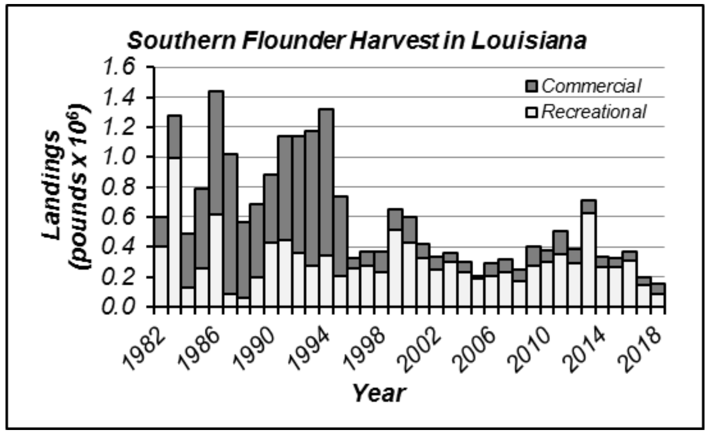
Assessment of Southern Flounder *Paralichthys lethostigma* in Louisiana Waters
2020 Report

<u>*Executive Summary*</u>

Landings of southern flounder (SF) in Louisiana have averaged just under 0.4 million pounds per year in the most recent decade. The 2017 and 2018 recreational and commercial harvests are the lowest on record. The highest harvests on record (over 1 million pounds) occurred prior to 1995. After commercial gear restrictions were enacted in 1995, commercial landings declined significantly and account for less than 25% of landings in the most recent decade.



A statistical catch-at-age model is used in this assessment to describe the dynamics of female southern flounder occurring in Louisiana waters from 1982-2018. The assessment model forward calculates abundance-at-age from estimates of abundance in the initial year of the time-series and recruitment estimates in subsequent years. The model is fit to the data with a maximum likelihood fitting criterion. Minimum data requirements are fishery catch-at-age and an index of abundance. Landings are taken from the Louisiana Department of Wildlife and Fisheries (LDWF) Recreational Creel Survey and Commercial Trip Ticket Programs, the National Marine Fisheries Service (NMFS) commercial statistical records, and the NMFS Marine Recreational Information Program (MRIP). Abundance indices are developed from the LDWF marine inshore trawl and trammel net surveys. Age composition of fishery catches are estimated with age-length-keys derived from direct samples of the fishery and a growth model.

There are currently no management thresholds established for the Louisiana southern flounder stock and no biological basis to establish management limits based on the history of the stock. Until biologically-based thresholds are established, a default limit of a 20% spawning potential ratio (SPR) is proposed. Based on results of this assessment and the proposed limit, the Louisiana southern flounder stock is currently overfished. Management actions will be needed in order to recover the stock from its current depleted condition.

There is also an alarming rapid downward trend in recruitment and spawning stock biomass. The 2017 and 2018 female recruitment and spawning stock biomass estimates are the lowest on record.

<u>*Summary of Changes from 2015 Assessment*</u>

Assessment model inputs have been updated through 2018. No changes have been made to the assessment model itself. A number of changes have been made to the data inputs of the assessment model that are described below. Because of these changes, this stock assessment is considered a benchmark assessment rather than an update of the previous assessment.

The time-series of recreational landings estimates used in this assessment has changed. In the previous assessment, recreational landing estimates were taken from the NMFS MRIP survey. In this assessment, recreational landings estimates are taken from the LDWF Recreational Creel Survey (LA Creel; 2014-2018) and estimates hindcast to the historic MRIP time-series (1982-2013; details in *Appendix 1*).

A new sampling program was established by LDWF in 2014, at the same time as the transition from MRIP to LA Creel, to provide biological information characterizing the size and age composition of LA fishery landings. In earlier assessments, size composition information of recreational landings was taken entirely from the MRIP survey. In this assessment, beginning in 2014, size composition of recreational landings was obtained from the LDWF Biological Sampling Program and from MRIP for years prior (details in *2. Data Sources*).

The prior assessment included landings of females and males combined. To remove uncertainty associated with male migration dynamics, only the female proportion of the stock is included in this assessment.

The LDWF inshore trawl survey and trammel net survey are used to develop indices of abundance as data inputs of the assessment model. These surveys were modified in October 2010 and again in 2013 (details in *2. Data Sources*).

The female southern flounder von Bertalanffy growth parameters used in the previous assessment to describe growth rates and develop age-length-keys for age assignments of fishery and survey catches has been replaced in this assessment with female von Bertalanffy growth parameters estimated from a larger LDWF/Louisiana State University (LSU) dataset (details in *Appendix 2*).

The female southern flounder maturity-at-age vector that was used in the previous assessment to calculate female spawning stock biomass has been replaced in this assessment with a vector developed from a logistic function fit to an LSU/Louisiana Sea Grant/LDWF dataset (details in *Appendix 2*).

The function used to assign the proportion female-at-size to fishery landings in the previous assessment has been replaced in this assessment with a logistic function fit to a larger LDWF dataset (details in *3. Life History Information*).

A change was also made to better represent the uncertainty of recreational and commercial landings in the assessment model. In the previous assessment, variability of landings was assumed constant across each time-series. In this assessment, annual values of variability are used to control model fits of fishery yield (details in *6. Assessment Model*).

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1. Introduction

A statistical catch-at-age model is used in this assessment to describe the dynamics of female southern flounder *Paralichthys lethostigma* (SF) occurring in Louisiana (LA) waters from 1982-2018. The assessment model forward projects abundance-at-age from estimates of abundance in the initial year of the time-series and recruitment estimates in subsequent years. The model is fit to the data with a maximum likelihood fitting criterion. Minimum data requirements are fishery catch-at-age and an index of abundance. Commercial landings values are taken from the Louisiana Department of Wildlife and Fisheries (LDWF) Trip Ticket Program and the National Marine Fisheries Service (NMFS) commercial statistical records. Recreational harvest estimates are obtained from the LDWF Recreational Creel Program (LA Creel) and the NMFS Marine Recreational Information Program (MRIP). Indices of abundance are developed from the LDWF marine inshore trawl and trammel net surveys. Age composition of fishery catches are estimated with age-length-keys derived from samples directly of the fishery (2002-2018) and a von Bertalanffy growth function (1982-2001).

1.1 Fishery Status

A comprehensive history of the SF resource and associated fishery within LA is described in Adkins et al. (1998) and for the Gulf of Mexico (GOM) in GSMFC (2000, 2015). A current summary of the LA SF fishery is presented below.

Commercial

The LA commercial SF fishery operates primarily within state inside waters (from the coastline upward to the saltwater line) and outside territorial waters (from the coastline seaward to the state water boundary), with some harvest from federal waters of the Exclusive Economic Zone (EEZ). Entanglement net bans in the late 1990's combined with other regulation changes caused a significant decline in commercial SF landings. Commercially harvested SF are landed primarily as incidental catch from shrimp fishers, with a smaller portion of the SF harvest from targeted activity.

Recreational

Similar to the commercial sector, the recreational SF fishery operates primarily within state inside waters and outside territorial waters. Southern flounder are infrequently targeted recreationally with less than 2% of LA anglers reporting southern flounder as their primary target in 2018 (LA Creel unpublished data).

1.2 Fishery Regulations

The LA southern flounder fishery is governed by the Louisiana State Legislature, the Louisiana Wildlife and Fisheries Commission, and the LDWF. Reviews of LA commercial and recreational SF regulations are presented below.

Commercial

Commercial SF harvest regulations changed substantially from 1995 through 1999. Commercial harvest methods were restricted on August 15, 1995, when the Marine Resources Conservation Act of 1995 (Act 1316 of 1995 Regular Legislative Session) became effective. This act prohibited the use of “set” gill nets or trammel nets in saltwater areas of Louisiana, and restricted flounder harvest by "strike" nets to the period between the third Monday in October and March 1 of the following year. A "Restricted Species Permit" issued by LDWF was also required in order to harvest SF with that gear. The Act also required annual stock assessments of southern flounder. In 1996, as a result of the first assessment of southern flounder finding the stock below a 30% SPR, and within the provisions of that Act, additional regulations became effective that outlawed the use of strike nets for SF harvest and limited possession to 10 fish per person aboard a commercial vessel. In 1997, regulations were changed by Acts 1163 and 1352 of the 1997 Regular Legislative Session in which commercial shrimping vessels were limited to 100 pounds of southern flounder per trip. In March of 1997, all flounder harvest by gill or trammel nets was banned. These regulations substantially reduced the commercial harvest of flounder. Regulations were changed in 1999 by Act 220 of the 1999 Regular Legislative Session which eliminated the 100-pound harvest limit on commercial shrimping vessels when southern flounder were harvested as incidental catch.

Current commercial regulations allow 10 fish for each licensed fisherman for each day on the water, except commercial shrimping vessels may retain all SF caught incidentally. There is no size limit on commercially harvested SF.

Recreational

Recreational regulations were first enacted in 1996 that established a creel limit of ten SF per day per licensed angler, with only a single day’s limit allowed in possession. Regulations were changed in August of 2004 by Act 460 of the 2003 Regular Legislative session, which allowed recreational harvest of SF with barbed gigs (prior to 2004 only barbless gigs were allowed). Current recreational regulations allow a 10 fish daily bag and possession limit per licensed angler with no size limit.

1.3 Trends in Harvest

Time-series of recreational and commercial SF landings are presented (Table 1, Figure 1).

Commercial

Commercial landings of southern flounder in LA remained below 0.4 million pounds until the 1970's. Commercial landings peaked from the mid-1980s through the mid-1990s with nearly 1 million pounds landed in 1987 and 1994. From 1986 through 1995, commercial SF harvest averaged over 0.7 million pounds. Commercial landings beginning in 1996 substantially declined due to regulatory changes and have not exceeded 0.2 million pounds to date. The lowest commercial harvests occurred in 2005 and 2017 (0.02 and 0.05 million pounds). In 2018, the commercial sector landed 0.06 million pounds of southern flounder.

The primary gears currently used in the commercial SF fishery are bottom trawls, butterfly nets, skimmer nets, trot lines, hand lines, and traps. The majority of commercial southern flounder landings occur during the annual offshore migration (October through December). Commercial SF landings before 2006 were relatively evenly distributed among the southeastern portion of the state, offshore, and the southwestern portion of the state. After 2005, commercial landings of SF became more concentrated in the southwestern portion of the state and remain so to date.

Recreational

Recreational LA SF landings have varied from an earlier low of 0.13 million pounds harvested in 1987 to a peak of 0.62 million pounds harvested in 2013. Since 2013, recreational SF landings have declined to a record low of 0.09 million pounds harvested in 2018.

The majority of recreational harvest occurs during the annual offshore migration (October through December). The most commonly used recreational gears to harvest southern flounder are rod-and-reel and a barbed gig.

2. Data Sources

2.1 Fishery Independent

The LDWF fishery-independent (FI) marine inshore trawl and trammel net surveys are used in this assessment to develop indices of abundance as inputs of the assessment model. Below are brief descriptions of each survey's methodology. Complete details can be found in LDWF (2018).

For sampling purposes, coastal Louisiana is currently divided into five LDWF coastal study areas (CSAs). Current CSA definitions are as follows: CSA 1 – Mississippi State line to South Pass of the Mississippi River (Pontchartrain Basin); CSA 3 – South Pass of the Mississippi River to Bayou Lafourche (Barataria Basin); CSA 5 – Bayou Lafourche to eastern shore of Atchafalaya Bay (Terrebonne Basin); CSA 6 – Eastern shore of Atchafalaya Bay to western shore of Freshwater Bayou Canal

(Vermillion/Teche/Atchafalaya Basins); CSA 7 – western shore of Freshwater Bayou Canal to Texas State line (Mermentau/Calcasieu/Sabine Basins).

The LDWF Marine Fisheries Section conducts routine standardized sampling within each CSA as part of a long-term comprehensive monitoring program to collect life-history information and measure relative abundance/size distributions of recreationally and commercially important species. These include the experimental marine gillnet, inshore trawl, trammel net, and bag seine surveys.

In this assessment, only the FI inshore trawl and trammel net surveys are used. The other FI gears mentioned above are excluded due to very low SF catches. The FI inshore trawl and trammel net surveys are conducted with standardized design. Hydrological and climatological measurements are taken with each biological sample, including water temperature, turbidity, conductivity and salinity.

The inshore trawl survey gear is a 16-foot flat otter trawl attached to a ½ inch diameter nylon or Kevlar rope, or stainless steel tow line and bridle. The length of the bridle is 2-3 times the trawl width. Samples are taken from ten minute tows at a constant speed and in a weaving or circular track to allow the prop wash to pass on either side of the trawl. All captured SF are enumerated and a maximum of 50 randomly selected SF are collected for length measurements.

This inshore trawl survey is conducted at fixed sampling stations within each LDWF CSA. In October 2010, additional fixed stations were added to this survey allowing more spatial coverage within each CSA. Prior to July 2013, sampling was conducted weekly from March to October and semi-monthly from November to February. Beginning July 2013, sampling was reduced to monthly samples from January-March and August- November and semi-monthly samples from April-July and December.

The trammel net survey gear is a 750-foot long and 6-foot depth net, consisting of 3 walls constructed of nylon. The inner wall has 1 5/8-inch bar mesh wall, and the two outer walls have 6-inch bar mesh wall. Samples are taken by ‘striking’ the net. All captured SF are enumerated and a maximum of 50 randomly selected SF are collected for length measurements, gender determination, and maturity information.

The trammel net survey was conducted from 1986 to October 2013 at fixed sampling stations within each CSA. In October 2010, additional fixed stations were added to allowing more spatial coverage within each CSA. Beginning in 2013, the survey design was modified where sampling locations are now selected randomly from the established stations within each CSA.

2.2 Fishery Dependent

Commercial

Commercial SF landings are taken from the LDWF Trip Ticket Program and the NMFS commercial statistical records (NMFS 2019; Figure 1). It's important to note that NMFS commercial records prior to 2000 did not differentiate landings of flatfish species in Louisiana. Several flatfish species can be found in LA waters, such as the gulf flounder *Paralichthys albigutta* and broad flounder *Paralichthys sauamilentus*, but the most common species is the southern flounder (GSMFC 2000). MRIP recreational landings estimates from 1985-1999 indicate gulf flounder comprises only 2.5% (on average as weight) of the annual recreational harvest relative to SF harvest, and none have been reported in that survey since then. Neither gulf nor broad flounder have been identified in LA Creel landings to date (2014-2019). Given these small landings, it is unlikely the inclusion of gulf or broad flounder in LA flatfish harvest estimates would have a major impact on SF stock status estimation. Therefore, for purposes of this assessment, commercial landings labeled as flatfish in LA are assumed as southern flounder.

Annual size compositions of commercial SF harvest (Table 2) are developed from samples from the Trip Interview Program (TIPS; 1982-2002), the Fishery Information Network (FIN; 2002-2013), and the LDWF Biological Sampling Program (2014-2018). Due to very limited size composition samples collected in early years of the commercial fishery, the 1994 TIPS size composition data are pooled with the available size data from earlier years and used as a proxy of the 1982-1993 size compositions. Due to very limited size composition samples collected from 1997-2001, the 2002 FIN samples are pooled with the available TIPS size information from 1997-2001 and used as a proxy of the 1997-2001 size compositions. For other years where annual size composition samples were < 200 (1996, 2008, 2011-2014, 2017), samples from the previous and prior years were pooled with that year's size composition samples. Due to very limited commercial size samples collected in 2018, the 2016-2018 samples are pooled and used as a proxy of the 2018 size composition.

Estimates of commercial live releases of SF are not available. Due to no size limit regulations, commercial live releases are assumed to be insignificant relative to commercial SF harvest and not considered further in this assessment.

Ages of commercial southern flounder landings are derived from a von Bertalanffy growth model (1982-2001) and otoliths collected directly from the commercial fishery (2002-2018; see *5. Catch at Age Estimation*).

Recreational

Recreational SF landings and live release estimates are taken from the LDWF recreational creel survey (LA Creel; 2014-2018) and estimates hindcast to the historic MRIP time-series (1982-2013; details in *Appendix 1*). Consequently, the pre-2014 recreational estimates used in this assessment differ from the LA estimates currently published by MRIP (https://www.st.nmfs.noaa.gov/recreational-fisheries/data-and-documentation/queries/index). Furthermore, due to changes made to the MRIP Access Point Angler Intercept Survey (APAIS) in 2013 (see https://www.fisheries.noaa.gov/topic/recreational-fishing-data#making-improvements) and the recent transition from the MRIP Coastal Household Telephone Survey to the new Fishing Effort Survey (FES; see https://www.fisheries.noaa.gov/recreational-fishing-data/types-recreational-fishing-surveys#fishing-effort-survey), harvest estimates currently available from MRIP also differ from those used in the prior LA SF stock assessment (Davis *et al.* 2015).

Annual size composition of recreational SF harvest estimates are derived from the LDWF Biological Sampling Program (2014-2018) and MRIP (1982-2013, prior to the APAIS and FES calibration changes; Table 3). Size composition estimates of recreational live releases are not available. Due to a no size limit regulation on the recreational fishery, annual size compositions of live releases are assumed equivalent to harvest. Statewide size compositions obtained from the LDWF Biological Sampling Program are derived by statistically weighting the CSA-specific size compositions by the corresponding recreational landings estimates.

Ages of recreational southern flounder landings are derived from a von Bertalanffy growth model (1982-2001) and otoliths collected directly from the recreational fishery (2002-2018; see *5. Catch at Age Estimation*).

3. Life History Information

3.1 Unit Stock Definition

Genetic studies of southern flounder utilizing allozymes (Blandon et al. 2001) and sequences of mitochondrial DNA (Anderson et al. 2012) suggest SF occurring in the GOM are a distinct stock. However, for purposes of this assessment and to remain consistent with the current statewide management strategy, the unit stock is defined as those female SF occurring in LA waters.

3.2 Morphometrics

The LA SF weight-length regression reported by Fischer and Thompson (2004) is used in this assessment for length-weight conversions. Regression equation slopes comparing males and females were not significantly different. For the purpose of this assessment, the non-sex-specific formulation is used with weight calculated from size as:

$$W = 3.47 \times 10^{-6}(TL)^{3.21} \quad [1]$$

where W is whole weight in grams and TL is total length in mm.

3.3 Growth

The von Bertalanffy parameter estimates for female southern flounder used in the previous assessment reported by Fisher and Thompson (2004) are replaced in this assessment with female von Bertalanffy growth parameters estimated from a larger LDWF/LSU dataset (see *Appendix 2*). Female southern flounder total length-at-age is calculated with the von Bertalanffy growth model as:

$$TL_a = 19.96 \times (1 - e^{-0.443(a+1.14)}) \quad [2]$$

where TL_a is TL-at-age in inches and years.

3.4 Sex Ratio

Southern flounder exhibit large differences in growth between males and females, with larger flounder being predominantly female (Fischer and Thompson 2004; see *Appendix 2*). The function used in the previous assessment to estimate the probability of being female at a particular size is replaced in this assessment with a logistic function fit to a larger LDWF dataset (Table 4). The probability of being female at a specific size is calculated from:

$$P_{fem,TL} = \frac{1}{[1+e^{[-0.516(TL-9.63)]}]} \quad [3]$$

where TL is in units of inches. The minimum sex ratio-at-size is assumed as 50:50. Equation [3] is used to estimate the proportion female-at -size for all years without sex composition records and for instances where n < 10 for year/size bins with sex composition records (Table 4).

3.5 Fecundity / Maturity

Total egg production is currently not estimable for LA southern flounder (see *8. Research and Data Needs*). For purposes of this assessment, female spawning stock biomass (SSB) is used as a proxy for total egg production. This may introduce bias if fecundity does not scale linearly with body weight (Rothschild and Fogarty 1989).

The age-specific female maturity vector used in the previous assessment (Fisher 2000) is replaced in this assessment with a vector developed from an age-specific logistic function fit to a LSU/Louisiana Sea

Grant/LDWF dataset (see *Appendix 2*) where 21% of age-1 females spawn, 60% of age-2 females spawn, 90% of age-3 females spawn, and 100% of age-4 and greater females spawn.

3.6 Natural Mortality

Southern flounder can live to at least eight years of age (Fisher and Thompson 2004). For purposes of this assessment, a value of constant M is assumed (0.53) based on longevity of the species, but is allowed to vary with weight-at-age to calculate a declining natural mortality rate with age. This value of M is consistent with a stock where approximately 1.5% of the stock remains alive to 8 years of age (Quinn and Deriso 1999, Hewitt and Hoenig 2005). Following SEDAR 12 (SEDAR 2006), the value of M is rescaled where the average mortality rate over ages vulnerable to the fishery is equivalent to the constant rate over ages as:

$$M_a = M \frac{nL(a)}{\sum_{a_c}^{a_{max}} L(a)} \qquad [4]$$

where M is the constant natural mortality rates over exploitable ages a , a_{max} is the oldest age-class (age-8 in this case), a_c is the first fully-exploited age-class, n is the number of exploitable ages, and $L(a)$ is the Lorenzen curve as a function of age. The Lorenzen curve as a function of age is calculated from:

$$L(a) = W_a^{-0.288} \qquad [5]$$

where -0.288 is the allometric exponent estimated for natural ecosystems (Lorenzen 1996) and W_a is weight-at-age.

3.7 Relative Productivity and Resilience

The key parameter in age-structured population dynamics models is the steepness parameter (h) of the stock-recruitment relationship. Steepness is defined as the ratio of recruitment levels when the spawning stock is reduced to 20% of its unexploited level relative to the unexploited level and determines the degree of compensation in the population (Mace and Doonan 1988). Populations with higher steepness values are more resilient to perturbation and if the spawning stock is reduced to levels where recruitment is impaired are more likely to recover sooner once overfishing has ended. Generally, this parameter is difficult to estimate due to a lack of contrast in spawning stock size (*i.e.,* data not available at both high and low levels of stock size) and is typically fixed or constrained during the model fitting process. Estimates of steepness are not available for southern flounder.

Productivity is a function of fecundity, growth rates, natural mortality, age of maturity, and longevity and can be a reasonable proxy for resilience. We characterize the relative productivity of LA southern flounder based on life-history characteristics, following SEDAR 9 (2006a), with a classification scheme developed at the FAO second technical consultation on the suitability of the CITES criteria for listing commercially-exploited aquatic species (FAO 2001). Each life history characteristic (von Bertalanffy growth rate, age at maturity, longevity, and natural mortality rate) is assigned a rank (low=1, medium=2, and high=3) and then averaged to compute an overall productivity score. In this case, the overall productivity score is 3.0 for GOM southern flounder (Table 5) indicating high productivity.

4. Abundance Index Development

Southern flounder indices of abundance (IOA) are developed from the LDWF FI inshore trawl and trammel net surveys.

The IOA developed from the inshore trawl survey represents young-of the year (age-0) SF catches only. Catches greater than age-0 are excluded based on size and date of capture and all age-0 catches are assumed as female. Only samples collected during the months of April through September are included in IOA development and samples from stations not sampled regularly through time are excluded. Catch-per-unit effort (CPUE) is defined as the number of age-0 female southern flounder caught per trawl tow.

The IOA developed from the trammel net survey uses October through December samples only. All female SF catches are included in this index, including age-0 catches. Catch-per-unit-effort is defined as the number of female SF caught per trammel net sample. To reduce unexplained variability in catch rates unrelated to changes in abundance, each IOA was standardized using methods described below.

A delta lognormal approach (Lo *et al.* 1992; Ingram *et al.* 2010) is used to standardize catch-rates in each year as:

$$I_y = c_y p_y \quad [6]$$

where c_y are estimated annual mean CPUEs of non-zero SF catches assumed as lognormal distributions and p_y are estimated annual mean probabilities of SF capture assumed as binomial distributions. The lognormal and binomial means and their standard errors are estimated with generalized linear models as least squares means and back transformed. The lognormal model considers only samples in which SF are captured; the binomial model considers all samples. The IOAs are then computed from equation [6] using the estimated least-squares means with variances calculated from:

$$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c,p) \quad [7]$$

where $\mathrm{Cov}(c,p) \approx \rho_{c,p}\left[SE(c_y)SE(p_y)\right]$ and $\rho_{c,p}$ represents the correlation of c and p among years.

Because of the designed nature of the FI surveys, model development was rather straightforward. Variables considered in model inclusion were year, CSA, and sampling location. Because only seasonal samples are included (*i.e.*, April-September and October-December respectively), time of year was not considered in model inclusion. To determine the most appropriate models, we began the model selection process with a fully-reduced model that included only year as a fixed effect. More complex models were then developed including interactions and random effects and compared using AIC and log-likelihood values. All sub-models were estimated with the SAS generalized linear mixed modeling procedure (PROC GLIMMIX; SAS 2008). In the final sub-models, year was considered a fixed effect, CSA was considered a random block effect, and sampling locations within CSAs were considered random subsampling block effects.

Sample sizes, proportion positive samples, nominal CPUE (of non-zero catches), standardized indices of abundance, and coefficients of variation of the standardized indices are presented (Table 6). Standardized and nominal CPUEs, normalized to 1 for comparison, are also presented graphically (Figure 2). Both indices depict similar trends, but unlike the trawl survey where both nominal CPUE and the probability of capture trend together, nominal CPUE of the trammel net survey is relatively flat through time but with a downward probability of capture.

For modeling purposes, where age-0 catches are not included in the assessment model but represent the majority of the survey catches, each IOA time-series is advanced forward a year to allow age-0 CPUE to become a proxy of age-1 CPUE (see *5. Catch at Age Estimation*). Survey timing is then set to the beginning of the year for each survey in the assessment model (see *6. Assessment Model*).

5. Catch at Age Estimation

Age-length-keys (ALKs) are developed to estimate the annual age composition/catch-at-age of fishery and survey catches as described below.

Southern flounder typically spawn December-January (GSMFC 2000). Ages of southern flounder in this assessment are assigned based on a biological January 1st birthday, where southern flounder become age-1 on January 1st and remain age-1 until the beginning of the following year.

5.1 Fishery

1982-2001 Probabilities of age a given length l for recreational and commercial female SF landings are computed from:

$$P(a|l) = \frac{P(l|a)}{\sum_a P(l|a)} \quad [8]$$

with probabilities of length given age estimated from normal probability densities as:

$$P(l|a) = \frac{1}{\sigma_a\sqrt{2\pi}}\int_{l-d}^{l+d} exp\left[-\frac{(l-l_a)^2}{2\sigma_a^2}\right] dl \quad [8b]$$

where length bins are 1 inch TL intervals with midpoint l, maximum $l + d$, and minimum $l - d$ lengths. Mean total length-at-age l_a is estimated from Equation [2]. The standard deviation in length-at-age is approximated from $\sigma_a = l_a CV_l$, where the coefficient of variation in length-at-age is assumed constant (in this case approximated as 0.05). To approximate changes in growth and vulnerability to the fishery through the year, mean l_a is calculated at the mid-point of the calendar/model year. The resulting $P(a|l)$ matrix (Table 7) is used in age assignments of 1982-2001 recreational and commercial landings and also for instances discussed below.

_2002-2018_ Fishery-specific f (*i.e.*, recreational and commercial) probabilities of age given length are computed from:

$$P(a|l)_{yf} = \frac{n_{layf}}{\sum_a n_{layf}} \quad [9]$$

where n_{layf} are annual fishery-specific southern flounder samples occurring in each length/age bin. For year/length bins with n <10, the $P(a|l)$ for that length interval is taken from equation [8] (Tables 8 and 9).

Annual fishery-specific catch-at-age is then calculated as:

$$C_{ayf} = \sum_l P_{fem,ly} C_{lyf} P(a|l)_{yf} \quad [10]$$

where C_{lyf} are annual fishery-specific catch-at-size in TL, $P_{fem,ly}$ are taken from Table 4, and $P(a|l)_{yf}$ are taken from Equations [8 or 9]. Recreational discard mortalities are incorporated directly into the recreational catch-at-age by applying a 10% discard mortality rate to the estimated live releases-at-size and combining them with the harvest-at-size estimates.

For modeling purposes, catches ≥ age-4 are summed into a plus group. Resulting annual fleet-specific catch-at-age and corresponding mean weights-at-age are presented (Tables 10 and 11).

5.2 Survey

Probabilities of age given length for female SF catches of the LDWF marine trammel net survey are computed from equation [8]. Mean total length-at-age is estimated from equation [2]. Variance in length-at-age is approximated as $\sigma_{as} = l_{as} CV_l$, where the coefficient of variation in length-at-age CV_l is assumed constant (0.05). To approximate survey timing, mean total length-at-age is calculated at the end of the calendar/model year. The resulting $P(l|a)$ matrix for female SF catches of the marine trammel net survey is presented (Table 12). Annual survey female catch-at-age is then taken from Equation [10] with annual survey female catch-at-size substituted (Table 13). Resulting annual age compositions of female SF catches of the LDWF marine trammel net survey are presented (Table 14).

6. Assessment Model

The Age-Structured Assessment Program (ASAP3 Version 3.0.12; NOAA Fisheries Toolbox) is used in this assessment to describe the dynamics of female SF occurring in LA waters. ASAP is a statistical catch-at-age model that allows internal estimation of a Beverton-Holt stock recruitment relationship and MSY-related reference points. Minimum data requirements are fishery catch-at-age, corresponding mean weights-at-age, and an index of abundance. ASAP projects abundance-at-age from estimates of abundance in the initial year of the time-series and recruitment estimates in subsequent years. The model is fit to the data with a maximum likelihood fitting criterion. An overview of the basic model configuration, equations, and their estimation, as applied in this assessment, are provided below. Specific details and full capabilities of ASAP can be found in the technical documentation (ASAP3; NOAA Fisheries Toolbox).

6.1 Model Configuration

Mortality

Fishing mortality is assumed separable by age a, year y, and fishery f as:

$$F_{ayf} = v_{af} Fmult_{yf} \quad [11]$$

where v_{af} are age and fishery-specific selectivities and $Fmult_{yf}$ are annual fishery-specific apical fishing mortality rates. Apical fishing mortalities are estimated in the initial year and as deviations from the initial estimates in subsequent years.

Commercial age-specific selectivities are modeled with double logistic functions as:

$$v_{af} = \left(\frac{1}{1+e^{-(a-\alpha_f)/\beta_f}}\right)\left(1 - \frac{1}{1+e^{-(a-\alpha 2_f)/\beta 2_f}}\right) \quad [12]$$

Recreational age-specific selectivities are modeled with a single logistic function as:

$$v_{af} = \frac{1}{1+e^{-(a-\alpha_f)/\beta_f}} \quad [13]$$

Total mortality for each age and year is calculated from the annual age-specific natural mortality rates and estimated annual fleet-specific fishing mortalities as:

$$Z_{ay} = M_{ay} + \sum_f F_{ayf} \quad [14]$$

For reporting purposes, annual age-specific fishing mortalities are averaged by weighting by population numbers at age as:

$$F_y = \frac{\sum_a F_{ay} N_{ay}}{\sum_a N_{ay}} \quad [15]$$

Population Abundance

Abundance-at-age in the initial year of the time series and recruitment in subsequent years are estimated and used to forward calculate the remaining numbers at age from the age and year-specific total mortality rates as:

$$N_{ay} = N_{a-1,y-1}e^{-Z_{a-1,y-1}} \quad [16]$$

Numbers in the 4-plus group A are calculated from:

$$N_{Ay} = N_{A-1,y-1}e^{-Z_{A-1,y-1}} + N_{A,y-1}e^{-Z_{A,y-1}} \quad [17]$$

Spawning Stock Biomass

Annual female spawning stock biomass is calculated from:

$$SSB_y = \sum_{i=1}^{A} N_{ay}W_{SSB,a}p_{mat,a}\, e^{-Z_{ay}(0)} \quad [18]$$

where $W_{SSB,a}$ are female spawning stock biomass weights-at-age (i.e., on January 1st), $p_{mat,a}$ are the proportion of mature females-at-age, and $-Z_{ay}(0)$ is the proportion of total mortality occurring prior to spawning on January 1st.

Stock Recruitment

Expected recruitment is calculated from the Beverton-Holt stock recruitment relationship, reparameterized by Mace and Doonan (1988), with annual lognormal deviations as:

$$\hat{R}_{y+1} = \frac{\alpha SSB_y}{\beta + SSB_y} + e^{\delta_{y+1}} \quad [19]$$

$$\alpha = \frac{4\tau(SSB_0/SPR_0)}{5\tau - 1} \text{ and } \beta = \frac{SSB_0(1-\tau)}{5\tau - 1}$$

where SSB_0 is unexploited female spawning stock biomass, SPR_0 is unexploited female spawning stock biomass per recruit, τ is steepness, and $e^{\delta_{y+1}}$ are annual lognormal recruitment deviations.

