 mm TL, K = 0.16, t_o = -1.32; Fig. 2.1.1.4). There was some discussion of how this equation was applied, as it was used initially to determine ages of mutton snapper caught by the fisheries, and whether it was appropriate to use this or to use an "uncorrected" growth model. The panel chose to use the population level von Bertalanffy growth curve. The average length-at-age and weight-at-age are shown in Table 2.1.1.

2.1.1.5. *Maturity*

Maturity was determined from histological slides of gonad samples from mutton snapper collected during the spawning season by an FWC South Florida study. However at the workshop, there was also a side discussion of the parameters determined from the FWC South Florida study in relation to another study conducted in Puerto Rico that was used during SEDAR 14 (CFMC yellowfin grouper, mutton snapper, and queen conch). A reconsideration of the Figuerola and Torres (2001) report on mutton snapper maturity in Puerto Rico resulted in a examination and re-analysis of the maturity data subsequent to AW1 and before AW2. The FWC South Florida study originally used data from stage 1 (immature) and mature stages 2 (developing) to 7 (resting or regenerating) from female specimens collected during March-October (spawning months) to examine size and age at maturity. After consultations with Karole Ferguson, Craig Faunce, Sue Barbieri, and Luiz Barbieri (all FWC-FWRI), and following recommendations from Hunter and Macewicz (2003) on the selection of maturity stages and specimens for size and age at maturity studies, only female specimens collected in the Florida Keys from the April-June period and stages 1-6 were included in the re-analysis. The reasoning behind the decision to exclude specimens classified as stage 7 (approximately half of the specimens) was that this stage should be uncommon during the spawning season (Hunter and Macewicz 2003), and the histological distinctions between stage 1 and stage 7 specimens are difficult and may lead to misclassification of the reproductive stage. The new maturity curves and solutions for the L_{50} and A_{50} parameters (Fig. 2.1.1.5) were incorporated into the assessment models where appropriate. The revised L_{50} was 402 mm TL which is similar to the current minimum size limit for mutton snapper of 16 inches (406 mm TL). The maturity schedule by age is shown in Table 2.1.1.

2.1.2. Fishery Characteristics

Being part of the reef fish complex that occurs over hardbottom habitat in south Florida, mutton snapper frequently is caught with other species such as yellowtail snapper (*Ocyurus chrysurus*), red grouper (*Epinephelus morio*), gag (*Mycteroperca microlepis*), margate (*Haemulon album*), gray snapper (*Lutjanus griseus*). Fishers are fishing the habitat and usually do not target mutton snapper except during the mutton snapper spawning season.

2.1.2.1. *Recreational fishery*

The recreational fishery has landed about 150,000 fish per year in recent years and occurs mostly in Southeast Florida. The two data sources for the recreational fishery are the NMFS Marine Recreational Fisheries Statistics Survey (MRFSS) and the NMFS Headboat Survey. Headboats account for approximately 10% of the recreational harvest.

There was a considerable amount of discussion at the AW1 of how the mutton snapper landed under the recreational limit during the commercial closed season entered the commercial market and whether there is double counting of some fish caught by the charter boat fleet and sold under a valid saltwater products license. These questions were resolved when it was noted that the commercial closed season is not a prohibition on the sale of mutton snapper but rather commercial fishers in May and June are reduced to a 10-fish trip limit and the sales of mutton snapper from charter boats on recreational trips can be tracked with trip tickets because the trip tickets have a box to indicate whether the fish being sold came from charter boats.

The effort used to characterize the recreational fishery came from estimated directed trips (those trips that caught or sought mutton snapper) from MRFSS and from the estimated total angler-days from the headboat survey. Analysis of the numbers of fish landed by anglers indicated that mutton snapper releases were not due to anglers filling their bag limit (none of the anglers intercepted by MFRSS between 1995 and 2006 landed 10 mutton snapper on a trip), but were due to the minimum size limit (see Section 2.10.1).

Biostatistical sampling was extensive for the headboat fishery since the early 1980's in the South Atlantic regions and since the mid 1980's in South Florida and the eastern Gulf. The MRFSS data were confined to lengths of landed mutton and these data were sparse until 1992.

2.1.2.2. *Commercial fisheries*

The commercial fishery was split into three disparate fisheries, commercial hook-and-line, longline, and a "traps/other" category that included a wide variety of gears that changed in composition over time, e.g., trap usage was restricted in the 1990s. The general trends seen in the data were: the number of Saltwater Product licenses, SPLs, has declined since the late 1980's and the number of wholesale dealers buying reef fish has declined since the mid 1990's. Commercial landings have been steady since the mid 1990's with increases in longline landings offsetting declines in the hook-and-line fishery. Most of the commercial landings came from the Keys and a small amount came from Southeast Florida. The issue of changes in the efficiency of the fishery was discussed and sensitivity runs were made with increasing catchability. We used the 2% increase per year that was used in the red grouper stock assessment (SEDAR 12, 2007). The 2% was an approximation stemming from the belief expressed by some fishers that they were about 35% more efficient now than they were 15 years ago.

Biostatistical samples such as lengths or otoliths for aging from the commercial fishery were sparse before 1992 and more numerous in recent years.

2.1.2.3. *Discards*

As with other fisheries, not every fish that is caught is landed, many fish are discarded because they are too small, some are used for bait, some are eaten, and some are released because a limit was already filled. We attempt to account for this additional level of removals in the stock assessment. Presently three programs collect discard information in addition to harvest information: the commercial reef fish logbook, the MRFSS, and the Headboat Survey.

2.1.2.3.1 *Recreational discards*

Because of the prevalence of released fish by anglers, MRFSS field samplers have asked anglers about the number of fish unavailable to the sampler (Type B fish) including released fish since the start of the program in 1979. Samplers ask for the number of fish that were released alive or the number released dead. MRFSS estimates the number of fish released dead and includes those fish as part of their Type B1 landings and MRFSS estimates the number of fish released alive as Type B2 landings. The number of fish that were released alive each year is shown in Table 2.1.2.3.0. We applied the release mortality rate of 15% to the fish that were released alive by anglers because Data Workshop panel thought that most of these fish were caught in waters of less than 30 m depth.

The NMFS Headboat Survey began in 1972 in North Carolina and in 2005 captains were asked to start recording the number of fish released as well as the number landed. The condition of each fish was recorded as alive, mostly alive, dead or mostly dead. Similar to the commercial logbook program, fish that were categorized as released alive or mostly alive were considered as being released alive and all other fish were considered dead and were included in the analyses as part of the landings. The intent was to determine the ratio between the number of mutton snapper landed and the number of mutton snapper released alive or discarded dead so that these ratios could be applied to the landings from earlier years to estimate the number of mutton snapper that were released alive or dead. From the headboat records for trips that reported discarding fish, there was a total of 7,202 mutton snapper landed in the 2005 and 2006 time period (Table 2.1.2.3.1). On those same trips, a total of 1,177 mutton snapper (16.3%) was released alive and a total of 39 mutton snapper was discarded dead (0.5%).

At the same time in 2005, a three-year observer program was initiated to verify the headboat logbook responses. On average, observers reported anglers discarding fish on 96% of the 665 headboat trips that were sampled. Mutton snappers were mostly discarded on headboat trips in Southeast Florida and the Florida Keys (approximately 20% of the trips). Table 2.1.2.3.1 shows the number of fish landed on headboat trips with observers for 2005 and for 2006 and the number of mutton snapper discarded. The ratio of the numbers released alive to the numbers kept estimated from the observer data was 34.5% which was more than twice the logbook estimate (16.3%) and the ratio of released dead to kept estimated from the observer data was more than nine times the logbook estimate. The panel chose to use the observer estimates of headboat discards. The ratios were applied to the landings, expressed in numbers, to estimate the number of fish discarded both alive and dead. To account for discards before the 16-inch minimum size was implemented, we used the proportion of fish less than 12 inches (305 mm TL). The number of mutton snapper released dead were added to the landings.

2.1.2.3.2. *Commercial discards*

Starting in July 2001, the Fisheries Logbook Program began to provide discard information forms to selected reef fish fishers. Fishers recorded the number of fish discarded and the condition of the discarded fish at release on approximately 10-15% of the annual logbook trips. If the fish was judged to be either alive or mostly alive at the time of release, then the fish was classified as released alive otherwise the fish was classified as released dead. Mutton snapper were rarely discarded by commercial reef fish fishers with only 162 reef fish trips out of the total of 23,407 reef fish trips reporting mutton snapper discards. While mutton snapper were caught on long line trips that reported discards, there were no reported mutton snapper discarded on long line trips. During the data workshop when we were discussing discards, we contacted a reef fish captain and he confirmed that the fish caught with long line gear were well above the minimum size.

For any trip that reported discarding any fish, we tallied the landings of mutton snapper, the number of mutton snapper released alive and the number of mutton snapper released dead by gear (Table 2.1.2.3.2). The rationale was to determine the number of mutton snapper discarded alive and dead per kilogram of landed mutton snapper so that the discards could be expanded to the entire sector. We used the annual ratios to estimate discards for 2002 through 2006 and the overall average ratios for earlier years. We used the proportion of fish measured by TIP during 1981-1994 that were less than 12 inches to approximate the discards in those years. Table 2.1.2.3.2 shows the discards by gear and year and the fish discarded dead were added to the landings in the analyses.

2.1.2.4. *Sizes of released fish*

Mutton snappers have been regulated with minimum size limits since 1985. The Florida Marine Fisheries Commission implemented a 12-inch (305 mm TL) minimum size in July 1985 and the South Atlantic Fishery Management Council implemented the 12 inch minimum size in Amendment 4 to the Snapper-Grouper FMP (SAFMC 1991). During the time when there was a 12-inch minimum size in state waters but not in federal waters (1985-1991), many anglers followed the state's minimum size because sixty percent of the kept fish in Southeast Florida came from state waters. The minimum size was increased to 16 inches (404 mm TL) in 1994 by both the South Atlantic Council (Amendment 7, Snapper Grouper FMP, SAFMC 1994) and Florida's Marine Fisheries Commission. Because none of the MRFSS intercepts with mutton snapper (3,462 intercepts) exceeded the 10-fish per angler aggregate snapper bag limit, we assume that the fish being released were smaller than the minimum size.

The only direct size information for released fish comes from the first two years of a three-year observer program for headboats. Observers went on headboat trips to interview anglers, measure their fish including those that would be released, and, for released fish, record the condition of the fish after release. We used the length frequencies, in 25-mm length categories, of the fish measured by observers to assign sizes to headboat discards. Anglers released mutton snapper when there was no minimum size (1981-1984), but lacking any lengths of released fish from that period, we used the same 12-inch minimum size. In the model that used direct aging of the catch, we used the ages of all fish that were less than 12 inches for 1981-1994 and all fish that were less than 16 inches from 1995-2006 to age the discards.

There were no length measurements for fish released alive by anglers that were intercepted by MRFSS. We used the lengths of landed mutton snappers less than 16 inches (406 mm TL) seen by creel clerks from 1981-1994 and then applied this size distribution to the fish discarded 1995-2006 and we used the length frequencies of landed fish less than 12 inches to size the discards in earlier years.

Similar to the lengths for the MRFSS discards, the sizes of fish that are released alive are not recorded in the commercial logbook information. Therefore, we had to assign sizes to those fish using length information prior to the minimum size regulations and assume that those proportions were still appropriate. For the commercial sectors, we tallied the sizes of mutton snappers less than 16 inches (406 mm TL) from 1981-1994 TIP data and then applied this size distribution to the discarded fish. As with the recreational fisheries, we used the length distribution of fish less than 12 inches to assign lengths to fish discarded in years prior to 1995.

2.1.3 CPUE Models

Twelve tuning indices were proposed by the Data Workshop participants as measures of mutton snapper relative abundance. The AW1 Panel reviewed these indices and considered their likely utility as tuning indices. The panel decided that the REEF index should not be used because it lacked a sampling design as seen in the other fishery independent indices. There was a question of whether any of the fishery dependent indices should be used in the assessment model since these could be affected by undocumented changes in the fisheries. However their long time scales and the relative agreement among the indices in trend, tended to convince the AW Panel to include them. The panelists also questioned how valid the early, prior to 1991, MRFSS data were as indices of abundance since they showed a marked increase in 1991 that was not seen in other indices. Subsequent to the AW1, the MRFSS data were re-analyzed and the abrupt 1991 change was found to be partly due to differences in how the total catch was aggregated on a trip prior to and after 1991. Other discussions on indices included questions about what were the most appropriate ages for each index. The AW2 panel members continued the discussions on appropriate ages to assign to each index.

2.1.3.1 *Fishery Independent Indices*

Six fishery-independent indices of abundance were developed for mutton snapper: SEAMAP video survey, an FWC Keys visual survey for exploited-sized and pre-exploited-sized fish, FWC fishery-independent monitoring seine program, Riley's Hump visual survey, and NMFS-University of Miami reef visual census.

The SEAMAP video survey (1992-97, 2002, 2004-06; Gledhill, et al. SEDAR15A-DW-01) was developed to provide an index of abundance for fish on the continental shelf. Four camcorders are mounted orthogonally, 30 cm above the bottom of the pod. A tape to be viewed is randomly selected and the estimator is the minimum count, i.e., the greatest number of a given taxon that appears on screen at one time. For mutton snapper, the data were restricted to surveys taken from blocks near the Dry Tortugas in the South Florida region. The SEAMAP video survey index values together with their coefficients of variation (CV) are shown in Table 2.1.3.1.

The Florida Keys visual survey (1999-2004, 2006; Acosta and Muller SEDAR15A-DW-02) is a stationary point count method in which a diver records the number of individuals of each target species that were observed from the center of an imaginary five-meter radius cylinder extending from the bottom upwards usually to the surface depending upon visibility. Thirty-nine sample sites are selected each month from a sampling universe of one minute square grids that contain either "Patch Reefs" or "Platform Margin Reefs". The lengths of the fish were estimated in 5-cm size classes and fish greater than 406 mm TL were categorized as exploited and fish less than 406 mm TL were considered pre-exploited. Because a single dive can encompass multiple habitats, the index was the number of mutton snapper per dive per bottom habitat type. Dive/habitat combinations where mutton could have been seen but were not observed were identified using the Stephens and MacCall (2004) logistic regression method. Once the surveys to be analyzed were identified, the index (number of fish per dive/habitat) was calculated with a generalized linear model that used a Poisson distribution with a log link. Potential explanatory variables used in the analysis were: year, month, zone, bottom habitat relief and type, secchi-disk category, and depth category. The FWC visual survey index values and CVs for both the pre-exploited and the exploited stages are included in Table 2.1.3.1.

The fishery-independent monitoring (FIM) haul seine survey (1999-2006; Ingram et al. SEDAR15A-DW-05) sampled estuaries throughout Florida but mutton snapper were only consistently captured in the Indian River and Tequesta estuaries. Fish above 80 mm SL were considered age1+ mutton snapper. Calculation of the index (number of fish per seine set) used a zero inflated binomial model for presence/absence with a lognormal model for the positive sets. Potential explanatory variables included year, estuary, shoreline vegetation type, station depth, salinity and temperature. For the age1+ dataset, all years had frequencies of occurrence of less than 5%. The FIM age 1+ index values and CVs are included in Table 2.1.3.1. The index for age-0 fish was not included because the age-structured model did not include age-0 fish.

The Riley's Hump visual census survey (2001-2006; Burton and Ingram SEDAR-15A-DW-10) samples 14 stations per year where divers descend and swim a predetermined number of fin kicks in a predetermined direction before deploying a 30 m transect tape. Visibility is measured and the area of the survey on a given dive is the transect length times twice the visibility distance. Typically, each diver can complete three transects per dive. The index (number per area surveyed) was calculated with a delta-lognormal model (Lo et al. 1992). The presence/absence portion was modeled with a binomial distribution and the numbers of fish per m^2 used a lognormal distribution. The Riley Hump index values and CVs are included in Table 2.1.3.1.

The NMFS-University of Miami Reef Visual Census (1994-2005; Bohnsack, et al. 1999, SEDAR-15A-06-07) uses a two-stage sample design with a sampling universe of 200 m x 200m (40,000 m^2) grids containing hard bottom in the Florida Keys and the Dry Tortugas and the second stage is the random allocation of the sampling 7.5 m radius cylinders (177 m^2). Two divers count fish in an imaginary cylinder extending from the bottom upwards to the visual limits. The divers also record the maximum, minimum, and the mean sized fish observed for a triangle distribution. The index was the number of mutton snapper with lengths exceeding 40 cm per dive i.e., legal sized mutton snapper. In 1999, they improved the sampling design to sample more primary grids and fewer dives per grid. The reef visual census index values and CVs are included in Table 2.1.3.1.

2.1.3.2. *Fishery Dependent Indices*

The fishery-dependent data used to develop catch-per-unit-effort estimates were from the NMFS Marine Recreational Fisheries Statistics Survey for the recreational fishery, and the NMFS Headboat Survey (NMFS SEFSC-Beaufort) for headboat anglers, and the National Marine Fisheries Service Fisheries Logbook Program for both the hook-and-line and long-line fisheries operating in the Gulf of Mexico.

The AW1 Panel noted an abrupt change in the MRFSS CPUE index in 1991. Further exploration revealed that the change was due to including ancillary interviews from other anglers on the same trip. The MRFSS interviews for mutton snapper were re-extracted and only the primary interviews were used (Num_typ6 = 0) to maintain compatibility with the earlier years. The data were then subset to include all intercepts for single-angler boat trips that occurred in the region from Martin County south through Monroe County where mutton snapper were either captured or were targeted (1981-2006, SEDAR 15A-DW-11-12). As with the FWC visual survey data, MRFSS catch rates were calculated with a generalized linear model using a Poisson distribution and a log link. The potential explanatory variables year, wave (two-month period), area, county, number of hours fished, and avidity. The revised MRFSS index values and their CVs are in Table 2.1.3.2.

The NMFS Headboat Survey data were subset using Stephens and MacCall's (2004) species-association technique, as described above for the fishery-independent FWC visual survey data. This overall dataset was first split into two datasets based on the timing of a change in minimum size limit and survey spatial coverage; 1981-1991 and 1995-2006 (SEDAR 15A-DW-11-12). The former utilized only data collected from headboats operating between Fort Pierce and Key West, while the latter also included collections made for headboats fishing the Tortugas. For the period 1981-1991, mutton snapper were significantly associated (positively or negatively) with 37 of the 52 species observed. For 1995-2006, the associations were significant for 31 of the 54 species observed. The standardization of headboat landings rates also followed that used for the FWC visual survey, a generalized linear model with an assumed Poisson data distribution and a log link. The model included explanatory variables for year, month, number of anglers, trip type, area fished and location. The headboat index values and their CVs for the two periods are in Table 2.1.3.2.

Separate standardized catch rates were developed from NMFS Fisheries Logbook Program data for hook-and-line (weight per hook-hour) and logline (weight per hook fished) trips (1990-2006 NMFS SEFSC- Miami, SEDAR 15A-DW-09). This standardization began with selecting only trips that met the criterion based on species association (Stephens and MacCall 2004) and the resultant datasets were analyzed using a delta-lognormal model (Lo et al. 1992), where a mixed-model analysis (GLMMIX) was used to include a random year effect in the two-way interaction terms. Potential explanatory variables were year, area, days at sea, month, number of crew members. The logbook hook-and-line and longline index values and their CVs are in Table 2.1.3.2.

2.2. Discussion and Critique of Each Model Considered

Several assessment models were used. In increasing level of complexity: non-equilibrium surplus production models (Excel and ASPIC5), a modified DeLury model, the untuned virtual population analysis, stochastic stock reduction analyses, and two versions of statistical catch-at-age analyses (ASAP and generic). The panel thought that the base model should be the peer-reviewed statistical catch-at-age analysis, ASAP, from the NMFS Toolbox. The generic SCAM model produced similar estimates of population size and fishing mortality rates but estimated quite different benchmarks and the AW2 panel members decided to drop the generic model from further consideration in the assessment.

The temporal scope of the analyses was discussed extensively and depended on the type of analyses. For instance, the stochastic stock reduction analyses was best served with the longest time series available for landings, 1902-2006, while it was less clear whether a time series beginning in 1986 would not be better for the more data-intensive models, e.g. ASAP. The AW1 panel members recommended using a time series for the data intensive models beginning in 1950 with the appropriate low weighting given to the early years of lower quality data. However, ASAP was found to have a data limitation that precluded extending the model prior to 1975. With further consideration and noting that there were no landings from either recreational fishery earlier than 1981 from Florida, the main region of the fishery, and because only hook-and-line landings were being added to the model in those years earlier than 1981, the panel decided to go with data from 1981-2006 for the statistical catch-at-age model and to use the entire landings history with the SRA.

2.2.1 Previous stock assessment models for mutton snapper

Scientists at NMFS Beaufort Laboratory developed two earlier assessments using catch curve, yield-per-recruit and spawning stock ratio (spawning potential ratio) methods. The first assessment was conducted by the South Atlantic Fishery Management Council's Snapper-Grouper Plan Development Team (PDT, SAFMC 1990) using data from 1981-88 and the second was by Huntsman et al. (1992) using length information from just 1990. Having only mutton snapper samples with ages 1 through 14, they used a natural mortality rate of 0.2 per year that was applied to all exploited ages. They used a von Bertalanffy growth curve with parameter estimates: $L\infty$ = 862 mm TL, K = 0.153, t_o = -0.579. This curve estimates smaller fish at age than does the equation in Section 2.1.1.4. The PDT estimated total mortality rates ranging from 0.28 per year in 1987 to 0.54 per year in 1984 for fish aged 4-14 years old. With an average total mortality of 0.42 per year and a knife-edge length at maturity that was half the asymptotic length (431 mm TL), they estimated an average spawning stock ratio (SPR) of 47%. Huntsman et al. (1992) again using a catch curve with the same configuration, obtained an average fishing mortality rate of 0.12 per year in 1990 for fish of the same ages (4-14 years old) and same natural mortality rate, 0.2 per year. Huntsman et al. (1992) credited their low estimated fishing mortality to a large proportion of measured fish coming from the Florida Keys and Dry Tortugas and they believed that older fish were over-represented in the age samples which led to underestimating total mortality and fishing mortality.

As was discussed above in the life history section, additional sampling in recent years has obtained otoliths from older fish than previously were collected. The current assessment is based on 5999 aged mutton snapper and those samples include fish of all ages from 0 to 40 years (Table 2.2.1). An age-length key was developed for each fishery by combining data across years and calculating the proportion of ages for each 25-mm length category. We used length information from TIP, the headboat survey, and MRFSS to construct the catch-at-length by fishery using a bootstrapping approach to fill any strata (fishery, region, and year) with less than 30 fish. Fish lengths and ages were pooled by fishery and region into three time periods roughly based on minimum size regulations: 1981-1991, 1992-1994, and 1995-2006 and strata that contained less than 30 fish were brought up to 30 fish by randomly drawing fish with replacement from the appropriate pool of fish. Commercial landings were converted from biomass to numbers using raising factors from the sample weight estimated for TIP length frequency data. The catch-at-length by fishery was converted to catch-at-age with the corresponding age-length key. To compare with the earlier mutton snapper assessment, we developed a composite catch curve (Robson and Chapman 1961) combining the numbers of fish at age by fishery for 2001-2006 and estimated an average total mortality of 0.53 per year for fish aged to 4-14 years old which was similar to the PDT estimates for 1982 (0.51 per year) or 1984 (0.54 per year) and higher than

Huntsman et al's 1990 estimate of 0.32 per year (Fig. 2.2.1). However because we used a lower natural mortality rate of 0.11 per year instead of 0.2 per year, the average fishing mortality rate for 2001-2006 was higher at 0.42 per year. If we use fish aged 4-40 years old, then the average fishing mortality drops to 0.28 per year.

2.2.2. Non-Equilibrium Surplus Production Model

A non-equilibrium, surplus production model was developed for mutton snapper in Microsoft Excel and based on the discussions presented in Hilborn and Walters (1992) and Prager (1994). Surplus production models describe biomass changes over time. There are two simple equations for the model, the first equation relates the biomass at a particular time (*t*) to the biomass at a future time (*t*+1):

$$B_{t+1} = B_t + rB_t(1 - B_t / K) - \sum_{f=1}^{fleets} C_{f,t} \tag{1}$$

where B_t is the biomass at time *t*, *r* is a dimensionless net rate of growth in biomass, *K* is the carrying capacity (biomass) of the environment and $C_{f,t}$ is the catch for fishery *f* during time *t*. This equation represents the logistic version or Schaefer (1954) surplus production model. The second equation relates the catch to the biomass:

$$\hat{C}_{f,t} = q_f E_{f,t} B_t \tag{2}$$

where q_f is the catchability coefficient (per unit effort) for fishery *f* which links effort by sector (fleet) to biomass, and $E_{f,t}$ is the effort expended by that fleet during time *t*. Two catchability coefficients per fishery were incorporated in this model to account for the change in minimum size effective 1995. The catch equation is an approximation since catch is actually a function of the average biomass during the year not the biomass at the beginning of the year. The final objective function minimized during the fitting process was:

$$Obj.Func. = \frac{n}{2} \sum_{f=1}^{fleets} \sum_{t=1}^{years} \ln(C_{f,t} / \hat{C}_{f,t})^2 \tag{3}$$

where *n* is the total number of years of catch by each fleet used in the model. A penalty was employed when the biomass at the beginning of the first year exceeded the carrying capacity.

Input data for this model were total harvest by weight and fishing effort in trips for the three sectors of the commercial fishery (longline, hook and line, and traps/other) and the two portions of the recreational fishery (anglers and headboat). The model fit 13 parameters: *Bo, K, r*, and the 10 catchability coefficients.

The model fit the landings well except for the early MRFSS landings (Fig. 2.2.2.1, residuals Fig 2.2.2.2)). The output of the surplus production model is the fishing mortality rate by fishery and year (Fig. 2.2.2.3) and the vulnerable biomass in kilograms by year (Fig. 2.2.2.4).

As a check, we developed a surplus production model running ASPIC5 from the NMFS Toolbox as recommended by the AW Panel. While the estimated fishing mortality rates from the two versions were correlated (r = 0.81, df = 24, P < 0.05), ASPIC estimated lower fishing mortality rates (Fig. 2.2.2.5).

2.2.3. Modified DeLury Model

A modified DeLury model (Rosenberg *et al.* 1990) was used to estimate population sizes and fishing mortality rates each year as an alternative to the surplus production model. The modified DeLury model is similar to the surplus production model except that it uses harvests in numbers instead of biomass and explicitly incorporates natural mortality and recruitment rather than combining these processes into the intrinsic rate of increase. The model's parameters include the initial number in the population, N_o, the catchability coefficients by sector and time period, and the number of recruits entering the fishery each year. As with the spreadsheet version of the surplus production model, we used two catchability coefficients per fishery sector to capture the effect of implementing the 16-inch minimum size limit in 1994. In other DeLury models that we have developed such as for stone crab (Muller et al. 2006), we assumed that recruitment occurred during a particular season but with the overlap of ages in mutton snapper, we used a continuous recruitment model developed by Dr. Carl Walters of the University of British Columbia. Dr. Walters' model stems from the simple idea that recruits increase the number of fish and mortality decreases it. Expressed mathematically,

$$\frac{dN}{dt} = R - ZN \qquad (4)$$

Where dN/dt is the change in numbers with time, R is the number of fish entering the exploited portion of the population, Z is the total instantaneous mortality rate, and N is the number of fish in the population. Integrating the differential equation (4) gives an expression for the number of fish at time $t+1$ from time t:

$$N_{t+1} = \frac{R_t}{Z_t} + (N_t - \frac{R_t}{Z_t})e^{-Z_t}$$

And the predicted catch for a given sector f and time t, $\hat{C}_{f,t}$, is:

$$\hat{C}_{f,t} = q_f E_{f,t} Nbar_t$$

where $Nbar_t$ is the average number in the population during the time step t; q_f is the catchability coefficient that relates the mortality expended by one unit of effort by fleet f; and $E_{f,t}$ is the effort expended by a fleet during time t. With continuous recruitment, $Nbar_t$ is also modified to:

$$Nbar_t = R_t + (N_t - \frac{R_t}{Z_t})\frac{(1-e^{-Z_t})}{Z_t} .$$

With the maximum observed age of 40 years for mutton snapper, we used the Hoenig (1983) estimate of natural mortality rate (M) of 0.11 per year and derived the fishing mortality rate ($F_{f,t}$) using the relation for instantaneous rates,

$$\sum_{f=1}^{fleets} F_{f,t} = Z_t - M .$$

The parameters that maximized the sum of the partial and full log likelihood functions included in the objective function:

$$Obj.Func. = \sum_{f=1}^{fleet/index} (n_f (\ln(\sigma_{c_f}) + \frac{\ln(2\pi)}{2}) + \sum_{t=1}^{years} \ln(C_{f,t} / \hat{C}_{f,t})^2 / 2\sigma^2_{c_f}) + \sum_{t=1}^{years} \frac{(a_t - 1)^2}{\sigma^2_a} ,$$

were used to calculate abundance and fishing mortality. The full likelihoods for the $\log_e$ catch deviations included terms for the observed standard deviation and variance, σ_{c_f} and $\sigma^2_{c_f}$, for the $\log_e$ catch across years for each fleet or index f and the number of years of catch data for each fleet or index, n_f. The partial log likelihood for the multiplicative recruitment deviations, a-1, included a user-assigned variance term set equal to 0.50. The standard deviations in the log likelihood were parameters fit by the model.

The input data for this model included: the annual harvest and number of fishing trips for each portion of the commercial fishery (longline, hook and line, and other) and for the recreational fisheries (anglers and headboat); plus the same 11 indices of abundance that were used in the age-structured models (FWC visual survey for both recruits and exploited-size mutton snapper, SEAMAP video survey, Riley's Hump visual survey, NMFS-UM Reef visual census, FWC age-1+ seine survey, MRFSS total number of fish per interview, Reef fish logbook hook-and-line biomass per 100 hooks, Reef fish logbook longline biomass per 100 hooks, Headboat survey 1981-1991, number per trip, and Headboat survey 1995-2006, number of fish per trip). The FWC visual survey for pre-exploited sized fish and the FWC FIM age-1+ seine survey were used to tune the pattern of recruitment and the other indices were used to tune the average population size ($Nbar_t$). The REEF index was excluded from this model following the recommendation from the first assessment panel for the statistical catch-at-age models.

The model solved for 64 parameters including the starting number of fish, two catchability coefficients for each of the five fishery sectors, 11 catchability coefficients for the indices, 26 relative annual recruitment values, standard deviations for each of the five fishery sectors and 11 indices in the log likelihood.

The fits to the landings appear reasonable except for the MRFSS prior to 1995 (Fig. 2.2.3.1, residuals Fig. 2.2.3.2). However the fits to the indices of abundance were more variable (Fig. 2.2.3.3, residuals Fig 2.2.3.4) with almost an exact fit to the FWC visual survey's index on exploited sizes to very poor fits to the SEAMAP video survey and to Riley's Hump visual survey.

The estimated fishing mortality rates by fishing sector (Fig 2.2.3.5) were much higher than those estimated by the other models but the rates were significantly correlated with the surplus production estimates (r = 0.78, df = 24, P < 0.05) indicating similar trends in fishing mortality rates but differences in the underlying population sizes. There was no apparent relationship between recruitment and population size (Fig. 2.2.3.6).

The AW Panel agreed that the modified DeLury model was a good model for a "reality check" but needs an independent estimate of fishing mortality or of population size to scale the results.

2.2.4. Untuned Virtual Population Analysis

A sequential population analysis using Gulland's cohort analysis approach (Pope 1972) was applied to the catch-at-age data estimated for the mutton snapper recreational and commercial harvest. The untuned VPA is meant to give an indication of the magnitude of the expected fishing mortality rates from a more complex age-structured model and, when run by fishery, the age-specific fishing mortality rates that can be used to estimate starting selectivity values for the more complex age-structured models. These analyses assume that the catch-at-age is known without error and a terminal (oldest age) fishing mortality is known. In order to estimate fishing mortality for the oldest observed age in incomplete cohorts (those that have not finished their lives within the fishery), a partial recruitment vector containing all 1.0's was used. This meant that the fishing mortalities for all ages present in the last year were assumed known. This analysis uses the relationship:

$$N_{t,a} = \frac{C_{t,a} Z_{t,a}}{F_{t,a}(1 - e^{(-Z_{t,a})})},$$

to estimate the abundance, $N_{t,a}$, for a given age a, at the beginning of year t. By iteratively solving for the previous year's and age's $F_{t-1,a-1}$ that satisfies:

$$\frac{Z_{t-1,a} - 1e^{(-Z_{t-1,a-1})}}{F_{t-1,a-1}(1 - e^{(-Z_{t-1,a-1})})} - \frac{N_{t,a}}{C_{t-1,a-1}} = 0$$

and sequentially solving for a given year's and age's N and previous year's and age's F, a complete set of year- and age-specific N's and F's can be generated.

Input data for this model included the catch-at-age for mutton snapper The catch-at-age for the untuned VPA was the composite of catches-at-age by fishery that were developed for the catch curves described in Section 2.2.1 and the model was run with a range of terminal fishing mortality rates from 0.1 to

0.6 per year. Fishing mortality rates either were stable until 1991 or they generally increased reaching a peak in 1993 after which the rates declined until 2001 when they began to increase again (Fig. 2.2.4.1).

The fishing mortality rates from the untuned VPA can provide selectivity patterns for other analyses such as the Stock Reduction Analysis (SRA) or the age-structured analysis. Because the terminal fishing mortality rate is assumed known in a VPA, which is not the case, the results for the last three years, 2004-2006 were disregarded in developing the selectivity patterns. For the SRA, the average fishing mortality rates by age for two time periods, 1981-1991 and 1995-2003, from the six runs using the aggregated catch-at-age mentioned in the previous paragraph were weighted by the estimated population sizes and normalized to 1.0 to provide selectivity patterns for before and after the implementation of the 16-inch minimum size limit (Fig 2.2.4.2). For the starting selectivities in the age-structured model, separate catch-at-age matrices were analyzed by fishery sector with terminal fishing mortality rates of 0.2 per year, 0.4 per year, and 0.6 per year for 1981-1991. As with the SRA, the fishing mortality rates from the three runs were averaged by weighting by the population sizes of the appropriate ages. The age-specific fishing mortality rates were then normalized to a maximum of 1.0 for the selectivity patterns by fishery sector (Fig 2.2.4.3). Repeating the process for the 1995-2003 time period provided insights as to the amount of change in selectivities that we could expected to find in the age-structured models resulting from the minimum size change in 1994.

The AW panelists thought that the virtual population analysis was useful for advice on the shape of the selectivity patterns of each fishery and the general magnitude of fishing mortality rates but not for further in-depth analysis.

2.2.5. Stochastic Stock Reduction Analysis

Stock reduction analysis reconstructs the historical fishery extending as far back as possible so as to match the observed landings while reasonably fitting more recent trends in biomass levels. We used a version of the stock reduction analysis called StochasticSRA developed by Dr. Carl Williams and his students at the University of British Columbia for the recent red grouper stock assessment conducted by NMFS's Southeast Fisheries Science Center (SEDAR 12). This version of the SRA estimates the uncertainty about maximum sustainable yield (MSY) and the fishing mortality associated with this level of yield (F_{MSY} but expressed as an exploitation rate, U_{MSY}) which is recasting the process in terms of parameters that are of interest to managers (Martell et al. 2007). The Beverton-Holt spawner recruit equation can be expressed as:

$$R_t = \frac{aB_t}{1 + bB_t}$$

where

$$a = \frac{recK}{\left(\frac{B_0}{R_0}\right)} \quad \text{and} \quad b = \frac{recK - 1}{R_0\left(\frac{B_0}{R_0}\right)},$$

or after substituting *a* and *b*

$$R_t = \frac{recKR_0B_t}{R_0\left(\frac{B_0}{R_0}\right) + (recK - 1)B_t}$$

therefore, one needs to obtain the compensation ratio, *recK*, the initial recruitment, R_0, and the biomass per recruit from the unfished population, B_0/R_0, given MSY and U_{MSY}. Martell et al. (2007) derive the analytical solutions that identify the stock-recruit relationship for any combination of MSY and F_{MSY}.

Operationally, StochasticSRA uses sampling-importance resampling (SIR, McAllister and Ianelli, 1997) to create an approximate distribution from the prior distribution to use as the starting points for the Monte Carlo - Markov Chain (MCMC) simulation (Metropolis-Hastings algorithm, Gelman et al. 1995) of the posterior distribution for MSY and U_{MSY}.

Input data for this analysis was the historical total harvest for both the commercial (1902- 2006, DW Table 3.1) and recreational fisheries (headboat, DW Table 4.5) in weight. The weight of MRFSS landings was calculated from the length frequencies and average weights-at-length. All landings were converted to kilograms for the analysis. Commercial landings were not reported annually in the early years of the time series; therefore the values for missing years were approximated with the average value of the previous and following landings values. There were no recreational landings estimates for Florida prior to 1981; so to approximate some level of recreational removals, we chose the end of World War II (1945) as a starting date for both headboat and MRFSS fisheries and linearly interpolated from zero landings in 1945 to the reported landings in 1981. The choice of 1945 was based on the four-year disruption of normal recreational activities by the war, Florida's population being less than 2.5 million people statewide, and on the state (reliability) of recreational boats and motors at that time. We have no idea of the magnitude of the artisanal fishery in prior years. The model-estimated vulnerable biomass was tuned with the MRFSS index (Table 2.1.3.2) which had the longest time series (1981-2006). We applied the 1981-1991 selectivity pattern from the untuned VPA (Fig. 2.2.5.2) to the landings from 1902-1994 and the selectivity pattern from 1995-2003 to the 1995-2006 landings.

Fig. 2.2.5.1 shows a plot of MSY on U_{MSY} (the current version of StochasticSRA only provides graphical output for MSY and U_{MSY}) for the run using the two dome-shaped selectivity patterns from the untuned VPA. The highest likelihood was graphically interpreted as an MSY value of 489 mt at U_{MSY} of 0.16 which is equivalent to F_{MSY} = 0.19 per year. The vulnerable biomass was reasonably stable until the late 1950s then the biomass declined bottoming out in 1989-90 and then slowly began to increase (landings have been below MSY since 1994, Fig. 2.2.5.2). The onset of the decline in vulnerable biomass coincided with the increase in landings (Fig. 2.2.5.3). The historical trajectory of exploitation is the converse of biomass being very low until the late 1950s and, ultimately, reaching a peak in 1989 and then declining to levels around 0.2 since 1995 (Fig. 2.2.5.4). The median exploitation rates estimated with MCMC were similar to those estimated with SIR (Fig 2.2.5.4).

There was another run of StochasticSRA with a logistical selectivity that was applied to the entire time series. The logistic equation was :

$$S_a = \frac{age^{ap}}{(Ah^{ap} + age^{ap})}$$

where *ap* controls the shape of the curve and we used a value 5.0 and *Ah* is the age at 50% selectivity and we used 2 years. The ascending portions of the logistic curve and selectivities from the untuned VPA were similar (Fig. 2.2.5.5). In our configuration of this model, we ran the priors with 50000 trials for SIR and then ran MCMC for one million accepted runs. The acceptance rate for the dome-shaped selectivities (9.8%) was similar to that for the logistic selectivity (8.8%). When we compared the results from two dome-shaped selectivities to the flat-topped, logistic selectivity, the vulnerable biomass and exploitations were very similar (Fig. 2.2.5.6) as were the MSY values (489 mt vs 495 mt) and both models estimated U_{MSY} at 0.16.

2.2.6. Statistical Catch-At-Age Analyses

The NMFS NEFSC Assessment Toolbox's Age Structured Assessment Program (ASAP, version 1.4.2)) was used to assess mutton snapper (Legault and Restrepo 1998). This assessment model follows the standard form common to forward-projection methods (Fournier and Archibald 1982; Deriso et al. 1985; Methot 1998). It is a highly flexible model allowing for fleet-specific selectivity and catchability patterns to vary over time, either in discrete time periods or in a random walk fashion. The model makes the standard separability assumption for fishing mortality having independent age- and year-specific components. The objective function minimized in the model fitting process contains a short-form lognormal negative log likelihood for total weight of the catch by fleet, a multinomial negative log likelihood for the proportions-at-age by fleet, and a lognormal negative log likelihood (with year- and gear-specific variance terms) for indices of abundance, each multiplied by user-input weight terms. Other user-weighted likelihood terms in the objective function represent the variance for time-varying parameters for selectivity, catchability, F-multipliers, and recruitment, for abundance at age in the first year, and for the fit to the Beverton-Holt spawner-recruit relation. Penalties are also included in the objective function to influence the curvature of selectivity, both over time and over age. The underlying equations are given in Legault and Restrepo (1998).

2.3. Preferred Model, Configuration, and Summary of Model Issues Discussed

The AW Panel decided that the ASAP model should be the preferred platform for the base assessment model, given that it could be configured to meet the all of the panel's suggestions. There was some discussion about the weighting in the model and that the model should begin in 1950. The generic age-structured assessment model was described and included some features not available in the standard ASAP model, e.g., nominal effort as input data, parametric selectivity models. The initial AW Panel thought that refinement of this model should continue as a back-up to the ASAP model; however, the generic model was later found to estimate very different benchmarks from those estimated in ASAP. The second AW Panel recommended dropping the generic model from further consideration. There was also a discussion about choosing weighting values in these models based on difference between the standard deviation of the standardized residuals and its ideal value of 1.0 (for lognormal likelihoods) and on the effective sample size match to the observed sample size (for multinomial likelihood). The panel also recommended diagnostics to be made available to judge the model fits, e.g. plots of residuals.

2.3.1. Statistical Catch-At-Age Analyses

2.3.1.1 *Configuration of base run*

The first AW chose ASAP as the preferred stock assessment model. The base run used age-specific natural mortality rates based on length-at-age using the Lorenzen (2005) equation and these values were scaled such that the average natural mortality rates for ages 3-40 was equal to Hoenig's (1983) estimate of 0.11 per year for a maximum age of 40 years. The Lorenzen natural mortality estimates were not very sensitive to the start age over the range of 1-7 years old. A set of sensitive runs were also made with the Lorenzen natural mortality rates set to average 0.08 per year which comes from the "M=3/max. age" relationship.

Steepness (h) is the parameter in the Beverton-Holt stock recruitment equation that indicates the resilience of the stock to declines in spawning biomass. When ASAP was allowed to estimate steepness in some preliminary runs, the model estimated values approaching steepness's upper limit of 1.0 indicating that recruitment would be stable even with severe depletion of the spawning biomass. The assessment panel thought that this stability was unrealistic especially for a fish that lives at least 40 years and the panel decided to select a value for steepness. The AW Panel discussed the steepness value used for red snapper in SEDAR 07 (h = 0.86 with a sensitivity run using h = 0.81) and the life history parameters for mutton snapper such as longevity that would suggest values in the range of 0.6 - 0.7 (Rose et al. 2001). The group finally chose a steepness value of 0.75 for the base run with sensitivity runs at 0.65 and 0.8. The steepness at 0.75 is equivalent to a compensation ratio of 12 (Goodyear 1980).

The ASAP model included landings from five fishery sectors: two recreational sectors, headboats and other recreational fisheries, and three commercial sectors, hook-and-line, longline, and traps/other. The last category, traps/other, is quite heterogeneous and includes those fish that were caught with gill nets, fish traps, spiny lobster traps, or were speared. This diversity of gears strains the concept of age-specific selectivity in that during the assessment period regulations eliminated gill nets in state waters and the councils restricted the use of fish traps. While landings of mutton snapper have been reported from North Carolina to Texas, most of the mutton snapper landings, by numbers and weight, came from Southeast Florida and the Florida Keys. Commercial landings were extracted from NMFS's Accumulated Landings System (www.st.nmfs.gov/st1/commercial/index.html) and the Florida trip ticket system (www.floridamarine.org/features/view_article.asp?id=19224) and covered the period 1981-2006, with fishing gear taken from the early General Canvass where dealers were asked what gears their fishers used. Commercial fishing gears used in Florida came from the Florida trip tickets since 1991. The starting year was based on the availability of recreational harvest information. The Headboat Survey based at NMFS's Beaufort Laboratory was extended to Florida's Atlantic coast in 1981 and the Marine Recreational Fisheries Statistics Survey estimates of recreational catch and harvest begin in 1981.

The AW panel discussed whether the biostatistical data were too sparse before 1988 to confidently generate landings by numbers or length- and age-composition. However, a strength of ASAP is that it does not require a complete catch-at-age and the panel decided against reducing the years covered by the assessment. Conversely the AW Panel recommended extending ASAP back to 1950 but ASAP version 1.4.2 did not have sufficient variable capacity for that run. The base run used the length frequencies in 25 mm increments by fishery, region, and year without any filling of strata lacking length measurements. For commercial landings, the associated length frequencies from TIP were used to determine the raising factors by gear (Gulland 1969) to convert the landings in biomass to landings in number. These catches-at-length by fishery were converted to ages (Table 2.3.1.1) using fishery specific age-length keys.

The selectivity patterns for 1981-1994 and 1995-2006 were estimated for all fisheries other than longline which used a single selectivity for the entire time period. The minimum sizes had little effect on the longline fishery because most of the mutton snapper that the longline fishery caught were above even the 16-inch minimum size. The South Atlantic Council adopted a 12-inch minimum size in 1992 but we did not try to estimate selectivity for 1992-1994 because Florida's Marine Fisheries Commission already had implemented a 12-inch minimum size back in 1985 and length data indicated little change in the size of fish caught in 1992-1994. *A priori,* the AW panel members thought that the selectivity in the commercial fisheries should follow a logistic curve and the selectivity in the recreational fisheries should be dome-shaped or follow a double logistic curve; however, ASAP fits selectivity by age and does not have the ability to fix selectivity to follow either a logistic curve or a double logistic curve. The starting selectivity patterns came from the untuned VPA (Sect. 2.2.4) and were smoothed by fitting double logistic curves to the age-specific selectivity by fishery. When ASAP was allowed to fit selectivity to each age, the selectivity patterns for mutton snapper were highly variable and irregular probably due to the low sample sizes. However, ASAP provides two penalties that can be varied to smooth the selectivity across ages and time and the number of ages that are fit can be reduced. We set the penalty for smoothing across time to zero to ensure that we could capture the effect of the 16-inch minimum size limit and used a penalty of 100 (equivalent to CV = 0.10, lognormal distribution) to smooth across ages. We were able to produce selectivity patterns that appeared reasonable to the panel members by also reducing the number of ages being fit per fishery.

There was a total of 246 parameters in the base run that included 27 initial selectivity values (5 ages for hook-and-line, 8 ages for longline, 7 ages for traps/other gears, 4 ages for headboat, and 3 ages for MRFSS) and another 27 for the second selectivity period beginning in 1995 even though the eight values for longlines were set to zero for the second period; 5 fishing mortality multipliers, 125 annual fishing mortality deviations 25 for each fishery, 26 recruitment deviations, 24 numbers of fish by age in first year, 11 catchability coefficients for the indices, and the virgin spawning biomass. The sensitivity runs that solved for steepness added another parameter.

2.3.1.2. *Weighting components in the objective function*

The weights for various components of ASAP's objective function represent how much emphasis that component should receive as compared to other components. Typically the weighting comes from the variances used in the likelihood but ASAP does not use full likelihoods for the different components in the objective function and hence the need for user-provided weightings (C. Legault, NMFS NEFSC, pers. comm.). The rationale for assigning weights is that annual landings in weight are probably well known so they were weighted with a lambda of 200 (CV = 0.07, lognormal distribution), the overall discards were weighted lower at 50 (CV = 0.14 lognormal distribution). In the initial runs, we weighted the age compositions by the number of age samples by fishery and year and then we adjusted the weights with the effective sample sizes from ASAP if the effective sizes were less than the number of age samples. The indices received an intermediate weight of 100 (CV = 0.10, lognormal distribution) plus the indices had a penalty of 100 to ensure that they were linear with their catchability coefficient, the fishing mortality multiplier by fishery was allowed to vary by assigning a penalty of zero as were the selectivity. Recruitment in ASAP has a penalty and a user defined CV; we set the user defined CV to 0.805 which, with a lognormal distribution, was equivalent to a variance of 0.5 and we set the penalty to 2 which is the same CV = 0.805.

2.3.1.3. *Base run results*

As expected, the model fit the landed biomass well (Fig. 2.3.1.3.1) but the estimated discards tended to be less than the 'observed' discards (Fig. 2.3.1.3.2). We made a run with higher emphasis on the discards; however, given the paucity of data for estimating discards there was no real justification for higher emphasis. The fits of the model to the indices were more variable (Fig. 2.3.1.3.3) with the model producing a poor fit to the SEAMAP video survey. Fits to the age composition were reasonable especially for those years with more fish being measured and more otoliths being extracted (Fig. 2.3.1.3.4 for landings age composition and Fig. 2.3.1.3.5 for discard age composition). As noted above, the age compositions were weighted by the number of ages in the fishery for that year or by the effective sample size whichever was lower. The resulting selectivities from ASAP were all dome-shaped (Fig. 2.3.1.3.6).

The age-specific annual fishing mortality rates by fishery are shown in Table 2.3.1.3.1 and the discard fishing mortality rates are shown in Table 2.3.1.3.2. The highest fishing mortality rates were on MRFSS age-3 fish (Fig. 2.3.1.3.7). With the existing mix of fisheries, the composite fishing mortality multiplier (fully recruited F) for 2006 was 0.18 per year and the $F_{30\%}$ fishing mortality rate was 0.34 per year. The number of fish by age and year are shown in 2.3.1.3.3. The trajectory of the estimated spawning biomass declined until 1995 and then increased (Fig. 2.3.1.3.8.) and recruitment began to increase a couple of years earlier. The spawning biomass trajectory follows the tuning indices (Fig. 2.3.1.3.9). The spawning biomass in 2006 was estimated at 7.14 million kg and the spawning biomass associated with F30% was 6.30 million kg. The estimated virgin stock size was 26.6 million kg and the virgin recruitment was 1.27 million age-1 fish.

2.4. Evaluation of uncertainty and model precision

Uncertainty was evaluated two ways: the standard errors of the estimates from the model and by running a variety of sensitivity runs (alternative configurations) of ASAP. Examples of the uncertainty measured by standard errors from ASAP are the box-and-whisker plots for spawning biomass and recruitment shown in Fig. 2.3.1.3.5. The distributions were generated with Monte Carlo simulations of 1000 outcomes using random, normal deviates. This uncertainty is observation error but process error is of more concern especially given the poorly defined stock-recruit relationship. Process error was examined through the use of sensitivity runs. While the base model used age compositions based upon length measurements that were converted to numbers of fish by age with fishery specific age-length keys, we developed another age composition just from the numbers of otoliths by fishery by year or direct aging (Table 2.4.1). Within these two basic configurations we examined a range of steepness values from 0.65 to 0.80 in addition to letting the model solve for steepness, made runs with a constant natural mortality value of 0.11 per year for all ages, made another set of runs with age-specific natural mortality values that averaged 0.08 per year instead of 0.11 per year, developed another set of runs that examined the effects of increasing catchability at 2% per year over the time series as was done for red grouper (SEDAR 12, 2007), made a set of runs that used only the fishery independent indices of abundance plus the MRFSS index, made some runs with recreational release mortality at 5% instead 15%, and some runs that did not include the SEAMAP video survey as a tuning index. There was a total of 72 ASAP runs (Table 2.4.2).

As expected, fishing mortality rates increased with increasing steepness in the stock-recruit relationship and, conversely, the spawning biomass decreased with increasing steepness. The runs that used the age composition from direct aging had lower fishing mortality rates than did runs that used length frequencies to generate the age compositions. The spawning biomass in 2006 varied from 3.0 million kg to 10.3 million kg while the benchmark spawning biomass at $F_{30\%}$ ranged from 2.9 million kg to 58.3 million kg. All of the runs estimated fishing mortality rates in 2006 that were below the corresponding $F_{30\%}$. While 29 of the 72 runs met the Councils' management objectives i.e. the spawning biomass estimates for 2006 were at MSST or higher, none of the runs with the low age-specific natural mortality rates (Table 2.4.2, Lorenzen 08) met those objectives. Upon closer inspection, we see that the fishing mortality rates and spawning biomasses estimated for 2006 are similar to those with the higher natural mortality rates but the $SSB_{F30\%}$ are much higher; hence, the low spawning biomass ratios. The other runs that did not meet the Council's overfished goal were runs that used constant natural mortality with either aging method and also the runs that only used the fishery independent indices and steepness values of 0.65 to 0.75 with the age composition from the age-length keys.

2.5. Discussion of YPR, SPR, Stock-Recruitment

2.5.1 Yield-per-recruit

In the base run, F_{MAX} was 0.52 (Fig. 2.5.1a) and most of the runs (70 out of 72 runs) produced maximum yield-per-recruit at fishing mortality rates (F_{MAX}) of 0.19 to 0.63 per year and all of the F_{MAX} rates exceeded the Council's F_{MSY} proxy rate of $F_{30\%}$ (Table 2.4.2). The two runs that estimated F_{MAX} rates that hit the upper limit of 10 were the runs that used direct aging with the lower age-specific natural mortality rates and without the SEAMAP video index.

2.5.2. Spawning potential ratio

Both the South Atlantic Fishery Management Council and the Gulf of Mexico Fishery Management Council chose $F_{30\%}$ as their proxy for F_{MSY} and all but one of the ASAP runs estimated fishing mortality rates in 2006 to be less than $F_{30\%}$ and only 17 of the runs exceeded $F_{40\%}$. The static SPR values associated with the fishing mortality rates from 1981to 2006 were all above 30% (Fig. 2.5.1b). The sSPR associated with the base run's fishing mortality multiplier in 2006 of 0.18 per year was 53%. The transitional SPR (tSPR) values were lower in the beginning of the time series but they began to rebuild starting in 1995 and now the tSPR are similar to the sSPR (Fig. 2.5.1b). When we offset the population to the beginning of the spawning season in May, the transitional SPR in 2006 was 60%. The static SPR values assume that the overall mix of the fisheries and their composite selectivity remains the same. The transitional SPR values were calculated using the observed fishing mortality rates and do not make this assumption.

2.5.3. Stock-Recruitment

The AW panel set the steepness parameter to 0.75 in the base run indicating that recruitment was not constant across a wide range of spawning biomass values but varied loosely with spawning biomass. For example, the estimated spawning biomass in the base run declined from 5.5 million kg in

1981 to 3.0 million kg in 1994-95 but the recruitment averaged 650,000 fish during that same period. After 1995, the spawning biomass began to increase but recruitment did not increase until the 1998 year class when recruitment doubled to 1.3 million fish followed by a return to the earlier level and then another doubling with the 2001 year class and another doubling with the 2004 year class. The estimated spawning biomass at the beginning of 2006 was 7.1 million kg. When ASAP solved for steepness instead of having steepness specified by the user (18 runs), the model estimated steepness values between 0.82 and 0.96 in 13 runs and, for the other five runs, the model hit the upper limit for steepness (0.99999) .

In addition to steepness, ASAP solves for other stock-recruit parameters including the Beverton-Holt coefficients, α and β, and the virgin spawning biomass, SSB_0. The recruitment at virgin stock size, R_0, was calculated from Restrepo and Legault's (1998) equation (4). Their equation with h being the steepness, was

$$\alpha = \frac{4hR_0}{5h-1}$$

which was rearranged to

$$R_0 = \frac{\alpha(5h-1)}{4h}$$

The estimated virgin spawning biomass, SSB_0, ranged from 11 million kg to 305 million kg. The runs with the very high SSB_0 estimates came from the sensitivity runs using the low natural mortality rates that averaged 0.08 per year. The runs that indicated that the stock was not overfished tended to have SSB_0 values around 25 million kg. When the spawning biomass and recruitment one year later are plotted for the different natural mortality rates, the points overlap (Fig. 2.5.3) and the patterns are similar but the details are different -- the base run had the spawning biomass at 5.5 million kg in 1981 decreasing to 3.0 million in 1994-95 and then increasing to 7.1 million kg in 2006, the run with the same steepness of 0.75 with the Lorenzen natural mortality vector averaging 0.08 per year had the spawning biomass at 2.8 million kg in 1981 decreasing to 2.5 million kg in 1990 and then increasing to 8.4 million in 2006. The run with the same steepness but with constant natural mortality of 0.11 per year across all ages had spawning biomass at 5.4 million kg in 1981 then decreasing to 2.6 million kg in 1995-96 and then increasing to 5.1 million kg in 2006. This also illustrates the uncertainty discussed in Section 2.4.

