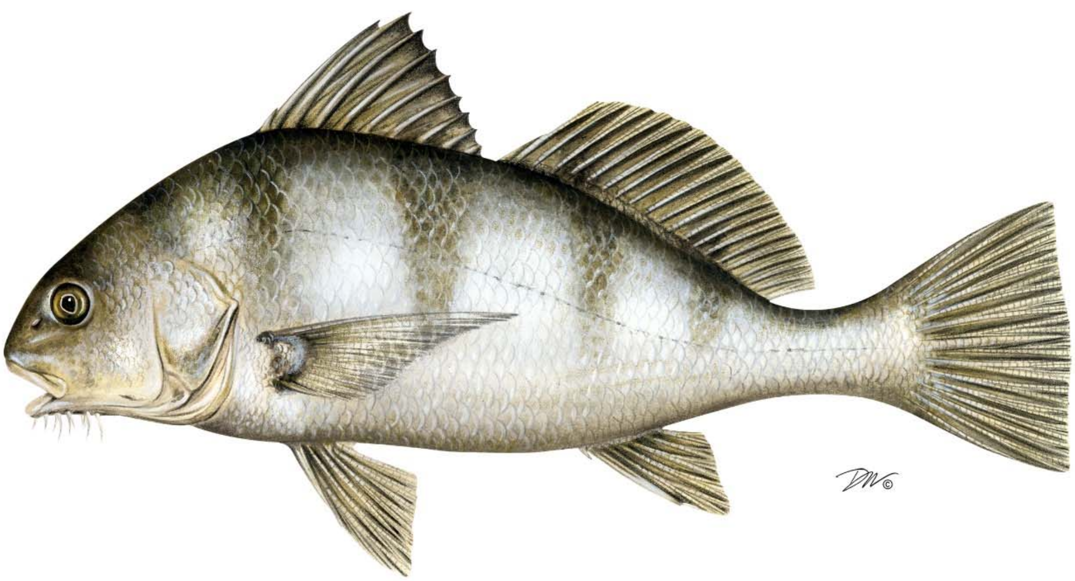
Atlantic States Marine Fisheries Commission

Black Drum Stock Assessment and Peer Review Reports



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Vision: Sustainably Managing Atlantic Coastal Fisheries

Overview

The 2015 Black Drum Benchmark Stock Assessment occurred through an Atlantic States Marine Fisheries Commission (ASMFC) external peer review process. ASMFC organized and held a Data Workshop on April 15-19, 2013. Assessment Workshops were held on February 24-27, 2014 and September 15-16, 2014. Participants of the Data and Assessment Workshops included the ASMFC Black Drum Stock Assessment Subcommittee and Technical Committee, as well as invited individuals from state and federal partners. ASMFC coordinated a joint Peer Review Workshop for the black drum and tautog assessments from November 11-14, 2014. Participants included members of the Black Drum Assessment Subcommittee and a Review Panel consisting of four reviewers appointed by ASMFC.

Black Drum Stock Assessment Peer Review Report (PDF Pages 1- 15)
The Peer Review Report provides a detailed evaluation of how each Term of Reference was addressed by the Stock Assessment Subcommittee, including the Panel's findings on stock status and future research recommendations.

Black Drum Stock Assessment for Peer Review (PDF Pages 16 - 351)
This report describes the background information, data used, and analysis for the assessment submitted by the Technical Committee to the Review Panel.

Atlantic States Marine Fisheries Commission

Black Drum Stock Assessment Peer Review Report

Conducted on
November 11-14, 2014
Virginia Beach, Virginia

Prepared by the
ASMFC Black Drum Stock Assessment Review Panel

Dr. Cynthia Jones, Panel Chair, Old Dominion University
Dr. Gary Nelson, Massachusetts Division of Marine Fisheries
Dr. Yan Jiao, Virginia Polytechnic University
Dr. Jason Cope, NMFS Northwest Fisheries Science Center

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Preface

Summary of the ASMFC Stock Assessment Review Process

The Stock Assessment Peer Review Process, adopted in October 1998 and revised in 2002 and 2005 by the Atlantic States Marine Fisheries Commission (ASMFC or Commission), was developed to standardize the process of stock assessment reviews and validate the Commission's stock assessments. The purpose of the peer review process is to: (1) ensure that stock assessments for all species managed by the Commission periodically undergo a formal independent review; (2) maintain the quality of Commission stock assessments; (3) ensure the credibility of the scientific basis for management; and (4) provide the public with a clear understanding of fisheries stock assessments. The Commission stock assessment review process includes an evaluation of input data, model development, model assumptions, scientific advice, and a review of broad scientific issues, where appropriate.

The Commission's *Benchmark Stock Assessment Framework* outlines options for conducting an independent review of stock assessments. These options are:

1. The stock assessment review process conducted by the Atlantic States Marine Fisheries Commission.

2. The Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) conducted by the National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC).

3. The Southeast Data and Assessment Review (SEDAR) conducted by the National Marine Fisheries Service, Southeast Fisheries Science Center (SEFSC).

Twice annually, the Commission's Interstate Fisheries Management Program (ISFMP) Policy Board prioritizes stock assessments for all Commission managed species based on species management board advice and other prioritization criteria. The species with highest priority are assigned to a review process to be conducted in a timely manner.

In November 2014, the Commission convened a Stock Assessment Review Panel comprised of scientists with expertise in stock assessment methods, data poor modeling, recreational fisheries data and indices, and black drum life history and ecology. The review of the black drum stock assessment was conducted at the Sheraton Oceanfront Hotel in Virginia Beach from November 11-14, 2014. Prior to the Review Workshop meeting, the Commission provided the Review Panel members with the 2014 Black Drum Stock Assessment Report.

The review process consisted of presentations by topic – data inputs, life history analyses, model results, reference points, and stock status – of the completed 2014 stock assessment. Each presentation was followed by general questions from the Panel. The second day involved a closed-door meeting of the Review Panel during which the documents and presentations were discussed and a review report prepared. The report is structured to closely follow the terms of reference provided to the Panel.

Acknowledgements

The Review Panel thanks members of the Black Drum Stock Assessment Subcommittee and Technical Committee, as well as staff of the Atlantic States Marine Fisheries Commission, particularly Patrick Campfield, for support during the review process.

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Executive Summary

The review panel met in Virginia Beach, VA from November 11-14, 2014. Prior to the review workshop, panel members read the stock assessment report and other relevant documents provided by ASMFC and the black drum (*Pogonias cromis*) stock assessment subcommittee (SASC). During the workshop, the Panel reviewed results of the data-poor models, and requested additional model explorations, including future projections from the models to assess the stability of their recommended harvest levels on stock biomass.

Black drum are an infrequent catch in the recreational and commercial fisheries along the U.S. East Coast. Although drum are easily and accurately aged, their rarity and migratory patterns lead to a highly variable catch history, making the use of statistical catch-at-age models difficult. For these reasons, the SASC used four data-poor modeling approaches to develop management guidance. The models yielded varying levels of predictive behavior. The Panel unanimously agreed with the SASC that the DB-SRA model was preferred. DB-SRA provided the most reasonable and stable estimates of biomass and an MSY reference point, while the Catch-MSY model proved unreliable for accurately characterizing the black drum stock and fishery.

Model results of the DB-SRA show the black drum stock is not overfished and overfishing is not occurring. The recommended base run of DB-SRA resulted in a median MSY (target) of 2.12 million lbs. and a median OFL harvest (threshold) at F_{msy}, 4.12 million lbs. Through a very comprehensive and commendable series of data analyses and modeling, the SASC has documented the not overfished status. The following Review Report evaluates the stock assessment findings, comments on strengths and weaknesses, and makes recommendations for future research priorities and assessments.

Terms of Reference for the Black Drum Stock Assessment Review

1. **Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment, including the following but not limited to:**

There have been previous studies of black drum life history that provide information on life history parameters, and also data on catch and effort from fishery-dependent and independent data. The fishery-dependent data are available from the commercial and recreational fisheries. Although there are state and coast wide fishery-independent surveys, none are designed to specifically evaluate trends in black drum abundance.

a. Presentation of data source variance (e.g., standard errors).