Expected Catch

Expected fishery catches are estimated from the Baranov catch equation as:

$$\hat{C}_{ayf} = N_{ay}F_{ayf}\frac{(1-e^{-Z_{ay}})}{Z_{ay}} \quad [20]$$

Expected fishery age compositions are then calculated from $\frac{\hat{C}_{ayf}}{\sum_a \hat{C}_{ayf}}$. Expected fishery yields are computed as $\sum_a \hat{C}_{ayf}\overline{W}_{ayf}$, where $\overline{W}_{ayf}$ are observed mean catch weights.

Survey Catch-rates

Expected annual survey catch-rates of age-1 female southern flounder catches of the trawl survey are computed from:

$$\hat{I}_{a=1,y} = qN_{a=1,y}(1 - e^{-Z_{a=1,y}(0)}) \quad [21]$$

where q is the estimated catchability coefficient of the marine trawl survey, and $-Z_{a=1,y}(0)$ is the proportion of the total mortality occurring on age-1 individuals prior to the time of the survey (January 1st).

Expected annual survey catch-rates of female southern flounder catches of the trammel net survey are computed from:

$$\hat{I}_{ay} = q \sum_a N_{ay}(1 - e^{-Z_{ay}(0)})v_a \quad [22]$$

where v_a is the survey selectivity, q is the estimated catchability coefficient of the trammel net survey, and $-Z_{ay}(0)$ is the proportion of the total mortality occurring prior to the time of the survey (January 1st). Survey selectivity is modeled with a double logistic function (Equation [12]). Expected survey age composition is then calculated from $\frac{\hat{I}_{ay}}{\sum_a \hat{I}_{ay}}$.

Parameter Estimation

The number of parameters estimated is dependent on the length of the time-series, number of fleets and selectivity blocks modeled, and number of tuning indices modeled. Parameters are estimated in log-space and then back transformed. In this assessment, 131 parameters are estimated:

1. 14 selectivity parameters (2 commercial selectivity blocks with 4 parameters per block, 1 recreational block with two parameters, and 1 survey selectivity block with 4 parameters).
2. 74 apical fishing mortality rates (F_{mult} in the initial year and 36 deviations in subsequent years for 2 fleets)
3. 37 recruitment deviations (1982-2018)
4. 3 initial population abundance deviations (age-2 through 4-plus)
5. 2 survey catchability coefficients
6. 1 stock-recruitment parameter (unexploited SSB)

The model is fit to the data by minimizing the objective function:

$$-ln(L) = \sum_i \lambda_i(-ln\, L_i) + \sum_j(-ln\, L_j) \quad [23]$$

where $-ln(L)$ is the entire negative log-likelihood , lnL_i are log-likelihoods of lognormal estimations, λ_i are user-defined weights applied to lognormal estimations, and lnL_j are log-likelihoods of multinomial estimations.

Negative log-likelihoods with assumed lognormal error are derived (ignoring constants) as:

$$-ln(L_i) = 0.5 \sum_i \frac{[ln(obs_i) - ln(pred_i)]^2}{\sigma^2} \quad [24]$$

where obs_i and $pred_i$ are observed and predicted values; standard deviations σ are user-defined CVs as $\sqrt{ln(CV^2+1)}$.

Negative log-likelihoods with assumed multinomial error are derived (ignoring constants) as:

$$-ln(L_j) = -ESS \sum_{i=1}^{A} p_i \, ln(\hat{p}_i) \quad [25]$$

where p_i and $\hat{p}_i$ are observed and predicted age compositions. Effective sample-sizes ESS are used to create the expected numbers $\hat{n}_a$ in each age bin and act as multinomial weighting factors.

6.2 Model Assumptions/Inputs

Model assumptions include: 1) the unit stock is adequately defined and closed to migration, 2) observations are unbiased, 3) errors are independent and their structures are adequately specified, 4) fishery vulnerabilities are dome-shaped, 5) abundance indices are proportional to absolute abundance, and 6) natural mortality, fecundity, and growth do not vary significantly with time. Lognormal error is assumed for catches, abundance indices, the stock-recruitment relationship, apical fishing mortality, selectivity parameters, initial abundance deviations, and catchability. Multinomial error is assumed for fishery and survey age compositions.

A base model was defined with an age-4 plus group, the steepness parameter fixed at 1.0, two commercial fishery selectivity blocks, one recreational selectivity block, and input levels of error and weighting factors as described below.

For the commercial fleet, two selectivity blocks are modeled that correspond to the following time-periods of consistent regulation: 1) 1982-1995 (no regulations), 2) 1996-2018 (entanglement nets banned). Within the recreational fleet, only one selectivity block is modeled due to no major regulation changes over the time-period modeled.

Input levels of error for commercial fishery landings were specified with CV's of 0.1 for years where landings were obtained from NMFS commercial records (1982-1998) and CV's of 0.05 for years where landings were obtained from the LDWF Trip Ticket Program (1999-2018; Table 10). Input levels of error for recreational fishery landings estimates were specified with the corresponding CV's estimated from the LDWF LA Creel survey (2014-2018) and estimates hindcast to the historic MRIP time-series (1982-2013; Table 11). Input levels of error for survey catch-rates were specified with CV's of 0.2 for all years of each time-series. Annual recruitment deviations were specified with CV's of 0.4 for all years of the time-series.

To allow reasonable estimates of population size in the first year of the time-series (*i.e.*, SSB_{1982}<SSB_0), the initial population abundance deviations were constrained with a CV of 0.1 to estimates from an exponential decline.

Lognormal components included in the objective function were equally weighted (all lambdas=1). Input effective sample sizes (ESS) for estimation of fishery age compositions were specified with ESS=50 for years where annual ALKs were available (2002-2018) and down weighted to ESS=10 for prior years. Input effective sample sizes (ESS) for estimation of survey age compositions were specified equally for all years of the time-series (all ESS=10).

6.3 Model Results

Objective function components, weighting factors, and likelihood values of the base model are summarized in Table 15.

Model Fit

The base model provides an overall reasonable fit to the data. Fits to the commercial and recreational landings are adequate, but are generally underestimated in the first half of each time-series and overestimated in the later half (Figures 3 and 4). Model estimated survey catch-rates provide reasonable fits to the data with little patterning observed in the residuals (Figures 5 and 6). Model estimated fishery and survey age compositions provide reasonable fits to the input age proportions (Figures 7-9).

Selectivities

Estimated fishery and survey selectivities are presented in Figure 10. Fishery estimates indicate full-vulnerability to the commercial fishery at age-4 during the 1982-1995 regulation block and age-3 for the 1996-2018 regulation blocks. Recreational estimates indicate full-vulnerability to the fishery at age-2 with over 97% vulnerability at age-1. Survey estimates indicate full vulnerability to the trammel net gear at age-1.

Abundance, Spawning Stock, and Recruitment

Total female stock size and abundance-at-age estimates are presented in Table 16. Female stock numbers have varied over the time-series with an overall downward trend. From 1982 through 1998 stock size remained relatively flat (mean of 2.2 million female fish). Stock size declined after 1998 from 1.8 million females in 1999 to 1.0 million females in 2001. Stock size increased after 2001 to a peak of 1.7 female fish in 2004 and remained relatively flat through 2011 (mean of 1.5 million female fish). Stock size began to decrease after 2011 to an all-time low of 0.3 million females in 2018.

Female spawning stock biomass (SSB) estimates are presented in Figure 12. As with (and related to) female stock size, female SSB has varied over the time-series with an overall downward trend. Female SSB remained above 1 million pounds from the beginning of the time-series through 2000 (mean of 1.4 million pounds). Female SSB began to decline after 2000 to a low of 0.7 million pounds in 2002. After 2002, female SSB increased to a peak of 1.3 million pounds in 2009. Female SSB began another decline in 2010 to a record low of 0.3 million pounds estimated in 2018.

Female age-1 recruitment has also varied over the time-series with an overall downward trend (Figure 11). The trend in female recruitment was relatively flat from the beginning of time-series until 1996. After 1996, female recruitment began to decline to a low of 0.7 million females estimated in 2001. Female recruitment increased after 2001 to a peak of 1.2 million females estimated in 2005. Female recruitment began another decline after 2005 to all-time lows estimated in 2017 and 2018 (0.2 and 0.1 million females respectively). Mean (geometric) recruitment of the entire time-series is 0.9 million females. Mean recruitment in the first and most recent decades of the time-series are 1.4 and 0.5 million females respectively. It's important to point out here the consequence of this decline on management reference point estimation. Because equilibrium conditions (i.e., average recruitment) are assumed in reference point estimation (see *6.4 Management Benchmarks*), management benchmarks will generally be biased when below average conditions persist for extended time periods.

Fishing Mortality

Estimated fishing mortality rates are presented in Table 17 (total apical, average, and age-specific) and Figure 13 (average only). Average rates are weighted by estimated stock numbers-at-age. Fishing mortality rates have varied over the time-series with an upward trend in the most recent decade. Fishing mortality generally increased from the beginning of the time-series through 1994. After commercial gear restrictions were enacted in 1995, fishing mortality decreased to a low of 0.14 yr^{-1} estimated in 1998. Fishing mortality began to increase after 1998, concurrent with the decline in female age-1 recruitment, to a peak of 0.50 yr^{-1} estimated in 2001. Fishing mortality decreased again following 2001 to an all-time low of 0.13 yr^{-1} estimated in 2008. After 2008, fishing mortality generally increased to record peaks of 0.74 yr^{-1} and 0.59 yr^{-1} estimated in 2013 and 2016. The 2018 average fishing mortality rate estimate is 0.44 yr^{-1}.

Stock-Recruitment

A downward relationship is observed between female SSB and subsequent age-1 female recruitment (Figure 14). The most recent data pairs are the lowest on record. The ASAP base model was run with steepness fixed at 1.0. The estimated unexploited female recruitment and unexploited female SSB was 0.9

million females and 2.1 million pounds. Alternate model runs with steepness values fixed at 0.9, 0.8, and 0.7 are discussed in the *Model Diagnostics* Section below.

Parameter Uncertainty

In the ASAP base model, 131 parameters were estimated. Asymptotic standard errors for the age-1 female recruitment time-series are presented in Figure 11. Markov Chain Monte Carlo (MCMC) derived 95% confidence intervals (CI) for the median female SSB and average fishing mortality rate time-series are presented in Figures 12 and 13.

6.4 Management Benchmarks

There are currently no management thresholds established for the Louisiana southern flounder stock and no biological basis to establish limits based on the history of the stock. Until biologically based thresholds are established, a default precautionary limit of a 20% spawning potential ratio (SPR; Goodyear 1993) is proposed. The method for calculating the SPR_{limit} and the corresponding spawning stock biomass and fishing mortality rate limit reference points is presented below.

When the stock is in equilibrium, equation [18] can be solved, excluding the year index, for any given exploitation rate as:

$$\frac{SSB}{R}(F) = \sum_{i=1}^{A} N_a W_{SSB,a} p_{mat,a}\, e^{-Z_a(0.0)} \quad [26]$$

where total mortality-at-age Z_a is computed as $M_a + v_a \times Fmult$; fishery vulnerability at age v_a is calculated by rescaling the current F-at-age estimate (geometric mean 2016-2018) to the maximum. Per recruit abundance-at-age is estimated as $N_a = S_a$, where survivorship at age is calculated recursively from $S_a = S_{a-1}e^{-Z_a}$, $S_1 = 1$. Per recruit catch-at-age is then calculated with the Baranov catch equation [20], excluding the year index. Yield per recruit (Y/R) is calculated as $\sum_a C_a \overline{W}_a$ where $\overline{W}_a$ are current mean fishery weights-at-age (arithmetic mean 2016-2018). Fishing mortality is averaged by weighting by relative numbers at age.

Equilibrium spawning stock biomass SSB_{eq} is calculated by substituting SSB/R estimated from Equation [24] into the Beverton-Holt stock recruitment relationship as $\alpha \times SSB/R - \beta$. Equilibrium recruitment R_{eq} and yield Y_{eq} are then taken as $SSB_{eq} \div SSB/R$ and $Y/R \times R_{eq}$. Equilibrium SPR (e.g., SPR_{limit}) is then computed as the ratio of SSB/R when F>0 to SSB/R when F=0.

As reference points to guide management, we estimate the equilibrium female spawning stock biomass and average fishing mortality rate that lead to a 20% SPR (SPR_{limit}, SSB_{limit}, and F_{limit}). Management targets for southern flounder were established by LAC 76: VII.385. The biomass target (SSB_{target}) is calculated as the average SSB (geometric mean) from the beginning of the assessed period through 2013. The average fishing mortality rate target (F_{target}) that corresponds to SSB_{target} when the stock is in equilibrium is then estimated from Equation [24].

The proposed limits and established targets of fishing are presented in Figure 15 relative to each time-series. Limit and target reference points are also presented in Table 18. Current estimates are taken as the geometric mean of the 2016-2018 estimates.

Also presented are a plot of the stock-recruitment data, equilibrium recruitment, and diagonals from the origin intersecting R_{eq} at the SSB_{target}, and the minimum and maximum SSB estimates of the time-series, corresponding with a SPR_{target} of 55%, and a minimum and maximum SPR of 14% and 82% (Figure 16).

6.5 Model Diagnostics

Sensitivity Analysis

In addition to the base model run, a series of sensitivity runs were used to explore uncertainty in the base model's configuration.

The ASAP base model was run with steepness fixed at 1.0. Alternate runs were conducted examining reference point estimates with steepness fixed at 0.9, 0.8, and 0.70 (Models 1-3).

Additional sensitivity runs were conducted by separately up-weighting the contributions of fishery yield and the IOA components within the base models objective function (lambdas increased from 1 to 10; Models 4 and 5).

Additional sensitivity runs were conducted using the maturity–at-age vector from the previous LDWF southern flounder stock assessment (Model 6) and only using the age-1 IOA developed from the marine inshore trawl survey as a data input of the assessment model (Model 7).

Another sensitivity run was conducted by increasing the discard mortality rate from 10% to 20% (Model 8).

An additional sensitivity run was conducted where the ALK developed from the von Bertalanffy growth model (Table 7) was used to assign ages to the entire time-series of fishery landings (Model 9).

Another sensitivity run was conducted using the MRIP ACAL time-series (see https://www.fisheries.noaa.gov/recreational-fishing-data/recreational-fishing-data-glossary#calibrated-data), rather than the FCAL time-series, to hindcast LA Creel estimates to the historic MRIP time-series (Model 10). This time-series was developed using the same approach described in *Appendix 1* with the ACAL estimates substituted for the FCAL estimates.

A final sensitivity run was conducted using the MRIP size distributions with the FES and APAIS calibrations applied (Model 11).

Results of each sensitivity run relative to the proposed limit reference points are presented in Table 19. Current estimates of female SSB and average F are taken as the geometric mean of the 2016-2018 estimates. Estimates from all sensitivity runs with the exceptions of Models 3, 4, 7, and 9 indicate the stock is currently below SSB_{limit}. All sensitivity runs with the exception of Model 5 indicate the fishery is currently operating below F_{limit}.

Also presented are estimates of maximum sustainable yield (MSY) and associated reference points for those sensitivity runs with the steepness parameter not fixed at 1 (Table 20). Results of the run with steepness fixed at 0.9 indicate that the fishery is currently operating under MSY and the stock is above SSB_{MSY}, where ratios of current F and SSB to F_{MSY} and SSB_{MSY} are below and above 1 respectively. Results of the run with steepness fixed at 0.8 indicate the fishery is currently operating under MSY but the stock is below SSB_{MSY}. The final run with steepness fixed at 0.7 indicates the fishery is operating above MSY and the stock is below SSB_{MSY}.

Retrospective Analysis

A retrospective analysis is conducted by sequentially truncating the base model by a year (terminal years 2015-2018). Retrospective estimates differed only marginally from the base run (Figure 17). Retrospective estimates of age-1 recruits and female SSB tend to decrease as additional years are added to the model. Retrospective estimates of the average fishing mortality rate tend to increase as additional years are modeled.

7. Stock Status

The history of the LA southern flounder stock relative to F/F_{limit} and SSB/SSB_{limit} is presented in Figure 18. Fishing mortality rates exceeding F_{limit} (F/F_{limit} >1.0) are defined as overfishing; spawning stock sizes below SSB_{limit} (SSB/SSB_{limit}< 1.0) are defined as the overfished condition.

Overfishing Status

The current estimate of F/F_{limit} is <1.0 (0.50), indicating the stock is not currently undergoing overfishing. The current assessment model also indicates that no overfishing occurred during the time-series examined.

Overfished Status

The current estimate of SSB/SSB_{limit} is <1.0 (0.94), indicating the stock is currently in an overfished state. The current SPR estimate is 19%.

Control Rules

There is currently no harvest control rule established for the LA southern flounder stock.

8. Research and Data Needs

As with any analysis, the accuracy of this assessment is dependent on the accuracy of the information of which it is based. Below we list recommendations to improve future stock assessments of southern flounder in Louisiana.

Factors that influence year-class strength of southern flounder are poorly understood. Investigation of these factors, including inter-annual variation in seasonal factors and the influence of environmental perturbations such as the Deepwater Horizon oil spill, should be a priority moving forward given the rapid decline observed in female age-1 recruitment and spawning stock biomass.

Fishery-dependent data alone is not a reliable source of information to assess status of a fish stock. Consistent fishery-dependent and fishery-independent data sources, in a comprehensive monitoring plan, are essential to understanding the status of fishery. Present monitoring programs should be assessed for adequacy with respect to their ability to evaluate stock status, and modified if deemed necessary.

Only limited catches of southern flounder occur in LDWF FI surveys. Expanding the LDWF FI surveys to a gear more effective in capturing adult southern flounder would allow an additional index of abundance in future modeling efforts that could help better characterize spawning stock size and also provide auxiliary life-history information.

The Southeast Area Monitoring and Assessment Program (SEAMAP) conducts fishery-independent monitoring surveys in the GOM. These surveys may provide useful information on adult southern flounder abundance in nearshore waters. Future efforts should explore these datasets and assess their potential for use in future stock assessments.

The GSMFC (2015) reviewed commercial and recreational GOM flatfish landings and came to the conclusion that landings were not adequately separated between gulf and southern flounder to be able to assess the stocks on a gulf-wide basis. In Louisiana, gulf flounder are an uncommon species, but broad flounder inhabit the nearshore and offshore areas of the state to some degree. Better definition of the distribution and harvest of southern flounder congeners will help better refine both fishery-independent and fishery-dependent inputs into future assessments.

Because existing and historic creel surveys have not sampled night fishing activities, recreational flounder harvest from gigging or bow fishing is not well-characterized. A specific survey to capture information on the scale of recreational flounder harvest that occurs at night could help improve the understanding of and the significance of those fisheries (note: commercial harvest of southern flounder from gigging is collected through the LDWF Trip Ticket Program).

The relationship between wetlands losses and the continuation of fishery production within Louisiana has been discussed by numerous authors. Understanding this relationship as it applies to the LA southern flounder stock should be an ongoing priority.

Female spawning stock biomass is used as a proxy of total egg production in this assessment. Spawning potential ratio estimates may be biased if egg production does not scale linearly with female body weight. Estimates of batch fecundity and spawning frequency as a function of age/size are needed.

With the recent trend toward ecosystem-based assessment models (Mace 2000; NMFS 2001), more data is needed linking southern flounder population dynamics to environmental conditions. The addition of meteorological and physical oceanographic data coupled with food web data may lead to a better understanding of the southern flounder stock and its habitat.

9. References

Adkins, G., S. Hein, P. Meier, and B. McManus. 1998. A biological and fisheries profile for southern flounder, *Paralichthys lethostigma* in Louisiana. Louisiana Department of Wildlife and Fisheries, Office of Fisheries, Fishery Management Plan Series No. 6, Part 1.

Anderson, J.D., W.J. Karel, and A.C.S. Mione. 2012. Population Structure and Evolutionary History of Southern Flounder in the Gulf of Mexico and Western Atlantic Ocean. Transactions of the American Fisheries Society. 141(1): 46-55.

Blandon IR, R. Ward, T.L. King, W.J. Karel, and J.P. Monaghan. 2001. Preliminary genetic population structure of southern flounder, *Paralichthys lethostigma*, along the Atlantic coast and Gulf of Mexico. U.S. National Marine Fisheries Service Fishery Bulletin 99:671-678

Davis, D., J. West, J. Adriance, and J.E. Powers. 2015. Assessment of southern flounder in Louisiana waters. 2015 Report of the Louisiana Department of Wildlife and Fisheries. 52 pp.

FAO. 2001. Second Technical Consultation on the Suitability of the CITES Criteria for Listing Commercially-exploited Aquatic Species: A background analysis and framework for evaluating the status of commercially-exploited aquatic species in a CITES context. Available: http://www.fao.org/docrep/MEETING/003/Y1455E.htm

Fischer, A. and B. Thompson. 2004. The age and growth of southern flounder, *Paralichthys lethostigma*, from Louisiana estuarine and offshore waters. *Bulletin of Marine Science*. 75(1):63-77.

Fisher, M.R. 2000. Assessment of western Gulf stocks- Stock assessment of southern flounder (*Paralichthys lethostigma*) in Texas waters. I*n* the Flounder Fishery of the Gulf of Mexico, United States: A Regional Management Plan. Ed. S.J. VanderKooy. Gulf States Marine Fisheries Commission. No. 83. 323 pp.

Goodyear, C.P. 1993. Spawning stock biomass per recruit in fisheries management: foundation and current use. *pp* 67-81 *in* S.J. Smith, J.J. Hunt and D. Rivard [ed.]. Risk evaluation and biological reference points for fisheries management. *Canadian Special Publication of Fisheries and Aquatic Sciences*. 442 pp.

GSMFC. 2000. The Flounder Fishery of the Gulf of Mexico, United States: A Regional Management Plan. Gulf States Marine Fisheries Commission. Ocean Springs, MS. https://www.gsmfc.org/publications/GSMFC%20Number%20083.pdf

GSMFC. 2015. Management Profile for the Gulf and Southern Flounder Fishery in the Gulf of Mexico. Gulf States Marine Fisheries Commission. Ocean Springs, MS. https://www.gsmfc.org/publications/GSMFC%20Number%20247.pdf

Hewitt, D.A., and J. M. Hoenig. 2005. Comparison of two approaches for estimating natural mortality based on longevity. *Fisheries Bulletin*. 103:433–437.

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

LDWF. 2018. Marine Fisheries Section Independent Sampling Activities Field Manual. Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA.

Lo, N.C.H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Canadian Journal of Fisheries and Aquatic Science*. 49:2515–2526.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. *Journal of Fish Biology* 49:627-642.

Mace, P.M., and I.J. Doonan. 1988. A generalized bioeconomic simulation model for fish population dynamics. Technical Report 88, New Zealand Fisheries Assessment Resource Document.

Mace, P.M. [ed.]. 2000. Incorporating ecosystem considerations into stock assessments and management advice. Proceedings of the 6th NMFS National Stock Assessment Workshop (NSAW). NOAA Technical Memorandum NMFS-F/SPO-46. 78 pp.

NMFS. 2001. Marine Fisheries Stock Assessment Improvement Plan. Report of the National Marine Fisheries Service National Task Force for Improving Fish Stock Assessments. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-56, 69 p., 25 appendices.

NMFS. 2019. Annual commercial landings statistics. National Marine Fisheries Service, Fisheries Statistics and Economics Division. Available: http://www.st.nmfs.noaa.gov/commercial-fisheries/index [accessed 10/2019].

NOAA Fisheries Toolbox. 2013. Age Structured Assessment Program (ASAP), Version 3.0.14. Available: https://www.nefsc.noaa.gov/nft/.

Rothschild, B.J., and M.J. Fogarty. 1989. Spawning-stock biomass: a source of error in recruitment/stock relationships and management advice. ICES Journal of Marine Science. 45:131-135.

SAS Institute Inc. 2008. SAS/STAT® 9.2 User's Guide. Cary, NC: SAS Institute Inc.

SEDAR. 2006. Gulf of Mexico Vermilion Snapper SEDAR 9 Assessment Report 3. SEDAR, Charleston, SC. Available at: https://sedarweb.org/docs/sar/SEDAR9_SAR3%20GOM%20VermSnap.pdf

SEDAR. 2006. Gulf of Mexico Red Grouper SEDAR 12 Assessment Report 1. SEDAR, Charleston, SC. Available at: http://sedarweb.org/docs/sar/S12SAR1%20Gulf%20Red%20Grouper%20Completev2.pdf

10. Tables

Table 1: Louisiana annual commercial and recreational southern flounder landings (pounds x 10^6; harvest only) derived from NMFS statistical records, LDWF Trip Ticket Program, MRIP, and LA Creel.

	Harvest			
Year	*Commercial*	*Recreational*	*%Commercial*	*%Recreational*
1982	*0.200*	*0.400*	*33.3%*	*66.7%*
1983	*0.276*	*0.997*	*21.7%*	*78.3%*
1984	*0.353*	*0.132*	*72.9%*	*27.1%*
1985	*0.530*	*0.261*	*67.0%*	*33.0%*
1986	*0.825*	*0.614*	*57.3%*	*42.7%*
1987	*0.938*	*0.083*	*91.9%*	*8.1%*
1988	*0.510*	*0.058*	*89.8%*	*10.2%*
1989	*0.492*	*0.193*	*71.8%*	*28.2%*
1990	*0.456*	*0.427*	*51.6%*	*48.4%*
1991	*0.692*	*0.443*	*61.0%*	*39.0%*
1992	*0.785*	*0.356*	*68.8%*	*31.2%*
1993	*0.899*	*0.270*	*76.9%*	*23.1%*
1994	*0.975*	*0.346*	*73.8%*	*26.2%*
1995	*0.533*	*0.204*	*72.3%*	*27.7%*
1996	*0.062*	*0.260*	*19.2%*	*80.8%*
1997	*0.095*	*0.276*	*25.6%*	*74.4%*
1998	*0.140*	*0.227*	*38.1%*	*61.9%*
1999	*0.141*	*0.510*	*21.7%*	*78.3%*
2000	*0.177*	*0.425*	*29.5%*	*70.5%*
2001	*0.092*	*0.325*	*22.0%*	*78.0%*
2002	*0.082*	*0.250*	*24.7%*	*75.3%*
2003	*0.064*	*0.300*	*17.5%*	*82.5%*
2004	*0.074*	*0.229*	*24.3%*	*75.7%*
2005	*0.022*	*0.186*	*10.4%*	*89.6%*
2006	*0.084*	*0.203*	*29.2%*	*70.8%*
2007	*0.079*	*0.235*	*25.1%*	*74.9%*
2008	*0.078*	*0.172*	*31.2%*	*68.8%*
2009	*0.132*	*0.274*	*32.5%*	*67.5%*
2010	*0.081*	*0.297*	*21.5%*	*78.5%*
2011	*0.154*	*0.348*	*30.7%*	*69.3%*
2012	*0.097*	*0.292*	*25.0%*	*75.0%*
2013	*0.089*	*0.624*	*12.5%*	*87.5%*
2014	*0.066*	*0.270*	*19.7%*	*80.3%*
2015	*0.063*	*0.263*	*19.3%*	*80.7%*
2016	*0.065*	*0.304*	*17.6%*	*82.4%*
2017	*0.047*	*0.148*	*24.2%*	*75.8%*
2018	*0.063*	*0.090*	*41.1%*	*58.9%*

Table 2: Annual size composition samples of Louisiana commercial southern flounder landings derived from the Trip Interview Program (TIPS; 1981-1992), the Fishery Information Network (FIN; 2002-2013), and the LDWF Biological Sampling Program (2014-2018). Cumulative size distributions are presented for years where only limited size composition data were available.

	Commercial, 1982-2018																					
TL_in	1982-1993	1994	1995	1996	1997-2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
6																						
7								1	1			2	2									
8					1	1	2	6		2		5	5									
9	7	6	3	3	15	15	10	41	2	17	16	28	12	16	24	9	8	1				
10	3	2	13	15	39	37	26	75	5	25	24	52	27	35	40	5	2				1	1
11	18	17	43	48	85	76	63	76	5	25	12	94	77	120	135	15	2	2	1	1	1	1
12	38	26	42	52	75	59	65	45	35	32	17	68	20	55	83	29	8	13	10	9	12	12
13	115	67	106	117	68	41	43	51	79	64	35	77	3	8	29	26	34	91	71	41	54	54
14	133	97	196	219	84	49	80	67	37	74	45	94	7	17	24	20	45	176	136	60	74	74
15	158	132	222	242	68	41	56	56	25	56	65	113	11	3	15	52	72	152	89	43	59	59
16	113	98	138	151	50	37	33	33	10	47	39	81	16	1	11	29	47	109	65	30	43	43
17	76	66	74	84	46	34	32	14	21	29	30	47	12	1	11	29	35	74	41	26	32	32
18	54	49	35	40	63	54	11	7	6	12	14	24	10	1	4	7	22	46	26	21	26	26
19	41	37	19	21	66	64	1	2	1	15	5	18	13			5	17	24	7	6	10	10
20	17	17	21	22	26	25	3	1	4	12	2	11	9			2	4	7	3	9	11	11
21	9	9	8	11	9	6		1	1	3		4	4					1	1			
22	11	9	2	3	3	2	2			1	2	4	2			1	2	3	1	2	2	2
23	8	6		2	10	8	1					1	1					1	1	2	2	2
24	3	1	1	1	1	1														1	1	1
25	2	2																				
26	1	1																				
27																						
Totals	807	642	923	1031	709	550	428	476	232	414	306	723	231	257	376	229	298	700	452	251	328	328

Table 3: Annual size frequency distributions of Louisiana recreational southern flounder harvest taken from MRIP (1982-2013) and the LDWF Biological Sampling Program (2014-2018).

	Recreational, 1982-2018																		
TL_in	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
4																			
5	0.004						0.004			0.006								0.003	
6	0.006	0.004																	
7	0.030	0.015			0.001	0.007			0.007			0.003	0.003	0.018				0.003	
8	0.108	0.010	0.026		0.009		0.006	0.005	0.007	0.004	0.007	0.010	0.007	0.019	0.004	0.012			0.015
9	0.137	0.013	0.003	0.033	0.019	0.021	0.015	0.003	0.038	0.031	0.038	0.026	0.020	0.053	0.017	0.036	0.021		0.004
10	0.057	0.017	0.018	0.057	0.075	0.102	0.021	0.068	0.112	0.069	0.056	0.057	0.048	0.140	0.046	0.056	0.060	0.039	0.036
11	0.125	0.046	0.043	0.033	0.174	0.170	0.100	0.129	0.185	0.119	0.103	0.108	0.064	0.097	0.088	0.077	0.124	0.093	0.042
12	0.151	0.020	0.279	0.110	0.233	0.248	0.112	0.066	0.114	0.159	0.139	0.159	0.139	0.170	0.186	0.158	0.183	0.143	0.152
13	0.077	0.180	0.073	0.168	0.092	0.092	0.151	0.108	0.099	0.166	0.109	0.132	0.234	0.096	0.155	0.165	0.196	0.203	0.130
14	0.057	0.008	0.222	0.201	0.220	0.122	0.167	0.201	0.116	0.184	0.138	0.129	0.157	0.069	0.153	0.204	0.169	0.156	0.162
15	0.090	0.337	0.170	0.256	0.085	0.093	0.139	0.157	0.158	0.118	0.176	0.112	0.121	0.130	0.137	0.081	0.109	0.140	0.177
16	0.061	0.169	0.078	0.024	0.063	0.072	0.114	0.101	0.069	0.060	0.101	0.117	0.090	0.103	0.073	0.093	0.051	0.101	0.089
17	0.011	0.006		0.070	0.020	0.038	0.053	0.092	0.052	0.041	0.047	0.087	0.061	0.044	0.046	0.066	0.053	0.057	0.110
18	0.043	0.176	0.083	0.018	0.006	0.028	0.043	0.040	0.024	0.011	0.045	0.048	0.034	0.037	0.044	0.025	0.019	0.043	0.042
19	0.011		0.006	0.014	0.001	0.008	0.039	0.020		0.016	0.019	0.009	0.003	0.017	0.026	0.016	0.006	0.017	0.027
20	0.013			0.007	0.002		0.035		0.007	0.010	0.012		0.010		0.011	0.004	0.004	0.003	
21	0.016			0.006	0.000		0.003	0.008	0.012	0.006	0.009		0.003	0.001	0.012	0.007	0.003		0.009
22	0.003			0.003	0.000						0.000	0.004	0.003				0.003		
23								0.001					0.003	0.005					0.007
24																0.001			
25																			
26																			
27																			

TL_in	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
4																		
5																		
6																		
7			0.003									0.002		0.000				0.007
8	0.010	0.020	0.006	0.006			0.006	0.006	0.023	0.001	0.008	0.013	0.001	0.002	0.005	0.004		0.026
9		0.037	0.026	0.036	0.002		0.008	0.042	0.013	0.003	0.026	0.006	0.008	0.009	0.037	0.008	0.006	0.033
10	0.020	0.138	0.075	0.099	0.018	0.031	0.027	0.026	0.038	0.041	0.076	0.071	0.016	0.047	0.103	0.019	0.029	0.067
11	0.049	0.102	0.093	0.103	0.162	0.070	0.175	0.072	0.055	0.081	0.089	0.067	0.047	0.098	0.191	0.109	0.069	0.110
12	0.105	0.114	0.160	0.147	0.177	0.175	0.140	0.192	0.142	0.159	0.108	0.100	0.071	0.197	0.182	0.198	0.127	0.133
13	0.119	0.103	0.225	0.170	0.155	0.173	0.127	0.137	0.162	0.173	0.154	0.228	0.091	0.178	0.231	0.240	0.223	0.143
14	0.220	0.151	0.156	0.164	0.213	0.170	0.173	0.149	0.150	0.179	0.144	0.106	0.186	0.157	0.108	0.188	0.259	0.231
15	0.160	0.174	0.114	0.125	0.113	0.149	0.148	0.160	0.152	0.182	0.128	0.114	0.229	0.098	0.070	0.096	0.170	0.116
16	0.120	0.100	0.086	0.084	0.098	0.128	0.063	0.064	0.145	0.073	0.124	0.113	0.202	0.131	0.048	0.076	0.054	0.053
17	0.095	0.043	0.018	0.029	0.042	0.052	0.073	0.073	0.061	0.045	0.090	0.093	0.081	0.053	0.013	0.035	0.043	0.036
18	0.057	0.014	0.020	0.014	0.007	0.021	0.028	0.047	0.021	0.038	0.023	0.045	0.048	0.024	0.000	0.013	0.006	0.026
19	0.007	0.004	0.003	0.018	0.001	0.020	0.028	0.012	0.017	0.021	0.014	0.027	0.020	0.001	0.004	0.011	0.012	
20	0.035		0.011	0.001		0.008	0.000	0.005	0.004	0.004	0.001	0.015		0.003	0.008	0.004		0.019
21	0.005		0.004	0.007	0.006		0.004	0.008			0.004	0.000			0.000	0.000	0.000	
22						0.002		0.010	0.018		0.012	0.000						
23					0.007	0.001							0.001					
24																		
25																		
26																		
27																		

Table 4: Southern flounder proportion female-at-size. Top Table depicts LDWF biological samples from the commercial and recreational fisheries combined (2002-2018), the observed and expected proportion of female southern flounder-at-size, and the corresponding logistic function parameter estimates and standard errors. Shaded cells represent size bins excluded from model fitting (n_total<10). Lower Tables depict the annual proportion female-at-size for the commercial and recreational fisheries. The 1982-2001 proportions are expected values; the 2002-2018 proportions are observations but with expected values substituted where n_total<10 for that size/year bin.

