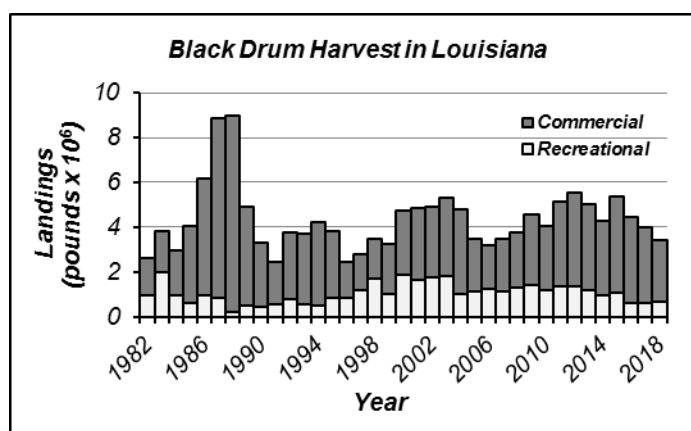


Assessment of Black Drum *Pogonias cromis* in Louisiana Waters 2020 Report

Executive Summary

Landings of black drum in Louisiana have remained above 4 million pounds per year in the most recent decade with the exception of 2018. The highest harvests on record (over 8 million pounds) occurred during the late 80's. After commercial regulations were enacted in 1989, black drum landings substantially declined. In the most recent years, recreational landings comprise less than twenty percent of the total Louisiana black drum harvest.

A statistical catch-at-age model is used in this stock assessment to describe the dynamics of the Louisiana black drum stock from 1982-2018. The assessment model 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. 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). An index of abundance is developed from the LDWF marine trammel net survey. Age composition of fishery catches are estimated with age-length-keys derived from samples directly of the fishery and a growth model.

There are currently no management thresholds established for the Louisiana black drum stock. Based on the species life history and the history of the stock, a 20% spawning potential ratio limit is proposed. Based on results of this assessment, the Louisiana black drum stock is currently neither overfished or experiencing overfishing. The current spawning potential ratio estimate is 49%.

Summary of Changes from 2015 Assessment

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 LDWF marine trammel net survey is used to develop an index of abundance as a data input of the assessment model. This survey was conducted from 1986 to October 2013 at fixed sampling stations within each LDWF Coastal Study Area (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 (details in 2. *Data Sources*).

The “linear” von Bertalanffy growth model generalization that were used in the previous assessment to describe black drum growth rates and develop age-length-keys for age assignments of fishery and survey catches has been replaced in this assessment with a growth model that accounts for decreasing growth rates (k) with age (details in *Appendix 2*).

The weight-length regression used in the previous assessment has been replaced in this assessment with a regression fit to a LDWF dataset (details in *Appendix 2*).

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*).

**Assessment of Black Drum *Pogonias cromis* in Louisiana Waters
2020 Report**

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1. Introduction

A statistical catch-at-age model is used in this assessment to describe the dynamics of black drum *Pogonias cromis* occurring in Louisiana (LA) waters from 1982-2018. The assessment model 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). An index of abundance is developed from the LDWF marine trammel net survey. Age composition of fishery catches are estimated with age-length-keys derived from samples directly of the fishery (2002-2018) and a growth model (1982-2001).

1.1 Fishery Status

A comprehensive history of the black drum (BD) resource and associated fishery within LA is described in Luquet et al. (2001) and for the Gulf of Mexico (GOM) in GSMFC (1993). A current summary of the Louisiana BD fishery is presented below.

Commercial

The commercial BD fishery operates primarily within state inside waters from the coastline inland to the saltwater line and outside territorial waters from the coastline seaward to 3 miles, with little harvest taken from federal waters of the Exclusive Economic Zone (EEZ).

Prior to the 1980s, the black drum fishery in LA was underutilized and had practically no regulations associated with the fishery. From 1961 to 1980, LA commercial BD harvest averaged approximately 0.4 million pounds. The growth of the commercial BD fishery in Louisiana was tied to the commercial fishery for red drum. In the late 1970s and early 1980s, the demand for red drum increased dramatically leading to a rapid increase in commercial red drum landings. In the 1980s, increased concern of overfishing led to regulations restricting the use of purse seines to the menhaden-type fishery and banning the use of spotter planes in the haul seine fishery. The increased demand and markets for red drum in the 1980s also led to an increase in black drum landings as they were harvested in the same gear and sold in the same markets. Subsequent bans on commercial red drum fishing led BD to become a suitable market substitute and it remains so to the present.

Recreational

The recreational BD fishery operates primarily within state inside waters from the coastline inland to the saltwater line and from the coastline seaward in state territorial waters to 3 miles offshore, with little harvest taken from federal waters of the EEZ.

Recreationally harvested BD are typically a secondary target of LA inshore marine sportfish anglers with less than 1% of LA anglers reported BD as their primary target in 2018 (LA Creel unpublished data). When BD are targeted or kept, anglers usually prefer smaller sized fish under 5 pounds. A variety of tackle are utilized to catch BD and anglers typically fish inshore or very near the coast.

1.2 Fishery Regulations

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

Commercial

The BD fishery in Louisiana was virtually unregulated until the late 1980s. In 1989, commercial regulations were established (LAC 76:331) that set a harvest slot consisting of a minimum size limit of 16-inches total length (TL) and a maximum size limit of 27-inches TL, with some commercial BD harvest allowed over 27-inches TL. The 1989 regulations also established annual commercial harvest quotas of 3.25 million pounds of 16 to 27-inch TL BD and 300,000 head (*i.e.*, individual fish) of BD \geq 27-inches TL. A commercial bull drum permit was required for commercial harvest of BD \geq 27-inches TL until late 2000. This permit requirement was removed when the LDWF Trip Ticket Program made it possible to monitor the harvest of both quotas without requiring individual harvest reports.

Authority for regulating gear lies with the Louisiana State Legislature. Act 1316 of the 1995 Regular Legislative Session (the Marine Resources Conservation Act of 1995) outlawed the use of "set" gill nets or trammel nets in saltwater areas of Louisiana, and restricted black drum harvest by the use of "strike" nets to the period between the third Monday in October and March 1 of the following year. A "Restricted Species Permit" was required in order to harvest black drum, and several criteria were established in order to qualify for that permit. After March 1, 1997, all harvest by gill or trammel nets was banned, and legal commercial gear to harvest black drum was limited to trawl, set lines and hook and line.

Currently the primary commercial fishing gears include baited trotlines and other set lines, otter trawls, and skimmer nets. The fishing year for commercial BD harvest is September 1 through August 31 of the following year. The fishery remains an open access fishery.

Recreational

In 1989, recreational BD harvest regulations were implemented that established a harvest slot consisting of a minimum size limit of 16-inches TL and a maximum size limit of 27-inches TL (with one fish allowed over the maximum size), and a five-fish per angler bag and possession limit. These regulations remain the current recreational limits.

1.3 Trends in Harvest

Time-series of LA commercial and recreational BD landings (1982-2018) are presented in Table 1.

Commercial

The time-series of LA commercial BD harvest (1950-2018) is also presented in Figure 1. Beginning in 1981, the commercial BD fishery in Louisiana experienced dramatic growth with landings reaching 2.9 million pounds in that year. Commercial harvest peaked in 1988 at 8.8 million pounds prior to the implementation of regulations in 1989. From 1981 through 1989 commercial BD landings averaged over 4 million pounds per year, a ten-fold increase from the average commercial landings of the previous 20 years. With the establishment of state quotas and harvest permits in 1989 coupled with market fluctuations, commercial BD landings dropped to an average of 3.0 million pounds from 1990 through 1995. Factors influencing harvest after 1989 were less fishing in the EEZ due to the red drum harvest moratorium, redirection of fishing effort to other species such as sheepshead and mullet, and decreasing demand for adult or “bull” BD coinciding with the red drum moratorium. After enactment of entanglement gear regulations in 1995, BD landings averaged 3.0 million pounds per year through 2018.

Currently both adult (“bull”) and juvenile (“puppy”) drum are harvested, often with similar gears. The market for adult drum has historically been more limited than the market for the juveniles due to the preference for the flavor and texture of the flesh of younger fish. Larger juvenile and adult fish tend to have high levels of a larval parasite in the flesh, making it less attractive and in some cases affecting the texture of the meat.

Recreational

Recreational landing estimates of BD in LA has varied considerably over the available time-series from a peak of 2.0 million pounds harvested in 1983 to a low of 0.22 million pounds harvested in 1988. After 1988, recreational BD landings generally increased to another high of 1.9 million pounds harvested in 2000. Landings decreased after 2000 to a low of 0.59 million pounds harvested in 2016. In 2018, 0.65 million pounds of BD were recreationally harvested in LA.

2. Data Sources

2.1 Fishery Independent

The LDWF fishery-independent (FI) marine trammel net survey is used in this assessment to develop an index of abundance as an input of the assessment model. Below is a brief description of this 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, trawl, trammel net, and bag seine surveys.

In this assessment, only the FI marine trammel net survey is used. This survey is conducted with standardized design from October-March. Hydrological and climatological measurements are taken with each biological sample, including water temperature, turbidity, conductivity and salinity. 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 BD are enumerated and a maximum of 50 randomly selected BD are collected for length measurements, gender determination, and maturity information. When more than 50 BD are captured, catch-at-size is derived as the product of total catch and proportional subsample-at-size.

This 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 black drum landings are taken from the LDWF Trip Ticket Program and NMFS commercial statistical records (NMFS 2019; Figure 1). Beginning in 2002, black drum landings from the LDWF Trip Ticket Program are further delineated into “juvenile” (<27 inches) and “bull” (≥27 inches) size categories (Table 2). Commercial live release estimates are currently not available (see *Research and Data Needs*) and are not considered further in this assessment.

Annual size compositions of commercial harvest (Table 3) are available from four eras of data collection. The earliest (pre-1994) are derived from a historical database (Russell et al. 1986, Russell et al. 1987, unpublished LSU data); the Trip Interview Program (TIPS) provides pre-2002 data; the Fishery Information Network (FIN) is used for 2002-2013, and the LDWF Biological Sampling Program is used for 2014-2018. Due to the very limited size composition samples collected in early years of the commercial fishery, the pre-1989 TIPS records are pooled with the pre-1989 size composition samples from the historical database to represent the size distribution of landings from 1982-1988 when purse seines were still a component of the commercial fishery. The size composition of landings from 1989-1993 (after purse seines were banned) are described by pooling the very limited TIPS samples in those years with the post-1988 records from the historical LSU database. For other years where annual TIPS size composition samples were < 200 (1998 and 1999), samples from the previous and prior years were pooled with that year’s size composition samples. Due to low sample size in 2002, the available TIPS and FIN size composition samples were combined. Because of the stratified nature BD FIN samples were collected from 2002-2013 (i.e., separate sampling goals for “juvenile” and “bull” BD), annual size compositions are developed separately for age estimation of “juvenile” and “bull” BD landings (2002-2013 only).

Ages of commercial black drum landings are derived from a growth function (1982-2001) and otoliths collected from LDWF sampling effort (2002-2018; see 5. *Catch at Age Estimation*).

Recreational

Recreational BD 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 (AP AIS) 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 BD stock assessment (Davis *et al.* 2015).

Live releases are further delineated as legal or illegal with LA Creel and MRIP catch disposition codes. Annual size compositions of BD 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 4); size composition of legal live releases is assumed equivalent. 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.

Size composition of under-sized releases in each year is estimated by first assuming all illegal discards as < 16-inches total length. Some catch, however, is in fact legal-sized, but coded as illegal due to catches greater than the creel limit. These catches (~1% of LA angler trips per year, 2016-2018; LA Creel unpublished data) occur infrequently and are thus considered negligible for purposes of this assessment. Size composition of BD catches < 16 inches are pooled from the years prior to recreational MLL implementation and used as proxies of sublegal size composition after the 16 inch MLL was implemented in 1989.

Ages of recreational black drum landings are derived from a 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

Black drum occur in estuaries and nearshore habitat along the Atlantic and Gulf Coasts from Nova Scotia southward through the GOM and Caribbean Sea to Argentina (GSMFC 1993). Most of the harvest is taken in the GOM with the largest harvest occurring in LA waters (Figure 1).

Studies using mitochondrial DNA markers (Gold and Richardson 1998) have confirmed spatial homogeneity in black drum haplotype frequencies across the GOM, implying that BD may be considered one stock in the GOM. However, for purposes of this assessment and to remain consistent with the current statewide management strategy, the unit stock is defined as those BD occurring in LA waters.

3.2 Morphometrics

The weight-length regression reported by Geaghan and Garson in GSMFC (1993) that was used in the previous assessment (Davis *et al.* 2015) is replaced in this assessment with a regression fit to a LDWF

dataset (see *Appendix 2*). Regressions 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:

$$W = 4.05 \times 10^{-4} (TL)^{3.08} \quad [1]$$

where W is whole weight in pounds and TL is total length in inches.

Fish with only FL measurements available are converted to TL from the following relationship reported by Geaghan and Garson in GSMFC (1993):

$$TL = 1.03 \times FL - 3.80 \quad [2]$$

where fork length is in units of mm.

3.3 Growth

Only minor differences have been found between male and female BD growth rates (Beckman et al. 1988; see *Appendix 2*). The non-sex-specific “linear” or sloped asymptote von Bertalanffy generalization reported by Geaghan and Garson in GSMFC (1993) that was used in the previous assessment is replaced in this assessment with a non-sex-specific growth model that accounts for decreasing growth rates with age (i.e., damped growth model; Porch et al. 2002; see *Appendix 2*). Total length-at-age is calculated with the damped growth model as:

$$TL_a = 37.2 \times (1 - e^{\beta - 0.0973(a+0.168)}) \quad [3]$$

$$\beta = \frac{0.193}{0.390} (e^{-0.390a} - e^{-0.390 \times -0.168})$$

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

3.4 Fecundity / Maturity / Sex Ratio

Black drum are group-synchronous batch spawners. To realistically estimate annual fecundity, the number of eggs spawned per batch and the number of batches spawned per season must be known. Furthermore, batch fecundity and spawning frequency likely vary as a function of fish weight/size/age (Beckman et al. 1990). Estimates of batch fecundity are available as a function of fish body weight (Fitzhugh and Beckman 1987), but spawning frequency estimates are not. Thus, for purposes of this assessment, female spawning stock biomass is used as a proxy of total egg production. This may introduce bias if fecundity does not scale linearly with body weight (Rothschild and Fogarty 1989).

An age-specific maturity vector reported by Geaghan and Garson in GSMFC (1993) is employed in this assessment where no fish age-0 to 3 spawn, 33% of age-4 fish spawn, 66% of age-5 fish spawn, and 100% of fish greater than age-5 spawn.

Fitzhugh and Beckman (1987) and Beckman et al. (1988) found only minor differences between male and female BD sex ratios outside of the spawning season. Sex ratios observed in LDWF fishery-independent and fishery-dependent samples are also very close to 1:1. For purposes of this assessment, the sex ratio-at-age is assumed to be 50:50.

3.5 Natural Mortality

Black drum can live to at least 44 years (see *Appendix 2*). For purposes of this assessment, a value of constant M is assumed (0.10) based on the observed 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 44 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:

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

where M is a constant natural mortality rate over exploitable ages a , a_{max} is the oldest age-class, 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:

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

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

3.6 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. Published estimates of steepness are not available for GOM black drum.

Productivity is a function of growth rates, natural mortality, age of maturity, and longevity and can be a reasonable proxy for resilience. We characterize the relative productivity of GOM black drum based on life-history characteristics, following SEDAR 9 (SEDAR 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; Table 5). 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 is averaged to compute an overall productivity score. In this case, the overall productivity score is 1.50 for GOM black drum indicating medium to low productivity. The von Bertalanffy growth rate typically used in the above analysis is not used in this assessment due to problems fitting a standard von Bertalanffy growth model to black drum length-at-age data, but is estimated here as the mean growth rate across ages from the damped growth model (see *Appendix 2*) weighted by expected relative abundance-at-age ($\bar{k} = 0.158$).

4. Abundance Index Development

A black drum index of abundance (IOA) is developed from the LDWF FI marine trammel net survey. Samples collected during the months of January, February, and March are grouped with the previous year's October, November, and December samples for IOA development. Catch per unit effort (CPUE) is defined as the number of BD caught per trammel net sample. To reduce unexplained variability in catch rates unrelated to changes in abundance, the IOA was standardized using methods described below.

A delta lognormal approach (Lo *et al.* 1992; Ingram *et al.* 2010) is used to standardize black drum 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 black drum catches assumed as lognormal distributions and p_y are estimated annual mean probabilities of black drum 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 black drum are captured; the binomial model considers all samples. The IOA is then computed from equation [6] using the estimated least-squares means with variances calculated from:

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

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

Because of the designed nature of the LDWF marine trammel net survey, model development was rather straightforward. Variables considered in model inclusion were year, CSA, and sampling location. Because only seasonal samples are included (*i.e.*, October-March), 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, the standardized index of abundance, and coefficients of variation of the standardized index are presented (Table 6). Standardized and nominal CPUEs, normalized to 1 for comparison, are also presented graphically along with the observed proportion of positive samples (Figure 2).

5. Catch at Age Estimation

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

Black drum exhibit a protracted spawning season, with spawning primarily occurring across a four-month window from February through May (Beckman et al. 1988). The midpoint of this season (April 1st) is typically assumed as a biological birthday. However, for purposes of this assessment, BD ages are assigned based on the calendar year by assuming a January 1st birthday, where BD spawned the previous year 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 black drum landings are computed from:

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

where the probability of length given age is estimated from a normal probability density 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 [3]. 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 0.10). 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 to assign ages to BD fishery landings from 1982-2001 and for instances discussed below.

2002-2018: Fishery-specific f (i.e., commercial and recreational) 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 black drum sample sizes occurring in each length/age bin. When $\sum_a n_{layf} < 10$, the $P(a|l)$ for that length interval is estimated with Equation [8]. The resulting $P(a|l)_{yf}$ matrices are presented (Tables 8 and 9).

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

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

where C_{lyf} are annual fishery-specific catch-at-size in TL and $P(a|l)_{yf}$ are taken from Equations [8 or 9]. Due to the stratified nature commercial size and age information were collected during FIN BD sampling (2002-2013), catch-at-size and probabilities of age given length are developed separately for “juvenile” (< 27 inches TL) and “bull” BD (≥ 27 inches TL) from 2002-2013 only. Recreational discard mortalities are incorporated directly into the recreational catch-at-age by applying a 5% discard mortality rate to the estimated live releases-at-size and combining them with the harvest-at-size estimates.

For modeling purposes, catches \geq age-10 are summed into a plus group. Resulting annual fishery-specific catch-at-age and corresponding mean weights-at-age are presented (Tables 10-12).

5.2 Survey

Probabilities of age given length for BD catches of the LDWF marine trammel net survey are computed from equation [8]. Mean total length-at-age is estimated from equation [3]. 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 (0.10). To approximate survey timing (i.e., a December 31st midpoint), mean total length-at-age is calculated at the end of the calendar/model year. The resulting $P(l|a)$ matrix for BD catches of the marine trammel net survey is presented (Table 13). Annual survey catch-at-age is then taken from Equation [10] with annual survey catch-at-size substituted (Table 14). Resulting annual age compositions of BD catches of the LDWF marine trammel net survey are presented (Table 15).

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 BD 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

For purposes of this assessment, the model is configured with annual time-steps (1982-2018) and a calendar year time-frame.