2.6. Recommended SFA parameters and Management Criteria

The Sustainable Fisheries Act parameters are the maximum sustainable yield (MSY), the fishing mortality rate that achieves MSY (F_{MSY}), the maximum fishing mortality threshold (MFMT) level usually F_{MSY}, the spawning biomass at MSY (SSB_{MSY}), and the minimum spawning stock threshold (MSST) usually (1-

M)*SSB_{MSY}. In the management of mutton snapper in the Southeast US, the two Councils have adopted $F_{30\%}$ as a proxy for F_{MSY} and $F_{40\%}$ as a proxy for optimum yield (OY, Amendment 11, Snapper Grouper FMP, SAMFC 1998). Therefore, the MFMT would be $F_{30\%}$, MSY would be the yield associated with $F_{30\%}$, SSB_{MSY} would be the spawning biomass at $F_{30\%}$, and the MSST would be (1- constant) times the spawning biomass at $F_{30\%}$ and the constant usually is the natural mortality. The SFA values for the base run are listed in Table 2.6. The AW panel did not recommend changing any of the management criteria for mutton snapper.

2.7. Status of Stock Declarations

As mentioned in Section 2.4, the estimated fishing mortality rates in 2006 from the 72 ASAP runs were all less than their corresponding $F_{30\%}$ rates; thus, as of 2006, the stock was determined to be not undergoing overfishing. However, less than half of the runs (29 out of 72) had spawning biomass estimates in 2006 that met or exceeded the MSST (Fig. 2.7). The non-shaded runs in Table 2.4.2 were the runs that did not achieve the MSST. Fourteen of the 43 runs that did not meet the MSST were the sensitivity runs that used the lower age-specific natural mortality rates that averaged 0.08 per year instead of the base 0.11 per year. Most of the other runs that did not meet the MSST were runs that used direct age compositions. Although the estimated spawning biomass of the base run was above $SSB_{F30\%}$ (SSB ratio = 1.14), the spawning biomass estimates for many of the sensitivity runs were below the Councils' objective. Therefore, the results are equivocal and it would be precautionary to declare the stock overfished.

2.8. Recommended Allowable Biological Catch

The recommended Allowable Biological Catch (ABC) is the Councils' optimum yield (OY) or $F_{40\%}$. Only 17 of the 72 runs had fishing mortality rates that exceeded the councils' OY rate or $F_{40\%.}$ For the base run, $F_{40\%}$ was estimated at 0.26 per year and F_{2006} was 0.18 per year. A projection of the base run using $F_{40\%}$ beginning in 2008 showed that the spawning biomass increased until 2013 and then declined slightly (Fig. 2.8). The projected directed harvest decreases from 745,000 kg in 2007 to 538,000 kg in 2036, the final year of the projection. For comparison, the total landings of the directed fisheries in 2006 were 432,000 kg.

2.9. Discussion of Stock Projection

We ran ASAP's projections using the base run and a similar run using the lower natural mortality averaging 0.08 per year. Because of the longevity of mutton snapper, we ran the projections out 50 years, 2007-2056 with the harvest in 2007 set equal to that in 2006 because any regulations would not be implemented prior to 2008. The mean generation time of spawning females with F = 0 would be 12 years (weighted average using Lorenzen natural mortality schedule averaging 0.11 and the maturity schedule over ages 0-40 years or 14.1 years if the natural mortality schedule averaged 0.08, Krebs 1972). The fishing mortality options were a) F=0, b) the Councils' OY fishing rate of $F_{40\%}$, c) the Councils' MSY fishing rate of $F_{30\%}$, and d) using the total harvest fishing mortality rate in 2006 (Fig. 2.9.1, Table 2.9.1). Because the fishing mortality rate in 2006 was less than either the MSY proxy or OY adopting either of these benchmark fishing mortality rates increases the harvest and reduces the spawning stock biomass. Figure 2.9.2 shows that the equilibrium landings associated with MSY and OY are higher than the observed landings since the 16-inch minimum size was implemented in 1995. If the reviewers decide that the stock is overfished, then there are projections that were run using the natural mortality rates that average 0.08 per year. With no fishing, F=0, the stock could be expected to reach MSST in 2015 and be rebuilt in 2017 if the restrictions were implemented in 2008 (Table 2.9.2). However, there is uncertainty in the stock-recruit relationship. To illustrate the volatility, the management objective, $SSB_{F30\%}$, moved from 6.3 million kg in the base run to 21.0 million kg with an average change in natural mortality of 0.03 per year with keeping all the other data and the model configuration the same.

2.10. Management Evaluation

2.10.1. Effectiveness/impacts of past management actions

Two types of management measures have been implemented for mutton snapper: size limits and a bag limit. The South Atlantic Fishery Management Council implemented a 12-inch (305 mm) total length minimum size limit in 1992; however, this measure was more an alignment with existing state regulations because the state of Florida had implemented a 12-inch minimum size for mutton snapper in 1985. In 1994, both the Councils and the state of Florida raised the minimum size to 16 inches (406 mm) TL. The increase in spawning stock after 1994 is clearly shown in Fig. 2.3.1.3.8 and, similarly, the increase in transitional SPR is shown in Fig. 2.5.1. To evaluate the efficacy of the 10-snapper aggregate bag limit, we looked at the number of trips that met or exceeded the limit during the 1995-2006 time period from MRFSS. There were 33,168 trips that landed at least one snapper and of those only 161 of those trips (0.5%) landed more than 10 snappers per angler. In terms of anglers instead of trips, there were 99,781 anglers on those trips and 403 (0.4%) of the anglers exceeded the snapper bag limit. Note: the aggregate encompasses all of the snappers except for lane and vermilion. Out of the 3462 MRFSS trips that reported landing mutton snapper in the 1995-2006 time period, only one MRFSS trip landed seven mutton snapper and all of the other trips landed less than seven per angler. Clearly the main reason for discarding fish was not the bag limit.

2.11. Research Recommendation Research Recommendations

2.11.1. Life History

The maturity analysis used in this assessment was based on only 32 fish. A study should be designed to collect mutton snapper for age and gonad samples at spawning sites during the spawning season. This would entail a multi-year study to identify the diurnal usage patterns at spawning sites during year and to collect gonad samples for histological examination. To maintain quality and ensure consistency among readers, a set of training histological slides should be developed.

2.11.2. Dependent Data Collections

It is essential that adequate numbers of aging structures be collected from all sectors of the fishery from all regions. A weakness of the assessment was the paucity of age samples in the 1980s and early 1990s.

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2.13 List of Tables

2.14 List of Figures

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Table 2.1.1. Average length at age, weight at age, maturity, and natural mortality rates at age.

				Natural mortality	
Age (yr)	Tl (mm)	Avg Wt (kg)	Maturity	Ave 0.11 per year	Ave 0.08 per year
1	271	0.248	0.01	0.27	0.20
2	360	0.596	0.05	0.22	0.16
3	436	1.074	0.22	0.18	0.13
4	501	1.644	0.62	0.16	0.12
5	556	2.268	0.91	0.15	0.11
6	603	2.912	0.98	0.14	0.10
7	643	3.549	1.00	0.13	0.09
8	678	4.162	1.00	0.12	0.09
9	707	4.737	1.00	0.12	0.09
10	732	5.268	1.00	0.12	0.08
11	753	5.751	1.00	0.11	0.08
12	771	6.185	1.00	0.11	0.08
13	786	6.572	1.00	0.11	0.08
14	799	6.915	1.00	0.11	0.08
15	810	7.216	1.00	0.11	0.08
16	820	7.479	1.00	0.10	0.08
17	828	7.709	1.00	0.10	0.08
18	835	7.908	1.00	0.10	0.07
19	841	8.081	1.00	0.10	0.07
20	846	8.230	1.00	0.10	0.07
21	850	8.359	1.00	0.10	0.07
22	853	8.469	1.00	0.10	0.07
23	857	8.564	1.00	0.10	0.07
24	859	8.646	1.00	0.10	0.07
25	861	8.716	1.00	0.10	0.07
26	863	8.776	1.00	0.10	0.07
27	865	8.827	1.00	0.10	0.07
28	866	8.871	1.00	0.10	0.07
29	868	8.908	1.00	0.10	0.07
30	869	8.940	1.00	0.10	0.07
31	869	8.968	1.00	0.10	0.07
32	870	8.991	1.00	0.10	0.07
33	871	9.011	1.00	0.10	0.07
34	871	9.028	1.00	0.10	0.07
35	872	9.042	1.00	0.10	0.07
36	872	9.055	1.00	0.10	0.07
37	873	9.065	1.00	0.10	0.07
38	873	9.074	1.00	0.10	0.07
39	873	9.082	1.00	0.10	0.07
40	873	9.088	1.00	0.10	0.07

Table 2.1.2.3.0. Estimated number of mutton snapper released alive and dead by fishery calculated from landings except for MRFSS which estimates the number discarded alive directly as Type B2 fish; however, MRFSS includes the number of fish that were discarded dead in their Type B1 fish which were considered part of the landings. The increase in discarded fish beginning in 1995 probably is a result of raising the minimum size to 16 inches in May 1994.

	Discarded alive Numbers of fish				Discarded dead Numbers of fish			
Year	Hook-and-line	Traps/other	Headboat	MRFSS	Hook-and-line	Traps/other	Headboat	MRFSS
1981	155	21	1080	0	8	6	158	*
1982	164	19	737	2204	8	5	108	
1983	144	17	683	20019	7	5	100	
1984	126	10	421	94752	6	3	62	
1985	106	8	514	32760	5	2	75	
1986	158	34	488	26704	8	9	72	
1987	209	35	477	145533	10	10	70	
1988	166	50	579	69954	8	14	85	
1989	175	63	606	17497	9	17	89	
1990	168	41	918	13639	8	11	135	
1991	179	31	454	131330	9	9	67	
1992	164	32	481	131424	8	9	70	
1993	204	46	590	183543	10	13	87	
1994	186	29	564	118664	9	8	83	
1995	3430	539	5499	77805	169	148	806	
1996	3550	492	3038	82972	174	135	445	
1997	3589	321	3344	161990	176	88	490	
1998	3620	781	2481	185159	178	215	364	
1999	2305	512	2587	64955	113	141	379	
2000	1770	320	2841	95234	87	88	416	
2001	2098	213	3553	60832	103	58	521	
2002	3128	0	2741	101897	173	0	402	
2003	1477	147	2513	85647	141	44	368	
2004	4019	62	2567	87860	60	73	376	
2005	1329	713	6151	195758	57	0	781	
2006	422	0	3325	191351	50	81	565	

* Not directly estimated by MRFSS

Table 2.1.2.3.1. The number of mutton snapper landed on headboat observer trips, the number released alive and the number released dead, the ratio of number released alive and dead to number landed, the total headboat landings of mutton snapper for 2005 and 2006, and the estimated number of mutton snapper released alive and dead. Discards prior to 2005 were extrapolated from 2005-2006 average ratio of discards to landings.

Source	Year	Landings on discard trips Number	Rel_alive Number	Rel_dead Number	Discard ratios Alive:Kept	Dead:Kept	Headboat Landings Number	Estimated Rel alive Number	Estimated Rel dead Number
Captain's logbooks	2005	3171	724	36	0.2283	0.0114	16500	3767	187
	2006	4031	453	3	0.1124	0.0007	10477	1177	8
	Totals	7202	1177	39	0.1634	0.0054			
Observers	2005	169	63	8	0.3728	0.0473	16500	6151	781
	2006	167	53	9	0.3174	0.0539	10477	3325	565
	Totals	336	116	17	0.3452	0.0506			

Table 2.1.2.3.2. Estimated number of mutton snapper released alive and dead by the commercial fishery calculated from logbook discard reports. Discards prior to 2002 were extrapolated from 2002-2006 average ratio of discards to landings.

Gear	Year	Trips with mutton discards Number	Rel alive Number	Rel dead Number	Mutton snapper Landings (kg) on discard trips	Discard ratios Alive Num:kg	Discard ratios Dead Num :kg	Total mutton snapper Landings Kilograms	Raised discards Rel alive Number	Raised discards Rel dead Number
Hook-and-line	2002	41	145	8	2659	0.0545	0.0030	57357	3128	173
	2003	21	63	6	2569	0.0245	0.0023	60214	1477	141
	2004	46	135	2	2055	0.0657	0.0010	61181	4019	60
	2005	21	47	2	1650	0.0285	0.0012	46665	1329	57
	2006	11	17	2	1684	0.0101	0.0012	41836	422	50
	Totals/ave	140	407	20	10617	0.0383	0.0019			
Longline	2002	0	0	0	3976	0.0000	0.0000	35715	0	0
	2003	0	0	0	6602	0.0000	0.0000	50196	0	0
	2004	0	0	0	3621	0.0000	0.0000	89300	0	0
	2005	0	0	0	2333	0.0000	0.0000	54539	0	0
	2006	0	0	0	2812	0.0000	0.0000	81202	0	0
	Totals/ave	0	0	0	19344	0.0000	0.0000			
Traps/other	2002	0	0	0	84			11773	0	0
	2003	8	10	3	715	0.0140	0.0042	10512	147	44
	2004	10	6	7	615	0.0098	0.0114	6379	62	73
	2005	3	24	0	166	0.1446	0.0000	4930	713	0
	2006	1	0	1	42	0.0000	0.0238	3423	0	81
	Totals/ave	22	40	11	1622	0.0247	0.0068			

Table 2.1.3.1 Fishery independent indices, coefficients of variation, and ages used for tuning.

Index	FWC Visual Survey-exploited		FWC Visual survey pre-exploited		FWC FIM Age 1+		NMFS UM Reef Visual Census		Riley's Hump Visual Survey		SEAMAP Video Survey	
Youngest	2		1		1		2		5		2	
Oldest	9		3		1		9		15		9	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991												
1992											0.245	1.143
1993											0.205	1.211
1994							0.022	0.534			0.001	1.000
1995							0.036	0.423			0.030	3.077
1996							0.006	0.700			0.349	0.604
1997							0.015	0.380			0.413	0.567
1998							0.007	0.500				
1999	0.589	0.139	1.286	0.165	0.025	0.786	0.014	0.554				
2000	0.596	0.105	0.936	0.143	0.013	1.118	0.034	0.307				
2001	0.865	0.098	0.523	0.229	0.010	1.167	0.067	0.243	0.351	0.272		
2002	0.753	0.106	0.597	0.291	0.006	1.699	0.054	0.200	0.267	0.248	0.401	0.543
2003	0.726	0.117	1.077	0.192	0.019	0.865	0.069	0.285	1.824	0.431		
2004	0.875	0.085	3.361	0.136	0.016	1.166	0.097	0.390	3.375	0.346	0.389	0.524
2005					0.103	0.650	0.032	0.296	1.456	0.256	0.378	0.570
2006	0.779	0.084	3.151	0.139	0.031	0.573			2.302	0.250	0.447	0.321

Table 2.1.3.2. Fishery dependent indices, coefficients of variation, and ages used for tuning.

Index	MRFSS		NMFS Headboat Survey		NMFS Headboat Survey		NMFS Logbook Hook-and-line		NMFS Logbook Longline	
Youngest	2		2		2		2		4	
Oldest	8		8		8		9		24	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1981	0.880	0.380	3.212	0.009						
1982	1.111	0.242	2.253	0.010						
1983	0.835	0.323	1.960	0.011						
1984	3.198	0.182	1.589	0.013						
1985	1.360	0.276	2.123	0.012						
1986	0.743	0.145	1.727	0.012						
1987	0.909	0.114	1.835	0.011						
1988	0.984	0.108	2.319	0.011						
1989	0.812	0.137	2.496	0.011						
1990	0.594	0.157	3.095	0.010			0.822	0.349	0.105	0.788
1991	1.443	0.129	2.130	0.012			1.290	0.342	0.402	0.534
1992	1.761	0.089					0.963	0.174	0.470	0.559
1993	1.739	0.090					1.147	0.154	0.377	0.438
1994	1.287	0.121					0.775	0.157	0.650	0.413
1995	1.430	0.155			2.197	0.018	0.859	0.152	0.591	0.404
1996	0.828	0.188			1.797	0.024	0.994	0.152	0.398	0.388
1997	1.196	0.165			1.673	0.030	0.914	0.151	0.758	0.373
1998	1.810	0.120			1.964	0.028	0.987	0.155	0.737	0.366
1999	1.251	0.137			1.361	0.040	0.869	0.161	0.851	0.397
2000	2.449	0.109			1.447	0.038	0.726	0.157	1.318	0.387
2001	1.639	0.140			2.542	0.033	0.962	0.158	1.006	0.374
2002	2.026	0.090			2.222	0.048	1.111	0.153	1.327	0.395
2003	1.474	0.121			2.460	0.040	1.199	0.157	1.483	0.376
2004	1.369	0.137			1.973	0.037	1.084	0.156	2.586	0.363
2005	2.562	0.100			2.892	0.034	1.114	0.157	1.475	0.360
2006	1.881	0.092			1.697	0.036	1.186	0.165	2.465	0.354

Table 2.2.1. The number of mutton snapper age samples by fishery and year.

Year	Hook-and-line	Longline	Traps/other	Headboat	MRFSS	Total
1981	0	0	0	150	0	150
1982	0	0	0	169	0	169
1983	0	0	0	4	0	4
1984	0	0	0	20	0	20
1985	0	0	0	76	0	76
1986	0	0	0	33	0	33
1987	0	0	0	14	0	14
1988	0	0	0	33	0	33
1989	0	0	0	2	0	2
1990	0	0	0	6	0	6
1991	0	0	0	11	0	11
1992	51	1	0	10	0	62
1993	38	11	0	52	0	101
1994	58	5	6	51	0	120
1995	35	2	1	127	0	165
1996	152	0	1	24	0	177
1997	193	24	17	19	0	253
1998	203	3	6	0	0	212
1999	223	5	9	0	0	237
2000	183	9	43	3	0	238
2001	284	51	5	13	5	358
2002	340	94	0	2	118	554
2003	262	146	0	146	238	792
2004	160	150	11	134	129	584
2005	197	148	0	242	264	851
2006	85	401	12	204	75	777
Totals	2464	1050	111	1545	829	5999

Table 2.3.1.1. Proportion of mutton snapper by age, fishery, and year using age-length keys. The numbers of fish including discards were converted from lengths to ages with fishery-specific age-length keys.

Hook-and-line	Proportion of Ages																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988	0.040	0.107	0.116	0.093	0.155	0.138	0.114	0.058	0.035	0.016	0.017	0.018	0.003	0.015	0.006	0.006	0.012	0.009	0.008	0.008	0.009	0.001	0.001	0.003	0.011
1989	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990	0.005	0.088	0.187	0.179	0.187	0.127	0.091	0.042	0.022	0.010	0.010	0.009	0.003	0.006	0.003	0.003	0.006	0.004	0.004	0.004	0.004	0.000	0.001	0.001	0.006
1991	0.023	0.111	0.146	0.157	0.185	0.128	0.091	0.041	0.027	0.010	0.014	0.008	0.006	0.007	0.004	0.003	0.005	0.009	0.004	0.005	0.003	0.001	0.001	0.003	0.009
1992	0.045	0.106	0.176	0.201	0.159	0.097	0.080	0.038	0.027	0.010	0.010	0.008	0.003	0.003	0.004	0.004	0.007	0.005	0.004	0.002	0.003	0.001	0.001	0.001	0.004
1993	0.021	0.082	0.138	0.153	0.165	0.126	0.110	0.049	0.041	0.017	0.014	0.011	0.006	0.006	0.007	0.004	0.011	0.010	0.006	0.004	0.003	0.001	0.002	0.003	0.010
1994	0.024	0.071	0.156	0.189	0.164	0.122	0.099	0.047	0.030	0.014	0.013	0.011	0.004	0.008	0.005	0.004	0.006	0.005	0.004	0.006	0.004	0.001	0.001	0.002	0.008
1995	0.003	0.150	0.324	0.179	0.093	0.049	0.046	0.030	0.025	0.010	0.016	0.008	0.004	0.010	0.003	0.004	0.007	0.010	0.005	0.004	0.003	0.001	0.001	0.004	0.012
1996	0.015	0.033	0.137	0.189	0.183	0.136	0.102	0.053	0.032	0.017	0.017	0.015	0.005	0.013	0.007	0.005	0.004	0.008	0.003	0.010	0.002	0.001	0.001	0.002	0.009
1997	0.005	0.041	0.120	0.176	0.211	0.165	0.121	0.052	0.030	0.013	0.011	0.010	0.004	0.005	0.005	0.003	0.005	0.004	0.003	0.006	0.002	0.000	0.001	0.001	0.006
1998	0.017	0.056	0.157	0.172	0.168	0.136	0.109	0.046	0.035	0.014	0.012	0.011	0.004	0.006	0.007	0.004	0.009	0.007	0.010	0.005	0.003	0.001	0.001	0.002	0.012
1999	0.005	0.044	0.111	0.123	0.145	0.128	0.121	0.066	0.052	0.021	0.028	0.016	0.007	0.019	0.007	0.008	0.017	0.015	0.011	0.008	0.010	0.002	0.003	0.008	0.025
2000	0.007	0.061	0.149	0.152	0.154	0.130	0.114	0.061	0.038	0.018	0.020	0.015	0.006	0.012	0.006	0.005	0.009	0.011	0.006	0.007	0.005	0.001	0.002	0.003	0.011
2001	0.007	0.056	0.193	0.235	0.178	0.105	0.081	0.040	0.025	0.010	0.012	0.008	0.004	0.005	0.003	0.003	0.006	0.007	0.004	0.003	0.003	0.001	0.001	0.002	0.007
2002	0.004	0.050	0.179	0.247	0.200	0.111	0.079	0.037	0.020	0.011	0.009	0.007	0.004	0.006	0.004	0.002	0.005	0.005	0.004	0.004	0.004	0.000	0.001	0.001	0.007
2003	0.002	0.034	0.170	0.232	0.188	0.125	0.090	0.039	0.025	0.012	0.012	0.010	0.005	0.008	0.005	0.002	0.006	0.007	0.005	0.005	0.001	0.000	0.002	0.003	0.011
2004	0.008	0.031	0.095	0.141	0.152	0.149	0.148	0.070	0.050	0.022	0.022	0.017	0.007	0.010	0.010	0.005	0.012	0.012	0.007	0.005	0.004	0.001	0.003	0.003	0.013
2005	0.003	0.042	0.131	0.150	0.161	0.128	0.112	0.063	0.044	0.019	0.023	0.014	0.010	0.014	0.007	0.005	0.011	0.018	0.007	0.008	0.005	0.001	0.003	0.004	0.019
2006	0.001	0.027	0.128	0.168	0.157	0.141	0.109	0.052	0.040	0.023	0.021	0.016	0.007	0.019	0.012	0.004	0.013	0.014	0.009	0.008	0.002	0.001	0.003	0.006	0.020

Table 2.3.1.1 continued. Proportion of mutton snapper by age, fishery, and year using age-length keys. The numbers of fish including discards were converted from lengths to ages with fishery-specific age-length keys.

Longline	Proportion of Ages																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987	0.000	0.000	0.009	0.024	0.078	0.172	0.233	0.150	0.090	0.045	0.063	0.025	0.020	0.009	0.021	0.008	0.015	0.007	0.004	0.011	0.000	0.002	0.001	0.002	0.013
1988	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990	0.000	0.005	0.019	0.049	0.124	0.177	0.183	0.112	0.047	0.034	0.041	0.023	0.022	0.018	0.018	0.019	0.011	0.009	0.008	0.012	0.007	0.007	0.003	0.004	0.047
1991	0.000	0.003	0.044	0.085	0.145	0.195	0.190	0.115	0.049	0.031	0.037	0.017	0.014	0.009	0.012	0.010	0.008	0.005	0.003	0.005	0.002	0.002	0.001	0.002	0.015
1992	0.000	0.000	0.013	0.055	0.157	0.236	0.237	0.131	0.041	0.025	0.027	0.016	0.008	0.008	0.008	0.011	0.005	0.005	0.002	0.002	0.001	0.004	0.000	0.001	0.007
1993	0.000	0.001	0.017	0.055	0.114	0.187	0.211	0.130	0.060	0.033	0.047	0.021	0.018	0.011	0.016	0.012	0.011	0.008	0.005	0.008	0.003	0.005	0.001	0.003	0.023
1994	0.000	0.001	0.012	0.048	0.107	0.159	0.177	0.119	0.055	0.039	0.050	0.029	0.028	0.020	0.020	0.020	0.014	0.010	0.009	0.012	0.007	0.008	0.003	0.005	0.048
1995	0.000	0.001	0.027	0.080	0.136	0.176	0.170	0.105	0.047	0.036	0.041	0.023	0.021	0.014	0.016	0.016	0.011	0.010	0.006	0.009	0.006	0.006	0.003	0.004	0.038
1996	0.000	0.000	0.009	0.043	0.095	0.121	0.142	0.107	0.060	0.047	0.061	0.035	0.039	0.030	0.027	0.025	0.018	0.014	0.011	0.015	0.010	0.008	0.006	0.007	0.068
1997	0.000	0.002	0.014	0.041	0.082	0.119	0.146	0.100	0.056	0.042	0.056	0.036	0.036	0.027	0.026	0.028	0.020	0.016	0.014	0.017	0.015	0.014	0.005	0.008	0.080
1998	0.000	0.001	0.016	0.051	0.092	0.134	0.149	0.100	0.057	0.040	0.054	0.034	0.033	0.023	0.025	0.024	0.019	0.015	0.013	0.015	0.012	0.012	0.005	0.007	0.070
1999	0.000	0.001	0.022	0.069	0.118	0.151	0.155	0.098	0.048	0.035	0.046	0.029	0.028	0.019	0.020	0.021	0.015	0.012	0.011	0.012	0.010	0.011	0.004	0.005	0.059
2000	0.000	0.001	0.015	0.056	0.107	0.145	0.160	0.108	0.057	0.041	0.053	0.030	0.031	0.022	0.022	0.021	0.016	0.012	0.010	0.013	0.009	0.008	0.004	0.006	0.055
2001	0.000	0.000	0.012	0.045	0.097	0.148	0.167	0.108	0.056	0.041	0.052	0.031	0.029	0.020	0.022	0.023	0.017	0.014	0.012	0.014	0.011	0.010	0.004	0.006	0.061
2002	0.000	0.001	0.014	0.054	0.106	0.156	0.163	0.103	0.050	0.037	0.047	0.031	0.026	0.020	0.021	0.023	0.015	0.014	0.012	0.013	0.012	0.011	0.004	0.006	0.062
2003	0.000	0.002	0.016	0.051	0.085	0.119	0.136	0.093	0.051	0.038	0.053	0.035	0.035	0.024	0.025	0.028	0.021	0.018	0.017	0.018	0.017	0.016	0.005	0.008	0.091
2004	0.000	0.001	0.021	0.072	0.127	0.155	0.151	0.097	0.048	0.036	0.043	0.027	0.025	0.020	0.020	0.020	0.015	0.012	0.010	0.013	0.010	0.010	0.004	0.006	0.057
2005	0.000	0.001	0.022	0.079	0.149	0.181	0.168	0.101	0.047	0.032	0.039	0.021	0.018	0.014	0.016	0.015	0.012	0.010	0.008	0.009	0.008	0.006	0.003	0.004	0.038
2006	0.000	0.000	0.015	0.059	0.120	0.161	0.170	0.109	0.055	0.036	0.047	0.025	0.025	0.018	0.020	0.018	0.015	0.011	0.009	0.012	0.008	0.008	0.003	0.005	0.050

Table 2.3.1.1 continued. Proportion of mutton snapper by age, fishery, and year using age-length keys. The numbers of fish including discards were converted from lengths to ages with fishery-specific age-length keys.

Traps/other gears	Proportion of Ages																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1991	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1992	0.008	0.113	0.161	0.190	0.071	0.110	0.091	0.102	0.028	0.012	0.018	0.012	0.011	0.012	0.008	0.007	0.005	0.005	0.004	0.006	0.003	0.003	0.001	0.003	0.017
1993	0.000	0.043	0.040	0.098	0.053	0.235	0.169	0.202	0.060	0.012	0.020	0.009	0.006	0.008	0.007	0.004	0.006	0.005	0.004	0.005	0.002	0.002	0.000	0.002	0.008
1994	0.009	0.043	0.119	0.098	0.032	0.240	0.201	0.171	0.037	0.007	0.010	0.005	0.004	0.004	0.003	0.002	0.002	0.002	0.002	0.003	0.001	0.001	0.000	0.001	0.003
1995	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1996	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1997	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1999	0.002	0.044	0.043	0.062	0.025	0.297	0.210	0.231	0.045	0.005	0.008	0.004	0.002	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.000	0.000	0.001	0.004
2000	0.001	0.189	0.163	0.156	0.056	0.148	0.090	0.097	0.022	0.006	0.010	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.001	0.002	0.011
2001	0.003	0.118	0.203	0.163	0.043	0.140	0.114	0.095	0.025	0.007	0.011	0.008	0.008	0.007	0.005	0.006	0.005	0.004	0.004	0.004	0.003	0.003	0.001	0.002	0.017
2002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2003	0.001	0.057	0.136	0.169	0.066	0.204	0.118	0.140	0.026	0.008	0.012	0.007	0.006	0.007	0.005	0.004	0.005	0.004	0.003	0.004	0.003	0.002	0.001	0.002	0.012
2004	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2005	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2006	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 2.3.1.1 continued. Proportion of mutton snapper by age, fishery, and year using age-length keys. The numbers of fish including discards were converted from lengths to ages with fishery-specific age-length keys.

Headboat	Proportion of Ages																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.011	0.116	0.358	0.211	0.106	0.062	0.046	0.038	0.018	0.006	0.006	0.004	0.003	0.003	0.001	0.002	0.001	0.001	0.001	0.002	0.000	0.001	0.001	0.000	0.001
1982	0.006	0.088	0.373	0.242	0.102	0.058	0.046	0.038	0.016	0.006	0.006	0.004	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.001
1983	0.010	0.066	0.268	0.280	0.154	0.074	0.054	0.042	0.020	0.007	0.007	0.005	0.002	0.002	0.001	0.002	0.002	0.001	0.001	0.002	0.000	0.001	0.001	0.000	0.001
1984	0.007	0.067	0.261	0.273	0.167	0.077	0.055	0.042	0.020	0.006	0.006	0.004	0.002	0.002	0.001	0.003	0.002	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.001
1985	0.009	0.087	0.307	0.243	0.136	0.069	0.055	0.042	0.021	0.006	0.007	0.004	0.002	0.003	0.001	0.003	0.001	0.001	0.001	0.002	0.000	0.001	0.001	0.000	0.001
1986	0.007	0.069	0.260	0.247	0.144	0.083	0.066	0.052	0.027	0.008	0.008	0.006	0.003	0.004	0.001	0.003	0.002	0.002	0.001	0.003	0.000	0.001	0.001	0.000	0.003
1987	0.022	0.130	0.288	0.212	0.128	0.066	0.053	0.041	0.022	0.006	0.006	0.003	0.003	0.004	0.002	0.003	0.001	0.001	0.002	0.003	0.000	0.002	0.001	0.000	0.001
1988	0.019	0.141	0.349	0.209	0.099	0.055	0.042	0.036	0.018	0.006	0.006	0.004	0.002	0.003	0.001	0.002	0.001	0.001	0.001	0.003	0.000	0.001	0.001	0.000	0.001
1989	0.016	0.149	0.412	0.213	0.084	0.037	0.029	0.024	0.012	0.003	0.004	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.000	0.001	0.000	0.000	0.001
1990	0.024	0.161	0.368	0.215	0.098	0.044	0.033	0.024	0.013	0.004	0.004	0.002	0.001	0.002	0.000	0.002	0.001	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.001
1991	0.011	0.111	0.366	0.244	0.096	0.045	0.033	0.032	0.020	0.003	0.004	0.002	0.004	0.006	0.003	0.003	0.000	0.001	0.003	0.005	0.000	0.003	0.001	0.000	0.002
1992	0.029	0.149	0.320	0.176	0.100	0.054	0.042	0.047	0.025	0.009	0.007	0.008	0.003	0.008	0.002	0.002	0.002	0.000	0.002	0.009	0.000	0.002	0.001	0.000	0.003
1993	0.017	0.127	0.333	0.206	0.109	0.061	0.050	0.040	0.021	0.006	0.006	0.003	0.002	0.004	0.001	0.004	0.001	0.001	0.001	0.003	0.000	0.001	0.001	0.000	0.003
1994	0.006	0.077	0.306	0.233	0.107	0.067	0.069	0.057	0.029	0.006	0.010	0.007	0.002	0.005	0.001	0.006	0.000	0.002	0.001	0.004	0.000	0.001	0.001	0.000	0.003
1995	0.006	0.094	0.350	0.223	0.096	0.058	0.050	0.041	0.020	0.006	0.007	0.005	0.032	0.002	0.001	0.003	0.000	0.001	0.001	0.002	0.000	0.001	0.001	0.000	0.002
1996	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1997	0.010	0.099	0.341	0.202	0.094	0.059	0.047	0.046	0.022	0.007	0.006	0.006	0.035	0.003	0.003	0.003	0.002	0.001	0.003	0.003	0.000	0.003	0.001	0.000	0.002
1998	0.009	0.083	0.274	0.182	0.112	0.080	0.071	0.065	0.030	0.011	0.010	0.007	0.035	0.006	0.003	0.003	0.001	0.002	0.003	0.005	0.000	0.003	0.002	0.000	0.004
1999	0.008	0.092	0.306	0.220	0.122	0.068	0.052	0.040	0.021	0.005	0.006	0.005	0.033	0.004	0.001	0.003	0.003	0.001	0.001	0.002	0.000	0.001	0.001	0.000	0.002
2000	0.007	0.089	0.288	0.194	0.102	0.078	0.068	0.058	0.029	0.010	0.010	0.007	0.032	0.009	0.000	0.004	0.005	0.001	0.000	0.007	0.000	0.000	0.001	0.000	0.002
2001	0.005	0.073	0.325	0.232	0.097	0.068	0.048	0.053	0.020	0.011	0.007	0.006	0.034	0.003	0.002	0.002	0.001	0.000	0.002	0.003	0.000	0.002	0.001	0.000	0.002
2002	0.006	0.074	0.326	0.258	0.116	0.068	0.047	0.035	0.016	0.008	0.005	0.003	0.032	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.005	0.064	0.284	0.242	0.131	0.076	0.059	0.046	0.022	0.009	0.008	0.005	0.032	0.005	0.000	0.003	0.002	0.001	0.000	0.003	0.000	0.000	0.001	0.000	0.002
2004	0.006	0.078	0.312	0.246	0.127	0.068	0.048	0.035	0.019	0.005	0.004	0.002	0.034	0.003	0.002	0.002	0.001	0.001	0.002	0.001	0.000	0.002	0.001	0.000	0.001
2005	0.006	0.102	0.394	0.248	0.096	0.040	0.031	0.022	0.012	0.002	0.004	0.002	0.034	0.001	0.000	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.001
2006	0.005	0.084	0.320	0.208	0.097	0.056	0.052	0.043	0.038	0.003	0.006	0.002	0.034	0.011	0.005	0.009	0.000	0.002	0.005	0.010	0.000	0.005	0.000	0.000	0.008

Table 2.3.1.1 continued. Proportion of mutton snapper by age, fishery, and year using age-length keys. The numbers of fish including discards were converted from lengths to ages with fishery-specific age-length keys.

MRFSS	Proportion of Ages																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986	0.091	0.085	0.281	0.188	0.130	0.068	0.014	0.025	0.025	0.001	0.002	0.029	0.000	0.037	0.018	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.090	0.093	0.308	0.142	0.094	0.052	0.029	0.038	0.011	0.000	0.007	0.035	0.000	0.094	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1991	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1992	0.067	0.136	0.338	0.074	0.047	0.056	0.048	0.045	0.021	0.012	0.008	0.041	0.000	0.092	0.008	0.003	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.126	0.138	0.344	0.103	0.076	0.037	0.011	0.011	0.003	0.001	0.001	0.033	0.000	0.108	0.005	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.097	0.163	0.361	0.087	0.060	0.038	0.020	0.011	0.003	0.000	0.001	0.037	0.000	0.121	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.029	0.100	0.302	0.180	0.076	0.053	0.038	0.026	0.015	0.015	0.003	0.063	0.000	0.094	0.002	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1997	0.042	0.100	0.251	0.080	0.105	0.057	0.011	0.011	0.009	0.005	0.002	0.118	0.000	0.209	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.071	0.098	0.272	0.106	0.054	0.040	0.025	0.014	0.007	0.006	0.001	0.108	0.000	0.195	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.069	0.083	0.242	0.131	0.112	0.072	0.042	0.027	0.019	0.012	0.004	0.069	0.000	0.110	0.005	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.026	0.089	0.334	0.170	0.087	0.047	0.018	0.010	0.008	0.005	0.004	0.072	0.000	0.127	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.021	0.103	0.358	0.181	0.096	0.043	0.017	0.011	0.005	0.004	0.001	0.056	0.000	0.098	0.002	0.002	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.022	0.091	0.323	0.190	0.104	0.054	0.028	0.021	0.006	0.003	0.003	0.054	0.000	0.098	0.002	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.018	0.088	0.328	0.194	0.105	0.056	0.029	0.021	0.009	0.004	0.003	0.052	0.000	0.088	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.029	0.100	0.350	0.210	0.077	0.038	0.013	0.010	0.005	0.002	0.005	0.057	0.000	0.102	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2006	0.032	0.093	0.315	0.177	0.098	0.052	0.014	0.011	0.003	0.002	0.001	0.070	0.000	0.131	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2.3.1.3.1. Directed fishing mortality rates by fishery, age and year from ASAP base run.

Hook-and-line	Fishing mortality rates																								
	Age																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.004	0.009	0.018	0.029	0.041	0.044	0.039	0.035	0.031	0.027	0.023	0.020	0.018	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003
1982	0.004	0.010	0.020	0.032	0.046	0.049	0.044	0.039	0.034	0.030	0.026	0.023	0.020	0.017	0.015	0.012	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.003	0.003
1983	0.004	0.009	0.018	0.029	0.042	0.045	0.040	0.035	0.031	0.027	0.024	0.021	0.018	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003
1984	0.004	0.008	0.017	0.027	0.039	0.041	0.037	0.033	0.029	0.025	0.022	0.019	0.017	0.014	0.012	0.010	0.009	0.008	0.006	0.006	0.005	0.004	0.003	0.003	0.003
1985	0.003	0.007	0.015	0.024	0.034	0.036	0.032	0.029	0.025	0.022	0.019	0.017	0.014	0.012	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.003	0.003	0.002	0.002
1986	0.005	0.011	0.022	0.036	0.051	0.054	0.049	0.043	0.038	0.033	0.029	0.025	0.022	0.019	0.016	0.014	0.012	0.010	0.009	0.007	0.006	0.005	0.004	0.004	0.004
1987	0.007	0.016	0.031	0.051	0.073	0.077	0.069	0.061	0.054	0.047	0.041	0.036	0.031	0.027	0.023	0.020	0.017	0.014	0.012	0.010	0.009	0.007	0.006	0.005	0.005
1988	0.006	0.014	0.028	0.045	0.065	0.069	0.062	0.055	0.048	0.042	0.037	0.032	0.028	0.024	0.020	0.017	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.005
1989	0.006	0.015	0.029	0.048	0.068	0.072	0.065	0.057	0.051	0.044	0.039	0.033	0.029	0.025	0.021	0.018	0.016	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.005
1990	0.005	0.012	0.025	0.040	0.058	0.061	0.055	0.049	0.043	0.037	0.033	0.028	0.024	0.021	0.018	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.004	0.004
1991	0.006	0.014	0.029	0.047	0.068	0.072	0.064	0.057	0.050	0.044	0.038	0.033	0.029	0.025	0.021	0.018	0.016	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.005
1992	0.006	0.014	0.028	0.045	0.065	0.069	0.062	0.055	0.048	0.042	0.037	0.032	0.028	0.024	0.020	0.017	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.005
1993	0.007	0.017	0.034	0.055	0.079	0.084	0.075	0.067	0.059	0.051	0.045	0.039	0.034	0.029	0.025	0.021	0.018	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.006
1994	0.007	0.016	0.032	0.051	0.073	0.078	0.070	0.062	0.054	0.048	0.041	0.036	0.031	0.027	0.023	0.020	0.017	0.014	0.012	0.010	0.009	0.007	0.006	0.005	0.005
1995	0.002	0.014	0.034	0.055	0.063	0.053	0.047	0.042	0.037	0.032	0.028	0.025	0.021	0.018	0.016	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.004	0.004	0.004
1996	0.004	0.010	0.029	0.048	0.055	0.046	0.041	0.037	0.032	0.028	0.025	0.021	0.018	0.016	0.014	0.012	0.010	0.009	0.007	0.006	0.005	0.004	0.004	0.003	0.003
1997	0.002	0.010	0.027	0.045	0.052	0.044	0.039	0.035	0.030	0.027	0.023	0.020	0.017	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003
1998	0.004	0.011	0.028	0.047	0.053	0.045	0.040	0.036	0.031	0.027	0.024	0.021	0.018	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003
1999	0.001	0.005	0.014	0.024	0.027	0.023	0.020	0.018	0.016	0.014	0.012	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002
2000	0.001	0.004	0.010	0.017	0.020	0.017	0.015	0.013	0.012	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001
2001	0.001	0.005	0.011	0.019	0.022	0.018	0.016	0.014	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001
2002	0.000	0.004	0.010	0.017	0.020	0.017	0.015	0.013	0.012	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001
2003	0.000	0.003	0.009	0.015	0.017	0.014	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001
2004	0.000	0.002	0.008	0.014	0.016	0.014	0.012	0.011	0.010	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001
2005	0.000	0.002	0.006	0.009	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2006	0.000	0.002	0.004	0.007	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000

Table 2.3.1.3.1 continued. Directed fishing mortality rates by fishery, age and year from ASAP base run.

Longline												Fishing mortality rates													
													Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.000	0.000	0.000	0.001	0.004	0.008	0.012	0.013	0.012	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002
1982	0.000	0.000	0.001	0.002	0.006	0.013	0.019	0.022	0.020	0.018	0.016	0.014	0.013	0.011	0.010	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.003
1983	0.000	0.000	0.001	0.002	0.006	0.013	0.019	0.022	0.020	0.018	0.016	0.014	0.012	0.011	0.010	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.003
1984	0.000	0.000	0.000	0.001	0.004	0.008	0.012	0.013	0.012	0.011	0.010	0.008	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
1985	0.000	0.000	0.000	0.002	0.004	0.009	0.013	0.015	0.013	0.012	0.011	0.009	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002
1986	0.000	0.000	0.001	0.003	0.009	0.019	0.028	0.032	0.029	0.026	0.023	0.020	0.018	0.016	0.014	0.012	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.004
1987	0.000	0.000	0.002	0.006	0.015	0.032	0.047	0.054	0.049	0.044	0.039	0.035	0.031	0.027	0.024	0.021	0.018	0.016	0.014	0.012	0.010	0.009	0.007	0.006	0.006
1988	0.000	0.000	0.001	0.004	0.010	0.022	0.032	0.037	0.033	0.030	0.027	0.024	0.021	0.018	0.016	0.014	0.012	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.004
1989	0.000	0.001	0.002	0.006	0.017	0.035	0.053	0.060	0.054	0.049	0.044	0.039	0.034	0.030	0.026	0.023	0.020	0.017	0.015	0.013	0.011	0.010	0.008	0.007	0.007
1990	0.000	0.000	0.002	0.005	0.014	0.029	0.043	0.050	0.045	0.040	0.036	0.032	0.028	0.025	0.022	0.019	0.017	0.014	0.012	0.011	0.009	0.008	0.007	0.006	0.006
1991	0.000	0.001	0.002	0.006	0.018	0.037	0.054	0.063	0.056	0.051	0.045	0.040	0.036	0.031	0.027	0.024	0.021	0.018	0.016	0.014	0.012	0.010	0.009	0.007	0.007
1992	0.000	0.000	0.001	0.004	0.011	0.023	0.034	0.039	0.035	0.031	0.028	0.025	0.022	0.019	0.017	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.005	0.005
1993	0.000	0.000	0.001	0.002	0.006	0.013	0.020	0.023	0.021	0.018	0.016	0.015	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.003
1994	0.000	0.000	0.000	0.001	0.004	0.008	0.011	0.013	0.012	0.011	0.009	0.008	0.007	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
1995	0.000	0.000	0.000	0.001	0.004	0.008	0.012	0.013	0.012	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
1996	0.000	0.000	0.000	0.001	0.004	0.008	0.012	0.014	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002
1997	0.000	0.000	0.001	0.002	0.005	0.010	0.015	0.017	0.015	0.014	0.012	0.011	0.010	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002
1998	0.000	0.000	0.001	0.002	0.006	0.013	0.019	0.021	0.019	0.017	0.015	0.014	0.012	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.003
1999	0.000	0.000	0.001	0.002	0.005	0.011	0.017	0.019	0.017	0.016	0.014	0.012	0.011	0.010	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002
2000	0.000	0.000	0.001	0.002	0.005	0.010	0.015	0.017	0.016	0.014	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002
2001	0.000	0.000	0.001	0.002	0.005	0.011	0.017	0.019	0.017	0.015	0.014	0.012	0.011	0.010	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002
2002	0.000	0.000	0.000	0.002	0.004	0.009	0.013	0.015	0.013	0.012	0.011	0.009	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002
2003	0.000	0.000	0.001	0.002	0.005	0.011	0.016	0.018	0.016	0.015	0.013	0.012	0.010	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002
2004	0.000	0.000	0.001	0.003	0.008	0.017	0.025	0.028	0.026	0.023	0.021	0.018	0.016	0.014	0.012	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003
2005	0.000	0.000	0.000	0.002	0.004	0.009	0.013	0.015	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002
2006	0.000	0.000	0.001	0.002	0.006	0.012	0.018	0.020	0.018	0.016	0.015	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002

Table 2.3.1.3.1 continued. Directed fishing mortality rates by fishery, age and year from ASAP base run.

Traps/other gears	Fishing mortality rates																								
	Age																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.000	0.000	0.001	0.002	0.004	0.008	0.012	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
1982	0.000	0.000	0.001	0.002	0.004	0.007	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
1983	0.000	0.000	0.001	0.002	0.004	0.007	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
1984	0.000	0.000	0.000	0.001	0.002	0.004	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
1985	0.000	0.000	0.000	0.001	0.002	0.004	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000
1986	0.000	0.000	0.001	0.004	0.008	0.015	0.023	0.019	0.017	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002
1987	0.000	0.000	0.002	0.004	0.009	0.017	0.026	0.022	0.019	0.017	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002
1988	0.000	0.001	0.002	0.006	0.014	0.026	0.040	0.034	0.030	0.026	0.023	0.020	0.017	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.003	0.003	0.003
1989	0.000	0.001	0.003	0.008	0.019	0.036	0.055	0.046	0.041	0.036	0.031	0.027	0.023	0.020	0.017	0.015	0.012	0.011	0.009	0.008	0.006	0.005	0.005	0.004	0.004
1990	0.000	0.001	0.002	0.006	0.013	0.024	0.037	0.031	0.028	0.024	0.021	0.018	0.016	0.014	0.012	0.010	0.009	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.003
1991	0.000	0.001	0.002	0.004	0.010	0.019	0.028	0.024	0.021	0.019	0.016	0.014	0.012	0.010	0.009	0.008	0.007	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.002
1992	0.000	0.001	0.002	0.005	0.010	0.020	0.030	0.025	0.022	0.020	0.017	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.002	0.002	0.002
1993	0.000	0.001	0.002	0.006	0.012	0.024	0.037	0.031	0.027	0.024	0.021	0.018	0.016	0.014	0.012	0.010	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.003
1994	0.000	0.000	0.001	0.004	0.009	0.017	0.025	0.021	0.019	0.017	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002
1995	0.001	0.003	0.004	0.007	0.009	0.012	0.013	0.012	0.011	0.010	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001
1996	0.001	0.002	0.004	0.006	0.008	0.011	0.011	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
1997	0.001	0.001	0.002	0.004	0.005	0.006	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1998	0.001	0.003	0.005	0.008	0.011	0.015	0.016	0.015	0.013	0.011	0.010	0.009	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001
1999	0.000	0.001	0.003	0.004	0.006	0.008	0.009	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
2000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
2001	0.000	0.001	0.001	0.002	0.002	0.003	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.001	0.001	0.002	0.003	0.003	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
2003	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2.3.1.3.1 continued. Directed fishing mortality rates by fishery, age and year from ASAP base run.

Headboat	Fishing mortality rates																								
	Age																								
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.005	0.019	0.045	0.061	0.057	0.048	0.040	0.032	0.025	0.020	0.015	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1982	0.003	0.012	0.030	0.040	0.037	0.032	0.026	0.021	0.017	0.013	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1983	0.003	0.013	0.032	0.043	0.040	0.034	0.028	0.023	0.018	0.014	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1984	0.002	0.008	0.020	0.027	0.025	0.021	0.017	0.014	0.011	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1985	0.003	0.011	0.025	0.034	0.032	0.027	0.022	0.018	0.014	0.011	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1986	0.002	0.011	0.027	0.036	0.034	0.029	0.024	0.019	0.015	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1987	0.003	0.011	0.026	0.035	0.033	0.028	0.023	0.018	0.015	0.011	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1988	0.003	0.011	0.027	0.036	0.034	0.029	0.024	0.019	0.015	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1989	0.003	0.012	0.030	0.040	0.037	0.031	0.026	0.021	0.017	0.013	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1990	0.005	0.018	0.042	0.057	0.053	0.045	0.037	0.030	0.024	0.018	0.014	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1991	0.002	0.008	0.019	0.025	0.023	0.020	0.016	0.013	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1992	0.003	0.009	0.022	0.029	0.027	0.023	0.019	0.015	0.012	0.009	0.007	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1993	0.003	0.011	0.027	0.037	0.034	0.029	0.024	0.019	0.015	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1994	0.002	0.011	0.027	0.037	0.034	0.029	0.024	0.019	0.015	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1995	0.002	0.015	0.035	0.036	0.012	0.010	0.008	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.003	0.009	0.019	0.019	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.002	0.008	0.019	0.020	0.006	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.002	0.007	0.015	0.016	0.005	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.001	0.006	0.013	0.014	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.001	0.006	0.013	0.014	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.001	0.005	0.012	0.012	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.003	0.008	0.008	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.000	0.003	0.008	0.009	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.003	0.008	0.008	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.001	0.006	0.013	0.014	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.001	0.005	0.011	0.011	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2.3.1.3.1 continued. Directed fishing mortality rates by fishery, age and year from ASAP base run.

MRFSS													Fishing mortality rates												
													Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.155	0.154	0.153	0.120	0.095	0.073	0.055	0.041	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
1982	0.136	0.135	0.134	0.105	0.083	0.064	0.048	0.036	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
1983	0.158	0.158	0.157	0.123	0.097	0.074	0.056	0.042	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
1984	0.230	0.230	0.227	0.179	0.141	0.108	0.082	0.061	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
1985	0.018	0.018	0.017	0.014	0.011	0.008	0.006	0.005	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1986	0.097	0.112	0.118	0.095	0.074	0.058	0.044	0.032	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
1987	0.101	0.175	0.205	0.172	0.126	0.104	0.078	0.058	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
1988	0.191	0.190	0.188	0.148	0.117	0.090	0.068	0.050	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037
1989	0.144	0.143	0.142	0.112	0.088	0.068	0.051	0.038	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
1990	0.076	0.076	0.076	0.059	0.047	0.036	0.027	0.020	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1991	0.154	0.154	0.152	0.120	0.094	0.072	0.055	0.041	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
1992	0.066	0.203	0.221	0.184	0.125	0.111	0.084	0.062	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
1993	0.120	0.181	0.201	0.169	0.120	0.102	0.077	0.057	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
1994	0.040	0.097	0.106	0.089	0.060	0.054	0.041	0.030	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
1995	0.032	0.129	0.325	0.070	0.055	0.043	0.032	0.024	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
1996	0.033	0.079	0.183	0.033	0.026	0.020	0.015	0.011	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
1997	0.011	0.070	0.185	0.054	0.046	0.037	0.028	0.019	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1998	0.027	0.061	0.170	0.047	0.037	0.030	0.023	0.016	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
1999	0.031	0.069	0.180	0.042	0.033	0.026	0.020	0.014	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
2000	0.006	0.054	0.153	0.034	0.027	0.021	0.016	0.011	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
2001	0.005	0.040	0.103	0.022	0.017	0.013	0.010	0.007	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2002	0.010	0.070	0.185	0.039	0.031	0.024	0.018	0.013	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2003	0.008	0.076	0.200	0.042	0.033	0.026	0.019	0.014	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
2004	0.013	0.057	0.150	0.032	0.025	0.020	0.015	0.010	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
2005	0.023	0.055	0.129	0.023	0.018	0.014	0.011	0.008	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2006	0.012	0.058	0.160	0.036	0.029	0.023	0.017	0.012	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

Table 2.3.1.3.2. Discard fishing mortality rates by fishery, age and year from ASAP base run.