Otoliths provide minimal ageing error (<1%), and otolith annuli have been validated through bomb radiocarbon analysis. Lengths can be taken with good accuracy, but weight is more difficult to measure in the field for larger specimens. Six data sets were used to provide information on size-at-age, maturity, and other life history parameters.

Recreational fisheries effort, catch, and CPUE were obtained from the access-point MRFSS/MRIP surveys. Variances appeared to be small around CPUE estimates and this concerned the Panel. There was considerable change in annual estimates of CPUE that did not appear to be consistent. This was due to the infrequency of intercepts from the black drum fishery, short seasonal availability of large black drum inshore, and expansions from sparse catch and effort data. The black drum fishery in the South Atlantic (FL-NC) has both small and large fish. The mid-Atlantic (VA-NJ) is populated by larger, older fish and the small, young fish (aside from YOY) are not available to the fishery. The fishery in the mid-Atlantic is mostly a trophy fishery.

Commercial fisheries are a smaller component of the catch. Landings by state and gear were available from 1887-1944 from the U.S. Fish Commission; from NMFS for 1945-1949; and from ACCSP coast wide dealer reports from 1950-2012. Given the disparate data sources, there were some inconsistencies in coverage over the years. Commercial landings came primarily from gill nets and fixed gears, such as pound nets. Commercial discard data were limited. Gill net mesh size differs from north to south with large net mesh nets used in the north's directed fishery. Similarly data on catch at length, weight, and age are limited.

The assessment team evaluated 28 fishery-independent surveys that captured various life stages of black drum but lacked independent surveys specifically designed to measure black drum. Because the capture of black drum are infrequent, the variability in survey information is high.

b. Justification for inclusion or elimination of available data sources.

Because the recreational catch predominates in the black drum fishery the inclusion of MRFSS/MRIP CPUE and catch estimates must provide the basis of model input. The commercial data has a longer time series but is variable, incomplete, and is a minor component of black drum fisheries. One of the strong assumptions of data-poor models used in the stock assessment is that variability in the catch history reflects the changes in population abundance, and this is reflected better in the recreational time series.

Because black drum intercepts in the recreational survey were infrequent, it was difficult to estimate the directed effort. Accordingly, the assessment team used a cluster analysis approach to group fishing trips for all species that are commonly found with black drum to indicate the proportion of directed trips. Data from 1981 were eliminated from further analysis because MRFSS did not conduct wave 1 sampling in Florida, an important time period for drum in this locale. This time series was filtered for waves and regions with fewer than 1% of black drum trips as a threshold for inclusion. After recalibration and filtering the data were standardized with the delta method for continuous variables that used two GLM models, a binomial for estimating the proportion of trips that caught black drum, and a lognormal of catch for trips that caught black drum. A negative binomial was used to standardize non-continuous data. The only limitation was that no comparison was done between the two approaches.

c. Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, ageing accuracy, sample size).

Black drum have been aged from a variety of hard parts, but otoliths are the hard part of choice and they can be aged in cross-section with little error. Because agencies have not collected great number of otoliths, and because fish can live to 60 years or more, age-length keys can be sparsely filled, particularly in the mid-Atlantic region populated with large, old fish.

The difficulty in obtaining a representative time series of catches is the temporal change in spatial availability of black drum and their segregation spatially over seasons by size and age. Sampling species with these types of life histories has proven difficult. Sample effort must be matched to temporal and spatial availability usually with specialized surveys for rare species. MRFSS/MRIP was designed to obtain overall measures of recreational catch and effort across many species, not to address the information needs for minor species.

Recreational fisheries data are available from the MRFSS survey from 1981-2012 with recalibration of CPUE from 2004-2012 following the MRIP calibration factor. The MRFSS survey was designed to obtain effort data from a random-digit dialing telephone survey and CPUE from a public access-point intercept survey. However, the inclusion of access sites was not probability based. The recreational survey obtains effort from the Coastal Household Telephone Survey (CHTS) and CPUE from a probability-based inclusion of public access points. MRIP is designed to provide unbiased estimates, while MRFSS has unknown bias. Because MRFSS intercepts more often included larger access sites, these were oversampled. Because black drum are an infrequent catch with short seasonal spawning aggregations, they are poorly sampled in the recreational surveys and sample size is low. Thus, variability in catch estimates can be high. Because of the expansion methods in estimating catch the reported CV's from MRIP minimized the true uncertainty in these estimates. Also note the MRFSS/MRIP survey provides estimates of CPUE and catch in number not weight, and numbers are converted to weight using values imputed across strata. Imputed values often provide minimal variance estimates.

Because the data poor methods used in the assessment require a long and representative catch history, and given the recreational survey began in 1980, the assessment team used the USFWS National Fishing License Reports from 1958-2013 for each state to expand the recreational time series. The expansion was done by propagating ratio estimates and likely provides an underestimate of uncertainty. Proportional standard errors (PSEs) throughout the recreational time series are high. Nonetheless this is an innovative approach to use when data are sparse.

Twenty-eight fisheries independent surveys were considered, but none were specifically designed to estimate the abundance of black drum life stages. The catchability coefficient for such surveys is assumed to be constant interannually, and that assumption may be violated for black drum given its pattern of temporal and spatial availability. Only eight of the surveys were able to reliably measure black drum life stages.

d. Calculation and/or standardization of abundance indices.

To use the recreational time series, the MRFSS values had to be corrected to be consistent with the MRIP series. Calibration factors were provided from the MRIP program. Additionally, MRFSS/MRIP catches are reported in numbers not in weight. Although weight information is available for some species it was very incomplete for black drum. The assessment team used imputed values across strata to provide estimates in weight for the catch history.

Twenty-eight fishery independent surveys were considered as potential indices of abundance of black drum at various life stages. Eleven survey indices were chosen and standardized using either the delta method and the lognormal, or a negative binomial GLM, and eight were deemed to reliably measure black drum abundance.

Overall, the Panel considers that a credible analysis of the available data was undertaken by the SASC.

2. **Evaluate the methods and models used to estimate population parameters (e.g., F, biomass, abundance) and biological reference points, including but not limited to:**
    e. Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of the species?
    f. If multiple models were considered, evaluate the analysts' explanation of any differences in results.
    g. Evaluate model parameterization and specification.

The SASC put forward models that did not use any of the multitude of relative abundance indices explored. Subsequently, the four main models explored relied only on catch and life history information. The four models considered by the SASC were 1) Per-Recruit Analysis, as done in previous state black drum assessments, 2) Catch-MSY, 3) Depletion-Corrected Average Catch (DCAC), and Depletion-Based Stock Reduction Analysis (DB-SRA). Per-Recruit

Analysis was included mainly as a point of reference, and not seriously considered as a preferred model in the coast wide stock assessment.

Yield and Spawner Per Recruit Analyses

The SASC conducted equilibrium yield and spawner per recruit analyses for black drum based on coast wide age-specific weights, maturity, and natural mortality, and incorporated release mortality for males and females combined to develop biological reference points. Most biological inputs to the model were reasonable. As an equilibrium method, the stock is assumed to have reached an equilibrium in age structure, recruitment is constant, and growth and mortality are constant over time. The biggest concern was the lack of knowledge of the coast wide selectivity pattern for black drum since the shape will dictate the resulting reference points common to yield per recruit (e.g., U_{max}) and spawner per recruit (e.g., $U_{30\%}$). However, based on a 16" size limit, the U_{msy} values obtained (0.08) was within the 95% confidence bounds of the DB-SRA model (the preferred model) suggesting it is comparable as a reference point.