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.

Age and fishery-specific selectivities are modeled with double logistic functions as:

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

Total mortality for each age and year is estimated from the age-specific natural mortality rate M_a and estimated annual fishery-specific fishing mortalities as:

$$Z_{ay} = M_a + \sum_f F_{ayf} \quad [13]$$

For reporting purposes, annual age-specific fishing mortalities are averaged by weighting by estimated population numbers at age N_{ay} as:

$$F_y = \frac{\sum_a F_{ay} N_{ay}}{\sum_a N_{ay}} \quad [14]$$

Population Abundance

Abundance 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:

$$N_{ay} = N_{a-1,y-1} e^{-Z_{a-1,y-1}} \quad [15]$$

Numbers in the plus group A are calculated from:

$$N_{Ay} = N_{A-1,y-1} e^{-Z_{A-1,y-1}} + N_{A,y-1} e^{-Z_{A,y-1}} \quad [16]$$

Stock Recruitment

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

$$\hat{R}_{y+1} = \frac{\alpha SSB_y}{\beta + SSB_y} + e^{\delta_{y+1}} \quad [17]$$

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

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.

Spawning Stock Biomass

Female spawning stock biomass in each year is calculated from:

$$SSB_y = \sum_{i=1}^A N_{ay} W_{SSB,a} p_{mat,ay} e^{-Z_{ay}(0.33)} \quad [18]$$

where $W_{SSB,a}$ are spawning stock biomass weights-at-age, $p_{mat,ay}$ are the annual proportion of mature females-at-age calculated as the product of the female maturity at age vector and the annual female sex-ratio-at-age (assumed 50:50 through time), and $-Z_{ay}(0.33)$ is the proportion of total mortality occurring prior to spawning on April 1st.

Expected Catch

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

$$\hat{C}_{ayf} = N_{ay} F_{ayf} \frac{(1-e^{-Z_{ay}})}{Z_{ay}} \quad [19]$$

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

Survey Catch-rates

Expected survey catch-rates are computed from:

$$\hat{I}_{ay} = q \sum_a N_{ay} (1 - e^{-Z_{ay}(1.0)}) v_a \quad [20]$$

where v_a are survey selectivities, q is the estimated catchability coefficient, and $-Z_{ay}(1.0)$ is the proportion of the total mortality occurring prior to the time of the survey (December 31st midpoint). Survey selectivities are modeled with a double logistic functions (Equation [12]). Expected survey age composition is then calculated as $\frac{I_{ay}}{\sum_a I_{ay}}$.

Parameter Estimation

The number of parameters estimated is dependent on the length of the time-series, number of selectivity blocks modeled, and number of abundance indices modeled. Parameters are estimated in log-space and then back transformed. In this assessment, 146 parameters are estimated:

1. 24 selectivity parameters (3 blocks for the commercial fishery, 2 blocks for the recreational fishery, and 1 block for the survey)
2. 74 apical fishing mortality rates (F_{mult} in the initial year and 28 deviations in subsequent years for 2 fisheries)
3. 37 recruitment deviations (1982-2018)
4. 9 initial population abundance deviations (age-2 through 10-plus)
5. 1 catchability coefficient (1 survey)
6. 1 stock-recruitment parameter (SSB_0 ; the steepness parameter is fixed at 1.0 for the base run).

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

$$-\ln(L) = \sum_i \lambda_i (-\ln L_i) + \sum_j (-\ln L_j) \quad [21]$$

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

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

$$-\ln(L_i) = 0.5 \sum_i \frac{[\ln(obs_i) - \ln(pred_i)]^2}{\sigma^2} \quad [22]$$

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:

$$-\ln(L_j) = -ESS \sum_{i=1}^A p_i \ln(\hat{p}_i) \quad [23]$$

where p_i and \hat{p}_i are observed and predicted age composition. 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 and survey vulnerabilities are dome-shaped, 5) abundance indices are proportional to absolute abundance, and 6) natural mortality, fecundity, growth and sex ratio-at-age 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-10 plus group, the steepness parameter fixed at 1.0, three commercial fishery selectivity blocks, two recreational selectivity blocks, and input levels of error and weighting factors as described below.

For the commercial fleet, three selectivity blocks are modeled that correspond to the following time-periods of consistent regulation: 1) 1982-1988 (no regulations), 2) 1989-1996 (commercial size limits implemented and purse-seines banned), and 3) 1997-2018 (commercial gill and trammel nets banned). Within the recreational fleet, two selectivity blocks are modeled that correspond to the following time-periods of consistent regulation: 1) 1982-1988 (no regulations) and 2) 1989-2018 (recreational size limits and creel limit implemented).

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 9). 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 10). Input levels of error for survey catch-rates were specified with CV's estimated from the IOA standardization (Table 5). Annual recruitment deviations were specified with CV's of 0.5 for all years of the time-series.

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 16.

Model Fit

The base model provides an overall reasonable fit to the data. Fits to the commercial and recreational landings match the observations well with no strong pattern in residuals (Figures 3 and 4) with the exception of the earlier years of the recreational time-series. Model estimated survey catch-rates also provide reasonable fits to the data given the relatively large CV's of the IOA and track the increase observed through time, but are generally overestimated in the earlier years of the time-series and underestimated in the more recent years (Figure 5). Model estimated fishery and survey age compositions provide adequate fits to the input age proportions (Figures 6-8) with noticeably better fits for the years annual ALKs were used for age assignments.

Selectivities

Estimated fishery and survey selectivities are presented in Figure 9. Fishery estimates indicate full-vulnerability to the commercial fishery at age-5 during the 1982-1988 regulation block and age-3 during the 1989-1996 and 1997-2018 regulation blocks. Selectivities of older fully-mature fish were reduced noticeably after each period of commercial regulations were enacted. Recreational estimates indicate full-vulnerability at age-1 for the 1982-1988 regulation block and increased to age-3 after recreational regulations were enacted in 1989. Survey estimates indicate full vulnerability to the FI survey gear at age-1.

Abundance, Recruitment, and Spawning Stock

Total stock size and abundance-at-age estimates are presented in Table 17. Stock size has generally increased over the time-series examined. Stock size decreased from 7.6 million fish in 1982 to a minimum of 4.6 million fish in 1989. After 1989, stock abundance increased to a peak of 14.8 million fish in 2001. Since 2001, stock size has varied but remained high with an all-time high of 14.9 million fish estimated in 2013. The 2018 stock size estimate is 13.3 million fish.

Estimates of age-1 recruitment are presented in Figure 10. The effect of including age information in the assessment model derived from direct age sampling (*i.e.* otoliths) of the fishery (2002-2018) is apparent in the reduced smoothing of recruitment estimates in the later years of the assessment. The lowest

estimates were in earlier years of the time-series examined. The 1984 and 1988 estimates are the lowest on record (1.1 million fish). Recruitment began to increase after the 80's to a peak of 4.6 million age-1 recruits estimated in 2001. After 2001, recruitment varied with an all-time high of 5.4 million age-recruits estimated in 2007. The average recruitment (geometric mean) of the entire time-series is 2.3 million fish. The average recruitment (geometric mean) of the first and most recent decade of the time-series are 1.4 and 2.6 million fish respectively. The 2018 age-1 recruitment estimate is 2.6 million fish.

Female spawning stock biomass (SSB) estimates are presented in Figure 11. Estimates decrease from over 30 million pounds in the early years of the time-series to a minimum of 8.9 million pounds in 1994. After 1994, SSB increased to a maximum of 41.8 million pounds estimated in 2018.

Fishing Mortality

Estimated fishing mortality rates are presented in Table 18 (total apical, average, and age-specific) and Figure 12 (average only). Average rates are weighted by estimated stock numbers-at-age. Fishing mortality rates have varied over the time-series with an increasing trend in earlier years shifting to a decreasing trend in later years. The highest F estimate was in 1988 (0.40 yr^{-1}). After 1988, fishing mortality decreased to a minimum of 0.06 yr^{-1} estimated in 2018.

Stock-Recruitment

The relationship between female SSB and subsequent age-1 recruitment is presented in Figure 13. Recruitment estimates in earlier years of the time-series are noticeably lower than later estimates. The steepness parameter was fixed at 1.0 in the ASAP base model run. The estimated unexploited SSB and age-1 recruitment was 84 million pounds and 2.3 million fish. Alternate 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, 146 parameters are estimated. Asymptotic standard errors (± 2) for the recruitment time-series are presented in Figure 10. Markov Chain Monte Carlo (MCMC) derived confidence intervals (95%) for the female SSB and average fishing mortality rate time-series are presented in Figures 11 and 12.

6.4 Management Benchmarks

Overfishing and overfished limits should be defined for exploitable stocks. The implication is that when biomass falls below a specified limit, there is an unacceptable risk that recruitment will be reduced to undesirable levels. Management actions are needed to avoid approaching this limit and to recover the stock if biomass falls below the limit.

There are currently no management thresholds established for the Louisiana black drum stock. Based on the life history of the species and the history of the stock, a 20% spawning potential ratio limit (SPR; Goodyear 1993) is proposed. The reproductive potential of the stock has been lower than the proposed limit (Figure 14), but given the species life history characteristics (relatively long lived, slow growing, later maturing), and associated relative productivity/resilience (Table 5) a precautionary 20% SPR limit is recommended. The method for calculating the SPR_{limit} and the corresponding limit reference points are presented below.

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

$$\frac{SSB}{R}(F) = \sum_{i=1}^A N_a W_{SSB,a} p_{mat,a} e^{-Z_a(0.33)} \quad [24]$$

where total mortality at age Z_a is computed as $M_a + v_a \times F_{mult}$; vulnerability at age v_a is taken 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 from the Baranov catch equation [21], excluding the year index. Yield per recruit (Y/R) is then taken as $\sum_a C_a \bar{W}_a$ where \bar{W}_a are current mean fishery weights at age (arithmetic mean 2016-2018). Fishing mortality is averaged by weighting by relative abundance-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 $F=0$.

Annual escapement rates of immature fish are calculated from:

$$E_y = e^{-(F_{1y}+F_{2y}+F_{3y}+F_{4y}+F_{5y})} \quad [25]$$

where $F_{1y} - F_{5y}$ are the total annual age 1-5 fishing mortality rates estimated from the ASAP base model run. Equilibrium escapement rates are calculated from equation [25] excluding the year index and equilibrium F-at-age calculated from equation [24].

As reference points to guide management, we estimate the equilibrium female spawning stock biomass, average fishing mortality rate, and escapement rate that lead to a 20% SPR (SPR_{limit} , SSB_{limit} , F_{limit} , E_{limit}). Management targets for black drum 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}), SPR target ($\text{SPR}_{\text{target}}$), and escapement rate target (E_{target}) that correspond to the $\text{SSB}_{\text{target}}$ when the stock is in equilibrium are then estimated from Equations [24 and 25].

The proposed limits and established targets of fishing are presented in Figure 14 relative to each respective time-series. Limit and target reference points are also presented in Table 19. 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 $\text{SSB}_{\text{target}}$, and the minimum and maximum SSB estimates of the time-series, corresponding with a $\text{SPR}_{\text{target}}$ of 25%, and a minimum and maximum SPR of 11% and 49% (Figure 15).

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 0.7 (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).

Another sensitivity run was conducted by increasing the discard mortality rate from 5% to 10% (Model 6).

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

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 8). 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 9).

Results of each sensitivity run relative to the proposed limit reference points are presented in Table 20. Current estimates of female SSB and average F are taken as the geometric mean of the 2016-2018 estimates. Estimates from all sensitivity runs indicate the stock is currently above SSB_{limit} and 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 21). Results of each run indicate that the fishery is currently operating under MSY, where ratios of current F and SSB to F_{MSY} and SSB_{MSY} are below and above 1 respectively.

Retrospective Analysis

A retrospective analysis was conducted by sequentially truncating the base model by a year (terminal years 2015-2018). Retrospective estimates of age-1 recruits, female SSB, and the average fishing mortality rate differed only marginally from the base run (Figure 16).

7. Stock Status

The history of the LA black drum stock relative to F/F_{limit} and SSB/SSB_{limit} is presented in Figure 17. 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 (0.39), indicating the stock is currently not undergoing overfishing. The current assessment model does indicate that overfishing occurred in earlier years of the time-series. The current escapement rate estimate is 59%.

Overfished Status

The current estimate of SSB/SSB_{limit} is > 1.0 (2.5), indicating the stock is not currently overfished. The current assessment model does indicate that the stock was considered overfished in earlier years of the time-series. The current SPR estimate is 49%.

Management Target Status

Management targets for black drum established by LAC 76: VII.385 indicate the stock is currently above its biomass target and the fishery is currently operating below its fishing mortality rate target.

Control Rules

There is currently no harvest control rule established for the LA black drum 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 additional recommendations to improve future LA stock assessments of black drum.

Only limited age data are available from the LDWF marine trammel net survey. Ages of survey catches in this assessment were assigned from a growth function. Age composition samples collected directly from the survey would allow a more accurate representation of survey age composition in future assessments.

Inclusion of information from the early years of the fishery is important to characterize the full range of dynamics of the stock. However, lack of information on age structure from those fisheries limits the current assessment. There was a large amount of age sampling of the commercial harvest in the mid-1980's, but the specifics of the sampling program are not currently available. Recovery of the field data, notes, and electronic data from that time period could help better characterize commercial harvest from those years, leading to a better understanding of the stock dynamics through the assessment period.

Commercial discard estimates are currently not available. If significant numbers of undersized commercially landed black drum are discarded, total fishery removals would be underestimated and consequent fishing mortality rate estimates would be biased low. A fishery-independent survey simulating the primary commercial landings gear and fishing method would allow insight into the magnitude of undersized commercially landed discards relative to harvestable size fish.

Estimates of black drum batch fecundity and spawning frequency as a function of age/size are needed.

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

Factors that influence year-class strength of black drum are poorly understood. Investigation of these factors, including inter-annual variation in seasonal factors (winter temperatures, seasonal salinities, food availability etc.) and the influence of environmental perturbations such as the Deepwater Horizon oil spill, could elucidate causes of inter-annual variation in abundance, as well as the species stock-recruitment relationship.

With the recent trend toward ecosystem-based assessment models (Mace 2000; NMFS 2001), more data is needed linking black drum 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 black drum stock and its habitat.

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.

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10. Tables

Table 1: Louisiana annual commercial and recreational black drum landings (pounds x 10⁶; harvest only) derived from NMFS statistical records, LDWF Trip Ticket Program, MRIP, and LA Creel.

Year	Harvest		%Commercial	%Recreational
	Commercial	Recreational		
1982	1.69	0.94	64.2%	35.8%
1983	1.86	1.98	48.4%	51.6%
1984	1.98	0.98	67.0%	33.0%
1985	3.42	0.60	85.1%	14.9%
1986	5.23	0.94	84.8%	15.2%
1987	8.02	0.84	90.5%	9.5%
1988	8.76	0.22	97.5%	2.5%
1989	4.41	0.49	90.0%	10.0%
1990	2.88	0.41	87.5%	12.5%
1991	1.91	0.52	78.6%	21.4%
1992	3.01	0.76	79.8%	20.2%
1993	3.18	0.54	85.6%	14.4%
1994	3.74	0.48	88.7%	11.3%
1995	3.00	0.83	78.4%	21.6%
1996	1.62	0.81	66.7%	33.3%
1997	1.64	1.16	58.6%	41.4%
1998	1.78	1.67	51.7%	48.3%
1999	2.20	1.02	68.3%	31.7%
2000	2.84	1.87	60.3%	39.7%
2001	3.20	1.66	65.8%	34.2%
2002	3.11	1.76	63.8%	36.2%
2003	3.51	1.79	66.2%	33.8%
2004	3.76	1.03	78.5%	21.5%
2005	2.38	1.09	68.5%	31.5%
2006	1.93	1.25	60.8%	39.2%
2007	2.36	1.09	68.4%	31.6%
2008	2.46	1.30	65.5%	34.5%
2009	3.15	1.42	69.0%	31.0%
2010	2.84	1.19	70.6%	29.4%
2011	3.77	1.38	73.3%	26.7%
2012	4.19	1.32	76.0%	24.0%
2013	3.88	1.17	76.9%	23.1%
2014	3.33	0.97	77.5%	22.5%
2015	4.28	1.08	79.8%	20.2%
2016	3.88	0.59	86.9%	13.1%
2017	3.41	0.60	85.0%	15.0%
2018	2.76	0.65	81.0%	19.0%

Table 2: Louisiana annual commercial black drum landings as juvenile (pounds x 10⁶) and head drum (numbers) derived from the LDWF Trip Ticket Program.

Year	Juvenile	Head Drum
2002	2.87	16,625
2003	3.40	7,684
2004	3.53	15,331
2005	2.19	12,142
2006	1.85	5,836
2007	2.24	8,267
2008	2.28	11,778
2009	2.95	12,914
2010	2.72	8,004
2011	3.62	10,088
2012	4.10	5,683
2013	3.67	13,811
2014	3.25	5,711
2015	4.09	12,243
2016	3.57	20,283
2017	3.08	22,018
2018	2.45	20,304

Table 3: Annual size frequency samples of Louisiana commercial black drum landings derived from historical LSU data collections (pre-1994), the Trip Interview Program (pre-2002), the Fishery Information Network (2002-2013), and the LDWF Biological Sampling Program (2014-2018). Shaded area represents “juvenile” (<27 inches) and “bull” (≥27 inches) black drum samples from the FIN sampling program, where annual size/age distributions are developed separately due to the stratified commercial sampling of juvenile and bull drum (*i.e.*, separate sampling quotas of juvenile and bull drum from 2002-2013).