Slope	0.516	(0.0627)
TL_50%	9.63	(0.223)

TL_in	n_female	n_total	obs_p_fem	exp_p_fem
6	1	1	---	0.50
7	2	8	---	0.50
8	31	66	0.47	0.50
9	140	316	0.44	0.50
10	486	918	0.53	0.61
11	1059	1645	0.64	0.72
12	2018	2326	0.87	0.81
13	2526	2673	0.95	0.88
14	2745	2825	0.97	0.93
15	2195	2234	0.98	0.95
16	1526	1548	0.99	0.97
17	977	990	0.99	0.98
18	545	556	0.98	0.99
19	277	278	1.00	0.99
20	171	171	1.00	1.00
21	61	62	0.98	1.00
22	32	32	1.00	1.00
23	23	23	1.00	1.00
24	4	4	---	1.00
25	1	1	---	1.00
26	1	1	---	1.00

	Commercial																	
TL_in/Year	1982-2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
6	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
7	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
8	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
9	0.50	0.53	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
10	0.61	0.50	0.57	0.50	0.61	0.50	0.50	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
11	0.72	0.50	0.58	0.56	0.72	0.50	0.73	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
12	0.81	0.82	0.82	0.93	0.90	0.81	0.88	0.87	0.81	0.50	0.50	0.81	0.81	0.81	0.90	0.81	0.81	0.81
13	0.88	0.88	0.88	0.91	0.96	0.97	0.94	0.92	0.88	0.88	0.88	0.88	0.88	0.93	0.86	0.93	0.67	0.88
14	0.93	0.89	0.92	0.98	1.00	0.97	1.00	1.00	0.93	1.00	0.93	0.93	0.92	0.96	0.99	0.98	0.85	0.93
15	0.95	0.97	0.91	0.98	1.00	1.00	1.00	1.00	1.00	0.95	0.95	0.95	1.00	0.96	1.00	1.00	0.93	0.95
16	0.97	0.94	0.97	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.97	0.97	1.00	1.00	1.00	1.00	1.00	0.97
17	0.98	0.88	0.88	1.00	1.00	1.00	1.00	0.98	1.00	0.98	0.98	0.98	1.00	1.00	0.98	1.00	0.98	0.98
18	0.99	1.00	0.73	0.99	0.99	1.00	1.00	0.99	1.00	0.99	0.99	0.99	0.99	1.00	1.00	1.00	0.99	0.99
19	0.99	1.00	0.99	0.99	0.99	1.00	0.99	0.99	1.00	0.99	0.99	0.99	0.99	1.00	0.99	0.99	0.99	0.99
20+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

	Recreational																	
TL_in/Year	1982-2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
6	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
7	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
8	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
9	0.50	0.52	0.66	0.57	0.60	0.64	0.69	0.54	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
10	0.61	0.63	0.70	0.70	0.72	0.63	0.67	0.62	0.60	0.79	0.55	0.55	0.59	0.57	0.66	0.50	0.61	0.50
11	0.72	0.66	0.78	0.75	0.81	0.85	0.59	0.77	0.64	0.65	0.66	0.80	0.86	0.74	0.82	0.55	0.50	0.50
12	0.81	0.89	0.91	0.97	0.91	0.96	0.88	0.95	0.88	0.94	0.90	0.90	0.80	0.55	0.91	0.85	0.78	0.71
13	0.88	0.95	0.98	0.99	0.98	0.99	0.97	0.96	0.97	0.98	0.97	0.96	0.97	0.61	0.91	0.92	0.90	0.80
14	0.93	0.98	0.96	0.99	0.99	0.99	0.98	0.97	0.98	1.00	1.00	0.93	0.92	0.80	0.93	0.96	0.97	1.00
15	0.95	0.99	0.98	0.99	0.99	0.99	0.98	1.00	1.00	0.99	0.98	0.89	0.97	0.98	0.97	0.99	0.97	0.96
16	0.97	0.95	0.98	0.98	0.99	1.00	1.00	1.00	0.99	1.00	0.98	0.97	0.97	0.98	0.95	0.98	1.00	1.00
17	0.98	0.98	0.98	0.98	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00
18	0.99	0.93	1.00	1.00	1.00	1.00	1.00	0.96	1.00	0.99	0.95	1.00	0.94	1.00	0.85	1.00	1.00	1.00
19	0.99	1.00	1.00	0.99	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00	0.99	0.99
20+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 5: FAO proposed guideline for indices of productivity for exploited fish species.

Parameter	**Productivity**			**Species**	
	Low	Medium	High	Southern Flounder	**Score**
M	<0.2	0.2 - 0.5	>0.5	**0.53**	3
K	<0.15	0.15 - 0.33	>0.33	**0.44**	3
tmat	>8	3.3 - 8	<3.3	**3**	3
tmax	>25	14 - 25	<14	**8**	3
Examples	orange roughy, many sharks	cod, hake	sardine, anchovy	**Southern Flounder Productivity Score = 3.0 (high)**	

Table 6: Annual sample sizes, percent positive samples, nominal CPUEs, standardized indices of abundance, and corresponding coefficients of variation derived from the LDWF fishery-independent marine trawl and trammel net surveys. Nominal CPUEs and standardized indices of abundance have been normalized to their individual long-term means for comparison.

	Trawl						**Trammel**				
Year	n	%Pos	CPUE	IOA	CV	**Year**	n	%Pos	CPUE	IOA	CV
1981	363	15%	1.92	1.93	0.41	1981	---	---	---	---	---
1982	459	15%	1.83	1.91	0.40	1982	---	---	---	---	---
1983	489	12%	1.04	1.19	0.41	1983	---	---	---	---	---
1984	475	5%	0.52	0.56	0.48	1984	---	---	---	---	---
1985	530	8%	0.59	0.64	0.44	1985	---	---	---	---	---
1986	447	14%	1.40	1.53	0.40	1986	85	26%	1.01	2.10	0.39
1987	556	10%	0.83	0.87	0.42	1987	86	20%	0.59	0.99	0.43
1988	542	9%	1.17	0.93	0.43	1988	76	18%	0.91	1.08	0.46
1989	535	12%	1.91	1.54	0.41	1989	97	12%	0.73	0.63	0.48
1990	600	13%	2.35	1.46	0.40	1990	94	14%	0.98	0.90	0.47
1991	580	5%	0.40	0.43	0.46	1991	99	20%	1.49	1.70	0.43
1992	547	9%	0.74	0.77	0.43	1992	107	16%	0.68	0.80	0.44
1993	579	12%	1.07	1.14	0.41	1993	109	23%	0.99	1.76	0.39
1994	564	8%	0.92	0.83	0.43	1994	112	26%	0.93	1.90	0.37
1995	604	13%	1.16	1.27	0.40	1995	106	26%	0.94	1.90	0.37
1996	628	15%	1.32	1.43	0.38	1996	108	19%	1.01	1.45	0.41
1997	657	12%	1.32	1.34	0.40	1997	111	16%	0.89	1.17	0.44
1998	642	8%	0.70	0.77	0.42	1998	111	19%	0.95	1.36	0.42
1999	655	8%	0.59	0.64	0.43	1999	106	17%	0.95	1.21	0.43
2000	647	4%	0.33	0.34	0.48	2000	98	12%	0.98	0.90	0.49
2001	636	9%	1.50	1.01	0.42	2001	108	11%	1.18	0.89	0.49
2002	640	11%	1.19	1.18	0.41	2002	107	9%	1.34	0.62	0.51
2003	644	15%	1.75	1.69	0.39	2003	111	14%	1.18	1.06	0.46
2004	638	8%	0.98	0.76	0.42	2004	111	13%	1.34	1.25	0.47
2005	590	12%	1.24	1.24	0.40	2005	104	16%	1.27	1.25	0.44
2006	648	10%	0.80	0.90	0.41	2006	106	10%	1.22	0.95	0.50
2007	628	12%	0.96	1.08	0.40	2007	115	14%	0.82	0.83	0.45
2008	672	9%	0.80	0.93	0.42	2008	111	14%	1.07	0.96	0.46
2009	661	10%	0.90	0.91	0.41	2009	111	11%	0.80	0.67	0.49
2010	588	12%	0.96	1.08	0.40	2010	242	16%	1.18	1.11	0.40
2011	557	16%	1.51	1.77	0.38	2011	271	12%	1.00	0.70	0.41
2012	580	8%	0.57	0.68	0.44	2012	266	11%	0.95	0.67	0.42
2013	478	3%	0.23	0.26	0.54	2013	137	7%	0.84	0.40	0.52
2014	298	11%	1.17	1.33	0.44	2014	135	12%	0.76	0.64	0.46
2015	279	9%	0.62	0.76	0.47	2015	135	8%	1.36	0.57	0.50
2016	285	2%	0.13	0.15	0.74	2016	135	7%	0.67	0.33	0.52
2017	297	1%	0.04	0.05	1.06	2017	135	1%	0.75	0.07	0.87
2018	282	9%	0.55	0.70	0.47	2018	135	3%	1.23	0.18	0.68

Table 7: Probabilities of age given length used in age assignments of female southern flounder fishery landings 1982-2001.

Fishery 1982-2001					
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*
5	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*
6	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*
7	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*
11	*0.95*	*0.05*	*0.00*	*0.00*	*0.00*
12	*0.00*	*1.00*	*0.00*	*0.00*	*0.00*
13	*0.00*	*0.99*	*0.01*	*0.00*	*0.00*
14	*0.00*	*0.78*	*0.21*	*0.00*	*0.00*
15	*0.00*	*0.05*	*0.86*	*0.09*	*0.01*
16	*0.00*	*0.00*	*0.53*	*0.35*	*0.12*
17	*0.00*	*0.00*	*0.07*	*0.40*	*0.52*
18	*0.00*	*0.00*	*0.00*	*0.12*	*0.88*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*

Table 8: Annual probabilities of age given length used in age assignments of commercial female southern flounder landings 2002-2018. Shaded cells represent rows where probabilities of age given length from Table 7 are substituted ($\sum_a n_{lay} < 10$).

2002						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*2*
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*3*
11	*0.54*	*0.46*				*13*
12	*0.26*	*0.65*	*0.04*	*0.04*		*23*
13		*0.88*	*0.08*	*0.04*		*24*
14	*0.08*	*0.44*	*0.40*	*0.08*		*25*
15		*0.67*	*0.33*			*24*
16		*0.67*	*0.29*	*0.05*		*21*
17		*0.44*	*0.56*			*16*
18		*0.84*	*0.16*			*19*
19		*0.89*	*0.11*			*27*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*7*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*4*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*3*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2003						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*1*
10	*0.20*	*0.80*				*10*
11		*1.00*				*20*
12	*0.09*	*0.76*	*0.12*	*0.03*		*34*
13		*0.90*	*0.10*			*21*
14		*0.79*	*0.21*			*53*
15		*0.72*	*0.28*			*39*
16		*0.74*	*0.26*			*19*
17		*0.45*	*0.30*	*0.20*	*0.05*	*20*
18	*0.00*	*0.00*	*0.00*	*0.12*	*0.88*	*5*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	*1*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*3*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*2*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

Table 8 (continued):

2004						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	2
10	1.00	0.00	0.00	0.00	0.00	7
11		1.00				16
12	0.03	0.94	0.03			36
13	0.03	0.69	0.28			32
14	0.06	0.43	0.46	0.03	0.03	35
15		0.71	0.23	0.06		31
16		0.38	0.31	0.25	0.06	16
17	0.00	0.00	0.07	0.40	0.52	9
18	0.00	0.00	0.00	0.12	0.88	4
19	0.00	0.00	0.00	0.01	0.99	2
20	0.00	0.00	0.00	0.00	1.00	1
21	0.00	0.00	0.00	0.00	1.00	1
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2005						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	
11	0.95	0.05	0.00	0.00	0.00	2
12		0.33	0.61	0.06		18
13		0.29	0.69	0.02		51
14		0.07	0.93			29
15		0.29	0.62	0.10		21
16	0.00	0.00	0.53	0.35	0.12	9
17		0.70	0.15	0.10	0.05	20
18	0.00	0.00	0.00	0.12	0.88	6
19	0.00	0.00	0.00	0.01	0.99	1
20	0.00	0.00	0.00	0.00	1.00	3
21	0.00	0.00	0.00	0.00	1.00	1
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2006						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	4
10	1.00	0.00	0.00	0.00	0.00	2
11	0.95	0.05	0.00	0.00	0.00	6
12	0.04	0.96				26
13	0.03	0.93	0.03			58
14	0.04	0.86	0.10			71
15	0.04	0.71	0.18	0.07		55
16		0.57	0.33	0.11		46
17		0.43	0.50	0.07		28
18		0.33	0.50	0.17		12
19		0.13	0.67	0.20		15
20		0.17	0.50	0.25	0.08	12
21	0.00	0.00	0.00	0.00	1.00	3
22	0.00	0.00	0.00	0.00	1.00	1
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2007						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	2
11	0.95	0.05	0.00	0.00	0.00	8
12	0.43	0.43	0.14			14
13	0.06	0.69	0.25			32
14	0.02	0.74	0.24			42
15		0.75	0.25			51
16		0.70	0.30			27
17		0.77	0.23			22
18	0.00	0.00	0.00	0.12	0.88	7
19	0.00	0.00	0.00	0.01	0.99	1
20	0.00	0.00	0.00	0.00	1.00	
21	0.00	0.00	0.00	0.00	1.00	
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2008						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	1
11	0.95	0.05	0.00	0.00	0.00	5
12		0.74	0.19	0.07		27
13		0.76	0.24			33
14		0.71	0.26	0.02		42
15		0.65	0.35			37
16		0.58	0.35	0.08		26
17	0.00	0.00	0.07	0.40	0.52	5
18	0.00	0.00	0.00	0.12	0.88	
19	0.00	0.00	0.00	0.01	0.99	
20	0.00	0.00	0.00	0.00	1.00	
21	0.00	0.00	0.00	0.00	1.00	
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2009						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	
11	0.95	0.05	0.00	0.00	0.00	
12	0.00	1.00	0.00	0.00	0.00	
13	0.00	0.99	0.01	0.00	0.00	
14	0.00	0.78	0.21	0.00	0.00	4
15	0.00	0.05	0.86	0.09	0.01	5
16	0.00	0.00	0.53	0.35	0.12	6
17	0.00	0.00	0.07	0.40	0.52	5
18	0.00	0.00	0.00	0.12	0.88	6
19	0.00	0.00	0.00	0.01	0.99	8
20	0.00	0.00	0.00	0.00	1.00	5
21	0.00	0.00	0.00	0.00	1.00	2
22	0.00	0.00	0.00	0.00	1.00	2
23	0.00	0.00	0.00	0.00	1.00	1
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

Table 8 (continued):

2010						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
11	*0.95*	*0.05*	*0.00*	*0.00*	*0.00*	
12	*0.00*	*1.00*	*0.00*	*0.00*	*0.00*	*2*
13	*0.00*	*0.99*	*0.01*	*0.00*	*0.00*	*8*
14		*1.00*				*17*
15	*0.00*	*0.05*	*0.86*	*0.09*	*0.01*	*2*
16	*0.00*	*0.00*	*0.53*	*0.35*	*0.12*	*1*
17	*0.00*	*0.00*	*0.07*	*0.40*	*0.52*	*1*
18	*0.00*	*0.00*	*0.00*	*0.12*	*0.88*	*1*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2011						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*1*
11	*0.95*	*0.05*	*0.00*	*0.00*	*0.00*	
12	*0.00*	*1.00*	*0.00*	*0.00*	*0.00*	*1*
13	*0.00*	*0.99*	*0.01*	*0.00*	*0.00*	*3*
14	*0.00*	*0.78*	*0.21*	*0.00*	*0.00*	*2*
15	*0.00*	*0.05*	*0.86*	*0.09*	*0.01*	*3*
16	*0.00*	*0.00*	*0.53*	*0.35*	*0.12*	*7*
17	*0.00*	*0.00*	*0.07*	*0.40*	*0.52*	*8*
18	*0.00*	*0.00*	*0.00*	*0.12*	*0.88*	*1*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2012						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
11	*0.95*	*0.05*	*0.00*	*0.00*	*0.00*	*1*
12	*0.00*	*1.00*	*0.00*	*0.00*	*0.00*	*2*
13	*0.00*	*0.99*	*0.01*	*0.00*	*0.00*	*8*
14	*0.00*	*0.78*	*0.21*	*0.00*	*0.00*	*1*
15	*0.00*	*0.05*	*0.86*	*0.09*	*0.01*	*5*
16	*0.00*	*0.00*	*0.53*	*0.35*	*0.12*	
17	*0.00*	*0.00*	*0.07*	*0.40*	*0.52*	
18	*0.00*	*0.00*	*0.00*	*0.12*	*0.88*	*1*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2013						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
11	*0.95*	*0.05*	*0.00*	*0.00*	*0.00*	
12	*0.00*	*1.00*	*0.00*	*0.00*	*0.00*	*1*
13	*0.00*	*0.99*	*0.01*	*0.00*	*0.00*	*4*
14		*0.75*	*0.25*			*12*
15		*0.70*	*0.25*	*0.05*		*40*
16		*0.37*	*0.53*	*0.11*		*19*
17		*0.44*	*0.50*		*0.06*	*16*
18	*0.00*	*0.00*	*0.00*	*0.12*	*0.88*	*3*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	*5*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*2*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2014						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
11	*0.95*	*0.05*	*0.00*	*0.00*	*0.00*	
12	*0.00*	*1.00*	*0.00*	*0.00*	*0.00*	*1*
13		*0.93*		*0.07*		*14*
14		*0.88*	*0.12*			*25*
15		*0.81*	*0.14*	*0.05*		*21*
16		*0.64*	*0.32*	*0.04*		*25*
17		*0.57*	*0.29*	*0.14*		*14*
18		*0.67*	*0.20*	*0.13*		*15*
19		*0.91*	*0.09*			*11*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*2*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2015						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
10	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
11	*0.95*	*0.05*	*0.00*	*0.00*	*0.00*	
12	*0.00*	*1.00*	*0.00*	*0.00*	*0.00*	*9*
13		*0.98*	*0.02*			*61*
14		*0.99*	*0.01*			*134*
15		*0.84*	*0.15*	*0.01*		*88*
16		*0.82*	*0.18*			*65*
17		*0.77*	*0.21*	*0.03*		*39*
18		*0.68*	*0.32*			*25*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	*7*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*3*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

Table 8 (continued):

			2016			
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	
11	0.95	0.05	0.00	0.00	0.00	1
12	0.00	1.00	0.00	0.00	0.00	6
13	0.03	0.55	0.39	0.03		38
14	0.02	0.41	0.58			59
15		0.35	0.63	0.02		43
16		0.27	0.73			30
17		0.24	0.68	0.08		25
18		0.24	0.62	0.14		21
19	0.00	0.00	0.00	0.01	0.99	6
20	0.00	0.00	0.00	0.00	1.00	8
21	0.00	0.00	0.00	0.00	1.00	
22	0.00	0.00	0.00	0.00	1.00	2
23	0.00	0.00	0.00	0.00	1.00	2
24	0.00	0.00	0.00	0.00	1.00	1
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

			2017			
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	1
11	0.95	0.05	0.00	0.00	0.00	
12	0.00	1.00	0.00	0.00	0.00	1
13	0.00	0.99	0.01	0.00	0.00	8
14		0.64	0.36			11
15		0.54	0.38	0.08		13
16		0.42	0.42	0.08	0.08	12
17	0.00	0.00	0.07	0.40	0.52	6
18	0.00	0.00	0.00	0.12	0.88	5
19	0.00	0.00	0.00	0.01	0.99	4
20	0.00	0.00	0.00	0.00	1.00	2
21	0.00	0.00	0.00	0.00	1.00	
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

			2018			
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	
11	0.95	0.05	0.00	0.00	0.00	
12	0.00	1.00	0.00	0.00	0.00	
13	0.00	0.99	0.01	0.00	0.00	1
14	0.00	0.78	0.21	0.00	0.00	1
15	0.00	0.05	0.86	0.09	0.01	1
16	0.00	0.00	0.53	0.35	0.12	1
17	0.00	0.00	0.07	0.40	0.52	
18	0.00	0.00	0.00	0.12	0.88	
19	0.00	0.00	0.00	0.01	0.99	
20	0.00	0.00	0.00	0.00	1.00	
21	0.00	0.00	0.00	0.00	1.00	
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

Table 9: Annual probabilities of age given length used in age assignments of recreational female southern flounder landings 2002-2018. Shaded cells represent rows where probabilities of age given length from Table 7 are substituted ($\sum_a n_{lay} < 10$).

			2002			
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	2
9	1.00	0.00	0.00	0.00	0.00	7
10	0.14	0.80	0.06			35
11	0.23	0.73	0.01	0.03		78
12	0.07	0.89	0.04			132
13	0.03	0.96	0.02			120
14	0.02	0.85	0.13	0.01		136
15		0.72	0.25	0.03		97
16		0.60	0.38	0.01	0.01	84
17		0.51	0.47	0.02		45
18		0.52	0.45	0.03		31
19		0.31	0.62		0.08	13
20	0.00	0.00	0.00	0.00	1.00	7
21	0.00	0.00	0.00	0.00	1.00	5
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	2
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	1
26	0.00	0.00	0.00	0.00	1.00	

			2003			
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	5
9	0.67	0.33				12
10	0.49	0.47	0.04			49
11	0.36	0.60	0.04			85
12	0.08	0.78	0.14			177
13	0.02	0.70	0.28			220
14	0.01	0.62	0.36		0.01	190
15		0.50	0.49	0.01		143
16		0.43	0.50	0.07		88
17		0.23	0.63	0.14		57
18		0.24	0.64	0.12		33
19		0.23	0.46	0.31		13
20			0.60	0.40		15
21	0.00	0.00	0.00	0.00	1.00	4
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	2
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

Table 9 (continued):

2004						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*2*
9	*0.05*	*0.90*	*0.05*			*20*
10	*0.07*	*0.87*	*0.07*			*75*
11	*0.04*	*0.93*	*0.02*			*91*
12	*0.01*	*0.88*	*0.11*	*0.00*		*209*
13	*0.01*	*0.68*	*0.30*	*0.01*		*187*
14		*0.54*	*0.45*	*0.01*		*193*
15		*0.37*	*0.52*	*0.11*		*133*
16	*0.01*	*0.34*	*0.42*	*0.22*		*85*
17		*0.16*	*0.50*	*0.34*		*56*
18			*0.42*	*0.58*		*31*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	*7*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*6*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*6*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2005						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*6*
10	*0.54*	*0.46*				*24*
11	*0.38*	*0.51*	*0.10*			*78*
12	*0.20*	*0.45*	*0.35*			*114*
13	*0.05*	*0.49*	*0.42*	*0.03*		*150*
14	*0.01*	*0.45*	*0.45*	*0.09*		*163*
15		*0.29*	*0.44*	*0.25*	*0.02*	*134*
16		*0.11*	*0.52*	*0.31*	*0.06*	*101*
17		*0.09*	*0.52*	*0.34*	*0.05*	*56*
18		*0.04*	*0.48*	*0.30*	*0.17*	*23*
19		*0.20*	*0.50*		*0.30*	*10*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*5*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*4*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2006						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*1*
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*6*
10	*0.04*	*0.92*		*0.04*		*26*
11	*0.06*	*0.92*	*0.01*			*78*
12	*0.05*	*0.93*	*0.01*	*0.01*		*190*
13	*0.00*	*0.95*	*0.04*	*0.01*		*271*
14	*0.00*	*0.92*	*0.07*	*0.01*		*224*
15	*0.01*	*0.73*	*0.18*	*0.07*	*0.01*	*146*
16		*0.66*	*0.25*	*0.07*	*0.01*	*95*
17		*0.39*	*0.45*	*0.15*	*0.01*	*67*
18		*0.30*	*0.50*	*0.20*		*30*
19		*0.27*	*0.45*	*0.27*		*11*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*9*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*4*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2007						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*2*
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*6*
10	*0.60*	*0.40*				*15*
11	*0.40*	*0.55*	*0.05*			*40*
12	*0.15*	*0.82*	*0.03*			*61*
13	*0.04*	*0.92*	*0.04*			*79*
14	*0.01*	*0.81*	*0.18*			*110*
15		*0.78*	*0.22*			*87*
16		*0.60*	*0.36*	*0.04*		*47*
17		*0.30*	*0.65*	*0.02*	*0.02*	*43*
18		*0.29*	*0.52*	*0.19*		*21*
19		*0.27*	*0.73*			*11*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*9*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*4*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2008						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*2*
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*7*
10	*0.63*	*0.37*				*19*
11	*0.42*	*0.58*				*60*
12	*0.25*	*0.72*	*0.03*			*102*
13	*0.08*	*0.78*	*0.14*			*112*
14	*0.01*	*0.72*	*0.26*	*0.01*		*100*
15		*0.58*	*0.42*			*78*
16		*0.28*	*0.69*	*0.03*		*67*
17		*0.29*	*0.63*	*0.08*		*38*
18		*0.26*	*0.53*	*0.21*		*19*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	*8*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*7*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*6*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*2*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

2009						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*1*
9	*1.00*	*0.00*	*0.00*	*0.00*	*0.00*	*3*
10	*0.83*	*0.08*	*0.08*			*12*
11	*0.32*	*0.64*	*0.04*			*28*
12	*0.17*	*0.81*	*0.02*			*63*
13	*0.06*	*0.83*	*0.10*	*0.01*		*83*
14		*0.84*	*0.15*	*0.01*		*85*
15		*0.60*	*0.35*	*0.05*		*78*
16		*0.44*	*0.54*	*0.02*		*63*
17		*0.53*	*0.30*	*0.17*		*30*
18		*0.21*	*0.63*	*0.16*		*19*
19	*0.00*	*0.00*	*0.00*	*0.01*	*0.99*	*8*
20	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*4*
21	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
22	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	*1*
23	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
24	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
25	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	
26	*0.00*	*0.00*	*0.00*	*0.00*	*1.00*	

Table 9 (continued):

2010						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	2
10	0.73	0.23	0.05			22
11	0.25	0.69	0.06			16
12	0.10	0.78	0.10	0.02		50
13	0.06	0.67	0.28			36
14		0.56	0.44			62
15		0.39	0.55	0.06		49
16		0.22	0.69	0.09		32
17		0.08	0.67	0.25		12
18	0.00	0.00	0.00	0.12	0.88	5
19	0.00	0.00	0.00	0.01	0.99	4
20	0.00	0.00	0.00	0.00	1.00	2
21	0.00	0.00	0.00	0.00	1.00	
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2011						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	5
9	1.00	0.00	0.00	0.00	0.00	3
10	0.63	0.38				16
11	0.50	0.47	0.03			32
12	0.22	0.76	0.02			51
13	0.04	0.83	0.13			53
14		0.87	0.13			68
15		0.64	0.36			50
16		0.48	0.48	0.05		44
17		0.41	0.48	0.11		27
18		0.50	0.33	0.11	0.06	18
19	0.00	0.00	0.00	0.01	0.99	2
20	0.00	0.00	0.00	0.00	1.00	4
21	0.00	0.00	0.00	0.00	1.00	2
22	0.00	0.00	0.00	0.00	1.00	2
23	0.00	0.00	0.00	0.00	1.00	1
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2012						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	1
9	1.00	0.00	0.00	0.00	0.00	1
10		1.00				10
11		1.00				21
12		0.96	0.04			46
13		0.86	0.14			44
14		0.78	0.22			46
15		0.57	0.37	0.07		30
16		0.18	0.79	0.04		28
17		0.09	0.82	0.09		22
18		0.13	0.44	0.44		16
19	0.00	0.00	0.00	0.01	0.99	8
20	0.00	0.00	0.00	0.00	1.00	8
21	0.00	0.00	0.00	0.00	1.00	1
22	0.00	0.00	0.00	0.00	1.00	1
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2013						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	1
9	1.00	0.00	0.00	0.00	0.00	2
10	0.41	0.59				17
11	0.17	0.81	0.02			53
12	0.05	0.92	0.03			37
13	0.13	0.68	0.19			31
14	0.10	0.60	0.31			42
15		0.53	0.44	0.03		36
16	0.04	0.41	0.52	0.04		27
17		0.52	0.45	0.03		33
18			0.92	0.08		13
19	0.00	0.00	0.00	0.01	0.99	
20	0.00	0.00	0.00	0.00	1.00	3
21	0.00	0.00	0.00	0.00	1.00	2
22	0.00	0.00	0.00	0.00	1.00	1
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2014						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	1
9	1.00	0.00	0.00	0.00	0.00	1
10	1.00	0.00	0.00	0.00	0.00	7
11	0.57	0.43				14
12	0.10	0.90				21
13	0.06	0.78	0.17			36
14		0.72	0.24	0.04		50
15		0.53	0.35	0.12		51
16		0.34	0.44	0.20	0.02	41
17		0.26	0.37	0.33	0.04	27
18		0.20	0.60	0.10	0.10	10
19	0.00	0.00	0.00	0.01	0.99	7
20	0.00	0.00	0.00	0.00	1.00	1
21	0.00	0.00	0.00	0.00	1.00	2
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2015						
TL_in	Age_0	Age_1	Age_2	Age_3	Age_4+	Total
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	2
10		1.00				19
11	0.04	0.96				51
12	0.03	0.96	0.01			72
13		0.93	0.07			81
14		0.92	0.08			90
15		0.78	0.22			58
16		0.49	0.49		0.03	39
17		0.41	0.50	0.09		22
18		0.40	0.40	0.20		10
19	0.00	0.00	0.00	0.01	0.99	1
20	0.00	0.00	0.00	0.00	1.00	2
21	0.00	0.00	0.00	0.00	1.00	2
22	0.00	0.00	0.00	0.00	1.00	1
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

Table 9 (continued):

2016						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	1
10	1.00	0.00	0.00	0.00	0.00	3
11	0.06	0.65	0.29			17
12		0.54	0.46			52
13		0.46	0.53	0.01		95
14	0.01	0.44	0.54	0.01		95
15	0.01	0.49	0.50			80
16		0.27	0.68	0.05		44
17		0.19	0.68	0.13		31
18		0.13	0.67	0.20		15
19	0.00	0.00	0.00	0.01	0.99	9
20	0.00	0.00	0.00	0.00	1.00	4
21	0.00	0.00	0.00	0.00	1.00	1
22	0.00	0.00	0.00	0.00	1.00	1
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2017						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	1.00	0.00	0.00	0.00	0.00	
9	1.00	0.00	0.00	0.00	0.00	
10	1.00	0.00	0.00	0.00	0.00	2
11	0.95	0.05	0.00	0.00	0.00	8
12	0.14	0.62	0.24			21
13	0.06	0.66	0.23	0.06		35
14	0.02	0.60	0.24	0.15		55
15	0.02	0.41	0.38	0.19		63
16		0.32	0.43	0.26		47
17		0.27	0.73			26
18		0.37	0.37	0.26		19
19	0.00	0.00	0.00	0.01	0.99	3
20	0.00	0.00	0.00	0.00	1.00	4
21	0.00	0.00	0.00	0.00	1.00	
22	0.00	0.00	0.00	0.00	1.00	1
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

2018						
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8	1.00	0.00	0.00	0.00	0.00	2
9	1.00	0.00	0.00	0.00	0.00	6
10	1.00					10
11	0.78	0.17	0.06			18
12	0.59	0.21	0.21			34
13	0.25	0.32	0.41	0.02		44
14	0.17	0.50	0.23	0.08	0.02	48
15		0.39	0.40	0.12	0.09	67
16	0.03	0.35	0.53	0.03	0.08	40
17		0.41	0.48	0.10		29
18		0.29	0.36	0.07	0.29	14
19	0.00	0.00	0.00	0.01	0.99	9
20	0.00	0.00	0.00	0.00	1.00	
21	0.00	0.00	0.00	0.00	1.00	5
22	0.00	0.00	0.00	0.00	1.00	
23	0.00	0.00	0.00	0.00	1.00	
24	0.00	0.00	0.00	0.00	1.00	
25	0.00	0.00	0.00	0.00	1.00	
26	0.00	0.00	0.00	0.00	1.00	

Table 10: Annual commercial female southern flounder catch-at-age, yield (pounds) and corresponding ASAP base model input coefficients of variation, and corresponding mean weights-at-age (pounds).