Catch-MSY

The SASC used the data-poor Catch-MSY method of Martell and Froese (2012) to estimate maximum sustainable yield (MSY) and related management quantities for black drum. This is a relatively new method of obtaining MSY from only catch and an understanding of a given stock's resilience. The SASC modified the method by incorporating the Pella-Tomlinson surplus production model that adds a shaper parameter to the calculation of B_{msy}/K. The method was applied to black drum removals from 1950-2012 which are considered uncertain prior to 1981. The ranges of prior distributions of relative biomass in 1950 (B_{1950}/K), r, K, B_{msy}/K and B_{2012}/K were based on expert opinion (B_{1950}/K), relative declines in an abundance index (B_{2012}/K), meta-analyses (r and B_{msy}/K) and ad hoc ranges derived from observed removals (K). The uniform distribution was assumed for all parameters except B_{msy}/K, where a beta distribution was used. The MSY value produced by the Catch-MSY model was the highest of the three data-poor methods examined. The Panel discussed the appropriateness of parameter ranges and the distributions assumed for each, given that only about 5% of the 10,000 runs were selected as acceptable, and recommended reducing the lower bound of r and the upper bound of K. The Panel also requested that the SASC provide biomass projections using the MSY estimate as catch to explore model behavior. The projections showed that the Catch-MSY model produced unstable estimates of biomass. The Panel agreed that since this modified method has not been fully explored, it should not be considered a preferred method.

Depletion-Based Stock Reduction Analysis (DB-SRA)

The preferred model put forward by the SASC was the DB-SRA model. DB-SRA uses a flexible production model within a lumped biomass (i.e., not age-structured) population dynamics model. Monte Carlo resampling is used to sample from a variety of inputs and subsequently solve for the initial biomass that fits those inputs. The mode is then run forward for a given catch history and calculates catch limits and selected reference points. The SASC also included uncertainty in catch histories, not typically done in other applications of DB-SRA. Given that black drum catch history is a major source of uncertainty, this was an excellent extension of the basic DB-SRA model. Of all the candidate models, DB-SRA was the most transparent in behavior and inputs. It was preferred over DCAC because it incorporates an underlying population dynamics model. It was preferred over Catch-MSY because the resultant population growth (r) values were deemed more realistic to the biology of black drum, as well as offering much better and stable behavior in the forward projection runs requested by the review panel. The population growth value is not a typical output of DB-SRA, so the Panel requested such calculations be made and the SASC did well in providing that very useful comparison in a timely manner.

The DB-SRA models were specified back to 1900, using essentially the full time series of the historical catch reconstruction. The specified distributions for natural mortality, F_{MSY}/M and B_{MSY}/B_0 were reasonably made using common approaches and references. The distribution of relative biomass (B_{2012}/K) reflected the SASC's belief that the coast wide black drum stock was not in an overfished state. The mean of the truncated beta distribution was set to the South Carolina trammel survey. While the Panel agreed this was a reasonable place to start, subsequent sensitivity analyses confirmed the common behavior of DB-SRA models to have high sensitivity to relative biomass assumptions. Given the strongest stock status statement that could be made was to say it was not overfished, the Panel suggested a new model run using a uniform distribution on B_{2012}/K from 0.5 to 0.9 be evaluated, a bit wider than the model run already provided from the SASC as a sensitivity run. The run requested by the Panel was ultimately chosen as the preferred model run as it incorporated the additional uncertainty in the highly sensitive B_{2012}/K input.

Depletion-Corrected Average Catch (DCAC)

The DCAC model is the precursor of DB-SRA and is meant to be used as a one-time calculator of a sustainable yield, not one that will maximize fishery yield. DCAC is based on a simplistic potential yield formula and does not use a model of population dynamics. In essence, it adjusts the average catch calculation over a specified period of years based on the assumed depletion of the stock. It does share all of the same parameters inputs as DB-SRA, and typically results in yield estimates below DB-SRA, as seen in the black drum comparisons. Given its static yield calculation and lack of population dynamics, DCAC was not preferred over DB-SRA and it did not have a comparable run using the uniform prior on depletion.

The Panel endorsed the SASC's selection of the DB-SRA model for use in the stock assessment. The Panel concluded that the SASC undertook an appropriate model selection process, adequately derived the range of input parameters, and undertook innovative model adjustments to addresses issues specific to black drum.

3. **Evaluate the diagnostic analyses performed, including but not limited to:**
    a. Sensitivity analyses to determine model stability and potential consequences of major model assumptions.

Yield and Spawner Per Recruit Analyses

No sensitivity analyses were performed for the YPR and SPR analyses.

Catch-MSY

A thorough exploration of the sensitivity of results to model inputs and assumptions was conducted by the SASC. In total, 14 sensitivity runs were listed in the assessment. Additional runs were requested by the Panel during the review. In general, model estimates of MSY were robust across a wide range of parameter values and across sensitivity runs. However, the analyses showed that Catch-MSY is very sensitive to the relative depletion level in the terminal year (B_{2012}/K).

DCAC and DB-SRA

Standard diagnostics were provided for the DB-SRA and DCAC models, which included posteriors draws for each retained model, as well as the number of retained samples (DB-SRA only). Sample retention for DB-SRA was over 90% and reasonable. Posteriors also did not exhibit any worrisome traits. The SASC was encouraged to include in the final assessment report the retained posteriors samples for each catch year so as to provide the distribution of catches explored. This should be a standard diagnostic for any DB-SRA or DCAC model that incorporates uncertainty in catch.

The SASC provided a suite of very useful sensitivity runs for DB-SRA and DCAC, and did a very good job of summarizing those results. The sensitivities included additional assumptions on all input distributions as well as the search space for the K estimator. Unsurprisingly, changing the prior on relative abundance (B_{2012}/K) showed the greatest sensitivities, though yield estimation was also sensitive to natural mortality and the assumption of catch in years 2008-2009. The final preferred model was predicated on the greater uncertainty in relative abundance that was presented from the sensitivity analysis.

4. **Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.**

Yield and Spawner Per Recruit Analyses

There were no estimates of uncertainty generated for YPR and SPR analyses.

Catch-MSY

Uncertainty in the estimates of MSY and management quantities is determined by the Monte Carlo sampling of the assumed prior distributions and is appropriate for the method.

DCAC and DB-SRA

Both DB-SRA and DCAC use a Monte Carlo approach to characterizing uncertainty to perpetuate input model parameter uncertainty into model-derived quantity uncertainty. The input parameter distributions were all clearly stated, and resultant model runs provided expected large uncertainty around model-derived outputs.

5. **Recommend best estimates of stock biomass, abundance, and exploitation from the assessment for use in management, if possible, or specify alternative methods/measures.**

The 2014 benchmark stock assessment for black drum provided estimates of stock biomass and fishing mortality based on 3 models: DCAC, DB-SRA and Catch-MSY. However both the SASC and the Panel realized the data poor models are designed to provide sustainable catch rather than stock biomass and fishing mortality estimation. Multiple scenarios in each model framework were provided by the SASC. The model that the SASC and Panel recommend to use for management purposes is the DB-SRA model. After multiple alternative sensitivity runs of the DB-SRA and Catch-MSY models, including those based on the Panel's request, the Panel and the SASC agreed the DB-SRA run with the less informative prior on depletion (U(0.5, 0.99)) is more appropriate for stock assessment purposes and provided the best available scientific foundation for management. The Panel and the SASC realized that the algorithm in dealing with Catch-MSY is confusing and caused unrealistic parameter estimates on both biomass and exploitation rate. The current algorithm used by the SASC is a full Monte Carlo simulation based on prior distribution, and no posterior likelihood given the data and/or model fitting to the observations were considered. Exploration of the Catch-MSY model with an appropriate parameter estimating algorithm is recommended for future application of this approach. The SASC is also encouraged to consider CPUE data in future stock assessments (see TOR7).

The DB-SRA model results indicated the population biomass is declining slowly with the steady increase of harvest in recent years. But current biomass is still above the B_{msy} level because catches in most of years were below MSY and F_{msy} levels. The recent depletion in 2012 from this model is 0.67 (based on median biomass 90.78 million lbs; and carrying capacity K =135.20 million lbs). Fishing mortality estimates have been increasing slightly over time and show high variation in most recent years because of the highly variable recreational catch statistics. The recent F estimate from DB-SRA is 0.046, lower than F_{msy} (0.048). Concerns about the appropriateness of the recommended reference points can be seen in TOR6.