Commercial, 1982-2018																												
TL_in	1982-1988	1989-1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
5																												
6	3				1																							
7	5	1																										
8	5	22																										
9	1	30			1																							
10	2	81		1																								
11	23	226			1																							
12	23	114				1	1																					
13	30	205	1								2					1		4			1			2		1		
14	41	237		1		1	1			4	2	1		3		5		12		1		2	6	1	2	1	3	
15	203	751	11	57	1	18	18	2	2	8	23	2	1	8	3	18	20	23	2	7	12	7	28	15	13	19	14	
16	273	701	46	201	21	21	33	25	13	52	120	23	13	35	32	45	47	97	17	25	25	18	70	48	45	44	60	
17	773	1198	48	250	21	35	71	58	22	70	132	34	21	60	26	73	59	192	31	52	54	24	102	80	54	89	83	
18	600	727	37	200	19	36	71	83	48	99	122	33	36	89	46	106	84	199	41	83	78	36	123	117	84	111	97	
19	795	948	41	171	28	40	73	99	66	71	82	28	29	70	61	146	116	167	53	137	92	55	123	126	130	102	130	
20	425	188	32	117	18	37	59	80	58	64	88	28	39	83	69	131	135	118	60	135	82	31	85	113	154	108	165	
21	503	278	19	96	16	28	37	47	38	45	67	32	20	55	61	113	104	95	46	122	110	39	88	92	154	97	124	
22	227	221	20	59	16	25	27	19	17	24	38	35	21	47	36	99	71	50	52	87	123	47	75	102	136	104	107	
23	253	309	10	26	10	18	24	13	7	7	35	38	15	38	31	71	73	32	46	103	101	83	33	100	100	123	88	
24	231	96	4	28	12	17	21	11	7	5	34	24	21	37	29	69	52	13	24	113	73	34	30	81	58	75	71	
25	405	77	8	13	17	16	26	22	12	2	24	13	20	34	21	65	57	28	32	105	64	23	28	81	44	46	40	
26	1106	63	2	1	16	12	14	6	4		7	8	17	18	15	84	52	41	28	78	46	17	29	65	39	39	50	
27	909	57	1	3	14	16	18	3	1		6	17	10	14	7	72	53	48	19	54	38	8	13	50	35	44	68	
28	1290	138		2	17	5	7	2			3	8	1	20	6	64	39	37	6	22	23	12	18	27	19	28	60	
29	984	112	1	2	14	2	4	2			2	2	1	15	11	37	31	20	3	12	7	6	11	19	12	5	54	
30	1255	205	1	2	10	1	3	2					3	1	7	2	29	21	15		6	9	5	21	9	3	11	32
31	652	156	2	2	16	5	9	4			1	1		8	2	17	4	5		8	1	3	12	7	2	4	13	
32	597	178	3	7	17	4	6	2						10	1	6	8	10		4		7	16	3	2	1	11	
33	234	89	9	4	23	3	7	4			2	1		5	2	2	3	3		5		4	8	1	3		2	
34	210	84	3	5	15	4	5	1			2			4	2	2	3	2		3		3	5	1	1	2	3	
35	96	36		4	10	3	4	1			3	1		4	1	3	3	3		1		3	4	1		1	1	
36	85	34	4	1	6									4		1	4	2				4	1		1	1	1	
37	41	14	6	1	2	1	1							1		2				4		2	1					
38	57	8	5		3	2	2							3								1	1	1	2			
39	15	5	6	1	3	1	2	1			1					1						1						
40	15	2	4	2	3																	1						
41	1	5	1																			1						
42	1	1			1																							
43		4	2																									
44	2			1																								
45																												
46																												
Totals	12371	7602	327	1258	352	352	544	487	295	451	796	332	266	672	464	1262	1039	1216	460	1176	943	464	930	1143	1093	1056	1275	

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

<i>Parameter</i>	<i>Productivity</i>			<i>Species</i>	<i>Score</i>
	<i>Low</i>	<i>Medium</i>	<i>High</i>	<i>Black drum</i>	
<i>M</i>	<0.2	0.2 - 0.5	>0.5	0.10	1
<i>K</i>	<0.15	0.15 - 0.33	>0.33	0.16	2
<i>t_{mat}</i>	>8	3.3 - 8	<3.3	6	2
<i>t_{max}</i>	>25	14 - 25	<14	44	1
Examples	orange roughy, many sharks	cod, hake	sardine, anchovy	Black Drum Productivity Score = 1.50	

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

<i>Year</i>	<i>n</i>	<i>%Pos</i>	<i>CPUE</i>	<i>IOA</i>	<i>CV</i>
1985	83	17%	0.27	0.37	0.63
1986	92	23%	0.30	0.35	0.56
1987	180	20%	1.96	0.54	0.50
1988	165	12%	0.53	0.14	0.59
1989	202	17%	0.18	0.25	0.51
1990	191	20%	0.61	0.50	0.50
1991	207	23%	2.88	0.67	0.48
1992	220	23%	2.38	0.66	0.47
1993	225	18%	0.80	0.43	0.50
1994	213	20%	0.94	0.54	0.49
1995	215	27%	1.98	0.92	0.45
1996	216	30%	2.41	1.34	0.43
1997	219	26%	1.26	0.96	0.45
1998	223	34%	1.70	1.59	0.40
1999	217	29%	3.29	1.34	0.43
2000	209	33%	1.65	1.92	0.41
2001	219	35%	1.29	1.26	0.40
2002	217	29%	0.66	1.11	0.43
2003	222	27%	1.64	0.89	0.44
2004	222	33%	0.60	1.03	0.41
2005	215	39%	0.57	1.35	0.38
2006	217	39%	0.73	1.43	0.37
2007	226	32%	0.32	0.93	0.41
2008	219	38%	0.90	1.55	0.38
2009	222	36%	0.54	1.52	0.39
2010	508	33%	0.46	1.17	0.36
2011	543	32%	0.44	1.21	0.37
2012	515	37%	0.37	1.46	0.34
2013	263	34%	0.42	1.32	0.38
2014	263	27%	0.58	1.29	0.42
2015	271	30%	0.36	0.97	0.40
2016	271	27%	0.30	0.66	0.43
2017	269	38%	0.43	1.49	0.36
2018	265	30%	0.27	0.86	0.40

Table 10: Annual commercial black drum catch-at-age and yield (pounds), and ASAP base model input coefficients of variation.

Year	Commercial Catch-at-age										Yield (lbs)	CV
	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10+		
1982	1,577	16,208	16,616	10,522	8,091	7,853	7,953	7,779	7,313	75,198	1,690,683	0.10
1983	1,734	17,820	18,269	11,569	8,896	8,634	8,744	8,553	8,041	82,677	1,858,847	0.10
1984	1,843	18,939	19,416	12,295	9,454	9,176	9,293	9,090	8,546	87,870	1,975,592	0.10
1985	3,191	32,799	33,624	21,292	16,372	15,892	16,094	15,742	14,799	152,170	3,421,267	0.10
1986	4,875	50,096	51,357	32,521	25,007	24,272	24,581	24,044	22,604	232,421	5,225,567	0.10
1987	7,482	76,893	78,829	49,917	38,383	37,256	37,729	36,905	34,695	356,745	8,020,765	0.10
1988	8,169	83,948	86,062	54,498	41,906	40,674	41,192	40,291	37,878	389,481	8,756,764	0.10
1989	91,461	266,223	163,569	76,635	40,105	23,797	15,979	12,041	9,896	119,104	4,405,495	0.10
1990	59,695	173,758	106,758	50,018	26,176	15,532	10,429	7,859	6,459	77,737	2,875,374	0.10
1991	39,734	115,658	71,061	33,293	17,423	10,339	6,942	5,231	4,299	51,743	1,913,922	0.10
1992	62,570	182,127	111,900	52,427	27,436	16,280	10,932	8,238	6,770	81,481	3,013,870	0.10
1993	65,976	192,041	117,991	55,281	28,930	17,166	11,527	8,686	7,139	85,916	3,177,916	0.10
1994	3,987	152,201	125,404	68,242	35,978	19,786	11,526	7,169	4,813	83,252	3,738,821	0.10
1995	5,601	267,872	208,348	103,569	50,527	25,949	14,194	8,289	5,179	29,334	2,999,438	0.10
1996	957	17,802	19,013	12,919	9,187	7,205	5,966	5,082	4,416	62,532	1,619,098	0.10
1997	2,717	55,634	57,285	38,419	24,752	16,646	11,637	8,365	6,165	39,208	1,643,434	0.10
1998	2,058	68,465	71,970	42,838	25,462	16,488	11,348	8,130	6,021	41,461	1,782,122	0.10
1999	453	99,759	140,806	81,437	41,832	23,050	13,797	8,826	5,971	30,502	2,199,519	0.05
2000	767	123,226	210,340	132,167	68,706	36,815	21,010	12,652	7,955	20,494	2,842,724	0.05
2001	6,564	272,795	280,333	148,241	69,253	32,781	16,335	8,633	4,831	9,285	3,197,869	0.05
2002	4,794	211,432	296,418	74,193	46,517	30,907	17,470	7,263	5,420	26,721	3,148,252	0.05
2003	10,732	29,579	243,656	240,826	79,036	25,206	32,193	7,425	2,286	10,185	3,494,846	0.05
2004	287	55,568	75,166	299,779	139,450	39,947	32,825	34,062	4,079	3,957	3,708,306	0.05
2005	8,697	95,805	119,373	45,055	105,756	55,273	15,056	5,775	5,784	9,448	2,392,317	0.05
2006	5,492	77,771	98,697	100,742	15,536	48,444	12,595	5,579	3,690	6,775	1,930,433	0.05
2007	3,475	153,722	93,419	64,539	47,820	9,495	34,956	12,525	3,423	6,995	2,353,166	0.05
2008		56,985	215,947	81,349	29,549	25,464	6,305	17,595	10,122	7,574	2,443,452	0.05
2009	8,190	51,519	466,707	130,710	21,065	9,392	15,012	3,614	9,344	15,921	3,132,906	0.05
2010	1,772	6,582	74,671	279,485	75,118	28,167	14,419	16,445	2,686	10,726	2,817,695	0.05
2011	764	32,144	205,158	121,129	231,807	21,813	10,601	3,359	3,566	6,826	3,771,672	0.05
2012	3,396	74,976	120,661	302,781	87,293	118,258	19,365	8,607	546	7,715	4,178,839	0.05
2013	6,759	262,698	92,220	33,940	169,064	35,980	62,076	11,395	800	9,209	3,878,368	0.05
2014	1,908	125,774	263,682	55,306	27,650	24,578	3,081	15,391	5,598	48,429	3,332,461	0.05
2015	2,585	39,864	262,169	166,862	77,332	38,033	35,924	13,843	22,666	34,256	4,278,500	0.05
2016	8,035	36,778	134,521	324,444	101,302	16,009	7,451	8,779	2,640	28,527	3,876,423	0.05
2017	18,880	92,687	143,859	102,285	137,849	33,112	5,765	1,414	13,126	30,555	3,411,888	0.05
2018	11,463	99,433	92,856	61,778	30,059	42,739	18,646	9,327	2,376	45,132	2,758,470	0.05

Table 11: Annual recreational black drum catch-at-age and yield (pounds), and ASAP base model input coefficients of variation.

Recreational Catch-at-age												
Year	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10+	Yield (lbs)	CV
1982	314,817	86,361	37,087	12,783	4,847	2,702	2,089	1,855	1,712	33,957	1,438,736	0.23
1983	227,247	153,688	119,786	70,768	32,082	14,673	7,432	4,235	2,697	28,662	2,228,255	0.34
1984	79,873	45,391	14,150	6,301	3,071	1,846	1,491	1,441	1,449	23,263	738,672	0.32
1985	86,144	18,785	6,480	3,832	2,381	1,519	1,022	729	551	6,339	312,325	0.43
1986	181,451	64,680	21,653	9,585	5,518	3,629	2,605	2,030	1,696	26,660	1,026,147	0.30
1987	137,215	53,418	18,061	12,242	8,559	5,603	3,611	2,391	1,672	31,406	1,260,175	0.26
1988	76,879	39,857	15,890	8,261	4,882	3,181	2,181	1,544	1,130	16,631	714,172	0.31
1989	57,593	23,792	11,546	6,094	3,983	2,841	2,081	1,552	1,185	15,468	595,246	0.23
1990	33,211	26,132	22,122	13,033	7,301	4,210	2,521	1,570	1,020	5,611	427,337	0.21
1991	32,687	29,102	10,843	6,065	3,715	2,520	1,870	1,453	1,154	10,327	416,951	0.24
1992	43,699	56,654	20,539	9,387	5,258	3,239	2,130	1,497	1,126	16,173	744,945	0.30
1993	47,946	49,131	30,427	15,355	7,562	3,968	2,253	1,379	904	6,592	551,663	0.17
1994	20,015	39,001	22,205	10,340	5,069	2,774	1,644	1,023	660	4,464	412,243	0.21
1995	25,854	60,866	35,296	14,227	6,025	2,801	1,408	756	431	2,415	463,597	0.34
1996	54,285	60,154	38,859	19,168	9,104	4,386	2,229	1,225	739	5,077	604,637	0.18
1997	49,617	75,767	44,842	21,862	10,665	5,328	2,766	1,516	894	8,342	757,628	0.22
1998	42,103	122,488	87,974	45,343	22,082	11,023	5,828	3,311	2,038	22,678	1,620,053	0.19
1999	40,633	114,140	80,469	36,067	16,028	7,758	4,108	2,358	1,454	6,166	1,021,341	0.16
2000	33,961	131,708	121,013	69,900	36,227	18,833	10,238	5,906	3,635	15,317	1,780,811	0.17
2001	52,646	119,074	91,712	52,289	27,778	14,832	8,268	4,895	3,101	18,572	1,591,678	0.17
2002	48,910	125,139	110,159	47,962	25,836	25,546	6,463	4,111	2,730	16,255	1,546,819	0.15
2003	31,876	34,491	100,013	57,252	27,083	9,777	15,698	5,826	4,413	36,942	1,872,482	0.17
2004	30,097	56,086	31,858	69,139	26,095	4,385	2,874	3,175	1,365	13,178	1,051,852	0.16
2005	17,009	51,506	69,790	17,495	28,386	4,248	4,470	2,425	3,173	18,832	1,149,987	0.16
2006	38,727	44,392	55,037	28,881	10,743	9,579	7,194	5,612	4,334	23,031	1,149,629	0.30
2007	21,684	69,696	36,631	22,711	13,248	5,420	6,337	3,443	2,898	29,177	1,215,216	0.16
2008	27,875	136,949	74,400	15,995	7,286	6,946	2,952	2,498	2,099	23,690	1,367,095	0.16
2009	51,229	54,505	217,762	25,413	4,088	2,670	2,539	2,136	1,979	19,546	1,529,159	0.17
2010	25,305	105,328	44,454	88,891	4,123	2,164	2,187	3,086	1,762	20,179	1,223,640	0.16
2011	33,065	95,412	137,098	15,328	17,246	5,306	2,555	3,007	2,654	17,166	1,357,427	0.15
2012	26,105	91,149	77,644	67,195	8,395	5,565	3,673	2,966	2,400	23,954	1,448,694	0.16
2013	41,778	138,717	40,671	25,170	6,637	1,573	3,269	1,669	537	9,452	951,511	0.13
2014	19,675	89,051	84,752	16,673	8,313	4,758	1,244	1,216	673	9,814	1,004,376	0.08
2015	15,139	31,059	117,620	34,645	10,521	5,763	4,023	1,537	1,486	15,566	1,087,113	0.07
2016	22,323	23,615	37,317	43,769	8,298	2,362	1,267	1,819	823	6,972	604,396	0.08
2017	19,260	53,895	42,014	13,320	14,277	2,415	1,557	836	1,077	6,534	623,611	0.07
2018	20,752	65,066	32,262	16,206	7,508	5,569	2,452	1,611	1,329	10,968	700,484	0.09

Table 12: Annual mean weights-at-age (pounds) of commercial and recreational black drum landings.

Commercial Mean Weight-at-age											Recreational Mean Weight-at-age										
Year	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10+	Year	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10+
1982	1.26	2.78	3.77	4.98	6.98	8.91	10.24	11.16	11.86	15.25	1982	0.78	2.17	3.22	3.68	4.72	6.87	9.06	10.69	11.91	21.80
1983	1.26	2.78	3.77	4.98	6.98	8.91	10.24	11.16	11.86	15.25	1983	0.97	2.31	3.89	4.38	4.69	5.14	5.80	6.69	7.81	19.45
1984	1.26	2.78	3.77	4.98	6.98	8.91	10.24	11.16	11.86	15.25	1984	1.01	1.99	3.29	4.29	5.25	7.04	9.57	11.58	12.83	17.87
1985	1.26	2.78	3.77	4.98	6.98	8.91	10.24	11.16	11.86	15.25	1985	0.72	2.04	3.49	4.86	5.81	6.71	7.63	8.62	9.67	20.07
1986	1.26	2.78	3.77	4.98	6.98	8.91	10.24	11.16	11.86	15.25	1986	0.82	2.09	3.21	4.50	5.80	6.96	8.19	9.55	10.94	19.20
1987	1.26	2.78	3.77	4.98	6.98	8.91	10.24	11.16	11.86	15.25	1987	0.79	2.05	3.54	5.16	6.04	6.64	7.18	7.85	8.80	24.43
1988	1.26	2.78	3.77	4.98	6.98	8.91	10.24	11.16	11.86	15.25	1988	0.90	2.13	3.43	4.64	5.81	6.84	7.67	8.41	9.19	22.63
1989	1.09	2.51	3.43	4.40	5.43	6.53	7.84	9.33	10.78	16.99	1989	0.79	2.26	3.43	4.79	6.15	7.23	8.09	8.86	9.66	21.98
1990	1.09	2.51	3.43	4.40	5.43	6.53	7.84	9.33	10.78	16.99	1990	0.72	2.56	3.74	4.66	5.48	6.17	6.73	7.22	7.71	16.21
1991	1.09	2.51	3.43	4.40	5.43	6.53	7.84	9.33	10.78	16.99	1991	1.14	2.12	3.45	4.77	5.89	7.16	8.32	9.27	10.07	16.55
1992	1.09	2.51	3.43	4.40	5.43	6.53	7.84	9.33	10.78	16.99	1992	1.00	2.19	3.24	4.51	5.63	6.57	7.49	8.52	9.69	23.34
1993	1.09	2.51	3.43	4.40	5.43	6.53	7.84	9.33	10.78	16.99	1993	0.91	2.38	3.56	4.39	5.11	5.80	6.48	7.19	7.95	18.47
1994	1.75	2.68	3.64	4.53	5.30	5.98	6.62	7.36	8.37	24.97	1994	1.02	2.42	3.44	4.31	5.19	6.04	6.71	7.20	7.57	24.60
1995	1.83	2.69	3.55	4.37	5.06	5.65	6.17	6.71	7.37	16.79	1995	0.98	2.53	3.32	4.03	4.68	5.19	5.57	5.86	6.16	21.59
1996	0.81	2.81	3.85	5.02	6.41	7.79	9.02	10.14	11.20	18.56	1996	0.94	2.51	3.51	4.36	4.90	5.28	5.67	6.23	7.10	17.66
1997	1.63	2.72	3.87	4.92	5.97	6.96	7.80	8.53	9.19	15.18	1997	0.84	2.43	3.48	4.38	5.02	5.44	5.74	6.10	6.75	19.86
1998	1.66	2.81	3.76	4.71	5.79	6.84	7.74	8.54	9.29	15.45	1998	1.06	2.57	3.59	4.41	5.00	5.48	5.94	6.50	7.28	22.23
1999	2.15	3.04	3.84	4.50	5.25	6.07	6.84	7.56	8.27	13.73	1999	0.94	2.62	3.47	4.16	4.81	5.42	6.00	6.57	7.17	13.90
2000	2.07	3.11	3.97	4.58	5.21	5.87	6.45	6.91	7.27	7.97	2000	0.94	2.70	3.74	4.56	5.16	5.65	6.10	6.58	7.16	13.07
2001	1.75	2.83	3.70	4.36	4.84	5.20	5.48	5.70	5.87	6.23	2001	0.97	2.58	3.68	4.60	5.25	5.78	6.28	6.85	7.55	16.98
2002	1.61	2.60	3.93	4.88	6.12	6.14	6.65	8.89	9.13	13.42	2002	1.30	2.47	3.18	4.09	4.97	4.68	6.90	7.43	8.02	17.37
2003	2.30	3.48	3.66	5.55	6.40	7.71	7.39	8.49	10.38	11.39	2003	1.34	2.48	3.44	4.35	5.18	7.83	6.12	8.89	9.47	20.15
2004	1.89	3.08	4.25	4.36	6.58	8.05	8.37	8.83	10.47	13.09	2004	1.67	2.62	3.61	3.64	4.20	6.72	7.32	6.63	8.77	22.37
2005	2.37	3.63	3.84	5.29	5.37	6.81	7.75	8.89	9.11	17.06	2005	1.21	2.71	3.31	4.73	4.52	7.65	7.01	8.79	7.31	23.33
2006	2.88	3.60	4.06	5.40	5.60	7.12	8.04	8.25	7.55	12.33	2006	2.03	3.04	3.42	4.79	7.12	7.73	8.56	9.13	9.61	13.21
2007	2.04	3.67	5.07	5.69	7.21	7.23	8.36	9.15	8.87	13.00	2007	1.37	2.86	3.76	4.87	5.52	7.71	7.78	10.00	10.65	17.42
2008		2.85	4.46	5.75	7.51	7.88	8.45	9.28	10.12	14.35	2008	0.92	2.85	3.74	4.72	6.16	6.55	9.17	9.91	10.73	18.30
2009	1.53	2.42	3.46	5.22	7.59	8.70	8.83	9.58	9.95	12.23	2009	1.42	2.52	3.21	5.10	7.42	7.73	10.20	11.13	11.59	18.73
2010	2.24	2.44	3.43	4.93	6.72	8.63	8.69	9.44	10.38	9.98	2010	0.99	2.46	2.99	3.89	6.29	9.32	9.86	8.02	11.18	17.23
2011	1.75	3.23	4.32	6.30	6.69	8.43	9.51	10.18	10.20	16.12	2011	1.39	2.82	3.44	4.58	6.17	8.67	9.27	9.63	10.05	15.62
2012	1.93	2.99	4.13	5.39	6.68	7.50	8.80	9.64	11.80	11.61	2012	0.96	2.68	3.54	4.81	6.95	7.84	8.84	9.49	10.34	16.45
2013	2.04	3.84	5.25	6.10	6.83	7.24	7.80	9.15	13.09	16.42	2013	1.33	2.70	3.43	4.12	5.19	8.92	10.38	10.46	9.75	18.26
2014	1.54	2.92	4.40	5.85	6.28	8.02	10.00	10.93	12.46	17.33	2014	1.21	2.71	3.76	5.13	7.06	9.13	9.02	10.45	11.33	20.53
2015	1.41	2.88	3.93	6.08	7.89	7.94	9.03	10.04	10.94	14.35	2015	0.91	2.74	3.25	4.75	6.49	7.31	7.41	11.08	11.66	17.13
2016	2.91	3.28	4.25	5.36	6.84	8.05	8.63	10.31	12.69	14.39	2016	1.79	2.70	3.27	4.10	4.92	6.52	8.69	6.97	10.31	15.84
2017	2.60	3.56	4.16	5.72	6.73	8.82	9.46	10.95	10.78	13.71	2017	1.42	2.92	3.63	4.99	4.77	7.17	7.24	9.93	8.42	16.23
2018	2.79	3.80	4.92	6.04	6.59	8.24	10.78	12.31	12.09	13.83	2018	1.44	2.95	3.65	4.18	4.99	5.46	8.30	9.80	10.41	16.02

Table 14: Annual black drum catch-at-size from the LDWF fishery-independent marine trammel net survey.