	Fishing mortality rates																			
	Hook-and-line				Longline				Traps/other gears				Headboat				MRFSS			
	Age				Age				Age				Age				Age			
Year	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1981	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.002	0.001	0.000
1987	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.009	0.003	0.000
1988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.007	0.003	0.000
1993	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.007	0.003	0.000
1994	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.003	0.002	0.000
1995	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.008	0.008	0.013	0.000
1996	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.014	0.029	0.001
1998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.011	0.021	0.001
1999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.011	0.000
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.006	0.008	0.000
2001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.004	0.000
2002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.005	0.007	0.000
2003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.005	0.007	0.000
2004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.005	0.000
2005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.006	0.009	0.000

Table 2.3.1.3.3. Numbers of fish by age and year from ASAP base run. To fit on the page, ages 24 and 25+ were combined.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24+
1981	579944	452101	317320	193225	163803	87114	74085	56419	45360	39403	39392	34045	31695	34655	26324	28156	32592	37956	50722	50397	17186	36552	18569	50422
1982	477960	375928	302270	213313	133031	115358	63235	55582	43894	36148	31771	32409	28253	26498	29155	22262	24157	28068	32788	43931	43728	14935	31806	60144
1983	622232	316270	257546	209794	151562	95974	85070	47875	43416	35038	29173	26150	26901	23624	22297	24666	19112	20822	24274	28438	38185	38082	13028	80381
1984	495077	402410	211796	174673	146402	107958	70165	64026	37251	34573	28206	23948	21645	22427	19817	18802	21104	16416	17942	20975	24623	33124	33084	81335
1985	462157	298603	252408	135755	117680	102095	78187	52812	50052	29849	27923	23169	19791	17982	18717	16603	15965	17970	14012	15347	17970	21125	28451	98439
1986	610405	344606	231218	198887	107430	93254	81646	63437	43649	41799	25131	23915	19967	17146	15651	16353	14700	14175	15994	12496	13707	16070	18913	113781
1987	760588	417516	241185	162869	142339	77543	68087	60693	48630	34241	33222	20411	19624	16532	14309	13150	13960	12614	12216	13835	10841	11922	14008	116043
1988	813322	507452	271245	154043	106250	94729	52116	46879	43469	36047	25824	25702	16011	15583	13270	11594	10851	11602	10547	10269	11680	9187	10136	111099
1989	724539	508323	327947	176994	103283	71978	65100	36534	34220	32740	27598	20264	20433	12875	12658	10873	9669	9109	9794	8947	8745	9980	7873	104348
1990	688157	474264	343498	222921	121818	70726	49114	44581	25940	25099	24509	21255	15866	16232	10360	10300	9024	8093	7680	8310	7631	7492	8583	97076
1991	818275	481641	341788	247797	160644	87198	50559	35323	33029	19724	19441	19493	17153	12967	13414	8644	8752	7723	6968	6647	7222	6655	6554	92860
1992	622552	530877	323755	232844	172375	111773	60873	35693	25718	24761	15038	15202	15454	13766	10520	10987	7211	7355	6531	5925	5678	6194	5727	85994
1993	512925	426240	337380	205190	151961	116461	76038	42552	26018	19373	18933	11771	12043	12372	11123	8569	9104	6012	6164	5499	5007	4814	5265	78301
1994	779861	337035	275186	215610	133686	101414	78675	52921	31000	19587	14821	14842	9345	9668	10030	9093	7128	7620	5059	5211	4666	4262	4109	71624
1995	801129	558100	237952	194296	153110	95906	73277	58228	40573	24322	15579	12052	12197	7752	8084	8445	7780	6129	6581	4386	4531	4067	3723	66372
1996	780928	583635	378199	131701	139823	114235	73493	57471	46815	33118	20020	13050	10162	10346	6609	6924	7334	6780	5357	5767	3851	3985	3583	61897
1997	642766	571911	423529	249649	100797	108957	90726	59312	47241	38896	27711	17028	11163	8738	8936	5731	6085	6465	5992	4745	5118	3423	3547	58409
1998	764695	478014	413244	271908	187615	77388	85542	72616	48540	39094	32404	23458	14493	9547	7505	7704	5007	5332	5678	5274	4184	4520	3027	54903
1999	1316870	561371	349272	271325	205437	144161	60457	67893	58818	39801	32313	27249	19856	12339	8171	6452	6717	4381	4679	4997	4651	3697	4000	51402
2000	1192850	969027	412506	233739	212198	163751	116601	49560	56572	49461	33640	27713	23468	17165	10702	7107	5684	5930	3875	4146	4434	4133	3289	49360
2001	1035820	897341	724309	285667	185698	171950	134457	96930	41827	48079	42207	29101	24055	20430	14983	9364	6294	5042	5269	3448	3693	3954	3688	47045
2002	675971	782024	683073	529996	229968	151905	142253	112367	82066	35634	41129	36605	25324	20996	17881	13144	8315	5599	4493	4702	3080	3303	3539	45473
2003	1410270	506915	577612	461449	421597	186257	124923	118602	95138	69979	30491	35659	31827	22076	18344	15654	11644	7377	4975	3997	4186	2745	2946	43760
2004	1254940	1058850	372398	384859	367008	341604	153105	104019	100240	81005	59793	26399	30963	27708	19264	16041	13852	10320	6548	4421	3555	3727	2446	41669
2005	2402660	940383	794541	261650	309535	299550	281472	127224	87515	84933	68925	51587	22857	26895	24138	16825	14184	12273	9160	5820	3935	3168	3325	39416
2006	1582160	1789140	708098	571974	212361	256285	250963	238355	109078	75417	73393	60309	45239	20085	23675	21281	15003	12664	10969	8194	5211	3525	2840	38346

Table 2.4.1. Proportion of mutton snapper by age, fishery, and year using direct aging.

Hook-and-line										Proportion of ages																
Year	n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1991		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1992	51	0.000	0.098	0.275	0.314	0.118	0.098	0.039	0.039	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	38	0.000	0.289	0.316	0.263	0.079	0.026	0.000	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	58	0.000	0.000	0.310	0.483	0.052	0.121	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	35	0.000	0.000	0.229	0.371	0.314	0.000	0.000	0.057	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	152	0.000	0.066	0.164	0.362	0.197	0.099	0.026	0.033	0.020	0.007	0.013	0.000	0.000	0.007	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	193	0.005	0.109	0.119	0.223	0.176	0.161	0.088	0.052	0.026	0.005	0.010	0.005	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.010
1998	203	0.020	0.103	0.300	0.172	0.192	0.094	0.074	0.015	0.005	0.015	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	223	0.004	0.193	0.287	0.202	0.179	0.049	0.045	0.018	0.004	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.004
2000	183	0.000	0.093	0.421	0.311	0.087	0.055	0.016	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000
2001	284	0.004	0.095	0.451	0.250	0.141	0.018	0.011	0.004	0.007	0.007	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.004	0.000	0.000	0.000	0.000
2002	340	0.000	0.018	0.282	0.353	0.218	0.079	0.015	0.006	0.006	0.000	0.012	0.006	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	262	0.000	0.011	0.195	0.504	0.168	0.042	0.023	0.011	0.000	0.004	0.004	0.008	0.004	0.004	0.000	0.000	0.004	0.004	0.004	0.008	0.000	0.000	0.000	0.004	0.000
2004	160	0.000	0.044	0.144	0.275	0.238	0.081	0.075	0.044	0.019	0.006	0.000	0.006	0.006	0.000	0.000	0.000	0.006	0.019	0.006	0.000	0.000	0.006	0.006	0.000	0.019
2005	197	0.000	0.025	0.208	0.269	0.137	0.061	0.086	0.030	0.020	0.005	0.010	0.015	0.000	0.020	0.010	0.005	0.015	0.010	0.015	0.005	0.010	0.000	0.000	0.005	0.036
2006	85	0.000	0.024	0.141	0.153	0.106	0.094	0.176	0.047	0.059	0.035	0.024	0.000	0.024	0.035	0.000	0.012	0.000	0.012	0.012	0.000	0.000	0.000	0.000	0.012	0.035

Table 2.4.1 continued. Proportion of mutton snapper by age, fishery, and year using direct aging.

Longline										Proportion of ages																
Year	n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1991		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1992	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	11	0.000	0.000	0.000	0.000	0.364	0.182	0.182	0.000	0.091	0.091	0.000	0.000	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	5	0.000	0.000	0.000	0.000	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000
1995	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1997	24	0.000	0.000	0.000	0.125	0.083	0.250	0.083	0.167	0.000	0.000	0.042	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.042	0.000	0.000	0.083	0.000	0.083
1998	3	0.000	0.000	0.000	0.000	0.000	0.667	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	5	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.400	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	9	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.222	0.333	0.111	0.000	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.000
2001	51	0.000	0.000	0.020	0.059	0.078	0.078	0.157	0.039	0.098	0.000	0.020	0.000	0.020	0.098	0.078	0.039	0.020	0.020	0.000	0.000	0.020	0.000	0.000	0.020	0.137
2002	94	0.000	0.000	0.021	0.085	0.106	0.096	0.128	0.053	0.032	0.021	0.043	0.021	0.032	0.032	0.021	0.053	0.011	0.021	0.011	0.032	0.011	0.021	0.011	0.000	0.138
2003	146	0.000	0.007	0.014	0.068	0.062	0.103	0.062	0.048	0.041	0.014	0.103	0.055	0.027	0.034	0.034	0.034	0.021	0.014	0.034	0.034	0.027	0.034	0.000	0.021	0.110
2004	150	0.000	0.007	0.040	0.060	0.140	0.140	0.107	0.087	0.047	0.040	0.033	0.027	0.007	0.027	0.013	0.007	0.033	0.027	0.013	0.007	0.007	0.020	0.000	0.007	0.107
2005	148	0.000	0.000	0.027	0.081	0.216	0.162	0.196	0.088	0.068	0.020	0.000	0.007	0.034	0.007	0.000	0.000	0.020	0.000	0.014	0.014	0.014	0.007	0.000	0.000	0.027
2006	401	0.000	0.000	0.020	0.082	0.107	0.165	0.160	0.102	0.027	0.047	0.047	0.032	0.027	0.007	0.025	0.030	0.012	0.015	0.007	0.010	0.015	0.007	0.002	0.005	0.045

Table 2.4.1 continued. Proportion of mutton snapper by age, fishery, and year using direct aging.

Traps/ other gears											Proportion of ages															
Year	n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1991		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1992		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1993		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1994	6	0.000	0.000	0.167	0.167	0.000	0.167	0.333	0.000	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	1	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	1	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	17	0.000	0.059	0.059	0.000	0.118	0.529	0.235	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	6	0.000	0.000	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	9	0.000	0.000	0.000	0.000	0.111	0.111	0.333	0.333	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	43	0.000	0.605	0.209	0.140	0.000	0.023	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	5	0.000	0.000	0.400	0.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2003	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2004	11	0.000	0.000	0.091	0.273	0.091	0.273	0.000	0.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2006	12	0.000	0.000	0.667	0.250	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2.4.1 continued. Proportion of mutton snapper by age, fishery, and year using direct aging.

Headboat										Proportion of ages																
Year	n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	150	0.000	0.073	0.567	0.193	0.027	0.040	0.020	0.033	0.007	0.013	0.007	0.000	0.000	0.000	0.000	0.007	0.000	0.007	0.000	0.000	0.000	0.007	0.000	0.000	0.000
1982	169	0.000	0.012	0.154	0.426	0.118	0.024	0.095	0.036	0.053	0.018	0.024	0.000	0.000	0.000	0.000	0.012	0.006	0.000	0.006	0.006	0.000	0.000	0.006	0.000	0.006
1983	4	0.000	0.250	0.000	0.500	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	20	0.000	0.550	0.100	0.000	0.100	0.200	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	76	0.000	0.079	0.461	0.250	0.000	0.066	0.118	0.013	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	33	0.000	0.121	0.091	0.606	0.061	0.000	0.030	0.000	0.061	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	14	0.143	0.214	0.143	0.071	0.429	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	33	0.000	0.242	0.364	0.242	0.061	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	2	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	6	0.000	0.000	0.167	0.500	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	11	0.000	0.091	0.273	0.273	0.273	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	10	0.000	0.200	0.100	0.300	0.100	0.100	0.000	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	52	0.000	0.077	0.250	0.154	0.192	0.192	0.038	0.038	0.019	0.000	0.000	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	51	0.000	0.059	0.255	0.157	0.118	0.078	0.098	0.118	0.020	0.020	0.020	0.020	0.000	0.020	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	127	0.000	0.094	0.417	0.276	0.142	0.031	0.024	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	24	0.000	0.083	0.250	0.292	0.208	0.083	0.042	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	19	0.053	0.158	0.316	0.211	0.211	0.000	0.000	0.000	0.000	0.000	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1999	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2000	3	0.000	0.333	0.333	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	13	0.000	0.154	0.769	0.000	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	2	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	146	0.014	0.055	0.384	0.363	0.110	0.027	0.014	0.014	0.007	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	134	0.000	0.187	0.269	0.284	0.157	0.060	0.022	0.007	0.007	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	242	0.004	0.120	0.521	0.153	0.095	0.058	0.012	0.021	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.004
2006	204	0.000	0.059	0.525	0.201	0.069	0.049	0.034	0.049	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2.4.1 continued. Proportion of mutton snapper by age, fishery, and year using direct aging.

MRFSS										Proportion of ages																
Year	n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1982		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1983		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1985		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1991		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1992		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1993		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1994		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1995		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1996		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1997		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1998		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1999		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2000		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2001	5	0.000	0.200	0.200	0.200	0.200	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	118	0.000	0.161	0.331	0.246	0.161	0.059	0.017	0.008	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	238	0.013	0.139	0.328	0.324	0.105	0.067	0.008	0.004	0.004	0.000	0.004	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	129	0.008	0.109	0.295	0.217	0.209	0.078	0.023	0.031	0.016	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	264	0.004	0.087	0.610	0.189	0.038	0.015	0.023	0.008	0.004	0.004	0.004	0.004	0.000	0.000	0.004	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
2006	75	0.000	0.053	0.573	0.213	0.107	0.027	0.000	0.013	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2.4.2. Results of ASAP runs showing the composite fishing mortality multiplier in 2006 (F_{2006}), the fishing mortality rate associated with a spawning potential ratio of 30% ($F_{30\%}$) that is the Councils' proxy for $F_{MSY,}$ spawning biomass in 2006 (SSB_{2006}), the spawning biomass associated with F30% ($SSB_{30\%}$), and F_{MAX}. The base run is No. 3 and the shaded runs indicate neither overfishing nor the stock being overfished.

Run	Model	Configuration	F_{2006}	$F_{30\%}$	SSB_{2006}	$SSB_{30\%}$	$F_{2006}/F_{30\%}$	$SSB_{2006}/SSB_{30\%}$	F_{MAX}
1	Age-len	h = 0.65	0.17	0.35	7340580	7273472	0.50	1.01	0.53
2	Age-len	h = 0.70	0.17	0.35	7219700	6692868	0.50	1.08	0.53
3	Age-len	h = 0.75	0.18	0.34	7145870	6295708	0.51	1.14	0.52
4	Age-len	h = 0.80	0.18	0.34	7096940	6017148	0.51	1.18	0.52
5	Age-len	Free	0.18	0.34	7033070	5623472	0.52	1.25	0.52
6	Age-len	No SEAMAP h=0.75	0.22	0.40	6923930	5942684	0.56	1.17	0.63
7	Age-len	No SEAMAP h=free	0.23	0.40	6805660	5403430	0.57	1.26	0.62
8	Age-len	h = 0.65, 5% rel mort	0.17	0.37	7611730	6682441	0.47	1.14	0.58
9	Age-len	h = 0.70, 5% rel mort	0.18	0.37	7497350	6280608	0.48	1.19	0.58
10	Age-len	h = 0.75, 5% rel mort	0.18	0.36	7424680	5995103	0.48	1.24	0.57
11	Age-len	h = 0.80, 5% rel mort	0.18	0.36	7375070	5789072	0.49	1.27	0.57
12	Age-len	h=free, 5% rel mort	0.18	0.36	7304210	5472131	0.49	1.33	0.57
13	Age-len	ConstantM h = 0.65	0.27	0.36	5246570	7828236	0.76	0.67	0.50
14	Age-len	ConstantM h = 0.70	0.28	0.36	5127450	6969287	0.78	0.74	0.49
15	Age-len	ConstantM h = 0.75	0.28	0.36	5060450	6395197	0.78	0.79	0.49
16	Age-len	ConstantM h = 0.80	0.28	0.35	5019860	6003718	0.79	0.84	0.49
17	Age-len	ConstantM free	0.28	0.35	4964190	5238578	0.79	0.95	0.49
18	Age-len	Inc q h = 0.65	0.24	0.35	5490280	6153207	0.69	0.89	0.54
19	Age-len	Inc q h = 0.70	0.24	0.35	5407720	5762350	0.69	0.94	0.54
20	Age-len	Inc q h = 0.75	0.24	0.35	5358690	5486192	0.70	0.98	0.54
21	Age-len	Inc q h = 0.80	0.25	0.35	5327650	5287960	0.70	1.01	0.53
22	Age-len	Inc q h = free	0.25	0.35	5280490	4871486	0.71	1.08	0.53
23	Age-len	Lorenz 08 h = 0.65	0.16	0.33	10287200	58333900	0.50	0.18	0.41
24	Age-len	Lorenz 08 h = 0.70	0.17	0.31	8933430	34536376	0.55	0.26	0.40
25	Age-len	Lorenz 08 h = 0.75	0.18	0.31	8425080	21013765	0.58	0.40	0.39
26	Age-len	Lorenz 08 h = 0.80	0.18	0.31	8244040	15075718	0.59	0.55	0.39
27	Age-len	Lorenz 08 free	0.18	0.31	8189360	13286264	0.59	0.62	0.39
28	Age-len	Lorenz 08 No SEAMAP h=0.75	0.26	0.37	6637260	13452377	0.72	0.49	0.52
29	Age-len	Lorenz 08 No SEAMAP h=free	0.27	0.36	6420530	8980512	0.74	0.71	0.52
30	Age-len	Fish Ind h = 0.65	0.14	0.26	5975380	11026207	0.54	0.54	0.34
31	Age-len	Fish Ind h = 0.70	0.14	0.25	5787370	8420976	0.56	0.69	0.34
32	Age-len	Fish Ind h = 0.75	0.14	0.25	5670790	7043072	0.57	0.81	0.34
33	Age-len	Fish Ind h = 0.80	0.14	0.25	5588000	6229742	0.57	0.90	0.34
34	Age-len	Fish Ind free	0.15	0.25	5456230	5158724	0.59	1.06	0.33
35	Age-len	Fish Ind no SEAMAP h = 0.75	0.24	0.37	5043900	5255120	0.65	0.96	0.57
36	Age-len	Fish Ind no SEAMAP h = free	0.24	0.37	4883330	4737535	0.66	1.03	0.57
37	Direct aging	h = 0.65	0.09	0.17	6442690	14251704	0.53	0.45	0.24
38	Direct aging	h = 0.70	0.10	0.17	5915630	12034440	0.57	0.49	0.24
39	Direct aging	h = 0.75	0.10	0.17	5589200	9675256	0.59	0.58	0.24
40	Direct aging	h = 0.80	0.10	0.17	5405820	7925454	0.61	0.68	0.24

Table 2.4.2 continued. Results of ASAP runs showing the composite fishing mortality multiplier in 2006 (F_{2006}), the fishing mortality rate associated with a spawning potential ratio of 30% ($F_{30\%}$) that is the Councils' proxy for $F_{MSY,}$ spawning biomass in 2006 (SSB_{2006}), the spawning biomass associated with F30% ($SSB_{30\%}$), and F_{MAX}. The base run is No. 3 and the shaded runs indicate neither overfishing nor the stock being overfished.

Run	Model	Configuration	F_{2006}	$F_{30\%}$	SSB_{2006}	$SSB_{30\%}$	$F_{2006}/F_{30\%}$	$SSB_{2006}/SSB_{30\%}$	F_{MAX}
41	Direct aging	h = free	0.10	0.17	5289470	6665114	0.62	0.79	0.24
42	Direct aging	No SEAMAP h = 0.75	0.12	0.17	4934680	8705297	0.69	0.57	0.24
43	Direct aging	No SEAMAP h = free	0.12	0.17	4634000	5776155	0.73	0.80	0.24
44	Direct aging	h = 0.65, 5% rel mort	0.09	0.18	6551270	13159361	0.50	0.50	0.28
45	Direct aging	h = 0.70, 5% rel mort	0.10	0.18	6075620	11049865	0.53	0.55	0.28
46	Direct aging	h = 0.75, 5% rel mort	0.10	0.18	5794040	8980423	0.55	0.65	0.28
47	Direct aging	h = 0.80, 5% rel mort	0.10	0.18	5637480	7491396	0.56	0.75	0.28
48	Direct aging	h=free, 5% rel mort	0.10	0.18	5556440	6633056	0.56	0.84	0.28
49	Direct aging	ConstantM h = 0.65	0.09	0.17	6846280	16730652	0.54	0.41	0.21
50	Direct aging	ConstantM h = 0.70	0.10	0.17	6216170	14514252	0.58	0.43	0.21
51	Direct aging	ConstantM h = 0.75	0.10	0.17	5796020	11685339	0.61	0.50	0.21
52	Direct aging	ConstantM h = 0.80	0.10	0.17	5550970	9368922	0.63	0.59	0.21
53	Direct aging	ConstantM h = free	0.11	0.17	5351110	7094274	0.65	0.75	0.21
54	Direct aging	Inc q h = 0.65	0.12	0.17	4770170	11271263	0.74	0.42	0.24
55	Direct aging	Inc q h = 0.70	0.13	0.17	4362680	9624491	0.78	0.45	0.24
56	Direct aging	Inc q h = 0.75	0.14	0.17	4124300	7902271	0.82	0.52	0.24
57	Direct aging	Inc q h = 0.80	0.14	0.17	3998660	6633736	0.84	0.60	0.24
58	Direct aging	Inc q h = free	0.15	0.17	3888440	5154699	0.86	0.75	0.24
59	Direct aging	Lorenz 08 h = 0.65	0.08	0.14	8183570	31220653	0.57	0.26	0.19
60	Direct aging	Lorenz 08 h = 0.70	0.09	0.14	7250200	29635436	0.62	0.24	0.19
61	Direct aging	Lorenz 08 h = 0.75	0.10	0.14	6499210	25008945	0.66	0.26	0.19
62	Direct aging	Lorenz 08 h = 0.80	0.10	0.14	5965410	19011074	0.71	0.31	0.19
63	Direct aging	Lorenz 08 h = free	0.11	0.14	5487030	10605909	0.75	0.52	0.19
64	Direct aging	Lorenz 08 no SEAMAP h = 0.75	0.09	0.16	8430310	13961389	0.56	0.60	10.00
65	Direct aging	Lorenz 08 no SEAMAP h = free	0.10	0.16	7954440	10304639	0.59	0.77	10.00
66	Direct aging	Fish Ind h = 0.65	0.14	0.17	3721720	2938630	0.86	1.27	0.24
67	Direct aging	Fish Ind h = 0.70	0.15	0.17	3606120	3129816	0.88	1.15	0.24
68	Direct aging	Fish Ind h = 0.75	0.15	0.17	3515690	3244065	0.89	1.08	0.24
69	Direct aging	Fish Ind h = 0.80	0.15	0.17	3444710	3310762	0.91	1.04	0.24
70	Direct aging	Fish Ind h = free	0.16	0.17	3282690	3378201	0.94	0.97	0.24
71	Direct aging	Fish Ind no SEAMAP h = 0.75	0.16	0.17	3276410	3211916	0.98	1.02	0.24
72	Direct aging	Fish Ind no SEAMAP h = free	0.17	0.17	3040370	3334729	1.04	0.91	0.24

Table 2.6. Sustainable Fisheries Act parameters for mutton snapper from the ASAP base run. Both councils have adopted F30% as their proxy for F_{MSY}.

Parameter	Value	Units
Maximum sustainable yield (MSY, $Yield_{F30\%}$)	688000	Kg
Spawning biomass at MSY ($SSB_{MSY,}$ $SSB_{F30\%}$)	6296000	Kg
Maximum Fishing Mortality Threshold (MFMT, $F_{30\%}$)	0.34	Per year
Minimum Spawning Stock Threshold (MSST, (1-0.11)*$SSB_{F30\%}$)	5603000	Kg
Optimum Yield (OY, $Yield_{F40\%}$)	524000	Kg
$F_{2006}/F_{30\%}$	0.51	--
$SSB_{2006/}SSB_{F30\%}$	1.14	--

Table 2.9.1. Projected spawning biomass and directed harvest from ASAP base run with different fishing mortality rates including MSY ($F_{30\%}$), OY ($F_{40\%}$), and F_{2006}.

	Spawning biomass (kg)			Directed harvest (kg)		
Year	MSY	OY	F_{2006}	MSY	OY	F_{2006}
2007	7938530	7938530	7938530	432600	432600	432600
2008	8981930	8981930	8981930	928851	708863	492672
2009	9494590	9715710	9932860	824689	646123	460589
2010	9644380	10102700	10565400	803414	643036	467920
2011	9572130	10255500	10962500	783622	639389	474006
2012	9412500	10302500	11243700	757327	629411	475015
2013	9226980	10303100	11464100	727479	614579	471269
2014	9038840	10281400	11646500	703190	602548	468454
2015	8851790	10242700	11796000	683254	592949	466694
2016	8674440	10198500	11926000	665965	584518	465103
2017	8504400	10147800	12035900	650941	577132	463696
2018	8342130	10092000	12127300	638003	570784	462550
2019	8190800	10036200	12206800	626945	565443	461727
2020	8050000	9981410	12276000	617533	561025	461242
2021	7922480	9932230	12341800	609476	557377	461040
2022	7805200	9886380	12402300	602524	554349	461053
2023	7697460	9843720	12457900	596535	551869	461258
2024	7595870	9801160	12505700	591282	549782	461569
2025	7500560	9759530	12547100	586608	547990	461934
2026	7411150	9718950	12582900	582388	546407	462307
2027	7330690	9683730	12618700	578685	545122	462785
2028	7255100	9649400	12649600	575321	543992	463266
2029	7187670	9620720	12682300	572413	543155	463887
2030	7121580	9589470	12706800	569663	542341	464434
2031	7059080	9558360	12726300	567050	541528	464884
2032	7001790	9530070	12744800	564618	540771	465294
2033	6949240	9504330	12762200	562337	540056	465663
2034	6900930	9480820	12778600	560205	539386	465996
2035	6856430	9459270	12793900	558220	538763	466301
2036	6815380	9439460	12808200	556372	538184	466580
2037	6777480	9421220	12821300	554652	537645	466836
2038	6742460	9404420	12833500	553051	537145	467070
2039	6710080	9388930	12844800	551560	536681	467284
2040	6680130	9374650	12855200	550174	536250	467481
2041	6652420	9361470	12864900	548884	535851	467661
2042	6626770	9349310	12873800	547685	535481	467827
2043	6603010	9338090	12882000	546569	535139	467980
2044	6581010	9327720	12889500	545533	534822	468120
2045	6560610	9318150	12896500	544569	534529	468250
2046	6541710	9309310	12903000	543672	534258	468369
2047	6524180	9301150	12908900	542839	534007	468478
2048	6507930	9293600	12914400	542065	533775	468580
2049	6492850	9286640	12919400	541345	533561	468673
2050	6478860	9280200	12924100	540675	533362	468758
2051	6465880	9274240	12928400	540053	533179	468838
2052	6453830	9268740	12932300	539475	533010	468910
2053	6442650	9263660	12936000	538937	532853	468978
2054	6432270	9258960	12939300	538437	532708	469040
2055	6422620	9254620	12942400	537972	532574	469097
2056	6413670	9250600	12945300	537540	532450	469149

Table 2.9.2. Projected spawning biomass and directed harvest from ASAP sensitivity run with age-specific natural mortality rates averaging 0.08 per year with different fishing mortality rates including, F=0, MSY ($F_{30\%}$), OY ($F_{40\%}$), and F_{2006}.

	Spawning biomass (kg)				Directed harvest (kg)		
Year	F=0	MSY	OY	F_{2006}	MSY	OY	F_{2006}
2007	7723550	7723550	7723550	7723550	432600	432600	432600
2008	8769190	8769190	8769190	8769190	753438	574424	398741
2009	10294900	9529690	9711770	9890300	717253	560201	398070
2010	11789600	10043700	10442300	10843200	728799	580282	420100
2011	13252700	10395900	11024100	11670500	740751	600066	441742
2012	14729900	10672500	11535300	12441000	745521	614456	459972
2013	16239100	10915500	12013000	13186300	744853	623727	474147
2014	17777500	11138000	12468300	13914300	746956	634429	488924
2015	19347700	11348000	12909100	14632100	750277	645611	503793
2016	20935100	11541100	13330200	15332300	753535	656210	517927
2017	22528700	11719900	13732400	16013800	756827	666333	531399
2018	24122700	11888600	14119500	16678400	760317	676130	544303
2019	25706700	12047100	14490700	17323700	763984	685624	556666
2020	27272000	12195600	14845500	17948200	767831	694855	568530
2021	28817200	12337600	15187700	18555000	771819	703822	579906
2022	30337200	12473900	15518000	19144000	775990	712597	590869
2023	31839500	12611000	15843700	19723400	780357	721224	601469
2024	33307300	12740100	16155200	20281900	784680	729521	611581
2025	34733900	12860600	16451300	20817600	788874	737431	621169
2026	36116100	12972800	16732400	21330200	792895	744931	630224
2027	37463800	13083600	17006200	21828700	796929	752214	638919
2028	38763000	13186900	17265600	22304300	800788	759128	647143
2029	40029900	13290100	17520000	22768400	804744	765944	655139
2030	41238800	13381500	17755000	23203800	808396	772313	662635
2031	42393500	13466400	17976400	23616400	811778	778262	669647
2032	43502600	13547900	18188300	24011400	814980	783883	676262
2033	44565700	13626100	18391200	24389300	817990	789181	682492
2034	45583600	13701000	18584900	24750300	820831	794182	688365
2035	46556600	13772500	18769700	25094500	823523	798908	693905
2036	47485200	13840600	18945700	25422300	826073	803373	699128
2037	48370500	13905500	19113100	25734300	828487	807590	704052
2038	49213700	13967300	19272300	26030800	830773	811573	708694
2039	50015800	14026000	19423600	26312600	832937	815334	713068
2040	50778400	14081900	19567300	26580100	834987	818886	717191
2041	51502700	14135000	19703800	26833900	836930	822240	721076
2042	52190200	14185400	19833200	27074600	838769	825408	724737
2043	52842400	14233400	19956100	27302700	840512	828398	728186
2044	53460700	14278900	20072500	27518800	842163	831221	731436
2045	54046600	14322200	20182900	27723500	843727	833886	734497
2046	54601400	14363200	20287500	27917200	845209	836401	737381
2047	55126700	14402200	20386500	28100400	846612	838776	740097
2048	55623700	14439200	20480400	28273700	847942	841017	742655
2049	56093900	14474300	20569200	28437600	849202	843132	745065
2050	56538500	14507700	20653300	28592500	850395	845129	747334
2051	56958800	14539300	20732800	28738900	851526	847012	749471
2052	57355900	14569300	20808100	28877200	852596	848790	751483
2053	57731200	14597700	20879300	29007700	853611	850467	753378
2054	58085600	14624700	20946600	29131000	854571	852050	755162
2055	58420200	14650200	21010200	29247400	855481	853543	756841
2056	58736200	14674500	21070400	29357300	856343	854952	758423

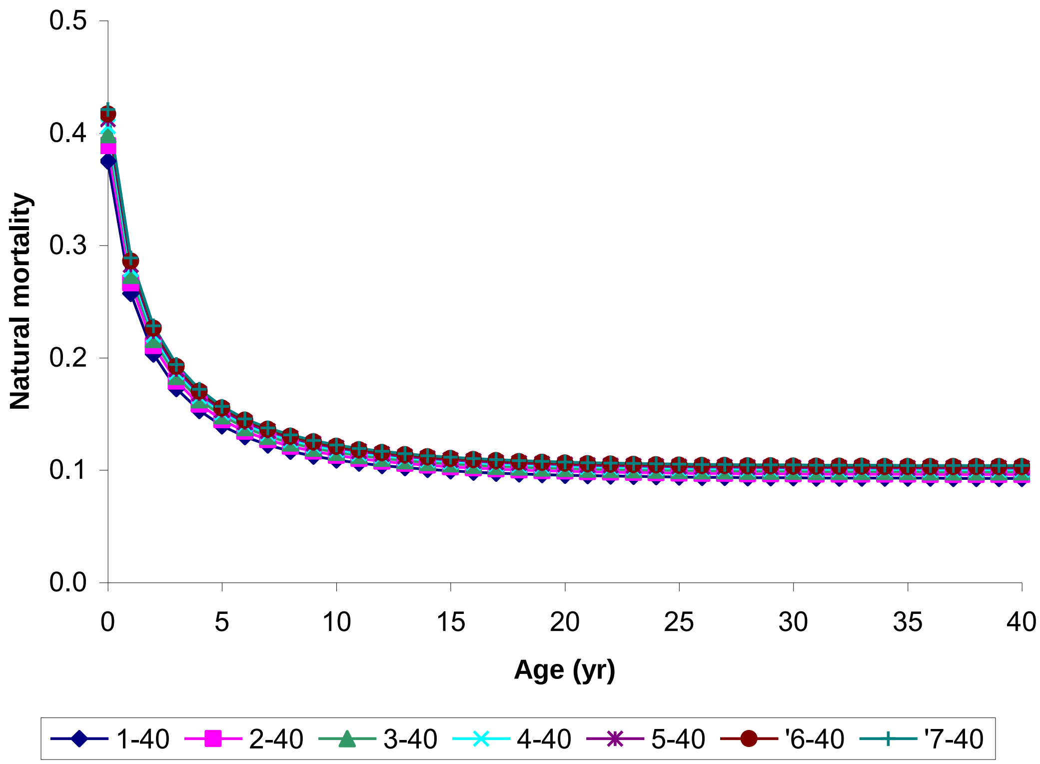


Figure 2.1.1.2. Comparison of age-specific natural mortality rates using different ranges of ages to scale the Lorenzen curve such that the rates averaged 0.11 per year.

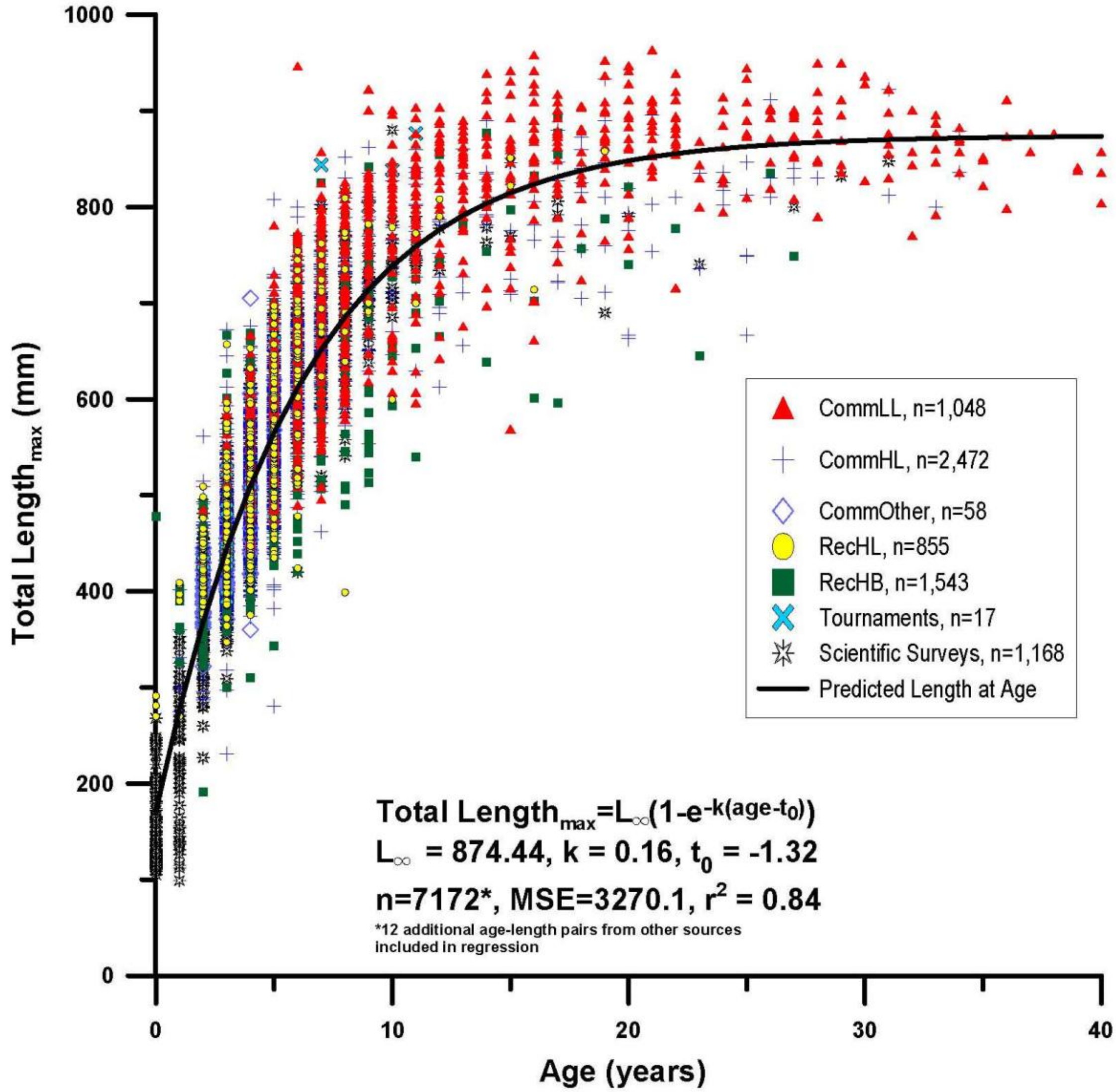
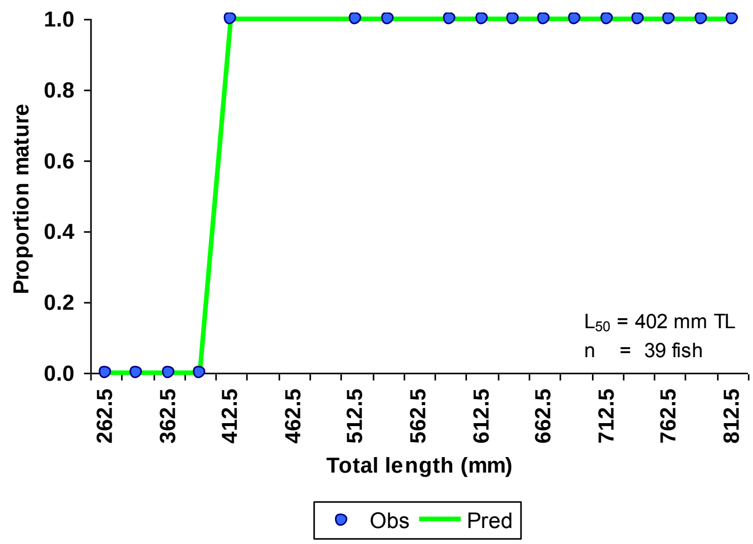


Figure 2.1.1.4. Population level von Bertalanffy growth curve. Copied from DW Life History Section, Fig. 2.10.

a.



b.

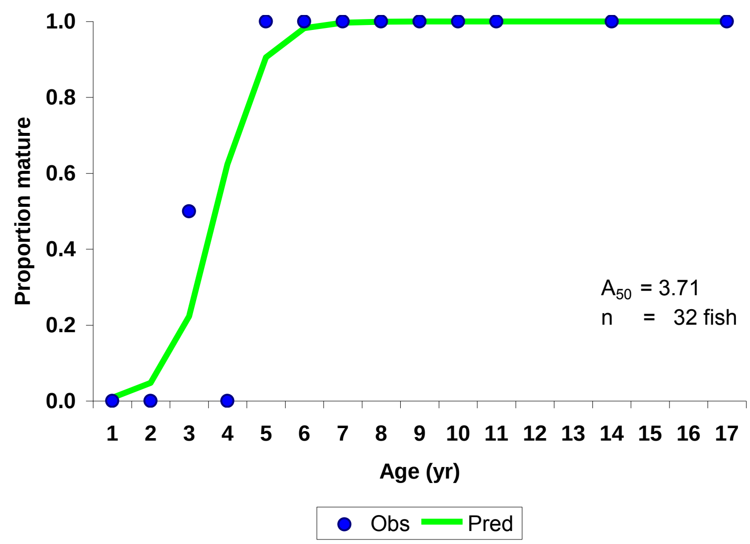


Figure 2.1.1.5. Maturity of female mutton snapper by length (a) and by age (b) for fish collected during the beginning of the spawning season, April-June, from the Florida Keys.

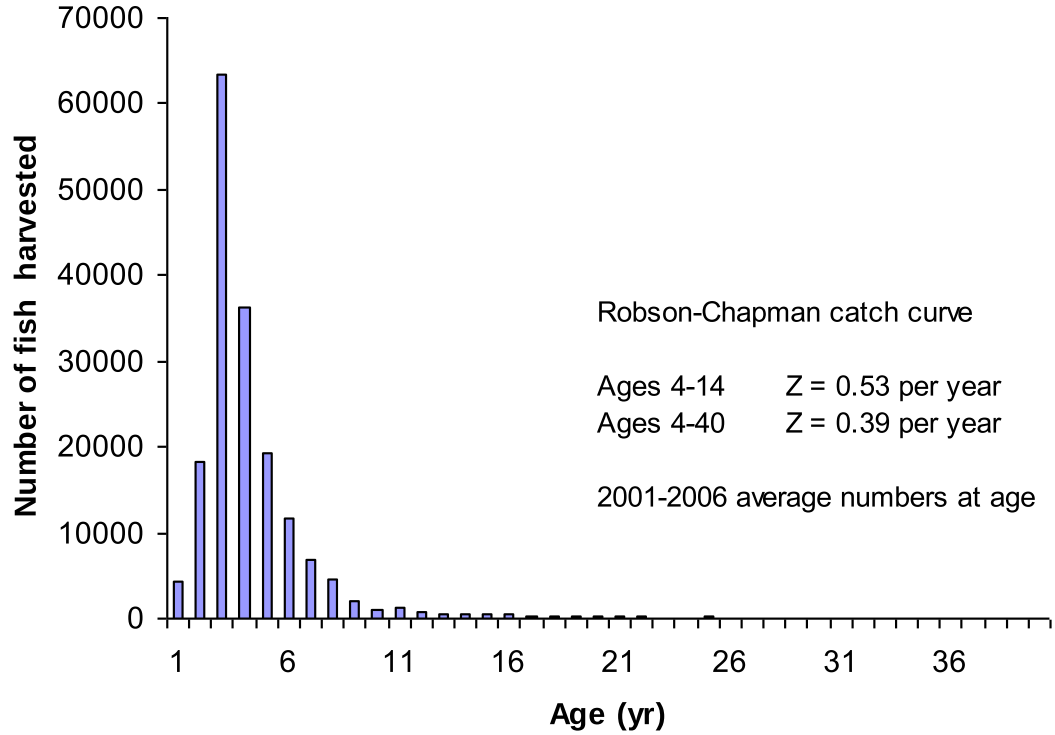


Figure 2.2.1. Composite estimated age composition (2001-2006) of fish across fisheries and Robson-Chapman (1960) estimates of total instantaneous mortality for ages 4-14 and ages 4-40 years.

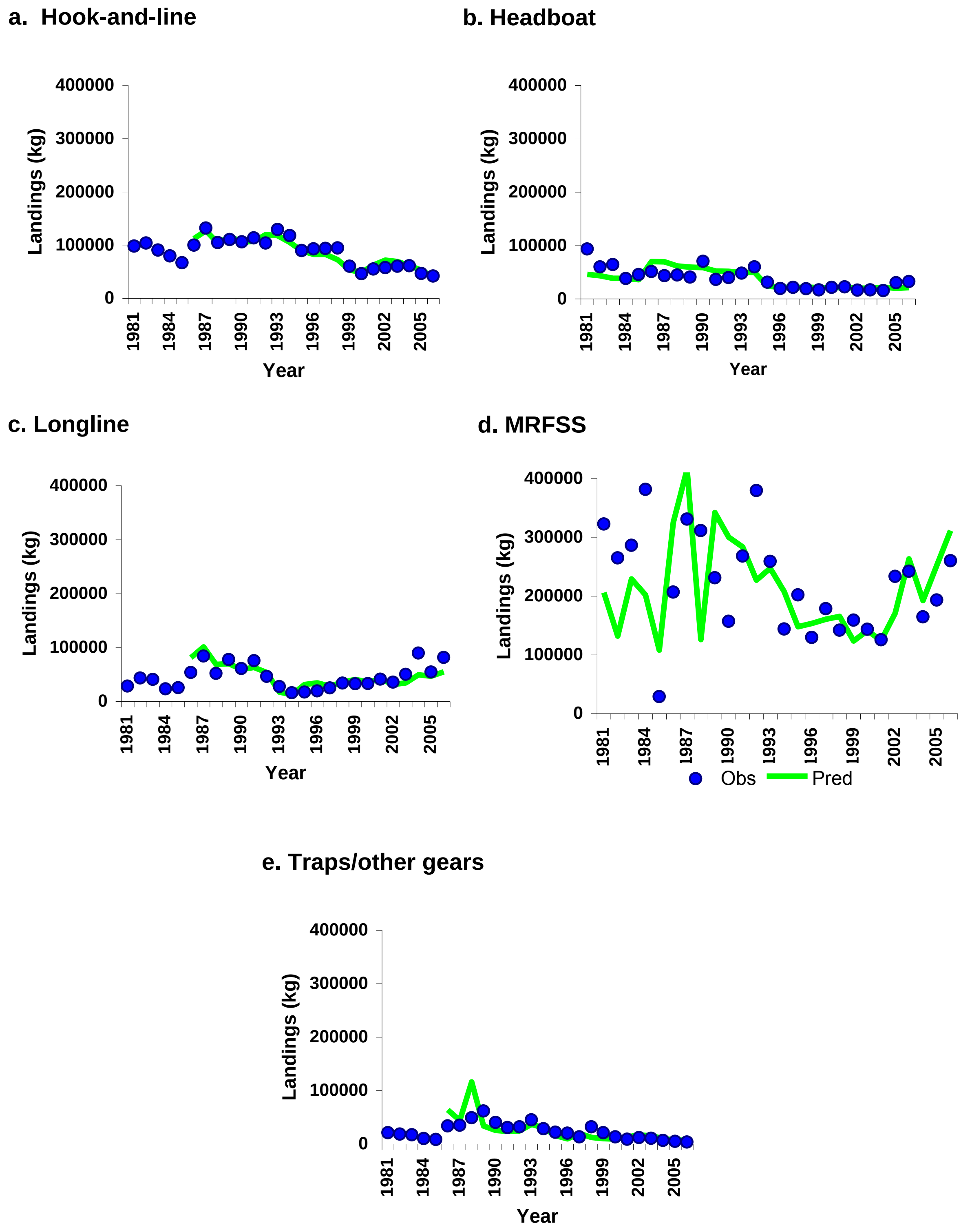


Figure 2.2.2.1. Observed (dots) and predicted (lines) landings by fishery from the Excel surplus production model.

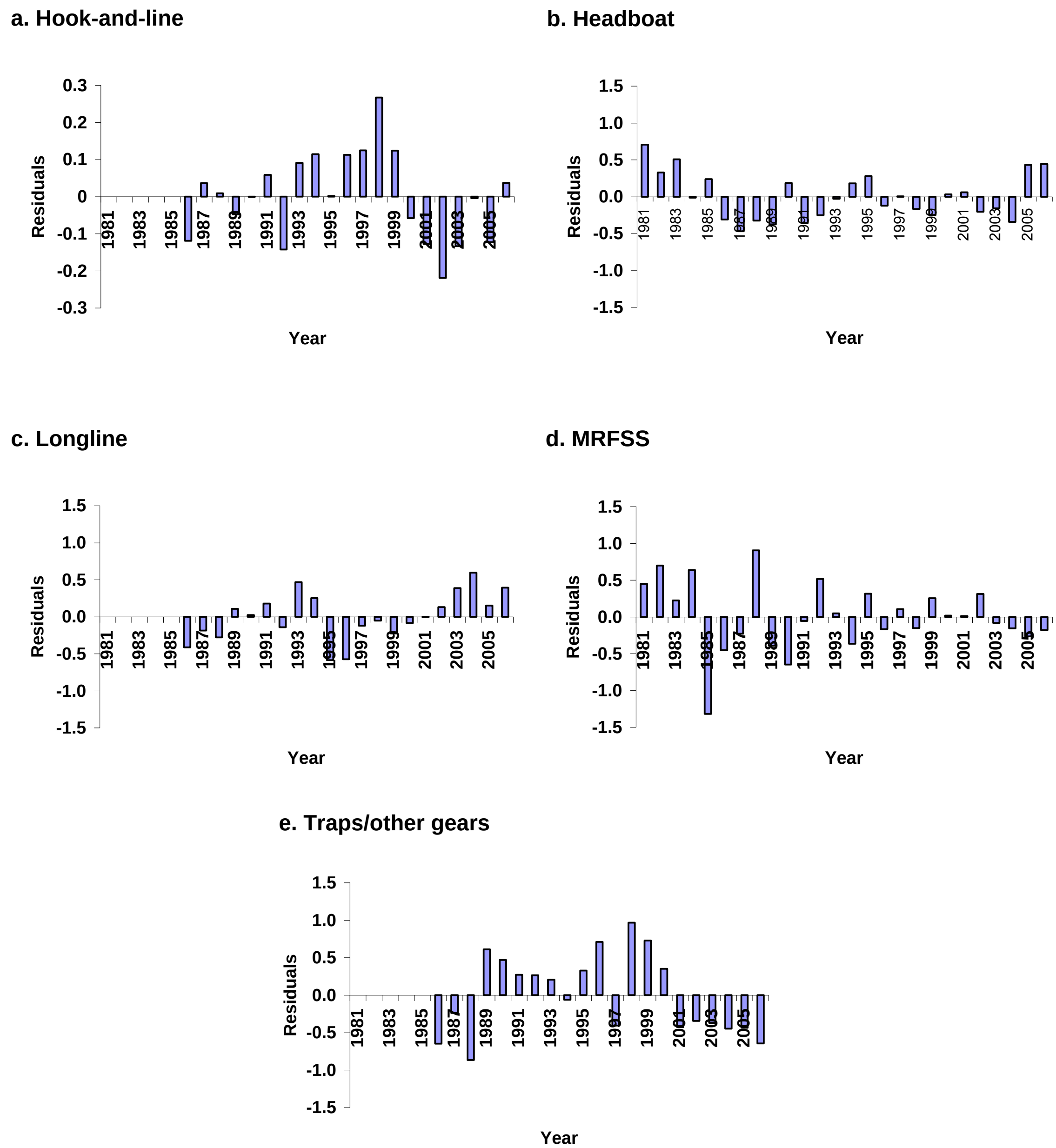


Figure 2.2.2.2. Landings residuals on logarithmic scale by fishery from the Excel surplus production model.

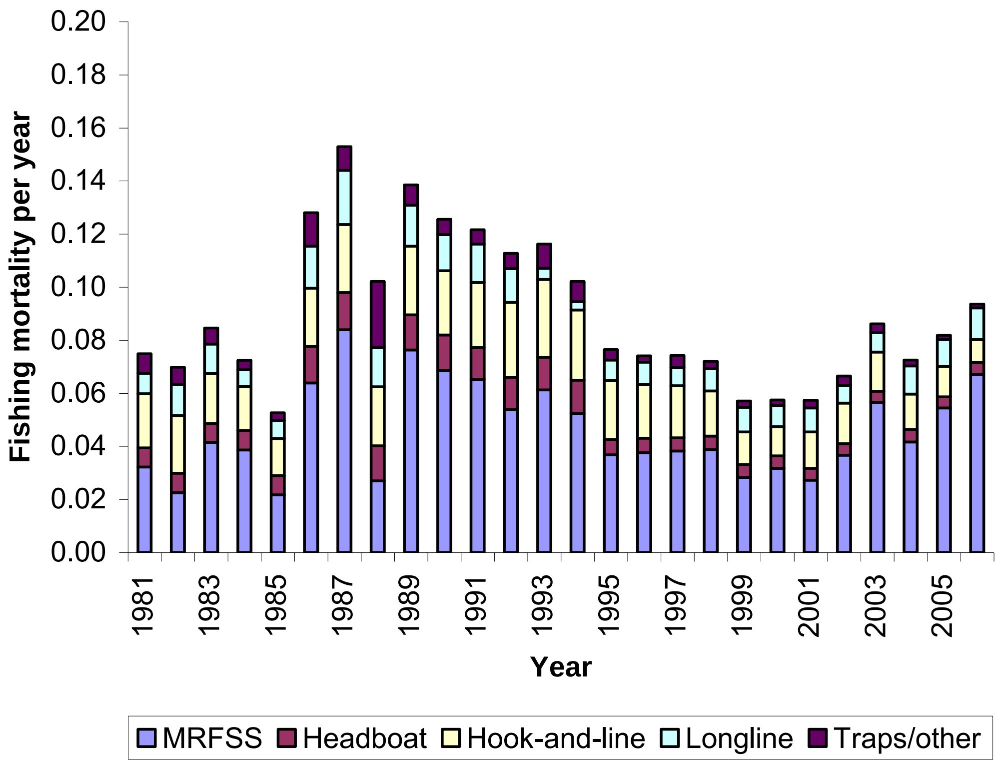


Figure 2.2.2.3. Fishing mortality rates estimated by fishery from the Excel surplus production model.

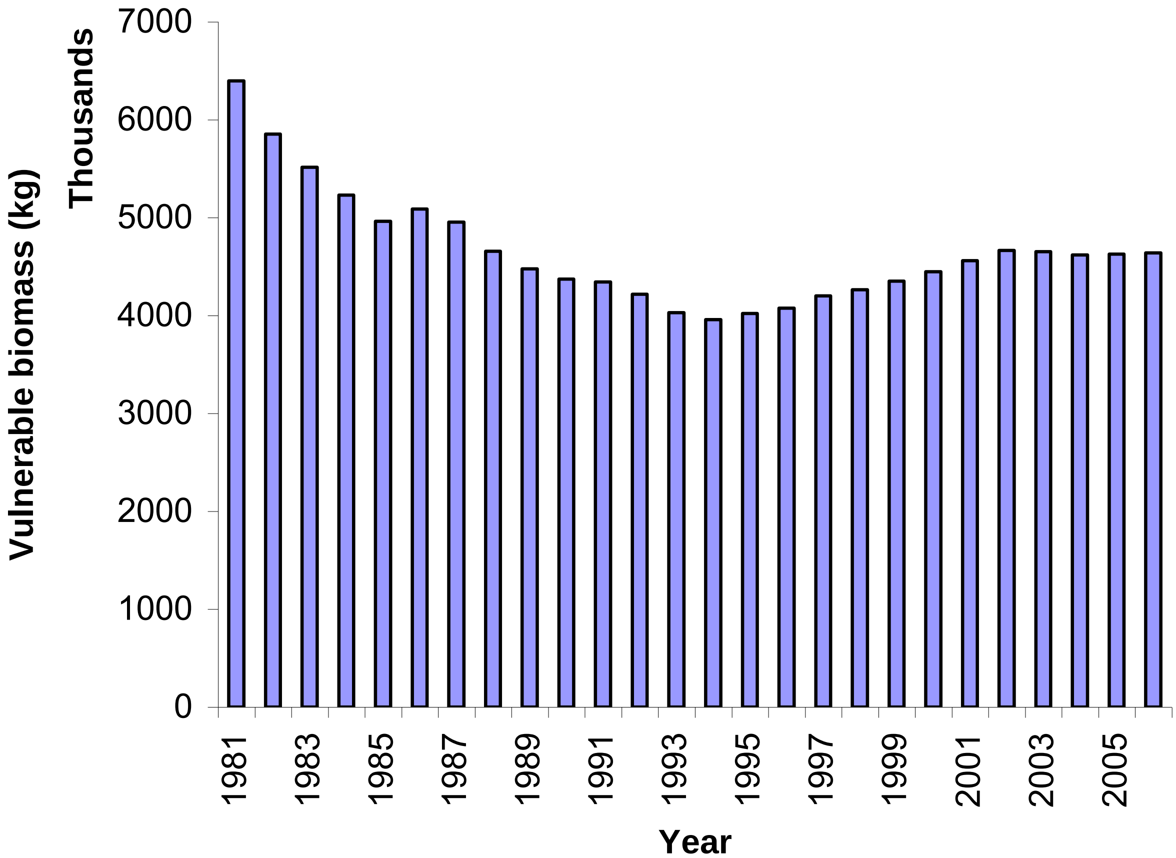


Figure 2.2.2.4. Estimated vulnerable biomass from the Excel surplus production model.