6. **Evaluate the choice of reference points and the methods used to estimate them. Recommend stock status determination from the assessment, or, if appropriate, specify alternative methods/measures.**

The SASC used four types of models to develop BRPs: Yield-per-Recruitment (YPR), DCAC, DB-SRA, and Catch-MSY. Because of the Catch-MSY model sensitivity to the relative depletion level in the terminal year, and highly constrained prior in DCAC, the BRPs developed from the DB-SRA model run with less the informative prior on current depletion was used for recommending the appropriate BRPs. The MSY (2.12 million lbs) resulting from DB-SRA is recommended as the target biomass reference point and harvest at Fmsy is recommended as the target F reference point (4.12 million lbs).

The Panel also noted that by using the Catch-MSY model, the recommended MSY and B_{MSY} are unreasonably high and caused by both the higher prior on r used in the model and the model computing algorithm itself.

The Panel's conclusion on the model and reference point recommendations are heavily based on the evidence from black drum's life history characteristics, vulnerability to fisheries, multiple relative abundance indices, and the harvest history. Although data quality is a concern (see TOR1 and TOR2), the Panel and the SASC agreed black drum is not experiencing overfishing and the population is not overfished.

Future effort on the Catch-MSY model may be needed with appropriate prior elicitation and computing algorithms. Because black drum has differential age distribution patterns along the coast, with larger fish appearing more frequently in the north than south, evidence from biological sampling, catch, and relative abundance sampling should be considered simultaneously when considering the population and fishery status.

7. Review the research, data collection, and assessment methodology recommendations provided by the TC and make any additional recommendations warranted. Clearly prioritize the activities needed to inform and maintain the current assessment, and provide recommendations to improve the reliability of future assessments.

The recommendations provided by the SASC were comprehensive and the Panel concludes they covered the primary areas needed to improve future assessments. The Review Panel has the following additional research and modeling recommendations:

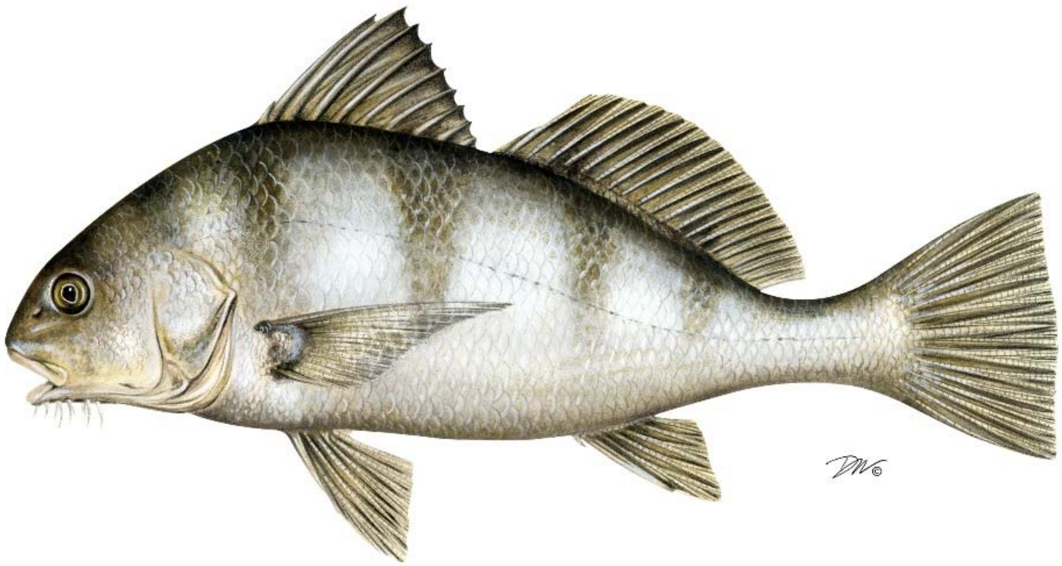
a. Develop a protocol to alert the SASC to any major changes in harvest and F that could trigger a reassessment of the reference points similar to the 'rumble strips' approach developed by the MAFMC for data-poor stocks.
b. Increase age sampling along the coast. Juvenescence of the population is a good indicator of overfishing, and the availability of age data is crucial to being alerted to such changes in age structure.
c. Indices, such as the South Carolina trammel net survey, could be used directly in an extended version of DB-SRA. The implementation of xDB-SRA could instead specify stock status at an earlier time period, thus allowing the most recent catches to inform population dynamics and thus stock status.

8. Recommend timing of the next benchmark assessment and updates, if necessary, relative to the life history and current management of the species.

Because black drum is not overfished and overfishing is not occurring, the Panel recommended the next benchmark assessment be done in 5 years, or sooner if 'rumble strips' indicate significant changes in the population requiring management attention.

Atlantic States Marine Fisheries Commission

Black Drum Stock Assessment for Peer Review



February 2015

Vision: Sustainably Managing Atlantic Coastal Fisheries

Atlantic States Marine Fisheries Commission

Black Drum Stock Assessment for Peer Review

Prepared by the
ASMFC Black Drum Assessment Subcommittee:

Dr. David Chagaris (Chair), Florida Fish and Wildlife Conservation Commission
Mr. Joe Cimino, Virginia Marine Resources Commission
Mr. Jeff Kipp, Atlantic States Marine Fisheries Commission
Mr. Chris McDonough, South Carolina Department of Natural Resources
Mr. Ray Mroch, North Carolina Division of Marine Fisheries
Dr. Geneviève Nesslage, Atlantic States Marine Fisheries Commission
Mr. Scott Newlin, Delaware Division of Fish and Wildlife
Mr. Kirby Rootes-Murdy, Atlantic States Marine Fisheries Commission
Mr. Jordan Zimmerman, Delaware Division of Fish and Wildlife

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The ASMFC Black Drum Technical Committee: Jordan Zimmerman (DE, Chair), Adam Kenyon (VA), Chris Stewart (NC), Chris McDonough (SC), David Chagaris (FL), Genny Nesslage (ASMFC), Harry Rickabaugh (MD), Jason Hearon (DE), Jeff Kipp (ASMFC), Kirby Rootes-Murdy (ASMFC), and Ryan Harrell (GA).

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EXECUTIVE SUMMARY

The management unit for Black Drum (*Pogonias cromis*) under the jurisdiction of ASMFC includes that portion of the black drum population occurring within U.S. water of the northwest Atlantic Ocean from the Gulf of Maine to Florida. The goal of the Black Drum Fishery Management Plan (approved May 2013) is to provide for an efficient management structure to implement coastwide management measures in a timely manner.

In the U.S., Black Drum support commercial and recreational fisheries, with young, small fish targeted in the southern portion of the range (as a food fish) while older, larger fish are targeted in the northern portion. During 1950 to 2013, black drum landings from the U.S. Atlantic Coast ranged between approximately 368,000 pounds in the 1950s and 60s, to approximately 211,000 pounds in the 1970s and 80s. Since 1990, landings have increased to an average of approximately 260,000 pounds, with North Carolina and Virginia accounting for approximately 73% of annual coastwide landings. In recent years, gill nets and pound nets have been the primary gear used. A majority of removals for the black drum stock over time have come from the recreational fishery. On average, recreational harvest is 4.2 times larger than the commercial harvest- mean harvest in weight from 1981-2012 is 1,142,742 lbs. /year.

For this assessment, the Stock Assessment Subcommittee (SASC) evaluated over 70 fishery-dependent and independent U.S. data sources representing several life stages and geographical and temporal scales. Sixteen fishery-dependent and independent data sources were selected for use in this assessment because they were considered adequate for describing life history characteristics, removals, or abundance trends of the black drum stock.