Survey, 1985-2001																	
TL_in	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
4				1						1							
5			1														
6			1			1											1
7																	
8		2										1	1	3	1		
9	1	2	163		9	12	139	217	27	65	88	332	51	220	81	18	2
10	10	4	313	10	18	43	603	665	123	189	505	960	88	659	777	116	37
11	1	4	277	6	12	100	608	294	55	54	224	231	70	195	601	56	52
12	2		36	1		58	145	32	23	42	55	48	163	29	140	56	185
13	2	3	11	4	2	29	16	5	39	21	32	4	175	19	53	65	198
14	2	4	7	5	7	16	20	23	22	21	55	12	71	50	67	136	89
15	4	15	6	6	3	3	14	38	35	18	107	40	33	48	106	106	75
16	8	15	3	7	2	5	4	52	12	9	71	59	7	22	97	78	45
17	3	8	1	5	1	4	11	17	10	10	34	16	30	29	113	94	137
18	2	6		5			14	25	7	15	60	17	27	35	88	107	81
19	2	3	1	10	1	3	7	8	10	13	45	19	18	30	100	116	37
20			1	10	1	1	2	2	4	3	14	12	22	30	68	110	55
21			1	19	1	1		4	5	2	13	35	21	27	62	121	54
22				14	3						8	22	13	22	28	87	40
23				6	2				1		6	12	7	16	17	43	31
24			1	7				1			1	4	11	20	17	22	25
25				5							1	3	5	14	4	9	6
26	1		1		1	1							2	9	1	2	1
27	1													3	1	2	
28	1	3			1								2		5	1	1
29	2							1						1	1	1	1
30						1							1	3		1	1
31					1									1		1	2
32					2								2				2
33			1					2		1		1	1			3	
34					2	1								1	2	1	
35	1							3				1	4	1		1	
36		1		1			1	1									2
37											2					1	2
38																	
39		1										1					1
40		1												1			1
41																	
42																	
Totals	44	72	825	122	70	278	1586	1393	373	464	1321	1830	826	1488	2430	1354	1166

Table 14 (continued):

Survey, 2002-2018																	
TL_in	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
4																	
5				1													
6					2	1	5	4				1					
7																	
8	24	26	7	37	77	9	221	34	22	33	46	27	6	4	3	9	3
9	76	141	21	71	292	22	202	51	25	123	75	36	11	10	34	56	29
10	25	142	112	25	113	23	51	54	21	50	55	9	16	17	23	33	24
11	4	95	36	17	24	16	15	40	18	14	35	25	12	20	17	38	15
12	12	149	20	17	3	26	30	35	11	15	32	22	26	16	4	22	10
13	21	253	29	25	13	18	22	23	18	13	25	22	20	18	6	12	9
14	33	114	16	25	12	7	31	25	26	18	18	22	16	17	12	16	8
15	26	27	8	49	8	5	23	22	31	23	14	38	18	8	10	18	5
16	42	23	15	53	10	6	23	19	46	26	12	25	18	16	9	16	5
17	28	32	18	42	5	7	19	19	68	35	11	20	20	15	11	12	5
18	28	21	12	41	6	9	15	15	62	41	6	20	15	6	8	9	5
19	23	13	22	35	9	2	4	17	65	48	9	15	8	13	13	17	11
20	19	19	19	11	17	8	7	28	59	41	23	10	7	10	12	15	5
21	30	30	20	8	15	5	10	21	60	64	35	9	5	13	10	19	7
22	19	19	17	11	14	14	10	21	77	80	44	6	12	11	13	29	4
23	20	16	9	14	7	13	9	15	42	36	37	7	15	17	10	27	5
24	13	5	10	13	13	12	11	10	23	26	64	17	13	17	2	20	5
25	6	5	11	9	9	14	13	11	22	42	52	11	23	17	8	16	3
26	7	4	30	5	15	2	11	2	34	28	35	9	22	23	6	18	10
27	5	2	50	13	13	8	10	6	26	27	46	22	23	17	6	18	8
28	1	2	12	8	11	8	17	1	25	23	21	5	16	12	2	19	11
29	1	3	4	4	4	5	11	3	21	17	23	9	18	15	10	16	10
30	2	2	4	4	8	10	16	4	17	14	19	11	31	12	6	10	11
31			8	3	4	3	15	4	16	15	11	7	36	6	1	11	7
32	1	2	5	1	2	4	7	6	16	7	27	10	24	4	5	8	8
33	2	2	5	4	5	3	14	4	11	9	15	4	16	1	6	13	9
34	1	2	1	2	4	5	11	1	12	5	9	2	21	5	4	8	8
35	1	5		3	5		11	2	6	9	12	4	8	1		6	6
36		1			3	4	15	2	5	2	7	5	2			3	3
37	2			1	1	1	11		5		3	1	2		1		
38	1		1		2		5	1	6			1			1	1	2
39							2	1	4		4	2	3			2	
40							1		5	1				1			
41	1								1			1					
42				1													
Totals	474	1155	522	553	726	270	878	501	906	885	825	435	483	342	253	517	251

Table 15: Annual black drum survey age composition and sample sizes (> age-0) derived from the LDWF fishery-independent marine trammel net survey.

Year	n>Age-0	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10+
1985	30	0.527	0.188	0.041	0.015	0.015	0.018	0.019	0.018	0.016	0.141
1986	60	0.623	0.220	0.044	0.010	0.004	0.004	0.004	0.005	0.005	0.082
1987	42	0.807	0.077	0.032	0.019	0.013	0.009	0.006	0.004	0.003	0.031
1988	104	0.226	0.229	0.214	0.137	0.077	0.043	0.024	0.014	0.008	0.028
1989	31	0.435	0.096	0.087	0.062	0.037	0.024	0.017	0.014	0.012	0.216
1990	72	0.842	0.090	0.027	0.010	0.005	0.003	0.002	0.002	0.001	0.017
1991	119	0.750	0.178	0.047	0.011	0.003	0.001	0.000	0.000	0.000	0.009
1992	191	0.649	0.226	0.057	0.018	0.007	0.003	0.002	0.001	0.001	0.036
1993	144	0.748	0.166	0.057	0.019	0.006	0.002	0.001	0.000	0.000	0.000
1994	118	0.657	0.231	0.072	0.020	0.006	0.002	0.001	0.000	0.000	0.009
1995	457	0.604	0.247	0.087	0.032	0.013	0.006	0.003	0.002	0.001	0.006
1996	269	0.451	0.223	0.146	0.081	0.041	0.020	0.011	0.006	0.003	0.018
1997	460	0.663	0.143	0.077	0.041	0.023	0.013	0.008	0.005	0.003	0.025
1998	387	0.402	0.217	0.135	0.083	0.051	0.032	0.020	0.013	0.009	0.039
1999	852	0.459	0.280	0.134	0.059	0.028	0.014	0.008	0.005	0.003	0.011
2000	1110	0.385	0.261	0.167	0.086	0.042	0.021	0.011	0.006	0.004	0.016
2001	896	0.533	0.214	0.109	0.058	0.030	0.016	0.009	0.005	0.003	0.021
2002	345	0.320	0.227	0.143	0.093	0.059	0.038	0.025	0.017	0.012	0.067
2003	750	0.712	0.108	0.057	0.037	0.022	0.014	0.009	0.006	0.004	0.032
2004	352	0.240	0.129	0.102	0.075	0.062	0.055	0.048	0.040	0.033	0.216
2005	401	0.346	0.258	0.116	0.060	0.040	0.029	0.022	0.017	0.013	0.100
2006	223	0.196	0.107	0.107	0.087	0.069	0.055	0.045	0.036	0.030	0.268
2007	201	0.288	0.092	0.079	0.077	0.066	0.052	0.041	0.033	0.027	0.246
2008	384	0.293	0.113	0.055	0.041	0.035	0.031	0.027	0.024	0.022	0.359
2009	322	0.353	0.166	0.128	0.088	0.057	0.037	0.025	0.018	0.013	0.115
2010	823	0.142	0.192	0.151	0.103	0.069	0.048	0.036	0.027	0.022	0.210
2011	666	0.127	0.155	0.151	0.118	0.085	0.061	0.045	0.035	0.027	0.196
2012	617	0.152	0.058	0.081	0.093	0.086	0.072	0.058	0.046	0.037	0.316
2013	339	0.329	0.162	0.079	0.051	0.042	0.035	0.030	0.026	0.022	0.223
2014	438	0.196	0.093	0.051	0.044	0.043	0.041	0.038	0.035	0.032	0.426
2015	293	0.231	0.113	0.084	0.075	0.068	0.059	0.049	0.041	0.034	0.246
2016	179	0.214	0.159	0.125	0.088	0.061	0.044	0.034	0.027	0.023	0.226
2017	385	0.199	0.101	0.095	0.086	0.070	0.056	0.044	0.036	0.030	0.283
2018	182	0.193	0.094	0.071	0.051	0.041	0.037	0.035	0.032	0.030	0.416

Table 16: Summary of objective function components and likelihood values of the ASAP base model.

Objective function=		4169.9		
Component	Lambda	ESS	negLL	
Catch_Recreational	1	--	-62.8	
Catch_Commercial	1	--	-99.0	
IOA	1	--	9.8	
Catch_agecomps	--	2100	3727.9	
IOA_agecomps	--	340	600.8	
Selectivity_parms_catch	20	--	6.3	
Recruitment_devs	1	--	-13.1	

Table 17: Annual black drum abundance-at-age and total stock size estimates from the ASAP base model.

Year	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10+	Totals
1982	1,404,240	658,297	445,886	314,145	261,069	240,706	224,555	222,509	222,948	3,653,520	7,647,875
1983	1,231,060	868,345	437,427	315,399	235,838	205,042	195,521	186,643	188,401	3,431,940	7,295,616
1984	1,117,420	621,622	473,311	265,125	211,716	171,348	157,914	156,691	154,096	3,170,550	6,499,793
1985	1,494,980	746,934	441,554	348,820	203,766	167,985	139,280	130,534	131,515	2,926,530	6,731,898
1986	1,576,190	1,078,860	557,361	328,186	265,201	157,796	132,021	110,690	105,192	2,628,690	6,940,187
1987	1,479,620	1,007,400	692,211	354,586	218,208	183,163	112,233	96,001	82,468	2,254,350	6,480,240
1988	1,117,190	898,990	574,738	371,134	199,114	128,161	111,440	70,239	62,205	1,785,100	5,318,311
1989	1,258,520	724,893	518,132	291,569	193,172	107,073	70,810	63,085	41,268	1,335,570	4,604,092
1990	1,594,150	895,467	414,025	286,457	170,081	119,073	69,780	48,693	45,731	1,102,120	4,745,577
1991	1,923,210	1,156,030	567,381	258,726	187,119	116,009	84,762	51,709	37,530	953,725	5,336,201
1992	2,185,940	1,415,400	796,846	391,872	185,509	138,812	88,898	66,879	41,966	850,426	6,162,548
1993	2,690,590	1,581,100	896,005	498,618	256,992	127,277	99,491	66,335	51,877	744,582	7,012,867
1994	2,586,030	1,962,500	1,030,410	578,459	335,412	179,840	92,608	75,084	51,887	667,060	7,559,290
1995	2,414,660	1,901,840	1,322,400	690,498	401,787	241,042	133,720	71,112	59,534	606,806	7,843,399
1996	2,817,680	1,784,460	1,322,120	920,162	497,057	298,367	184,538	105,294	57,573	569,541	8,556,792
1997	4,054,190	2,106,320	1,339,210	1,009,510	723,798	400,577	245,758	154,780	89,844	554,193	10,678,180
1998	3,198,800	3,051,600	1,617,310	989,099	772,247	577,261	331,814	209,559	134,915	579,609	11,462,214
1999	3,115,530	2,385,860	2,277,800	1,163,030	741,294	606,558	472,789	280,594	181,558	640,245	11,865,258
2000	4,364,590	2,342,920	1,823,870	1,669,000	883,543	588,121	500,592	402,174	244,207	737,859	13,556,876
2001	4,561,210	3,253,690	1,727,410	1,263,640	1,208,800	676,137	473,150	418,593	346,150	876,695	14,805,475
2002	1,474,290	3,410,290	2,402,660	1,177,120	900,047	913,248	539,348	393,711	359,400	1,090,210	12,660,324
2003	2,473,410	1,103,520	2,551,660	1,696,540	866,022	696,945	740,959	453,643	340,203	1,296,640	12,219,542
2004	2,046,860	1,844,010	813,983	1,769,490	1,229,740	663,134	560,938	619,759	390,516	1,462,730	11,401,160
2005	1,865,510	1,536,640	1,377,730	559,594	1,268,290	933,388	530,860	468,061	533,273	1,657,340	10,730,686
2006	3,117,340	1,400,160	1,162,990	990,509	418,093	993,594	763,554	448,970	405,893	1,962,870	11,663,973
2007	5,427,610	2,340,330	1,066,090	851,463	752,509	331,731	819,933	649,319	390,593	2,128,230	14,757,808
2008	1,922,270	4,077,540	1,780,520	774,520	642,065	593,672	272,700	695,658	564,189	2,263,110	13,586,244
2009	3,594,830	1,445,850	3,122,110	1,309,790	590,497	510,777	490,875	232,247	605,883	2,540,350	14,443,209
2010	1,870,080	2,698,260	1,092,800	2,233,600	974,120	460,990	416,843	414,538	201,229	2,821,480	13,183,940
2011	1,840,400	1,406,600	2,057,500	792,866	1,681,290	767,429	378,636	353,535	360,172	2,721,410	12,359,838
2012	3,754,380	1,381,760	1,060,690	1,457,910	584,391	1,303,580	623,375	318,834	305,816	2,766,770	13,557,506
2013	4,392,600	2,808,690	1,014,530	706,089	1,015,920	434,191	1,028,080	515,083	272,656	2,748,300	14,936,139
2014	1,849,150	3,309,400	2,122,920	706,112	511,053	776,756	349,443	861,136	444,402	2,713,070	13,643,442
2015	1,851,620	1,395,740	2,541,770	1,537,400	529,741	401,546	637,037	296,237	748,356	2,839,830	12,779,277
2016	2,351,570	1,393,230	1,052,590	1,772,600	1,115,450	405,801	323,552	533,892	255,625	3,213,220	12,417,530
2017	3,316,730	1,776,960	1,064,990	744,058	1,299,740	861,245	328,881	272,307	462,092	3,120,930	13,247,933
2018	2,647,880	2,507,000	1,363,830	761,471	551,296	1,011,530	701,820	277,748	236,167	3,221,900	13,280,642

Table 18: Annual age-specific, apical, and average black drum fishing mortality rates estimated from the ASAP base model.