Commercial Catch-at-age						
Year	Age_1	Age_2	Age_3	Age_4+	Yield (lbs)	CV
1982	29,883	27,915	11,315	24,295	190,556	0.10
1983	41,314	38,593	15,644	33,589	263,451	0.10
1984	52,851	49,370	20,012	42,968	337,017	0.10
1985	79,289	74,066	30,023	64,462	505,606	0.10
1986	123,432	115,302	46,738	100,351	787,092	0.10
1987	140,344	131,100	53,142	114,100	894,936	0.10
1988	76,343	71,314	28,908	62,067	486,818	0.10
1989	73,614	68,765	27,874	59,849	469,419	0.10
1990	68,179	63,688	25,816	55,430	434,760	0.10
1991	103,579	96,757	39,221	84,210	660,499	0.10
1992	117,376	109,645	44,445	95,428	748,480	0.10
1993	134,479	125,621	50,921	109,332	857,536	0.10
1994	117,147	136,828	57,748	127,299	932,720	0.10
1995	95,577	101,428	34,056	46,658	498,496	0.10
1996	11,092	11,447	3,886	5,513	57,759	0.10
1997	13,840	7,531	3,667	14,663	86,242	0.10
1998	20,408	11,106	5,407	21,622	127,173	0.10
1999	20,603	11,212	5,459	21,828	128,387	0.05
2000	25,873	14,080	6,855	27,412	161,228	0.05
2001	13,383	7,283	3,546	14,179	83,398	0.05
2002	21,215	6,259	701	3,361	72,839	0.05
2003	29,041	6,433	933	1,754	54,341	0.05
2004	28,304	9,928	2,947	3,110	60,553	0.05
2005	3,868	8,742	806	903	20,724	0.05
2006	30,620	9,411	2,543	659	76,749	0.05
2007	27,260	9,448	292	3,572	72,640	0.05
2008	21,637	9,311	2,601	6,205	69,758	0.05
2009	11,156	8,321	5,277	18,852	103,080	0.05
2010	24,335	1,355	482	667	29,222	0.05
2011	42,215	11,183	4,684	4,972	82,855	0.05
2012	17,377	17,357	7,271	8,911	88,684	0.05
2013	24,298	11,447	1,836	7,101	86,529	0.05
2014	27,472	5,723	1,796	631	64,724	0.05
2015	31,053	3,669	176	1,054	61,539	0.05
2016	11,964	17,778	991	2,740	63,875	0.05
2017	10,331	5,007	1,846	5,322	43,815	0.05
2018	11,656	9,034	3,678	7,236	60,034	0.05

Commercial Mean Weight-at-age				
Year	Age_1	Age_2	Age_3	Age_4+
1982	1.15	1.71	2.16	3.46
1983	1.15	1.71	2.16	3.46
1984	1.15	1.71	2.16	3.46
1985	1.15	1.71	2.16	3.46
1986	1.15	1.71	2.16	3.46
1987	1.15	1.71	2.16	3.46
1988	1.15	1.71	2.16	3.46
1989	1.15	1.71	2.16	3.46
1990	1.15	1.71	2.16	3.46
1991	1.15	1.71	2.16	3.46
1992	1.15	1.71	2.16	3.46
1993	1.15	1.71	2.16	3.46
1994	1.16	1.72	2.16	3.42
1995	1.18	1.70	2.09	3.05
1996	1.17	1.70	2.10	3.11
1997	1.07	1.70	2.27	3.43
1998	1.07	1.70	2.27	3.43
1999	1.07	1.70	2.27	3.43
2000	1.07	1.70	2.27	3.43
2001	1.07	1.70	2.27	3.43
2002	2.05	2.04	1.29	4.67
2003	1.23	1.59	2.17	3.64
2004	1.13	1.44	2.03	2.69
2005	1.44	1.23	1.76	3.28
2006	1.46	2.38	2.60	4.69
2007	1.63	1.63	2.91	3.36
2008	1.38	1.52	2.12	3.26
2009	0.93	1.80	2.23	3.49
2010	0.99	1.70	2.16	2.64
2011	0.98	1.68	2.18	2.51
2012	1.05	1.73	2.15	2.79
2013	1.54	1.91	2.12	3.28
2014	1.70	1.99	2.05	4.61
2015	1.59	2.08	2.10	4.03
2016	1.50	1.78	2.33	4.36
2017	1.37	1.65	2.28	3.22
2018	1.17	1.70	2.18	3.18

Table 11: Annual recreational female southern flounder catch-at-age, yield (pounds) and corresponding ASAP base model input coefficients of variation, and corresponding mean weights-at-age (pounds).

Recreational Catch-at-age						
Year	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Yield (lbs)*	*CV*
1982	80,836	39,960	12,905	31,903	282,832	0.22
1983	129,633	241,428	71,633	118,275	1,032,921	0.59
1984	42,180	20,502	4,703	8,088	109,952	0.27
1985	69,832	47,377	10,653	15,317	223,192	0.27
1986	228,100	76,595	19,804	13,679	438,905	0.45
1987	26,242	9,676	3,524	4,167	60,974	0.22
1988	51,041	30,369	11,217	22,384	201,437	0.31
1989	43,013	32,084	12,657	17,458	180,361	0.26
1990	85,006	58,748	18,459	23,220	297,160	0.25
1991	136,067	54,634	15,767	22,702	338,260	0.17
1992	77,078	54,861	17,816	27,917	296,681	0.17
1993	68,215	36,448	17,709	22,439	234,139	0.17
1994	108,558	45,030	17,215	23,324	298,409	0.22
1995	46,691	29,434	11,351	15,106	165,774	0.17
1996	74,254	33,593	11,049	21,960	225,907	0.15
1997	91,486	34,494	14,719	20,152	246,984	0.15
1998	82,884	28,308	9,226	12,091	188,429	0.16
1999	148,276	72,300	26,558	35,135	433,814	0.15
2000	100,468	63,936	26,084	40,840	395,401	0.16
2001	78,987	53,884	21,953	35,258	332,879	0.17
2002	140,639	30,072	2,337	321	233,867	0.19
2003	153,950	77,241	5,047	1,567	316,286	0.17
2004	112,957	53,945	11,075	5,185	235,849	0.17
2005	55,577	54,050	14,951	3,915	177,868	0.15
2006	121,319	19,219	6,485	2,165	215,458	0.13
2007	108,024	32,540	1,746	1,082	216,852	0.23
2008	67,276	31,487	2,418	4,397	167,904	0.14
2009	115,257	41,156	5,534	7,718	275,086	0.17
2010	109,410	76,395	8,684	13,649	304,277	0.17
2011	141,020	50,131	4,619	8,113	330,396	0.17
2012	115,594	59,134	8,474	9,037	297,807	0.16
2013	197,844	141,503	7,910	8,399	602,434	0.10
2014	89,507	49,443	19,686	8,704	293,932	0.09
2015	167,859	25,292	1,407	3,212	256,881	0.09
2016	85,588	112,465	5,794	6,215	329,094	0.12
2017	40,876	29,998	13,474	1,732	143,785	0.12
2018	18,677	18,477	3,400	5,596	82,860	0.10

Recreational Mean Weight-at-age				
Year	*Age_1*	*Age_2*	*Age_3*	*Age_4+*
1982	0.98	1.71	2.10	3.39
1983	1.08	1.72	2.09	2.76
1984	1.04	1.64	2.06	2.81
1985	1.12	1.62	2.09	3.02
1986	1.05	1.63	2.02	2.54
1987	0.99	1.69	2.12	2.66
1988	1.09	1.70	2.12	3.14
1989	1.15	1.69	2.16	2.84
1990	1.06	1.68	2.10	2.99
1991	1.07	1.64	2.09	3.08
1992	1.06	1.69	2.10	3.02
1993	1.04	1.74	2.18	2.73
1994	1.07	1.69	2.14	2.98
1995	0.99	1.73	2.11	2.94
1996	1.05	1.67	2.14	3.12
1997	1.08	1.69	2.16	2.90
1998	1.05	1.64	2.14	2.89
1999	1.07	1.70	2.13	2.75
2000	1.07	1.69	2.19	3.00
2001	1.13	1.69	2.17	2.98
2002	1.24	1.81	1.60	2.32
2003	1.14	1.58	2.74	3.70
2004	1.01	1.48	2.05	3.78
2005	1.09	1.39	1.79	3.93
2006	1.27	2.04	2.16	3.84
2007	1.30	2.07	2.56	4.03
2008	1.25	1.86	2.54	4.37
2009	1.34	1.82	2.06	4.40
2010	1.14	1.55	2.04	3.16
2011	1.36	1.86	2.36	4.35
2012	1.11	1.96	2.49	3.65
2013	1.46	1.89	2.12	3.53
2014	1.42	1.94	2.14	3.26
2015	1.15	1.82	2.58	4.17
2016	1.37	1.56	2.28	3.86
2017	1.49	1.75	1.75	3.84
2018	1.58	1.66	1.71	3.01

Table 12: Probabilities of age given length for age assignments of female southern flounder catches from the LDWF fishery-independent marine trammel net survey.

Survey				
TL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3+*
5	1.00	0.00	0.00	0.00
6	1.00	0.00	0.00	0.00
7	1.00	0.00	0.00	0.00
8	1.00	0.00	0.00	0.00
9	1.00	0.00	0.00	0.00
10	1.00	0.00	0.00	0.00
11	1.00	0.00	0.00	0.00
12	1.00	0.00	0.00	0.00
13	0.50	0.50	0.00	0.00
14	0.00	0.97	0.03	0.00
15	0.00	0.72	0.26	0.02
16	0.00	0.10	0.65	0.25
17	0.00	0.00	0.28	0.72
18	0.00	0.00	0.03	0.97
19	0.00	0.00	0.00	1.00
20	0.00	0.00	0.00	1.00
21	0.00	0.00	0.00	1.00
22	0.00	0.00	0.00	1.00
23	0.00	0.00	0.00	1.00
24	0.00	0.00	0.00	1.00
25	0.00	0.00	0.00	1.00
26	0.00	0.00	0.00	1.00

Table 13: Annual female southern flounder catch-at-size from the LDWF fishery-independent marine trammel net survey.

	Survey, 1986-2018																
TL_in	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*
4																	
5																	
6						1											
7							1	1	1	1			1				1
8	2	1	2	3	3	2	2	5	3	8	5	7	2	2		1	3
9	9	2	2	2	4	4	5	6	6	6	7	1	5	4	1	3	3
10	5	2	3		2	5	2	5	2	5	3	2	4	4	1	5	2
11	6	1	1	1	3	4	4	5	7	4	1	4	5	3	4	5	1
12		3	2	2	2	4	2	5	5	2	3	1	3	1	3	2	4
13	2	1	2	3	2	5			4	2		2	2	3	1	3	
14	1	1	2		1	2		1	2	3	3	2	2				
15			2	1		4		2	1	2	3		3	1	2		2
16	2	1	1		1	4	2	3	2		2			1	2		
17	1	1	1			2		1	1	2	1	1		2			2
18	1					1				1	1	1		2	2		
19						1			1		1						
20	1					1			1								1
21						1											
22														1			
23																	
24																	
Totals	30	13	18	12	18	41	18	34	36	36	30	21	27	24	16	19	19

TL_in	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
4																
5																
6																
7							1	1								
8	4	2	3	2	1	2	3	5	4	7	1	1	1	1		
9	4	2	9	5	5	3		7	10	8	2	3	4	1		1
10	6	9	3	3	4	6		12	9	7	3	3	1	2		1
11	2	4	6			3	3	10	3	3	4	7		1		2
12	1	1	3	2	3	2	2	11	3	2		1	7	1	1	2
13	1	4	1	1	1		2	3	2	2	1		1	3		
14	2	1			2	1	1	2	2	3	1	2	2			
15	1	1	3	1		4	1	3	5	1			1		1	
16	2	1		2	1			5	3				2			
17			2	1				1	1				1			1
18	1			1	1					1						
19		1				1			1		1					
20								2		1						
21																
22																
23																
24																
Totals	24	26	30	18	18	22	13	62	43	35	13	17	20	9	2	7

Table 14: Annual female southern flounder survey age composition and sample sizes derived from the LDWF fishery-independent marine trammel net survey.

Year	n	Age_0	Age_1	Age_2	Age_3+
1986	30	0.770	0.070	0.050	0.110
1987	13	0.750	0.110	0.070	0.070
1988	17	0.610	0.240	0.080	0.060
1989	12	0.810	0.170	0.020	0.000
1990	17	0.840	0.110	0.040	0.010
1991	40	0.540	0.190	0.100	0.160
1992	16	0.870	0.010	0.080	0.030
1993	33	0.790	0.080	0.080	0.040
1994	36	0.730	0.130	0.050	0.090
1995	35	0.760	0.140	0.030	0.070
1996	28	0.610	0.190	0.090	0.110
1997	20	0.760	0.140	0.020	0.080
1998	27	0.780	0.190	0.030	0.000
1999	23	0.630	0.100	0.070	0.200
2000	16	0.590	0.140	0.120	0.160
2001	19	0.920	0.080	0.000	0.000
2002	18	0.720	0.080	0.060	0.140
2003	24	0.730	0.140	0.070	0.060
2004	25	0.770	0.140	0.040	0.050
2005	29	0.810	0.090	0.050	0.050
2006	18	0.690	0.080	0.100	0.120
2007	18	0.750	0.140	0.040	0.070
2008	22	0.730	0.170	0.050	0.050
2009	13	0.770	0.200	0.020	0.000
2010	60	0.760	0.100	0.070	0.070
2011	43	0.700	0.160	0.080	0.060
2012	35	0.810	0.130	0.010	0.060
2013	11	0.780	0.130	0.000	0.090
2014	16	0.880	0.110	0.000	0.000
2015	20	0.670	0.170	0.090	0.060
2016	9	0.830	0.170	0.000	0.000
2017	2	0.500	0.360	0.130	0.010
2018	7	0.850	0.000	0.040	0.110

Table 15: Summary of objective function components and likelihood values of the ASAP base model.

Objective function=	2445.31		
Component	**Lambda**	**ESS**	**negLL**
Catch_Recreational	1	--	-46.2
Catch_Commercial	1	--	-92.4
IOA_trammel	1	--	-7.6
IOA_trawl	1	--	4.1
Catch_agecomps	--	2100	2243.3
IOA_agecomps	--	320	279.5
Selectivity_parms_catch	10	--	5.3
Selectivity_parms_index	4		0.76
N_year_1	1	--	51.7
Recruitment_devs	1	--	6.7

Table 16: Annual female southern flounder abundance-at-age and total female stock size estimates from the ASAP base model.

Year	Age_1	Age_2	Age_3	Age_4+	Totals
1982	1,129,640	400,938	177,528	155,317	1,863,423
1983	1,855,670	474,977	182,938	152,572	2,666,157
1984	1,589,230	719,678	197,438	137,285	2,643,631
1985	975,133	701,367	339,307	153,352	2,169,159
1986	1,127,060	400,957	299,960	196,170	2,024,147
1987	1,861,360	416,289	144,944	148,775	2,571,368
1988	1,124,060	722,623	152,683	81,722	2,081,088
1989	1,167,110	447,746	291,599	83,813	1,990,268
1990	1,416,220	469,490	183,590	139,282	2,208,582
1991	1,899,860	560,466	192,059	120,927	2,773,312
1992	957,210	721,509	213,253	103,243	1,995,215
1993	1,179,200	343,035	250,052	89,973	1,862,260
1994	1,831,900	398,698	106,040	79,150	2,415,788
1995	1,286,220	593,253	114,213	36,331	2,030,017
1996	1,315,450	487,731	219,863	47,033	2,070,077
1997	1,204,460	560,211	233,782	136,705	2,135,158
1998	1,131,560	508,626	266,123	189,842	2,096,151
1999	866,997	483,276	244,334	236,834	1,831,441
2000	654,364	317,243	197,988	213,945	1,383,540
2001	493,821	213,705	115,484	163,028	986,038
2002	859,481	149,802	72,162	102,556	1,184,001
2003	907,769	312,577	61,018	77,583	1,358,948
2004	1,178,410	323,354	124,636	60,168	1,686,568
2005	609,152	463,800	142,866	87,889	1,303,707
2006	1,045,800	253,541	217,213	116,629	1,633,183
2007	905,111	438,991	119,717	169,870	1,633,689
2008	784,679	378,300	206,367	148,389	1,517,735
2009	723,331	339,318	184,147	186,720	1,433,516
2010	853,143	277,809	146,098	173,408	1,450,458
2011	895,335	316,379	115,523	144,500	1,471,737
2012	794,608	328,549	129,992	116,316	1,369,465
2013	587,776	277,887	128,451	104,417	1,098,531
2014	398,456	138,326	72,278	65,598	674,658
2015	908,895	118,957	45,950	49,674	1,123,476
2016	423,709	328,346	48,114	42,029	842,198
2017	235,085	116,395	100,139	29,801	481,420
2018	94,153	79,929	44,191	52,849	271,122

Table 17: Annual age-specific, apical, and average fishing mortality rates for female southern flounder estimated from the ASAP base model.

Year	Age_1	Age_2	Age_3	Age_4+	Apical F	Avg. F
1982	0.15	0.19	0.25	0.29	0.29	0.18
1983	0.23	0.29	0.35	0.42	0.42	0.26
1984	0.10	0.16	0.24	0.31	0.31	0.14
1985	0.17	0.26	0.37	0.47	0.47	0.25
1986	0.28	0.43	0.62	0.80	0.80	0.41
1987	0.23	0.41	0.66	0.89	0.89	0.32
1988	0.21	0.32	0.47	0.60	0.60	0.28
1989	0.20	0.30	0.44	0.57	0.57	0.27
1990	0.21	0.30	0.42	0.53	0.53	0.27
1991	0.25	0.38	0.54	0.69	0.69	0.32
1992	0.31	0.47	0.68	0.87	0.87	0.44
1993	0.37	0.58	0.87	1.14	1.14	0.51
1994	0.41	0.66	0.99	1.30	1.30	0.51
1995	0.26	0.40	0.60	0.78	0.78	0.33
1996	0.14	0.14	0.14	0.14	0.14	0.14
1997	0.15	0.15	0.15	0.15	0.15	0.15
1998	0.14	0.14	0.14	0.14	0.14	0.14
1999	0.29	0.30	0.30	0.30	0.30	0.30
2000	0.41	0.42	0.42	0.42	0.42	0.41
2001	0.48	0.49	0.50	0.49	0.50	0.49
2002	0.30	0.31	0.31	0.31	0.31	0.30
2003	0.32	0.33	0.33	0.33	0.33	0.32
2004	0.22	0.23	0.23	0.22	0.23	0.22
2005	0.16	0.17	0.17	0.17	0.17	0.17
2006	0.15	0.16	0.16	0.16	0.16	0.16
2007	0.16	0.16	0.16	0.16	0.16	0.16
2008	0.12	0.13	0.13	0.13	0.13	0.13
2009	0.24	0.25	0.25	0.25	0.25	0.25
2010	0.28	0.29	0.29	0.29	0.29	0.28
2011	0.29	0.30	0.30	0.30	0.30	0.29
2012	0.34	0.35	0.35	0.35	0.35	0.34
2013	0.73	0.76	0.76	0.75	0.76	0.74
2014	0.49	0.51	0.51	0.51	0.51	0.50
2015	0.30	0.31	0.31	0.31	0.31	0.31
2016	0.58	0.60	0.60	0.59	0.60	0.59
2017	0.36	0.38	0.38	0.38	0.38	0.37
2018	0.43	0.45	0.45	0.44	0.45	0.44

Table 18: Limit and target reference point estimates for the Louisiana female southern flounder stock. Spawning stock biomass units are pounds x 10^6. Fishing mortality units are year^{-1}.

Management Benchmarks		
Parameters	*Derivation*	*Value*
SPR_{limit}	*Proposed Limit*	*20.0%*
SSB_{limit}	*Equation [26] and SPR_{limit}*	*0.454*
F_{limit}	*Equation [26] and SPR_{limit}*	*0.918*
SSB_{target}	*LAC 76: VII.385 (Geometric mean SSB 1982-2013)*	*1.24*
SPR_{target}	*Equation [26] and SSB_{target}*	*54.8%*
F_{target}	*Equation [26] and SSB_{target}*	*0.243*

Table 19: Sensitivity analysis table of proposed limit reference points. Current estimates are taken as the geometric mean of the 2016-2018 estimates. Yield and spawning stock biomass units are millions of pounds, and fishing mortality units are years^{-1}.

Model run	***negLL***	***SPR_{limit}***	***$Yield_{limit}$***	***F_{limit}***	***SSB_{limit}***	***$SPR_{current}$***	***$F_{current}/F_{limit}$***	***$SSB_{current}/SSB_{limit}$***
Base Model (h=1)	*2445.3*	*20.0%*	*0.77*	*0.92*	*0.45*	*18.7%*	*0.50*	*0.94*
Model 1 (h=0.9)	*2455.5*	*20.0%*	*0.65*	*0.90*	*0.39*	*16.0%*	*0.71*	*0.77*
Model 2 (h=0.8)	*2439.1*	*20.0%*	*0.61*	*0.91*	*0.36*	*19.4%*	*0.62*	*0.96*
Model 3 (h=0.7)	*2434.3*	*20.0%*	*0.48*	*0.91*	*0.28*	*20.8%*	*0.71*	*1.08*
*Model 4 (Yield lambdas*10)*	*1021.4*	*20.0%*	*0.79*	*0.91*	*0.47*	*22.4%*	*0.37*	*1.12*
*Model 5 (IOA lambdas*10)*	*1981.0*	*20.0%*	*0.67*	*0.90*	*0.40*	*11.8%*	*1.56*	*0.59*
Model 6 (Maturity 2015)	*2445.3*	*20.0%*	*0.77*	*0.92*	*0.45*	*16.7%*	*0.50*	*0.84*
Model 7 (Trawl IOA only)	*2169.6*	*20.0%*	*0.70*	*0.90*	*0.42*	*20.2%*	*0.46*	*1.01*
Model 8 (Discard M=0.2)	*2457.8*	*20.0%*	*0.72*	*0.90*	*0.43*	*15.5%*	*0.65*	*0.78*
Model 9 (Growth Model ALKs 1982-2018)	*2774.2*	*20.0%*	*1.11*	*0.92*	*0.77*	*35.5%*	*0.17*	*1.77*
Model 10 (ACAL MRIP hindcast)	*2437.2*	*20.0%*	*0.77*	*0.91*	*0.46*	*17.2%*	*0.53*	*0.86*
Model 11 (MRIP Size with FES APAIS)	*2457.5*	*20.0%*	*0.68*	*0.90*	*0.40*	*15.2%*	*0.70*	*0.76*

Table 20: Sensitivity analysis table of MSY related reference points. Current estimates are taken as the geometric mean of 2016-2018 estimates. Yield and spawning stock biomass units are millions of pounds, and fishing mortality units are years^{-1}.

Model run	***negLL***	***SPR_{MSY}***	***MSY***	***F_{MSY}***	***SSB_{MSY}***	***$SPR_{current}$***	***$F_{current}/F_{MSY}$***	***$SSB_{current}/SSB_{MSY}$***
Base Model (h=1)	*2445.3*	*--*	*--*	*--*	*--*	*18.7%*	*--*	*--*
Model 1 (h=0.9)	*2455.5*	*11.8%*	*0.69*	*1.54*	*0.21*	*16.0%*	*0.41*	*1.45*
Model 2 (h=0.8)	*2439.1*	*21.9%*	*0.61*	*0.83*	*0.41*	*19.4%*	*0.68*	*0.85*
Model 3 (h=0.7)	*2434.3*	*30.4%*	*0.54*	*0.58*	*0.57*	*20.8%*	*1.12*	*0.54*

11. Figures

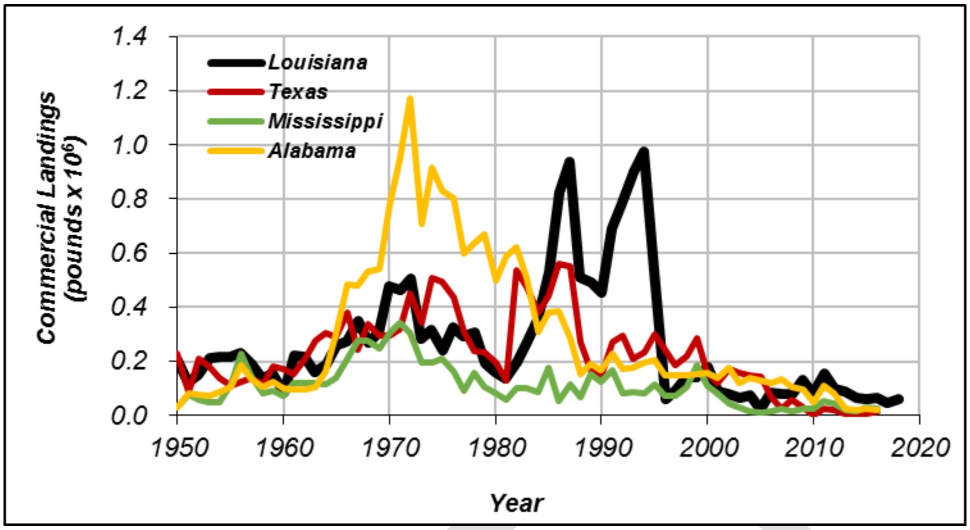


Figure 1: Reported commercial flatfish landings (pounds x 10^6) of the northern Gulf of Mexico derived from NMFS statistical records and the LDWF Trip Ticket Program. (Note: NOAA did not distinguish between southern flounder and other flatfish species prior to 2000 in Louisiana).

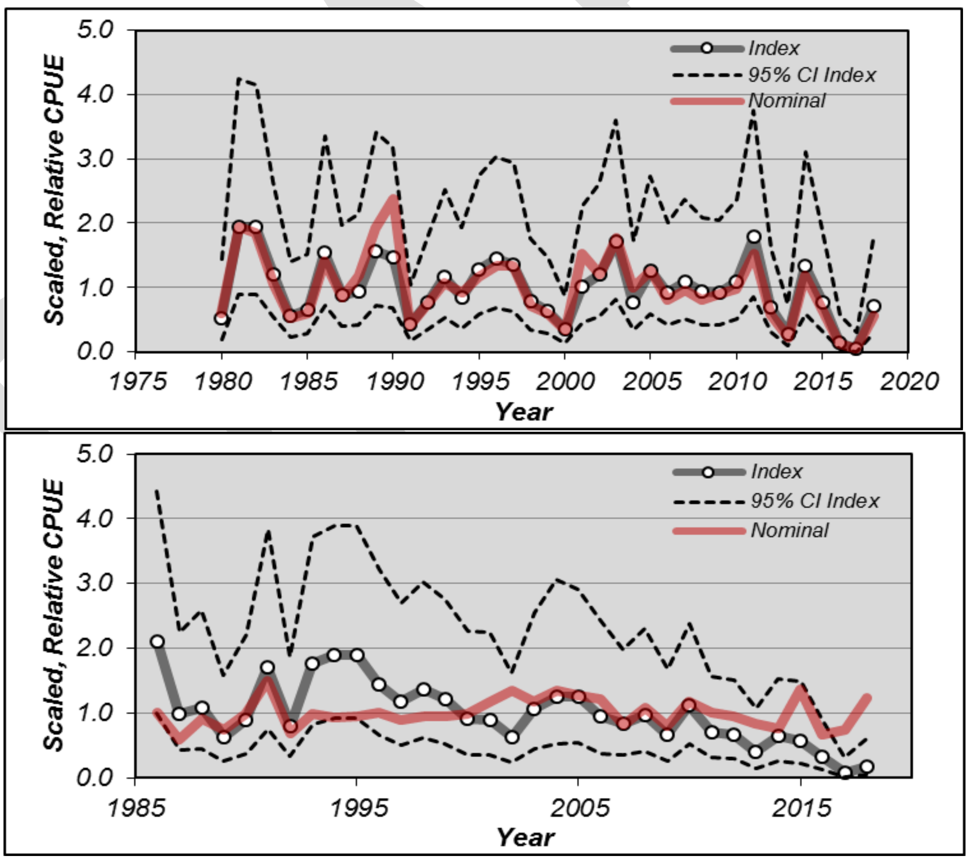


Figure 2: Standardized indices of abundance, nominal catch-per-unit-efforts, and 95% confidence intervals of the standardized indices derived from the LDWF marine inshore trawl (top) and trammel net (bottom) surveys. Each time-series has been normalized to its individual long-term mean for comparison.

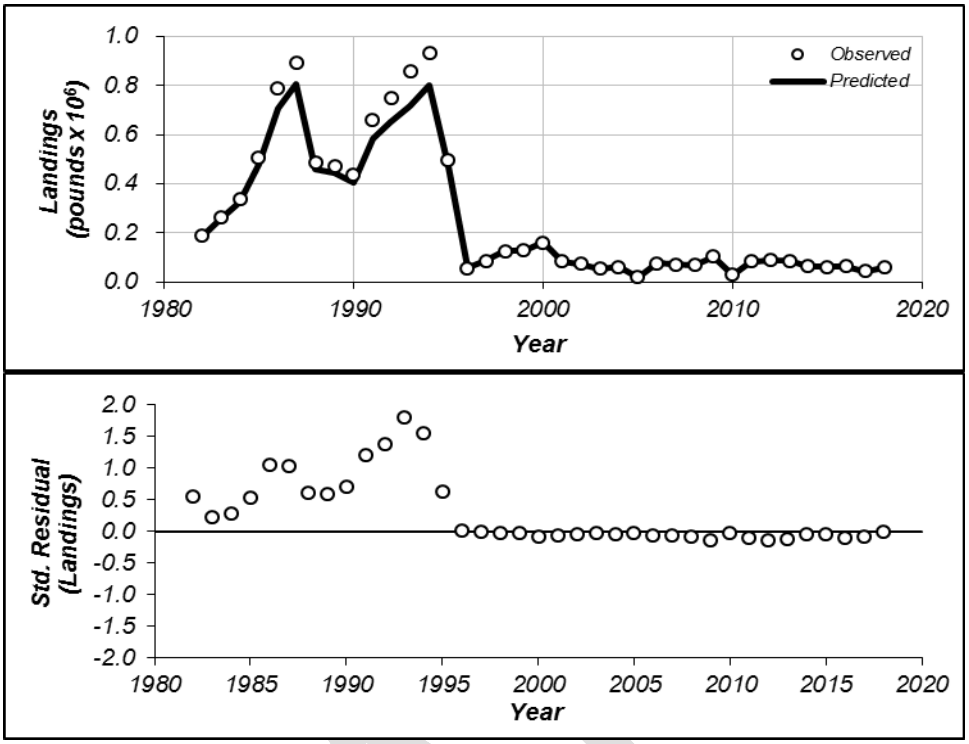


Figure 3: Observed and ASAP base model estimated commercial yield (top) and standardized residuals (bottom).