Per recruit analyses completed for the assessment were useful for estimating reference points based on age-structured dynamics and changes in reference points due to potential management scenarios. However, the lack of stock-wide fishing mortality or abundance estimates precludes the use of these analyses to determine black drum stock status.

Three catch-based methods were used in the assessment, a method developed by Martell and Froese (2012) referred to through the remainder of this document as the Catch-MSY method, Depletion-Based Stock Reduction Analysis (DB-SRA; Dick and McCall, 2011), and Depletion-Corrected Average Catch (DCAC; McCall, 2009). These methods incorporate stock removals to estimate catch reference points, but were not designed to estimate stock condition. The estimates are directly controlled by subjective depletion parameters that are informed by limited data. The methods do not fit estimates to any external abundance data and may not be rigorous enough to determine stock status with any certainty. The only methods attempted that did fit to abundance data, surplus and age-structured production models, failed to produce stable or realistic estimates. The SASC's confidence in abundance data reflective of the entire stock was diminished following these analyses and highlights the need for comprehensive abundance data.

Further complicating the SASC's ability to determine stock status was the lack of data indicating fluctuations in the condition of the black drum stock due to exploitation and the stock's response to varying conditions. The SASC could not determine a reference point for an index indicator to trigger concern for the stock. ~~No stock status determination was made for the black drum stock~~[1]. Based on the DB-SRA results, black drum life history, indices of abundance, and history of exploitation, the black drum stock is not overfished and not experiencing overfishing.

The SASC selected the DB-SRA method as the preferred method for estimating catch reference points. DB-SRA estimates two catch reference points that have been provided in the results section, MSY and OFL. The SASC assumed the black drum stock was not overfished in 2012 (i.e., $B_{2012} > B_{MSY}$) due to light exploitation and minor decreases in the SC Trammel index and therefore the OFL will be greater than MSY. Due to uncertain inputs and the nature of data poor methods, the SAS recommends the more precautionary MSY estimate as a catch reference point for black drum. ~~The median MSY estimate is 2.60 million pounds with an interquartile range of 1.76-4.10 million pounds.~~[2] The median MSY estimate of the final preferred DB-SRA configuration as amended at the peer review workshop is 2.12 million pounds with an interquartile range of 1.60 – 3.05 million pounds. The catch reference points may further be limited by the one-way removal time series observed for black drum. If the stock has not reached levels of maximum productivity, the data may not be informative of overall maximum productivity and the reference points may only correspond to observed exploitation, which is assumed to be relatively low. For a data-poor stock, this precautionary approach was determined favorable by the SASC.

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[1] During the peer review workshop, the assessment team and review panel agreed that the stock was not overfished and overfishing was not occurring. This stock status determination was based on the DB-SRA results, black drum life history, indices of abundance, and history of exploitation. See the peer review report.

[2] The peer review panel recommended that an uninformative, uniform distribution with bounds of 0.5-0.9 be used for the Br/K parameter in the DB-SRA model. This was accepted for the final preferred DB-SRA configuration.

LIST OF TABLES

LIST OF FIGURES

TERMS OF REFERENCE

1. Characterize precision of fishery-dependent and fishery-independent data used in the assessment, including the following but not limited to:
    a. Provide descriptions of each data source (e.g., geographic location, sampling methodology, potential explanation for outlying or anomalous data, and other caveats).
    b. Summarize biological data (e.g., length frequency, age distribution, maturity information) if available.
    c. Describe calculation and potential standardization of abundance indices.
    d. Discuss trends and associated estimates of uncertainty (e.g., standard errors).
    e. Justify inclusion or elimination of all available data sources.
    f. Discuss the effects of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, aging accuracy, sample size) on model inputs and outputs.
2. Review estimates and PSEs of recreational fishing from MRIP. Compare historical and current data collection and estimation procedures and describe data caveats that may affect the assessment.
3. Develop simple, empirical indicators of stock abundance, stock characteristics, and fishery characteristics.
4. Develop models used to estimate population parameters (e.g., F, biomass, abundance) and biological reference points, and analyze model performance.
    a. Describe stability of models (e.g., ability to find a stable solution).
    b. Perform sensitivity analyses for starting parameter values and conduct other model diagnostics as necessary.
    c. Clearly and thoroughly explain model strengths and limitations.
    d. Briefly describe history of model usage, its theory and framework, and document associated peer-reviewed literature.
    e. If multiple models were considered, justify the choice of preferred model and the explanation of any differences in results among models.
5. State assumptions made for all models and explain the likely effects of assumption violations on synthesis of input data and model outputs.
6. Characterize uncertainty of model estimates and biological or empirical reference points.
7. Recommend stock status as related to reference points (if available).
8. Develop detailed short and long-term prioritized lists (high, moderate, or low) of recommendations for future research, data collection, and assessment methodology. Highlight improvements to be made by next benchmark review.
9. Recommend timing of next benchmark assessment and intermediate updates, if necessary, relative to biology and current management of the species

1 INTRODUCTION

1.1 Fisheries Management

1.1.1 Management Unit Definition

The management unit is defined as the black drum (*Pogonias cromis*) resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the estuaries eastward to the offshore boundaries of the EEZ. The selection of this management unit is based on the distribution of the species along the Atlantic coast, as noted in tagging studies from Maryland, Virginia, South Carolina, and Georgia, and historical harvest patterns that have identified fisheries for black drum from Florida north through New Jersey.

1.2 Regulatory History

No coastwide management program, whether among the states or at the federal level, existed for Black Drum on the Atlantic coast prior to the development of the Interstate Fishery Management Plan (FMP) in 2013. At present, eight states have implemented harvest regulations for black drum (Table 1).

New Jersey: New Jersey currently has a 10,000 pound commercial trip limit and a 65,000 pound annual quota in the commercial fishery. For the recreational fishery, the minimum size is 16 inches total length and the bag limit is 3 fish. The state is considering adoption of new recreational (two fish greater or less than 32 inches) regulations for harvest of black drum. If adopted, similar regulations will be considered by Delaware in the Delaware River and Bay areas.

Delaware: The Delaware Division of Fish and Wildlife entered a joint management plan with the state of New Jersey for black drum in the Delaware Bay in March 2010. This bi-state fishery management plan established the same recreational size and bag limits (16 inches and 3 fish) and commercial quota (65,000 pound annual quota) as New Jersey for the shared waters of the Delaware Bay and River. Upon adoption of the ASMFC Black Drum FMP these regulations were extended to all Delaware waters.

Maryland: Prior to 1994 Maryland had no restrictions on the harvest of black drum. In 1994 regulations were adopted including a 30,000 pound Chesapeake Bay commercial quota, a 1 fish per angler recreational creel limit, and a 16 inch total length size limit for both commercial and recreational fisheries. In 1998 the Chesapeake Bay commercial fishery was closed except for scientific studies and a 1,500 pound per year cap was placed on the Atlantic Ocean commercial fishery. Also, a 6 fish per boat limit was added to the recreational fishery in addition to the one fish per person creel limit.

Virginia: The minimum size limit for black drum in Virginia's commercial fishery has been 16 inches (total length) since 1987. In 1992, a one fish possession limit (recreational and commercial) was established for any person using hook and line, rod and reel, or hand line. The commercial Black Drum Harvesting and Selling permit was created in 1987. This permit is required to land more than one black drum per day for commercial purposes. Until 1993, any commercial fisherman was able to attain a permit, but by 1993 that fisherman was required to be a registered commercial fisherman. In 1994, the harvesting and selling permit was tied to specific previous permit and documentation of harvest requirements for the 1988-1993 period. In addition, any fisherman active in 1992 or 1993 was required to have reported that activity in order to maintain a permit in 1994; weekly mandatory reporting of daily activity has been required since 1987. Since 2002, the annual commercial quota has been 120,000 pounds in order to cap landings.

North Carolina: Currently, there is a 500 lbs. trip limit and slot limit of 14-25 inches for black drum in North Carolina for the commercial fishery. Since 1994 all black drum commercial landings have required documentation in the North Carolina Division of Marine Fisheries Trip Ticket Program. Recreationally, smaller black drum are harvested while larger drum are typically caught and released for sport. The same slot limit (14-25 inches) and as well as a 10 fish bag limit are in place for the recreational fishery.