Year	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10	Apical F	Avg. F
1982	0.21	0.22	0.19	0.15	0.11	0.09	0.07	0.06	0.04	0.03	0.25	0.10
1983	0.41	0.42	0.35	0.26	0.19	0.14	0.11	0.08	0.06	0.04	0.46	0.19
1984	0.13	0.16	0.15	0.13	0.10	0.09	0.08	0.07	0.05	0.03	0.19	0.08
1985	0.06	0.11	0.14	0.14	0.13	0.12	0.12	0.11	0.09	0.06	0.16	0.08
1986	0.18	0.26	0.30	0.27	0.24	0.22	0.20	0.19	0.15	0.10	0.35	0.18
1987	0.23	0.38	0.47	0.44	0.41	0.38	0.35	0.32	0.27	0.17	0.54	0.28
1988	0.16	0.37	0.52	0.52	0.49	0.47	0.46	0.42	0.35	0.23	0.58	0.31
1989	0.07	0.37	0.44	0.40	0.36	0.31	0.26	0.21	0.17	0.13	0.44	0.22
1990	0.05	0.27	0.32	0.29	0.26	0.22	0.19	0.15	0.12	0.09	0.32	0.16
1991	0.04	0.19	0.22	0.20	0.17	0.15	0.12	0.10	0.08	0.06	0.22	0.11
1992	0.05	0.27	0.31	0.28	0.25	0.21	0.18	0.15	0.11	0.09	0.31	0.17
1993	0.05	0.24	0.28	0.26	0.23	0.20	0.17	0.14	0.11	0.08	0.28	0.15
1994	0.04	0.21	0.25	0.23	0.20	0.18	0.15	0.12	0.10	0.07	0.25	0.14
1995	0.03	0.18	0.21	0.19	0.17	0.15	0.12	0.10	0.08	0.06	0.21	0.13
1996	0.02	0.10	0.12	0.10	0.09	0.07	0.06	0.05	0.04	0.03	0.12	0.07
1997	0.02	0.08	0.15	0.13	0.10	0.07	0.05	0.03	0.02	0.01	0.15	0.06
1998	0.02	0.11	0.18	0.15	0.11	0.08	0.05	0.03	0.02	0.01	0.18	0.09
1999	0.02	0.08	0.16	0.14	0.10	0.07	0.05	0.03	0.02	0.01	0.16	0.08
2000	0.02	0.12	0.21	0.19	0.14	0.10	0.06	0.04	0.03	0.02	0.21	0.10
2001	0.02	0.12	0.23	0.20	0.15	0.11	0.07	0.04	0.03	0.02	0.23	0.10
2002	0.02	0.10	0.19	0.17	0.13	0.09	0.06	0.04	0.02	0.01	0.19	0.10
2003	0.02	0.12	0.21	0.18	0.14	0.10	0.06	0.04	0.03	0.02	0.21	0.11
2004	0.02	0.11	0.22	0.20	0.15	0.10	0.07	0.04	0.02	0.01	0.22	0.10
2005	0.02	0.09	0.18	0.15	0.12	0.08	0.05	0.03	0.02	0.01	0.18	0.08
2006	0.02	0.09	0.16	0.14	0.10	0.07	0.05	0.03	0.02	0.01	0.16	0.06
2007	0.02	0.09	0.17	0.15	0.11	0.08	0.05	0.03	0.02	0.01	0.17	0.05
2008	0.02	0.08	0.15	0.13	0.10	0.07	0.05	0.03	0.02	0.01	0.15	0.07
2009	0.02	0.09	0.18	0.16	0.12	0.08	0.06	0.03	0.02	0.01	0.18	0.08
2010	0.02	0.09	0.17	0.15	0.11	0.08	0.05	0.03	0.02	0.01	0.17	0.07
2011	0.02	0.10	0.19	0.17	0.13	0.09	0.06	0.04	0.02	0.01	0.19	0.09
2012	0.02	0.12	0.25	0.22	0.17	0.12	0.08	0.05	0.03	0.02	0.25	0.09
2013	0.01	0.09	0.21	0.19	0.14	0.10	0.06	0.04	0.02	0.01	0.21	0.07
2014	0.01	0.08	0.17	0.15	0.11	0.08	0.05	0.03	0.02	0.01	0.17	0.07
2015	0.02	0.10	0.21	0.18	0.14	0.10	0.06	0.04	0.02	0.01	0.21	0.09
2016	0.01	0.08	0.19	0.17	0.13	0.09	0.06	0.04	0.02	0.01	0.19	0.07
2017	0.01	0.08	0.18	0.16	0.12	0.09	0.05	0.03	0.02	0.01	0.18	0.06
2018	0.01	0.07	0.14	0.13	0.10	0.07	0.04	0.03	0.02	0.01	0.14	0.05

Table 19: Limit and target reference point estimates for the Louisiana black drum stock. Spawning stock biomass units are pounds x 10⁶. Fishing mortality and escapement rate (E) units are years⁻¹.

Management Benchmarks		
Parameters	Derivation	Value
SPR_{limit}	Proposed Limit	20.0%
SSB_{limit}	Equation [24] and SPR _{limit}	16.9
F_{limit}	Equation [24] and SPR _{limit}	0.156
E_{limit}	Equations [24 and 25] and SPR _{limit}	31.7%
SSB_{target}	LAC 76: VII.385 (Geometric mean SSB 1982-2013)	21.0
SPR_{target}	Equation [24] and SSB _{target}	24.9%
F_{target}	Equation [24] and SSB _{target}	0.131
E_{target}	Equations [24 and 25] and SSB _{target}	37.0%

Table 20: 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 and escapement rate units are years⁻¹.

Model run	negLL	SPR_{limit}	Yield_{limit}	F_{limit}	SSB_{limit}	E_{limit}	SPR_{current}	E_{current}	F_{current}/F_{limit}	SSB_{current}/SSB_{limit}
Base Model (<i>h</i> =1)	4169.9	20.0%	4.99	0.16	16.89	31.7%	49.0%	58.7%	0.39	2.45
Model 1 (<i>h</i> =0.9)	4170.0	20.0%	5.05	0.16	17.16	31.5%	49.2%	61.7%	0.35	2.69
Model 2 (<i>h</i> =0.8)	4171.6	20.0%	4.93	0.16	16.81	31.2%	49.8%	65.1%	0.31	3.16
Model 3 (<i>h</i> =0.7)	4173.5	20.0%	4.33	0.16	14.81	30.9%	50.5%	69.0%	0.26	4.26
Model 4 (Yield <i>Lambdas</i> *10)	2708.2	20.0%	4.97	0.16	16.82	31.7%	49.1%	58.7%	0.39	2.46
Model 5 (IOA <i>Lambda</i> *10)	4074.0	20.0%	7.14	0.16	24.54	30.8%	91.4%	79.9%	0.15	4.57
Model 6 (Discard <i>M</i> =0.1)	4175.1	20.0%	4.96	0.16	17.26	31.4%	48.9%	59.2%	0.37	2.44
Model 7 (Growth model ALK's 1982-2018)	4449.0	20.0%	5.39	0.14	19.73	39.9%	54.2%	70.6%	0.35	2.71
Model 8 (ACAL MRIP hindcast)	4170.8	20.0%	4.98	0.16	16.85	31.7%	48.3%	58.5%	0.40	2.41
Model 9 (MRIP Size with FES and APAIS)	4175.8	20.0%	4.99	0.16	16.73	31.7%	48.6%	57.3%	0.41	2.43

Table 21: 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 and escapement rate units are years⁻¹.

Model run	negLL	SPR_{MSY}	MSY	F_{MSY}	SSB_{MSY}	E_{MSY}	SPR_{current}	E_{current}	F_{current}/F_{MSY}	SSB_{current}/SSB_{MSY}
Base Model (<i>h</i> =1)	4169.9	--	--	--	--	--	49.2%	--	--	--
Model 1 (<i>h</i> =0.9)	4170.0	19.2%	5.06	0.16	16.32	30.5%	49.2%	61.7%	0.34	2.83
Model 2 (<i>h</i> =0.8)	4171.6	27.0%	5.13	0.12	25.40	39.0%	49.8%	65.1%	0.39	2.09
Model 3 (<i>h</i> =0.7)	4173.5	34.4%	5.45	0.10	37.57	46.2%	50.5%	69.0%	0.43	1.68

11. Figures

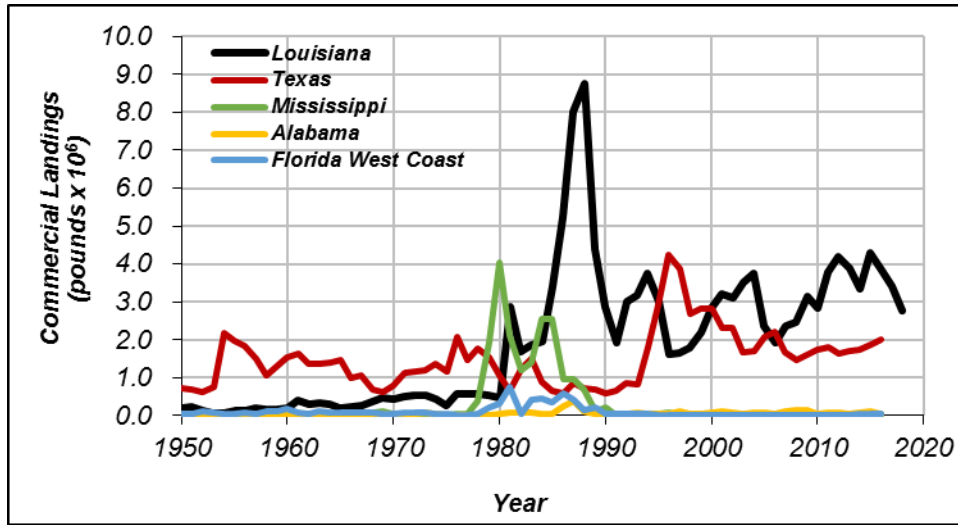


Figure 1: Reported commercial black drum landings (pounds x 10⁶) of the Gulf of Mexico derived from NMFS statistical records and the LDWF Trip Ticket Program.

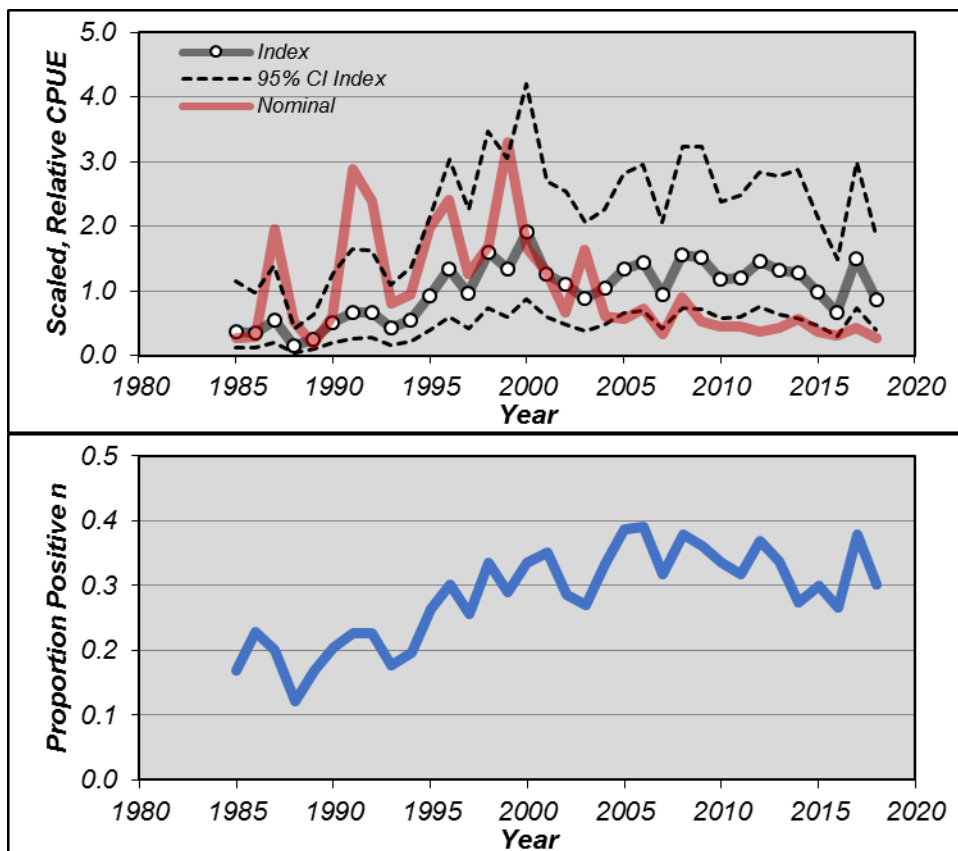


Figure 2: Standardized index of abundance, nominal catch-per-unit-effort, and 95% confidence intervals of the standardized index derived from the LDWF marine trammel net survey (top). Each time-series has been normalized to its individual long-term mean for comparison. Bottom graphic depicts annual observed proportion positive samples of black drum catches from the LDWF marine trammel net survey.

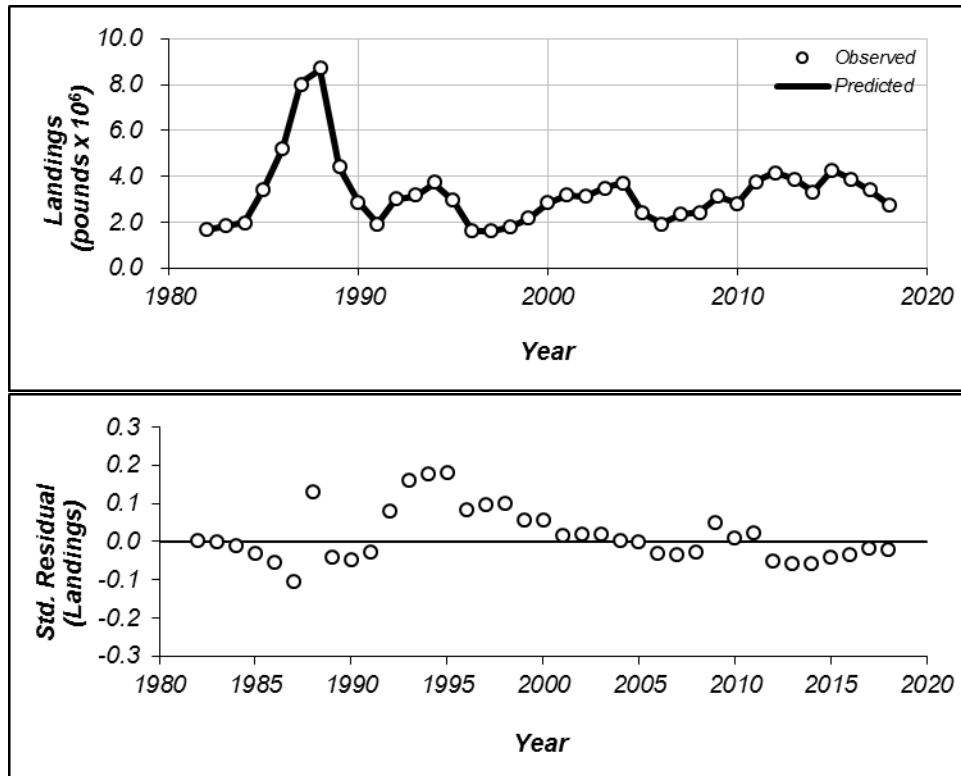


Figure 3: Observed and ASAP base model estimated commercial yield (top) and standardized residuals (bottom).

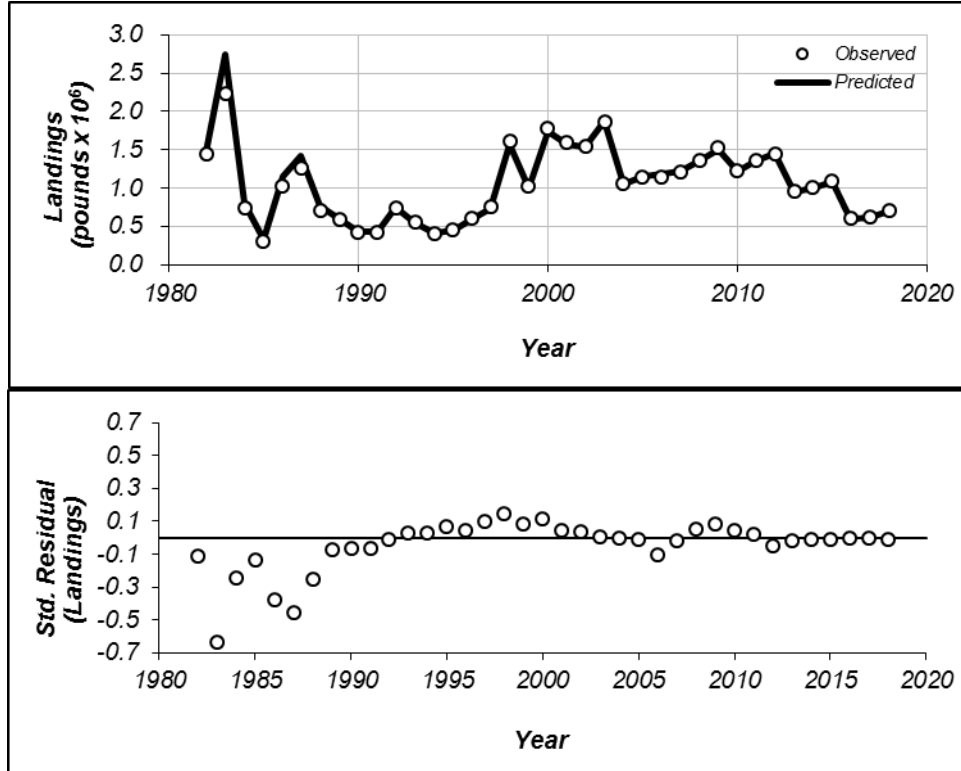


Figure 4: Observed and ASAP base model estimated recreational yield (top) and standardized residuals (bottom).

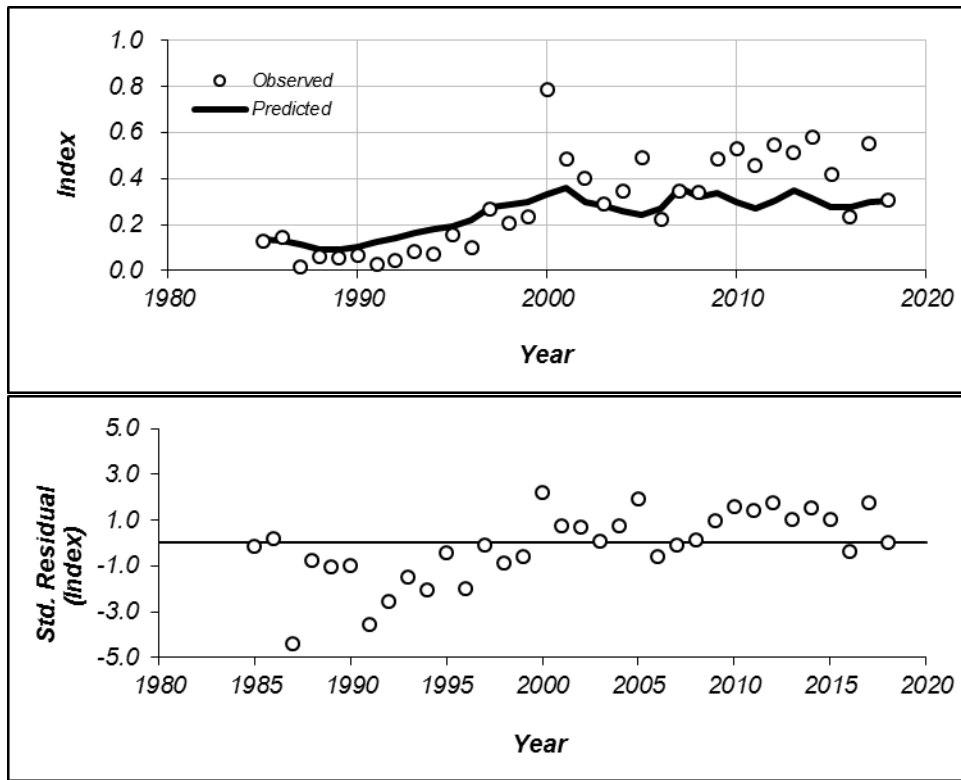


Figure 5: Observed and ASAP base model estimated survey CPUE (top) and standardized residuals (bottom).

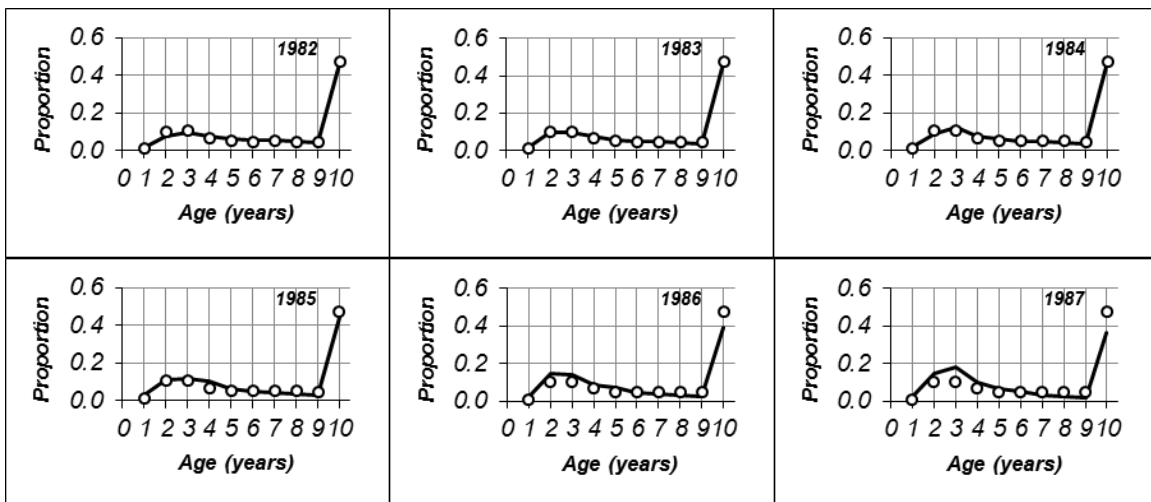


Figure 6: Annual input (open circles) and ASAP estimated (bold lines) commercial black drum harvest age compositions.