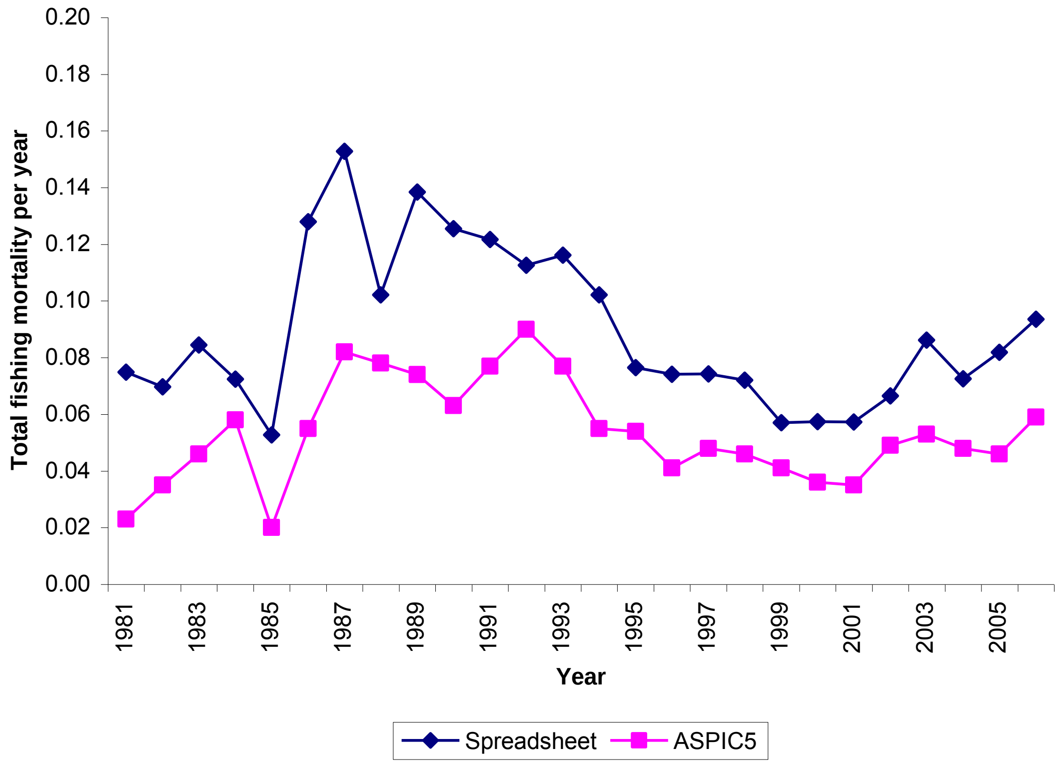


Figure 2.2.2.5. Comparison of fishing mortality rates estimated by the spreadsheet surplus production model and those estimated with ASPIC5.

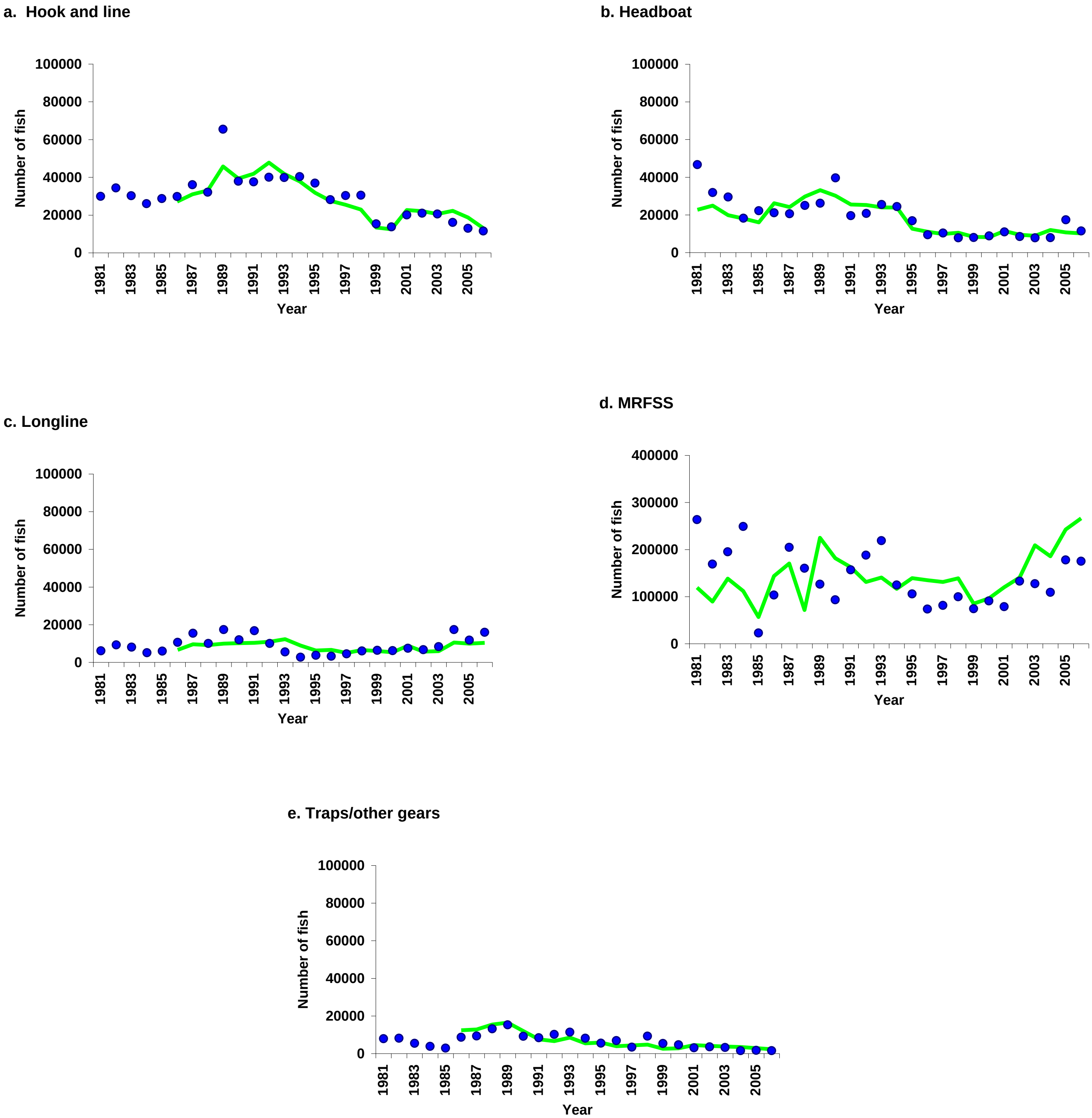


Figure 2.2.3.1. Observed landings by fishery sector (dots) and predicted (lines) values the modified DeLury model.

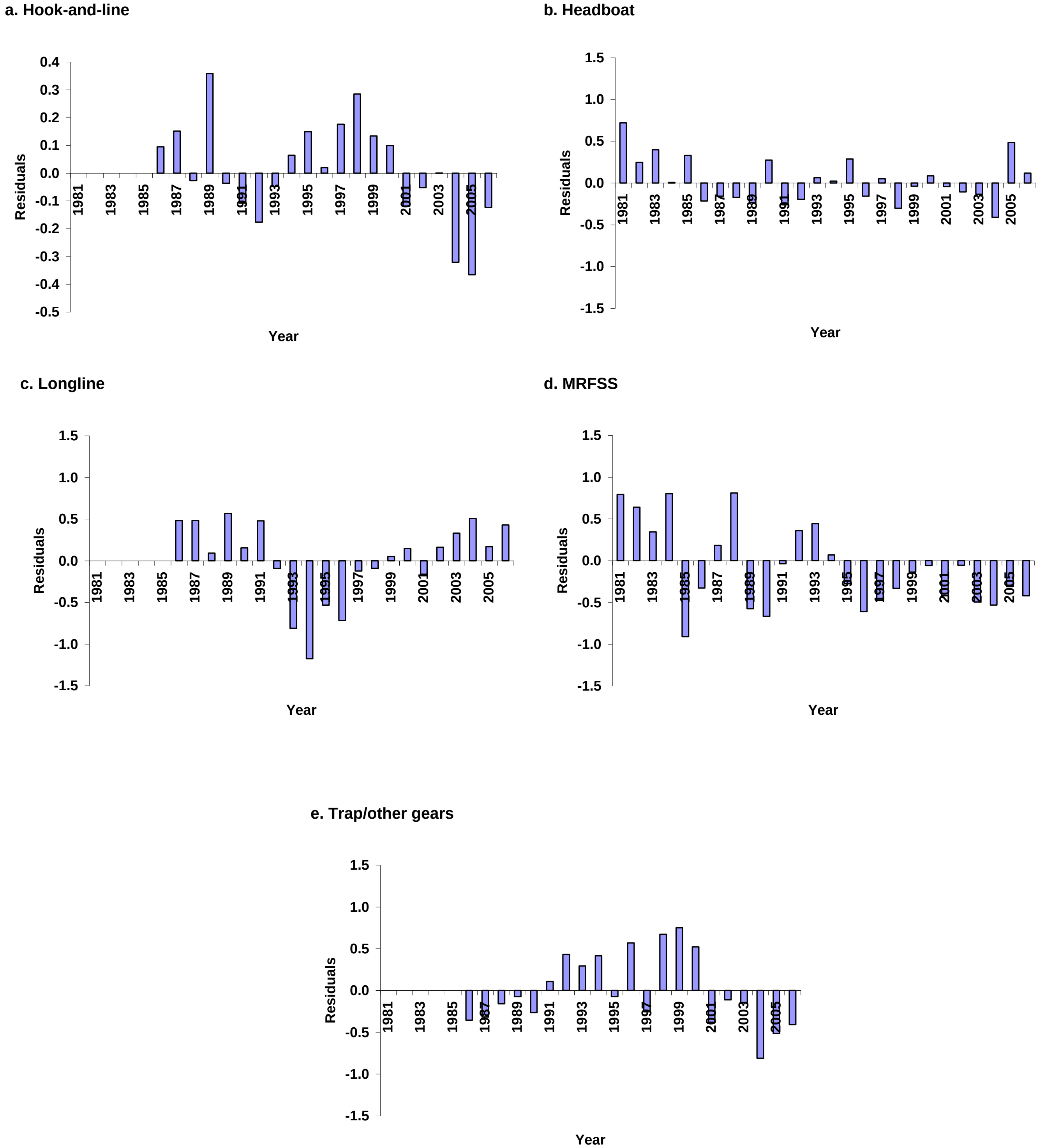


Figure 2.2.3.2. Landings residuals on a logarithmic scale by fishery sector from the modified DeLury model.

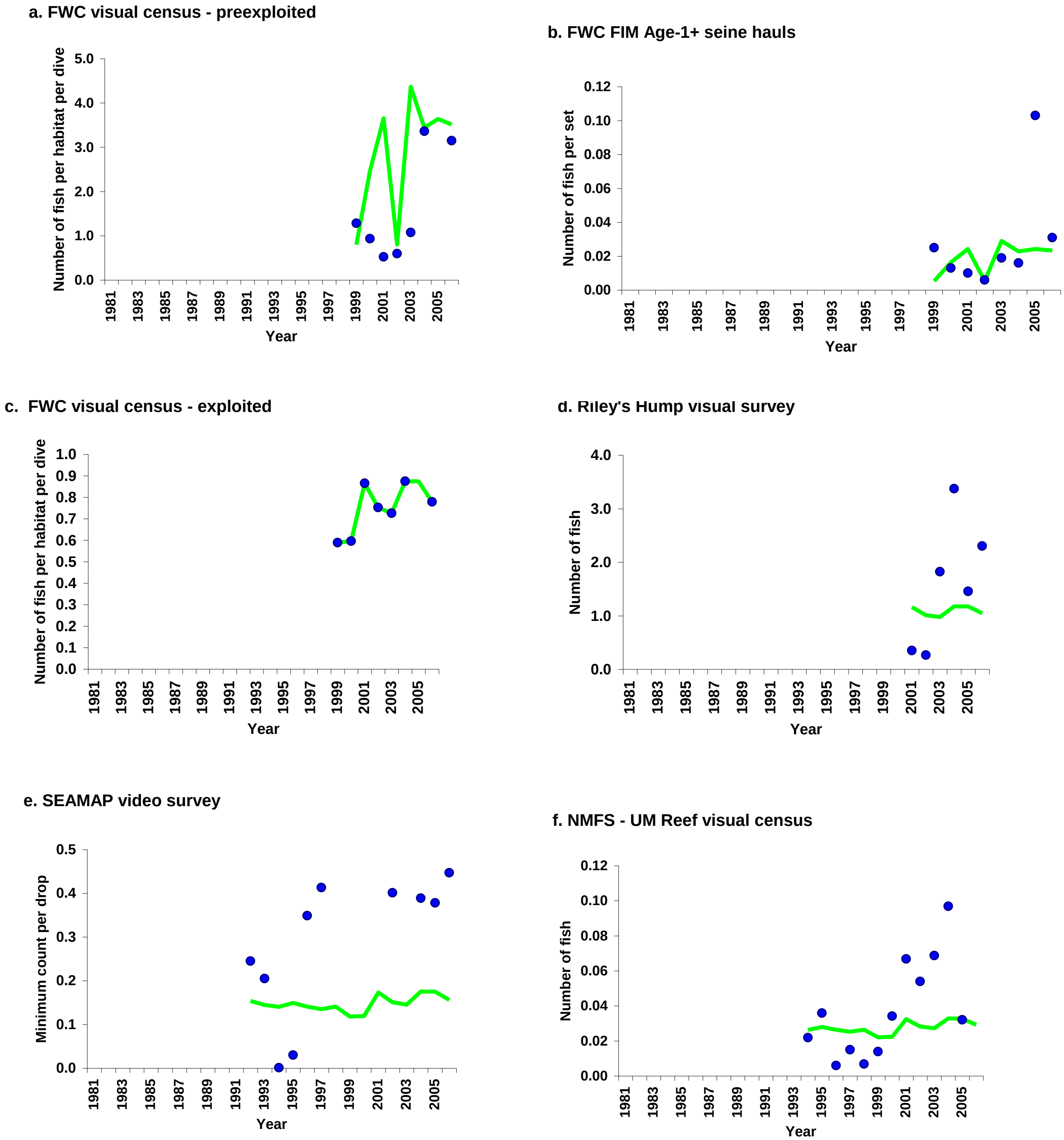


Figure 2.2.3.3. Observed (dots) indices of abundance and predicted (lines) estimates from the modified DeLury model.

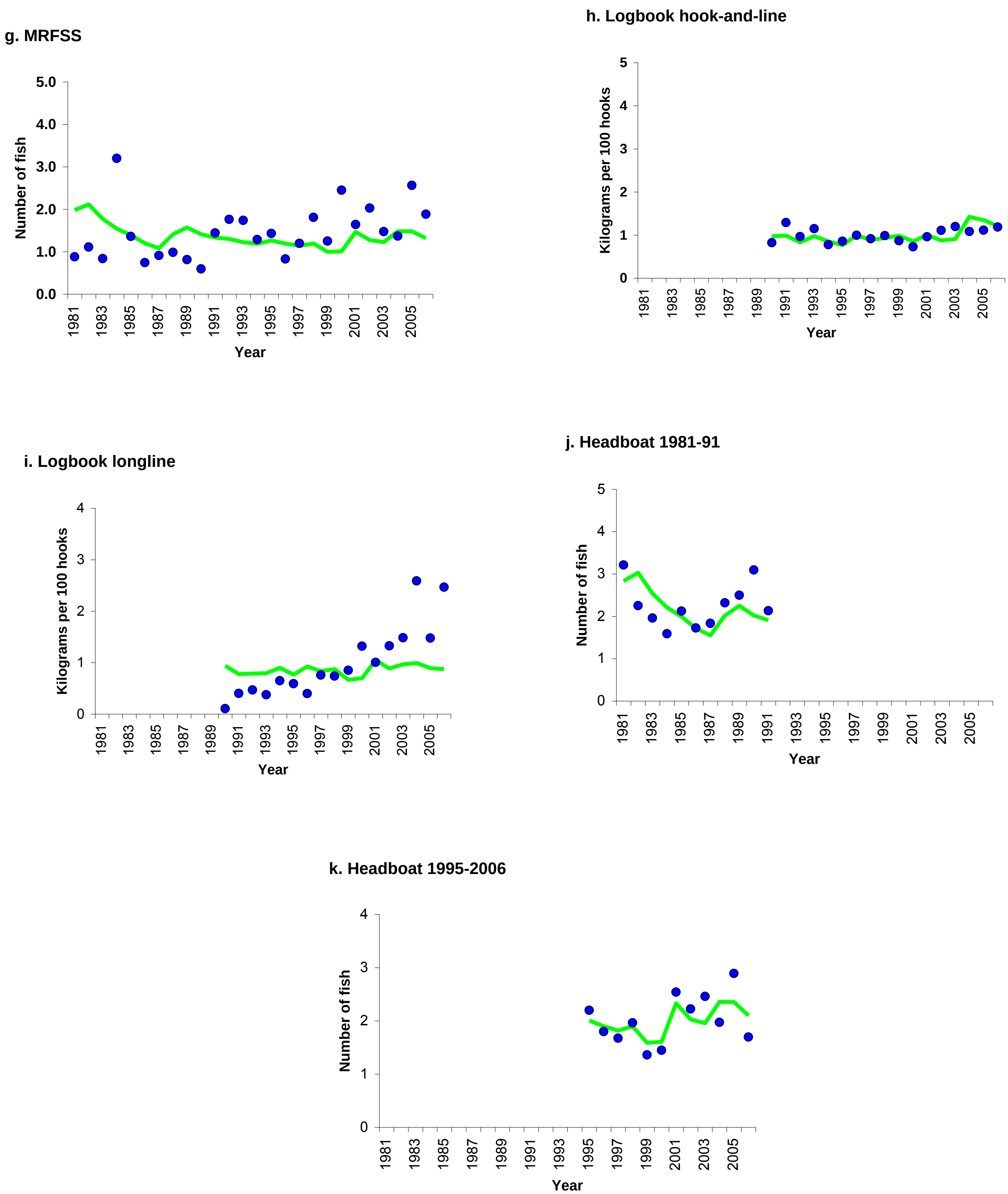


Figure 2.2.3.3 continued. Observed (dots) indices of abundance and predicted (lines) estimates from the modified DeLury model.

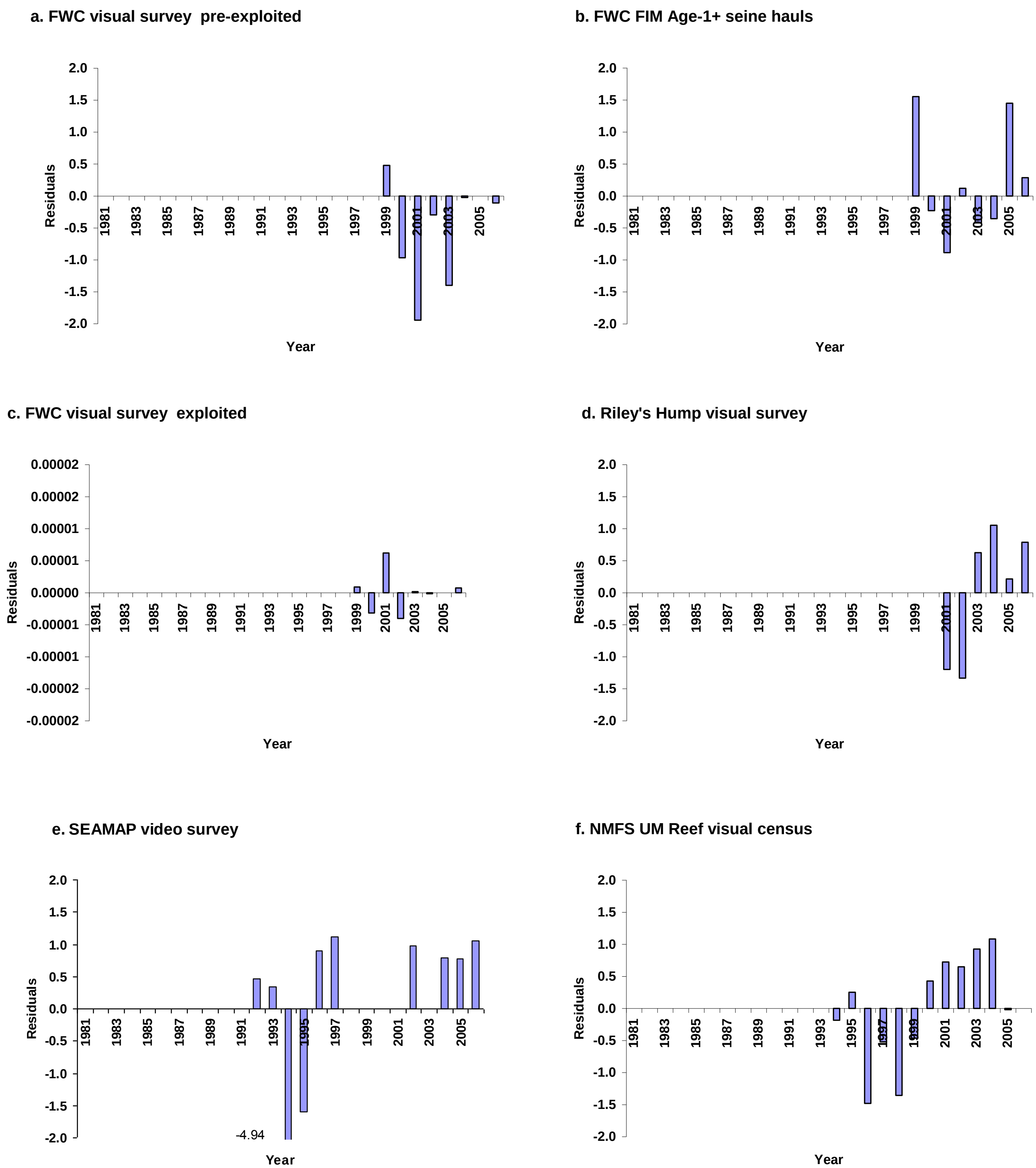


Figure 2.2.4.4. Residuals of indices of abundance on a logarithmic scale from the modified DeLury model.

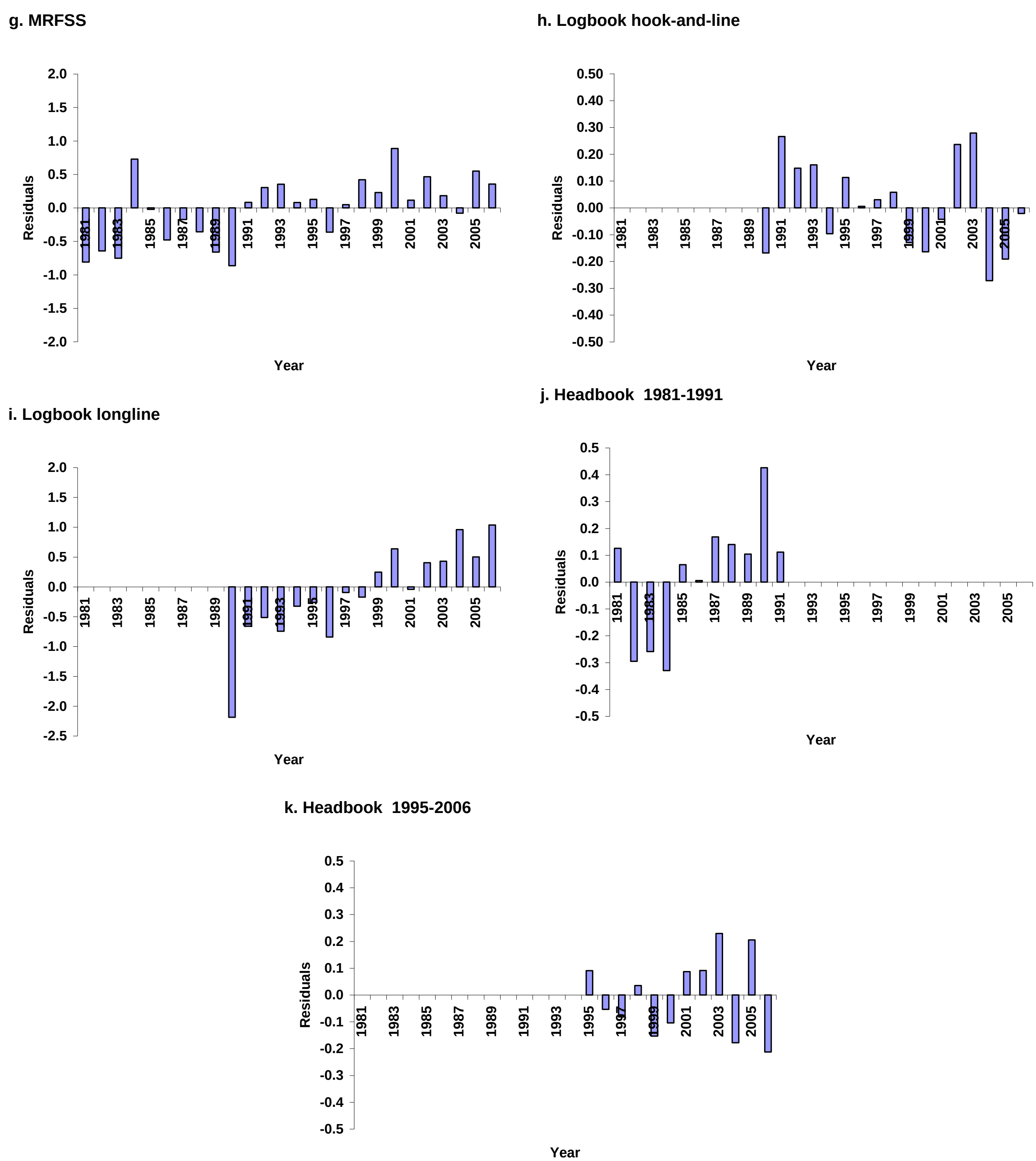


Figure 2.2.4.4 continued. Residuals of indices of abundance on a logarithmic scalefrom the modified DeLury model.

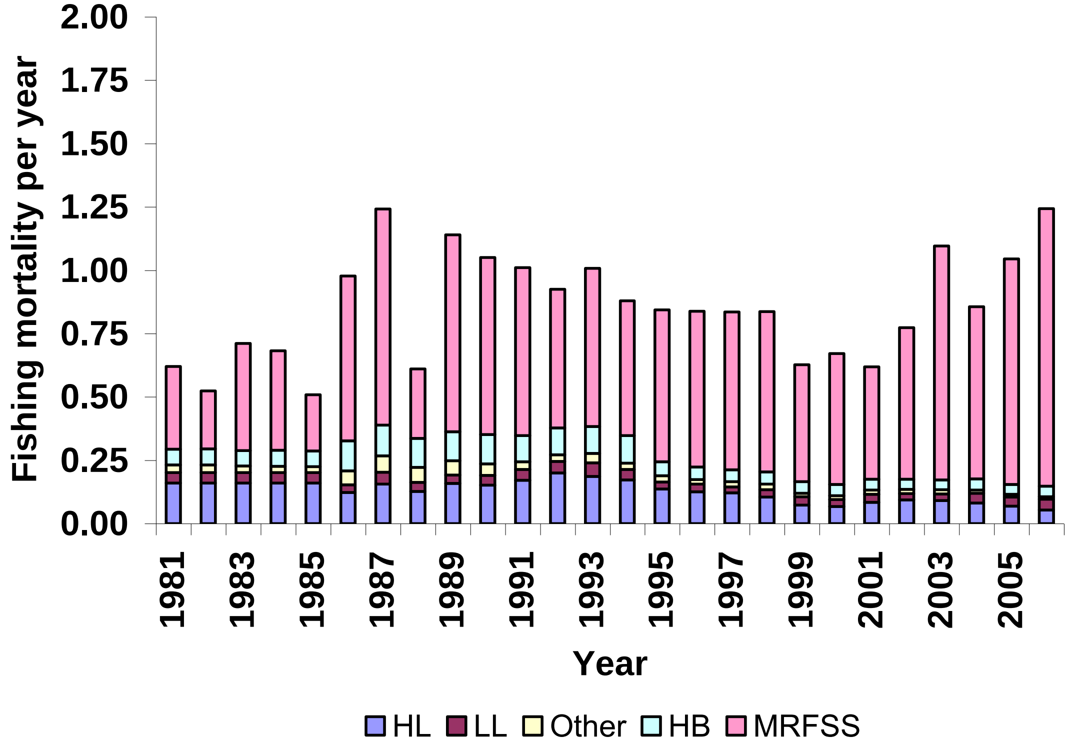


Figure 2.2.3.5. Fishing mortality rates by fishing sector from the modified DeLury model.

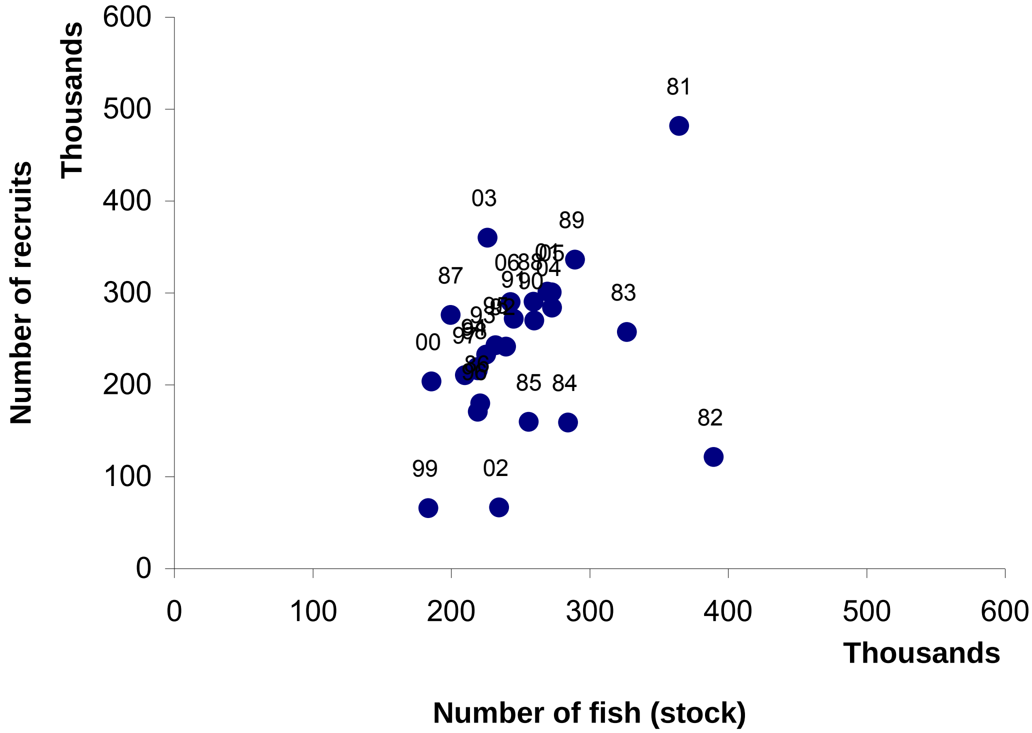


Figure 2.2.3.6. The numbers of fish recruiting during the year and the average population size in numbers of fish as estimated by the modified DeLury model. The numbers above the points refer to the year.

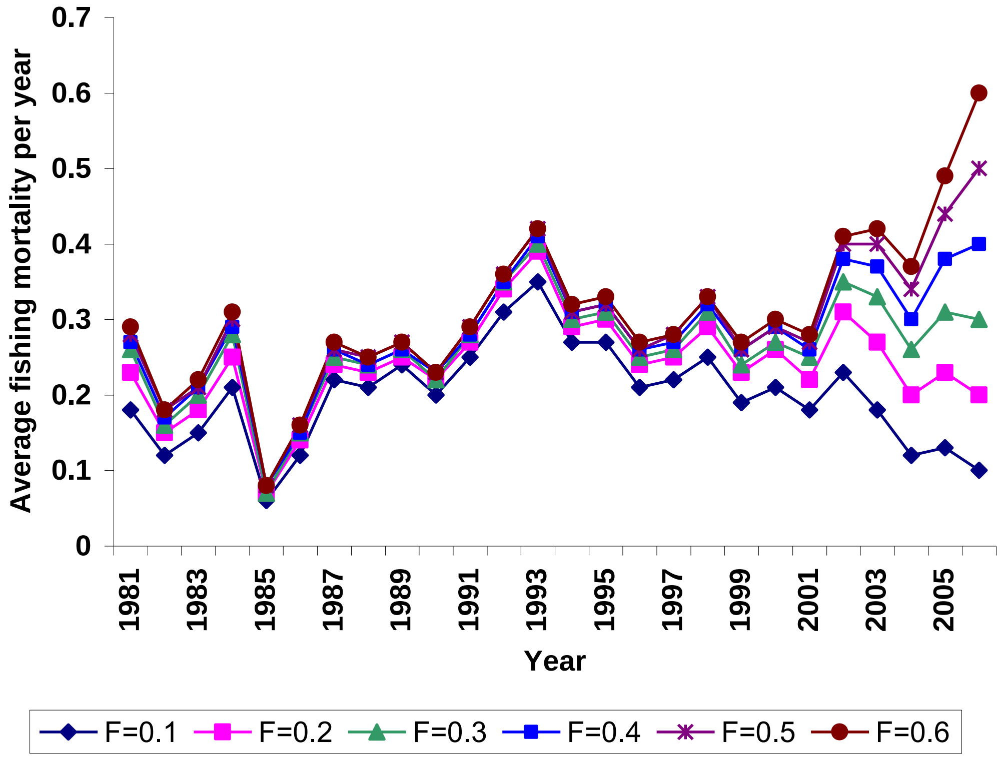


Figure 2.2.4.1 Average fishing mortality rates by year weighted by annual catches for a range of terminal fishing mortality rates of 0.1 to 0.6 per year.

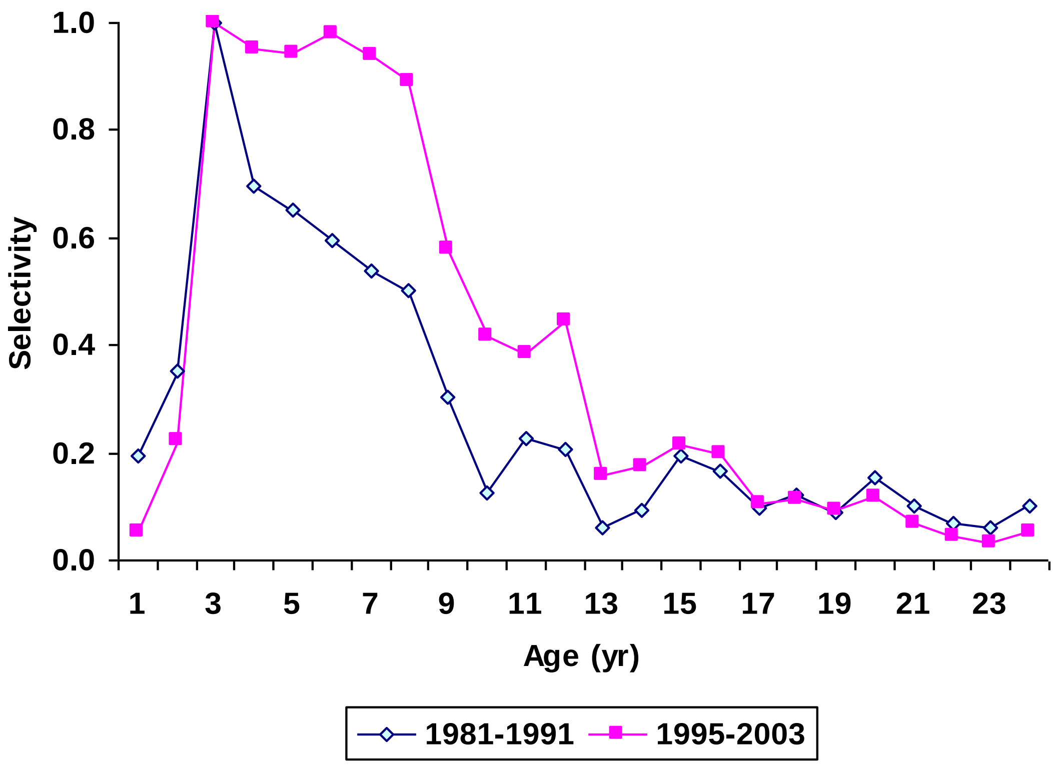


Figure 2.2.4.2. Selectivity for two time periods estimated with the untuned VPA from the aggregated catch-at-age. The patterns are weighted averages using terminal fishing mortality rates of 0.1 to 0.6 per year in 0.1 increments and weighted by estimated population sizes.

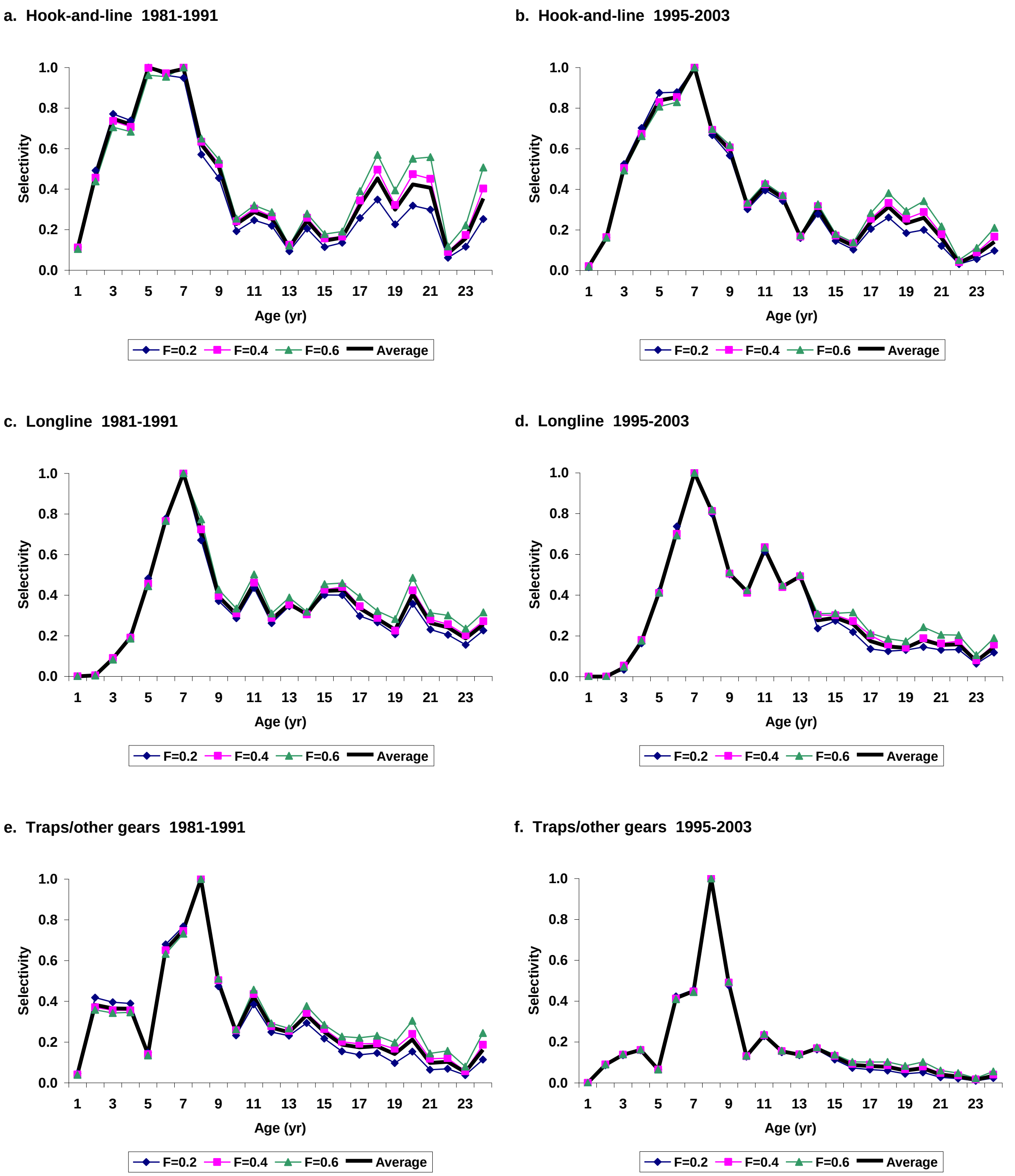
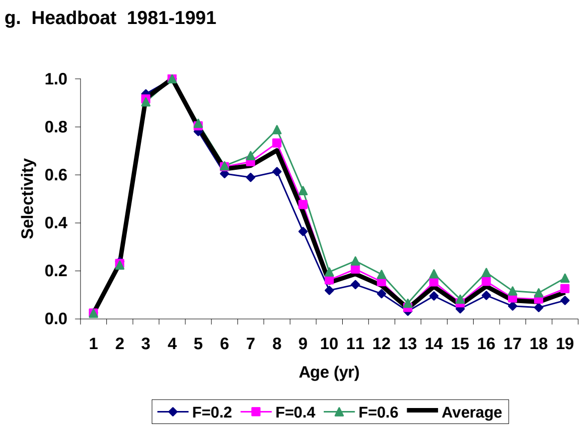
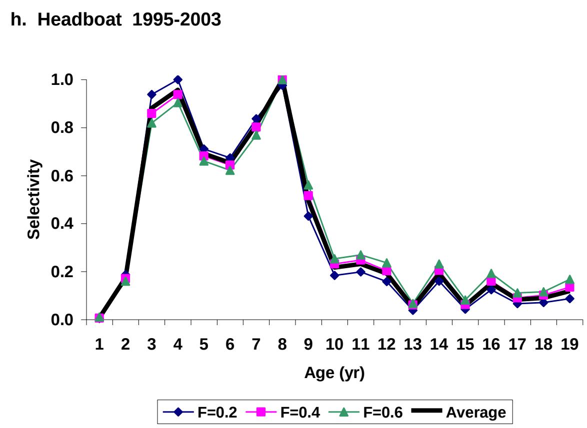
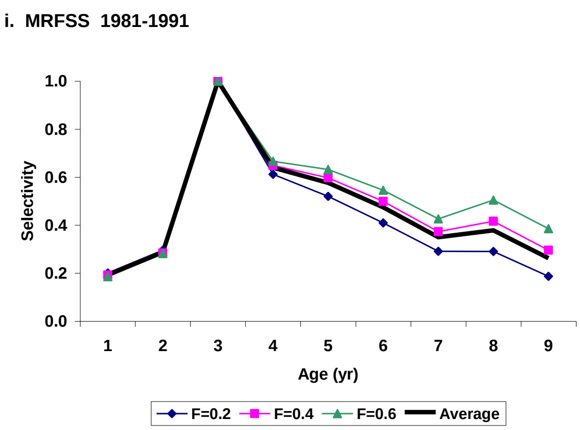


Figure 2.2.4.3. Selectivity by fishery sector and year from the untuned virtual population analysis with three terminal fishing mortality rates, 0.2 per year, 0.4 per year, and 0.6 per year. The line labeled 'Average' is the annual average of the results with the three terminal-fishing-mortality-rates models weighted by the corresponding estimated population size in numbers.







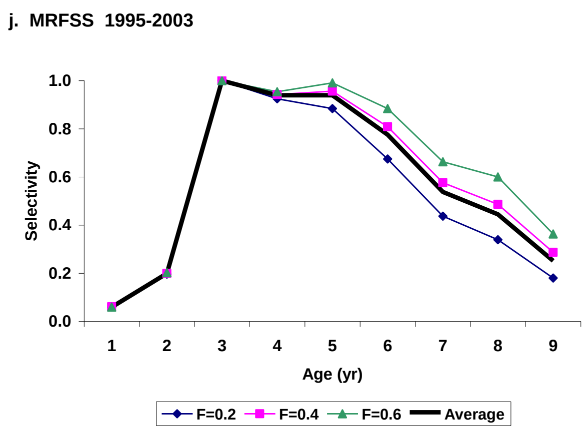
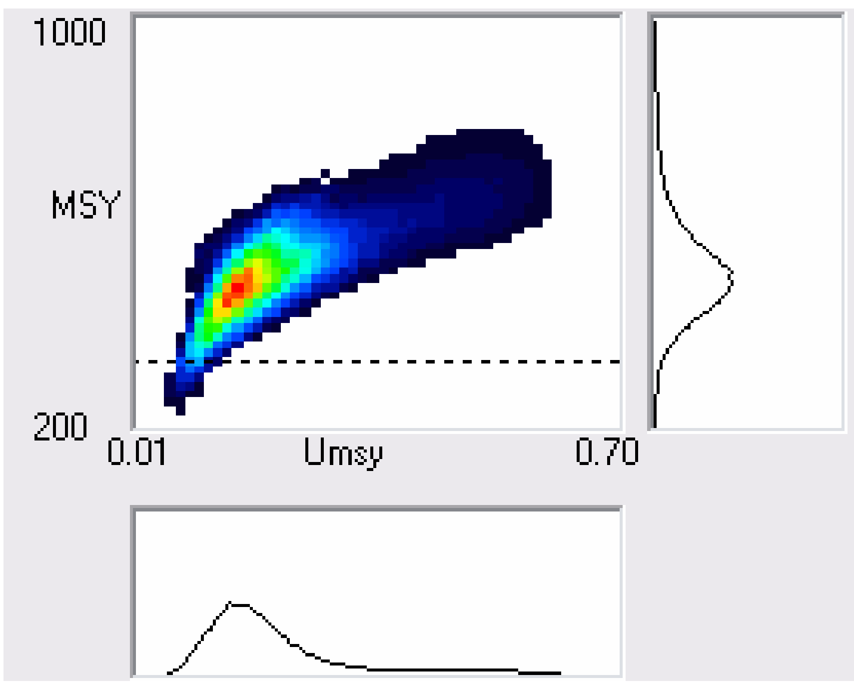


Figure 2.2.4.3 continued. Selectivity by fishery sector and year from the untuned virtual population analysis with three terminal fishing mortality rates, 0.2 per year, 0.4 per year, and 0.6 per year. The line labeled 'Average' is the annual average of the results with the three terminal-fishing-mortality-rates models weighted by the corresponding estimated population size in numbers.



MSY = 489 mt.

Umsy = 0.16

Figure 2.2.5.1. Distributions of maximum sustained yield (MSY) and its associated exploitation (Umsy) from input dome-shaped selectivity patterns from the Stochastic Stock Reduction Analysis.

.

b.

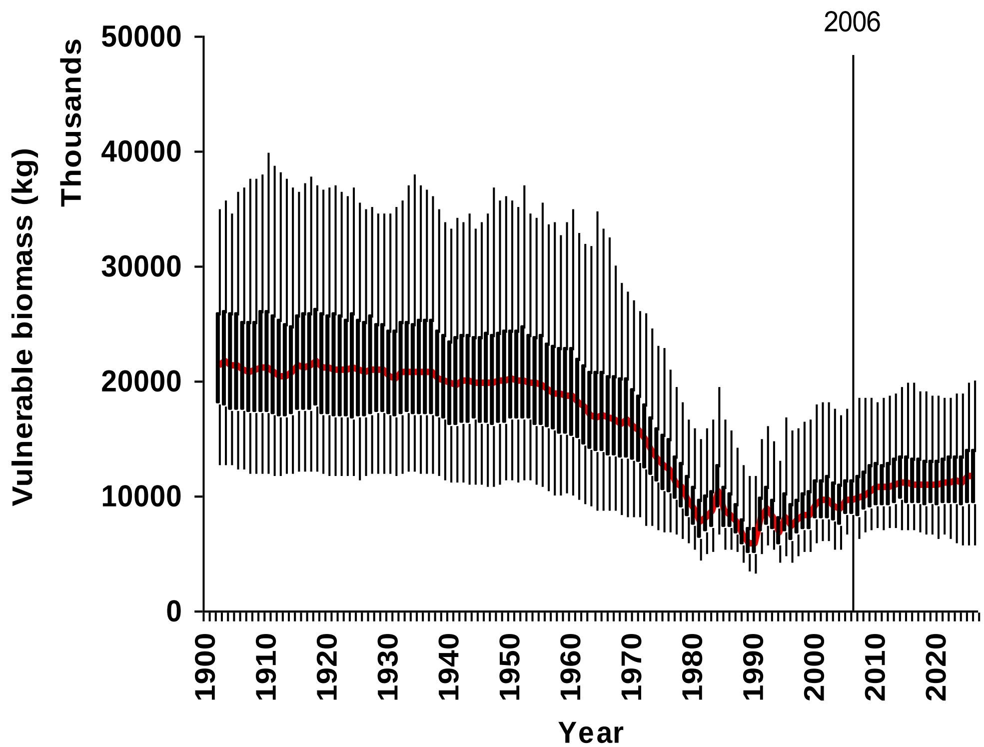


Figure 2.2.5.2. Vulnerable biomass estimated by stock reduction analysis using two dome-shaped selectivity patterns and aggregated landings from 1902 to 2006 and projected to 2026. The SRA was tuned with the MRFSS index (longest time series) and the projections used an exploitation rate of 0.2. The vertical lines are the 95% confidence limits, the darker shaded region is the inter-quartile ranges, and the heavy line is the median.

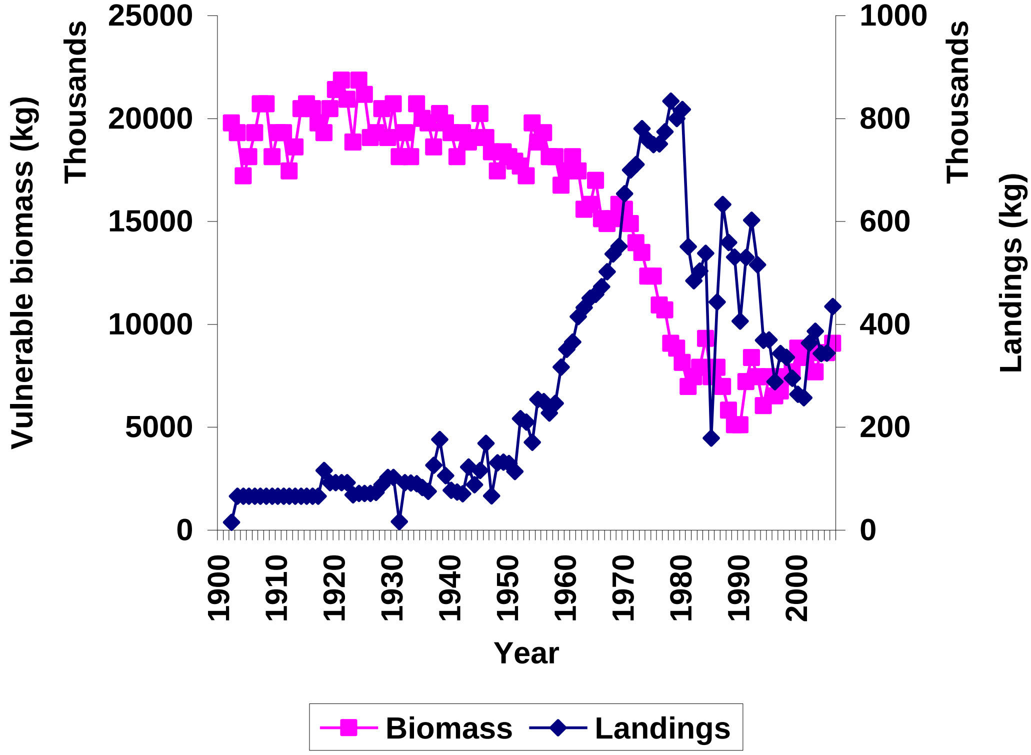


Figure 2.2.5.3. Estimates of vulnerable biomass with annual landings superimposed from the Stock Reduction Analysis.

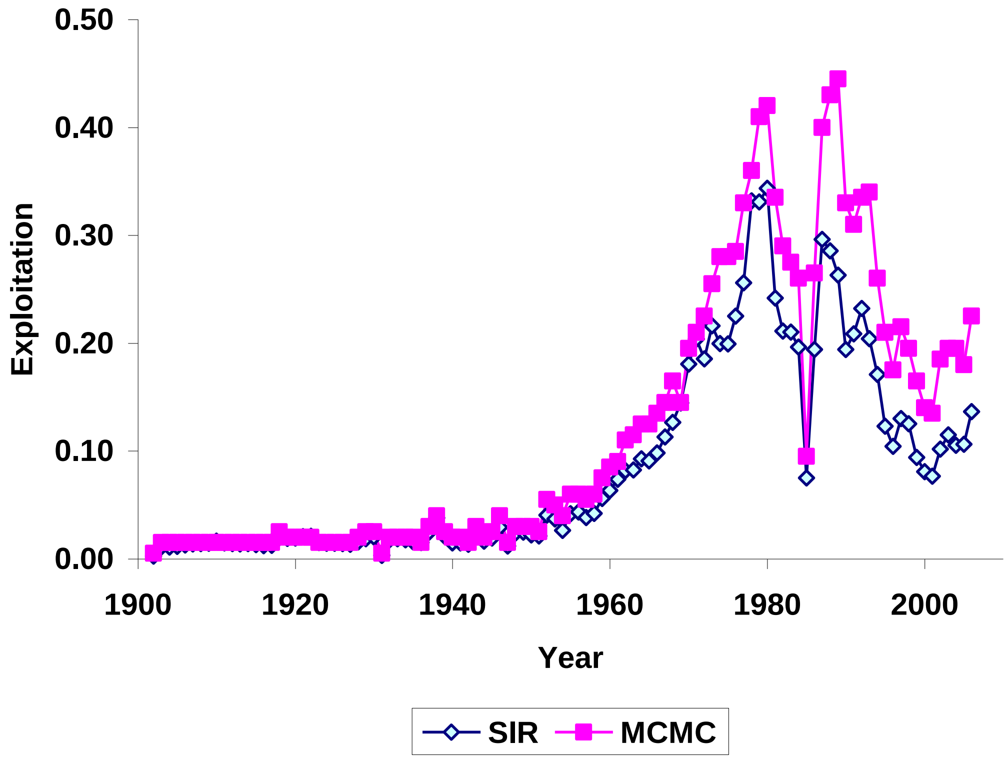


Figure 2.2.5.4. Exploitation rates estimated by the sampling-importance resampling (SIR) and the Monte Carlo-Markov Chain (MCMC) simulation.

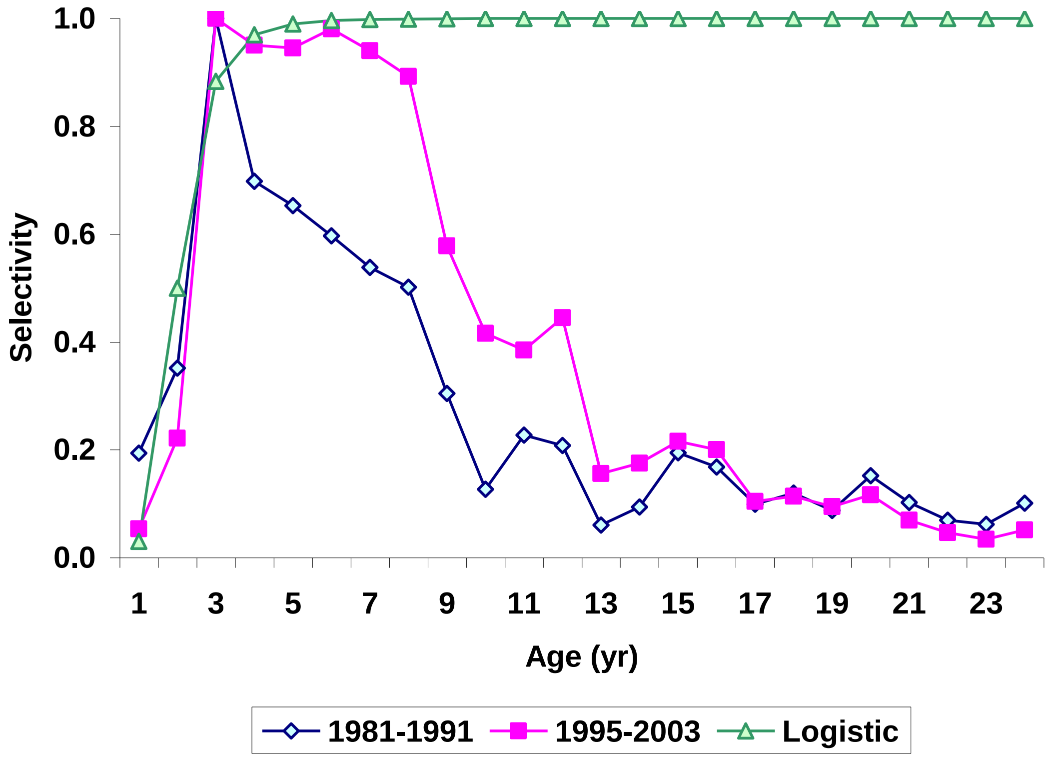
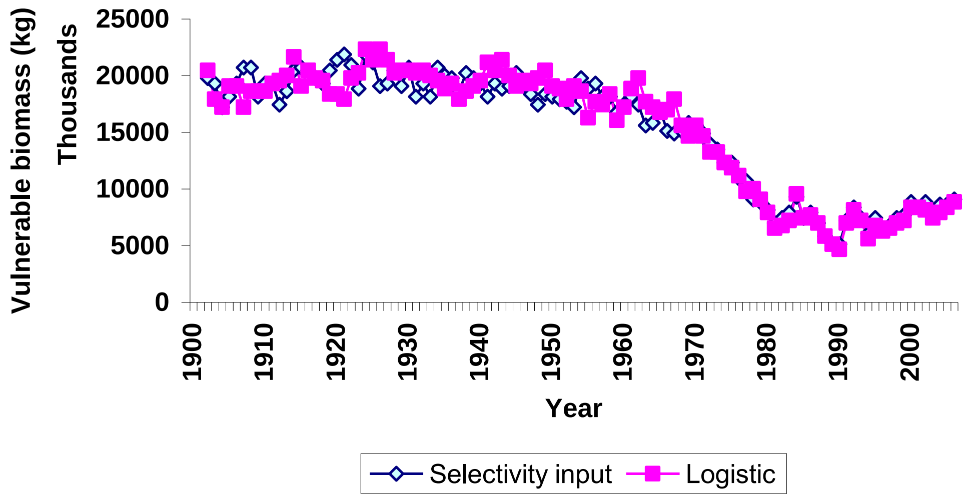


Figure 2.2.5.5. Selectivity for two time periods estimated with the untuned VPA from the aggregated catch-at-age and the logistic selectivity used in the Stock Reduction Analysis.

a.



b.