South Carolina: Commercial landings in South Carolina reported by NMFS are generally low and indicative of reported bycatch rather than a targeted fishery. Section 50-5-360 of the South Carolina Code requires that anyone, who buys, receives or handles any live or fresh saltwater fish or any saltwater fishery products taken or landed in the state for sale, must obtain a wholesale dealers license. Prior to 2007, there were no recreational management regulations for black drum in South Carolina. In 2007 the South Carolina legislature amended section 50-5- 1705 of the South Carolina Code creating a slot limit of 14 to 27 inches total length and a daily bag limit of 5 fish per person that applies to both commercial and recreational fisheries.

Georgia: Black drum were not regulated in Georgia until April 1998, when the current fifteen fish bag limit and 10-inch minimum total length regulations were enacted. Commercial regulations are the same as those for the recreational fishery.

Florida: With the increase in popularity of blackened redfish dishes in the 1980s, concerns were raised about subsequent overfishing of drums. Therefore, regulations were established in Florida in 1989, including a minimum size limit for both recreational and commercial black drum fisheries of 14 inches and a maximum size limit of 24 inches. Possession of one fish over 24 inches is allowed for recreational fishers only. The recreational fishery has a daily limit of 5 fish per day, and the commercial fishery has a limit of 500 pounds per day.

1.3 Assessment History

Prior to the 2015 Benchmark Stock Assessment, a coastwide stock assessment had not been conducted for Black Drum on the Atlantic coast. Two prior stock assessments conducted along the Atlantic coast were at the state/regional level; Florida (Murphy and Muller 1995) and the Chesapeake Bay (Jones and Wells 2001). The first regional stock assessment (1995) for black drum, conducted in Florida, utilized recreational CPUE data, commercial landings data and state surveys. Both catch per commercial trip and number of black drum kept by recreational anglers showed decreases after 1989. Florida black drum condition appeared favorable due in part to a combination of very conservative fishing mortality (F) estimates, new regulations, and recent high recruitment events. The second regional stock assessment (2001), evaluated yield per recruit estimates under different potential mortality rates and mean age at capture. Estimates of current fishing mortality were determined lower than Fmax. In turn, overfishing, specifically growth overfishing, was determined unlikely under fishing practices at the time.

2 LIFE HISTORY

The black drum (*Pogonias cromis*) is the largest member of the family Sciaenidae found along the Atlantic coast of the United States. Black drum range from Argentina to New England with infrequent reports as far north as Canada (Bleakney 1963). They are common from the mid-Atlantic region to the Gulf of Mexico but considered rare north of Delaware Bay (Murdy et. al. 1997). Black drum have an unusual combination of life history characteristics as they grow quickly and are relatively long-lived. Unlike most other long-lived species, black drum are sexually mature at a relatively young age and can spawn millions of eggs annually.

Black drum support commercial and recreational fisheries in the United States which primarily target young, small fish in the southern portion of their range and older, larger fish in the northern portion (Jones and Wells 2001). Small black drum are valued as a food fish; however, larger black drum generally have reduced value, frequently being infested with parasitic "spaghetti" worms *Poecilancistrium robustum* (Silverman 1979). Collagen extracted from black drum bone and skin is reported to be comparable to land-based collagen and have anti-inflammatory properties (Venugopal 2008); however, no information indicates that drum are extensively harvested for collagen.

2.1 Stock Definitions

Multiple lines of evidence suggest that black drum on the US east coast are from a common stock and have been summarized by Jones and Wells (1998). However, black drum form at least three distinct populations in the waters of the United States, one encompassing the entire Atlantic coast of the United States and two in the Gulf of Mexico (Gold and Richardson 1998). Recent evidence using nuclear microsatellite markers indicates genetically distinct populations in the Gulf of Mexico and the Atlantic coast of the United States (Leidig 2014). Leidig (2014) found that along the U.S. Atlantic coast, there appears to be weak, but significant, genetic divergence among southern states, specifically between the Carolinas and Florida. An isolation-by-distance pattern was also observed from North Carolina to Florida. On a larger scale, results suggest a lack of genetic divergence between Delaware and Virginia and the southern states, which may be influenced by the life history patterns of Black Drum. This supports the management of Black Drum as one unified stock along the U.S. Atlantic coast and indicated the need for common management regulations among Atlantic states. Growth function parameters are nearly identical for black drum captured in Florida, Virginia, and Delaware suggesting growth within populations may not vary significantly by latitude despite small differences. Tagging data has shown that large adults move from Florida to the Chesapeake Bay indicating mixing within the Atlantic coast stock (Murphy et. al 1998).

2.2 Migration Patterns

Black drum in the western North Atlantic Ocean make long migrations north/inshore in the spring and south/offshore in the fall. Black drum in the southeast United States and Gulf of Mexico appear to be more sedentary compared to the northeastern U.S. as many researchers have reported little movement of tagged fish from release sites (Music and Pafford 1984; Beaumariage and Wittich 1966; Simmons and Breuer 1962). Osburn and Matlock (1984) suggested managing Texas bays as "closed systems" for black drum due to substantial intrabay movement and little (<14% of all tag returns) interbay movement. However, there is believed to be a significant proportion of adult fish that migrate extensively along the Atlantic coast. Two fish tagged in Florida in February were recaptured in the Chesapeake Bay by recreational anglers in May and June of the same year, nearly 1370 kilometers away (Murphy et al. 1998). Mass emigration of young-of-the-year has been documented in Delaware Bay (Thomas and Smith 1971) and the Chesapeake Bay (Frisbie 1961) in the fall. Northward movement of adults in the spring has been attributed to a spawning migration, as it coincides with peak spawning along the Atlantic coast (Murphy et. al. 1998). While black drum are known to migrate substantial distances along the eastern U.S., the amount of time spent in transport is likely low as one individual moved 229 km in 5 days in Virginia (Lucy and Bain 2003).

2.3 Life History Characteristics

2.3.1 Age

Researchers have looked at various hard parts to accurately age adult black drum. Scales have been found to be inaccurate and imprecise when ageing black drum greater than ten years of age (Richards 1973). Instead, thin sections of black drum otoliths processed by a low speed isomet saw are the most accurate, precise, and discernible hard parts to interpret. Between-reader precision for otolith thin sections was 100 percent versus 27.3 percent for dorsal spines and 47.4 percent for fin rays (Jones and Wells 1998). Black drum otolith age has been validated indirectly through intra-year progression of annulus formation (Beckman et. al. 1990), directly by mark-recapture studies (Murphy et. al. 1998) and by radiocarbon from nuclear testing (Campana and Jones 1997). Maximum age has been reported at 67 years old (VMRC 2013).

2.3.2 Growth

Black drum are generally considered long-lived and fast growing as they have been reported to obtain 80% of their growth potential over 20% of their life span (Jones and Wells 1998). The International Game Fish Association all-tackle world record weighed 51.36 kilograms (IGFA 2009) while the largest individual ever captured was 66.22 kilograms (Thomas 1971). Black drum exhibit similar growth rates along the Atlantic coast of the United States although some geographic variation in growth rate has been documented between fish in northeast Florida and Virginia. Variation in growth may be attributable to differences in spatial and temporal scale of sampling. As reported in Bobko (1991), average length and weight of fish in Murphy and Taylor's 1989 study from Florida were significantly different from the average length and weight of Virginia fish. A small proportion (>12%) of Murphy and Taylor's sample were greater than 75 cm while Bobko did not obtain data from fish less than 83 cm. Absence of size classes can lead to different results in growth analyses and may account for the discrepancy between the two studies. Linear regressions of total weight vs. total length performed on black drum captured in Virginia (Bobko 1990) predicted weights that were significantly heavier than for those of Florida (Murphy and Taylor 1989) and Louisiana (Beckman et. al. 1990). There is no evidence of sex-specific growth although maturity schedules differ by sex (Murphy and Taylor 1989, Bobko 1991). Atlantic coast black drum appear to grow slower than fish from the Gulf of Mexico black; however they attain higher maximum sizes (Jones and Wells 1998).