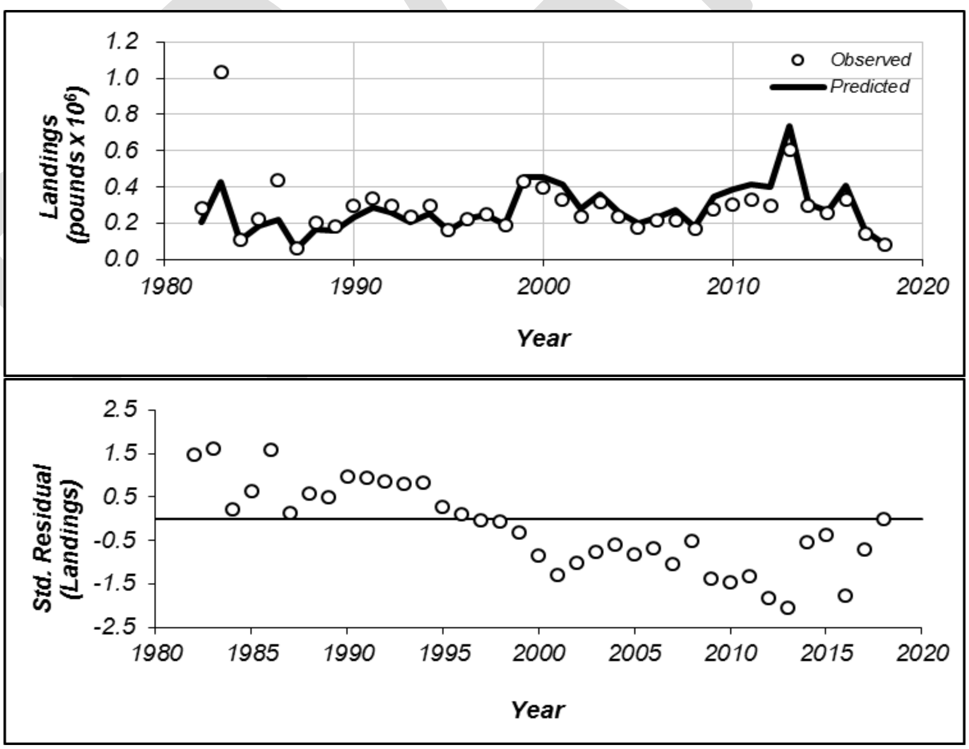


Figure 4: Observed and ASAP base model estimated recreational yield (top) and standardized residuals (bottom).

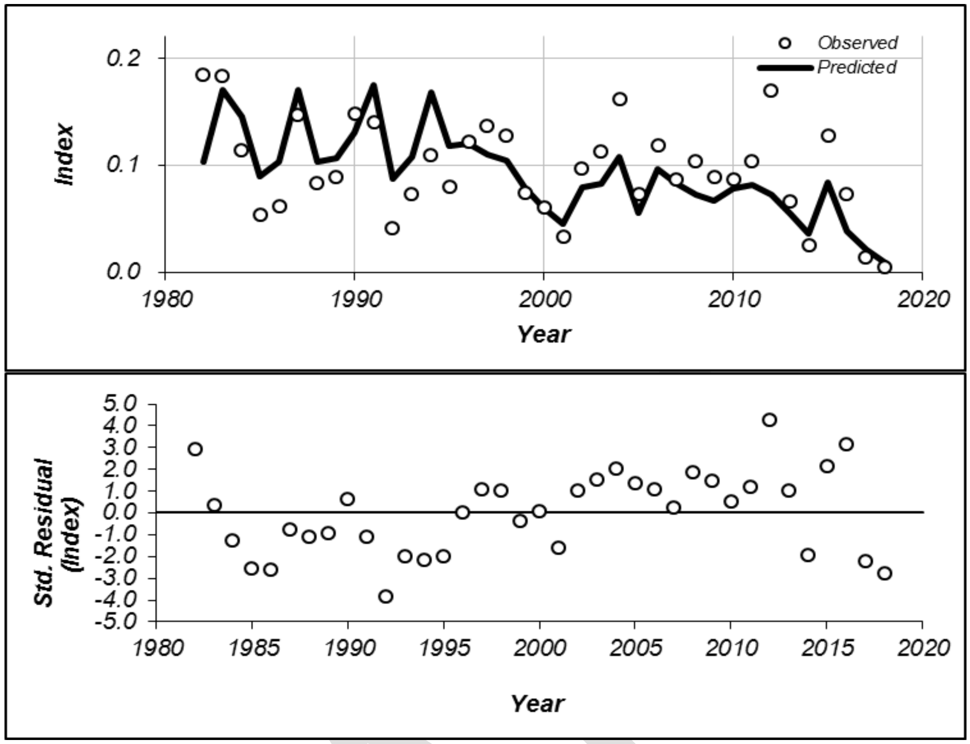


Figure 5: Observed and ASAP base model estimated age-1 trawl survey CPUE (top) and standardized residuals (bottom).

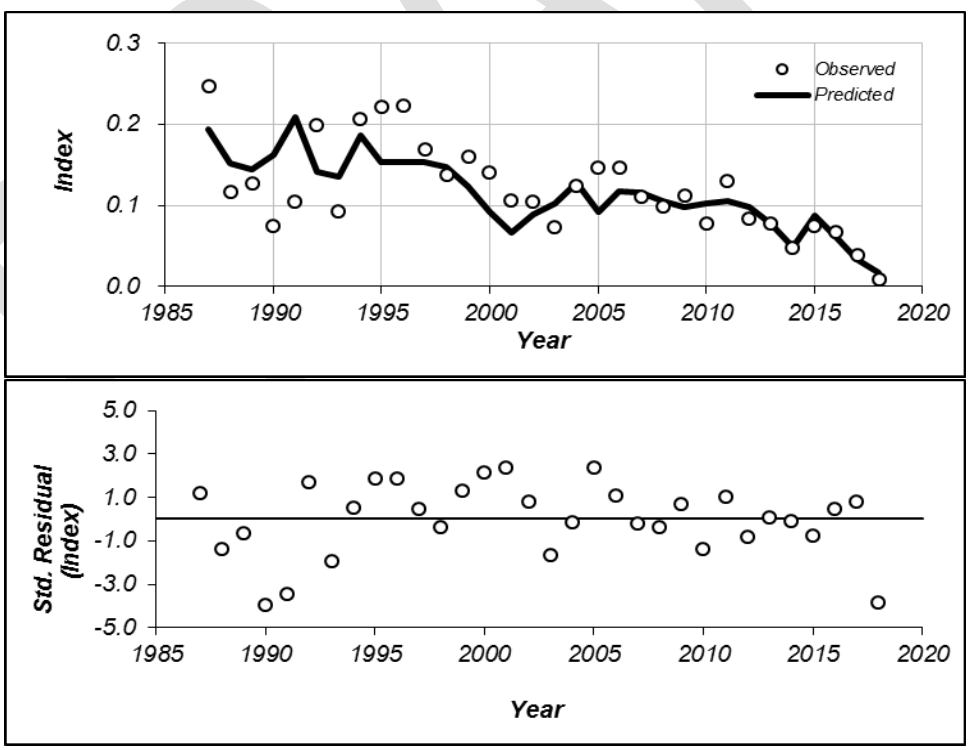


Figure 6: Observed and ASAP base model estimated trammel net survey CPUE (top) and standardized residuals (bottom).

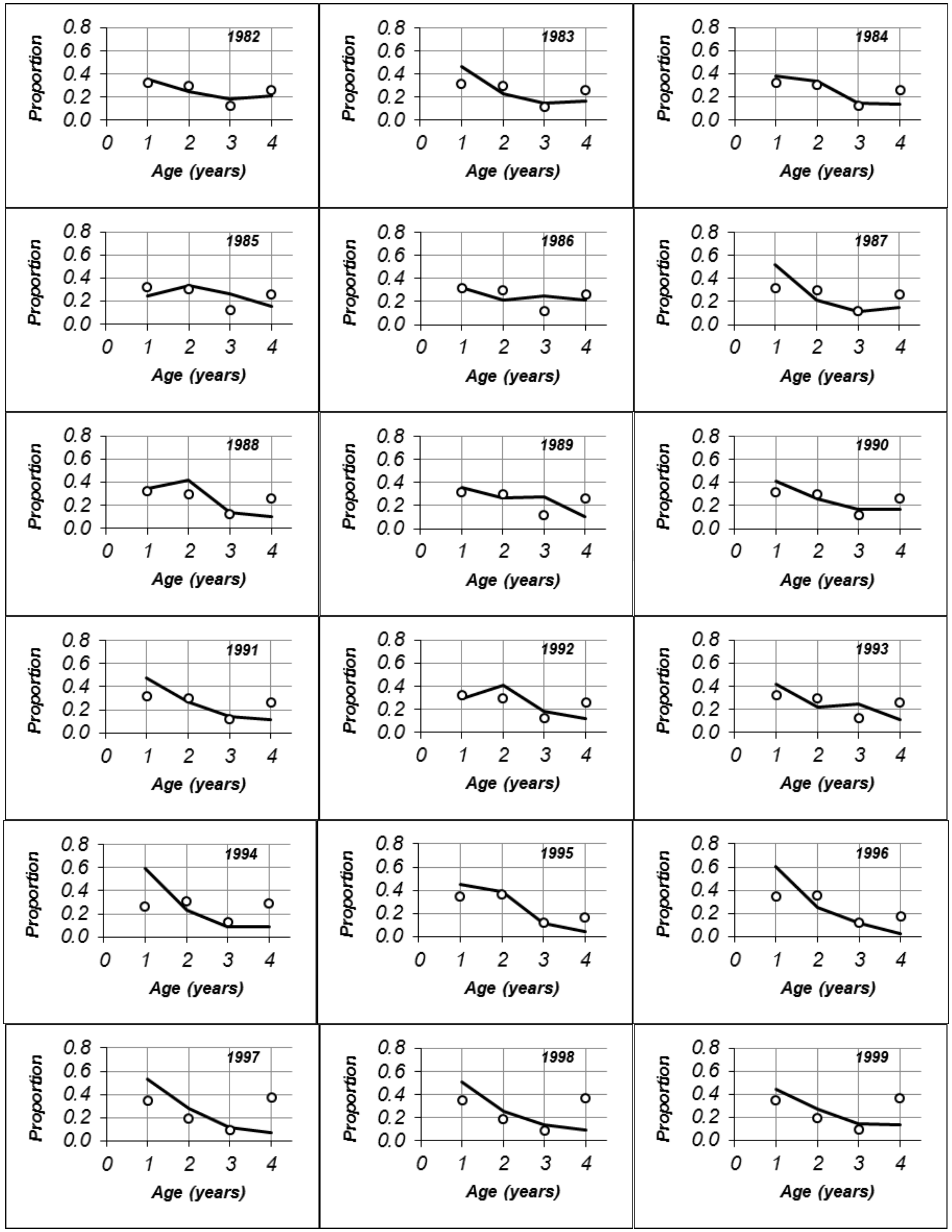


Figure 7: Annual input (open circles) and ASAP estimated (bold lines) commercial female southern flounder harvest age compositions.

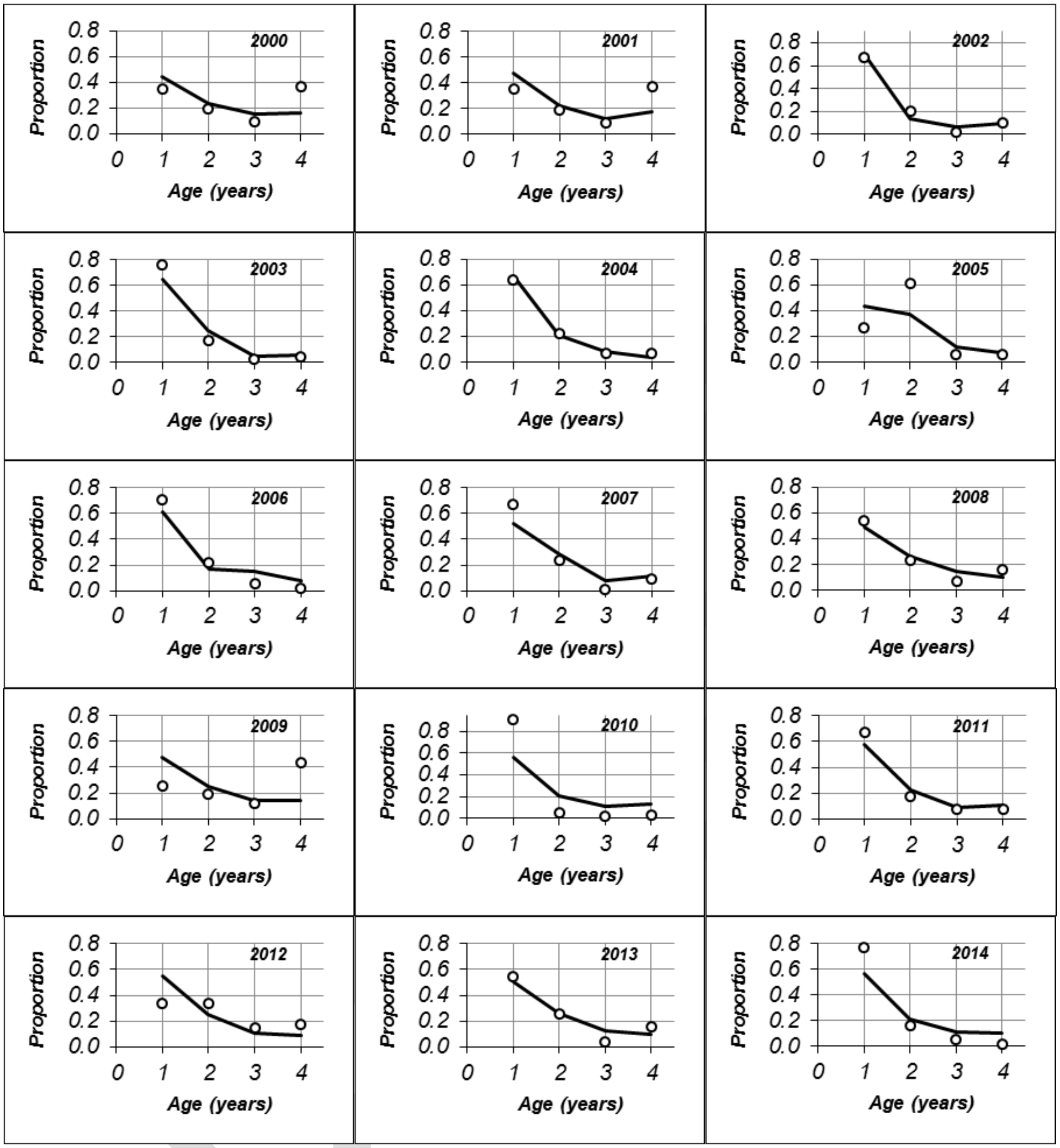
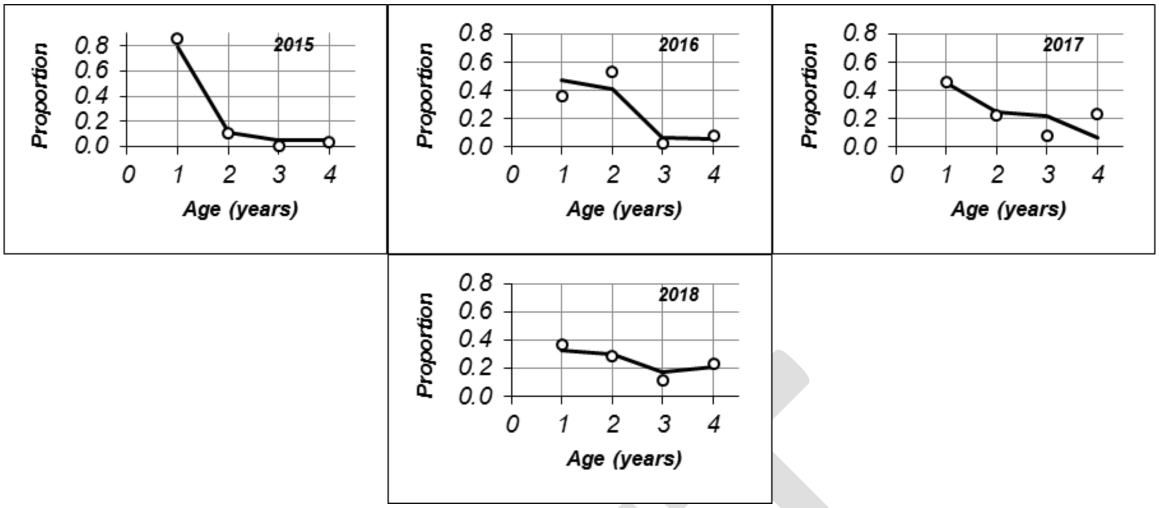


Figure 7 (continued):



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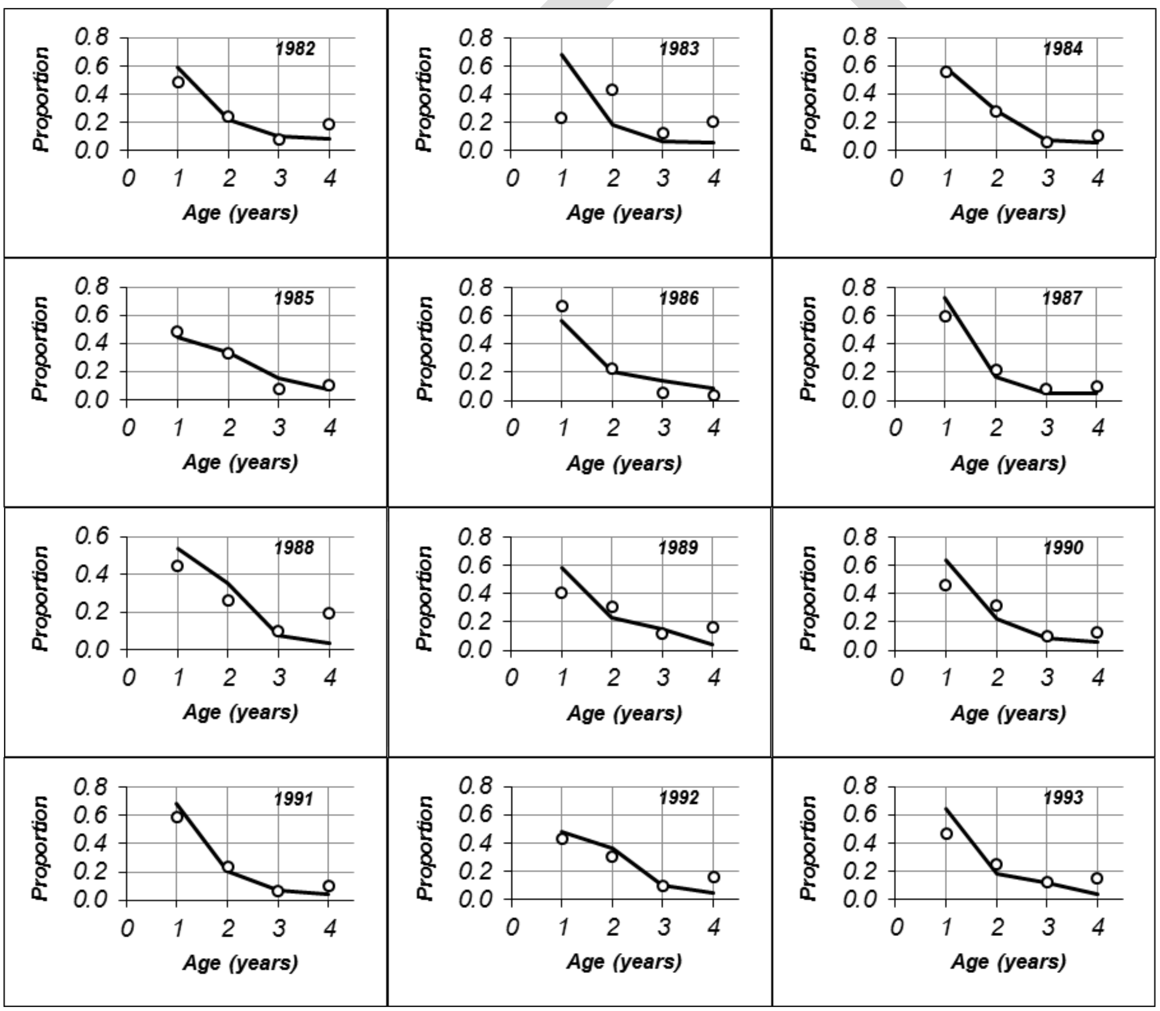


Figure 8: Annual input (open circles) and ASAP estimated (bold lines) recreational female southern flounder harvest age compositions.

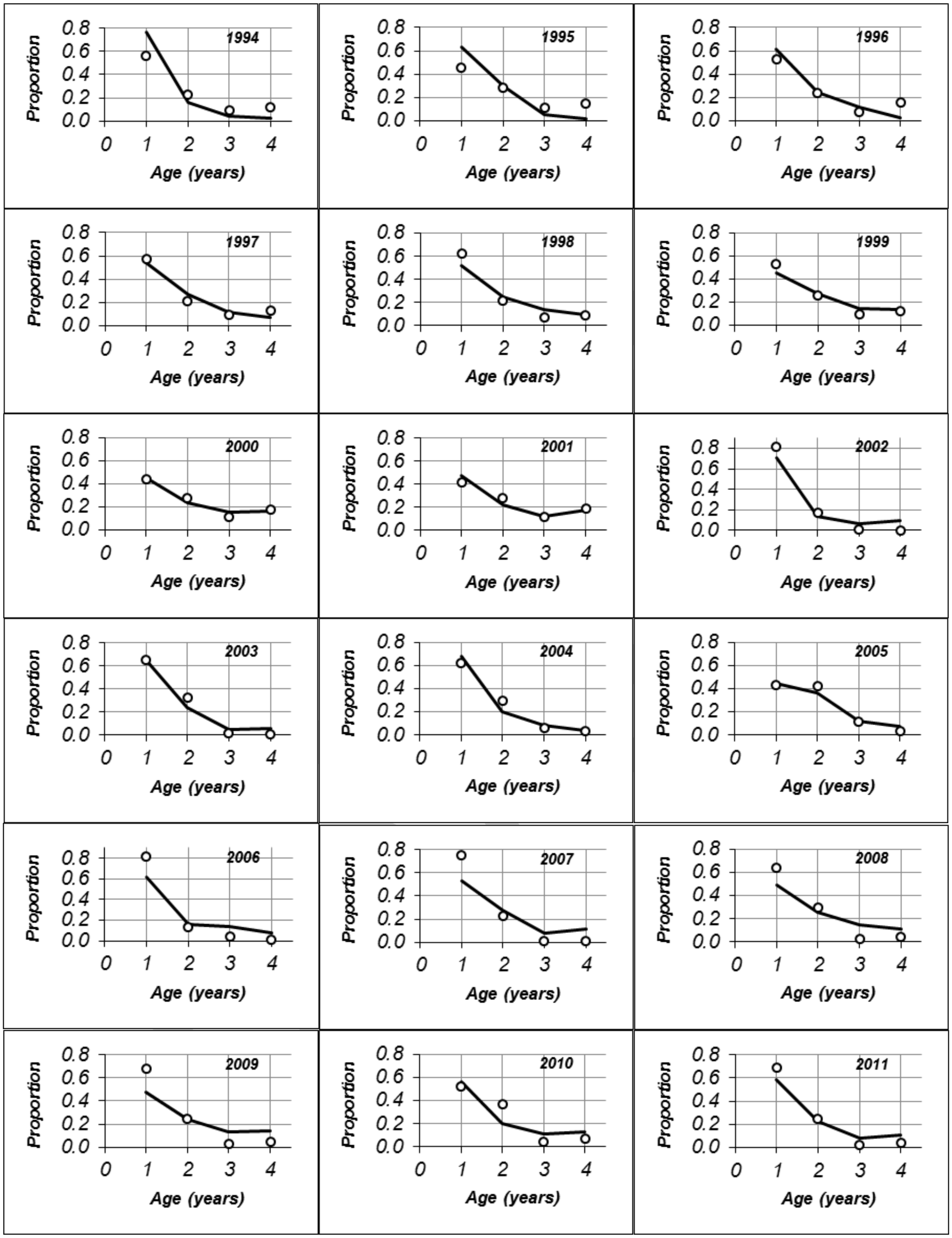
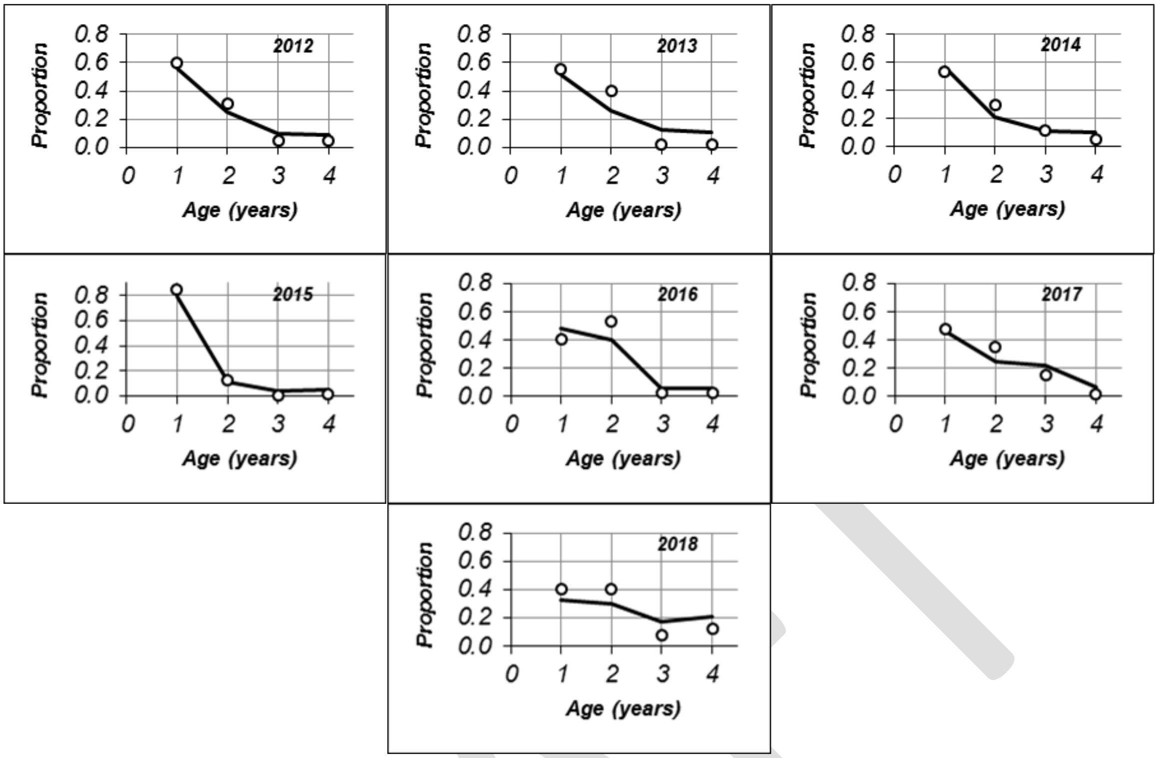


Figure 8 (continued):



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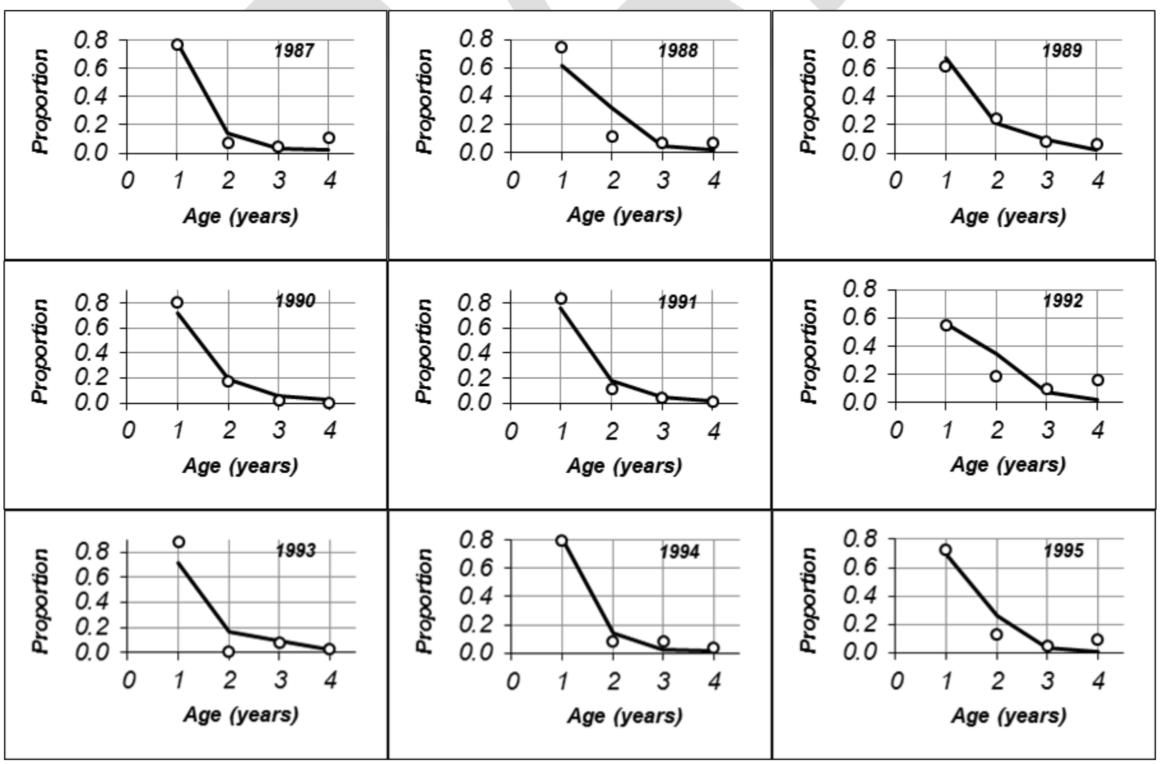
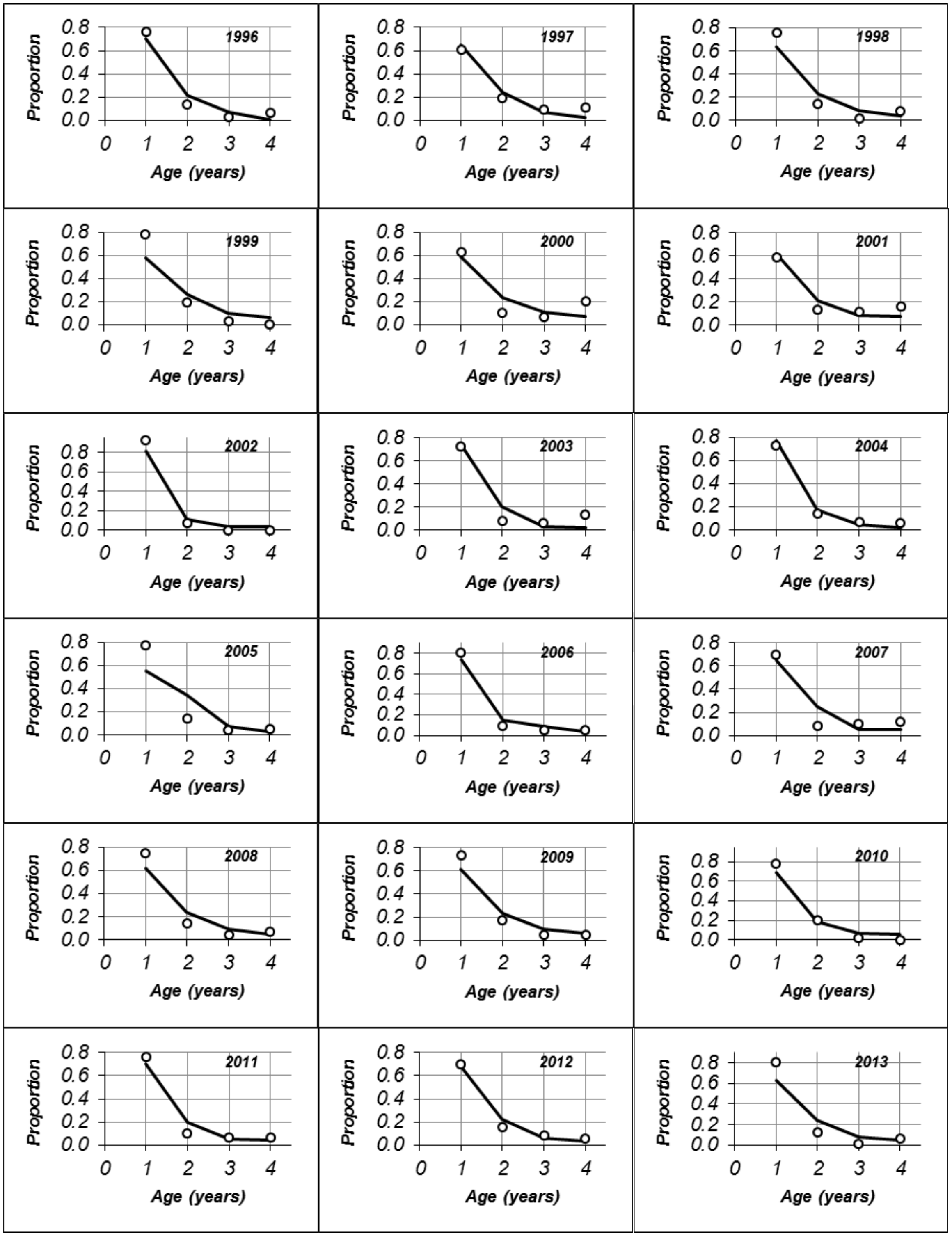


Figure 9: Annual input (open circles) and ASAP estimated (bold lines) trammel net survey female southern flounder age compositions.