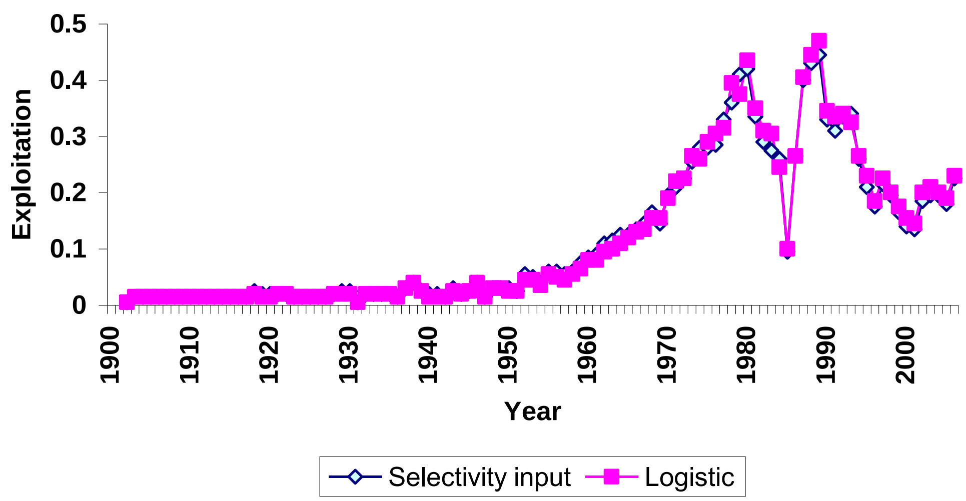


Figure 2.2.5.6. Comparing SRA-estimated of vulnerable biomass for the two selectivity patterns run (from the untuned Virtual Population Analysis) and the logistic-selectivity model run (a). Exploitation rates (b) estimated by the Stock Reduction Analysis using the different selectivity patterns.

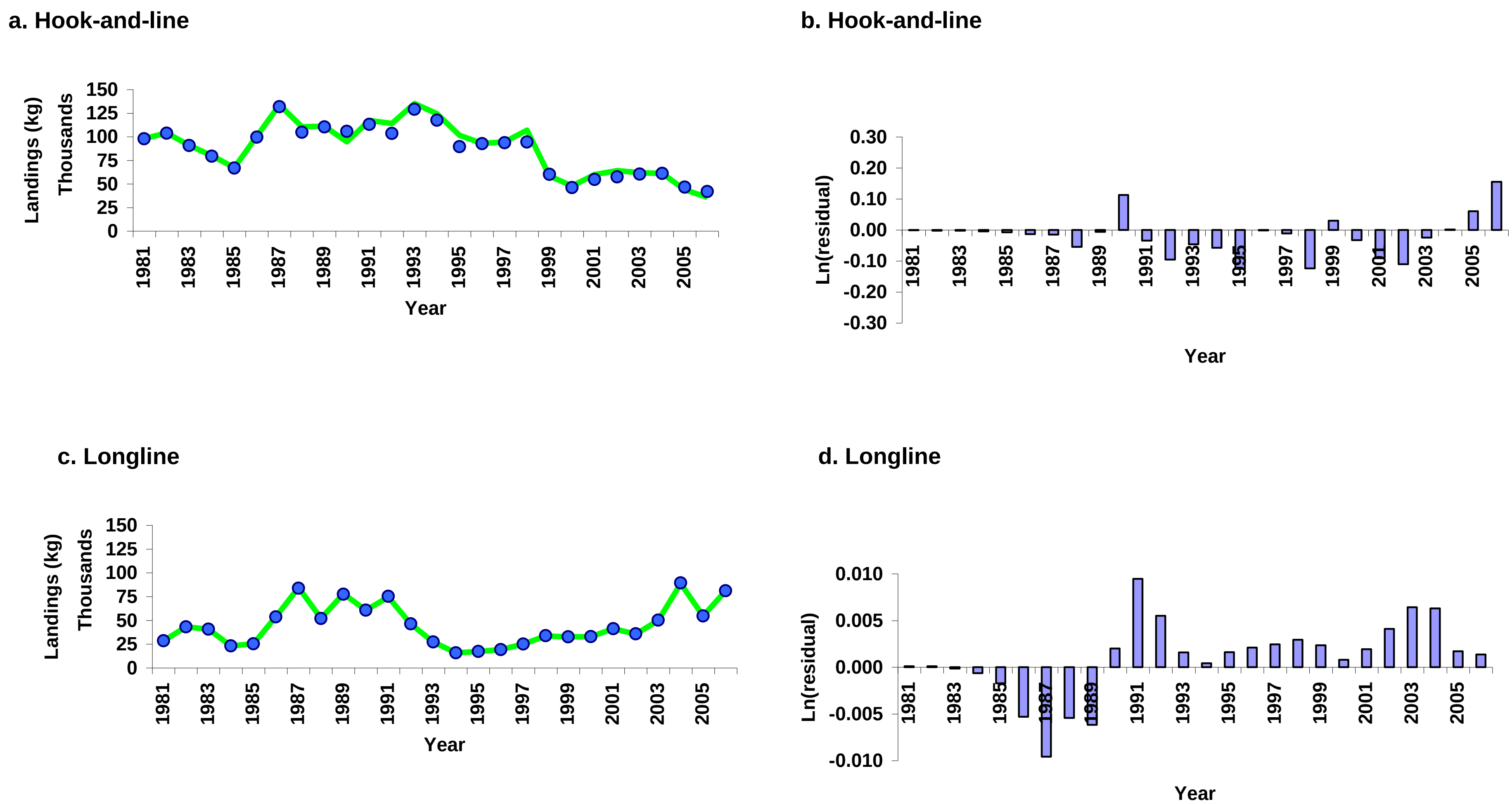
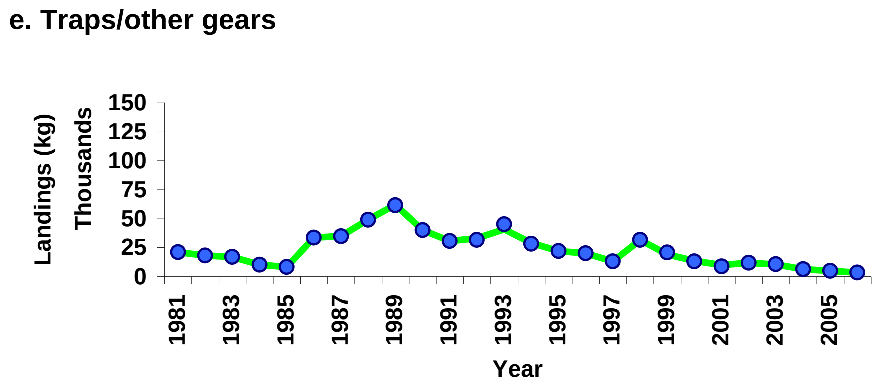
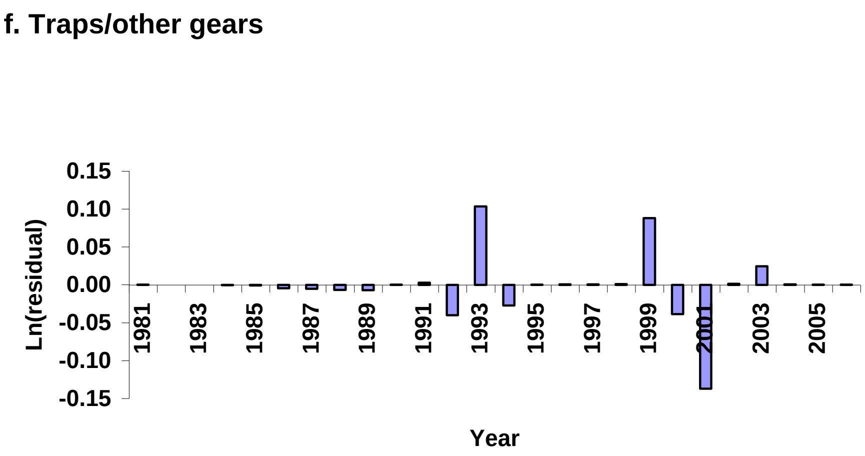
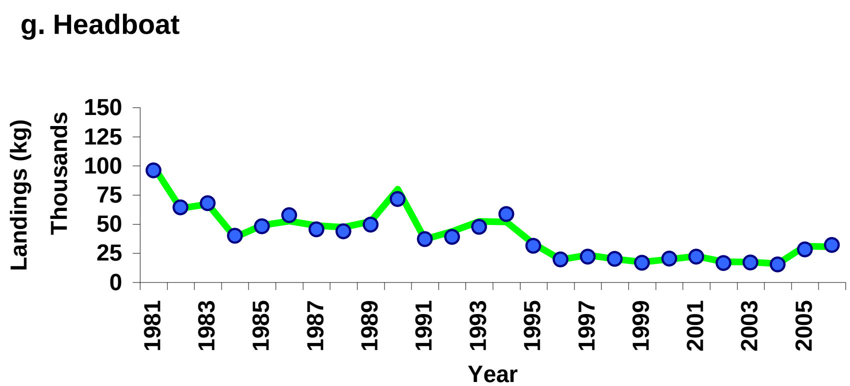


Figure 2.3.1.3.1. Fits of the ASAP model to annual landings in kilograms by fishery. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by fishery and year.







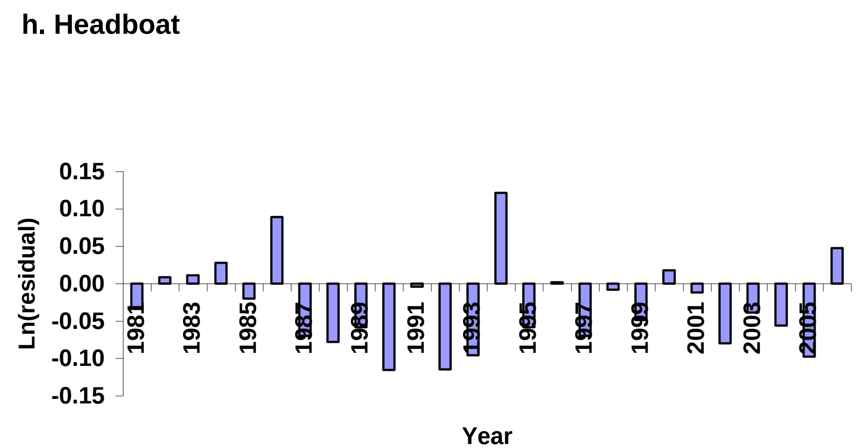
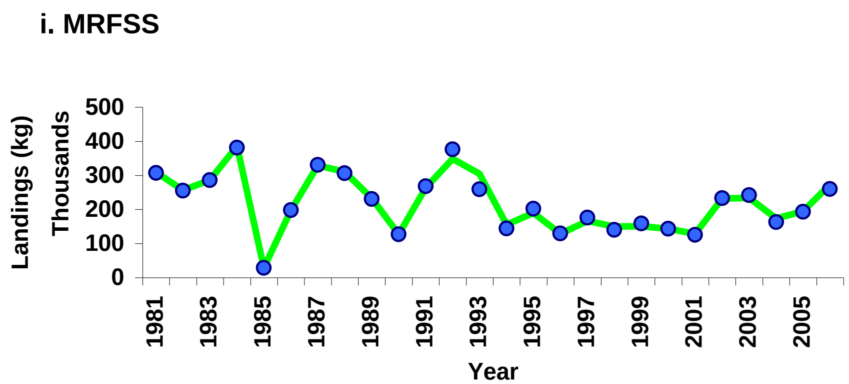


Figure 2.3.1.3.1 continued. Fits of the ASAP model to annual landings in kilograms by fishery. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by year.



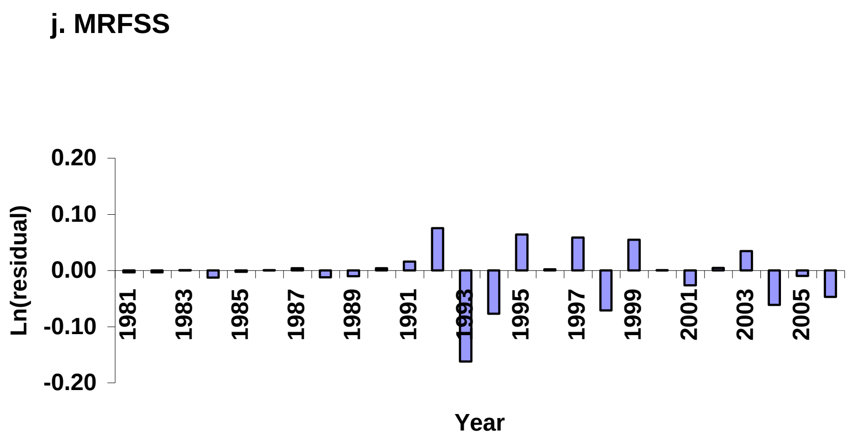


Figure 2.3.1.3.1 continued. Fits of the ASAP model to annual landings in kilograms by fishery. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by year.

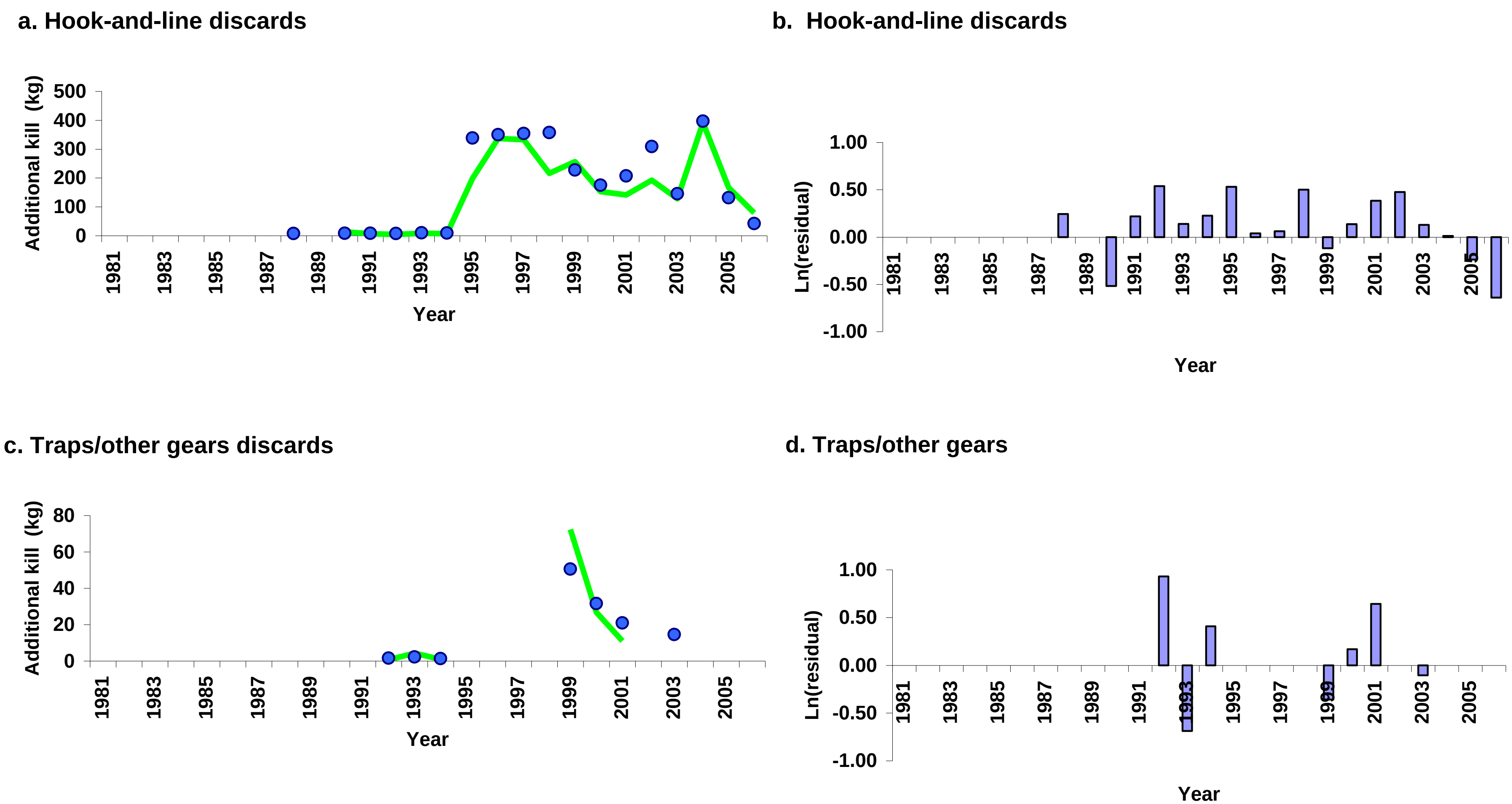


Figure 2.3.1.3.2. Fits of the ASAP model to annual discards in kilograms by fishery. There were no discards from longline trips. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by year. Note that there were not lengths of discards in every year for every fishery.

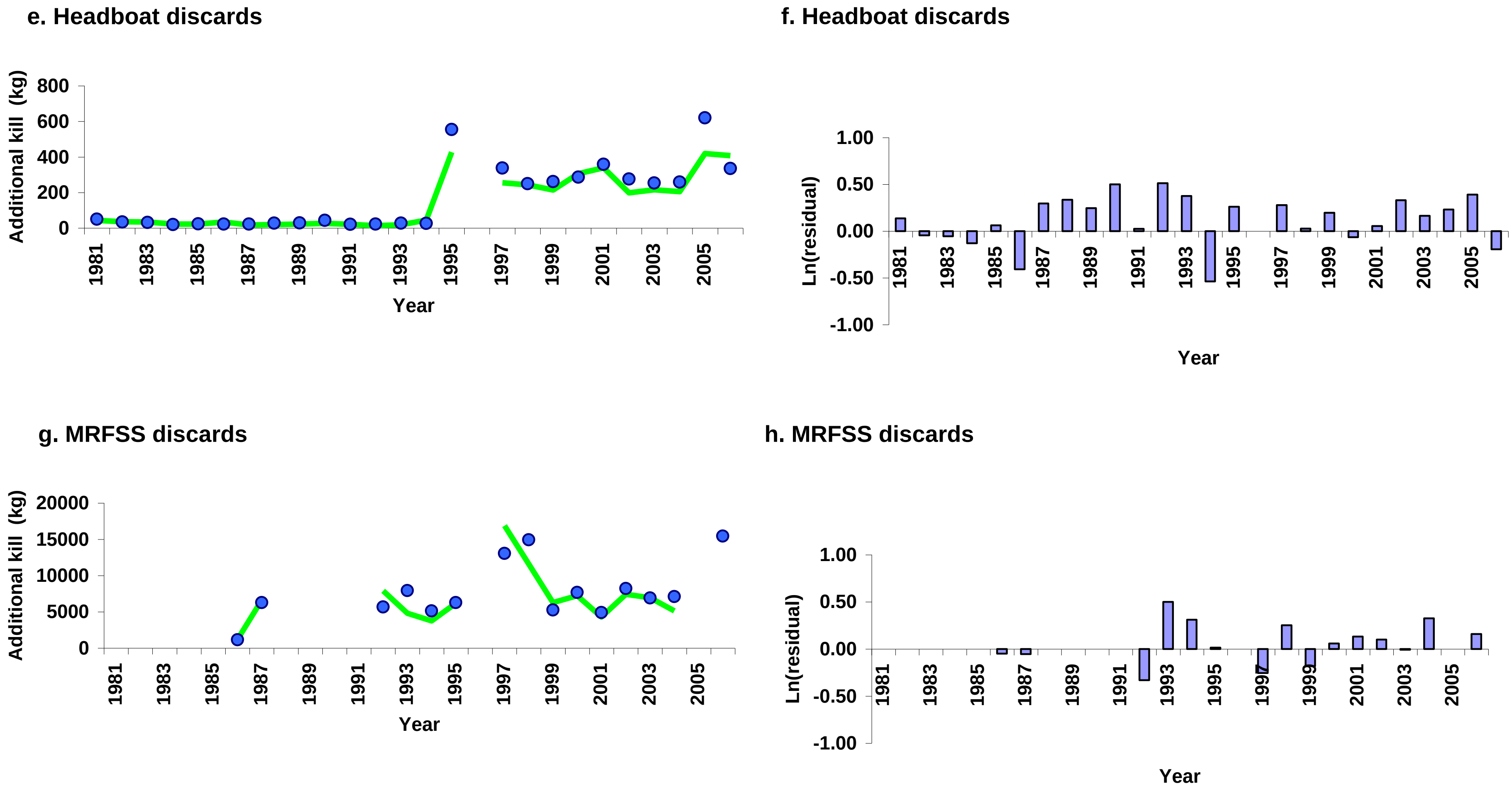
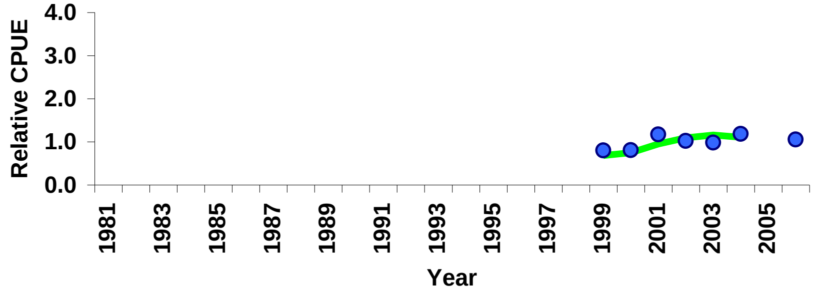
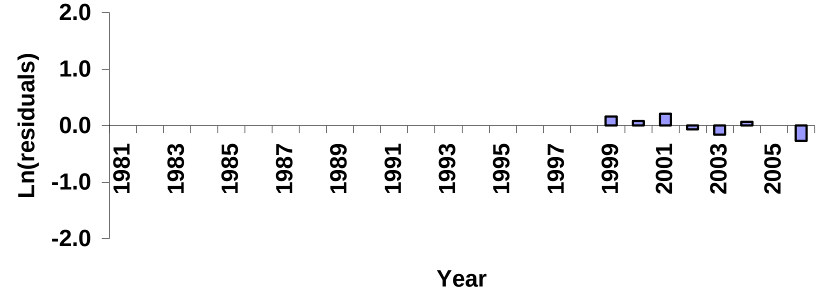


Figure 2.3.1.3.2 continued. Fits of the ASAP model to annual discards in kilograms by fishery. There were no discards from longline trips. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by year. Note that there were not lengths of discards in every year for every fishery.

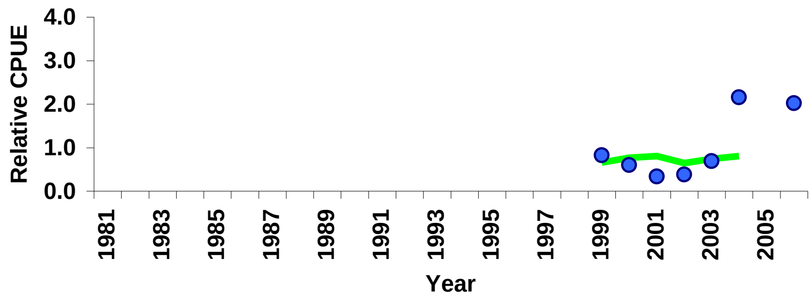
a. FWC Visual survey Exploited



b. FWC Visual survey Exploited



c. FWC Visual survey Pre-exploited



d. FWC Visual survey Pre-exploited

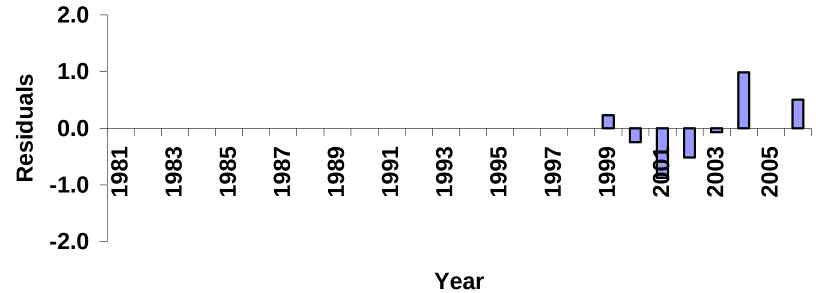
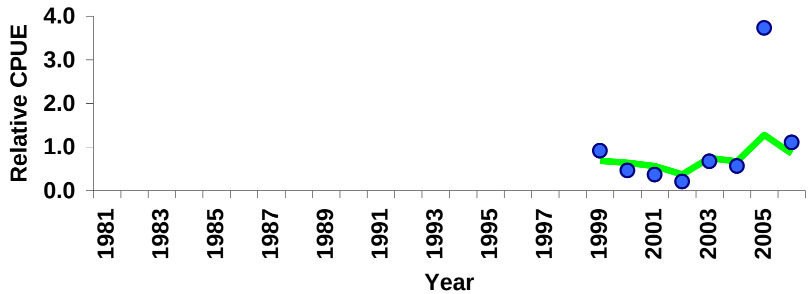
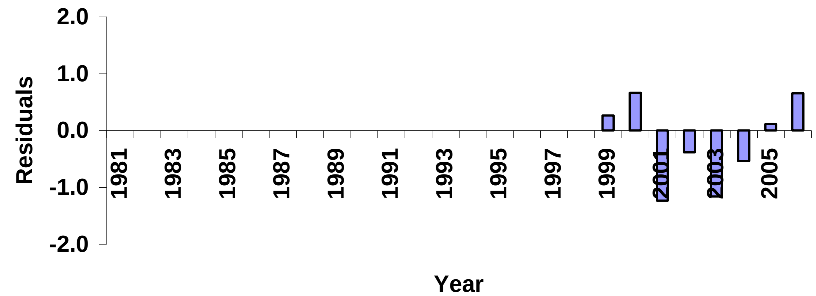


Figure 2.3.1.3.3. Fit of ASAP model to the 11 relative indices of abundance. Each index is scaled to its mean such that a value of 1.0 is equal to the mean of the index. The indices included in this model were: FWC Visual survey for exploited ages, FWC Visual survey of pre-exploited ages, FWC Fishery Independent Monitoring haul seine sets, NMFS-UM Reef visual census, NMFS Riley's Hump visual survey, SEAMAP Video survey, NMFS MRFSS total catch index, NMFS Logbook hook-and-line, NMFS Logbook longline, NMFS Headboat survey 1981-1991, and NMFS Headboat 1995-2006.

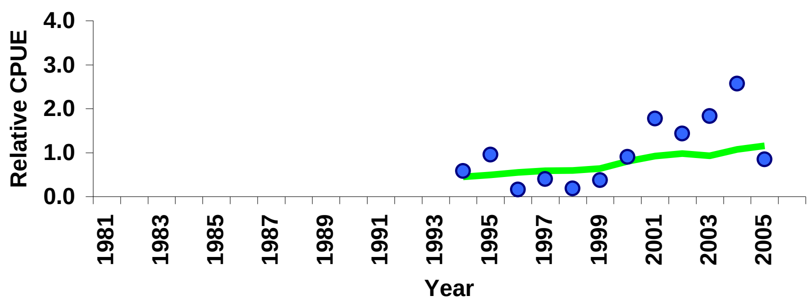
e. FWC Haul seines Ages 1+



f. FWC Haul seines Ages 1+



g. NMFS-UM Reef visual census



h. NMFS-UM Reef visual census

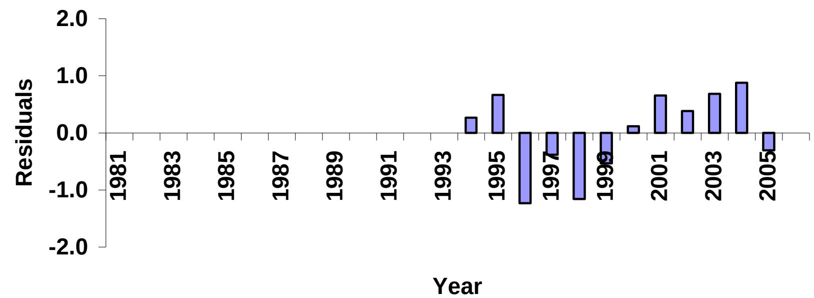
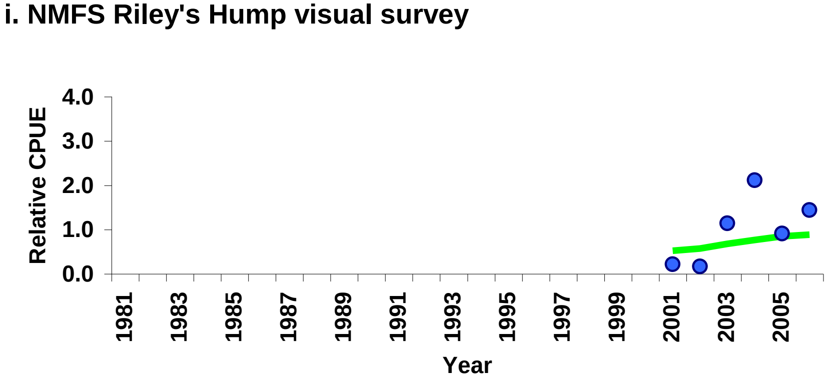
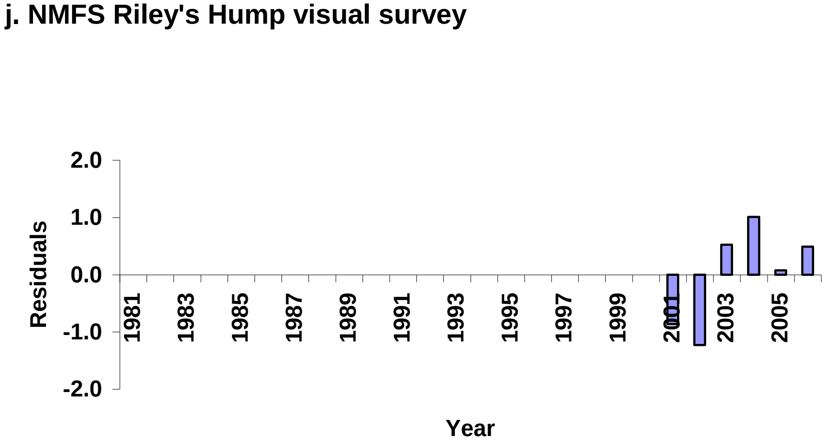
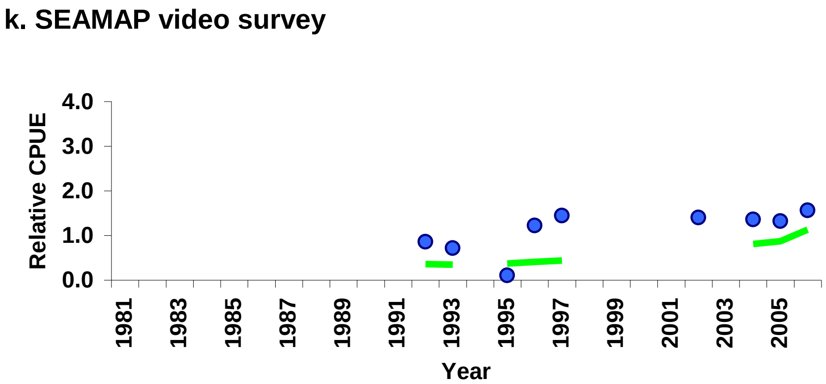


Figure 2.3.1.3.3 continued. Fit of ASAP model to the 11 relative indices of abundance. Each index is scaled to its mean such that a value of 1.0 is equal to the mean of the index. The indices included in this model were: FWC Visual survey for exploited ages, FWC Visual survey of pre-exploited ages, FWC Fishery Independent Monitoring haul seine sets, NMFS-UM Reef visual census, NMFS Riley's Hump visual survey, SEAMAP Video survey, NMFS MRFSS total catch index, NMFS Logbook hook-and-line, NMFS Logbook longline, NMFS Headboat survey 1981-1991, and NMFS Headboat 1995-2006.







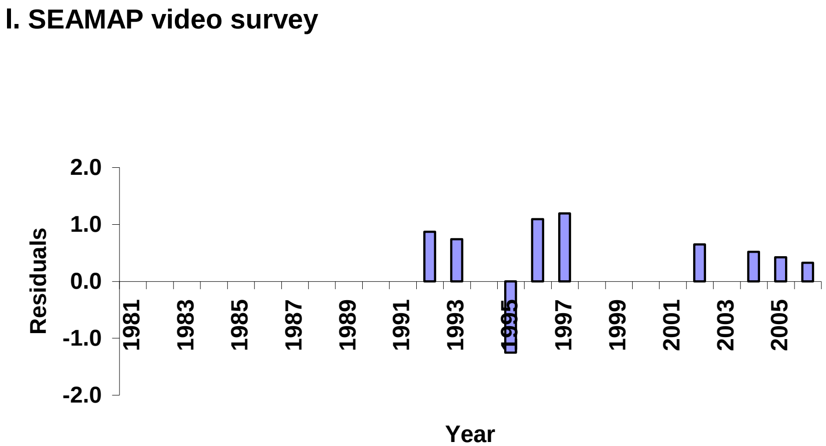
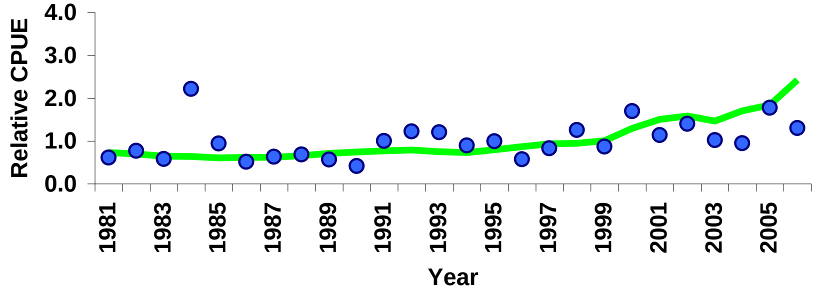
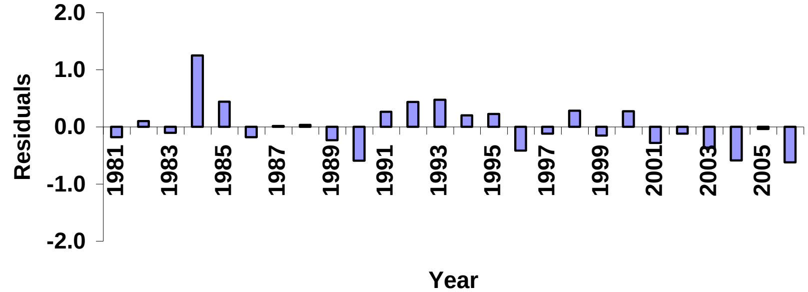


Figure 2.3.1.3.3 continued. Fit of ASAP model to the 11 relative indices of abundance. Each index is scaled to its mean such that a value of 1.0 is equal to the mean of the index. The indices included in this model were: FWC Visual survey for exploited ages, FWC Visual survey of pre-exploited ages, FWC Fishery Independent Monitoring haul seine sets, NMFS-UM Reef visual census, NMFS Riley's Hump visual survey, SEAMAP Video survey, NMFS MRFSS total catch index, NMFS Logbook hook-and-line, NMFS Logbook longline, NMFS Headboat survey 1981-1991, and NMFS Headboat 1995-2006.

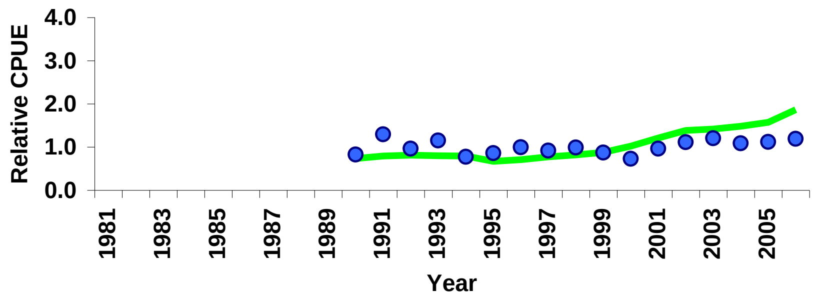
m. MRFSS



n. MRFSS



o. NMFS Logbook hook-and-line



p. NMFS Logbook hook-and-line

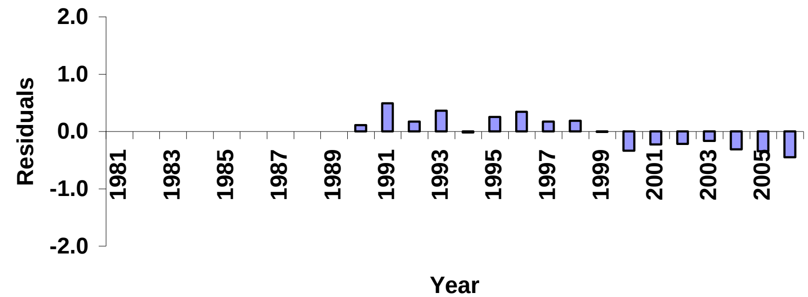
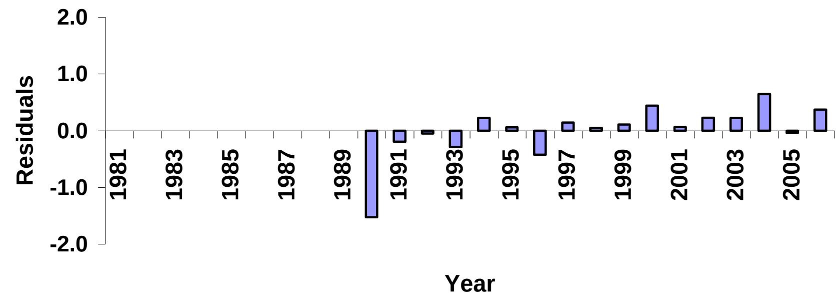
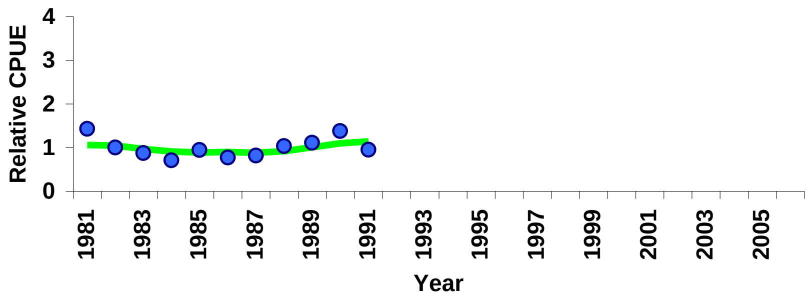


Figure 2.3.1.3.3 continued. Fit of ASAP model to the 11 relative indices of abundance. Each index is scaled to its mean such that a value of 1.0 is equal to the mean of the index. The indices included in this model were: FWC Visual survey for exploited ages, FWC Visual survey of pre-exploited ages, FWC Fishery Independent Monitoring haul seine sets, NMFS-UM Reef visual census, NMFS Riley's Hump visual survey, SEAMAP Video survey, NMFS MRFSS total catch index, NMFS Logbook hook-and-line, NMFS Logbook longline, NMFS Headboat survey 1981-1991, and NMFS Headboat 1995-2006.

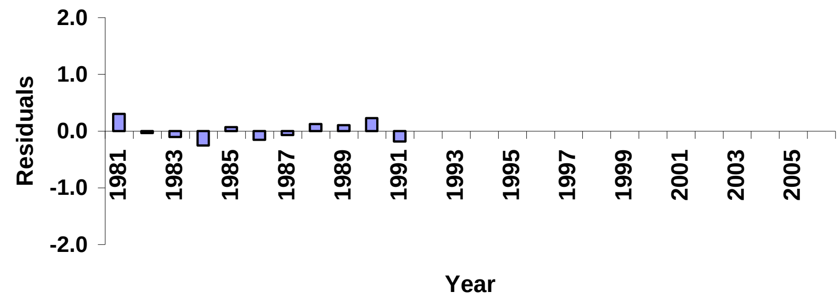
r. NMFS Logbook longline



s. NMFS Headboat logbook 1981-1991



t. NMFS Headboat logbook 1981-1991



q. NMFS Logbook longline

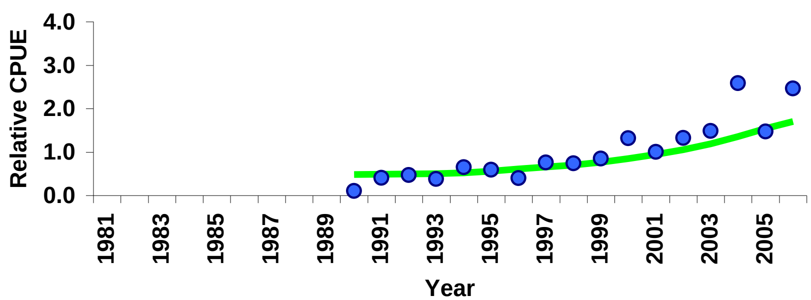
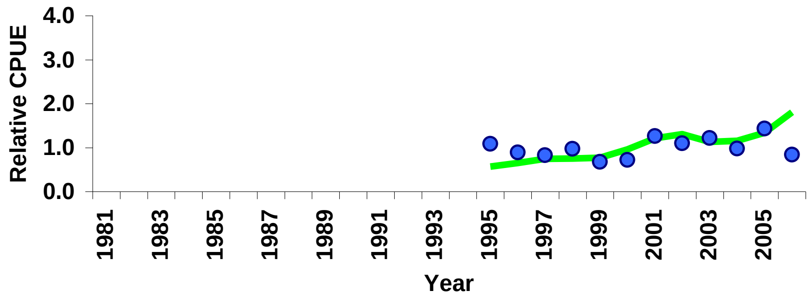


Figure 2.3.1.3.3 continued. Fit of ASAP model to the 11 relative indices of abundance. Each index is scaled to its mean such that a value of 1.0 is equal to the mean of the index. The indices included in this model were: FWC Visual survey for exploited ages, FWC Visual survey of pre-exploited ages, FWC Fishery Independent Monitoring haul seine sets, NMFS-UM Reef visual census, NMFS Riley's Hump visual survey, SEAMAP Video survey, NMFS MRFSS total catch

index, NMFS Logbook hook-and-line, NMFS Logbook longline, NMFS Headboat survey 1981-1991, and NMFS Headboat 1995-2006.

u. NMFS Headboat logbook 1995-2006



v. NMFS Headboat logbook 1995-2006

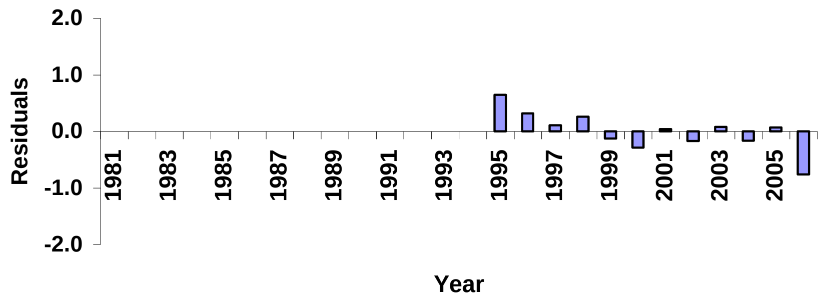


Figure 2.3.1.3.3 continued. Fit of ASAP model to the 11 relative indices of abundance. Each index is scaled to its mean such that a value of 1.0 is equal to the mean of the index. The indices included in this model were: FWC Visual survey for exploited ages, FWC Visual survey of pre-exploited ages, FWC Fishery Independent Monitoring haul seine sets, NMFS-UM Reef visual census, NMFS Riley's Hump visual survey, SEAMAP Video survey, NMFS MRFSS total catch index, NMFS Logbook hook-and-line, NMFS Logbook longline, NMFS Headboat survey 1981-1991, and NMFS Headboat 1995-2006.