2.3.3 Reproduction

Black drum spawn in coastal bays and estuaries along the Atlantic coast from Florida to New Jersey. Black drum spawning has been documented in every calendar month for the Gulf of

Mexico and the south Atlantic coast of the United States although spawning varies throughout their range (Leard et. al. 1993). Spawning in Louisiana waters of the Gulf of Mexico occurs from February through April with peak activity occurring in February and March (Fitzhugh and Beckman 1987). On the Atlantic coast of Florida, black drum spawning took place from January to March (Murphy and Taylor 1989). Chesapeake Bay spawning occurs in April and May (Bobko 1991, Jones and Wells 1994). Black drum eggs were found inside the mouth of the Chesapeake Bay during mid to late May, but not after June 7^{th}, indicating spawning completion (Joseph et. al. 1964). Spawning in the Delaware Bay occurs from April through early June (DDFW unpublished data) with peak spawning occurring in the middle of May (Thomas 1971, Wang and Kernehan 1979).

Black drum are batch spawners and exhibit multiple oocyte development stages within female ovaries during spawning (Nieland and Wilson 1993, Wells 1994, Murphy and Taylor 1989, Fitzhugh et. al. 1993). Discrepancies in the literature exist regarding patterns of oocyte development. Fitzhugh et. al. (1993) reported asynchronous recruitment of vitellogenic oocytes while Nieland and Wilson (1993) and Wells (1994) observed group synchronous oocyte development. Spawning frequency has been estimated to be 3 to 4 days (Fitzhugh et. al. 1993, Nieland and Wilson 1993). Batch size may vary with reproductive period or size of the individual. Fitzhugh et. al. (1993) and Wells (1994) found that the relationship between batch fecundity and body size to be variable in Louisiana waters. While Nieland and Wilson (1993) found that batch fecundity was positively correlated with total weight, fork length, and age. Mean batch fecundity was estimated at 1.22 million to 1.6 million hydrated oocytes for black drum in Louisiana (Nieland and Wilson 1993, Fitzhugh et. al. 1993). Total fecundity, a function of the length of spawning season, spawning frequency, and batch fecundity, has been estimated at 5.5 to 26.6 million eggs per female in Virginia for black drum ranging from 985 mm to 1165 mm in total length (Bobko 1991). Fitzhugh et al. (1993) estimated annual fecundity for Louisiana drum between 660-876 mm as high as 32 million eggs per fish. Overall mean annual fecundities for 41 black drum sampled by Nieland and Wilson (1993) was reported as 37.67 million ova.

Developing ovaries have been found in black drum as small as 270 mm (Pearson 1929). Simmons and Breuer (1962) reported length and age at maturity to be 320 mm and two years. Murphy and Taylor (1989) examined sex specific maturity schedules and found 50% of the males in northeast Florida waters occurred at 590 mm (4 to 5 years old) were mature and that males reached 100% maturity at 675 mm (6 years old). Whereas, females achieved 100 % maturity at sizes of 650 mm and ages from 5-6 years old. Fitzhugh et. al. (1993) found length at first maturity to be similar to Murphy and Taylor (640 mm) with corresponding ages of 3 to 8 years.

2.3.4 Mortality

Little research has been reported on black drum mortality. The long life span of this species suggests that natural mortality is relatively low. Due to the size of adult black drum, most of the mortality caused by predation likely occurs at larval and juvenile stages. Abundance of jellyfish on spawning grounds in Chesapeake Bay is believed to be a major source of mortality on eggs and larvae. Peaks in jellyfish abundance may be responsible for episodic periods of reduced black drum recruitment (Cowan et. al. 1992). Jones and Wells (1998) converted estimates of instantaneous total mortality, Z, to annual total mortality, A, of less than 13 percent for fish in the Chesapeake Bay. Their estimate of total mortality may be low as current exploitation patterns are believed to be much greater than those witnessed more than two decades ago. Furthermore, their estimate assumes low fishing mortality on young fish throughout the stock's range. It is evident from landings data, that exploitation patterns differ by latitude as older, larger fish comprise a bigger proportion of harvest in the mid-Atlantic while younger, smaller fish are harvested in greater numbers in the southeastern states. Stocks with low natural mortality, *M*, typically do not have surplus natural mortality that can be transferred to fishing mortality (Murphy and Taylor 1989). However, as stated previously, black drum differ from most species that have low natural mortality in that they mature early and are highly fecund. The reproductive strategy of broadcasting eggs over a number of suitable, but diverse, habitats up and down the Atlantic coast may enable the species to mitigate adverse environmental impacts to recruitment.

2.3.5 Feeding

Adult black drum are primarily benthic feeders, schooling in spatial patches where food is plentiful (Simmons and Breuer 1962), capable of crushing the shells of mollusks and crabs with their strong pharyngeal teeth (Simmons and Breuer 1962). Adult black drum feed on several commercially and recreationally important shellfish species. Captive black drum were capable of consuming more than two commercial-sized oysters per kilogram of body weight per day (Cave and Cake 1980). Plunket (2003) reported black drum fed on blue crab, mud crab, ribbed mussels and dwarf surf clams. Delaware Bay commercial watermen associate black drum abundance (presumably adults) with large sets of blue mussels (*Mytilus edulis*) (De Sylva et al. 1962). Adult black drum sampled from the commercial and recreational fisheries in Delaware and New Jersey commonly contained blue mussels and soft-shelled clams within their stomachs (J. Zimmerman, Delaware Division Fish and Wildlife, personal communication). However, larval black drum feed primarily on zooplankton (Benson 1982); while young black drum feed largely on copepods, amphipods, annelids and isopods (Thomas 1971).

3 HABITAT DESCRIPTION

3.1 Spawning, egg, and larval habitat

Spawning: Black drum spawn from April to June in the northern range (Joseph et al. 1964; Richards 1973; Silverman 1979). Spawning has been documented in the mouth of the Chesapeake Bay and seaside inlets on the Eastern shore (Chesapeake Bay Program 2004). The presence of a large spring/early summer fishery during this time period in the Delaware Bay also provides evidence of spawning occurring inshore and in the spring. Evidence in Florida suggests spawning occurs in deep waters inshore, from November through April, with peaks in February and March (Murphy and Taylor 1989). As in the northern range, Florida's highest catches occur during the peak of spawning season (Murphy and Muller 1995).

Larval: Larval black drum tend to settle in the salt marshes and estuaries (ASMFC 2011). Peters and McMichael (1990) reported black drum larvae in the bays of Florida, where salinities ranged from 22 – 30 ppt. They found these larvae primarily feeding on copepods. Thomas and Smith (1973) observed larval drum disperse into the shore zone and into creeks and ditches in the Delaware Bay in June. They were typically found in areas with little or no current and often over a mud bottom. Gold and Richardson (1998) characterized black drum as estuarine-dependent in the early years. Work by Rooker et al. (2004) on strontium concentrations deposited in otoliths supported movement into lower-salinity, estuarine environments during early life stages.

3.2 Juvenile and adult habitats

Juvenile: Black drum juveniles have been found in salt marshes and estuaries along the coast, suggesting these areas serve as nurseries for sub-adults (ASMFC 2011; Murphy and Muller 1995; Pearson 1929). Beach seine sampling in Florida nearshore lagoons found high numbers of juveniles, suggesting juvenile black drum remain inshore. Juveniles tolerate a wide range of salinities and temperatures but have been found often in low to medium salinities and over unvegetated mud bottoms in Florida waters (Peters and McMichael 1990). Thomas and Smith (1973) reported catching juveniles in waters with a salinity range from 0 – 28 ppt in the Delaware Bay estuary. As juveniles grow, they range into higher salinity areas, more similar to adult habitat (Rooker et al. 2004). Small juveniles primarily feed on amphipods, mollusks, polychaetes, and small fish (Peters and McMichael 1990). Peters and McMichael (1990) found that as juveniles increase in size their consumption of shrimp, crabs, fish, and mollusks became more dominant, with the crossover correlating with the development of pharyngeal molars. Richards (1973) correlated muddy, nutrient rich, marsh habitat during the first three months of life with rapid growth.