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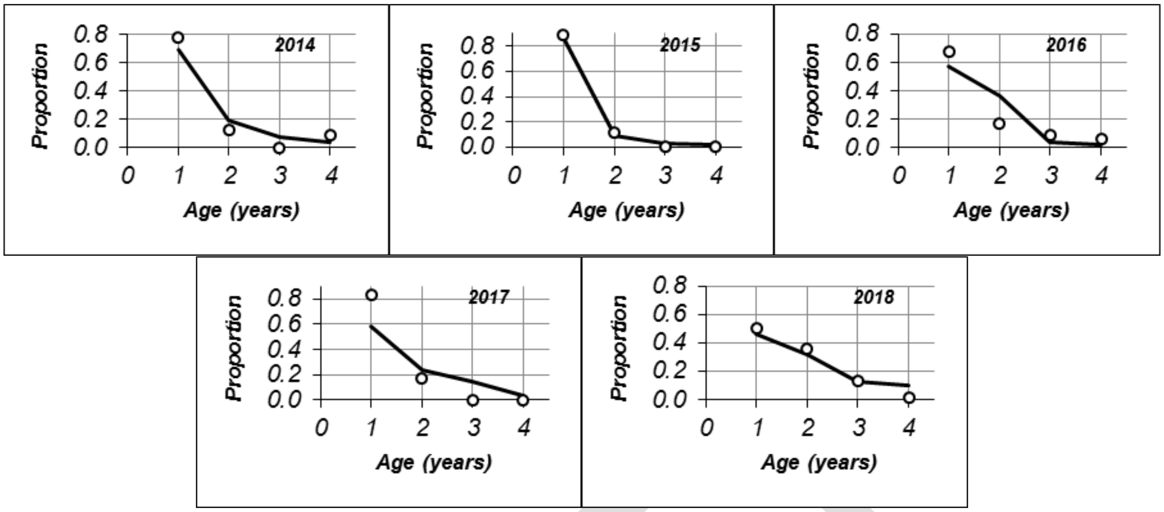

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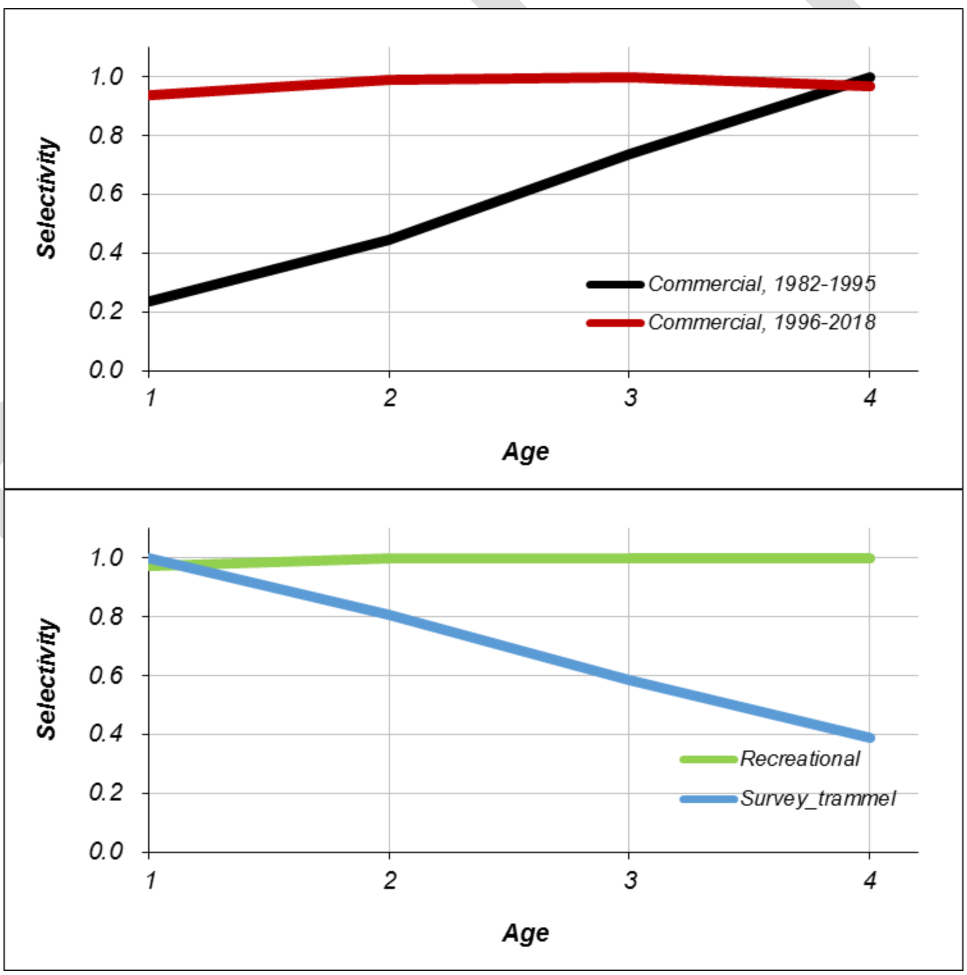

Figure 10: ASAP base model estimated commercial (top), and recreational and survey (bottom) selectivities (ages 1-4+).

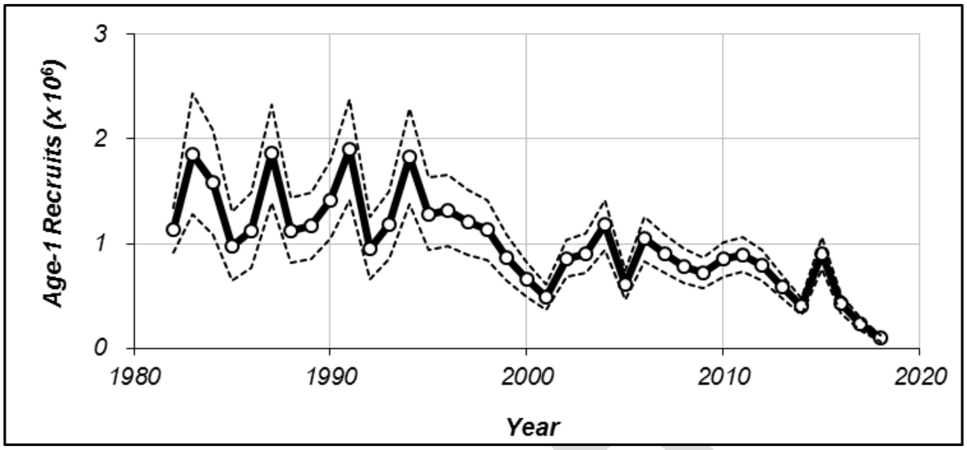

Figure 11: ASAP base model estimated age-1 female recruitment. Dashed lines represent ±2 asymptotic standard errors.

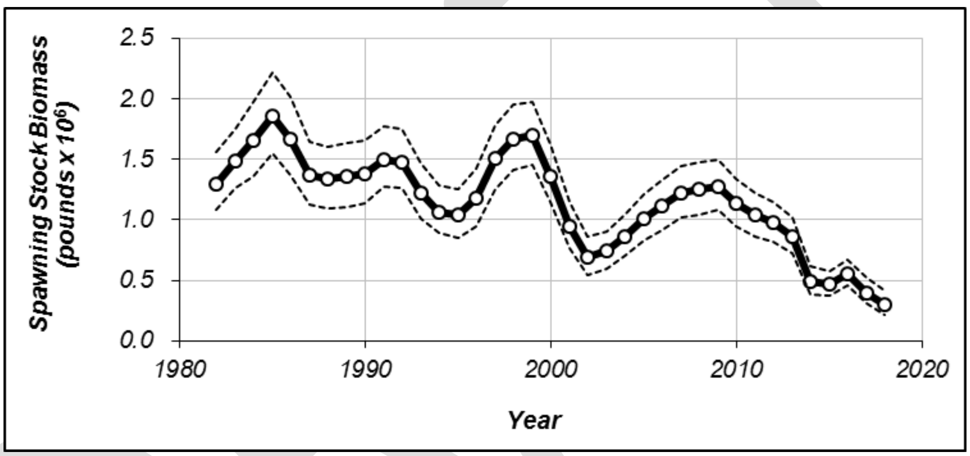

Figure 12: ASAP base model estimated female spawning stock biomass (MCMC median). Dashed lines represent 95% MCMC derived confidence intervals.

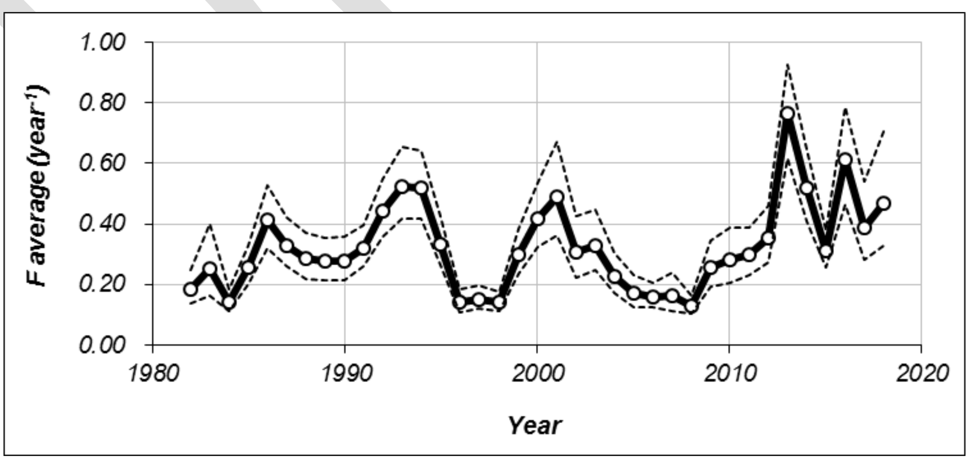

Figure 13: ASAP base model estimated average fishing mortality rates (MCMC median). Dashed lines represent 95% MCMC derived confidence intervals.

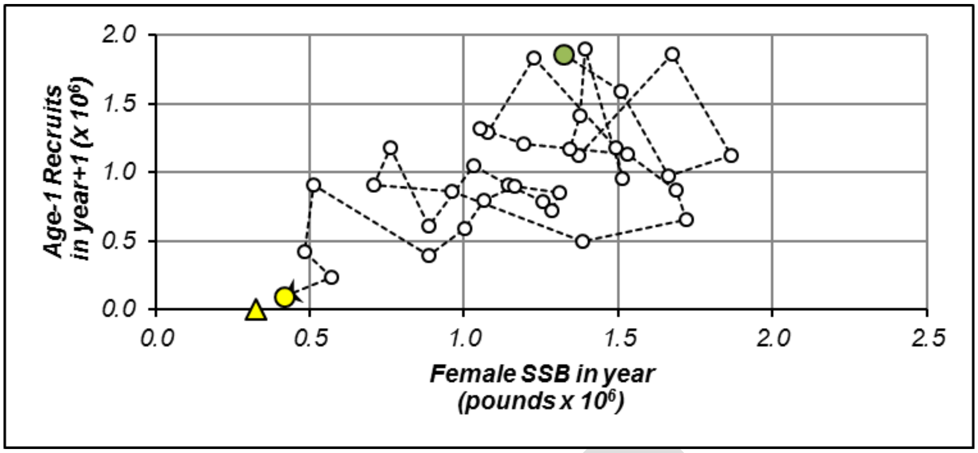

Figure 14: ASAP base model estimated age-1 female recruits and female spawning stock biomass. Arrow represents direction of the time-series. The yellow circle represents the most current data pair (2018 age-1 female recruits / 2017 female SSB) and the yellow triangle represents the 2018 SSB estimate. The green circle represents the first data pair (1983 age-1 female recruits / 1982 female SSB).

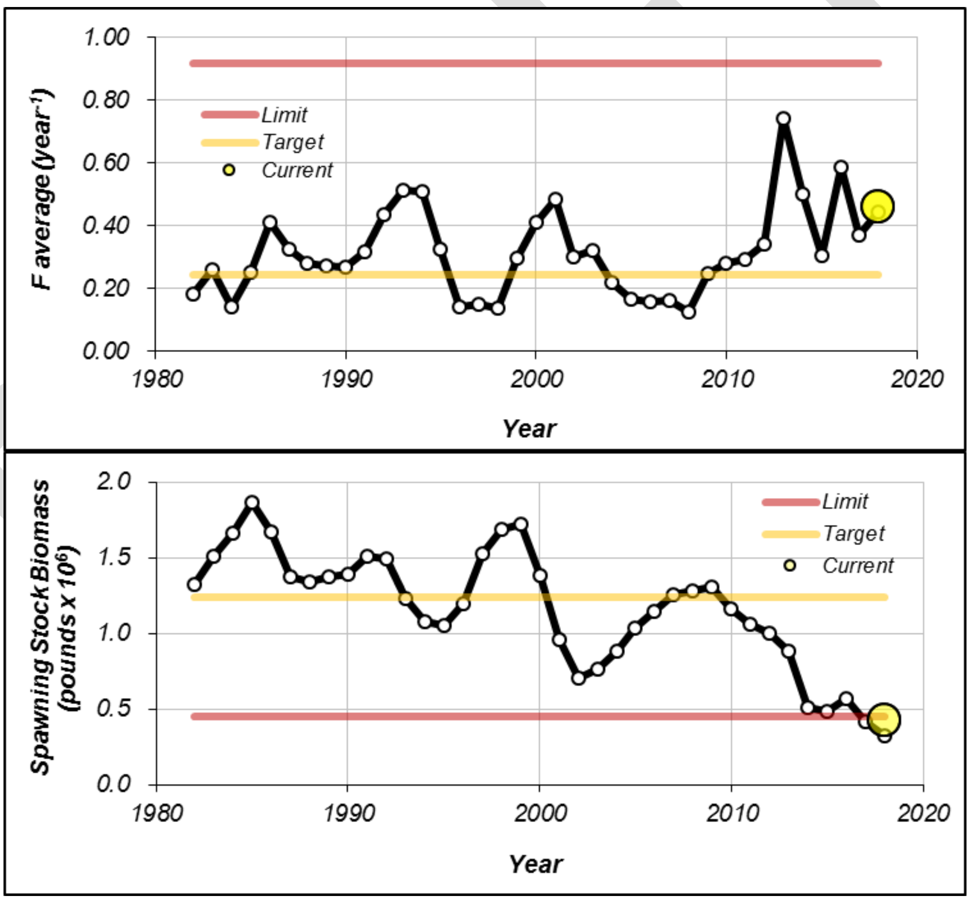

Figure 15: Time-series of ASAP base model estimated average fishing mortality rates, female spawning stock biomass, and spawning potential ratios relative to proposed limit and established target reference points. Current values represent the geometric mean of the 2016-2018 estimates.

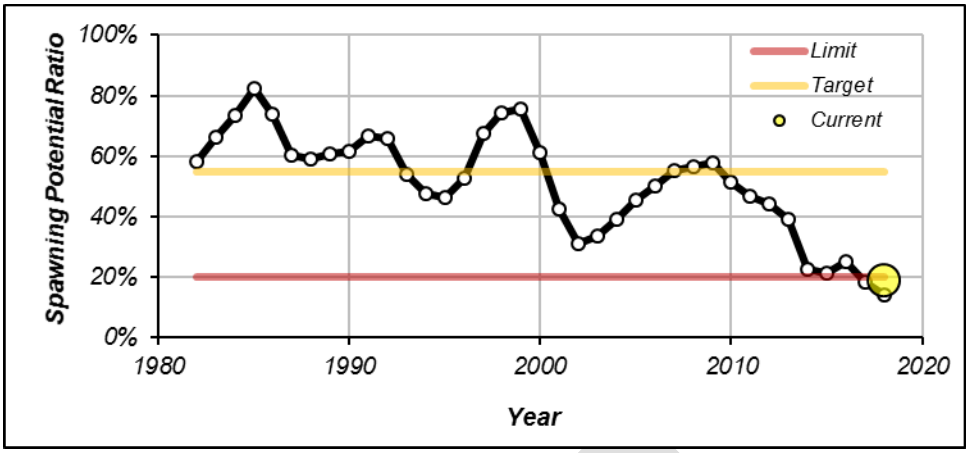

Figure 15 (continued):

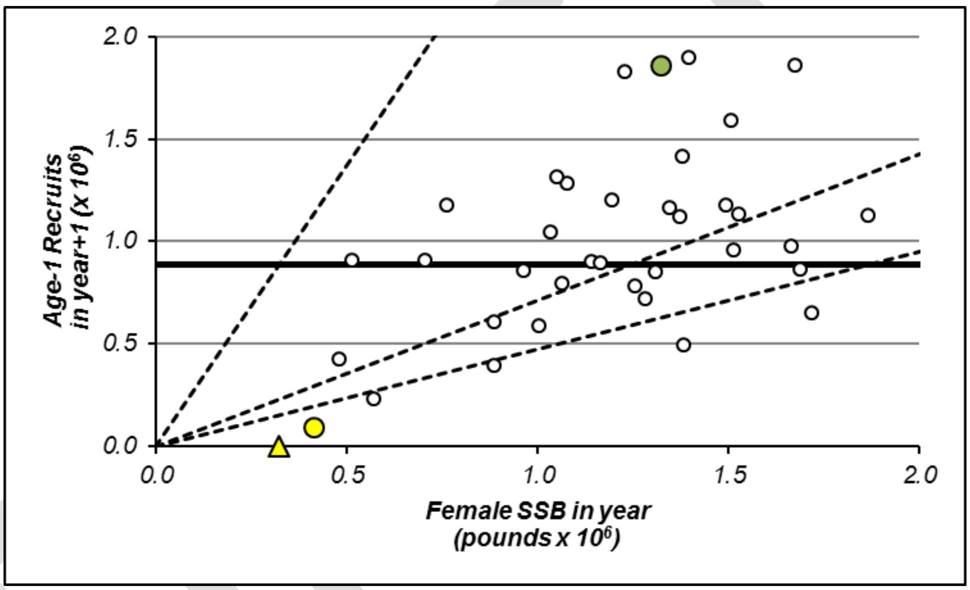

Figure 16: ASAP base model estimated age-1 female recruits and female spawning stock biomass (open circles). Equilibrium recruitment is represented by the bold horizontal. The yellow circle represents the most current data pair (2018 age-1 female recruits / 2017 female SSB) and the yellow triangle represents the 2018 SSB estimate. The green circle represents the first data pair (1983 age-1 female recruits / 1982 female SSB). Equilibrium recruitment per spawning stock biomass corresponding with the target spawning stock biomass reference point estimate and the minimum and maximum spawning stock biomass estimates are represented by the slopes of the dashed diagonals (min. SSB=14% SPR; SSB_{target}=55%; max. SSB=82% SPR).

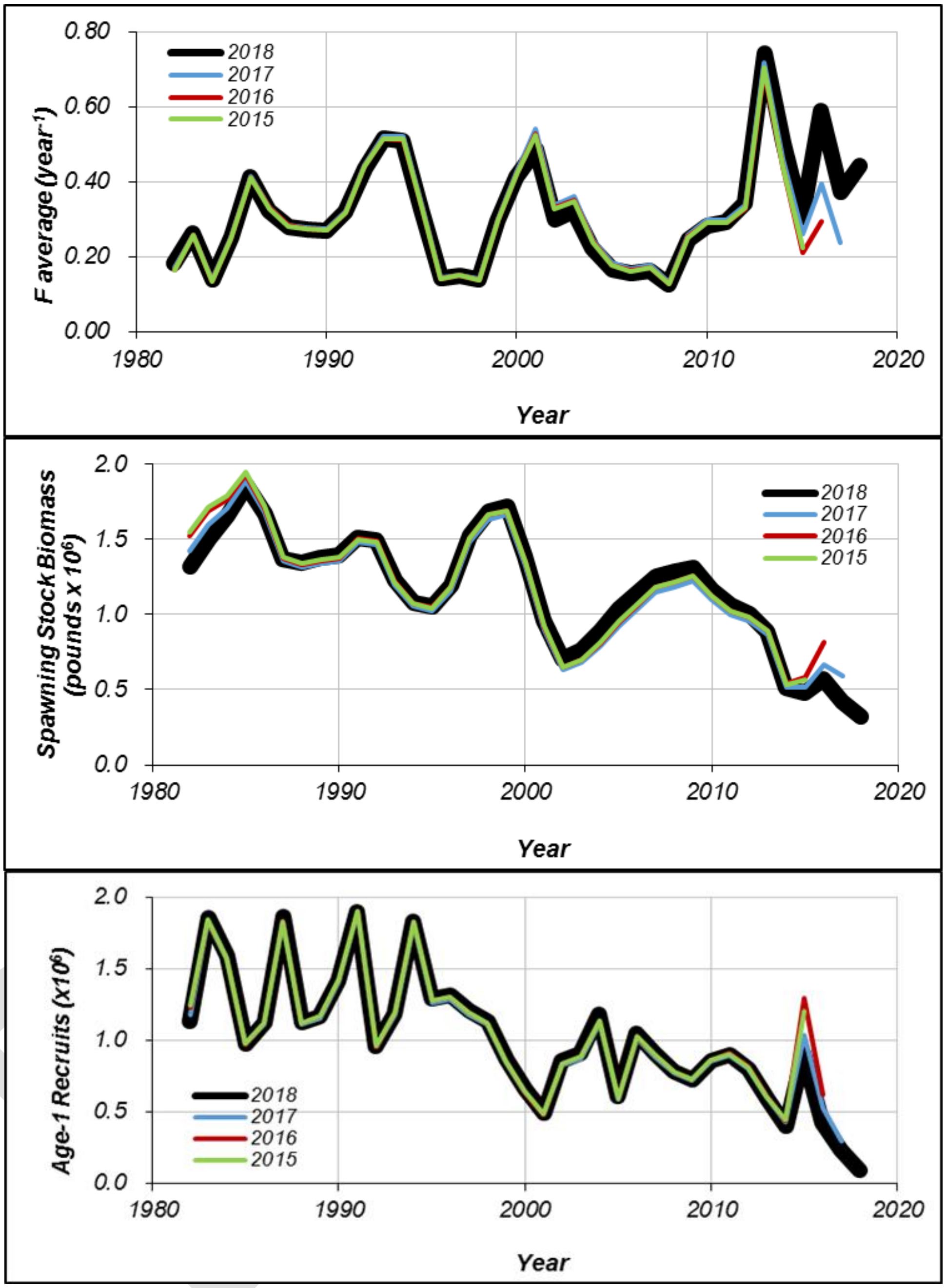

Figure 17: Retrospective analysis of ASAP base model. Top graphics depict annual average fishing mortality and female spawning stock biomass estimates. Bottom graphic depicts estimated age-1 female recruits.

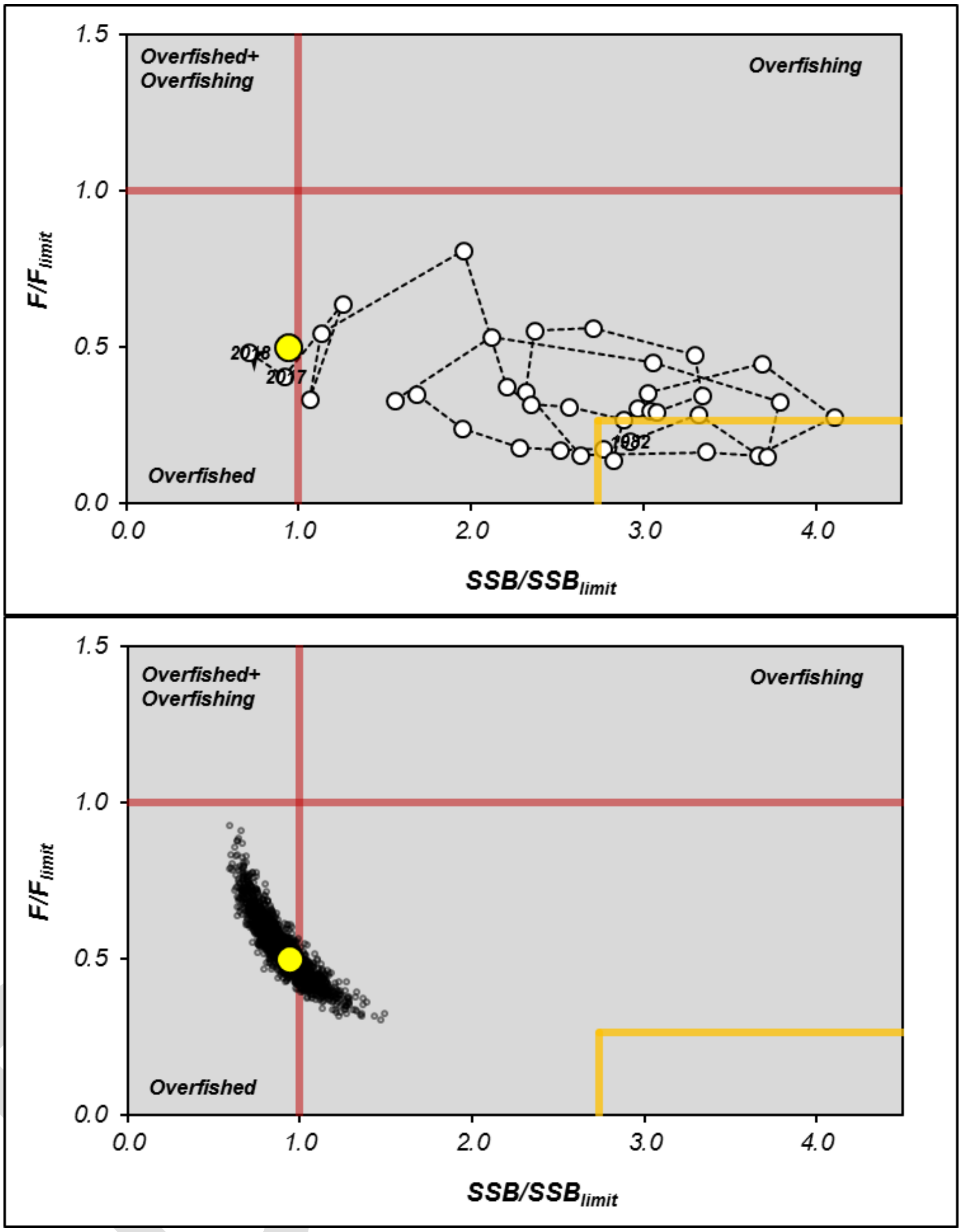

Figure 18: ASAP base model estimated ratios of annual average fishing mortality rates and female spawning stock biomass to the proposed limit reference points (F_{limit} and SSB_{limit}). Also presented are the target reference points (yellow lines). Arrow represents direction of time-series. The first and last year of the time-series are identified along with the years where the stock was considered overfished. The yellow circle represents current status (geometric mean 2016-2018). Bottom graphic depicts current status and results of 2000 MCMC simulations relative to limit and target reference points.

Appendix 1:

LA Creel/MRIP Calibration Procedure

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10/8/2018

Overview

The Louisiana Department of Wildlife and Fisheries (LDWF) conducts stock assessments on important recreationally and commercially landed species. Time-series of fishery removals are critical components of these stock assessments as they provide the level of depletion of the resource through time. Beginning in 2014, LDWF started its own creel survey (LA Creel) to provide recreational landings estimates for Louisiana-specific fishery management and stock assessment purposes. Prior to 2014 recreational landings estimates were taken from the National Marine Fisheries Service's Marine Recreational Intercept Program and the earlier Marine Recreational Fisheries Statistical Survey (MRIP/MRFSS). The MRIP and LA Creel surveys were conducted simultaneously in 2015 for benchmarking purposes. Methods are now needed to calibrate MRIP landings estimates to LA Creel landings estimates for species with upcoming LDWF stock assessments.

Calibration Methodology

A ratio estimator approach is described below allowing hind-casting of LA Creel recreational harvest estimates to 1982. The calibration procedure to hind-cast LA Creel discard estimates is presented in the Appendix of this document.

Concurrent harvest rate estimates of LA Creel and MRIP are only available for the single year (2015) both surveys were conducted simultaneously. Effort estimates, however, are available from both surveys for multiple years (2015-2017). The reliability of this calibration procedure could be greatly improved with more comparison years of the surveys.

Note: MRIP private fishing effort is distributed across the various fishing modes (shore, inshore, and offshore) by applying the observed distribution of those modes from the dockside survey. In 2016 and 2017, the MRIP effort estimation process required additional estimations, as the dockside portion of that survey was not conducted in Louisiana. NOAA Fisheries applied the proportions of trips by fishing mode observed in 2015 to the effort data collected in 2016 and 2017 to obtain estimates of angler trips by fishing mode. While this method is clearly not optimal, it does allow comparison of effort over additional years.

Abbreviations used in this document:

- E - Fishing effort
- FM - Fishing mode
  - C - charter
  - CI - charter inshore
  - CO - charter offshore
  - P - private
  - PI - private inshore (LA Creel)
  - PO - private offshore
  - PR - private boat (MRIP)
  - SH - shore (MRIP)
- H - Harvest
- HR - Harvest rate
- D - Discards
- DR – Discard rate
- PSE - Percent standard error
- R - Ratio
- V - Variance
- y – Year
- w – Bimonthly period
- wk – Week of year

The LA Creel survey provides estimates for four fishing modes (FM): private inshore (PI), private offshore (PO), charter inshore (CI), and charter offshore (CO). The MRIP survey provides estimates for five fishing modes: private boat (PR), shore (SH), PO, CI, and CO. For calibration purposes, LA Creel estimates are transformed into a fifth fishing mode equivalent to the MRIP surveys SH mode by separating the PI mode into PR and SH modes. Additionally, the inshore/offshore fishing modes of each survey are collapsed into overall private (P) and charter (C) fishing modes for the species included in this report that support predominantly inshore fisheries.

Fishing effort (E) estimates of the two surveys are calibrated separately by collapsed fishing mode (P and SH only) and bimonthly period (w). Because the charter fishing effort frame used by the LA Creel and MRIP surveys are functionally equivalent, charter fishing effort and corresponding variance estimates of the two surveys are assumed equivalent and not adjusted. Harvest rates and corresponding variance estimates of the MRIP and LA Creel surveys for the species included in this report are also assumed equivalent and not adjusted. Calibrated effort estimates of the shore and private fishing modes are then combined with unadjusted MRIP harvest rate estimates to provide time-series of recreational harvest estimates for species with upcoming LDWF stock assessments as described below.

Fishing Effort

To allow hind-casting of LA Creel effort estimates to the historic MRIP effort time-series, fishing effort calibration factors are calculated as the ratio of mean fishing effort (2015-2017) from each survey by fishing mode (P and SH only) and bimonthly period as:

$$\hat{R}_{E,FM,w} = \frac{\bar{E}_{LAcreel,FM,w}}{\bar{E}_{MRIP,FM,w}} \qquad [1]$$

Note: MRIP effort estimates in Equation [1] are based on the FES and APAIS methodologies.

Survey-specific mean fishing effort (angler trips) and calibration factors for the P and SH fishing modes by bimonthly period are presented below.

FM	w	$\bar{E}_{LAcreel}$	$\bar{E}_{MRIP}$	$\hat{R}_E$
P	1	141,988	683,741	0.208
P	2	229,436	539,929	0.425
P	3	425,433	913,075	0.466
P	4	349,345	1,131,685	0.309
P	5	284,077	898,045	0.316
P	6	277,228	865,312	0.320
SH	1	50,377	692,050	0.073
SH	2	80,580	588,099	0.137
SH	3	151,142	865,279	0.175
SH	4	73,203	1,056,573	0.069
SH	5	105,286	1,115,605	0.094
SH	6	64,342	902,530	0.071

The hind-cast LA Creel fishing effort estimates (1982-2013) are then calculated by fishing mode and bimonthly period as:

$$\hat{E}_{y,w,FM,\hat{R}} = \hat{R}_{E,FM,w}\hat{E}_{y,w,FM,MRIP} \quad [2]$$

Note: MRIP effort estimates in Equation [2] have been calibrated to the FES and APAIS design changes (FCAL).