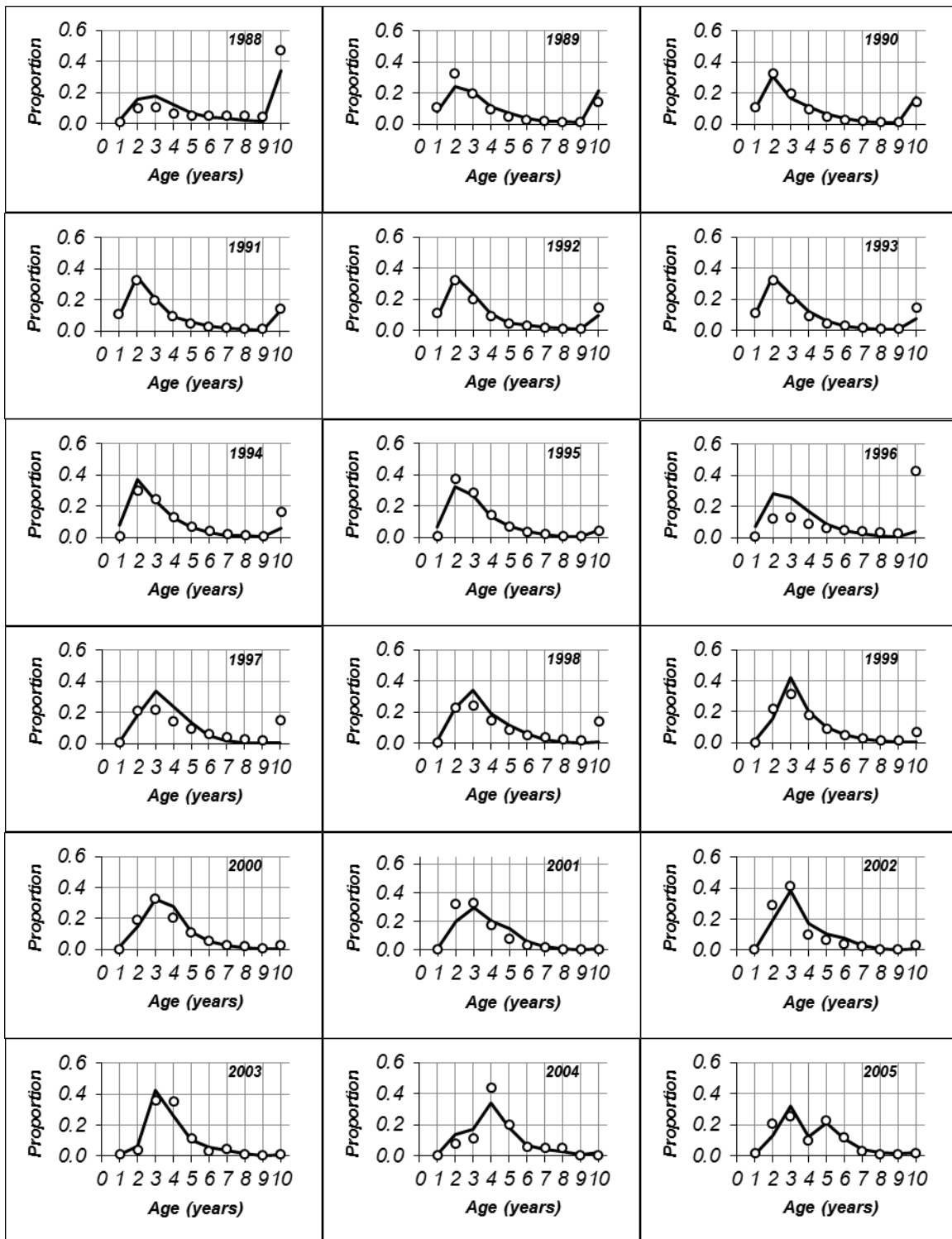


Figure 6 (continued):

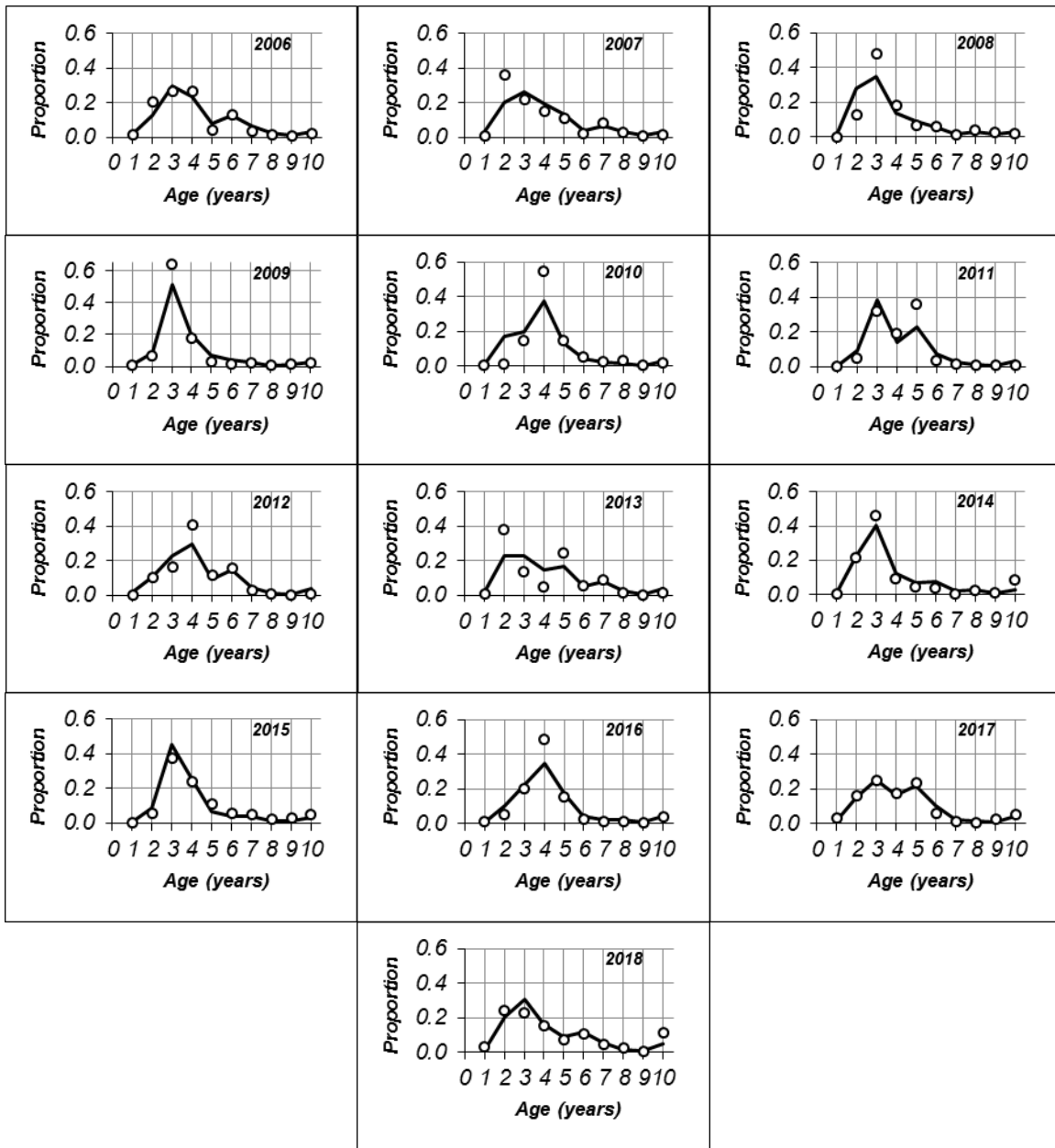


Figure 6 (continued):

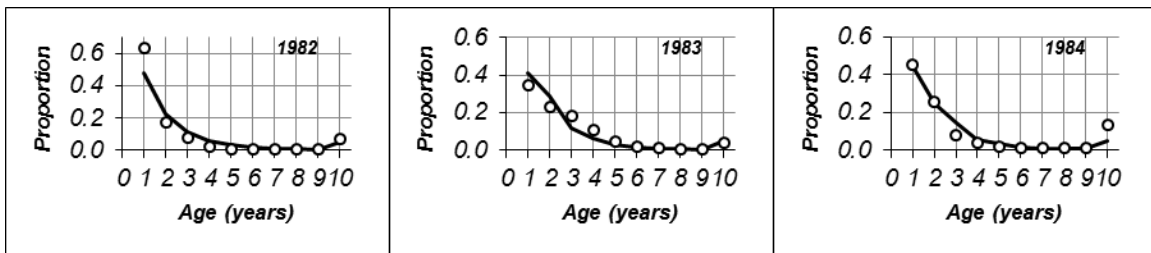


Figure 7: Annual input (open circles) and ASAP estimated (bold lines) recreational black drum harvest age compositions.

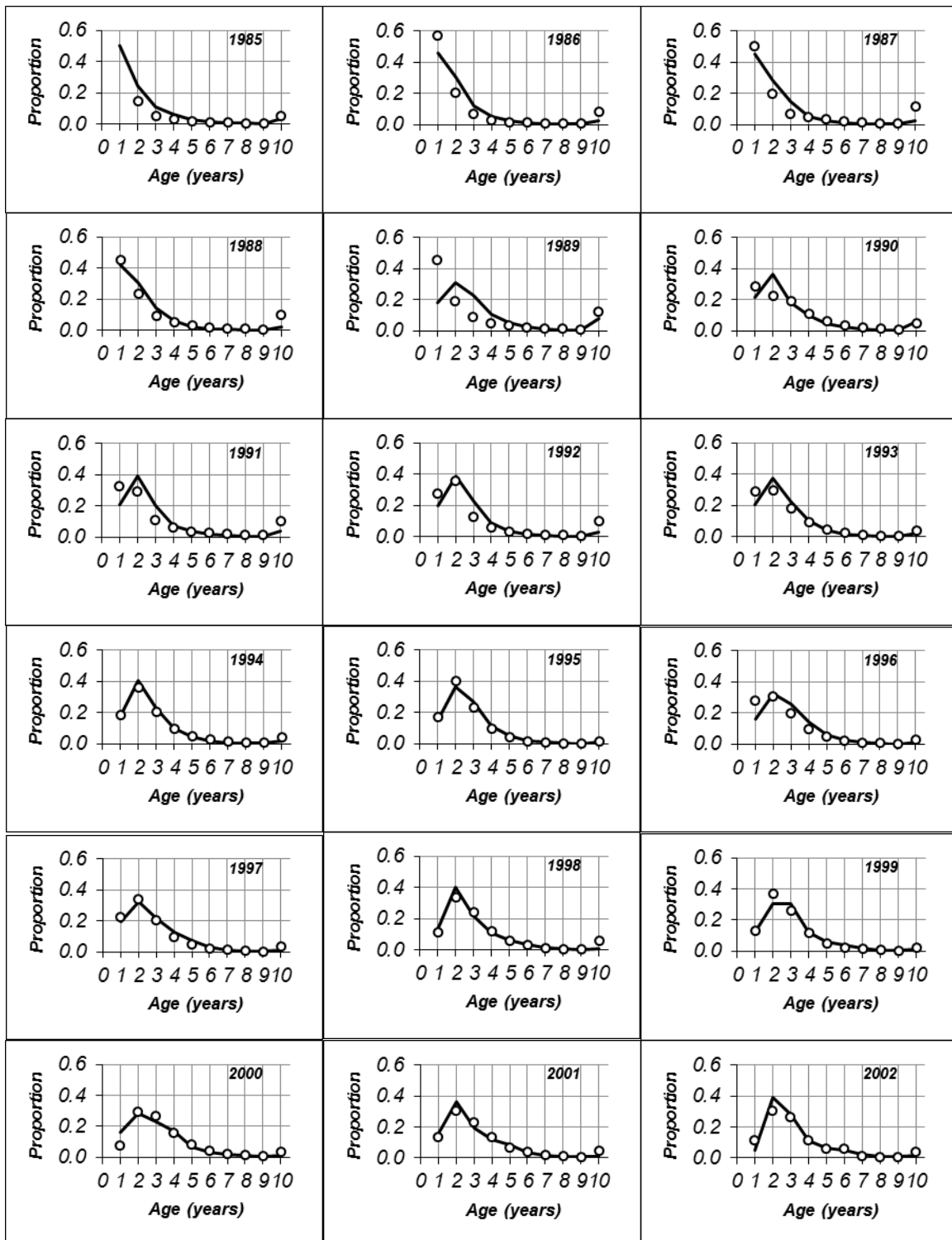


Figure 7 (continued):

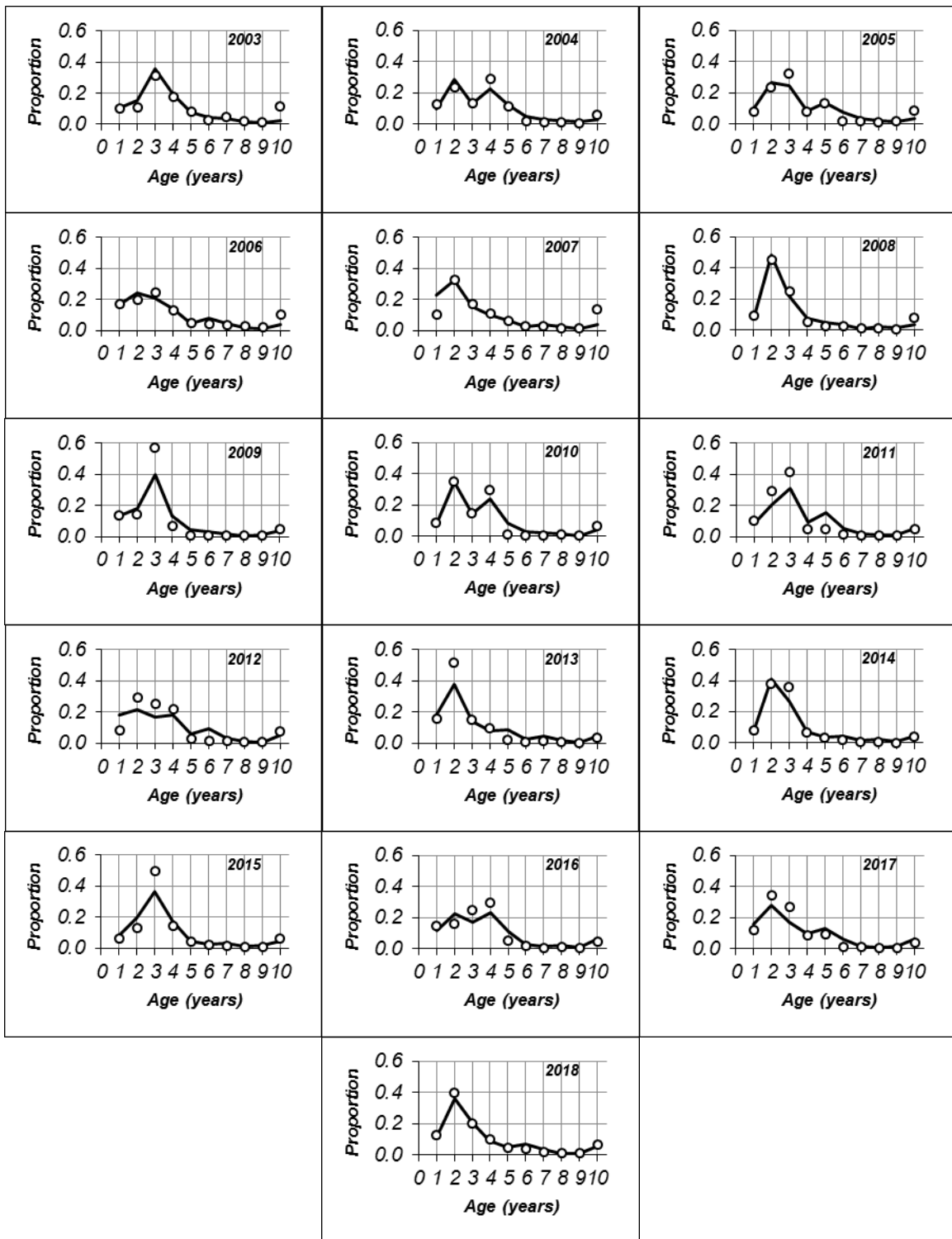


Figure 7 (continued):

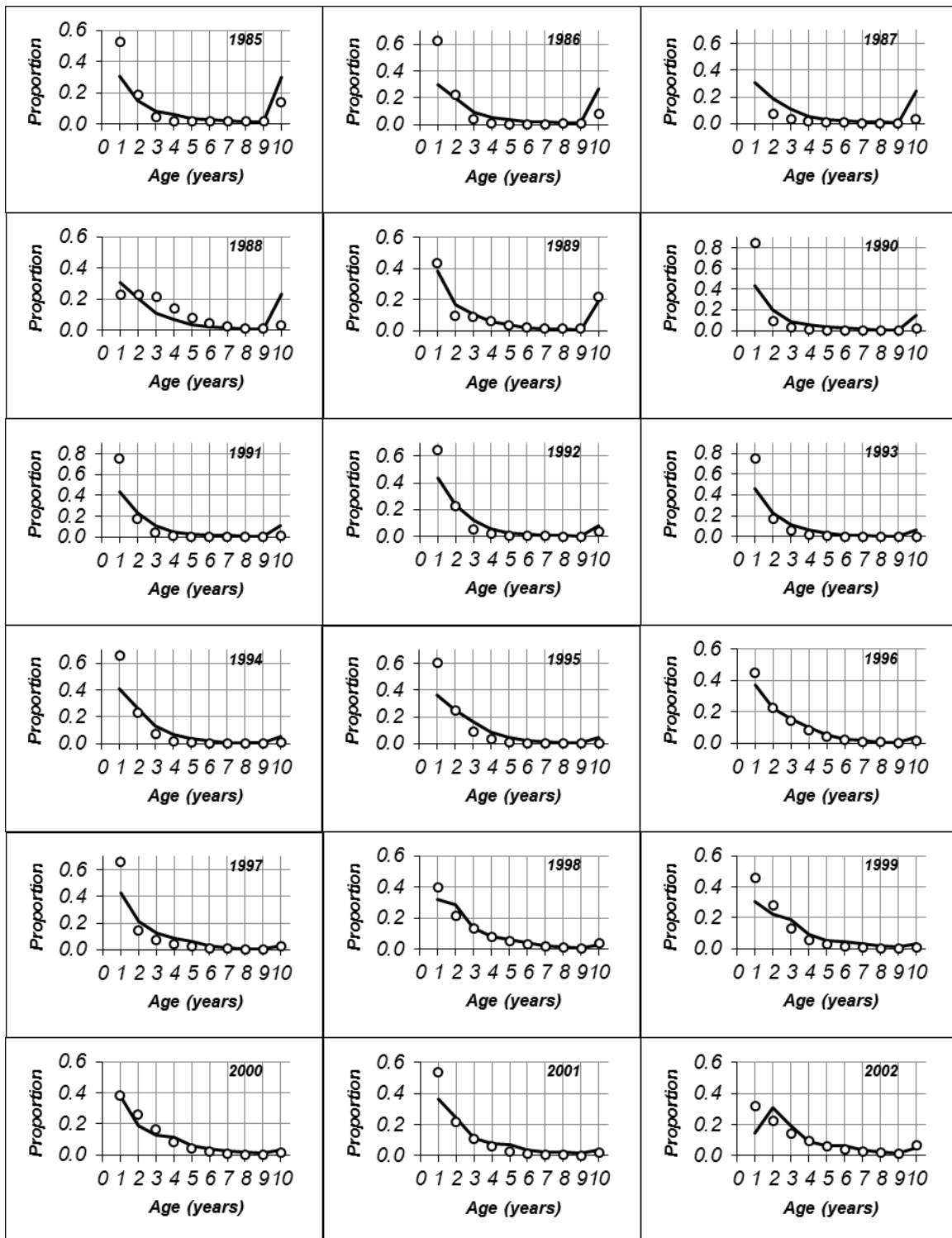


Figure 8: Annual input (open circles) and ASAP estimated (bold lines) survey age compositions.