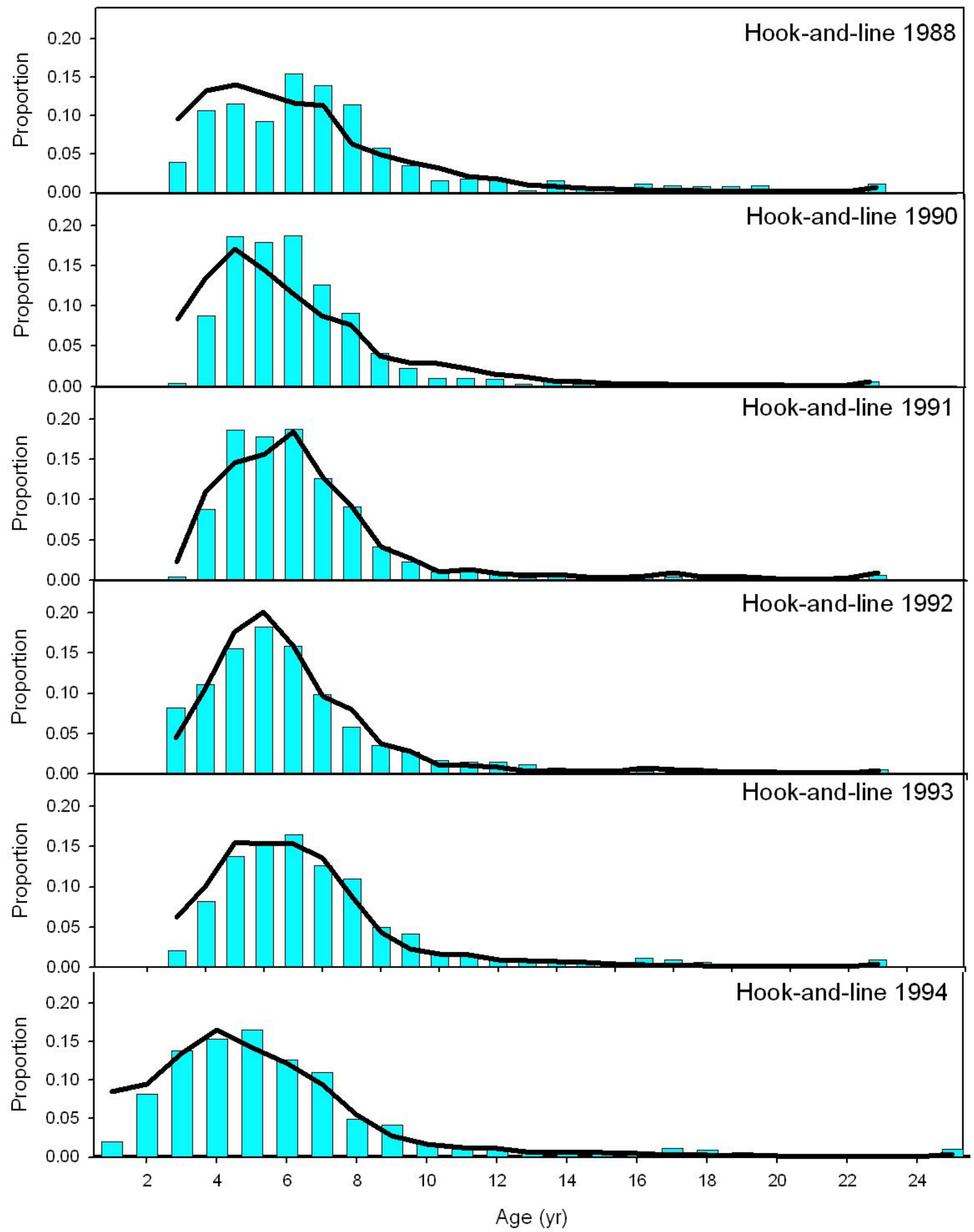


Figure 2.3.1.3.4. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

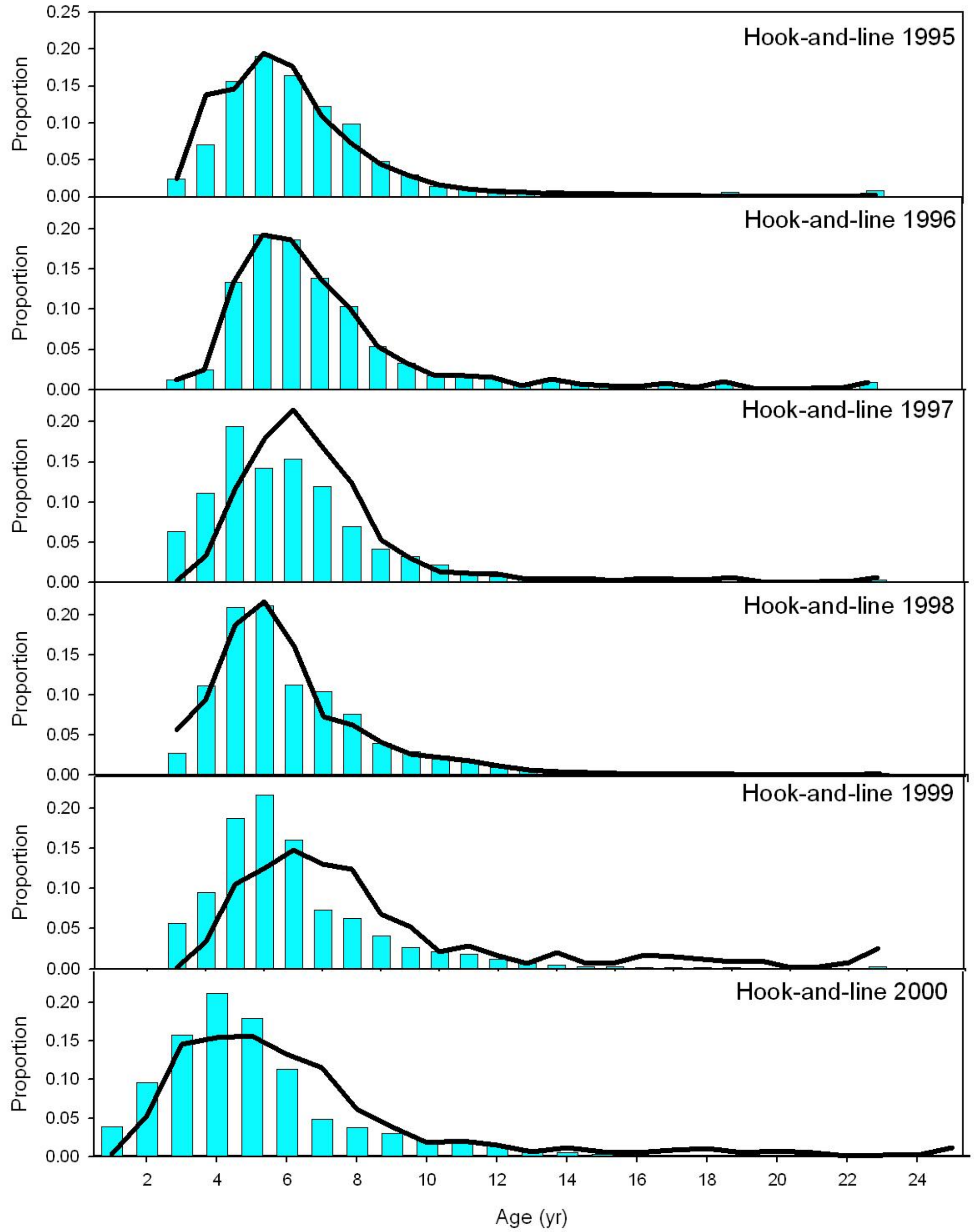


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

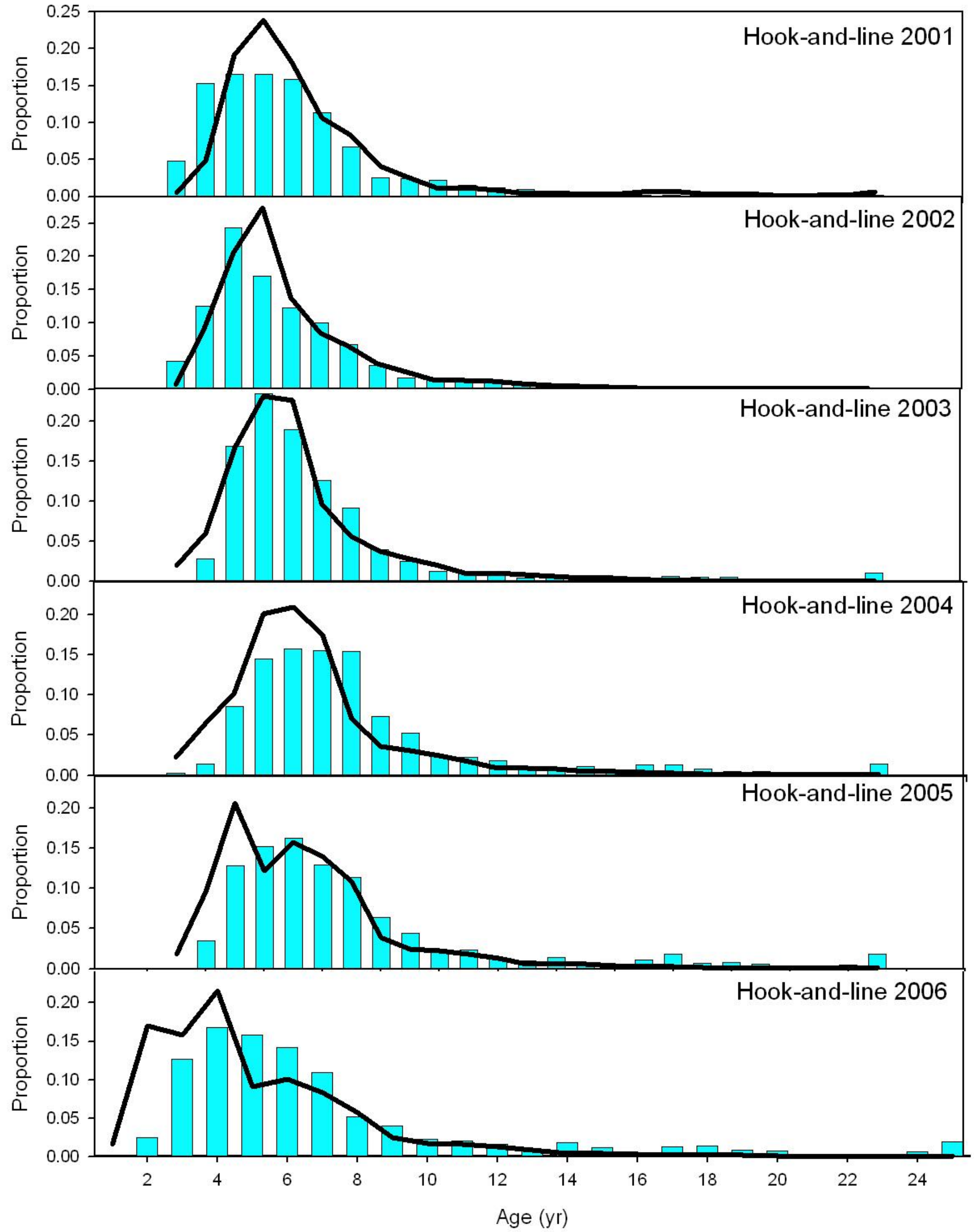


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

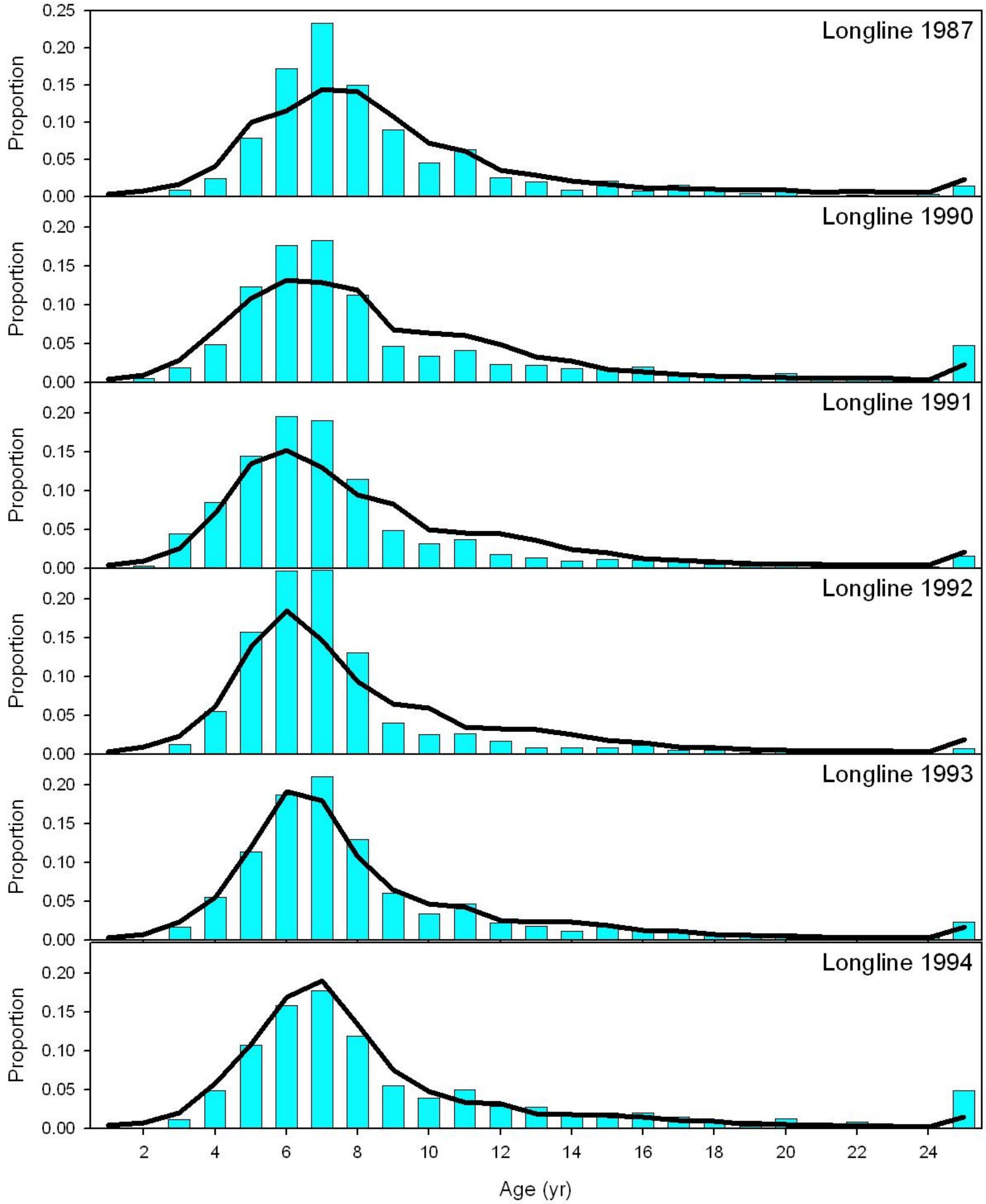


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

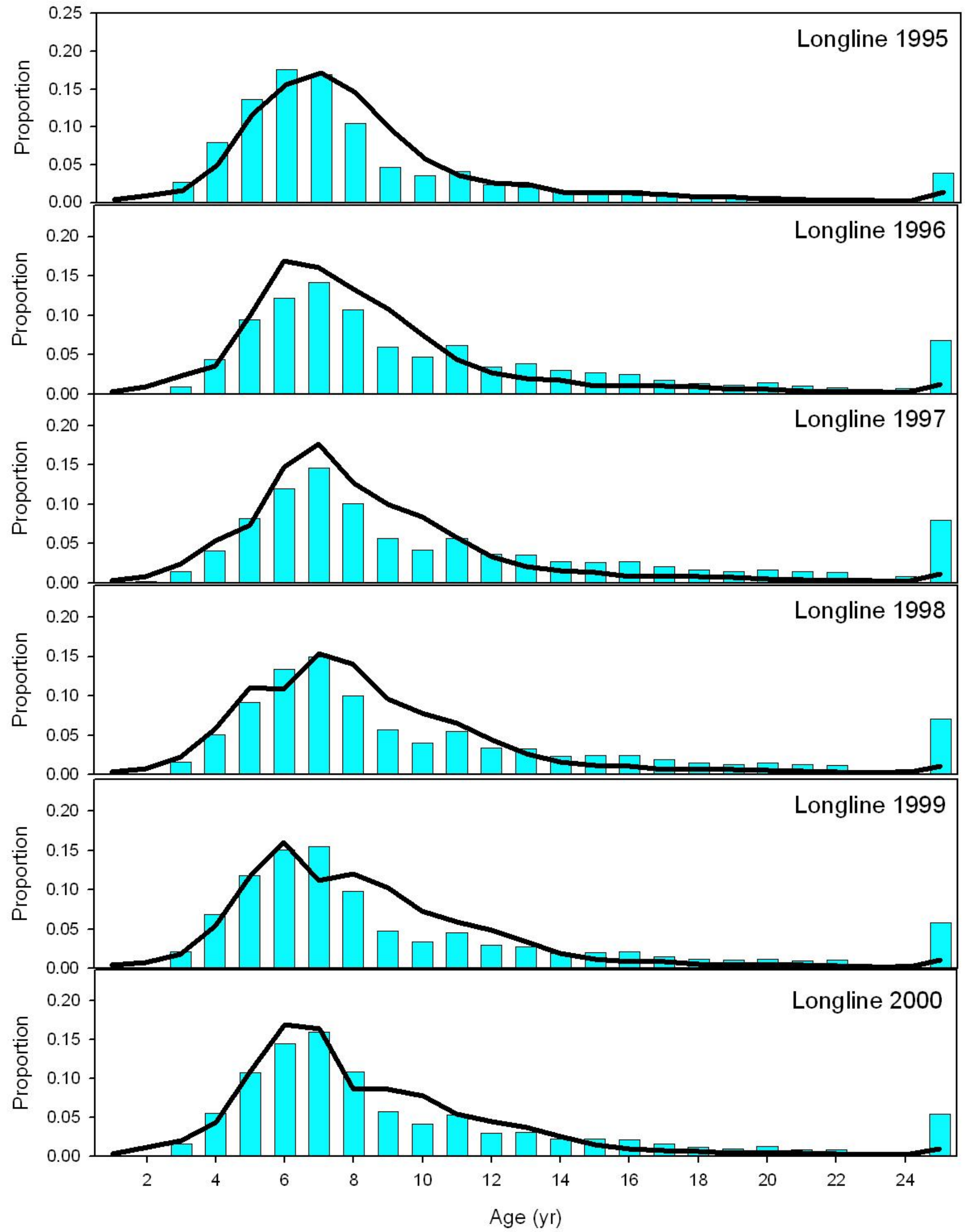


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

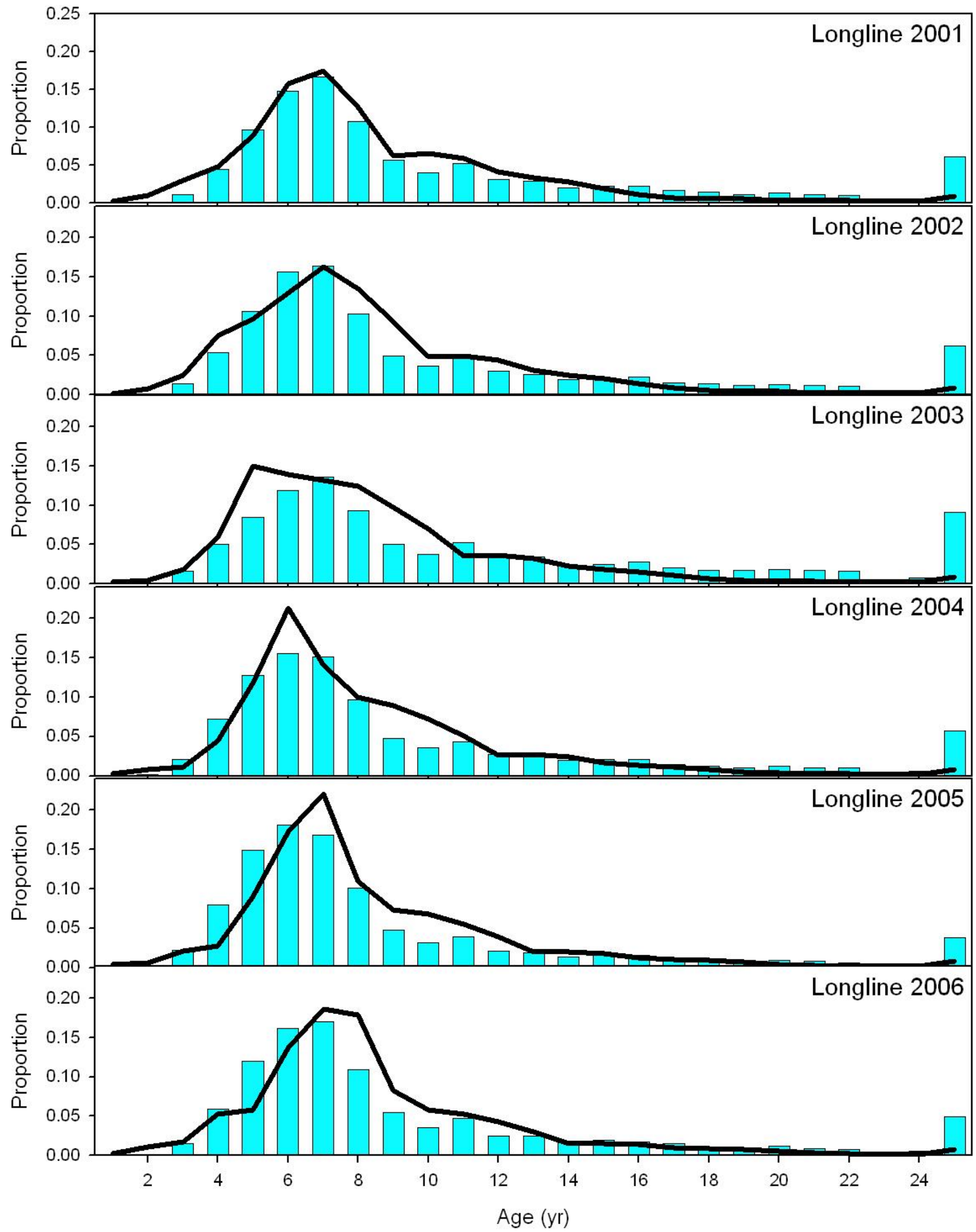


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

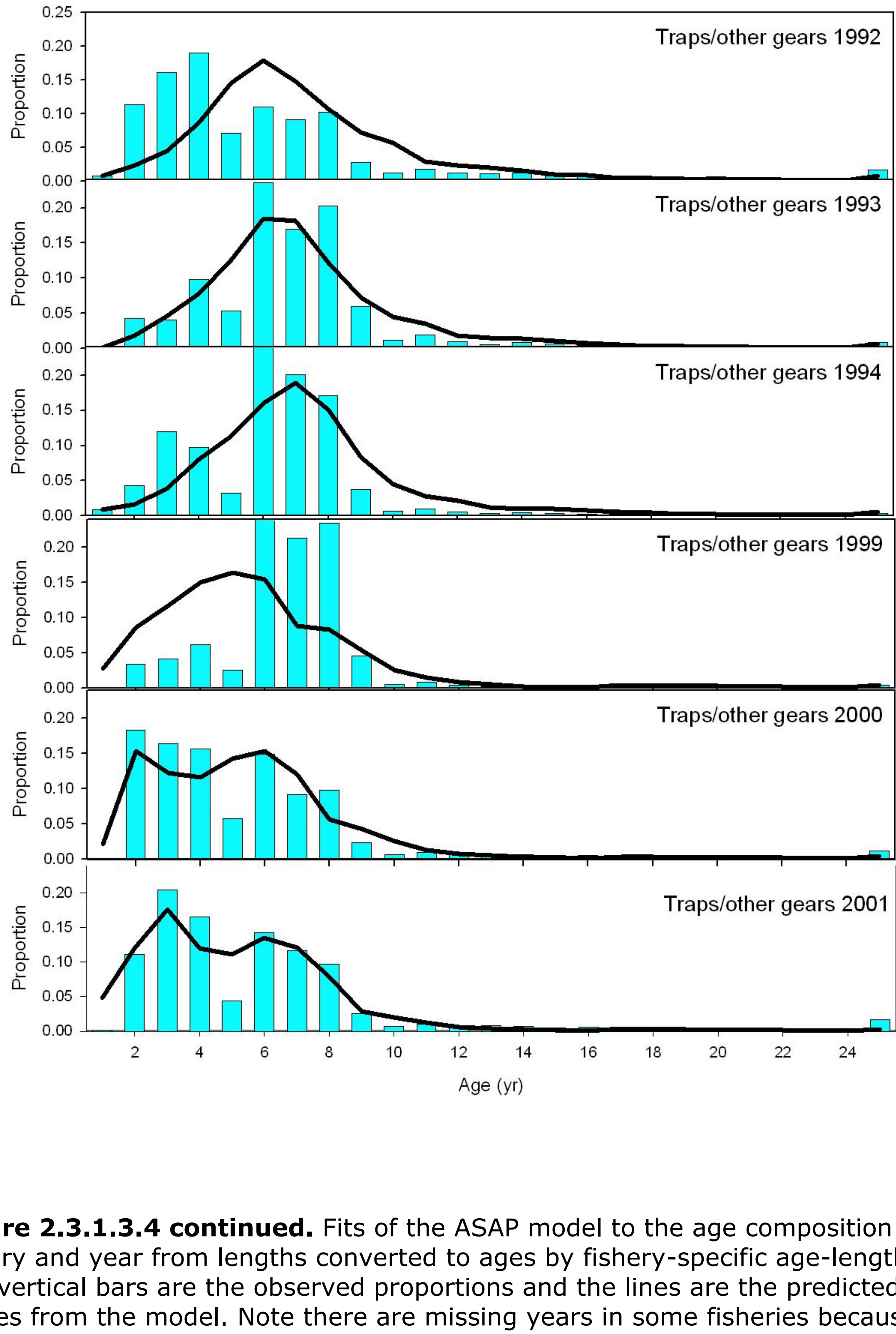
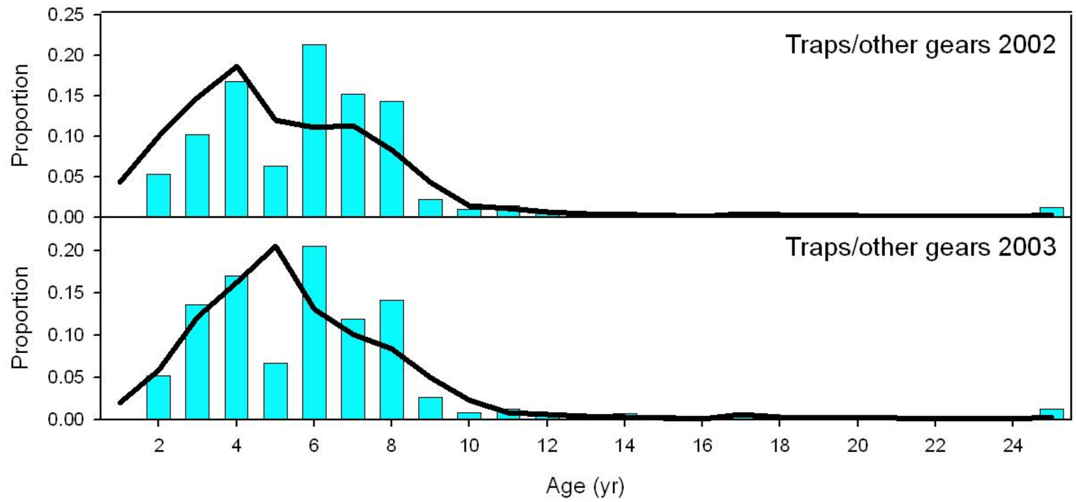


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.



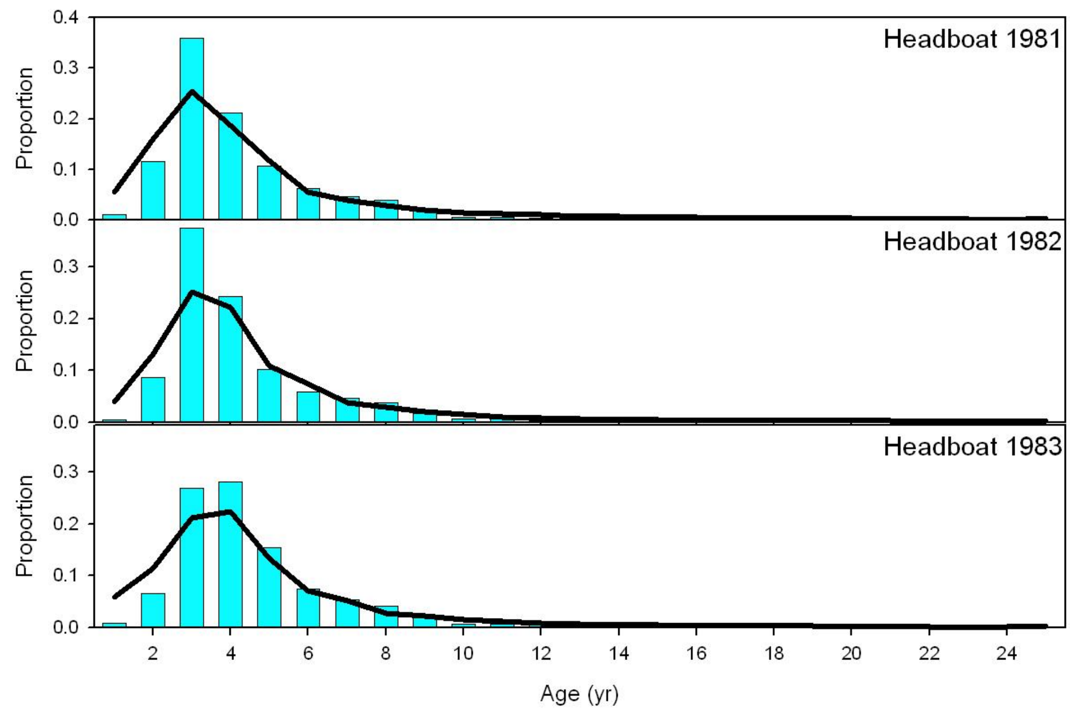


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

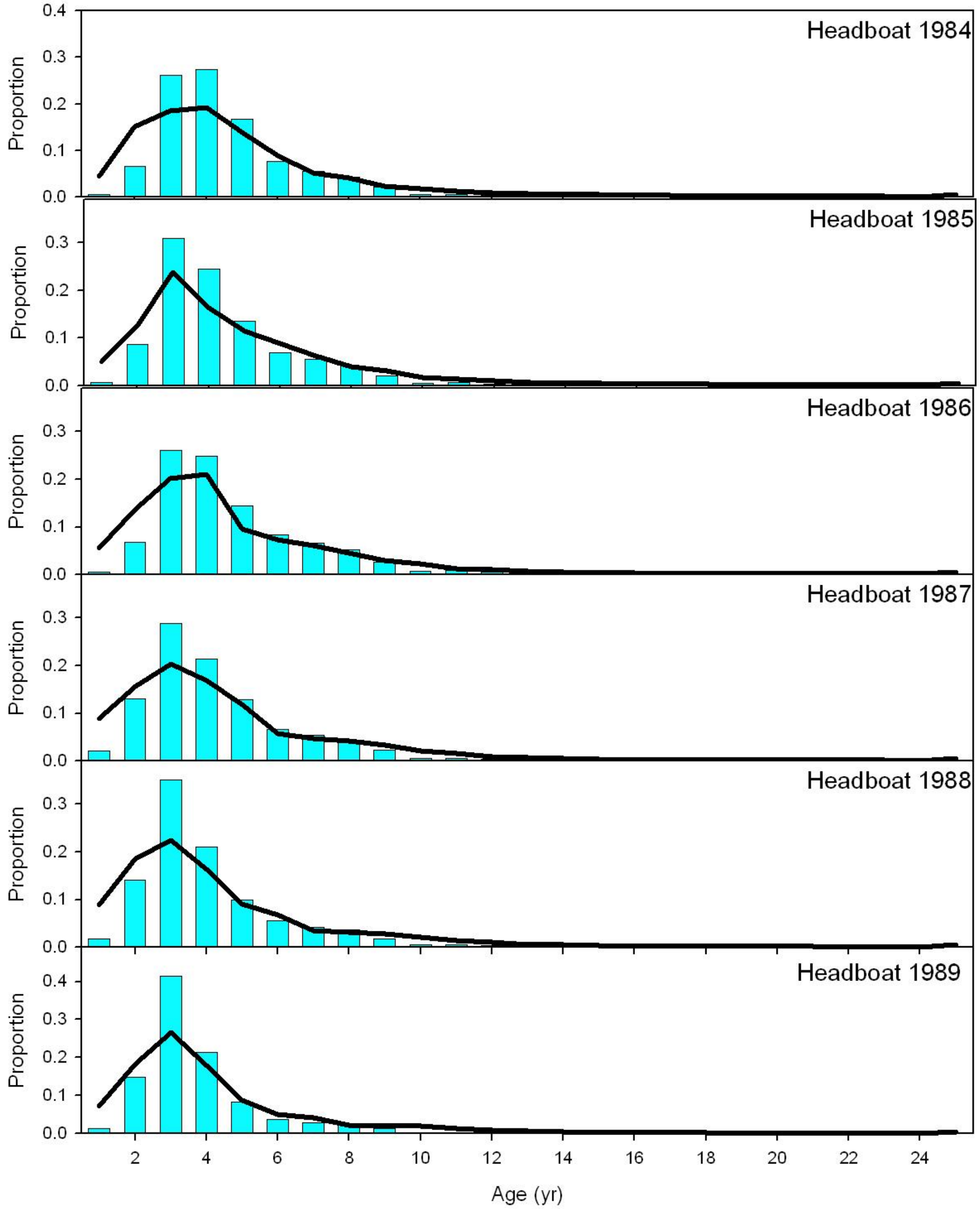


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

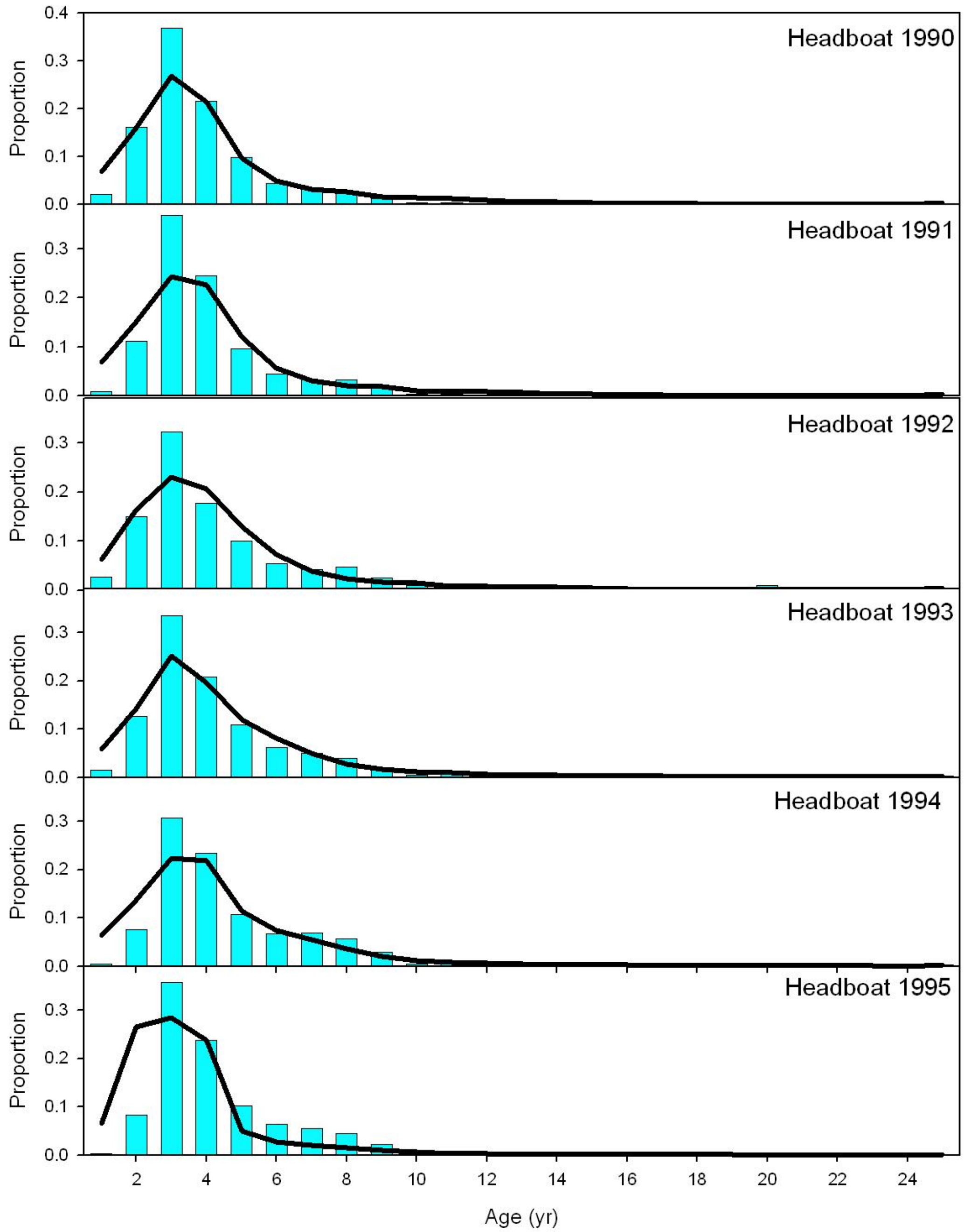


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

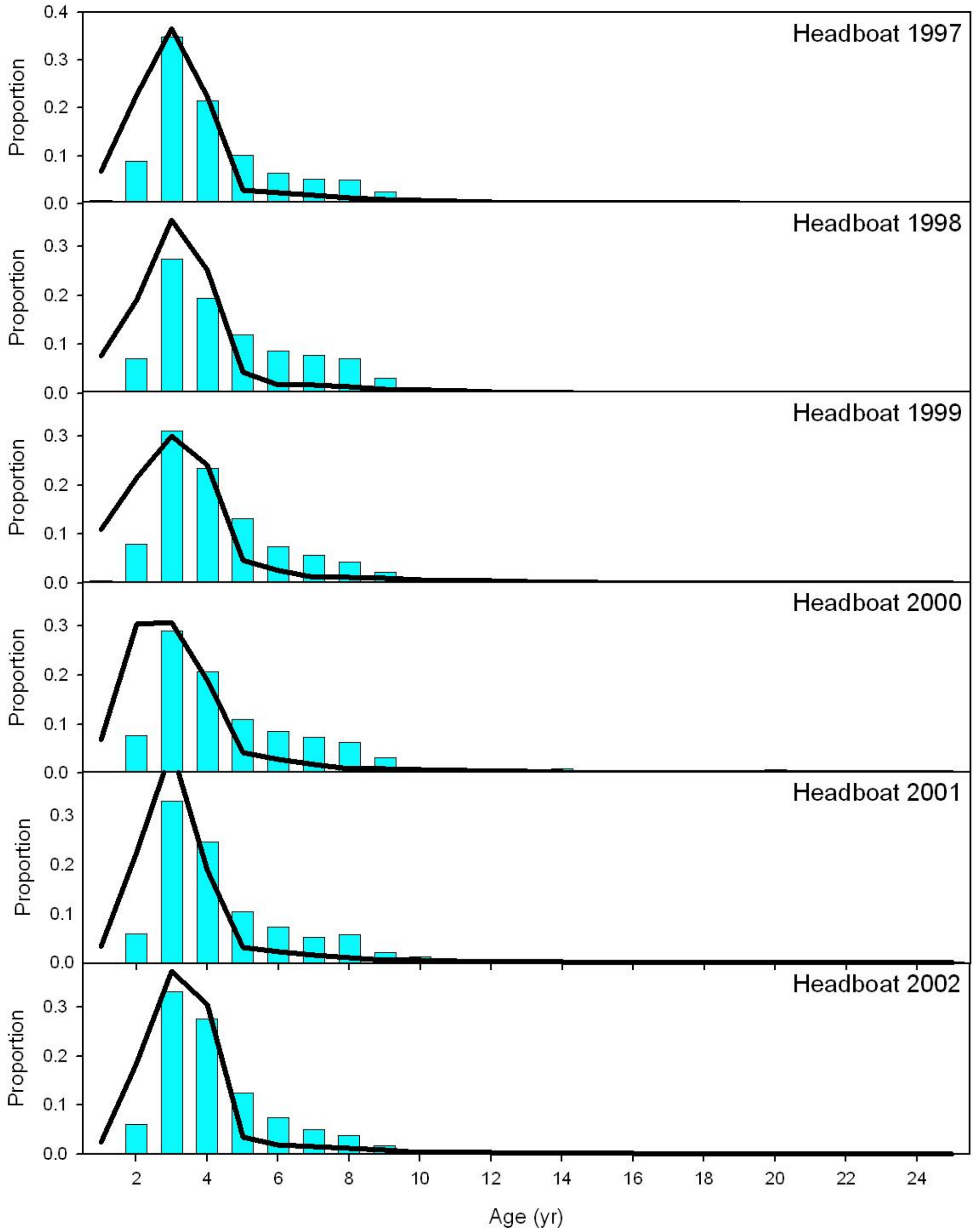
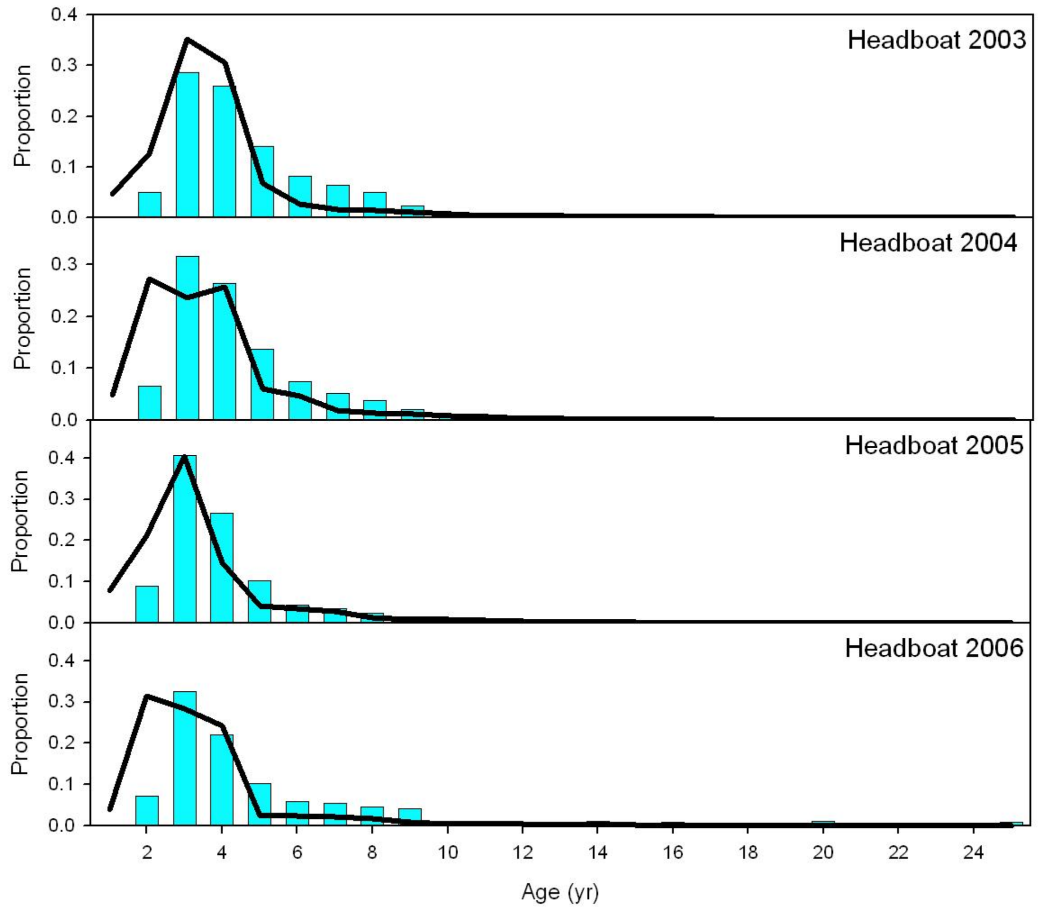


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.



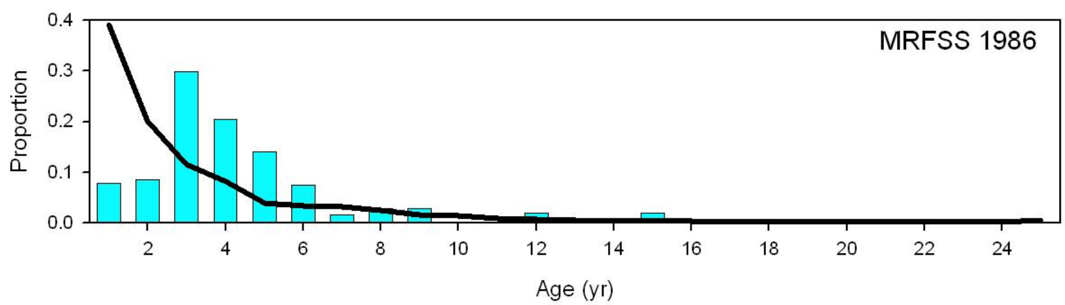


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

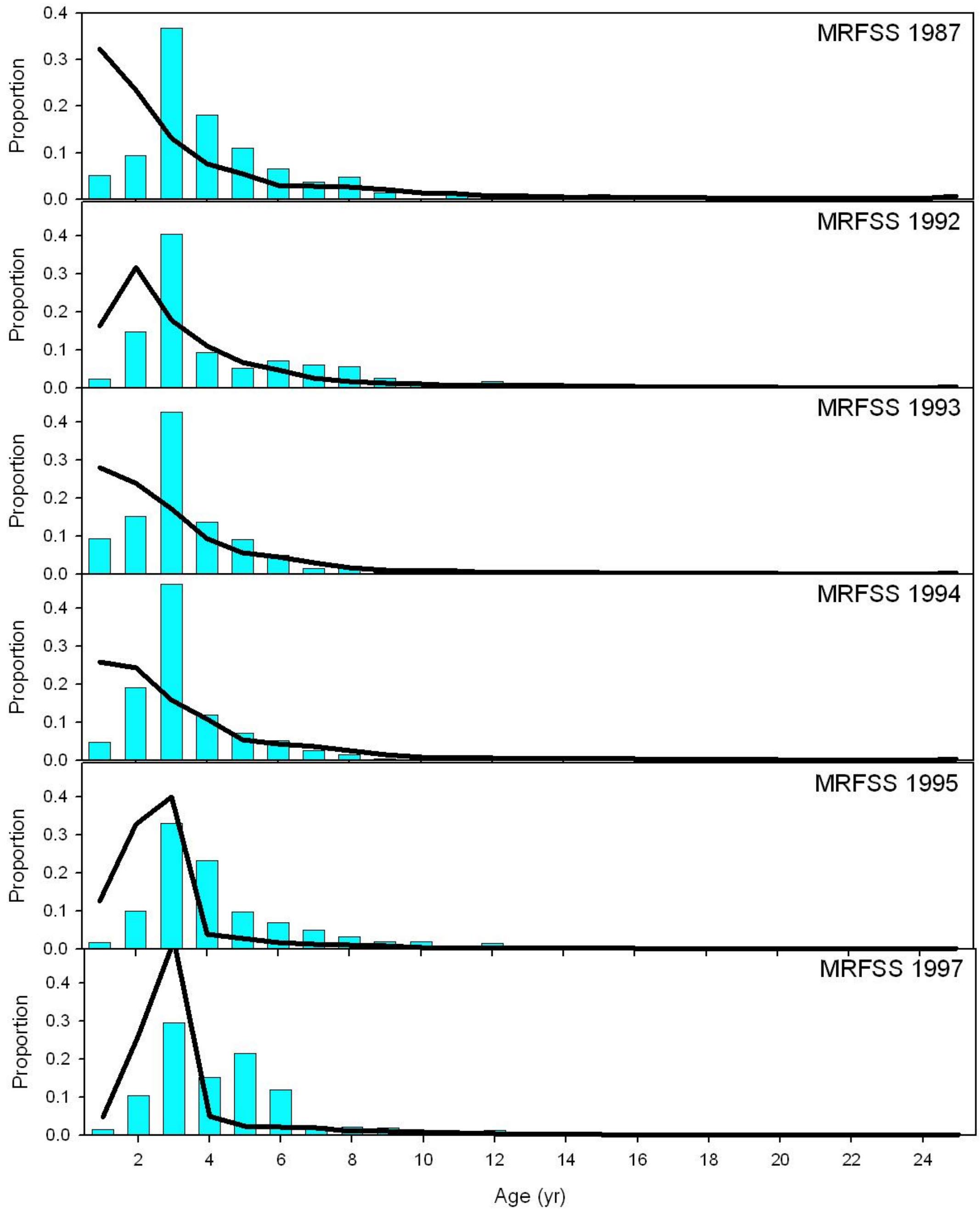


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

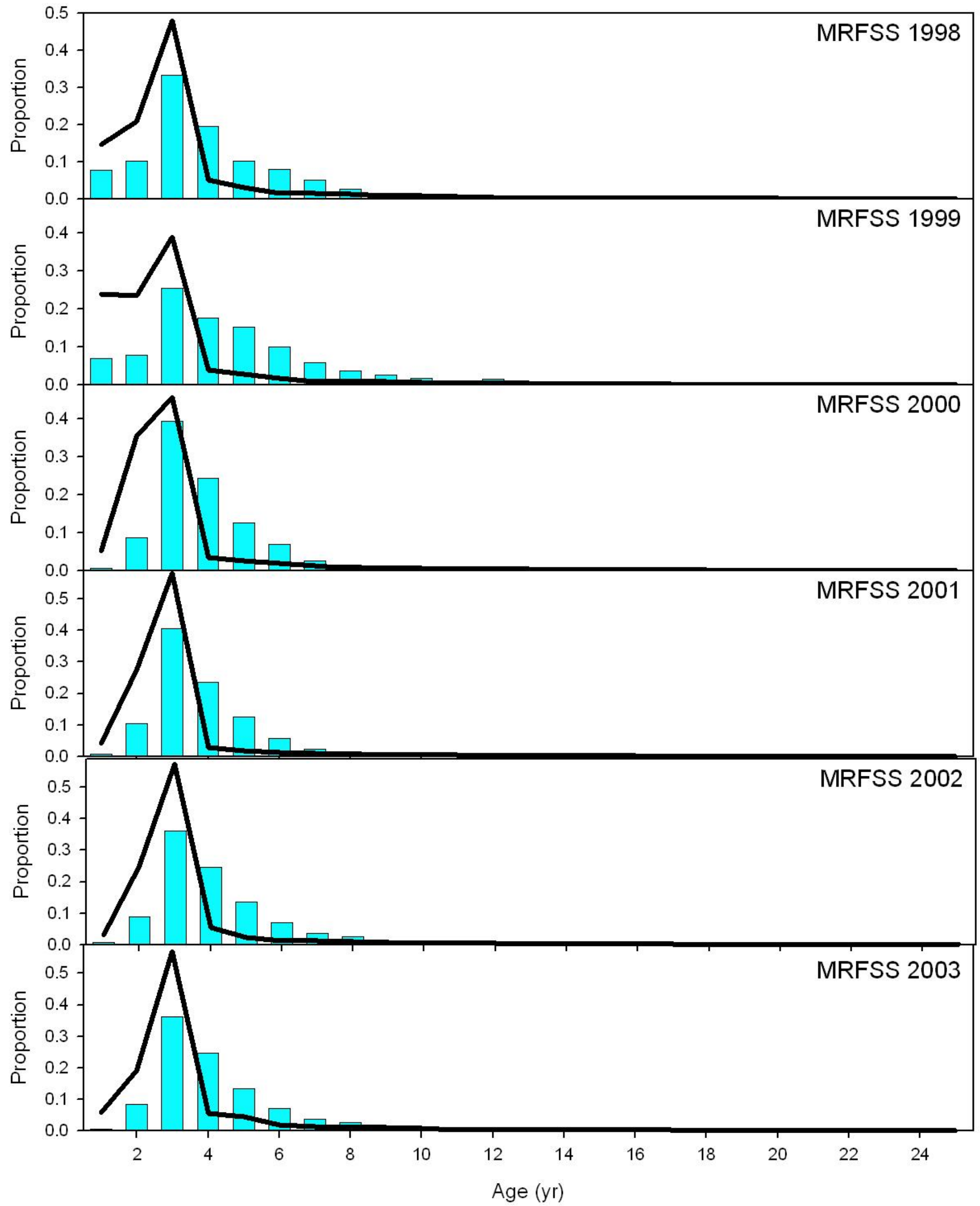


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

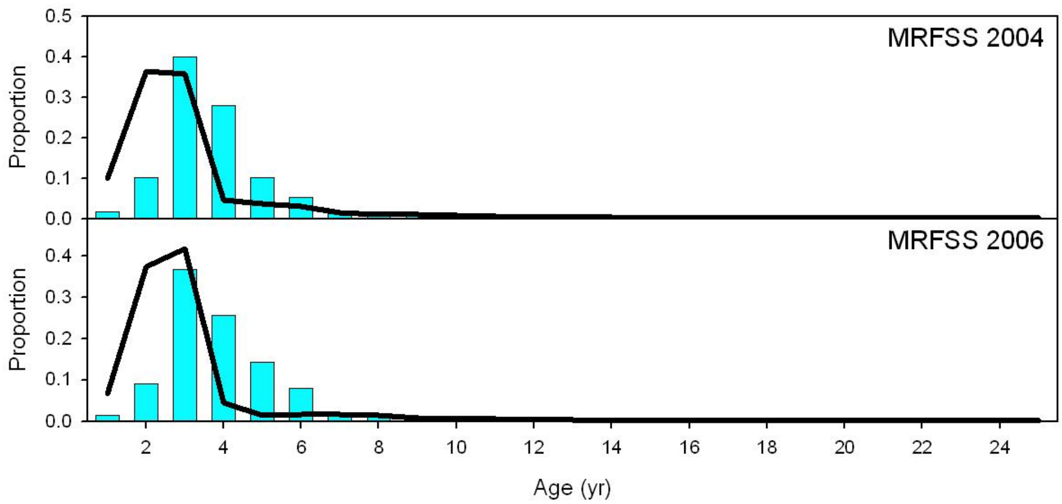


Figure 2.3.1.3.4 continued. Fits of the ASAP model to the age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. Note there are missing years in some fisheries because of the absence of length measurements.

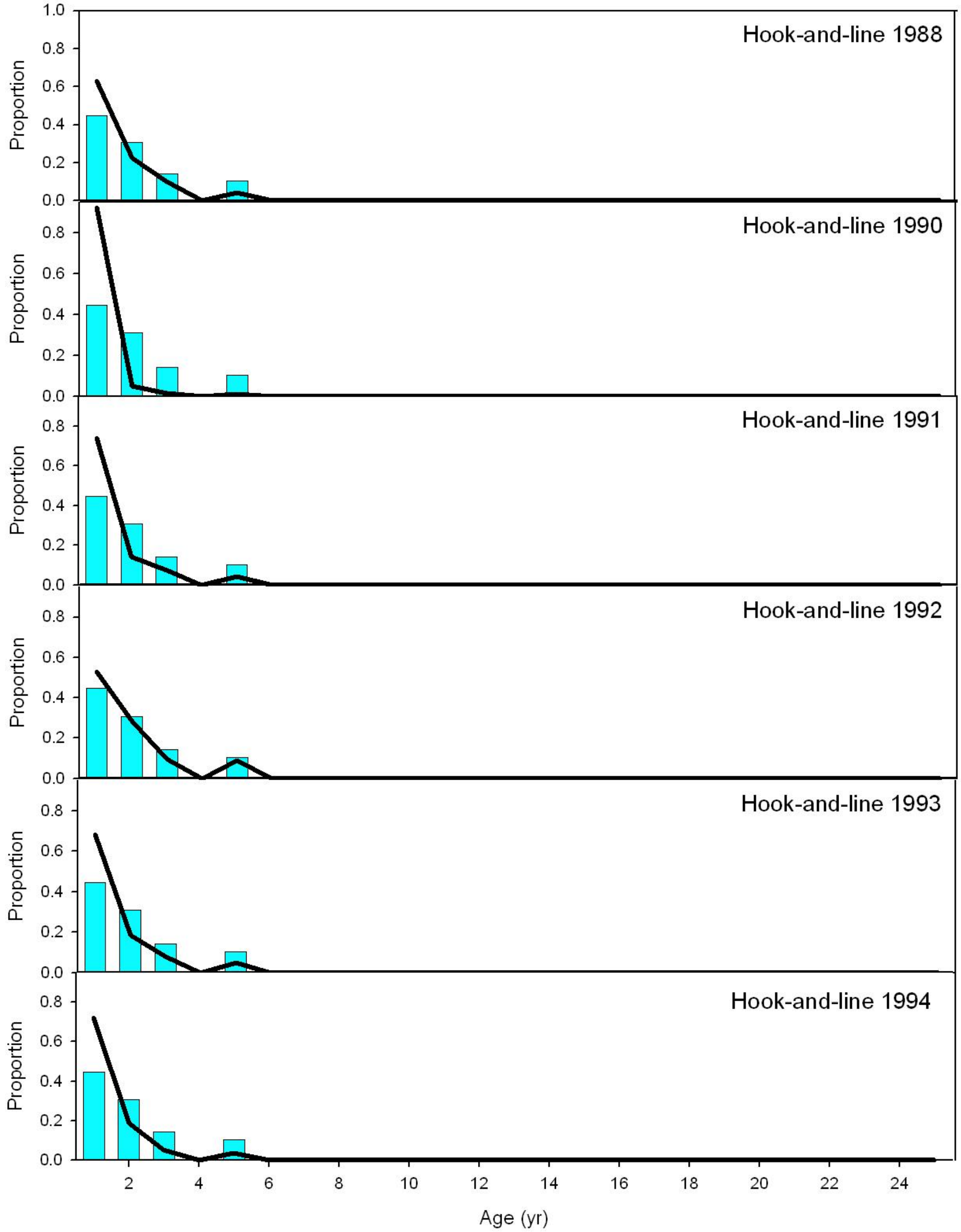


Figure 2.3.1.3.5. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

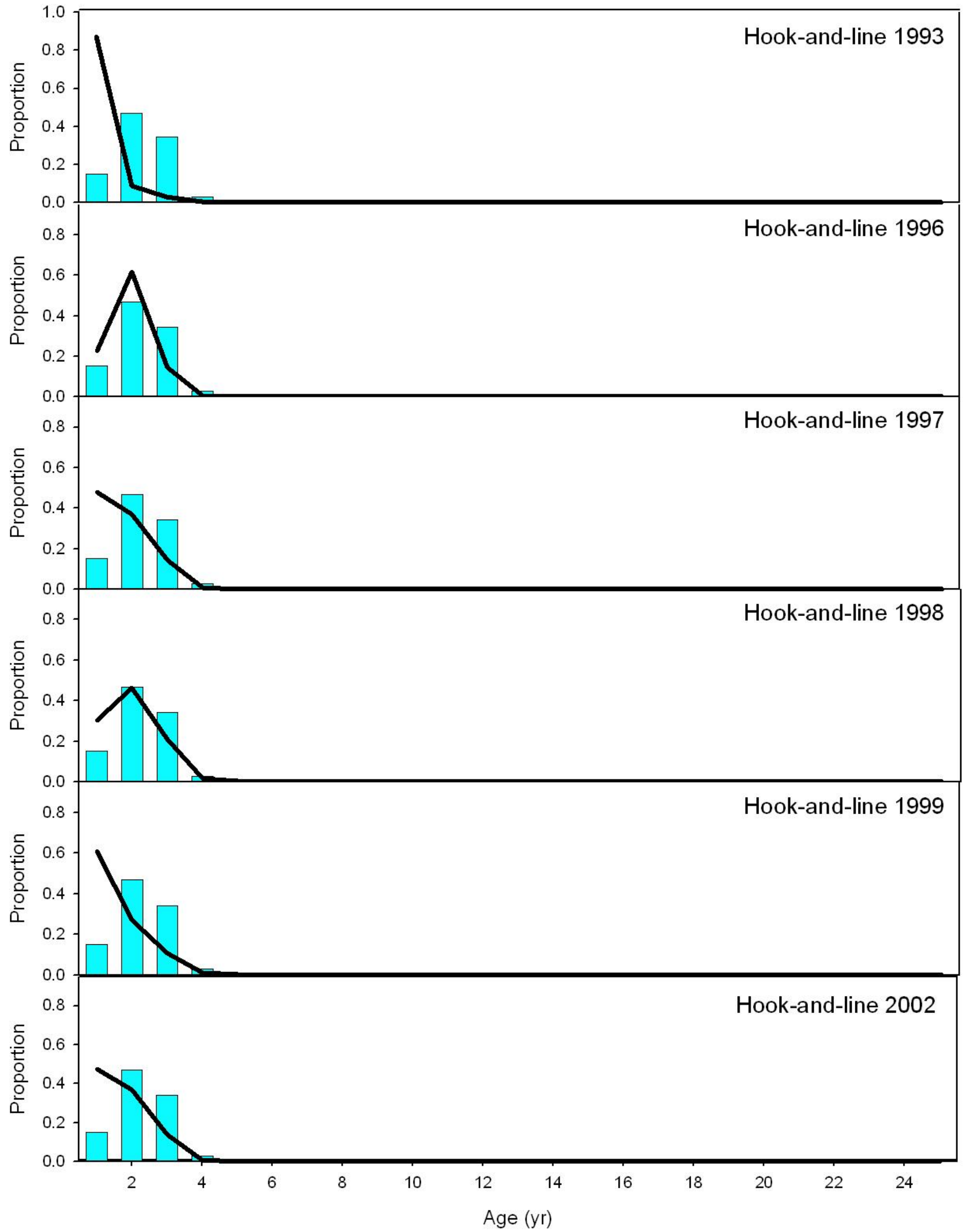
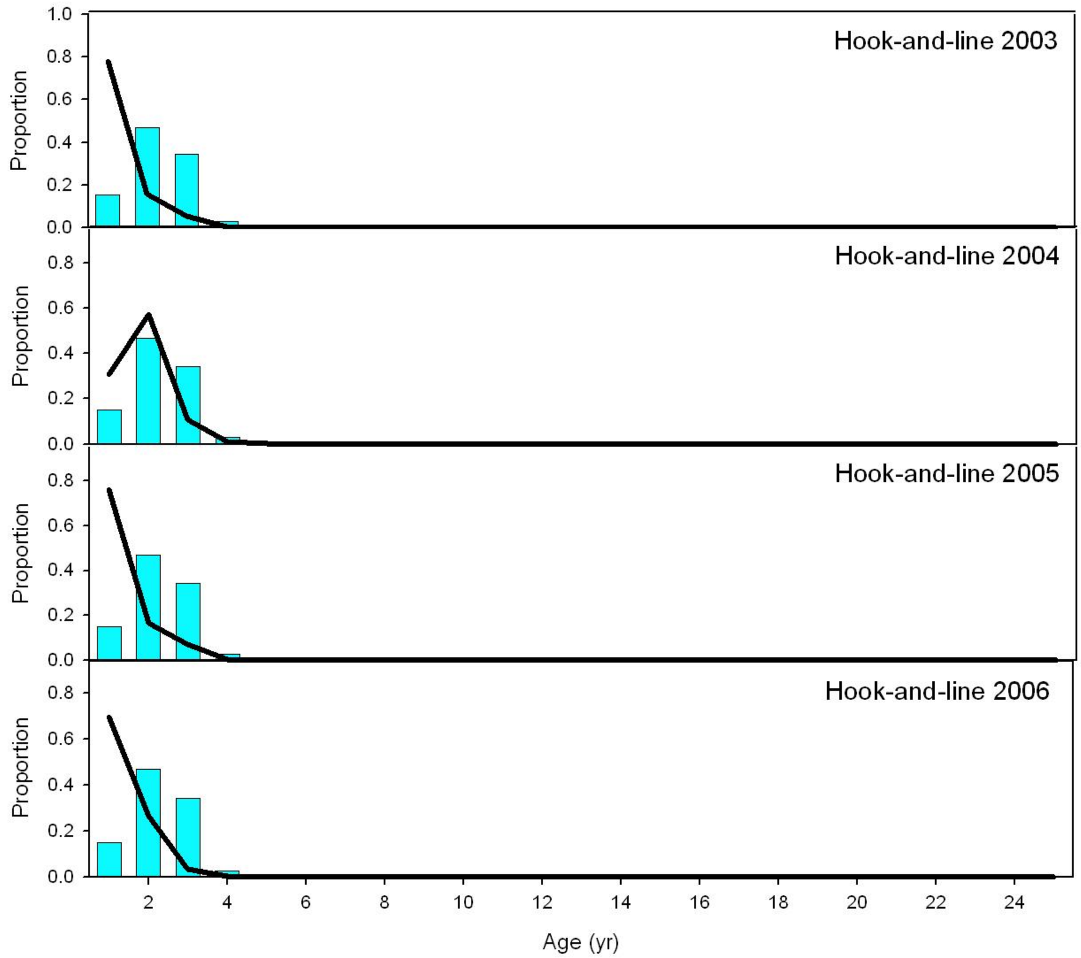


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.