Variances of the hind-cast LA Creel fishing effort estimates from Equation [2] are approximated by fishing mode and bimonthly period as:

$$\hat{V}\left(\hat{E}_{y,w,FM,\hat{R}}\right) = \hat{E}^2_{y,w,FM,MRIP}\hat{V}\left(\hat{R}_{E,FM,w}\right) + \hat{R}^2_{E,FM,w}\hat{V}\left(\hat{E}_{y,w,FM,MRIP}\right) - \hat{V}\left(\hat{R}_{E,FM,w}\right)\hat{V}\left(\hat{E}_{y,w,FM,MRIP}\right) \quad [3]$$

where

$$\hat{V}\left(\hat{R}_{E,FM,w}\right) = \hat{R}_{E,FM,w}{}^2\left[\frac{\hat{V}(\bar{E}_{LAcreel,FM,w})}{\bar{E}_{LAcreel,FM,w}{}^2} + \frac{\hat{V}(\bar{E}_{MRIP,FM,w})}{\bar{E}_{MRIP,FM,w}{}^2} - 2\,\frac{Cov(\bar{E}_{LAcreel,FM,w},\bar{E}_{MRIP,FM,w})}{\bar{E}_{LAcreel,FM,w}\bar{E}_{MRIP,FM,w}}\right]$$

Effort variances $\hat{V}\left(\hat{E}_{y,w,FM,MRIP}\right)$ in Equation [3] are post-calibration (i.e. after applying a mean fishing effort variance ratio estimator $\frac{\hat{V}(\bar{E}_{LAcreel,FM,w})}{\hat{V}(\bar{E}_{MRIP,FM,w})}$ to the MRIP variance estimates).

Harvest

The hind-cast LA Creel harvest estimates (1982-2013) by fishing mode (P and SH only) for the species included in this report are then calculated as:

$$\hat{H}_{y,FM,\hat{R}} = \sum_w \hat{E}_{y,w,FM,\hat{R}}\,\widehat{HR}_{y,w,FM,MRIP} \quad [4]$$

Note: MRIP harvest rate estimates in Equation [4] are FCAL estimates and represent A+ B1 landings only.

Variances of the calibrated harvest estimates are then calculated as:

$$\hat{V}\left(\hat{H}_{y,FM,\hat{R}}\right) = \sum_w \left[\hat{E}_{y,FM,w,\hat{R}}{}^2\hat{V}(\widehat{HR}_{y,FM,w,MRIP}) + \widehat{HR}_{y,FM,w,MRIP}{}^2\hat{V}\left(\hat{E}_{y,FM,w,\hat{R}}\right) - \hat{V}\left(\hat{E}_{y,FM,w,\hat{R}}\right)\hat{V}(\widehat{HR}_{y,FM,w,MRIP})\right] \quad [5]$$

Percent standard errors of the calibrated harvest estimates are then calculated as:

$$PSE\left(\hat{H}_{y,FM,\hat{R}}\right) = 100 \times \frac{\sqrt{\hat{V}\left(\hat{H}_{y,FM,\hat{R}}\right)}}{\hat{H}_{y,FM,\hat{R}}} \quad [6]$$

The MRIP (FCAL) and hind-cast LA Creel harvest estimate time-series and corresponding PSEs by fishing mode for species with upcoming LDWF stock assessments are presented below.

FM = Private

	Black Drum				Red Drum				Sheepshead				Southern Flounder				Spotted Seatrout			
	MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel	
Year	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE
1982	1,106,821	27.1	426,166	31.2	3,046,664	12.0	925,323	21.4	511,387	34.3	184,011	40.4	497,263	19.5	190,801	23.4	9,160,786	16.2	3,111,188	23.8
1983	1,659,509	34.3	595,673	38.8	4,758,470	32.7	1,542,955	41.7	1,064,824	38.1	334,974	43.8	1,929,817	51.4	610,002	58.6	7,402,179	20.0	2,660,990	25.0
1984	362,104	26.0	138,699	29.8	2,976,458	38.9	960,611	40.8	548,364	47.5	176,510	39.5	213,064	23.0	73,394	28.5	2,503,426	29.8	790,913	33.0
1985	356,406	30.0	115,179	34.5	2,563,074	14.5	865,588	21.9	340,142	32.1	114,127	35.8	431,284	24.5	150,115	27.3	5,947,072	15.2	2,109,649	22.2
1986	918,541	24.1	317,533	28.9	2,635,843	10.0	843,830	21.1	252,644	15.5	84,282	23.6	1,464,132	48.5	483,555	47.8	14,077,720	7.8	4,947,892	16.4
1987	683,049	25.6	237,415	30.7	2,602,974	23.0	876,900	30.6	270,702	33.7	87,926	33.0	147,601	25.2	52,016	27.6	11,023,715	10.1	4,035,139	15.6
1988	344,681	15.4	115,234	22.3	1,160,955	20.2	349,965	26.3	277,793	21.3	90,608	28.5	358,099	13.2	123,628	18.1	6,890,452	14.3	2,511,864	21.3
1989	227,336	20.4	76,002	25.3	2,015,801	12.6	676,453	24.5	789,892	49.3	254,087	50.2	341,489	25.9	111,900	29.0	8,082,318	11.9	2,753,203	18.0
1990	231,168	22.9	79,940	26.9	1,469,547	16.8	481,003	25.0	270,726	27.1	104,809	31.1	805,964	23.6	264,106	26.8	4,881,711	13.7	1,640,863	21.0
1991	183,005	19.4	62,265	26.3	1,824,768	20.0	582,125	33.1	402,935	32.6	138,862	35.4	694,466	16.1	248,442	20.6	13,468,560	9.9	4,744,596	18.2
1992	333,217	23.9	119,606	28.4	2,807,145	8.7	936,586	15.5	563,816	25.3	182,360	27.9	615,928	14.6	217,218	17.6	10,680,755	9.3	3,584,240	20.0
1993	246,588	17.6	88,970	24.2	2,581,130	9.9	880,530	16.3	885,380	26.7	320,661	35.5	500,023	14.8	175,907	18.0	7,757,436	12.1	2,655,102	18.2
1994	234,272	16.9	79,717	24.5	2,311,786	9.5	778,462	16.4	508,883	17.8	170,439	24.2	578,264	21.0	216,551	26.3	10,418,883	10.5	3,481,640	17.6
1995	335,507	18.4	109,385	22.1	3,842,177	8.7	1,269,660	19.6	920,809	20.4	274,232	26.3	398,528	14.0	146,807	19.4	12,135,672	13.2	3,937,329	27.0
1996	414,798	12.9	137,386	20.9	3,197,497	9.0	1,120,688	16.0	760,607	21.7	243,914	29.8	416,737	11.4	148,322	15.5	10,306,475	11.3	3,488,899	20.1
1997	477,705	16.1	161,196	20.3	2,861,918	9.6	987,223	16.3	1,005,406	18.2	318,972	22.9	445,579	11.7	155,574	18.2	10,415,118	11.9	3,599,696	17.9
1998	920,933	14.6	311,906	20.5	2,762,600	8.0	955,164	15.1	1,138,280	15.6	358,340	25.5	393,018	13.8	148,318	18.2	10,005,379	8.7	3,578,852	18.8
1999	681,905	11.9	236,111	18.6	3,459,681	6.9	1,208,361	14.4	793,093	16.2	246,697	26.4	758,946	10.4	272,110	16.0	14,037,235	8.5	4,731,081	18.3
2000	1,017,717	12.8	352,152	18.8	4,249,272	6.9	1,474,223	16.0	769,653	28.0	246,219	34.0	670,295	13.3	246,882	18.4	15,977,551	7.7	5,264,946	19.6
2001	765,815	13.7	259,288	20.5	4,322,843	7.7	1,456,752	14.4	567,945	15.8	193,751	22.4	427,914	12.2	155,260	16.0	12,618,114	8.0	4,269,752	15.9
2002	908,616	12.6	315,701	19.5	3,445,574	8.2	1,168,322	15.9	1,249,437	18.7	408,449	30.9	443,758	18.8	173,052	23.0	9,816,916	10.3	3,441,381	16.8
2003	659,209	14.7	229,521	22.3	2,977,090	7.4	1,014,320	17.2	1,257,175	23.2	396,409	28.7	647,034	15.7	250,097	18.7	10,528,223	9.6	3,662,095	20.0
2004	546,776	12.0	183,643	18.3	2,605,118	8.1	898,352	15.2	1,722,589	24.9	586,483	33.7	408,006	12.6	148,846	17.3	9,728,915	10.5	3,334,545	18.8
2005	461,775	13.0	156,509	21.3	2,236,920	9.4	772,472	15.8	962,130	23.6	302,340	30.7	286,521	12.9	108,654	15.8	10,699,116	8.5	3,616,229	17.8
2006	354,910	14.3	117,386	19.2	2,385,907	10.7	812,152	16.3	430,504	25.3	125,365	32.5	285,429	11.9	98,401	15.3	13,779,620	8.7	5,016,008	16.0
2007	415,104	15.7	142,698	18.7	3,049,990	8.3	1,045,909	15.6	320,952	21.9	95,855	25.9	355,606	19.0	123,052	23.8	11,790,003	8.3	3,967,935	18.2
2008	668,820	12.8	224,335	20.6	3,336,041	7.9	1,155,421	14.9	623,988	17.6	205,809	26.8	239,893	10.9	88,186	16.8	15,551,638	9.5	5,347,885	19.1
2009	908,297	13.6	308,638	19.6	3,414,547	8.2	1,187,696	16.4	1,055,358	22.6	315,386	32.0	398,573	14.6	140,011	19.7	15,667,348	8.8	5,452,613	16.8
2010	697,188	14.5	231,949	19.1	5,128,842	8.0	1,797,454	14.5	753,414	22.4	261,214	29.3	571,870	14.4	214,026	18.3	14,465,717	10.7	4,974,270	23.5
2011	679,614	15.1	232,721	20.6	4,548,266	8.3	1,584,573	14.9	1,425,042	35.5	525,042	44.9	544,173	14.7	198,755	17.6	17,697,003	9.6	5,977,076	18.1
2012	694,257	12.8	241,481	18.1	3,458,029	8.8	1,210,182	15.5	577,843	16.7	175,722	24.4	524,259	14.8	184,915	17.5	17,938,248	8.9	6,201,433	19.0
2013	528,084	14.3	172,534	20.4	4,523,043	8.7	1,512,033	15.4	311,155	16.9	95,381	24.0	930,394	13.1	317,618	25.0	12,928,606	9.4	4,374,563	17.4

FM = Shore

	Black Drum				Red Drum				Sheepshead				Southern Flounder				Spotted Seatrout			
	MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel	
Year	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE	Harvest	PSE
1982	880,444	22.8	113,540	38.2	2,388,907	23.1	293,698	36.1	676,628	29.0	66,012	30.5	834,940	21.4	103,180	36.3	2,787,818	23.5	296,866	35.0
1983	500,922	29.9	62,566	38.0	1,351,640	25.0	123,385	34.4	2,326,172	25.9	276,981	40.7	327,205	34.7	31,100	37.4	2,927,094	47.2	258,452	45.3
1984	536,866	34.1	51,163	46.2	660,866	35.0	57,459	34.8	987,229	41.9	85,083	40.5	112,657	45.9	9,755	45.9	331,308	40.5	32,117	42.3
1985	181,986	27.0	16,397	32.7	618,693	30.8	46,417	33.4	656,976	30.2	51,856	35.9	284,046	29.1	23,081	33.1	500,629	27.9	43,400	33.5
1986	469,638	52.0	39,289	48.9	243,647	45.9	18,934	47.8	782,112	81.2	57,566	79.5	189,325	42.5	18,019	48.7	1,815,727	55.4	142,905	52.4
1987	260,971	52.0	26,358	51.9	665,407	54.3	49,467	55.0	65,880	46.2	4,878	52.4	185,090	37.3	14,954	38.7	965,130	44.3	112,992	58.7
1988	429,974	36.6	48,607	46.1	237,418	45.6	18,170	48.4	662,260	57.5	57,664	53.5	90,283	40.5	8,305	40.6	398,803	39.6	41,221	48.1
1989	484,955	58.2	47,183	67.1	472,062	35.4	45,444	43.7	179,471	40.2	16,156	43.5	127,388	33.6	12,077	38.8	402,794	68.4	30,056	67.0
1990	122,352	47.4	15,821	63.4	627,617	29.6	54,607	36.3	80,673	46.7	7,631	52.3	238,834	24.9	22,144	31.2	1,178,966	28.6	120,340	42.6
1991	80,287	38.8	7,830	45.0	497,827	35.7	39,572	39.7	109,726	43.1	8,166	45.0	617,776	26.6	69,562	37.3	1,611,329	29.8	190,451	48.5
1992	266,722	39.0	24,559	43.7	535,731	21.7	57,486	31.8	1,470,811	61.9	111,109	64.6	197,948	31.2	17,703	32.4	1,622,752	18.8	160,534	25.9
1993	332,409	38.4	32,083	46.0	1,058,829	26.2	102,231	30.1	438,233	37.3	34,539	38.3	152,286	34.8	14,994	35.2	1,262,891	19.3	139,848	32.3
1994	111,090	26.4	12,000	35.3	973,065	30.5	86,198	33.8	339,821	55.8	27,751	51.7	245,182	26.2	26,246	30.4	2,585,733	32.7	225,016	34.0
1995	122,762	40.4	10,791	37.0	747,219	23.9	61,587	28.3	338,135	43.2	33,177	41.4	56,558	30.7	5,970	40.2	1,432,447	21.4	141,769	30.2
1996	529,054	58.3	42,278	55.7	864,227	22.6	85,059	27.2	682,583	41.1	54,497	42.0	134,402	31.1	14,417	42.1	2,327,551	27.4	272,968	42.0
1997	123,564	39.8	14,500	55.8	347,632	21.5	33,897	27.2	283,171	25.4	28,012	31.1	307,330	23.1	31,614	33.0	1,905,584	21.5	196,046	32.0
1998	86,575	34.3	11,850	53.2	397,083	31.2	39,546	33.4	450,254	36.2	34,658	37.6	128,645	26.4	15,533	39.9	2,415,887	30.1	316,704	52.1
1999	385,329	39.6	34,484	42.0	492,350	25.7	58,215	38.6	202,445	35.8	17,647	34.4	641,276	32.9	57,671	36.5	3,530,688	27.9	302,816	33.9
2000	625,217	26.3	55,444	30.4	822,698	21.3	74,515	25.1	202,744	52.7	18,710	49.9	136,953	43.0	13,647	44.9	2,697,901	36.0	235,416	36.6
2001	675,474	30.1	74,021	37.8	621,324	23.2	56,647	29.7	399,908	49.4	46,027	53.6	305,296	67.4	40,328	72.5	2,657,545	28.5	284,780	35.3
2002	399,178	23.6	39,488	28.7	945,520	31.8	86,759	37.0	872,663	35.4	77,666	40.1	323,826	31.2	35,596	40.3	923,988	31.5	104,622	40.0
2003	288,546	23.4	29,030	28.5	280,366	33.2	26,439	34.2	983,844	36.8	108,655	37.5	199,400	38.3	17,629	37.0	945,730	42.3	70,559	43.3
2004	137,240	36.0	13,664	36.9	559,991	19.0	53,877	26.8	603,693	36.9	49,237	39.0	395,552	36.1	39,848	47.2	1,303,971	45.1	186,126	62.8
2005	138,758	28.0	13,443	36.2	704,981	30.9	57,698	36.6	563,322	29.6	52,206	36.7	450,207	38.7	35,117	45.5	632,798	30.7	54,561	34.2
2006	261,544	30.8	25,308	39.5	389,280	25.4	35,566	35.1	593,305	31.2	44,987	35.3	335,766	29.1	34,011	31.9	788,193	22.7	75,533	29.7
2007	286,213	35.5	28,210	37.6	187,726	25.1	17,832	35.4	257,091	36.2	27,901	42.7	348,752	28.0	38,995	36.9	771,812	27.5	84,196	35.4
2008	247,234	25.5	22,539	32.8	374,463	27.9	30,507	30.4	1,396,084	30.3	113,710	33.3	260,865	36.4	23,363	33.9	1,140,758	33.3	131,023	47.6
2009	100,842	26.9	10,221	33.5	123,122	28.0	12,120	33.8	523,105	46.9	62,220	56.4	470,681	44.6	39,588	45.3	611,298	25.2	62,519	33.2
2010	184,668	41.2	16,865	42.9	531,708	32.4	50,704	34.5	561,648	40.1	46,001	39.1	94,348	29.4	8,854	31.9	584,064	43.3	45,383	43.2
2011	380,669	21.7	36,537	27.0	983,461	22.1	96,717	27.3	1,318,064	44.8	124,632	55.1	430,717	40.0	39,973	40.9	651,281	27.8	67,792	37.1
2012	283,508	22.6	26,638	30.9	279,299	36.1	23,109	38.3	695,553	42.6	54,144	43.8	155,170	30.6	15,176	33.3	727,577	29.5	80,824	39.4
2013	471,823	13.0	36,871	21.6	849,762	9.3	80,731	27.2	659,450	12.4	48,095	25.1	573,922	18.3	51,029	30.3	2,682,372	11.4	241,359	21.8

Appendix (Discard Hindcast):

A ratio estimator approach is described below allowing hind-casting of LA Creel recreational discard estimates to 1982. Concurrent discard estimates of the LA Creel and MRIP surveys are not available.

Analogous to the procedure to hind-cast LA Creel harvest estimates, the hind-cast LA Creel effort estimates of the shore and private fishing modes are combined with unadjusted MRIP discard rate estimates to provide time-series of recreational discard estimates for species with upcoming LDWF stock assessments as described below. Discard estimates of the charter fishing mode for the LA Creel and MRIP surveys are assumed equivalent and not adjusted.

Discards (1982-2013)

The hind-cast LA Creel discard estimates (1982-2013) are calculated by collapsed fishing mode (P and SH only) and bimonthly period as:

$$\hat{D}_{y,FM,\hat{R}} = \sum_{w} \hat{E}_{y,w,FM,\hat{R}} \, \widehat{DR}_{y,w,FM,MRIP} \quad [1a]$$

Note: MRIP discard rate estimates in Equation [1a] are FCAL estimates and represent B2 landings only. The calibrated effort estimates are taken from Equation [2].

Variances of the calibrated discard estimates from Equation [1a] are then calculated as:

$$\hat{V}\left(\hat{D}_{y,FM,\hat{R}}\right) = \sum_{w}\left[\hat{E}_{y,FM,w,\hat{R}}^{\;2}\hat{V}(\widehat{DR}_{y,FM,w,MRIP}) + \widehat{DR}_{y,FM,w,MRIP}^{\;2}\hat{V}\left(\hat{E}_{y,FM,w,\hat{R}}\right) - \hat{V}\left(\hat{E}_{y,FM,w,\hat{R}}\right)\hat{V}(\widehat{DR}_{y,FM,w,MRIP})\right] \quad [2a]$$

Percent standard errors of the calibrated discard estimates are then calculated as:

$$PSE\left(\hat{D}_{y,FM,\hat{R}}\right) = 100 \times \frac{\sqrt{\hat{V}\left(\hat{D}_{y,FM,\hat{R}}\right)}}{\hat{D}_{y,FM,\hat{R}}} \quad [3a]$$

Discards (2014-2016)

Discard estimates of the LA Creel survey are only available from week 19 of 2016 to present. Discard estimates prior to week 19 of 2016 are imputed by fishing mode (P, SH, and C) and week of year (wk) by calculating discard to harvest ratios from the LA Creel estimates from week 19 of 2016 to week 18 of 2017 as:

$$\hat{R}_{D/H,FM,wk} = \frac{\hat{D}_{LAcreel,FM,wk}}{\hat{H}_{LAcreel,FM,wk}} \quad [4a]$$

The imputed LA Creel discard estimates are then calculated by fishing mode from week 1 of 2014 to week 18 of 2016 as:

$$\hat{D}_{y,wk,FM,\hat{R}_{D/H}} = \hat{R}_{D/H,FM,wk}\hat{H}_{y,wk,FM,LAcreel} \quad [5a]$$

Variances of the imputed LA Creel discard estimates from Equation [5a] are approximated by fishing mode and week of year as:

$$\hat{V}\left(\hat{D}_{y,wk,FM,\hat{R}_{D/H}}\right) = \hat{H}^2_{y,wk,FM,LAcreel}\hat{V}\left(\hat{R}_{D/H,FM,wk}\right) + \hat{R}^2_{D/H,FM,wk}\hat{V}\left(\hat{H}_{y,wk,FM,LAcreel}\right) - \hat{V}\left(\hat{R}_{D/H,FM,wk}\right)\hat{V}\left(\hat{H}_{y,wk,FM,LAcreel}\right) \quad [6a]$$

where

$$\hat{V}\left(\hat{R}_{D/H,FM,wk}\right) = \hat{R}_{D/H,FM,wk}{}^2\left[\frac{\hat{V}(\hat{D}_{LAcreel,FM,wk})}{\hat{D}_{LAcreel,FM,wk}{}^2} + \frac{\hat{V}(\hat{H}_{LAcreel,FM,wk})}{\hat{H}_{LAcreel,FM,wk}{}^2}\right]$$

Harvest variances $\hat{V}\left(\hat{H}_{y,wk,FM,LAcreel}\right)$ in Equation [6a] are post-calibration (i.e. after applying a discard to harvest variance ratio estimator $\frac{\hat{V}(\hat{D}_{LAcreel,FM,wk})}{\hat{V}(\hat{H}_{LAcreel,FM,wk})}$ to the LA Creel harvest variance estimates).

The MRIP (FCAL) and hind-cast/imputed LA Creel discard estimate annual time-series and corresponding PSEs by fishing mode for species with upcoming LDWF stock assessments are presented below.

FM = Private

	Black Drum				Red Drum				Sheepshead				Southern Flounder				Spotted Seatrout			
	MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel	
Year	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE
1982	818,734	54.5	345,860	60.5	274,870	40.0	94,664	41.5	515,459	44.8	200,681	47.1	1,083,668	45.5	415,439	50.2	1,654,868	35.7	609,681	39.2
1983	671,251	47.1	224,549	50.1	793,805	34.3	265,412	40.0	833,079	71.7	268,324	76.4	145,644	54.4	50,553	55.2	2,092,864	42.4	754,795	47.4
1984	284,254	68.2	93,240	65.6	346,317	56.3	111,489	56.2	309,986	35.6	93,467	45.2	65,411	64.9	21,520	65.9	197,040	21.8	64,439	30.9
1985	291,106	38.5	95,314	41.4	243,413	40.1	91,863	46.5	317,951	28.8	109,302	37.0	61,785	68.0	19,987	66.6	1,709,137	23.1	579,765	29.5
1986	448,236	20.4	152,135	27.7	451,777	15.3	162,385	19.5	393,569	19.8	127,427	29.5	367,830	40.1	162,331	43.1	4,745,760	10.2	1,630,190	19.8
1987	300,153	41.9	93,694	44.6	2,360,122	24.5	759,753	32.9	210,127	21.2	74,868	25.8	10,809	42.4	4,341	46.5	6,980,249	12.7	2,367,280	21.1
1988	350,541	21.1	118,251	29.1	3,062,822	16.2	1,010,542	22.4	398,058	25.6	135,054	32.6	375,399	58.9	119,109	60.9	5,610,284	10.4	2,077,053	16.1
1989	228,012	35.0	75,276	40.5	2,998,273	20.9	986,135	30.8	483,464	37.6	174,497	44.9	260,401	93.8	84,574	91.5	5,656,036	14.2	1,879,166	20.3
1990	653,511	28.7	214,860	36.2	1,880,922	19.7	575,989	24.4	408,363	25.1	146,133	30.3	334,821	40.3	107,726	42.4	4,750,794	18.0	1,566,570	24.0
1991	389,398	26.0	130,884	32.2	7,412,013	11.2	2,413,187	27.7	272,267	26.1	100,654	28.7	114,636	37.5	35,343	33.6	12,341,402	9.3	4,316,171	17.6
1992	559,417	33.2	179,758	38.0	5,753,237	9.1	1,845,345	17.5	440,289	16.8	142,247	23.5	42,988	21.4	14,876	24.2	8,795,484	8.4	2,994,762	16.4
1993	710,873	18.2	235,327	23.6	4,143,002	11.2	1,394,760	19.0	758,778	20.8	261,093	28.4	45,686	33.2	16,234	35.7	6,905,906	11.3	2,294,599	17.5
1994	440,825	29.8	144,491	33.2	4,086,816	12.5	1,292,596	19.6	608,190	19.3	200,928	25.0	34,050	29.6	11,832	31.0	7,780,829	9.7	2,545,253	17.4
1995	816,070	17.5	288,067	20.8	4,248,542	15.4	1,356,682	22.3	558,424	25.6	180,589	31.0	59,357	34.4	21,731	33.3	7,603,172	11.0	2,469,940	22.8
1996	525,560	20.4	180,919	27.4	3,312,106	11.9	1,066,067	18.3	878,282	23.1	280,982	30.9	80,897	23.0	28,339	27.1	8,055,743	10.2	2,790,011	17.6
1997	1,057,203	18.5	357,381	27.0	5,150,476	11.3	1,623,792	20.9	1,138,193	23.4	388,364	33.4	98,494	29.1	33,249	32.9	10,917,063	19.7	3,714,497	25.0
1998	1,439,547	24.7	488,061	28.2	5,753,271	10.8	1,852,465	18.5	1,056,926	17.9	341,063	28.4	99,007	29.1	32,096	32.3	9,977,400	9.3	3,525,435	17.2
1999	820,371	13.6	272,222	19.4	5,477,613	9.4	1,855,481	17.3	699,825	18.9	218,048	29.4	84,447	20.8	29,392	26.0	11,688,515	8.8	3,900,534	18.2
2000	1,833,450	16.2	636,903	21.0	6,018,948	8.2	2,015,680	18.4	586,993	21.9	204,594	28.9	121,790	28.3	37,513	29.7	11,091,619	7.9	3,696,143	17.1
2001	1,781,293	17.4	641,432	22.0	6,184,966	9.5	1,893,106	18.7	816,650	16.4	289,672	22.4	88,936	21.8	33,827	26.2	7,365,829	11.2	2,385,033	19.6
2002	1,670,431	17.1	549,754	23.8	6,266,166	10.8	2,051,328	21.1	854,311	17.0	278,770	22.5	90,982	26.1	32,596	28.9	6,778,238	11.5	2,325,982	18.2
2003	1,172,837	17.8	408,312	22.5	5,286,909	10.2	1,707,282	22.5	930,576	20.8	286,148	31.2	172,327	23.4	67,664	27.1	10,682,302	9.5	3,656,768	20.8
2004	1,155,649	17.0	384,622	24.5	3,841,642	10.1	1,251,295	17.5	701,938	19.9	253,961	27.9	149,844	27.6	53,175	29.8	9,847,326	11.5	3,329,014	17.7
2005	954,552	24.2	324,774	29.3	3,505,968	11.8	1,125,035	19.3	770,173	15.0	252,100	25.9	87,557	25.3	31,613	26.7	10,903,988	9.7	3,699,324	17.6
2006	699,933	16.3	227,542	20.8	4,124,647	11.7	1,352,670	19.7	616,668	30.1	179,470	34.3	41,784	27.7	14,147	30.4	11,930,250	9.1	4,253,200	16.1
2007	818,643	15.4	279,976	19.3	4,630,404	11.5	1,534,744	20.7	308,039	21.2	101,638	25.6	78,231	25.8	28,165	30.1	9,924,934	8.4	3,345,776	18.0
2008	1,320,182	14.8	447,658	22.4	5,074,358	8.1	1,704,655	15.5	609,401	23.6	193,005	30.6	50,063	26.0	17,325	28.4	13,158,192	9.4	4,628,268	17.0
2009	1,788,575	14.5	598,396	22.8	6,242,208	9.6	2,046,201	20.1	744,464	19.5	224,182	27.5	89,961	28.4	32,910	34.0	13,919,234	10.0	4,655,798	17.8
2010	1,813,254	14.9	636,963	18.6	7,335,948	10.2	2,585,291	15.8	711,836	21.9	248,894	26.2	111,912	23.5	40,129	23.3	9,190,616	12.6	3,180,901	22.2
2011	1,390,360	14.9	475,469	19.2	4,744,947	9.7	1,532,673	16.4	259,735	17.7	86,064	22.2	85,027	24.1	31,745	26.9	10,091,732	9.5	3,443,856	16.2
2012	1,136,427	13.3	373,501	18.6	5,374,152	8.9	1,776,461	17.9	422,968	13.4	136,234	19.8	152,363	24.3	53,417	25.2	13,175,745	8.7	4,524,702	18.2
2013	1,709,164	12.2	586,398	18.1	6,088,863	9.9	2,013,792	17.0	398,767	14.8	130,785	21.7	197,844	21.3	72,578	23.8	13,404,945	10.3	4,608,071	16.5
2014			330,955	24.0			1,609,006	11.8			148,454	38.3			44,345	56.6			2,316,191	11.3
2015			295,893	21.4			1,486,227	10.3			98,800	30.3			30,296	41.4			3,440,509	12.3
2016			161,733	21.0			1,096,370	6.4			47,135	25.6			29,612	24.3			3,643,636	8.6