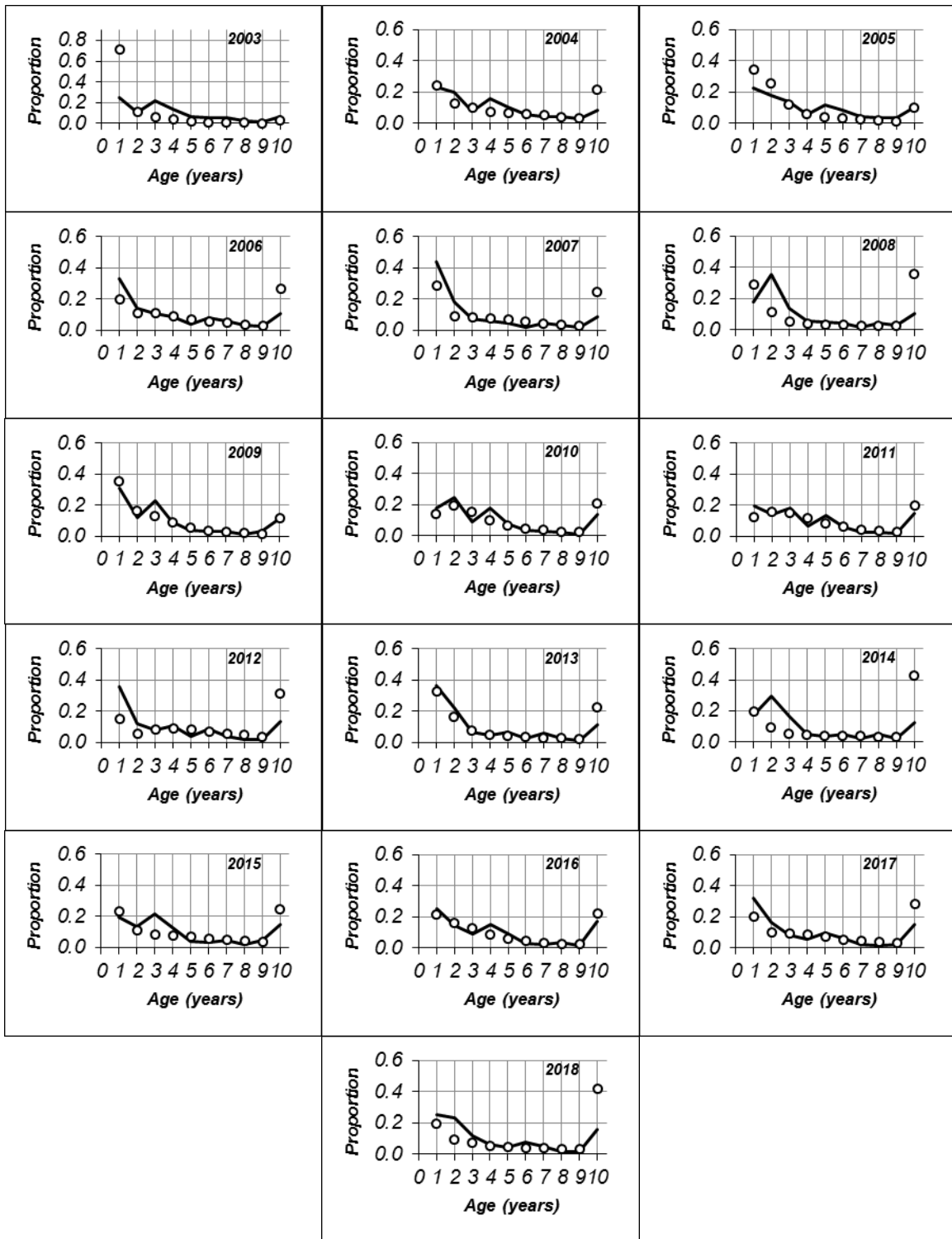


Figure 8 (continued):

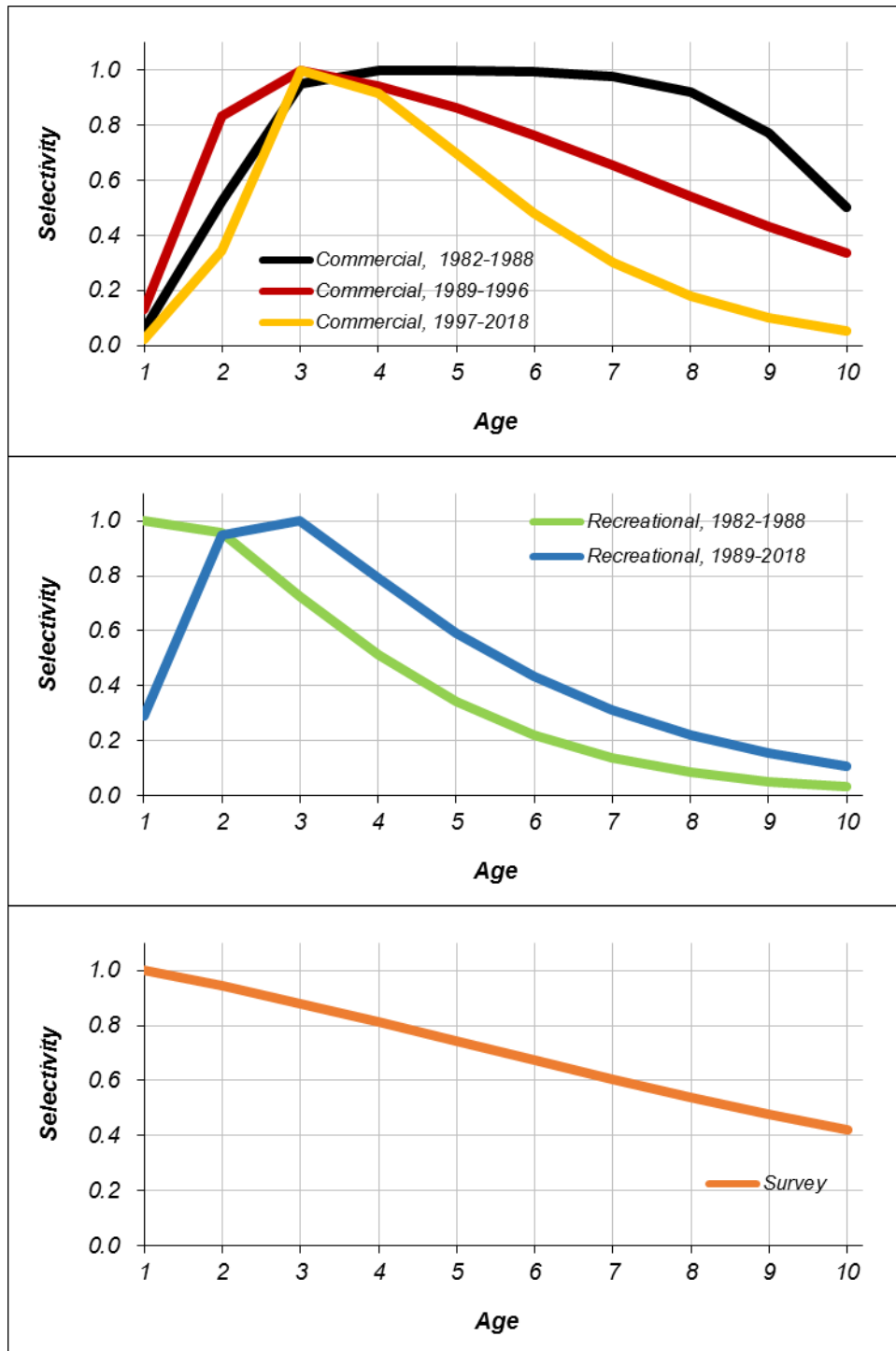


Figure 9: ASAP base model estimated commercial (top), recreational (middle), and survey (bottom) selectivities (ages 1-10+).

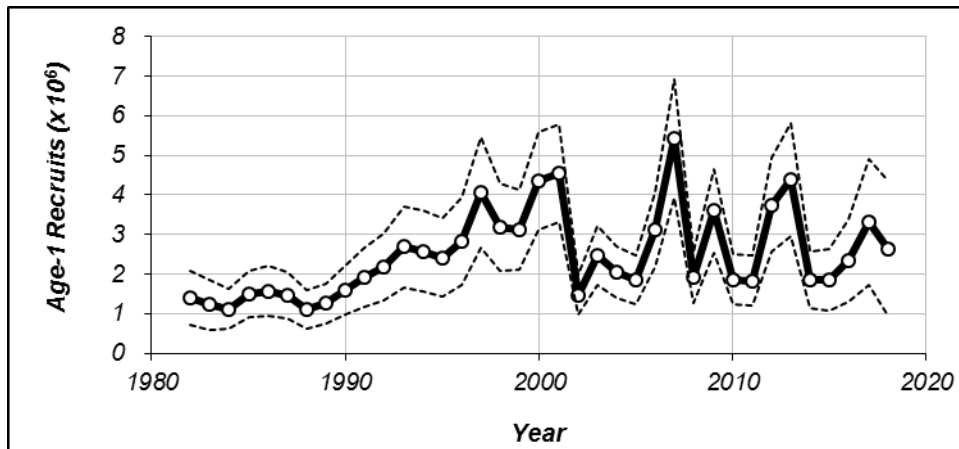


Figure 10: ASAP base model estimated age-1 recruitment. Dashed lines represent ± 2 asymptotic standard errors.

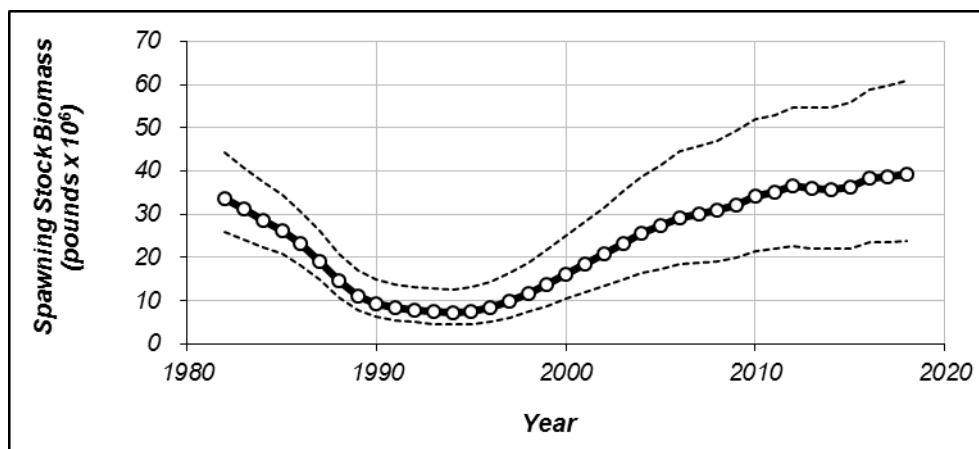


Figure 11: ASAP base model estimated spawning stock biomass (MCMC median). Dashed lines represent 95% MCMC derived confidence intervals.

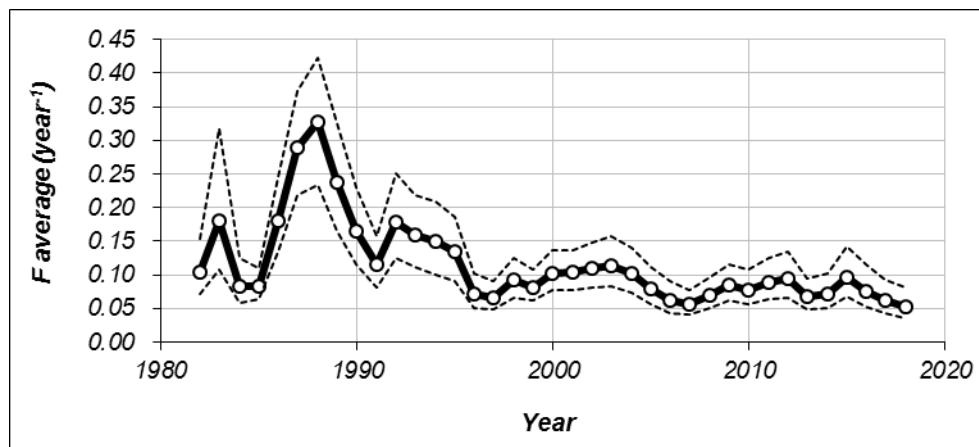


Figure 12: ASAP base model estimated average fishing mortality rates (MCMC median). Dashed lines represent 95% MCMC derived confidence intervals.

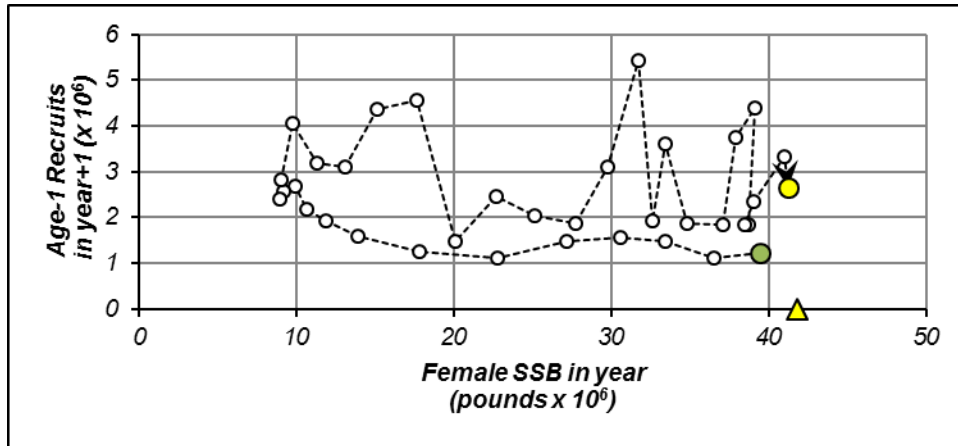


Figure 13: ASAP base model estimated age-1 recruits and female spawning stock biomass. Arrow represents direction of the time-series. The yellow circle represents the most current data pair (2018 age-1 recruits / 2017 female SSB) and the yellow triangle represents the 2018 SSB estimate. The green circle represents the first data pair (1983 age-1 recruits / 1982 female SSB).

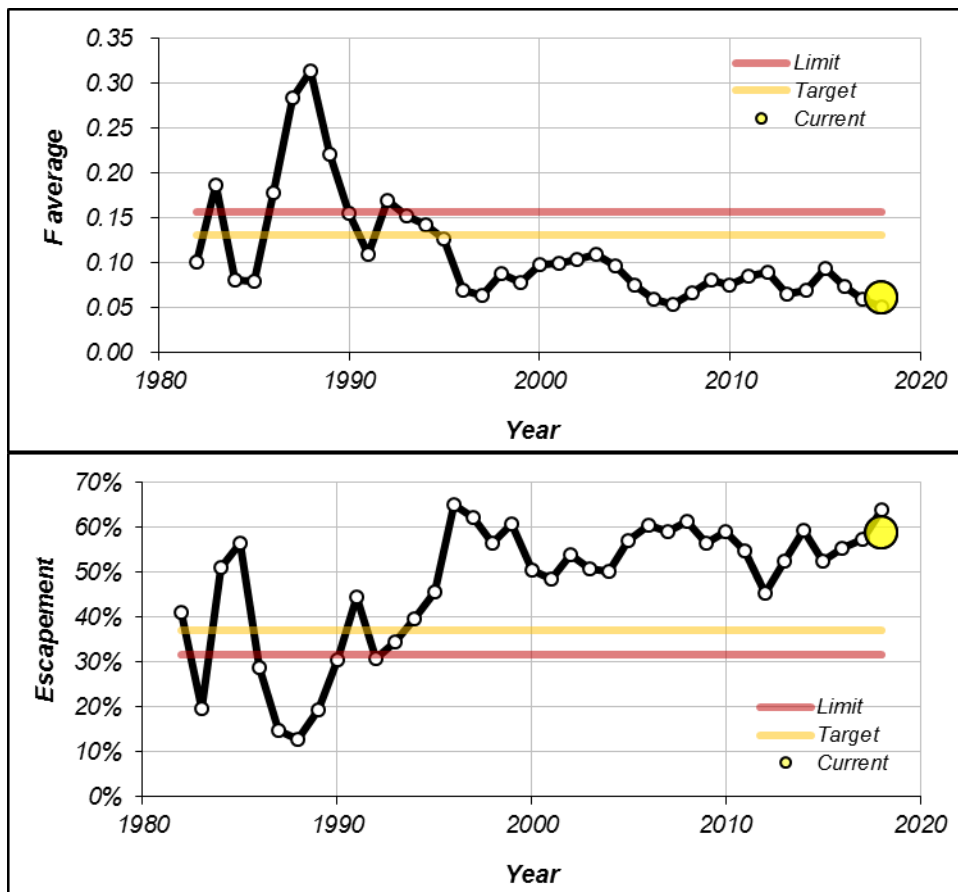


Figure 14: Time-series of ASAP base model estimated average fishing mortality rates, escapement rates, female spawning stock biomass, and spawning potential ratio relative to proposed limit and established target reference points. Current values represent the geometric mean of the 2016-2018 estimates.