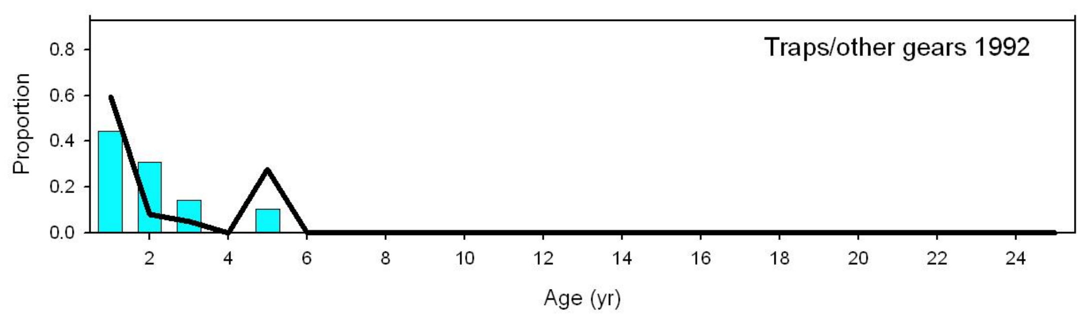


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

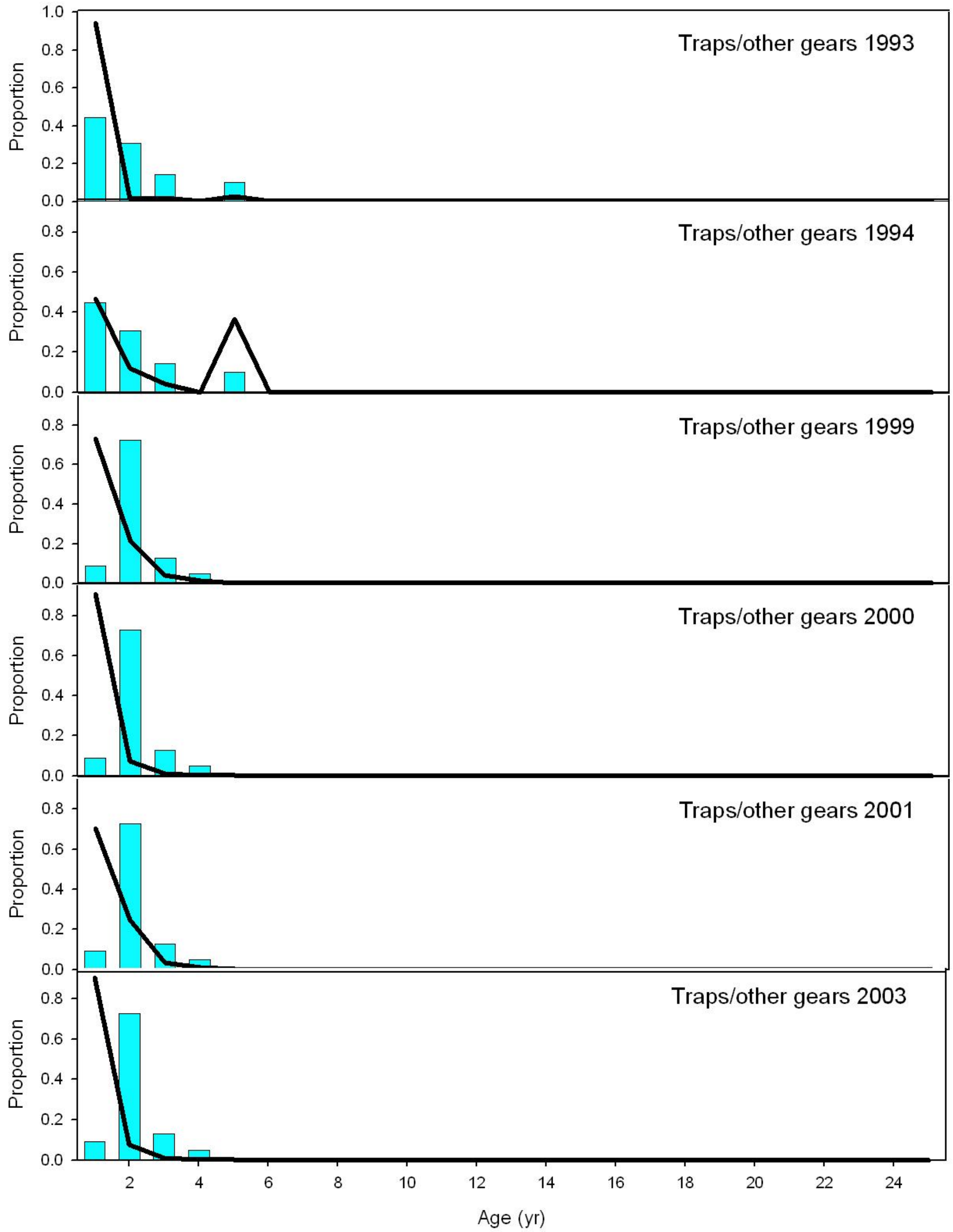


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

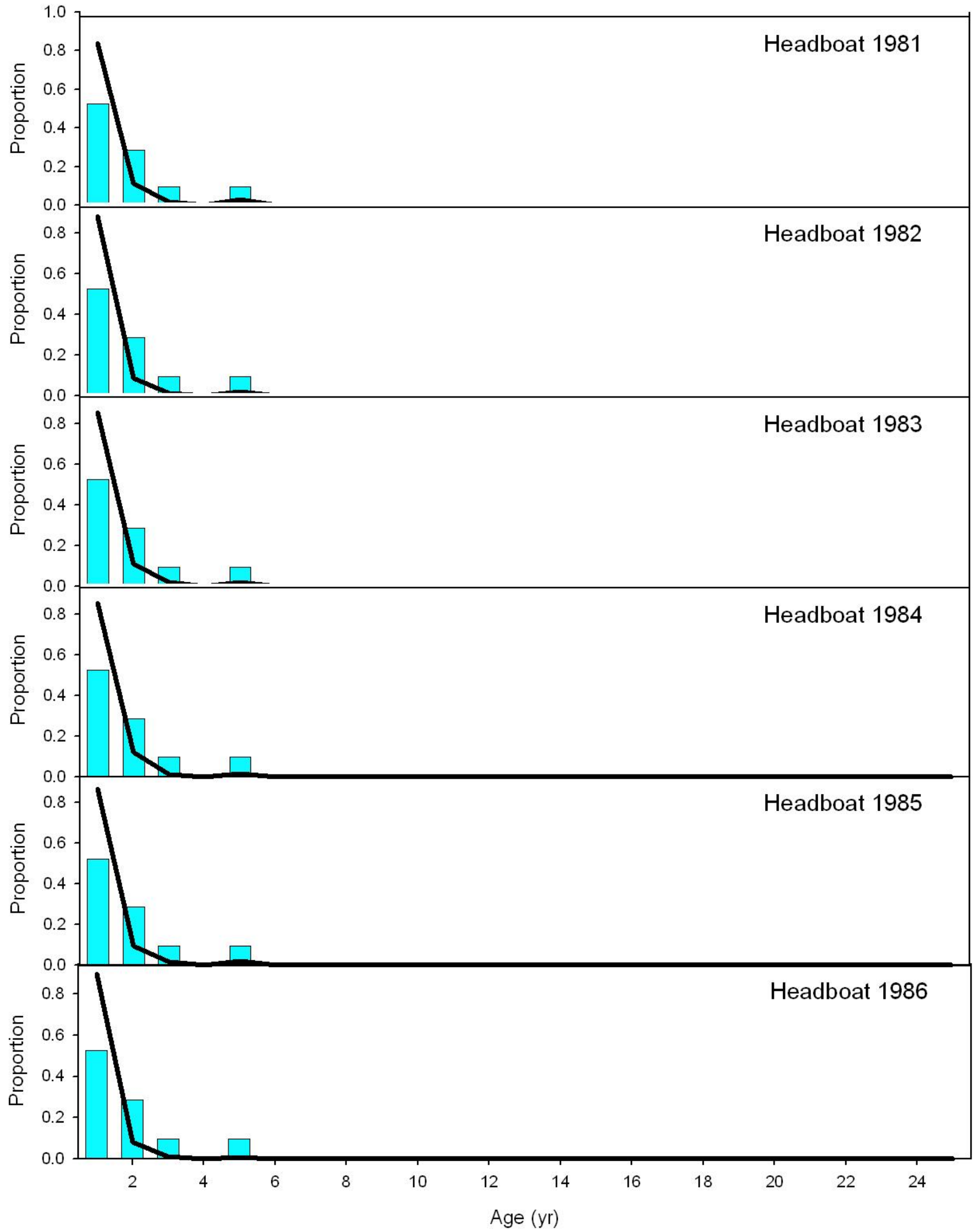


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

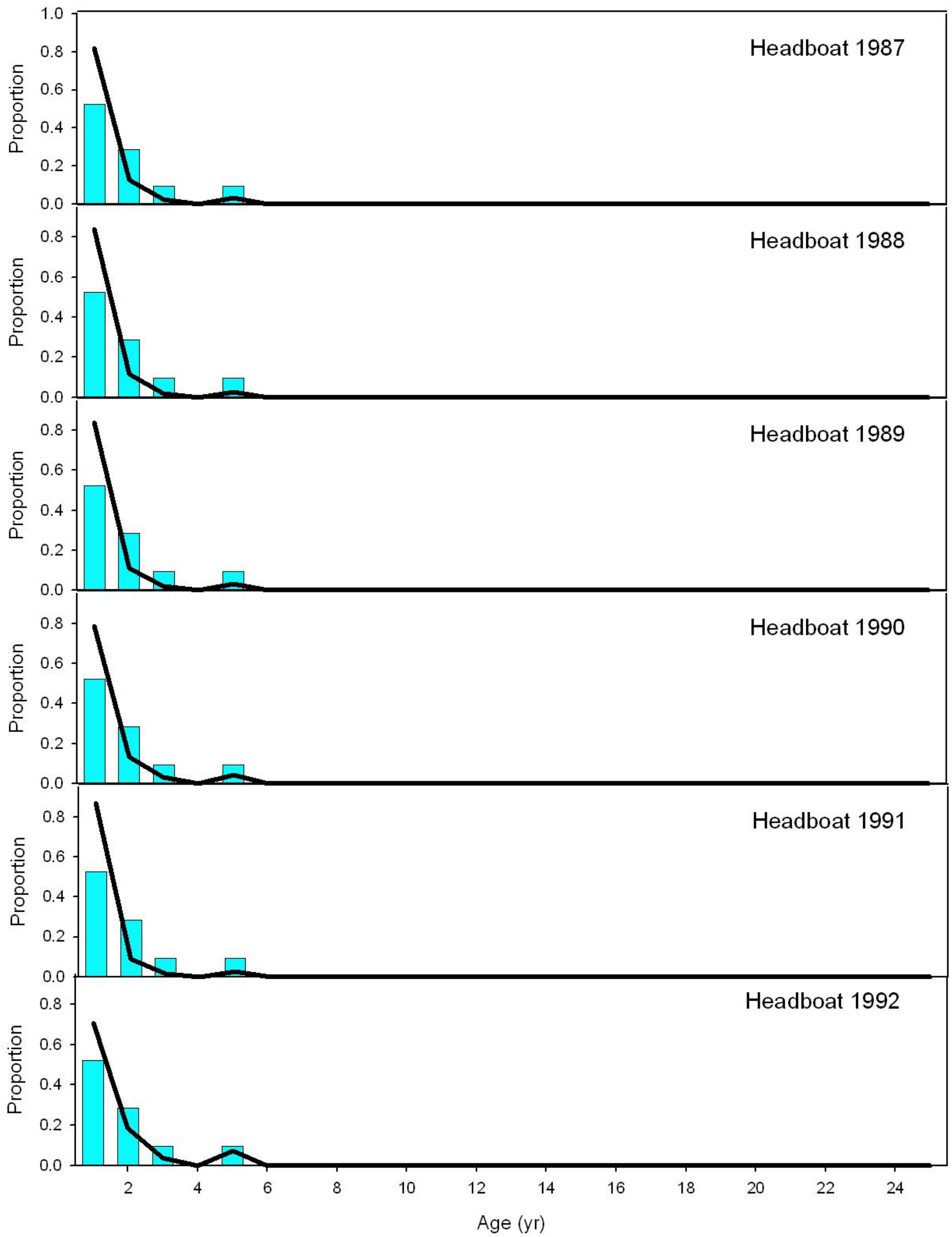


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

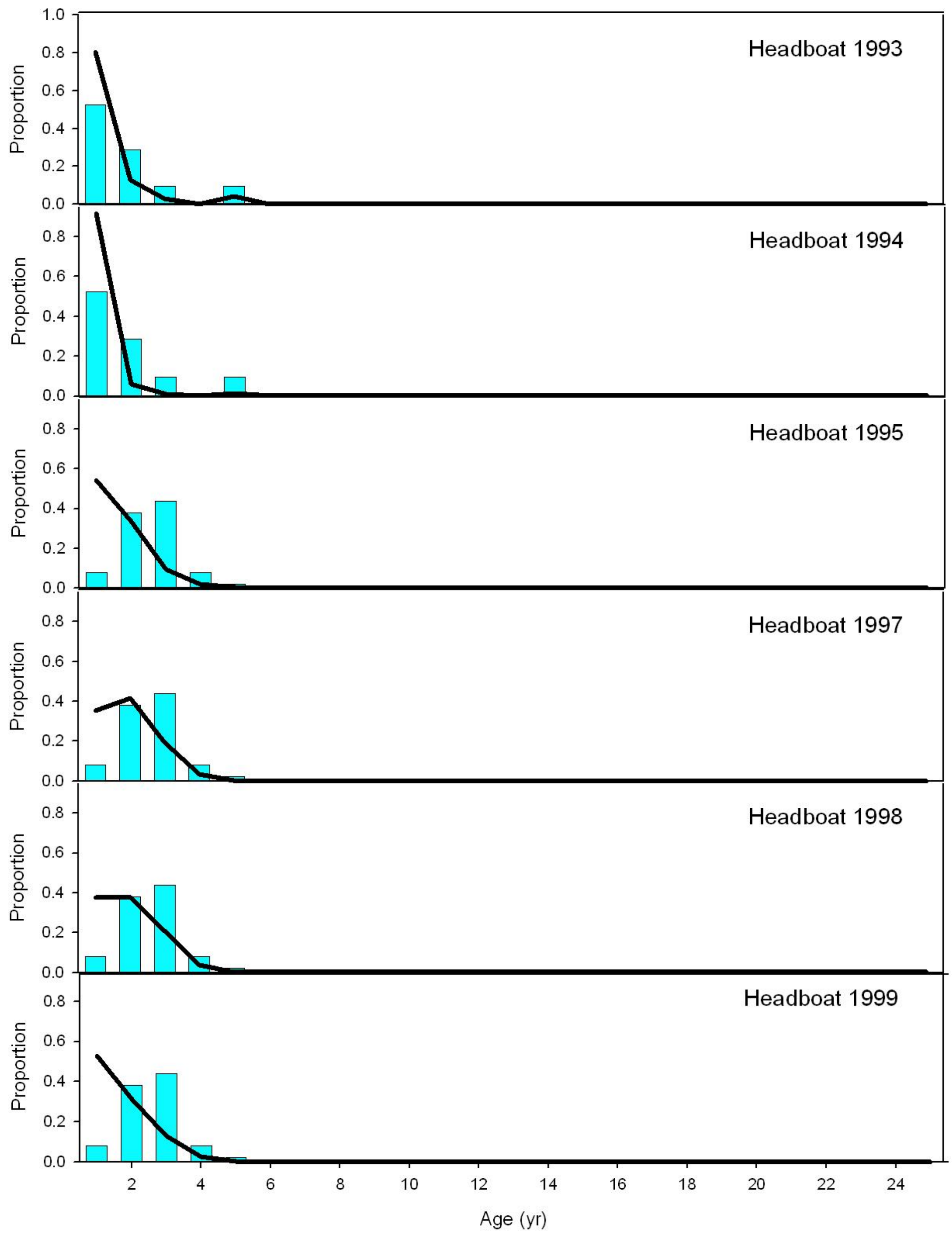


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

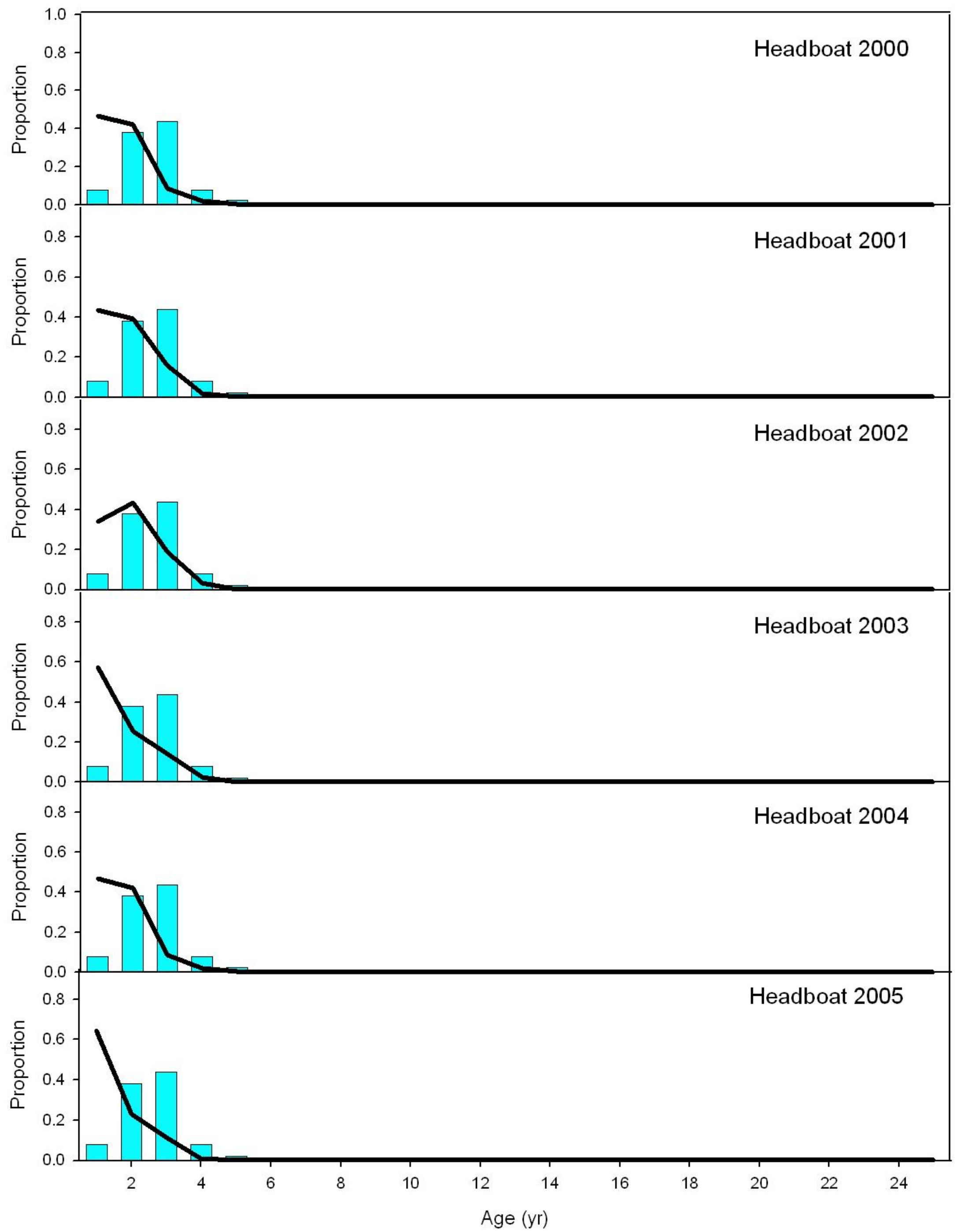
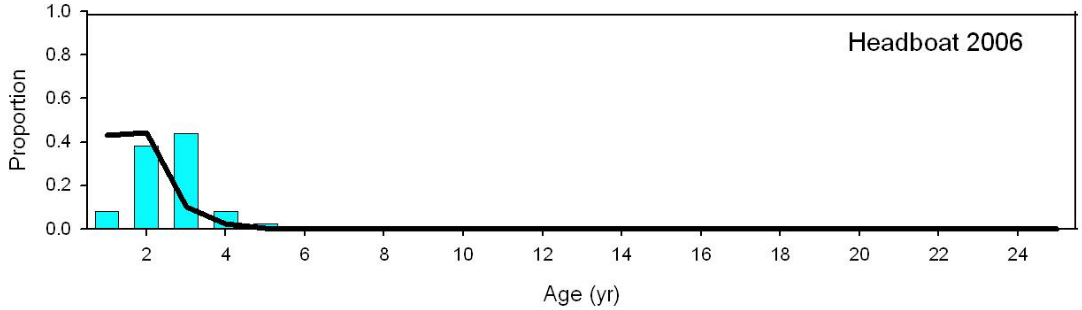


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.



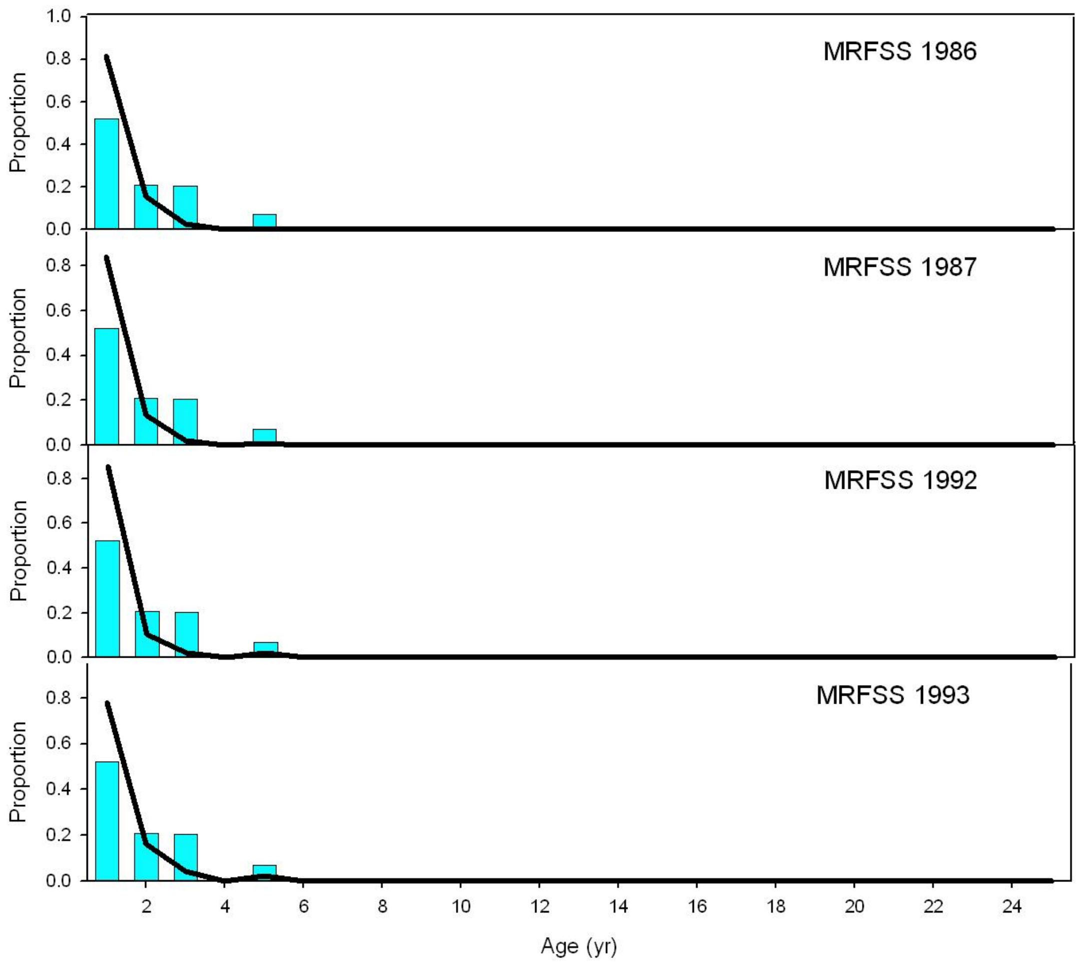


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

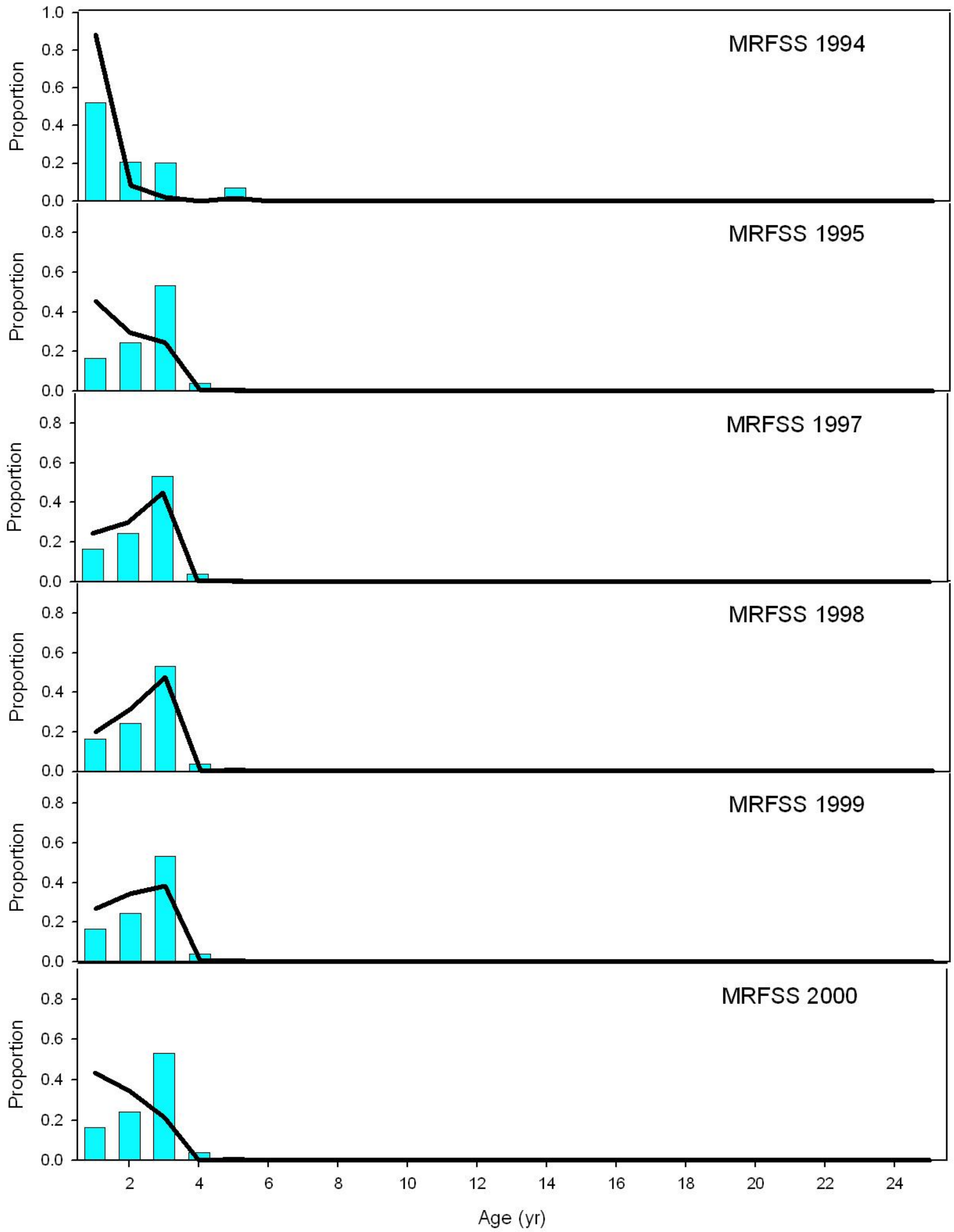


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

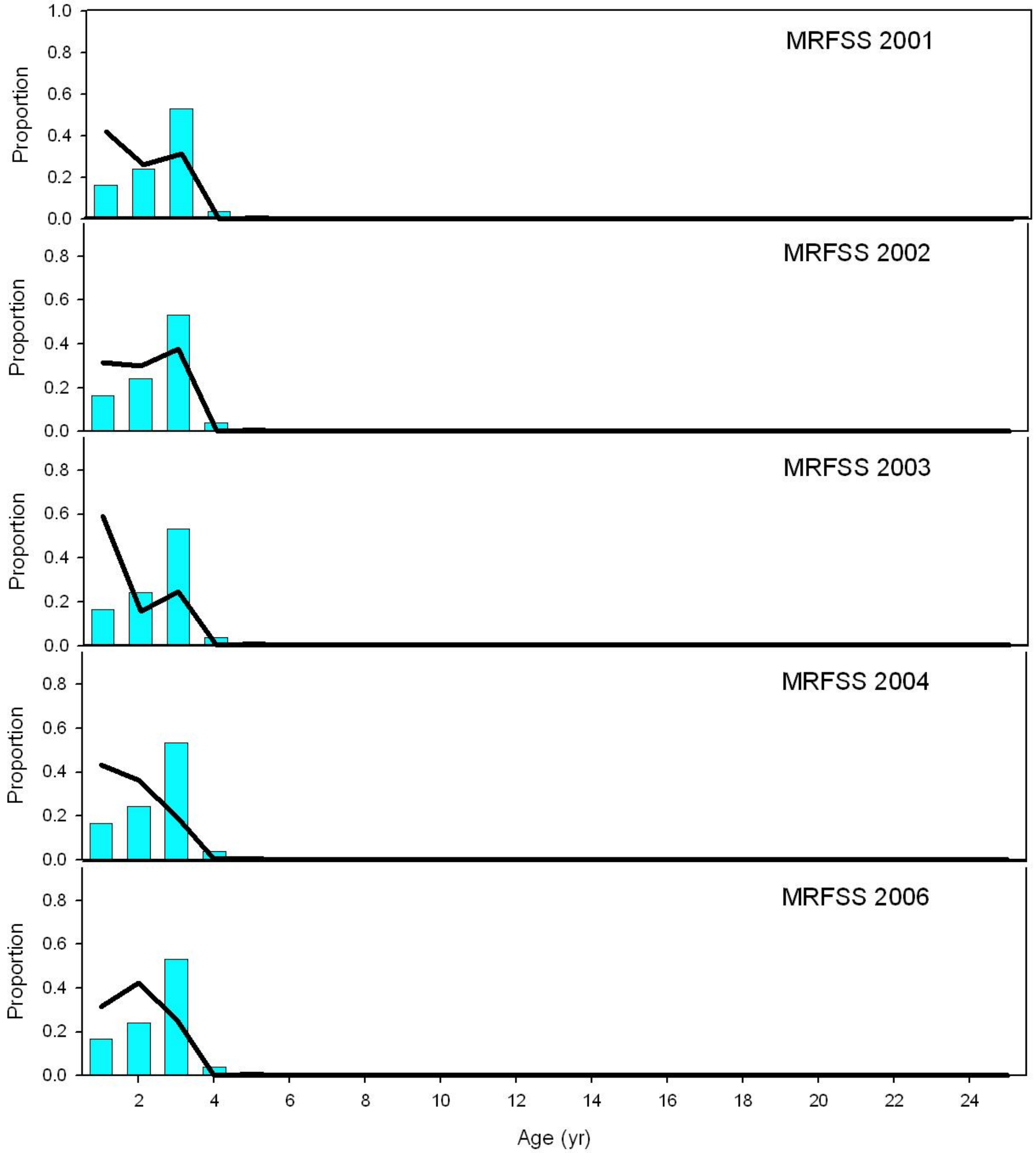


Figure 2.3.1.3.5 continued. Fits of the ASAP model to the discard age composition by fishery and year from lengths converted to ages by fishery-specific age-length keys. The vertical bars are the observed proportions and the lines are the predicted values from the model. The years match those with landings and the 1981-1994 time period uses the same length frequencies by fishery and the 1995-2006 uses the same length frequencies by fishery.

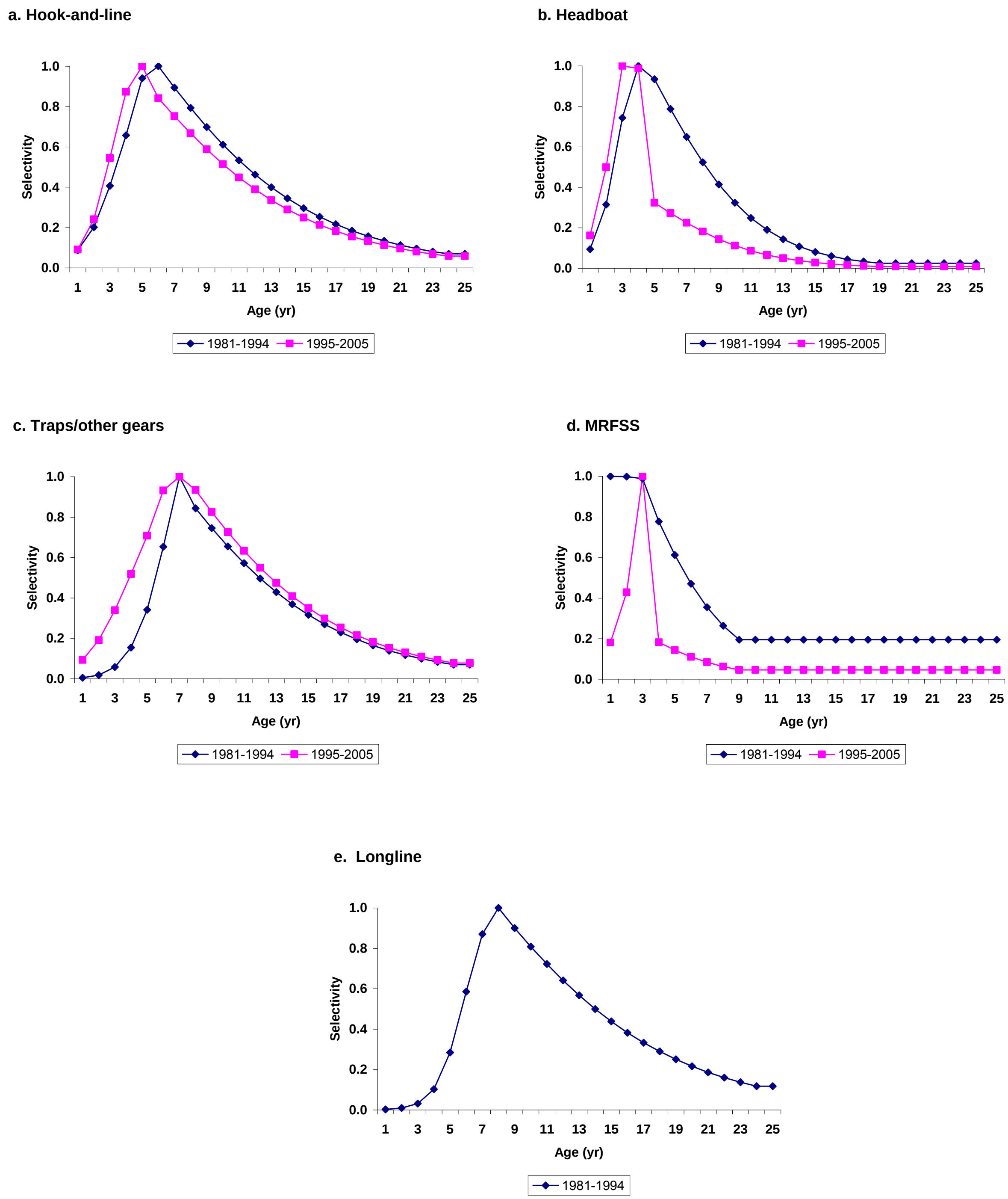


Figure 2.3.1.3.6. Selectivity patterns from ASAP by fishery and time period based upon minimum sizes. The longline fishery lands larger fish and was modeled with a single selectivity pattern.

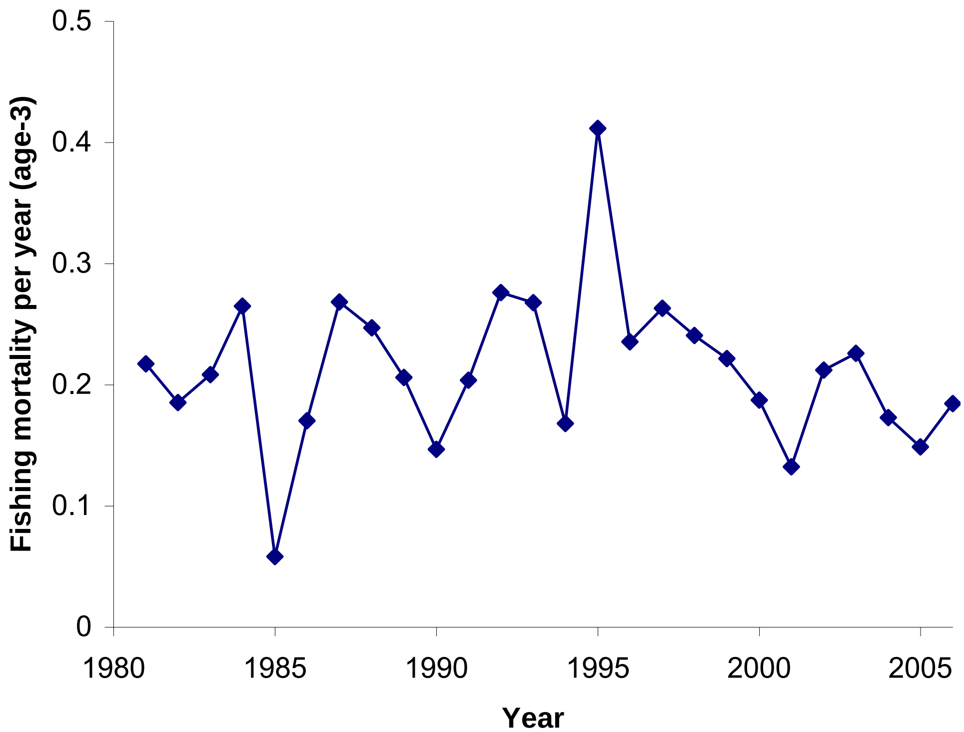
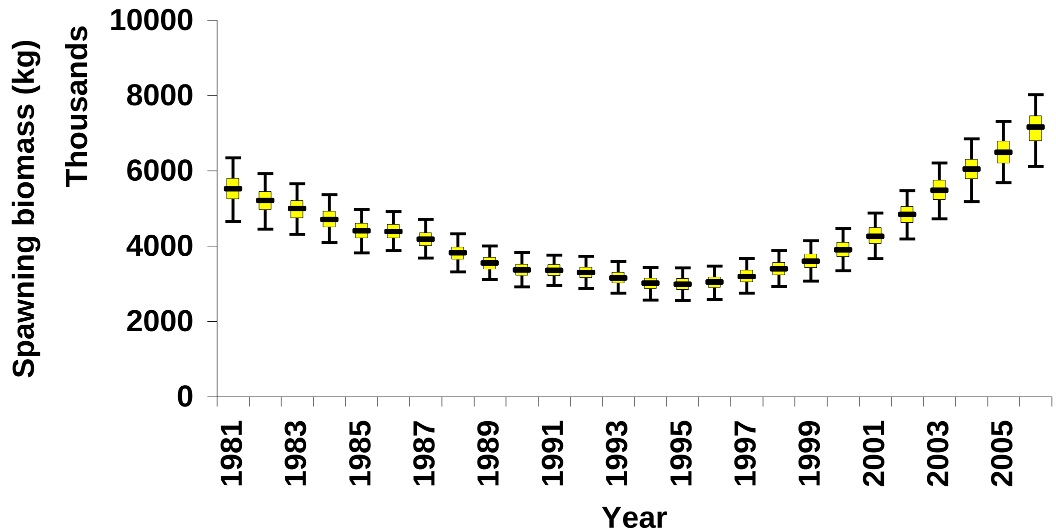


Figure 2.3.1.3.7. Total fishing mortality rate on age-3 fish by year including discards from ASAP base run.

a.



b.

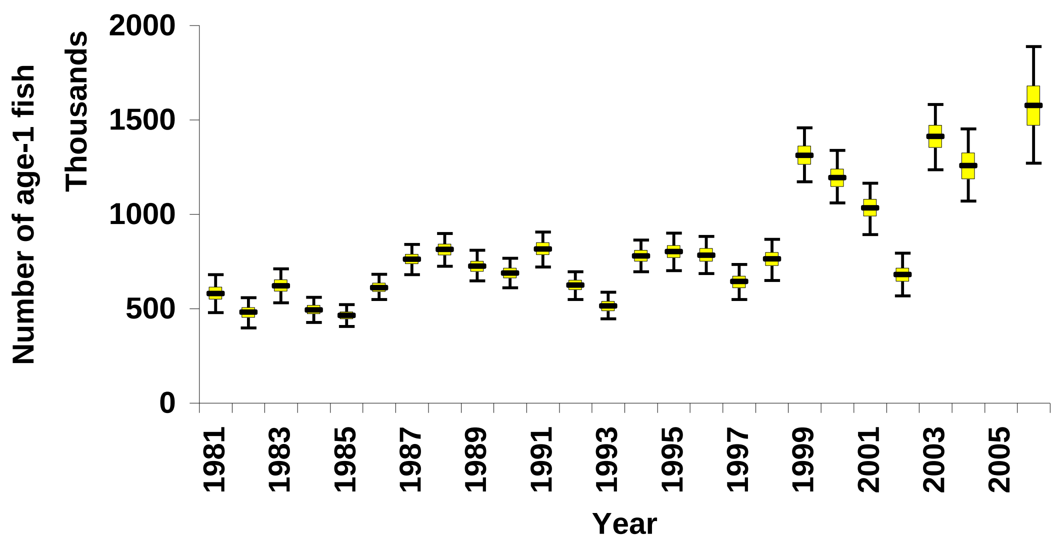


Figure 2.3.1.3.8. The annual spawning biomass (a) and the number of age-1 fish (b) estimated by the base run of ASAP. The vertical lines are the 95% confidence limits, the boxes are the inter-quartile ranges, and the horizontal lines are the medians from 1000 Monte Carlo simulations.

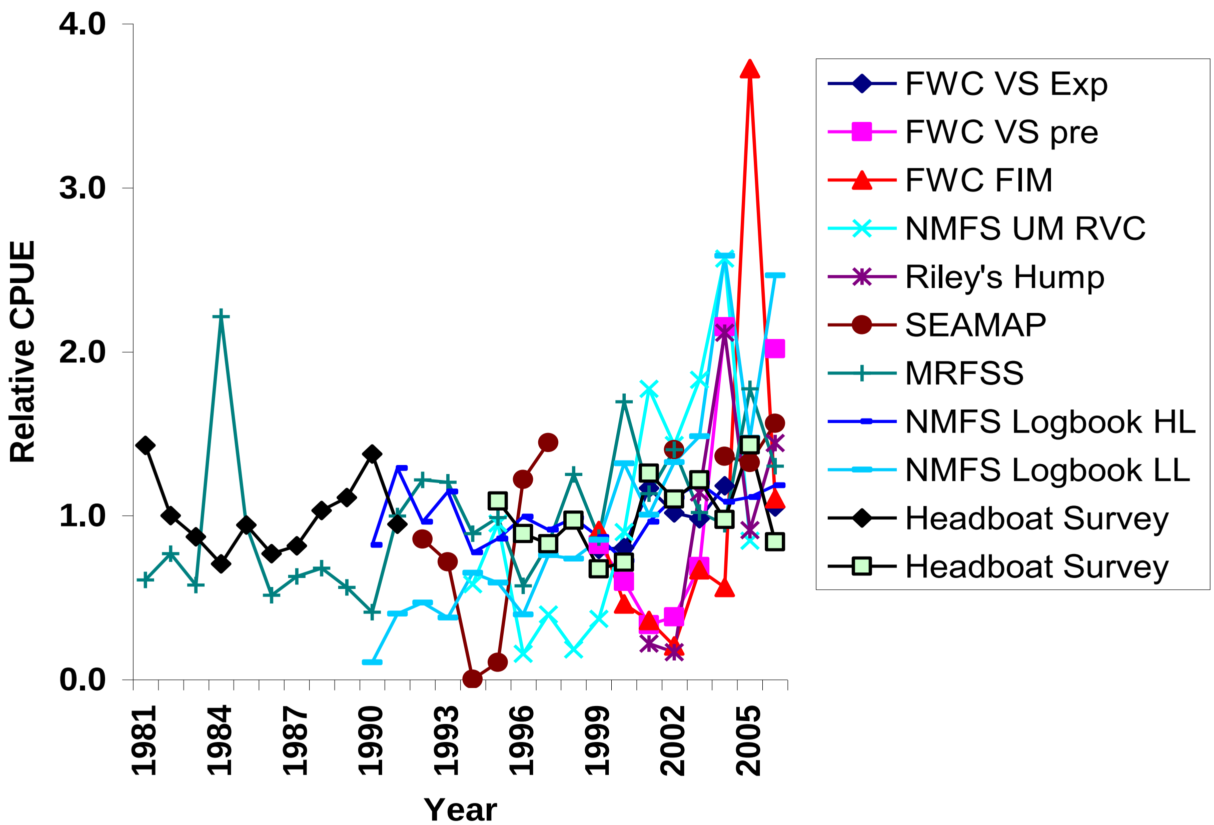
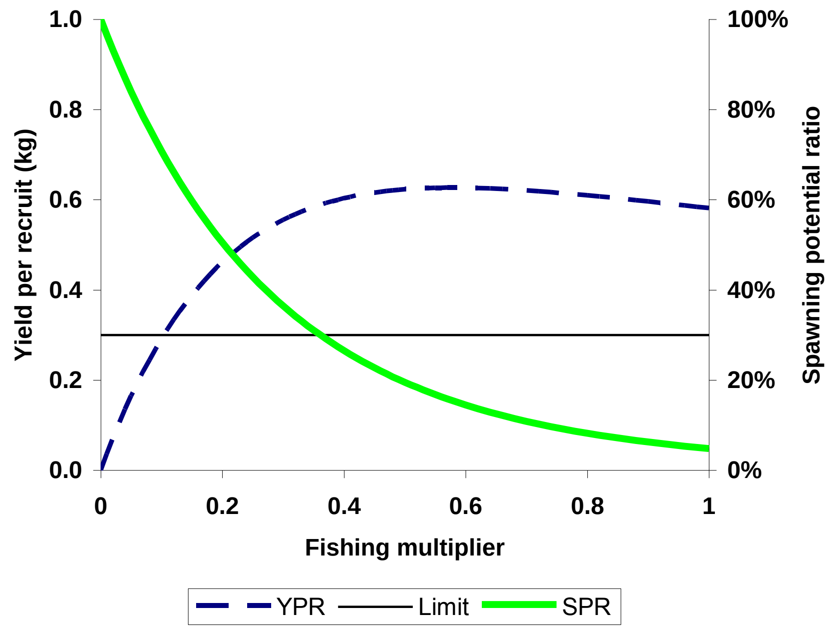


Figure 2.3.1.3.9. Relative indices of abundance (scaled to their means).

a.



b.

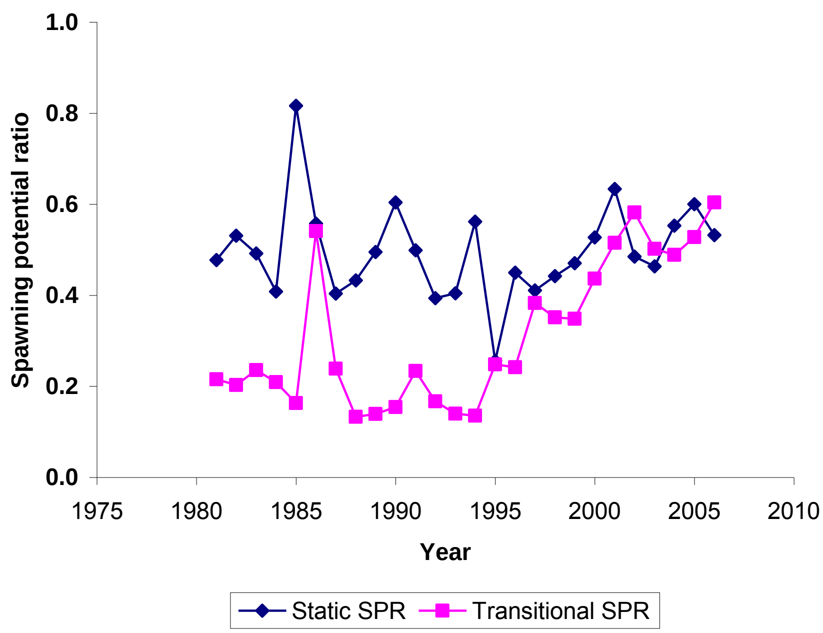


Figure 2.5.1. a) Yield-per-recruit, spawning potential ratio, and the SPR = 30% limit from the base run that had a steepness of 0.75 and age-specific natural mortality averaging 0.11 per year for ages 3-40. F_{MAX} was at 0.52 per year and $F_{30\%}$ was 0.34 per year. b) Static and transitional spawning potential ratios by year from the base run.

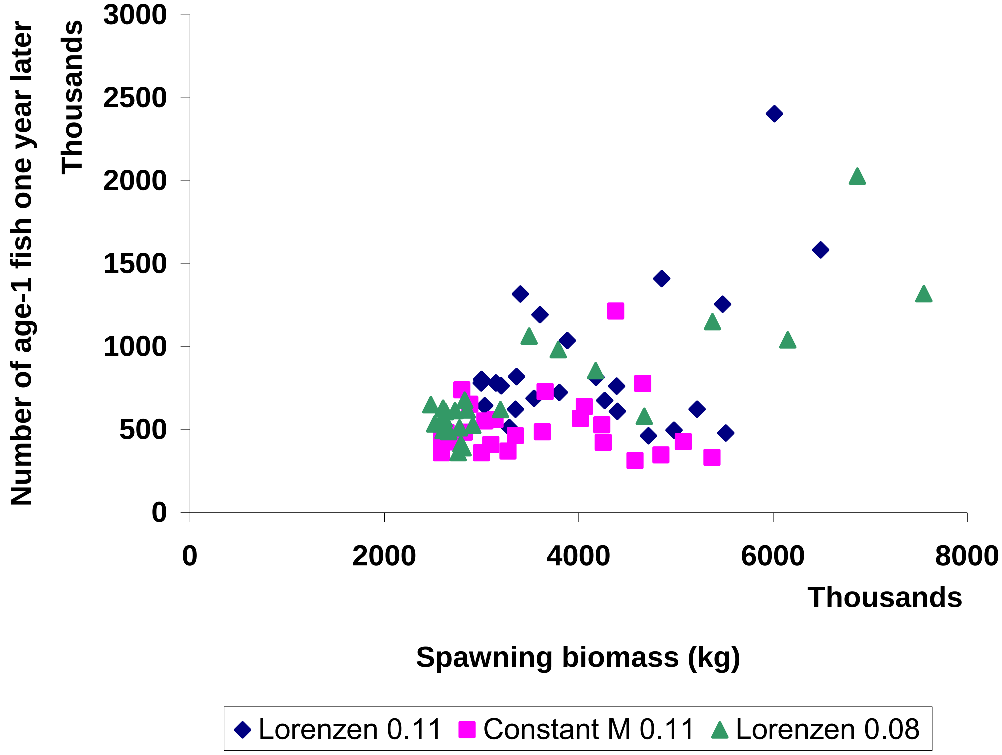


Figure 2.5.3. Spawning biomass and subsequent recruitment one year later for three natural mortality schedules: Lorenzen averaging 0.11 per year, constant natural mortality of M = 0.11 per year, and Lorenzen averaging 0.08 per year.

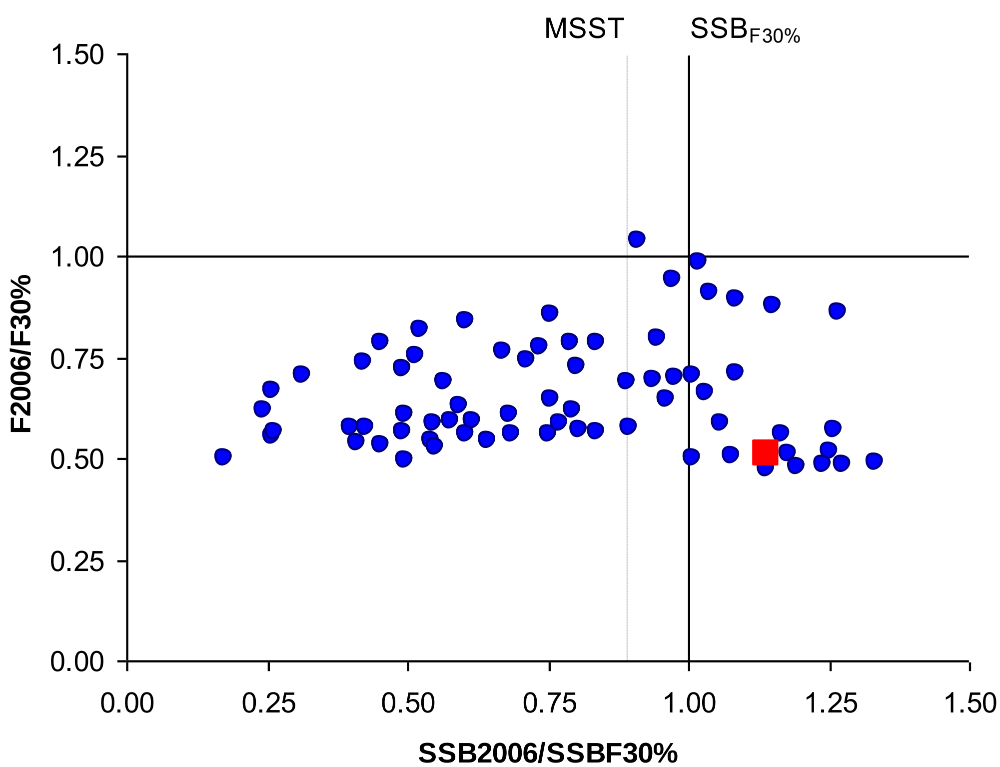
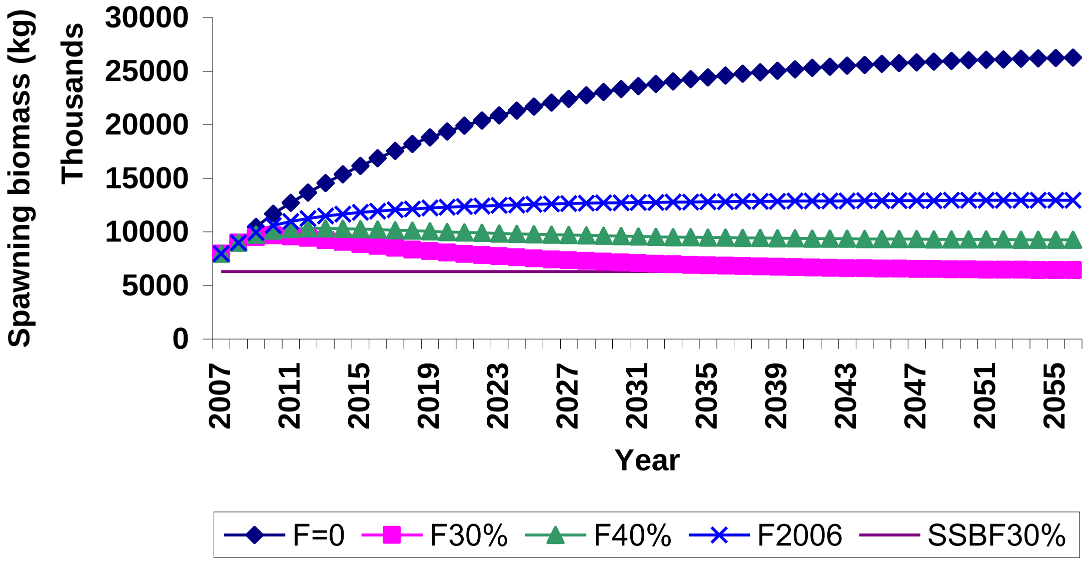


Figure 2.7. Ratios of **f**ishing mortality multiplier in 2006 to the $F_{30\%}$ and the spawning biomass in 2006 to spawning biomass at F30% for the 72 ASAP runs. The square marks the outcome of the base run.

a.



b.