FM = Shore

Year	Black Drum				Red Drum				Sheepshead				Southern Flounder				Spotted Seatrout			
	MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel	
	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE
1982	149,995	64.4	19,897	80.7	364,343	26.2	52,316	41.6	89,674	57.7	11,246	70.6	128,975	30.5	15,915	45.2	386,524	48.1	49,802	62.2
1983	69,276	40.0	6,493	59.5	15,283	79.9	1,470	73.4	25,959	61.6	2,914	58.8					7,794	83.8	1,361	89.1
1984	285,887	32.0	20,494	39.5	83,103	84.6	5,758	89.8	12,248	103.2	2,139	105.1	3,384	99.3	319	100.5	59,529	52.1	4,864	50.1
1985	138,851	42.9	12,304	55.2	32,336	53.0	2,919	51.6	155,985	38.0	11,628	41.9	12,292	79.8	881	80.3	603,943	44.5	47,922	44.9
1986	107,212	49.6	7,822	51.3	19,379	65.3	1,723	60.3	473,615	72.5	34,777	72.6	11,853	75.8	1,010	78.1	267,044	41.3	22,713	38.7
1987	102,949	71.9	8,596	74.4	352,180	47.9	26,897	48.2	36,133	89.7	3,410	94.8	13,517	87.5	1,198	89.8	642,898	37.9	64,120	42.0
1988	185,774	51.5	16,072	60.9	329,574	30.8	28,447	35.6	116,937	36.7	10,973	40.9	7,726	52.0	616	56.8	205,385	41.4	24,387	50.9
1989	61,484	38.9	5,723	46.1	1,080,247	72.5	128,194	83.5	115,300	39.3	11,720	45.4	49,549	66.9	3,586	66.6	311,869	36.9	27,571	40.1
1990	96,587	44.0	13,477	59.9	327,612	37.7	28,235	45.2	18,485	89.3	1,318	92.6	783,955	82.6	72,564	86.6	736,838	34.5	65,803	38.9
1991	237,878	30.6	24,906	36.8	1,544,560	43.0	124,239	43.5	207,958	30.7	14,829	39.1	91,471	44.6	10,241	47.2	1,902,261	22.7	219,559	37.7
1992	860,902	31.0	76,139	32.3	1,833,394	25.8	167,249	28.7	514,453	32.0	41,930	37.4	49,674	57.6	4,587	56.0	1,468,815	20.7	142,809	28.3
1993	1,345,395	39.9	110,604	41.5	1,630,396	23.1	171,511	31.8	1,109,224	51.0	86,564	51.4	51,220	62.5	3,860	64.5	2,544,151	26.7	323,743	45.9
1994	947,564	31.5	99,539	33.8	2,220,435	25.8	190,194	29.9	690,548	35.8	54,745	36.3	27,765	64.3	2,143	65.9	2,280,973	19.3	214,069	27.3
1995	602,888	40.5	48,383	40.0	942,643	25.9	86,408	28.5	72,571	30.1	8,839	38.7	18,216	63.3	1,309	62.8	1,617,673	19.6	162,345	29.9
1996	493,436	28.1	52,883	32.7	1,516,179	39.1	120,897	39.3	295,818	49.5	24,464	47.5	123,621	57.8	16,558	74.1	2,271,614	31.3	308,086	52.8
1997	1,032,761	51.8	90,230	49.3	1,179,933	27.3	100,418	31.4	199,864	33.2	17,257	35.4	71,388	41.3	8,442	48.4	2,076,029	22.6	207,557	32.1
1998	1,033,214	43.8	84,752	44.3	2,262,074	26.0	204,593	31.1	207,500	34.3	20,284	40.9	39,280	40.3	3,276	42.0	1,721,873	25.1	220,941	47.8
1999	532,125	37.2	45,165	42.1	1,281,413	23.5	130,179	31.6	51,091	32.2	4,474	39.5	68,459	49.6	7,292	57.3	4,103,241	23.1	371,893	29.8
2000	955,854	28.8	73,538	36.4	1,948,980	22.8	182,824	29.6	265,642	61.1	21,463	56.0	24,518	50.4	2,069	53.3	2,552,559	34.6	207,540	35.3
2001	1,404,055	37.8	143,215	44.1	1,702,671	23.4	159,705	28.0	627,865	66.9	49,516	64.4	267,359	75.6	37,792	76.1	2,252,160	31.5	187,174	32.3
2002	559,039	30.6	45,914	33.0	1,187,635	24.6	99,572	27.3	192,094	28.9	16,154	33.4	132,712	47.7	11,419	48.6	1,035,758	30.9	94,081	34.7
2003	1,024,308	33.3	104,601	38.7	744,196	31.1	73,392	36.7	114,932	46.8	11,660	47.4	299,436	63.4	31,155	65.2	1,546,106	34.1	119,188	35.8
2004	477,328	44.0	37,608	44.0	944,587	31.1	83,721	31.6	83,683	37.1	9,645	45.2	24,033	55.8	1,683	59.3	1,547,223	44.2	179,206	58.2
2005	793,236	24.4	78,009	30.6	1,986,884	22.7	197,746	37.7	322,768	29.1	27,129	33.4	127,575	57.7	10,772	59.1	895,780	34.2	88,581	36.9
2006	1,085,517	44.4	94,206	40.6	2,355,407	21.3	246,212	35.5	670,528	47.6	51,507	48.7	109,904	38.3	14,722	53.3	1,144,271	28.0	114,481	33.4
2007	464,018	30.3	53,814	41.9	1,109,367	20.9	108,758	29.6	256,654	49.1	23,186	43.8	96,680	53.7	16,221	68.5	929,550	25.0	101,536	36.6
2008	901,587	24.4	79,859	28.4	1,912,635	19.8	158,866	23.6	248,799	29.8	18,285	34.4	12,748	60.9	1,302	65.4	1,377,270	27.7	120,320	31.0
2009	417,567	31.0	39,805	30.9	1,414,008	28.6	126,475	32.2	384,706	30.4	37,443	32.7	87,082	93.5	6,332	93.7	927,737	30.0	109,736	43.9
2010	572,004	29.7	56,545	30.2	1,506,818	23.6	154,439	35.8	583,189	30.2	46,495	32.6	74,678	40.5	7,726	48.6	828,375	54.9	63,464	53.8
2011	1,434,105	21.3	134,468	28.0	1,860,121	22.2	162,394	25.3	249,435	48.1	22,119	43.9	103,717	65.2	7,384	66.2	719,286	25.7	64,218	31.8
2012	1,263,476	24.4	132,282	31.2	977,186	35.2	90,057	34.4	175,964	43.2	13,443	45.1	52,159	45.4	6,074	56.4	674,174	31.1	75,140	37.8
2013	2,271,755	9.7	195,413	19.6	3,675,890	9.3	327,093	18.3	939,354	18.9	77,379	32.1	41,427	37.2	3,162	40.7	5,525,367	8.1	504,444	24.1
2014			79,920	38.8			375,249	12.4			51,901	55.7			9,346	53.3			594,294	15.1
2015			76,780	21.4			378,245	11.5			23,835	34.1			9,300	45.9			727,719	12.3
2016			50,106	21.9			275,986	8.7			24,951	66.9			9,495	37.5			892,875	11.4

FM = Charter																				
	Black Drum				**Red Drum**				**Sheepshead**				**Southern Flounder**				**Spotted Seatrout**			
	MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel	
Year	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE	Discards	PSE
1982																	7,252	32.4		
1983													352	57.8			121,816	54.1		
1984	182	112.8							1,166	78.8							116	101.5		
1985									587	107.7							42,739	26.9		
1986					25	55.4			266	97.1							16,514	42.5		
1987	2,752	45.9			2,597	42.5			2,484	64.6							64,522	30.1		
1988	5	106.1			1,561	59.4											59,254	37.7		
1989	298	63.1			26,854	45.6			1,199	62.5			1,401	106.9			190,285	38.2		
1990	6,449	56.2			30,305	40.5			16,177	94.7			445	57.1			39,578	32.1		
1991	3,258	52.2			46,366	44.7			1,641	52.5			280	82.8			144,689	30.9		
1992	7,421	46.7			63,966	35.7			3,664	55.2			225	61.5			91,373	31.5		
1993	410	71.7			58,230	19.2											155,919	30.0		
1994	329	100.1			70,705	32.6			1,123	61.4							243,186	36.3		
1995	2,606	72.8			198,687	34.0			1,654	110.7							300,673	31.6		
1996	4,776	74.9			113,101	28.6			406	56.1			843	103.1			223,999	36.0		
1997	20,581	37.1			157,816	23.0			19,422	46.2			490	68.4			260,983	23.5		
1998	18,161	43.4			138,650	25.5			8,030	44.8			647	48.0			199,955	31.8		
1999	12,980	33.2			105,462	22.3			5,944	40.9			520	57.8			277,771	21.3		
2000	10,335	28.4			108,340	13.2			1,739	48.3			259	59.4			175,694	15.8		
2001	13,566	28.8			203,577	19.3			12,615	31.6			1,224	72.4			211,516	15.0		
2002	9,657	30.9			138,601	17.2			4,954	29.6			1,248	50.0			104,977	25.3		
2003	25,831	34.0			129,125	18.5			16,306	53.2			982	53.9			170,658	26.6		
2004	13,050	32.7			105,936	14.2			10,370	38.8			503	55.6			221,275	16.5		
2005	5,692	45.0			53,333	25.0			3,190	61.4							263,044	26.2		
2006	30,916	38.8			144,300	48.0			10,206	71.3							464,015	26.8		
2007	13,350	37.3			178,892	21.5			23,101	34.4			486	60.6			238,335	19.0		
2008	31,830	33.1			198,411	16.5			30,031	55.1			1,197	59.3			323,315	17.3		
2009	62,094	27.2			332,961	19.7			16,588	52.9			98	71.3			356,216	17.4		
2010	38,261	33.5			151,250	23.0			10,938	36.4			69	107.9			167,473	21.6		
2011	29,517	38.0			203,917	17.0			5,021	34.4			640	62.2			149,933	27.4		
2012	21,344	30.0			153,584	17.6			5,844	46.6			2,353	48.7			205,441	22.7		
2013	83,501	7.5			281,131	7.2			48,342	11.3			12,017	15.1			222,879	7.6		
2014			14,093	31.5			353,243	19.2			2,706	40.6			442	53.7			316,892	29.4
2015			14,464	32.7			403,525	14.1			16,575	50.0			553	46.7			413,119	18.4
2016			16,975	33.3			338,910	7.4			10,778	23.1			497	31.4			439,247	9.6

Appendix 2:

LSU Southern Flounder (*Paralichthys lethostigma)* Biological Parameter Appendix

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Size and Age at Maturity

Length and age at maturity were estimated for female southern flounder caught between September 2018 and January 2019 in Louisiana waters. The probability of a fish being mature was developed using a logistic regression with maturity based on the most advanced oocyte stage from histological samples. Cortical alveoli (or later) stage oocytes were assigned as mature, while fish exhibiting only primary growth were assigned immature.

Table 1. Length-at-maturity parameter estimates for fish sizes in inches and millimeters (total length; TL). Note that the same individual fish were used for both estimates. L_{50} is a ratio of the parameters and is interpreted as the size at which 50% of the population is expected to be mature. The value in the cell is the estimated parameter, with the standard error following in parentheses.

Measurement	α (intercept)	β (slope)	L_{50}[1]
Inches	-12.83201 (2.807)	0.9198007 (0.203)	13.951
Millimeters	-12.83201 (2.806)	0.03621262 (0.008)	354.352

Table 2. Age-at-maturity parameter estimates for fish using year-class ages (integer-ages). A_{50} is a ratio of the parameters and is interpreted as the age at which 50% of the population is expected to be mature. The value in the cell is the estimated parameter, with the standard error following in parentheses.

Measurement	α (intercept)	β (slope)	A_{50}
Years	-3.064 (0.611)	1.727 (0.363)	1.774

[1] Note that both L_{50} and A_{50} are not directly estimated parameters, but ratios of other parameters. Estimating any variance on the ratio of two parameters is not straightforward, but we can generate ratio uncertainty if needed.

Size at Age

Length at age was estimated separately for male and female southern flounder caught between 2002 and 2019 in Louisiana waters. Length was measured as total length (TL), and ages were estimated from otolith sections that were prepared in accordance with LDWF protocols. Length at age was then estimated using the von Bertalanffy growth equation.

Table 3. Length-at-age parameter estimates by sex and measurement (inches and millimeters total length). The value in the cell is the estimated parameter, with the standard deviation following in parentheses. All parameters are estimated from a bon Bertalanffy equation.

Sex and Measurement	L_∞	K	t_0
Female (mm)	503.92 (7.04)	0.453 (0.026)	-1.11 (0.08)
Male (mm)	441.03 (29.63)	0.312 (0.064)	-2.06 (0.33)
Female (inches)	19.96 (0.33)	0.443 (0.029)	-1.14 (0.09)
Male (inches)	17.38 (1.19)	0.312 (0.069)	-2.07 (0.35)

Figures

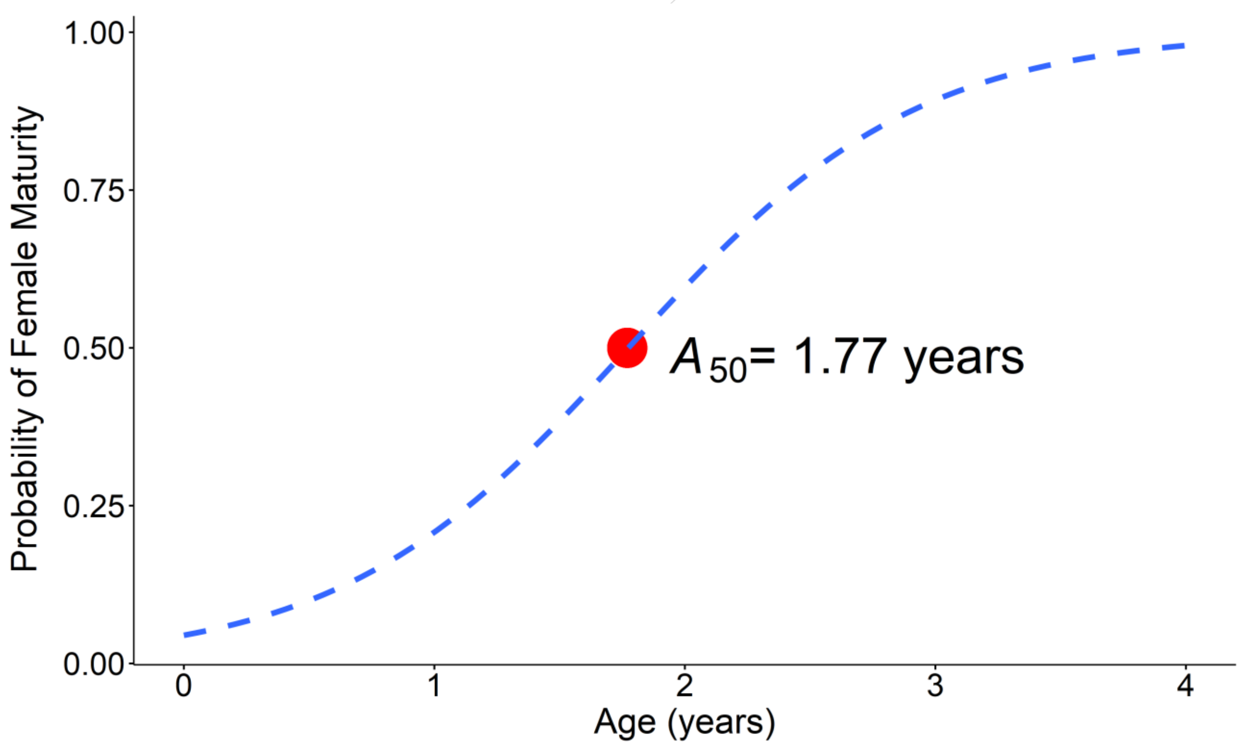


Figure 1. Probability of maturity for female southern flounder as a function of age class based

on Louisiana southern flounder caught between September 2018 and January 2019 (*n* = 89). The dotted blue line represents the population-level estimate using a generalized linear model and each black dot is an individual fish. The red dot and text indicate the parameter of interest, which was the length at which 50% of females are mature (A_{50}), where A_{50} = 1.77 years.

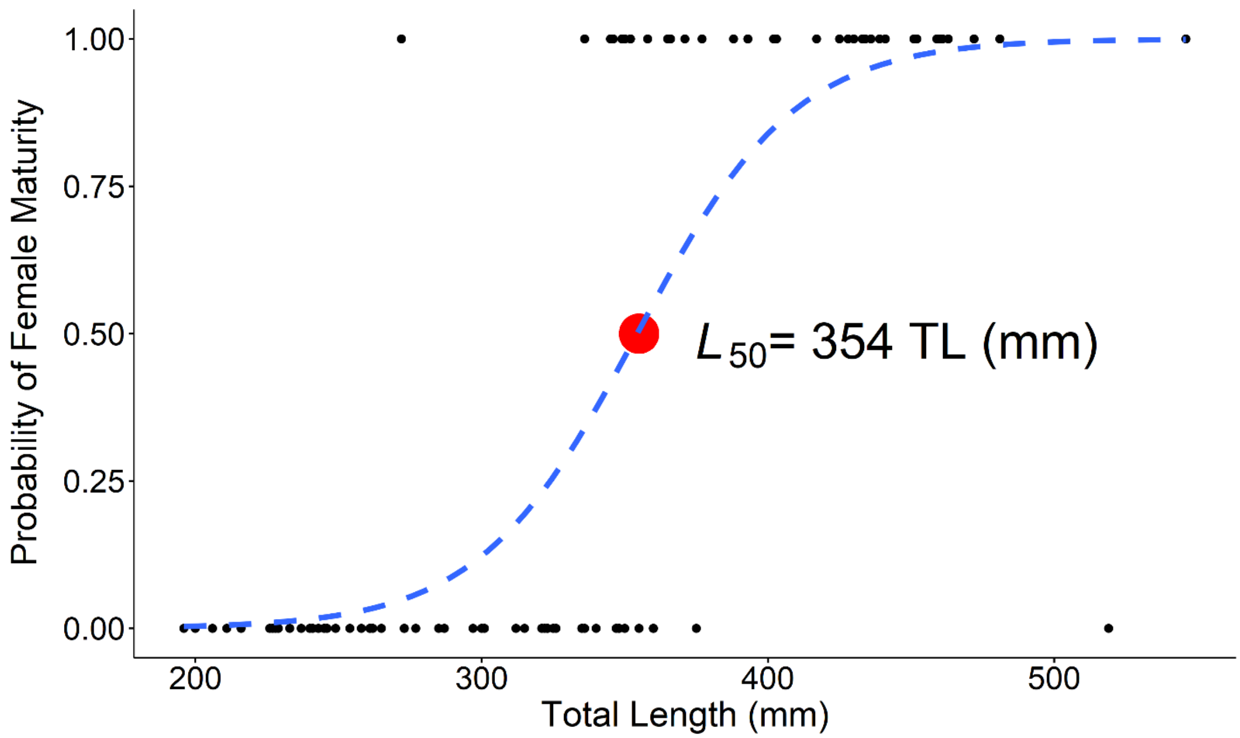


Figure 2. Probability of maturity for female southern flounder as a function of total length (mm) based on Louisiana southern flounder caught between September 2018 and January 2019 (*n* = 89). The dotted blue line represents the population-level estimate using a generalized linear model and each black dot is an individual fish. The red dot and text indicate the parameter of interest, which was the length at which 50% of females are mature (L_{50}), where L_{50} = 354 mm.

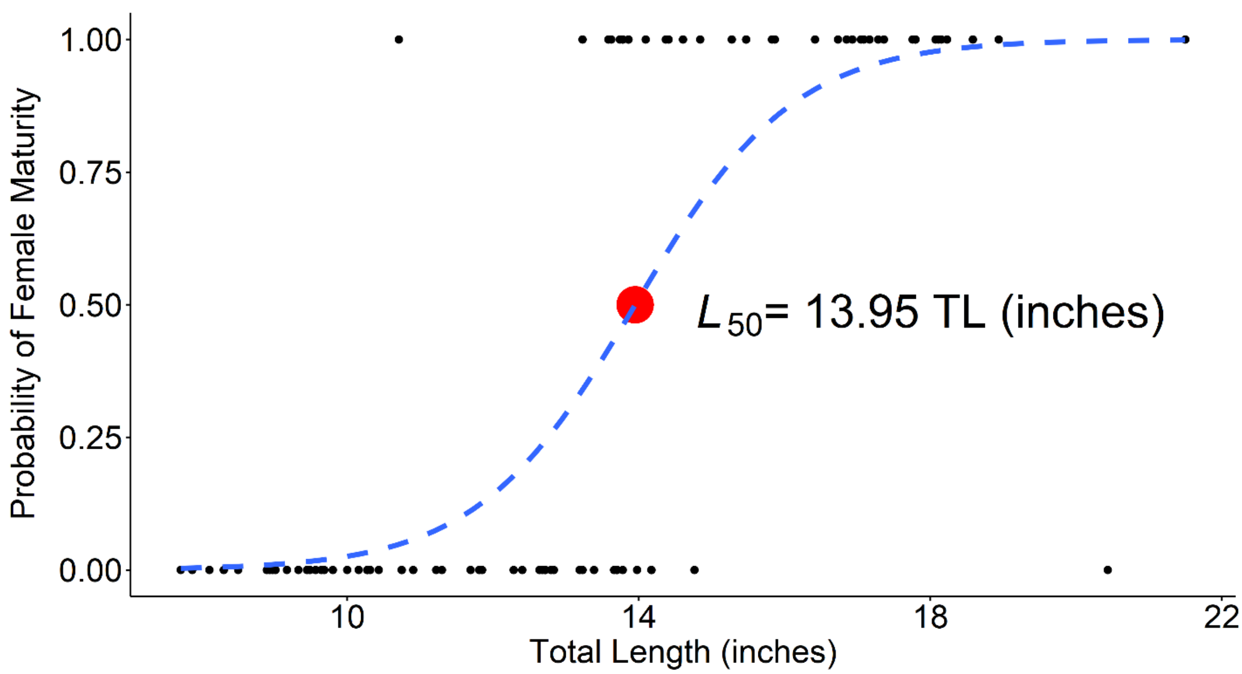
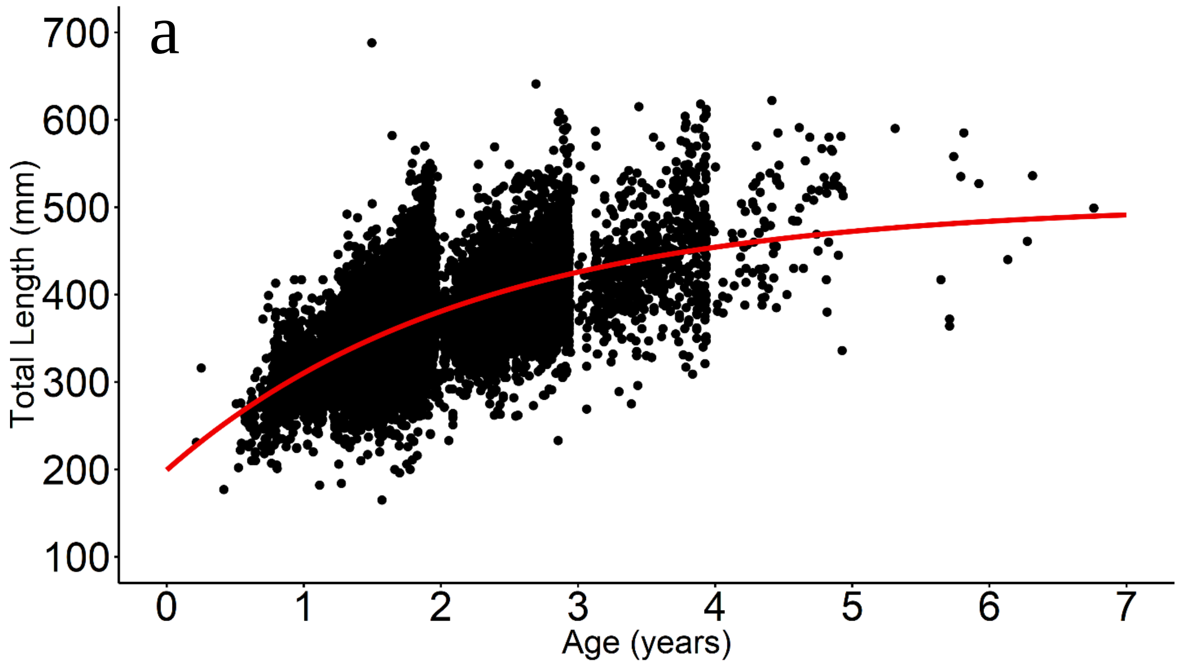


Figure 3. Probability of maturity for female southern flounder as a function of total length (inches) based on Louisiana southern flounder caught between September 2018 and January 2019 (n = 89). The dotted blue line represents the population-level estimate using a generalized linear model and each black dot is an individual fish. The red dot and text indicate the parameter of interest, which was the length at which 50% of females are mature (L_{50}), where L_{50} = 13.95 inches.


a
700
600
500
400
300
200
100
Total Length (mm)
0
1
2
3
4
5
6
7
Age (years)

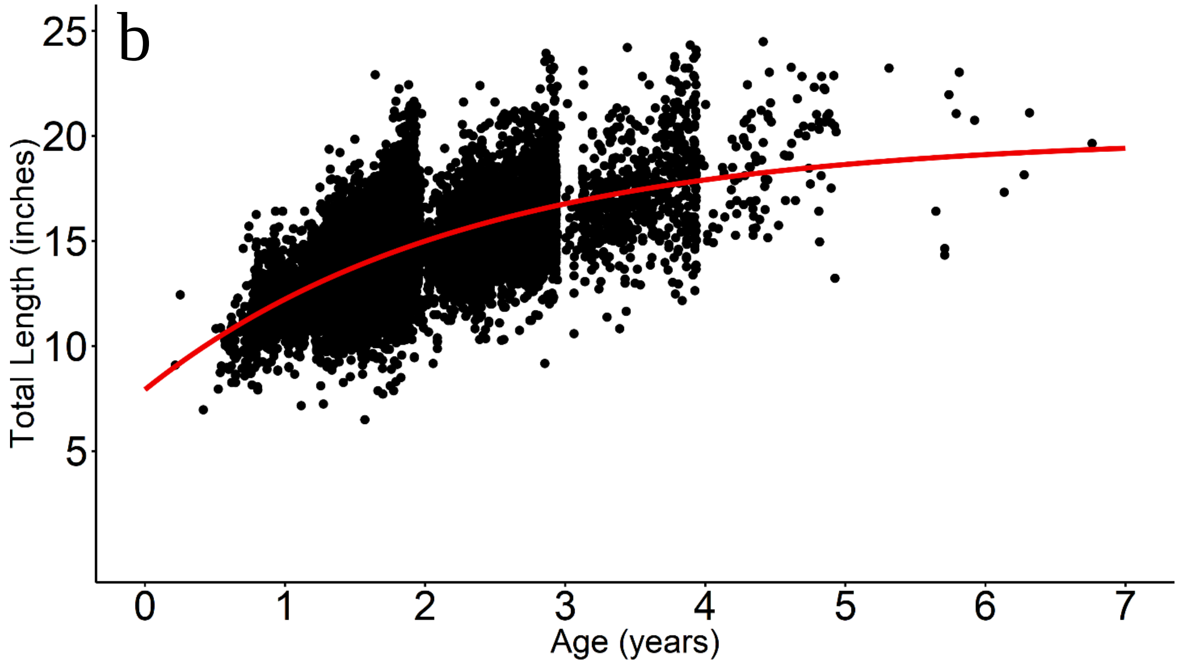


Figure 4. von Bertalanffy growth model fitted to female southern flounder (*n*=12,460) in Louisiana captured between 2002 and January 2019. The red line represents the growth equation and the black dots represent individual fish. Each fish was assigned a fractional age as a function of the number of annuli present and the month of capture (January 1 birthdate). Figure (4a) lists the total length in millimeters and Figure (4b) lists the total length in inches.

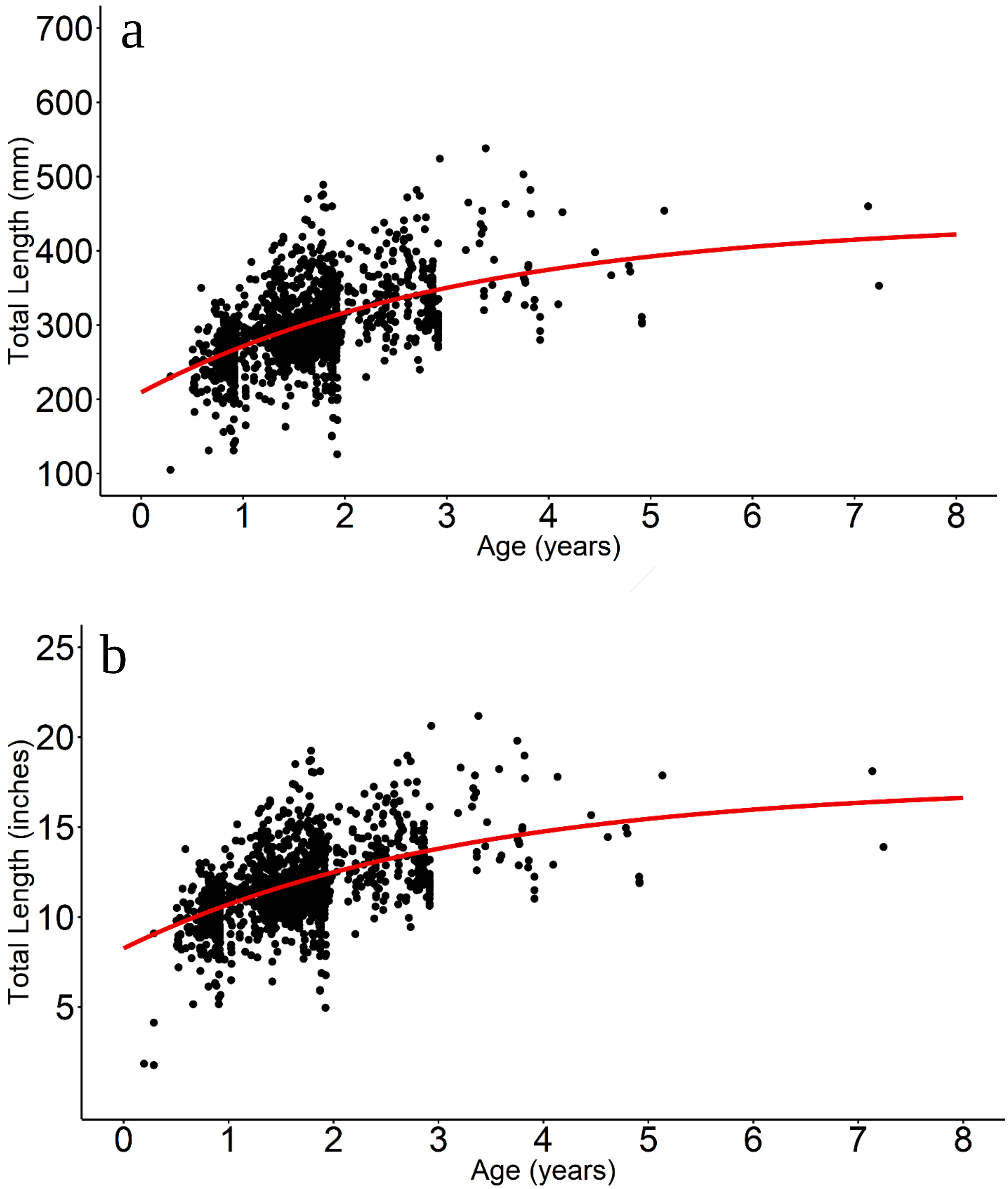


Figure 5. von Bertalanffy growth model fitted to male and indeterminate southern flounder (*n*=1830) in Louisiana captured between 2002 and January 2019. The red line represents the growth equation and the black dots represent individual fish. Each fish was assigned a fractional age as a function of the number of annuli present and the month of capture (January 1 birthdate). Figure (5a) lists the total length in millimeters and Figure (5b) lists the total length in inches.

Data Collection and Analysis

N = 14,344 southern flounder (*Paralichthys lethostigma*) lengths and otoliths were collected from Louisiana Department of Wildlife and Fisheries (LDWF) historical aging collection (*n* = 14,184), LDWF fishery-independent sampling in 2018 and 2019 (*n* =104), and fishery-dependent sampling of commercial and recreational landings by Louisiana State University and Louisiana Sea Grant in 2018 and 2019 (*n* = 56). Length was measured as the total length in millimeters of the whole fish.

Aging

To determine fish age, the left sagittal otolith was first embedded in a mixture of Araldite and Aradur and allowed to cure for 24 hours. Next, three 5 mm serial sections were taken from each otolith using a Buehler Isomet 1000 saw. One section was cut just to the right of the core, the second section directly on the core, and the final section to the left of the core. In cases where the otolith was too small to section three times, as many sections were taken as possible. Sections were mounted on glass microscopy slides and set with Loctite and Shannon Mount. Finally, ages were estimated by two independent readers using a compound microscope.

Growth parameters were modeled using the three-parameter von Bertalanffy Growth Equation (VBGE). The three parameter VBGE can be expressed as:

$$L_t = L_\infty\left[1 - e^{-k(t-t_0)}\right] + \varepsilon$$

where L_t is the length at some age (*t*), L_∞ is the asymptotic length, *k* is the von Bertalanffy growth constant, t_0 is the age at which a fish has a length of zero millimeters (von Bertalanffy, 1938), and ε is the error term for the model. Growth was estimated separately for males and females as flounder exhibit sexually dimorphic growth. Indeterminate sexed fish were included in the VBGE for males as they improved model performance and contributed to a more realistic estimate by anchoring the curve at smaller sizes and lowering the asymptotic length.

Maturity

To determine maturity at age and length, histological sections of gonadal tissue were prepared and analyzed. Histological analyses provided information about the specific reproductive (developmental) stage of each female, contributed to a more robust estimate of maturity, and more accurately identified the sex. A middle section of tissue from each gonad was removed, placed inside a microcassette case, and stored in 10% neutral buffered formalin. Tissues were then embedded using Leica Surgipath Paraplast tissue embedding medium and allowed to set at a low temperature in a refrigerator. From the embedded tissues, 5-μm tissue sections were cut with a microtome (Leica RM 2125 RTS) and placed in a 36℃ water bath (Leica HI 1210) before being dried onto a glass microscopy slide. Finally, each slide was stained using standard hematoxylin and eosin-y stains (Leica ST 5020). Samples were then viewed under a compound microscope by one reader and classified according to the most advanced stage. From these stages, a maturity classification (mature or immature) was generated, with anything estimated as cortical alveolus oocytes, or a more advanced stage, considered mature. One outlier was a 519mm female that showed primary growth oocytes and thus was classified as immature. While it is likely that this female would have developed mature oocytes later in the spawning season, its inclusion in the maturity estimate does not affect it by more than a few millimeters and thus it remains included in the model.

Maturity data were then used in a generalized linear model (GLM) with a binomial distribution (i.e., logistic regression), in an effort to estimate parameters for length at maturity and age at maturity. The GLM used TL (mm) as a predictor and maturity as the response. A L_{50} value was estimated for Louisiana and each CSA using the GLM parameters in the ratio $L_{50} = -\alpha/\beta$ (GLM 1). Procedures were repeated to calculate A_{50}, using a binomial GLM with age as the predictor and maturity as the response (GLM 2) and $A_{50} = -\alpha/\beta$. All data analyses were performed in the statistical computing environment R (R Core Team, 2018) and length at age data utilized a Bayesian approach with the JAGS package (Plummer, 2018).

References

Plummer, M. (2018). rjags: Bayesian Graphical Models using MCMC. R package version 4-8.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.