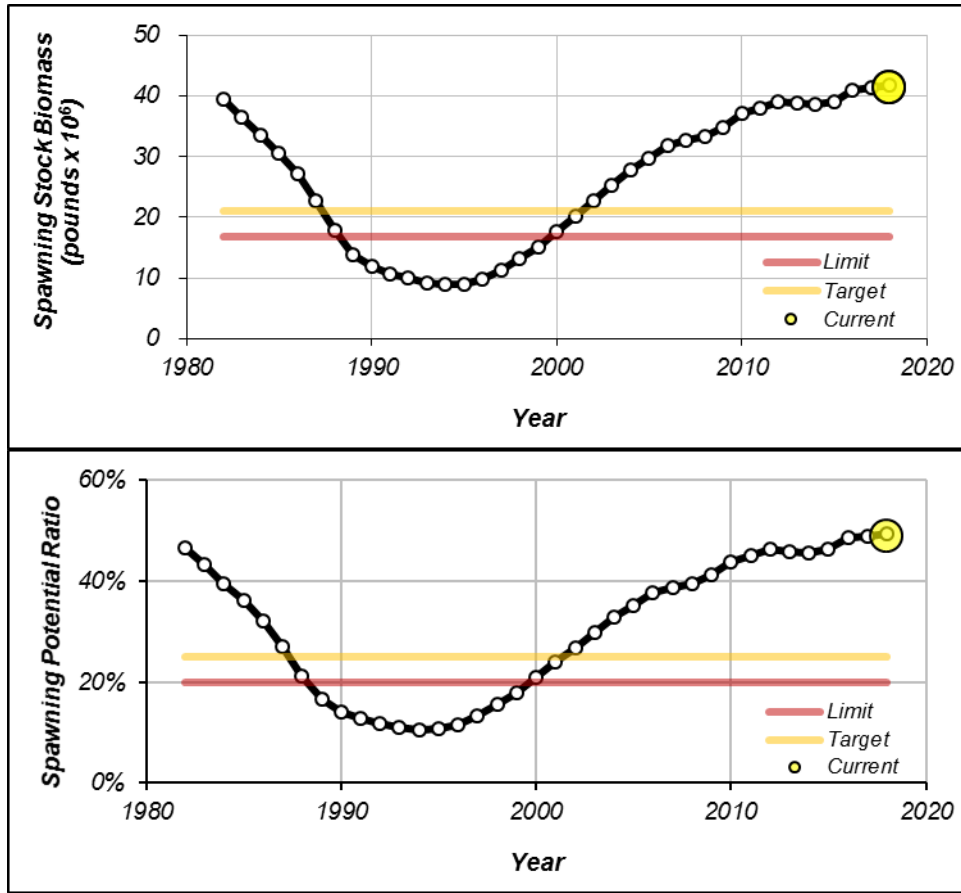


Figure 14 (continued):

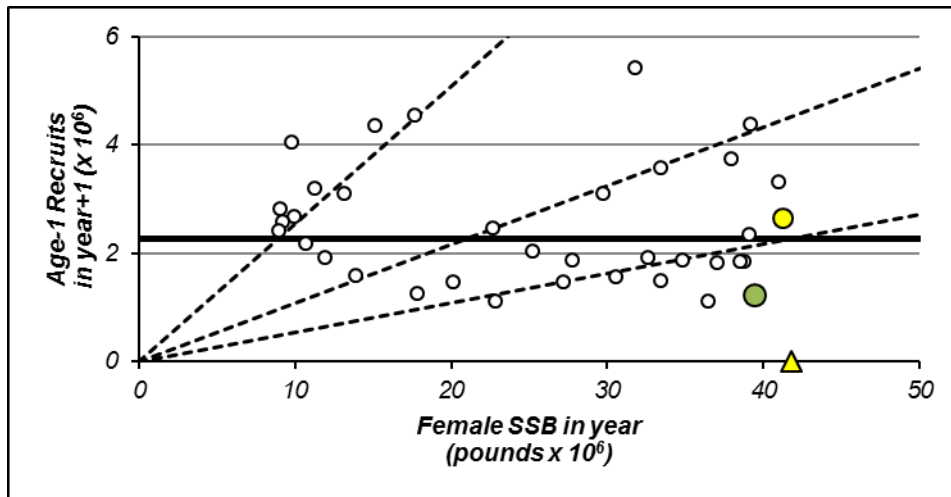


Figure 15: ASAP base model estimated age-1 recruits and female spawning stock biomass (open circles). Equilibrium recruitment is represented by the bold horizontal. The yellow circle represents the most current data pair (2018 age-1 recruits / 2017 female SSB) and the yellow triangle represents the 2018 SSB estimate. The green circle represents the first data pair (1983 age-1 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=11% SPR; SSB_{target}=25%; max. SSB=49% SPR).

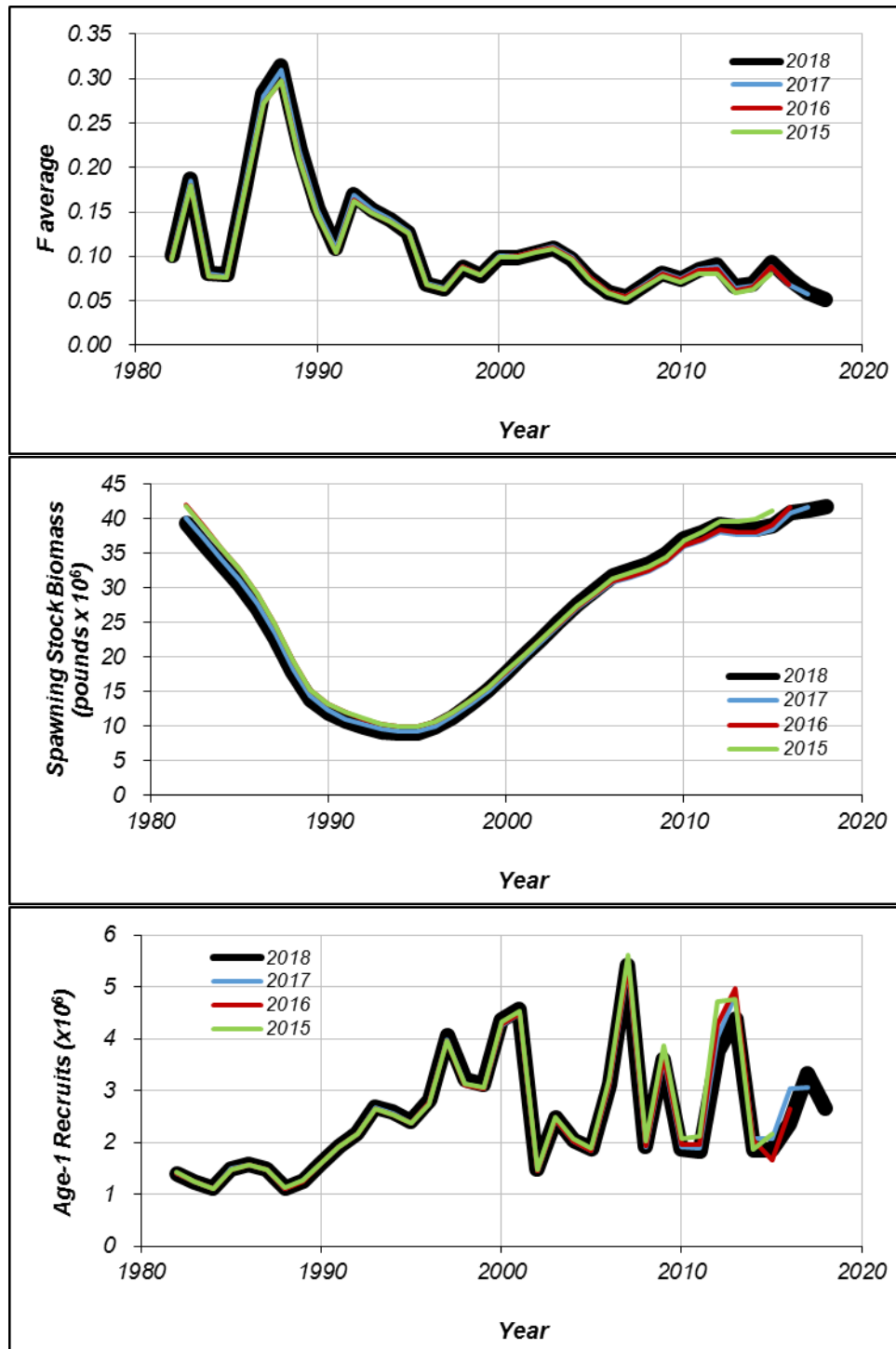


Figure 16: Retrospective analysis of ASAP base model. Top graphics depict annual average fishing mortality and female spawning stock biomass estimates. Bottom graphic depicts estimated age-1 recruits.

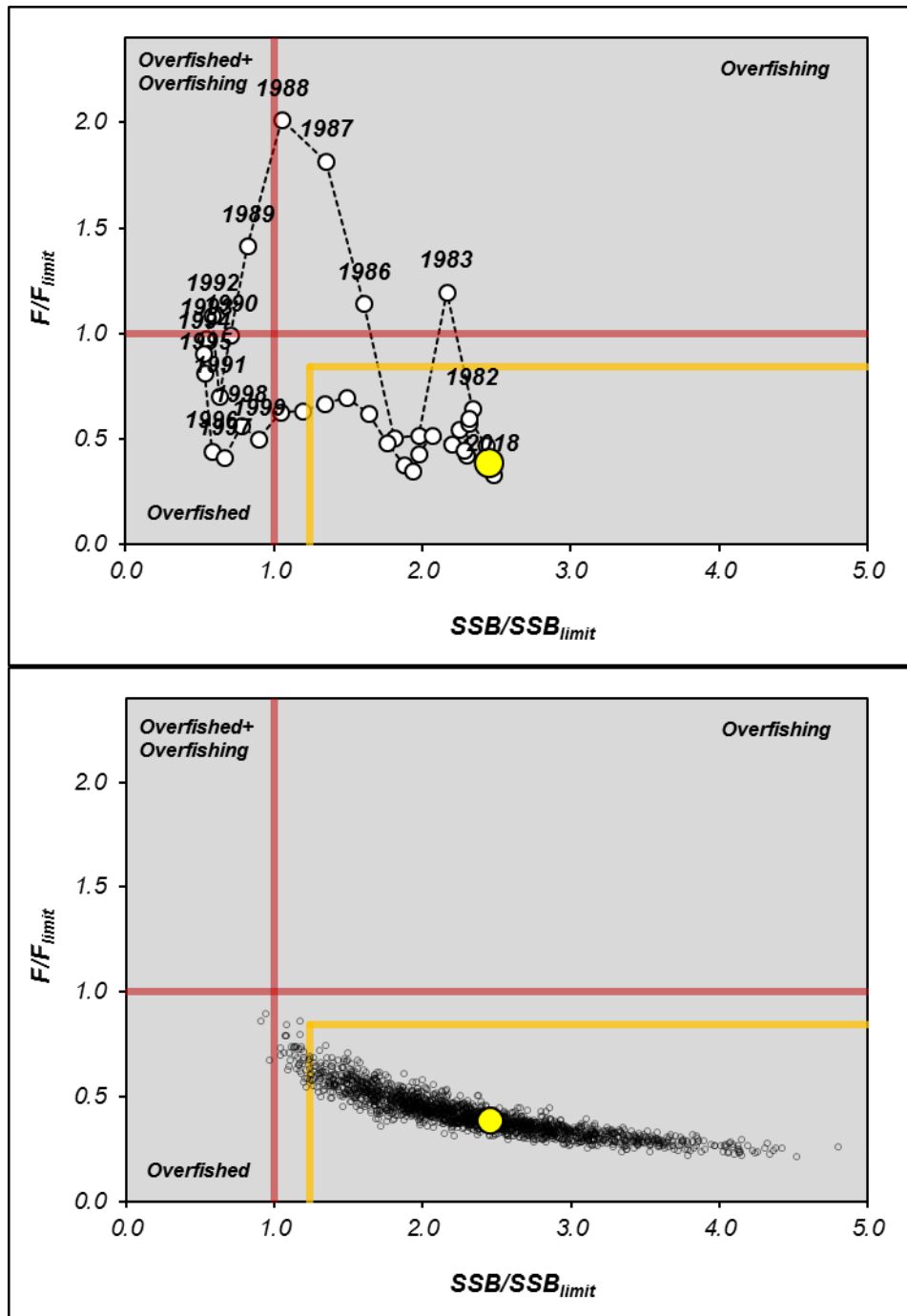


Figure 17: ASAP base model estimated ratios of annual average fishing mortality rates and female spawning stock biomass to the proposed limit reference points (F_{limit} and SSB_{limit}). Also presented are the target reference points (yellow lines). Arrow represents direction of time-series. The first and last year of the time-series are identified along with the years where the stock was considered either overfished or overfishing was occurring. 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 I:**LA Creel/MRIP Calibration Procedure**

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Office of Fisheries
Louisiana Department of Wildlife and Fisheries
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:

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

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:

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

where

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

Effort variances $\hat{V}(\hat{E}_{y,w,FM,MRIP})$ 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:

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

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:

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

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

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

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			
Year	MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		MRIP		LA Creel		
	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

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	
	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:

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

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:

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

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

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

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:

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

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

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

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

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

where

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

Harvest variances $\hat{V}(\hat{H}_{y,wk,FM,LAcreel})$ 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			
Year	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	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	53,343	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			
Year	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																		7,252	32.4		
1983																		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:**Louisiana Black Drum Growth**

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Overview

The traditional three parameter von Bertalanffy growth model has been proven inadequate for several sciaenid species, including black drum (Beckman *et al.* 1988). Because of the rapid growth exhibited in juveniles and the relatively slow growth of adults, predicted lengths-at-age of younger black drum tend to be overestimated and predicted lengths-at-age of older fish underestimated with the standard von Bertalanffy model. In the previous Louisiana black drum stock assessment (Davis *et al.* 2015), a generalization of the von Bertalanffy growth model was used where the asymptotic length was modeled as a linear function of age (*i.e.*, “linear” or sloped-asymptote von Bertalanffy model). While this formulation provided a better fit to black drum length-at-age observations than the standard von Bertalanffy model, its parameters lack a biological interpretation.

Methods

A different growth model has been developed that accounts for decreasing growth rates with age (damped growth, Porch *et al.* 2002), rather than the constant growth rate across ages inherent to the standard von Bertalanffy model. The damped growth model allows a continuous change in growth rates across ages rather than a single discontinuous change at a particular age such as the “double” von Bertalanffy generalization. Length-at-age is calculated with the damped model as:

$$l_t = l_\infty (1 - e^{\beta - k_0(t-t_0)})$$

$$\beta = \frac{k_1}{\lambda} (e^{-\lambda t} - e^{-\lambda t_0})$$

where $k = k_0 + k_1 e^{-\lambda t} \geq 0$ (*i.e.*, assuming fish will not shrink with age). The λ parameter is the damping coefficient allowing growth rates to decline with age.

Sex-specific and non-sex-specific damped growth models were fit to LDWF black drum length-at-age observations. Due to the minimum size limit in the fishery, only the fishery-independent datasets were used for model fitting. Biological ages were assigned by assuming an April 1st birthdate. Additional length data for individuals ≤ 200 mm were also taken from the LDWF fishery-independent marine seine survey with ages assigned by assuming individuals as either young-of-the year or age-1 by visual assignment. Growth curves were fit to the data with the SAS nonlinear regression fitting procedure

(PROC NLIN; SAS 2008) using the Newton iterative method. Growth curves were compared with an analysis of the residual sums of squares and Kimura's likelihood ratio tests (Haddon 2001).

Sex-specific and non-sex-specific length-weight regressions were also fit using the dataset described above with weight records with the power model:

$$W = aL^b$$

where W is weight, L is length, a is the weight-length constant and b is the allometric exponent. The model, after common logarithmic transformation, was fit with the SAS linear regression procedure (PROC REG; SAS 2008). Sex-specific regressions were compared with an analysis of covariance.

Fish with only fork length (FL) measurements available were converted to total length (TL) from the following relationship reported by Geaghan and Garson in GSMFC (1993):

$$TL = 1.03 \times FL - 3.80$$

where FL is in units of mm.

Results

Parameter estimates of the sex-specific and combined damped growth curves are presented in Table 1. The analysis of residual sum of squares indicated the growth curves were not coincident ($p=0.006$). Further analysis using Kimura's likelihood ratio test indicated only the k_1 parameters as statistically different ($p=0.01$). While statistically different, the difference in k_1 between sexes was minor and we consider the overall difference between male and female growth curves biologically insignificant. The combined sex growth curve and TL-at-age observations are presented in Figure 1.

Table 1: Parameter estimates and corresponding approximate standard errors of the combined and sex-specific damped growth models. Units are total length in inches and time in years.

<i>Model</i>	L_{∞}	<i>SE</i>	<i>Model</i>	k_0	<i>SE</i>	<i>Model</i>	t_0	<i>SE</i>
<i>Combined</i>	37.2	0.329	<i>Combined</i>	0.0973	0.00840	<i>Combined</i>	-0.168	0.0212
<i>Female</i>	37.2	0.516	<i>Female</i>	0.0915	0.0148	<i>Female</i>	-0.199	0.0239
<i>Male</i>	39.1	0.867	<i>Male</i>	0.0676	0.0111	<i>Male</i>	-0.172	0.0193
<i>Model</i>	k_1	<i>SE</i>	<i>Model</i>	λ	<i>SE</i>			
<i>Combined</i>	0.193	0.00723	<i>Combined</i>	0.390	0.0501			
<i>Female</i>	0.177	0.00703	<i>Female</i>	0.298	0.0572			
<i>Male</i>	0.200	0.00658	<i>Male</i>	0.320	0.0365			

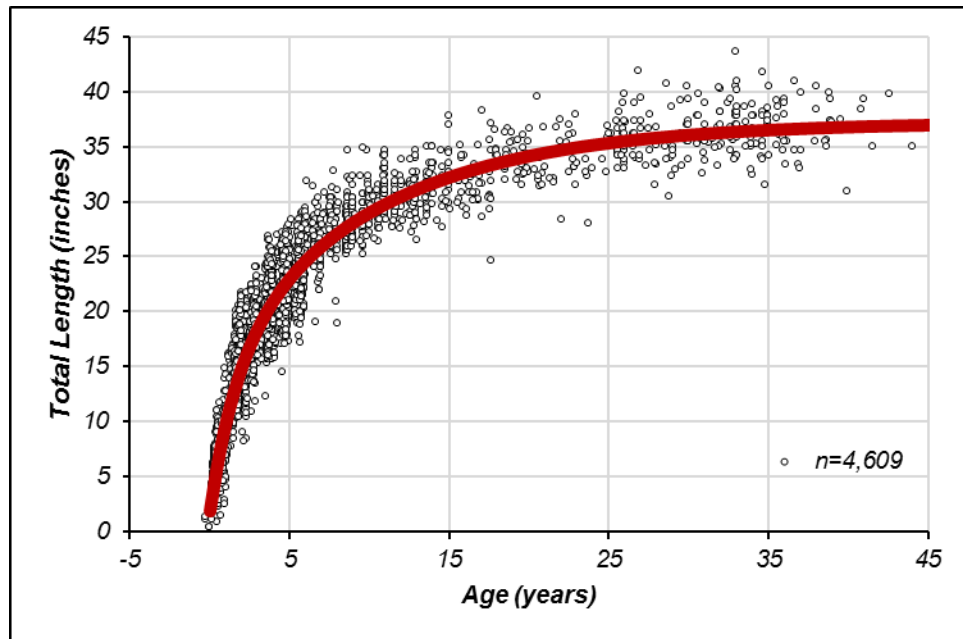


Figure 1: Black drum total length-at-age observations and predicted total length-at-age from the damped growth model.

Parameter estimates of the sex-specific and combined weight-length regressions are presented in Table 2. The analysis of covariance indicated the slope and intercepts of the male and female regressions as not statistically different ($p > 0.05$).

Table 2: Parameter estimates, approximate standard errors of the allometric exponent, coefficients of determination, and sample sizes of the combined and sex-specific weight-length regressions. Units are total length in inches and weight in pounds.

Model	a	b	$SE(b)$	r^2	n
Combined	4.05E-04	3.08	0.00438	0.993	3390
Female	3.84E-04	3.10	0.00646	0.993	1616
Male	3.80E-04	3.10	0.00845	0.991	1221

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