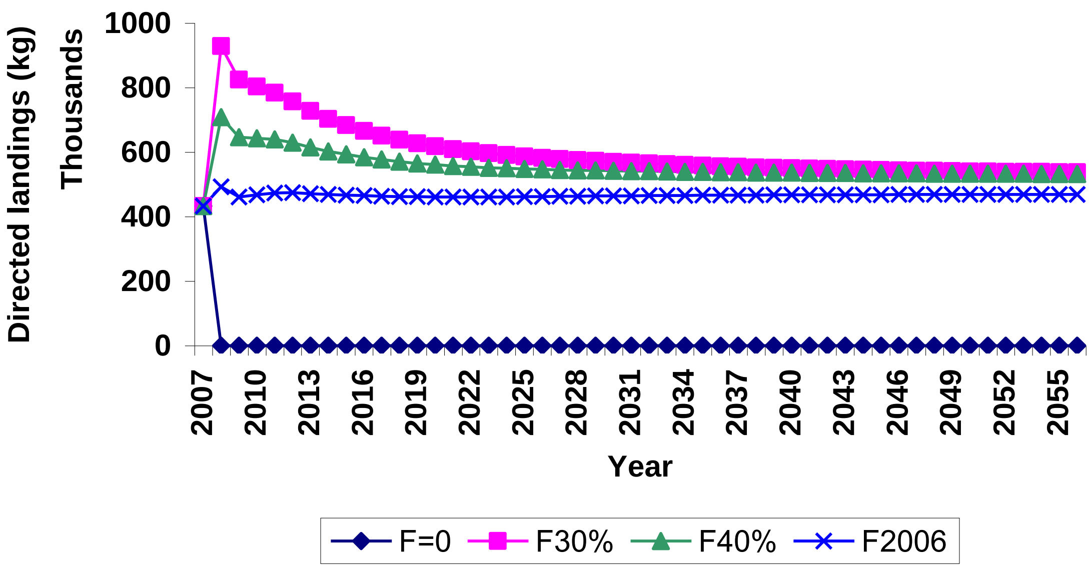


Figure 2.9.1. Projection of spawning biomass (a) and directed harvest (b) from the ASAP base run under four fishing mortality rates: F = 0, F= $F_{30\%}$, F=$F_{40\%}$, and F=F_{2006}.

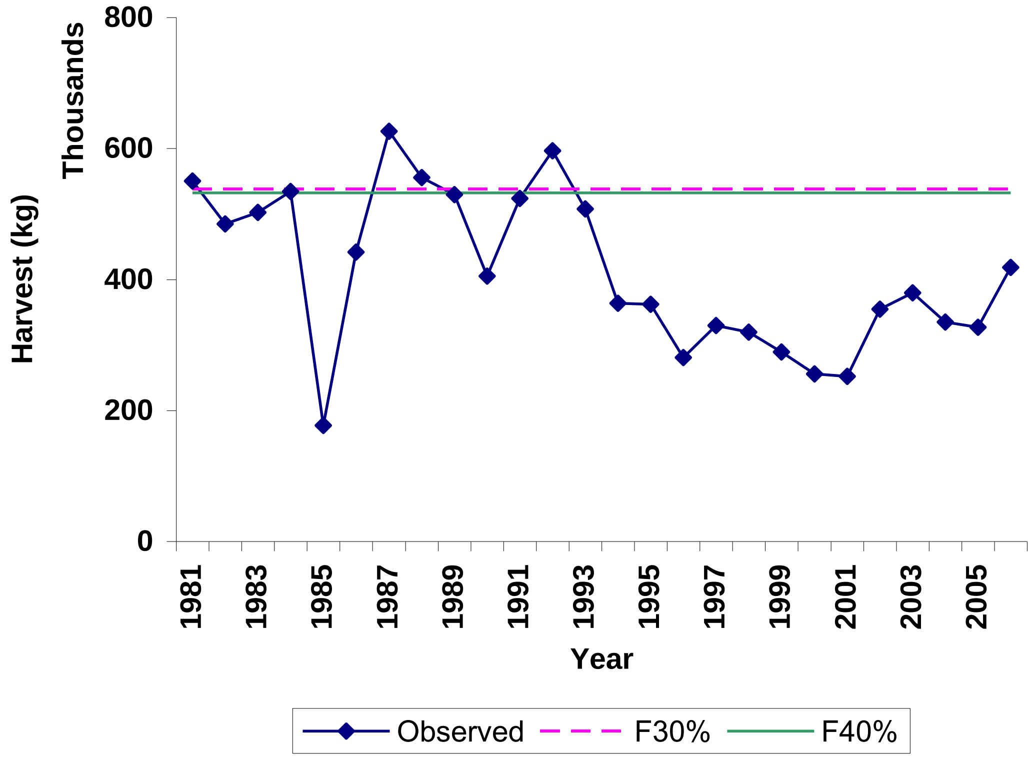
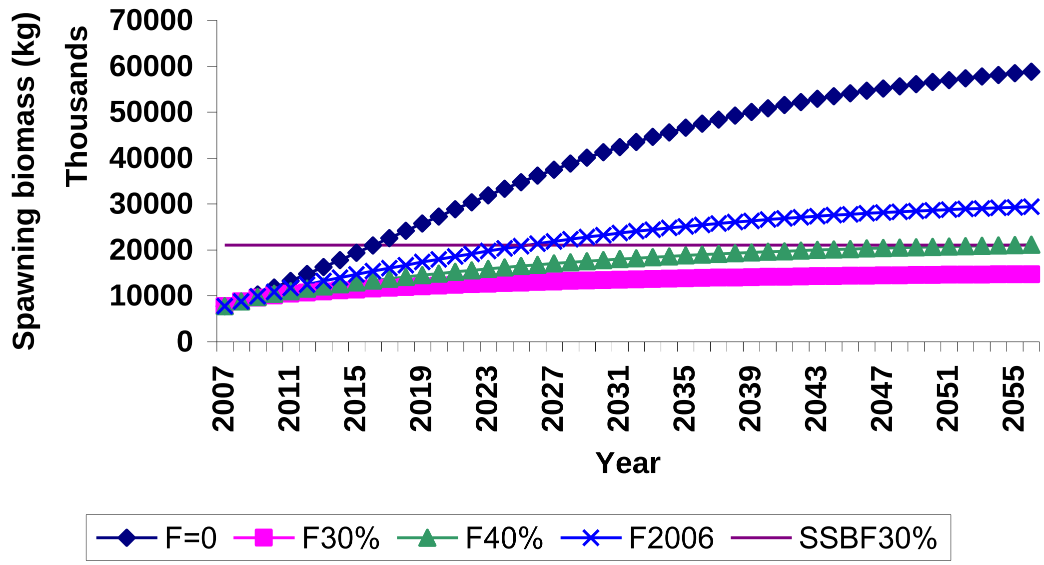


Figure 2.9.2. Comparison of historical directed harvest and the equilibrium maximum sustainable yield ($F_{30\%}$) and optimum yield ($F_{40\%}$).

a.



b.

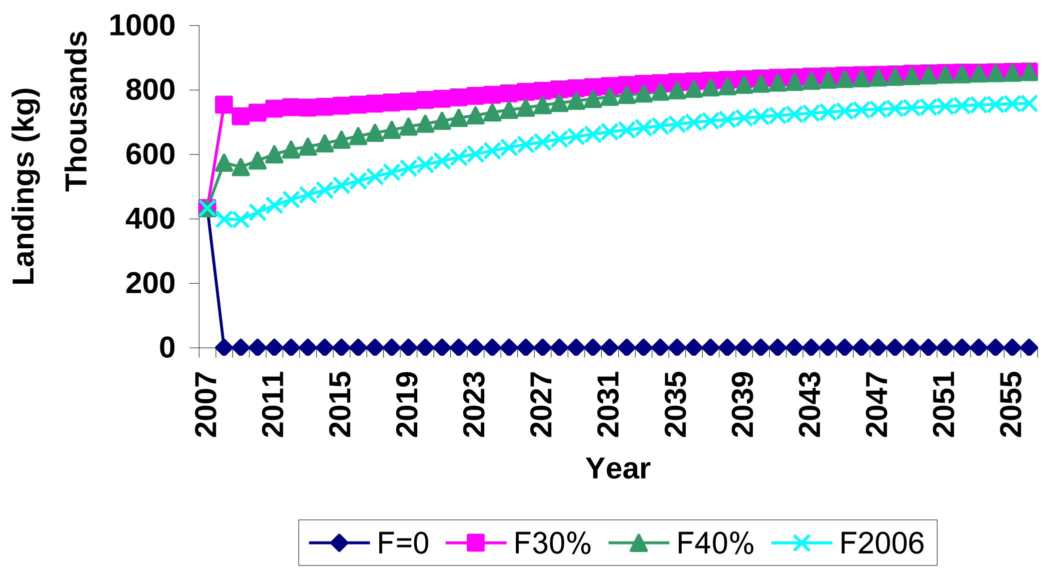


Figure 2.9.3. Projection of spawning biomass (a) and directed harvest (b) from the ASAP sensitivity run with age-specific natural mortality averaging 0.08 per year under four fishing mortality rates: F = 0, F= $F_{30\%}$, F=$F_{40\%}$, and F=F_{2006}.

Section IV. Review Workshop Report

Contents

1. Introduction

1.1. Workshop Time and Place

The SEDAR 15 Review Workshop was held at the Brownstone Holiday Inn in Raleigh, North Carolina on January 28 through February 1, 2008.

1.2. Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment*.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock*.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation*.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status*.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition* (e.g., exploitation, abundance, biomass).
6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters*. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and Advisory Report and that reported results are consistent with Review Panel recommendations**.
8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.
9. Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment.
10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Prepare an Advisory Report summarizing key assessment results. (Reports to be drafted by the Panel during the review workshop with a final report due two weeks after the workshop ends.)

* The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the

review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

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

1.3. List of Participants

SEDAR 15A Review Workshop
January 28-February 1, 2008
Raleigh, NC

NAME	Affiliation
Workshop Panel	
Kevin Friedland, Chair	NMFS NEFSC
Robin Cook	CIE
Vivian Haist	CIE
Joe Hightower	USGS
Graham Pilling	CIE
Presenters	
Kyle Shertzer	NMFS SEFSC
Doug Vaughan	NMFS SEFSC
Erik Williams	NMFS SEFSC
Robert Muller	FL FWC
Appointed Observers	
Jeff Buckel	SAFMC SSC/NCSU
Brian Cheuvront	SAFMC/NC DMF
Rob Cheshire	NMFS SEFSC
Paul Conn	NMFS SEFSC
Doug Gregory	GMFMC SSC
Tony Iarocci	SAFMC
Joe O'Hop	FL FWC
Observers	
Mac Currin	SAFMC
Mike Waine	NCSU
Will Smith	NCSU
Staff	
John Carmichael	SAFMC
Tyree Davis	NMFS SEFSC
Rachael Lindsay	SEDAR

Andi Stephens .... SAFMC
Dale Theiling .... SEDAR

1.4. List of Review Workshop Working Papers & Documents

Document#	Title	Authors
SEDAR15A-DW-01	SEAMAP Reef Fish Survey of Offshore Banks: Yearly Indices of Abundance for Mutton Snapper (*Lutjanus analis*)	Gledhill, C.T., Ingram, G.W.,Jr., Rademacher, K.R., Felts, P., Trigg, B.
SEDAR15A-DW-02	Annual Indices of Abundance of Mutton Snapper for Florida Keys. Stratified-random sampling (SRS) with Visual Point Counts.	Acosta, A., Muller, R.
SEDAR15A-DW-03	Annual Indices of Abundance of Mutton Snapper for Florida Keys. Juvenile Snapper Seining Program.	Ferguson, K.
SEDAR15A-DW-04	Nearshore Hard-Bottom Community Survey of the Florida Keys.	Tellier, M.
SEDAR15A-DW-05	Annual Indices of Abundance of Mutton Snapper of Florida Estuaries.	Ingram, W., Acosta, A., Colvocoresses, J., MacDonald, T., Barbieri, L.
SEDAR15A-DW-06-07	Baseline Data for Evaluating Reef Fish Populations in the Florida Keys, 1979-1998.	Bohnsack, J.A., McClellan, D.B., Harper, D.E., Davenport, G.S., Konoval, G.J., Eklund, A., Contillo, J.P., Bolden, S.K., Fischel, P.C., Sandorf, G.S., Javech, J.C., White, M.W., Pickett, M.H., Hulsbeck, M.W., Tobias, J.L., Ault, J.S., Meester, G.A., Smith, S.G., Luo, J.
SEDAR15A-DW-08	Fishery independent indices of abundance for mutton snapper, *Lutjanus analis*, from REEF fish surveys along Florida's Atlantic coast including the Dry Tortugas.	Muller, R.
SEDAR15A-DW-09	Revised standardized catch rates of mutton snapper from the United States Gulf of Mexico and South Atlantic handline and longline fisheries, 1990-2006.	McCarthy, K.
SEDAR15A-DW-10	Visual Census Surveys at Riley's Hump, Tortugas South Ecological Reserve.	Burton, M., Ingram, W.
SEDAR15A-DW-	Recreational catch rates for	Muller, R.

11-12	mutton snapper, *Lutjanus analis*, in the Southeast United States from the Marine Recreational Fisheries Statistics Survey and the Headboat Logbook Program.	
SEDAR15A-DW-13	Commercial Fishery	Brown, S., Beaver, R., Little, L.
SEDAR15A-DW-14	Recreational Fishery	Sauls, B.J., Cummings, N.
SEDAR15A-DW-15	Life History of *Lutjanus analis* inhabiting Florida waters.	Faunce, C., Tunnell, J., Burton, M., Ferguson, K., O'Hop, J., Muller, R., Feeley, M., Crabtree, L.
SEDAR15A-DW-16	Mortality estimates for mutton snapper, *Lutjanus analis* inhabiting Florida waters.	Faunce, C., Muller, R., O'Hop, J.
SEDAR15A-DW-17	Calibration and quality control of aging mutton snapper.	Tunnell, J, Crabtree, L., Burton, M., E. Ault
SEDAR15A-DW-18	Bottom longline fishery bycatch of mutton snapper from observer data.	Hale, L.

2. Consensus Report

2.1. Statements addressing each TOR

1. **Evaluate the adequacy, appropriateness, and application of data used in the assessment.**

Generally, the data available for mutton snapper is adequate for conducting a variety of analytical analyses to inform the assessment, and application of the data to the individual models was appropriate. The data workshop was thorough in investigating all potential data sources, and responded to all items in their terms of reference. The review panel discussed areas of data uncertainty and noted some areas where data analysis may be improved.

Mutton snapper life history information is generally adequate for the assessment. The panel notes the number of maturity samples is small and hence the maturity ogive may be biased. Additional analyses conducted after the Data Workshop (DW) resolved some of the differences between maturation estimates from a study conducted in Puerto Rico with those estimated for the FWC South Florida study. Revised selection criteria were applied to the FWC data and the resultant maturation schedule was used in the assessment.

Commercial catch estimates appear fairly reliable, although there are some differences between alternative data sources (i.e. FWC trip tickets and NMFS logbooks). The commercial annual landings estimates time series begins in 1902 although continuous annual estimates are not available until 1959. Models run from 1902 use interpolated catch to fill in missing year estimates. A peak in landings seen in the 1980s may result from a switch from a port agent system to a dealer reporting system.

Commercial fishery discard data is available from the Fisheries Logbook Program for 2002 to 2006. Average ratios of discards to landings for that period were used to create synthetic discard estimates for earlier years; this requires additional assumptions about size-specific discards in years prior to the 16 inch size limit, and results in higher uncertainty in these estimates. Commercial discard rates are low so the impact of this source of uncertainty on the assessment should be minor.

Recreational catch data are available from the Headboat and MRFSS survey programs, which have consistent survey designs since 1981. MRFSS estimates of landings in numbers should be fairly reliable, but landings in biomass are less reliable due to small samples sizes for average weight estimates (particularly in early years). Discards have been consistently reported in the MRFSS survey; headboat discard data is available for 2005 and 2006 from both logbook and observer programs. Headboat discards for earlier years are extrapolated from the 2005/2006 data, making these data less reliable than other discard estimates.

Length and age-frequency data for many of the fisheries is limited, particularly in earlier years of the time series.

The method used to develop CPUE indices from the MRFSS recreational fishery is a standard approach used for this type of data, and is based on all records (i.e. trips) where mutton snapper were caught or where mutton snapper was stated as the target species. This could result in a biased index because it includes all cases where mutton snapper were caught but does not consider trips that had the potential to catch mutton snapper (i.e. suitable habitat) but did not. It was noted that the methods used for this assessment are the standard approach for calculating CPUE indices from the MRFSS database. The Stephens and MacCall (2004) method for identifying species assemblages associated with a target species may be a better approach for identifying fishing trips for inclusion in CPUE calculations.

The GLM CPUE standardization for the Longline and Hook and Line fisheries included *year/area* interaction terms. Generally GLM CPUE standardizations do not include interaction terms with *year* because the objective is to have the *year* term capture all inter-annual variability in catch rates. The review panel questioned the approach used here. They were told that *year* was used as a random effect in the CPUE model, and was included with area in the interaction term. Apparently there is ongoing debate in the southeast region about the appropriateness of this approach. The procedures are experimental and still being explored and developed for stock assessment in general. The review panel could not agree with this approach – although a random effects CPUE model could potentially capture more uncertainty in the *year* effects (indices), subsuming *year* effects in the *year/area* interaction term seems undesirable. The panel asked to see the results of the GLMs run with and without the *year* interaction terms. Not including *year* interaction terms in the GLM had minor effect on the CPUE indices, so the panel was comfortable with the indices used in the assessment.

The panel discussed the rationale for splitting the Headboat data into two time series for conducting the CPUE standardization. The time series was split to account for the changes in legal size limit. The panel felt that this approach was appropriate when using the Headboat index in models that were not age-structured, but for age-structured models the selectivity function should account for changes in minimum legal size.

The DW developed a series of abundance indices from 9 fishery independent surveys. From these, the Assessment Workshop (AW) selected 6 indices to include in the assessment models. Indices were rejected based on lack of survey design, short time series, and local geographical coverage. The panel agreed with the reasons for rejecting indices, and noted that all of the surveys encompass only a fraction of the geographical range covered by the assessment. Thus, they potentially represent local mutton snapper abundance rather than stock abundance.

In addition, the panel provided the following suggestions about the use of the fishery independent surveys for future assessments:

- Two indices are developed for the FWC Visual Survey, a "pre-exploited" and an "exploited" index, based on fish size relative to the minimum legal size. Because the size range of 3-year-olds spans the minimum legal size, age 3 is included in the age range associated with both indices. A more consistent approach would be to use a size that effectively separates age 2 and age 3 fish.

- The SEAMAP Video survey excluded data collected in the Pulley Ridge area, and this exclusion does not appear warranted.

2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

A variety of analytical models were used to analyze the mutton snapper data sets. The panel endorsed this approach as the alternative assumptions and data sets used in the analyses result in a wider range of stock reconstructions, which better reflects the true uncertainty relative to the uncertainty generally estimated for a single model.

Two formulations of non-equilibrium surplus production models were fit to the catch and nominal effort time series; an Excel implementation and the NMFS Tool Box ASPIC model. Results from ASPIC were deemed unreliable because the estimate of *K* (the carrying capacity parameter) was at its' upper bound. The panel discussed the possibility that "trips" do not adequately capture changes in fishing effort; however other measures of nominal effort have not been consistently reported. An alternative would be to translate the standardized CPUE indices to effort. The panel also suggested that fitting the fishery independent abundance indices in the surplus production model may improve the analysis. Biomass and fishing mortality estimates from the surplus production analysis reflect one plausible series of values for these parameters.

A modified DeLury model, which assumes continuous rather than discrete recruitment, was fitted to the same data series as used in the surplus production analysis. The AW suggested that this model requires an independent estimate of biomass. The panel noted that the recruit estimates were of similar magnitude to the recruited biomass estimates and felt that these were unrealistic. Utility of this model for the current assessment is limited.

An untuned VPA model was fitted to the time series of catch-at-age data. The utility of this modeling approach is to provide starting estimates of selectivity parameters and stock abundance for the statistical catch-at-age models.

A Bayesian implementation of Stock Reduction Analysis (SRA), an age-structured approach to production modeling, was also used to fit to the mutton snapper catch and the MRFSS index time series. Of the analytical models used in the mutton snapper assessment, the SRA was based on the longest time series with catch beginning in 1902. As such, SRA model results are useful for investigating the historical biomass trajectory. Additionally, the Bayesian approach used in this model fitting provides realistic estimates of uncertainty in the stock trajectory and stock parameters.

The review panel questioned why the SRA model was fitted to MRFSS abundance index, as this is generally considered the less reliable of the fishery dependent abundance indices. The rationale given was that the MRFSS index is the longest of the time series and that it is less sensitive to regulatory changes because it estimates the total catch including discards.

The primary tool for assessing the mutton snapper resource was a statistical catch-at-age model, ASAP. An alternative catch-at-age model was investigated in the early stages of the AW analyses, but inconsistent estimates of population benchmarks resulted in this model being rejected for use in the assessment.

The panel noted several features of the ASAP model that limited the range of assumptions that could be evaluated.

ASAP is strictly an age-based model and it requires input of age composition data. Length frequency data from the mutton snapper fisheries were converted to age frequencies using fishery specific age-length keys. Annual age-length keys were not calculated, rather the age-at-length data were aggregated across years that had constant minimum size limits. This approach will tend to `normalize` the data and relative year-class signals will be lost. The impact of this approach for estimating the age composition of the catch could not be explored, but sensitivity trials that used only the direct ageing data provide some idea of the potential impact on the assessment. The direct ageing sensitivity trials all tended to estimate current biomass below the $F_{30\%}$ benchmark, while the trials with the synthetic age frequency data estimated higher current abundance. These differences may result from there being less direct ageing data, particularly in earlier years, but could also be the result of the age-length key conversions of length to age.

The review panel was concerned that the selectivity curves estimated for all fisheries were highly dome shaped, while there is reason to believe that the longline fishery has asymptotic selectivity. Dome-shape selectivity results in cryptic biomass, and the potential to overestimate SSB if selectivity is actually asymptotic. The review panel requested that an ASAP run that approximated asymptotic longline selectivity be attempted; asymptotic selectivity cannot be directly specified for the ASAP model so this requires `fooling` the model. A run that was able to fix the longline fishery with asymptotic selectivity (beginning at age 7), and included asymptotic selectivity for some other fisheries in the first period, was generated. While this run did not modify the assessment of current fishing mortality rates, it did result in a change in the spawning biomass trajectory (see Section 2.3).

Additionally, the review panel wanted to look at two runs using the alternative age-structured model that differed only in the specification of domed and asymptotic selectivity for the longline fishery. These runs could not be completed in the time allowed as they required changes to the data input files. The review panel does not feel that the effect of an asymptotic longline selectivity assumption on key model outputs has been fully explored.

The review panel questioned splitting the Headboat abundance index into two time series, and requested an ASAP model run based on a single index. Because ASAP models a change in the selectivity function when the minimum legal size changes, there is no need to estimate separate catchability parameters for the two periods. This sensitivity run had minimal effect on the stock reconstruction relative to the base run (see Section 2.3).

The review panel noted that the estimates of numbers-at-age in the first year of the analysis (1981), which are free model parameters, were extremely close to the initial values. The panel requested a sensitivity run where the initial values of these parameters were set to an F=0.45 assumption for 1981. An alternative run, initialized with higher values for the 1981 numbers-at-age parameters resulted in similar initial conditions to the base run (see Section 2.3).

The review panel made some suggestions that may improve future mutton snapper assessments:

- The ASAP analysis had lower weighting on discard biomass than on landings – while there is greater uncertainty with the discards than with landings, the data is unlikely to have information that would allow the model to estimate the direction of errors in the estimates. Alternative data streams based on the range of plausible assumptions about discards should be tested in the model as the basis for additional sensitivity runs.
- All indices were given the same weight in the ASAP model, but some may be more reliable than others. Additional information about the reliability of individual indices (scope of survey relative to the population, inter-annual variation in the index) could be used to develop more objective weighting.

3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

The review panel endorses the base run of the catch-at-age (ASAP) model as the basis for estimates of stock abundance, biomass and exploitation. There are substantial uncertainties in model results and the ASAP sensitivity trials illustrate some of the range of that uncertainty. Additional uncertainty is demonstrated when biomass trajectories from the other analytical models used in the assessment (surplus production, stock reduction, etc.) are examined. The analyses show qualitatively similar results, however uncertainty in absolute biomass is large (Figure 4).

There is no unique ‘best estimate model run’ that stands out as superior to other runs. Recognizing the need to use a reference run to characterize the stock and its status, the panel suggests using the ASAP base run for estimates of stock abundance, biomass and exploitation. The values need to be interpreted as one realization of a number of equally plausible runs and are conditioned on the particular assumptions made about the data and the population dynamics model. Alternative assumptions could yield equally plausible but different values as may arise in future assessments.

4. Evaluate the methods used to estimate population benchmarks and management parameters (e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status.

The two councils responsible for management of mutton snapper (the South Atlantic Fishery Management Council and the Gulf of Mexico Fishery Management Council) have adopted the $F_{30\%}$ proxy for managing this resource. The review panel supports the use of a SPR-based proxy for F_{msy} because F_{msy} is highly uncertain when the spawner-recruit relationship is uncertain, as is the case for mutton snapper (see Figure 2, Section 2.3).

All but one model run (of a total of 75 runs) for mutton snapper support the conclusion that overfishing is not occurring, and fishing mortality rates are well below the $F_{30\%}$ limit. Results relative to the overfished limit are equivocal; the base configuration of the ASAP model and many of the sensitivity trials suggest that $SSB_{2006}/SSB_{F30\%}$ is greater than 1; however many of the sensitivity trials suggest that $SSB_{2006}/SSB_{F30\%}$ is less than 1.

The review panel notes that $F_{30\%}$ may not be a highly risk-averse strategy for managing a species with a life history like mutton snapper (low M, long-lived). Mace (1994) recommends $F_{40\%}$ as an F_{msy} proxy and later studies have found that $F_{40\%}$ may be too high across some life-history strategies (Clark 2002, Williams and Shertzer 2003). The review panel is unable to provide advice on the appropriate MSY proxies to adopt for managing mutton snapper. Fishery managers must select the level of risk they will accept for a stock, and then a thorough risk analysis can be conducted to select stock-specific fishery benchmarks consistent with that risk level.

The Review Panel (RP) noted that its instruction specified that it "…shall not provide specific management advice. Such advice will be provided by existing Council Committees, such as the Science and Statistical Committee and Advisory Panels, following completion of the assessment." Given these guidelines the RP could not provide ABCs and felt that it was an inappropriate task for a review panel. The RP could review the methodology to arrive at an ABC if provided.

5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

The review panel endorses the method used to project future stock status. The projections conducted by the AW are conditioned on the base run. They are deterministic and do not include uncertainty about current stock abundance or future recruitment. As such, they represent only a single realization, taken from a multitude of equally likely realizations, about future conditions. The review panel considered whether a projection with stochastic recruitment would be useful, but decided that uncertainty would still be grossly underestimated and as such would not be informative.

The review panel recommends there be a relatively short interval (on the order 3 years) before the next mutton snapper stock assessment. This recommendation is motivated by the combination of uncertainty in current stock status relative to the overfished definition and the inability to fully explore alternative structural assumptions with the ASAP model.

6. **Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.**

A number of approaches are used to characterize uncertainty in the mutton snapper stock assessment. Analytical estimates of standard errors for key model parameters are provided for the base case ASAP run. These estimates are dependent upon the weightings used for the alternative data sets (e.g. small CVs for the indices) and the structural assumptions of the base case model formulations, and uncertainty will be grossly underestimated with this approach.

The level of uncertainty in the assessment is better characterized by the results of the sensitivity runs with the ASAP model. These examine the change in the assessment when a range of assumptions are varied. A large number of sensitivity runs were performed, which the panel considered. While these offer useful insight into the robustness of the assessment, the review panel was unable to explore the full range of “asymptotic longline selectivity” runs due to limitations of the ASAP code.

A final approach for examining uncertainty in the assessment was the use of alternative assessment models that differed in their structural assumptions and the data used. The panel suggested a subset of the ASAP sensitivity runs and the alternative assessment models as a summary of the uncertainty in the assessment. The results are given in Table 1 and Figure 1 and Figure 4.

Table 1. Summary of selected ASAP runs (14 of 72, and the two additional runs requested by the RP) to illustrate uncertainty in the estimates.

Run	Model	Configuration	F_{2006}	$F_{30\%}$	SSB_{2006}	$SSB_{30\%}$	$F_{2006}/F_{30\%}$	$SSB_{2006}/SSB_{30\%}$	Yield $F_{30\%}$	$F_{40\%}$	Yield $F_{40\%}$	Steepness	Ro
Base	Age-len	Steepness = 0.75	0.18	0.34	7145870	6295708	0.51	1.14	687611	0.26	524174	0.75	1166706
1	Age-len	Steepness = 0.65	0.17	0.35	7340580	7273472	0.50	1.01	701412	0.26	534793	0.65	1667068
5	Age-len	Steepness Free	0.18	0.34	7033070	5623472	0.52	1.25	678656	0.26	517309	0.91	869450
15	Age-len	ConstantM = 0.11	0.28	0.36	5060450	6395197	0.78	0.79	464120	0.27	355164	0.75	756476
20	Age-len	2% Inc catchability	0.24	0.35	5358690	5486192	0.70	0.98	515785	0.26	393512	0.75	1016684
25	Age-len	Lorenzen 0.08	0.18	0.31	8425080	21013765	0.58	0.40	611067	0.25	457744	0.75	1999378
32	Age-len	Fish Indep indices	0.14	0.25	5670790	7043072	0.57	0.81	597817	0.18	442374	0.75	1305205
39	Direct aging	Steepness = 0.75	0.10	0.17	5589200	9675256	0.59	0.58	637465	0.13	477829	0.75	1792991
37	Direct aging	Steepness = 0.65	0.09	0.17	6442690	14251704	0.53	0.45	703312	0.13	527830	0.65	3266455
41	Direct aging	Steepness Free	0.10	0.17	5289470	6665114	0.62	0.79	610074	0.13	457127	0.86	1084355
51	Direct aging	ConstantM = 0.11	0.10	0.17	5796020	11685339	0.61	0.50	584884	0.12	440630	0.75	1382233
56	Direct aging	2% Inc catchability	0.14	0.17	4124300	7902271	0.82	0.52	476464	0.13	357225	0.75	1464430
61	Direct aging	Lorenzen 0.08	0.10	0.14	6499210	25008945	0.66	0.26	519578	0.11	389922	0.75	2383498
68	Direct aging	Fish Indep indices	0.15	0.17	3515690	3244065	0.89	1.08	421042	0.12	313554	0.75	601181
RW 1	Age-len	Logistic selectivity	0.15	0.33	7835530	9941835	0.46	0.79	747358	0.25	570899	0.75	1842399
RW 2	Age-len	Single headboat index	0.23	0.36	5567860	5919352	0.62	0.94	553684	0.27	422785	0.75	1096957

7. **Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and Advisory Report and that reported results are consistent with Review Panel recommendations.**

The RP ensured that the stock assessment results were clearly and accurately presented in the SEDAR Summary Report for Mutton Snapper and that the results were consistent with the RP recommendations.

8. **Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.**

The RP had no specific comments about the SEDAR process in regard to the review process for mutton snapper. However, the RP discussed issues of relevance to the overall SEDAR review process.

The review panel appreciated the standardized layout of the data and assessment workshop reports, which greatly aided the reviewers in assimilating information on the different stocks.

Panel members noted that the documents had been received approximately one week before the review panel convened, rather than the two weeks stipulated in the Terms of Reference. This delay hampered a more thorough review by the panel members, although this was mitigated by the thorough presentations provided by the stock experts.

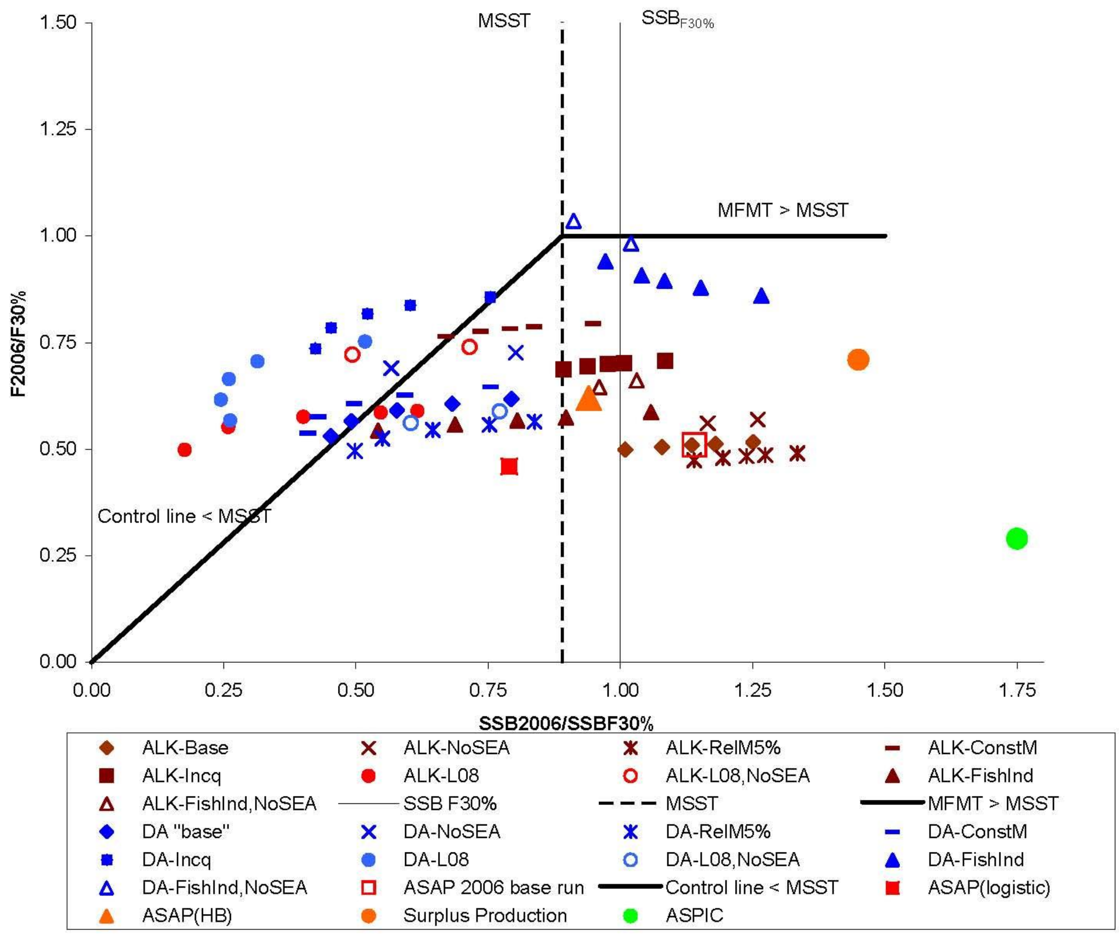


Figure 1. Comparison of ASAP model run configurations and results against fishery benchmarks. Results from additional sensitivity runs requested by the Review Panel using an asymptotic selectivity pattern for the different fisheries, a configuration using a new index for the Headboat Survey for the 1981-2006 time period (rather than a split time series for this index), and benchmark values from the Surplus Production and ASPIC models are plotted along with the ASAP benchmarks from the mutton snapper stock assessment.

The review panel thanked the rapporteurs for their assistance in developing the consensus summary reports, and noted that their contribution was invaluable and critical in preparing reports prior to the closure of the Review Workshop. The panel suggested that the process could further be improved by SEDAR helping to prepare the rapporteurs for this task with a more detailed guide on how to prepare a rapporteur's report.

The panel suggested that a fisherman-friendly one-page summary of the review proceedings be prepared for the Council. This could subsequently be disseminated at the docks to inform fishermen of the review workshop activities and findings.

The international members of the review panel appreciated the presentation of a short summary of US management regulations and benchmarks, which was a useful reminder of the legislative framework in which the review panel operated.

9. Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment.

The DW and AW made numerous recommendations regarding further research that might improve future assessments of mutton snapper. The review panel supports those recommendations, and in particular endorses the following:

- Collection of specimens for maturity analysis. After selection criteria had been applied to select an appropriate subset of potential samples, only 32 specimens were available to estimate the maturation schedule for the current assessment,

- Continued monitoring of discards in the commercial and recreational (headboat) fisheries to estimate magnitude and size frequency of discards is endorsed.

- Continuation of the various fishery independent surveys was recommended by the DW. The panel endorses this recommendation, but notes that the current surveys generally encompass only a portion of the habitats and regions of the mutton snapper stock, which may limit their utility for stock assessment. A fishery independent survey that encompasses the range of the stock would have greater value for stock assessment than a multitude of surveys that each are limited in geographic range.

The review panel noted the limited flexibility of the age-structured model (ASAP) used for the mutton snapper assessment and recommends that a more flexible age-based model be used in future assessments. Particular functionality that was missing from the ASAP model includes: ability to model both asymptotic and dome-shaped selectivity; ability to fit length frequency data directly; ability to fit longer time series of data; and, ability to initialize the population assuming a constant historical exploitation rate. The RP encouraged the continued development of ASAP as it provides an accessible software platform that can be used by a wide range of users.

10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Prepare an Advisory Report summarizing key assessment results.

The RP prepared a Review Panel Consensus Summary and provided comments on the SEDAR Summary Report for Mutton Snapper, and in particular stressed that the report was perhaps too detailed for the target audience.

Additional Comments

The panel discussed whether it was necessary to recommend that similar benchmarks be used for all three assessments (greater amberjack, red snapper, and mutton snapper) presented during this review. The consensus of the panel was that fishery managers must choose an appropriate level of biological risk in harvest management by selecting an appropriate proxy for F_{MSY} and other benchmarks, and that they need a thorough risk analysis to decide on the setting of fishery benchmarks for each species rather than using one proxy for F_{MSY} for all species.

Reviewer Statements

The panel attests that the Review Panel Consensus Summary for mutton snapper provides and accurate and complete summary of the issues discussed during the review.

References

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

Mace, P. M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Canadian Journal of Fisheries and Aquatic Sciences 51:110-122.

Clark, W. G. 2002. $F_{35\%}$ revisited ten years later. North American Journal of Fisheries Management 22:251-257.

Williams, E. H., and K. W. Shertzer. 2003. Implications of life-history invariants for biological reference points used in fishery management. Canadian Journal of Fisheries and Aquatic Science 60:710-720.

2.2. Panel Comments on the SEDAR Process

See term of reference 8

2.3. Summary Results of Analytical Requests

In relation to the discussion on the selection of appropriate fishery benchmarks and advice to fishery managers, the Review Panel requested a table summarizing additional model output values particularly for $F_{40\%}$. Because the Councils have adopted $F_{30\%}$ as a proxy for F_{MSY} for some species, but for other species have adopted other benchmarks such as $F_{40\%}$, the RP wanted the values for $F_{40\%}$ made available on the table. F_{MSY} is sensitive to steepness in the stock-recruitment relationship, whereas $F_{30\%}$ and $F_{40\%}$ are not. The different fishery benchmarks were available from the ASAP model runs, but were not contained in Table 2.4.2 of the Assessment Report. The RP requested a subset to be drawn from the ASAP model configurations that would illustrate the ranges in parameter values obtained with the different model configurations (Table 1). With the different model configurations, the RP noted that some of the parameter estimates sometimes varied greatly, and may represent some of the uncertainty based upon the assumptions being used in the model runs regarding stock-recruitment relationships, natural mortality, selectivities, and other model inputs. While the median value for the $SSB_{F30\%}$ was at 7.01 M kg, with modal values at 4-5 and 5-6 M kg, 11 of the configurations produced values over 15 M kg and up to 58 M kg. These higher values tended to be in age-length key configurations when natural mortality was set to 0.08, or more frequently where direct ageing was used (which supplied fewer catch-at-age data to the model), and natural mortality was set to 0.08 or at a constant M of 0.11 (Table 2.4.2). These results may help to illustrate some of the uncertainty in estimating the spawning stock biomass where the choice of model configurations is from a range of many possible configurations.

The results of all of the model runs against the current fishery benchmarks ($F_{30\%}$, $SSB_{F30\%}$, MSST, MFMT) were summarized for the Review Panel during the presentation, and the RP requested two additional ASAP model run re-configurations. The two additional configurations involved changing the shape of the selectivity patterns from

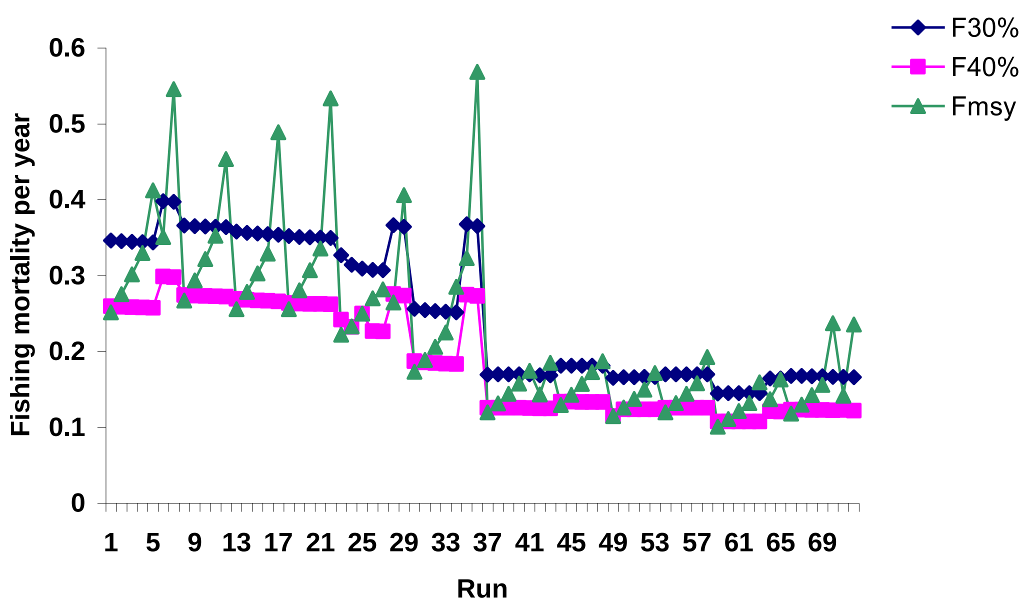


Figure 2. Comparison of $F_{30\%}$, $F_{40\%}$, and F_{MSY} for the different ASAP sensitivity runs.

dome-shaped to logistic in the base run, and re-calculating the Headboat Survey Index into a single time series rather than the split series (1981-1991, and 1995-2006) as used in the original runs. In addition, the RP requested that the fishery benchmarks from the surplus production and ASPIC analyses be added to the plot for comparison to the ASAP-produced results. The benchmark estimates from the requested ASAP runs and for the Surplus Production analysis (Figure 1) were in the same general region as most of the other ASAP configurations, and these results showed that changing the selectivity patterns for the fisheries and substituting a single index for the split index had relatively minor impacts on the estimated benchmarks. Furthermore, it was encouraging that the surplus production analysis also produced estimated benchmarks that were in the same general region as many of the ASAP runs even though the input data streams and model assumptions are greatly different. The ASPIC run produced benchmarks that were suspect due to the limit being reached on one of the model parameters (K, or "carrying capacity"), and the model results fishing mortality and population biomass estimates were unrealistic. The ASPIC analysis was only attempted to provide a comparison to the other models used in the mutton snapper assessment; it was not further explored and was never intended to be an important part of the assessment, especially since the model was reaching a limit within the software (i.e., the results from the run were probably not reliable due to computation or convergence problems).

The RP requested a plot of $F_{30\%}$, $F_{40\%}$, and F_{MSY} for the ASAP model runs. Figure 2 shows the magnitudes of these benchmarks and their relationship to each other in each of the model runs, while also demonstrating the effect of the stock-recruitment relationship in particular model configurations where the steepness was fixed at various levels or was free (i.e., calculated by the model). This may help provide some guidance when selecting benchmarks to use as proxies for F_{MSY} because the strength of the underlying stock-recruitment relationship would play a large role in determining the amount of risk associated with the choice of benchmarks.

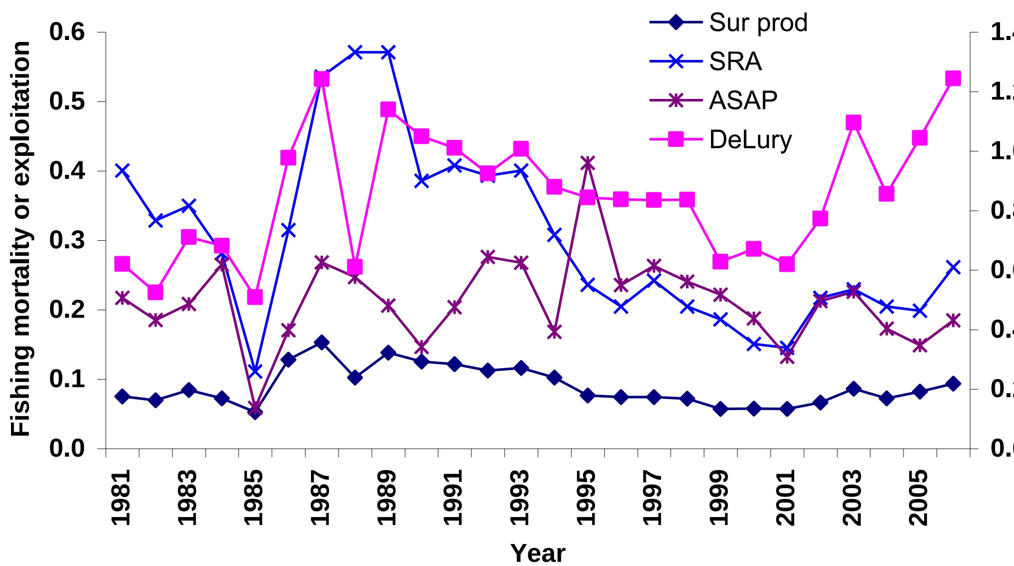


Figure 3. Comparison of fishing mortality trajectories across different assessment models. The rates from the DeLury model are plotted on the second axis.

Lastly, the RP requested two additional plots comparing some of the results from the different models used in this assessment. The fishing mortality rates (surplus production, DeLury, and ASAP base run) or exploitation rates (SRA) were plotted across the 1981-2006 time series to provide a visual comparison of the patterns from the different model results (Figure 3). Though noisy, all of the models provided reasonably similar patterns in fishing mortalities, and thus appear to be estimating similar signals in the data even though the input streams and assumptions differ between the models. The final requested plot was a comparison of the population biomass estimated over the 1981-2006 time series by the different models (Figure 4).

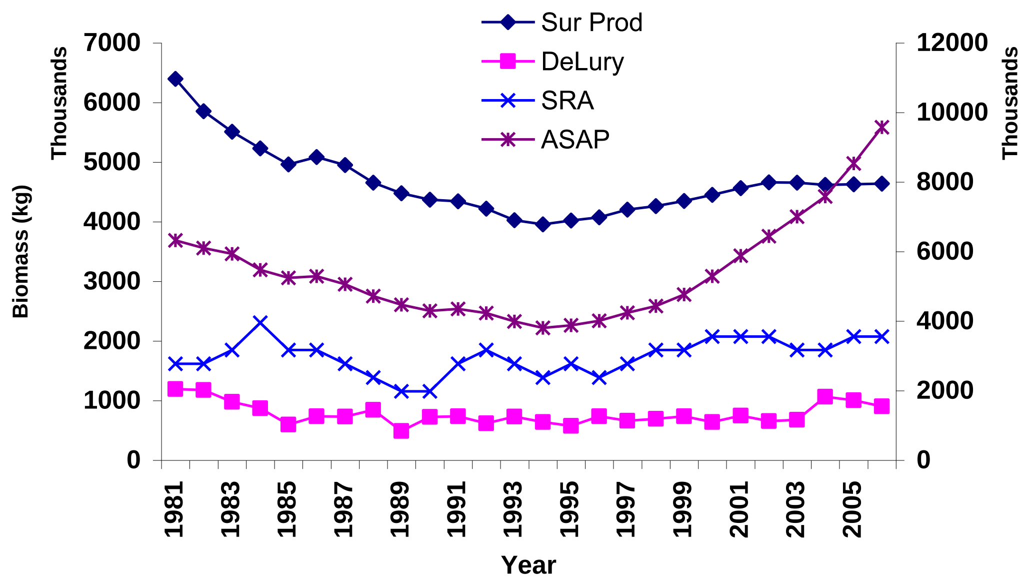


Figure 4. Comparison of biomass trajectories among different assessment models. The biomass estimates ASAP are plotted on the second axis.

4. Submitted Comments

Comments were received in the following memorandum from Captain Bill Kelly addressed to SAFMC member Captain Tony Iarocci. The four-page memorandum was discussed at the review workshop. Comments of the review panel follow the memorandum.

To: Capt. Tony Iarocci

From: Capt. Bill Kelly

Date: January 29, 2008

Subj: Stock Assessment Comments On Greater Amberjack, Mutton Snapper And Red Snapper.

<u>Comments</u>:

Tony,

Here is a cross section of comments I received from charter boat captains in Miami down through the Islamorada area.

<u>Capt. Jimbo Thomas Thomas Flyer Bayside Marina</u>
Jimbo and his brother Rick are lifetime 20+ year charter fishermen in Miami. Greater Amberjack are done, gone, non-existent off the Miami area. He would support a complete spawning closure, an additional one month closure to match the commercial fishery, reduced bag, slot and increase in minimum size to match commercial fishery.

Mutton snapper are plentiful in shallow on the patch reefs but all are under minimum size. They no longer catch muttons in 100 to 150 feet of water. The few they do catch are out deep on wrecks in 200 to 250 feet of water and they are usually big fish of 12-18 pounds. However, the numbers seem to be dwindling.

Red snapper are not abundant off the Miami area and he might catch three or four a year deep dropping.

Jimbo sees law enforcement as a serious issue off the mainland says for the most part it is non-existent as well.

Jimbo holds Restricted Species Endorsement, Federal Kingfish License, Unlimited Reef Fish Permit.

<u>Capt. Bouncer Smith Bouncer's Dusky Miami Beach Marina</u>
Lifetime charter boat fisherman off South Florida. He does not sell fish but respects the right of charter fishermen with permits to sell their catch and said many will not survive the economic turn-down if that aspect is taken away from them.

Greater Amberjack are severely depleted. In days gone by you could catch them until the customers couldn't wind anymore. Now you might catch one in a hard day of trying. Bouncer would support a full spawning closure, an additional one month closure to match the commercial fishery and reduced bag limits. He also favors a narrower slot favoring the bigger fish.

With regard to mutton snapper Bouncer agrees there are lots of little ones on the patches but no more 10-15 pounders and only scattered action on the deeper wrecks for fish of 15 pounds when they used to catch them to 20. Bouncer would support spawning closure, reduced bag limits, increase in size limits.

Red snapper are not a part of his directed fishery although he has caught more in recent years than ever amounting to perhaps 8 to 9 fish per year.

Bouncer also talked about the shortage of law enforcement in the area. He said his boat has been stopped once in the last two years and Susan Cocking of the Miami Herald was on board doing an article. Considering the number of days he spends on the water as one of the top fishing guides in South Florida he actually felt he should have been stopped and inspected more times.

Capt. Chuck Schimmelan Dee Cee Holiday Isle Marina

Chuck is a thirty year charter boat fishermen out of Holiday Isle Marina in Islamorada. Chuck sees a major decline in Greater Amberjack and drop in weight from an average of 60 pounds to 40. They can still be caught with some regularity at the Islamorada Hump but not in numbers of the past. He would support a full spawning closure, increase in the recreational closed sees to match the commercial fleet and increase in minimum size to match commercials.

Mutton snapper seem to be holding their own and fishing is neither up nor down. He would support a spawning closure.

Red Snapper are not part of his fishery.

Capt. Greg Pope Tag 'Em Holiday Isle Marina

Greg sees the Greater Amberjack population as down with fish averaging about 35 pounds down from the 50"s & 60"s of years gone by. He targets commercial fishermen as the cause of their depletion. He would support a full spawning closure, additional closure to match the commercial fishery and an increase in minimum size.

Mutton snapper seem to be holding their own according to Greg with fair numbers of 7-8 pounders on the patch reefs and along the reef line in 80 to 100 feet of water.

Red snapper are not part of his fishery.

Capt. Steve Leopold Yabba Dabba Do Holiday Isle Marina
Steve does not target a lot of amberjack but from his experience the fish seem to average about 35-40 pounds. He would support a spawning closure and increased closure to match the commercial fishery as well as an increase in minimum size.

Steve has found mutton snapper fishing about the same with no significant changes. There seem to be a fair amount of fish on the patch reefs of Hawk Channel and along the reef line. He would support a spawning closure.

Red snapper are not part of his fishery.

Capt. Rob Dixon Challenger Whale Harbor Marina
Greater amberjack are not a big part of his fishery but he sees an average of about 30 pounds per fish and says they are in decline. He would support spawning closure, increased in minimum size, changes in bag limits, etc. to correct the reduction in numbers. Feels commercial fishermen have a lot to do with the reduced stocks.

Mutton snapper seem to be about the same with no significant changes. He would support a spawning closure.

Red Snapper are not part of his fishery.

Rob does sell fish and said it is an important part of his business and vital to his overall income.

Capt. Robert Morrison Miller Time Whale Harbor Marina
Does not target greater amberjack but says stocks are on the decline and fish now run 30-40 pounds compared to 50-60 in past years. He would support a spawning closure, increase in size limits, closure to match the commercial fishery.

Mutton snapper action to the south and west of Islamorada is on the decline. He attributes part of it to commercial divers and states he sees significant numbers of speared fish at local fish houses.

Red snapper are not part of his fishery.

Capt. Randy Towe Quit Yer Bitchin' Private Dock
Randy has been fishing in the Keys for close to thirty years. Greater amberjack are not a part of his fishery.

Mutton snapper fishing for Randy has been fair and he sees signs of improvement. Randy fishes both sides of the islands and this year his anglers are catching and releasing record numbers of mutton snapper back in Florida

Bay. The action happens while targeting Spanish and king mackerel in water 10-12 feet deep and he usually catches and releases as many as 25 juvenile muttons while mackerel fishing. Randy would support spawning closures.

Red snapper are not part of his fishery.

<u>Capt. Alex Adler Kalex Bud N Mary's Marina</u>
Alex is a thirty year fisherman in the Islamorada. He sells fish and it constitutes a significant portion of his income. Alex feels greater amberjack stocks have been decimated primarily by commercial fishermen and would endorse any efforts to help rebuild the stock including a complete closoure, spawning closure, etc.

Mutton snapper are also in short supply according to Alex and the impact on these stocks over the past few years has been significant. He is gravely concerned there are no longer any spawning stocks in the area between Islamroada and Marathon. He would support spawning closures, reduced bag and increased size limit to improve stocks.

Red snapper are not part of his fishery.

Alex felt law enforcement was an issue, especially with regard to private boats.

<u>Capt. Bill Kelly OH-MI Private Dock</u>
Bill has been a fishing guide in Islamorada for the past 31 years. Although he no longer targets greater amberjack he has seen the average fish go from 60 to 30 pounds and in the past two years back up to 35. Bill feels the burden lies equally on recreational and commercial fishermen and recreational anglers should at least have to raise their minimum size limit of 28" to 32" to match the commercial sector and the recreational closure should match the commercial fishery. He also supports spawning closures.

Mutton snapper are not as prevalent as they used to be although this year seemed to be better than last and there were a lot of juvenile fish on the patch reefs of hawk channel which is good for recruitment. He would support spawning closures.

Red snapper are not part of his fishery.

Law enforcement is an issue and Bill would like to see more of it, especially on recreational boats for undersized fish and bag limit violations.

The review panel discussed a submission from Captain Bill Kelly that presented the opinions of a number of fishermen from Miami down through the Islamorada area on the status of greater amberjack and mutton snapper resources (few of the fishers had red snapper in their fisheries). The panel welcomed the document and noted a number of points.

There was considerable consistency between the opinions of the fishermen on declines in greater amberjack average catch weights, from 50-60 lbs to around 30 lbs. It was noted that this decline was fully consistent with the model results, reflecting the fishing of stock from a relatively unexploited state to one near MSY.

The panel recognized the valuable contribution that fishermen can provide, including expert opinion and data collection. Undertaking co-operative approaches to survey resources in a structured way, providing information that might otherwise be unavailable to stock assessments, are extremely worthwhile, and the panel supported efforts to expand these activities.