Murphy and Taylor (1989) noticed the capture of small drum throughout the year by recreational and commercial fishermen in Florida's nearshore areas, suggesting year-round occupation of these nearshore estuarine to marine habitats.

Adult: Data suggests adults are euryhaline, although high salinities tend to cause stress as do sudden drops in temperature (Simmons and Breuer 1962). Adults move between estuaries and nearshore shelf waters, although they tend to move to deeper channel areas as they grow and mature (ASMFC 2011). Evidence supports an age-specific migration in the Mid-Atlantic: northward and inshore in the spring; southward and offshore in the fall (Jones and Wells 2001). Mollusks, decapods, fishes, and annelids dominate the diet for adults (Murphy and Muller 1995).

Black drum move offshore at sexual maturity and form large, offshore schools that migrate extensively (Simmons and Breuer 1962). Work by Rooker et al. (2004) on strontium concentrations deposited in otoliths supports movement into more saline, oceanic conditions when older.

4 FISHERIES-DEPENDENT DATA SOURCES

4.1 Commercial

Black drum landings by state and gear from 1887-1944 were compiled from U.S. Fish Commission annul reports (http://www.lib.noaa.gov/collections/imgdocmaps/fish_com_annualreport.html). Landings from 1945-1949 were provided by the National Marine Fisheries Service. Coast wide dealer reported commercial landings (live pounds) from 1950-2012 were queried from the Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse. Landings from 1950-2012 are a combination of landings data reported to NMFS on an annual, monthly, or trip level basis and landings reported to states on a trip level basis (http://www.accsp.org/Metadatapage_FL.html). Landings were queried by month, gear, and state. These landings were reviewed by state database administrators from NJ-FL to identify discrepancies. Discrepancies were identified for Virginia, North Carolina, and Delaware landings during various years. VMRC landings data were used in place of ACCSP landings data for the years 1989, 1994, 1996-1997, and 1999-2012. NC DMF landings data were used in place of ACCSP landings data for the years 1972-1977, 1994-2000, and 2002-2007. Delaware DFW landings data were used in place of ACCSP landings data for the years 1985-1996, 2002, 2005-2008, and 2011.

Prior to 1920, landings are highly variable, including the fifth (1918; 536,332 lbs.) and seventh (1904; 453,080 lbs.) greatest annual landings in the time series (Figure 1 and Table 2). There are 23 of 33 years from 1887-1919 with no documented landings identified. Landings steadily increased from 1920-1967, with the exception of the early 1940s during World War II. Landings then decreased from a time series maximum of 664,100 lbs. in 1969 to 141,397 lbs. in 1980. There has been a slight increasing trend in landings from 1980 to 2012 with a mean of 244,882 lbs./year landed. Interannual variability has been high relative to total annual landings throughout the time series. Historically, landings have primarily been from gill net and fixed net (i.e., pound net) fisheries (Figure 35, Table 3). Gill net and fixed net landings have accounted for 36% and 23% of known gear-specific landings from 1950-2012, respectively. There have also been significant landings in seine (haul and purse; 15%), trawl (10%), and hook and line fisheries (long line, hook and line, hand line; 10%). Other gears (gears accounting for <1% of coastwide landings) combined have accounted for 4% of the coastwide landings from 1950-2012. Other gears included pots and traps, cast nets, rakes, hoes, and tongs, dredges, by hand, and spears and gigs. There was an issue identified with landings not being coded with gears in the 1980s and 1990s. These non-coded landings accounted for the remaining 3% of coastwide landings from 1950-2012. Primary gears accounting for annual landings through the 1950s and 1960s were fixed nets and seines. Primary gears varied through the 1970s. Landings in gill net fisheries increased in the mid-1980s and have dominated coastwide landings from 1983-2012 (with the exception of 2002; fixed nets), accounting for 59% of coastwide landings. The second most dominant gear from 1983-2012 was fixed nets, accounting for 14% of the coastwide landings. Landings by other gears from 1983-2012 include trawls (6%), hook and line (5%), seines (%5), and other gears (3%). Non-coded landings accounted for 7% of coastwide landings from 1983-2012.

Since 1990, when Florida put in harvest restriction and then banned gill netting in state waters, the vast majority of black drum harvested coastwide are landed in North Carolina and Virginia (Figure 34; averaging 73% for 1990-2012). A smaller portion of the coastwide black drum harvest is landed in Delaware, Florida, New Jersey, and Maryland. Landings reported from South Carolina are generally low and indicative of reported bycatch rather than a targeted fishery. Georgia, New York, Connecticut, Rhode Island, and Maine occasionally report small amounts of black drum landings as well; however, the magnitude of these landings is so small that the total annual state landings records are confidential. Landings from New York to Maine have averaged 135 lbs./year combined from 1993-2012 and never exceeded 1,000 lbs. Landings were reported in only 4 years prior to 1993 (1926 and 1931-1933). Due to confidential landings at the year/state/gear level and even year/state level, limited commercial landings data are provided in this report. State percentage contributions to annual commercial landings are in Figure 34.

4.1.1 New Jersey

4.1.1.1 Data Collection

4.1.1.1.1 Landings

All black drum commercial landings in New Jersey have been collected by NMFS.

4.1.1.1.2 Discards
No black drum commercial discard data are collected in New Jersey.

4.1.1.1.3 Biological Sampling
No black drum biological samples have been collected in New Jersey commercial fisheries.

4.1.1.1.4 Catch Estimation Methodology
No black drum catch-at-length, weight, or age has been developed, as no biological samples have been collected from New Jersey commercial fisheries.

4.1.1.2 Trends

4.1.1.2.1 Landings
New Jersey landings averaged 22,716 lbs. /year between 1950 and 2012. On average, New Jersey landings have accounted for 9% of the annual coastwide landings. Landings were consistently above average from 1971-1976 and 1990-2000 (with the exception of 1998). There was an increasing trend in landings from the early 1980s through the 1990s. Landings averaged 53,257 lbs. /year from 1990-2000, reaching a time series maximum of 126,687 lbs. in 1999 (38% of the coastwide harvest). New Jersey implemented a trip limit of 10,000 lbs. and an annual quota of 65,000 lbs. in 2001 and the average landings decreased to 10,012 lbs./year from 2001-2012.

The black drum fishery is a directed fishery when the fish are in the area. Black drum landings by gear have fluctuated. The majority of landings are from gill nets (40.4%), followed by purse seines (25.8%), and trawls (20.8%). New Jersey's reported black drum landings were largely taken by pound and gill nets in the 1950's, but were taken largely by purse seine, gill nets, and trawls in subsequent years. Landings since 2000 were principally dominated by the trawl and gill net fisheries. New Jersey trawl landings were taken outside of the Delaware Bay, as trawling within the Bay is illegal. Highest landings occur in May through August with the majority in July.

4.1.1.2.2 Catch-at-Length/Weight/Age
No black drum catch-at-length, weight, or age has been developed, as no biological samples have been collected from New Jersey commercial fisheries.

4.1.1.2.3 Commercial Discards
No black drum commercial discard data are collected in New Jersey.

4.1.1.2.4 Catch Rates
No catch rates were developed from New Jersey commercial data.

4.1.2 Delaware

4.1.2.1 Data Collection

4.1.2.1.1 Landings

Commercial fishermen are required to submit logbooks on a monthly basis. Total harvest, effort as trip days and net yards, port landed and location fished are required data elements. Annual commercial landings are also collected by NMFS.

4.1.2.1.2 Discards

No black drum commercial discard data are collected in Delaware.

4.1.2.1.3 Biological Sampling

Mature black drum were sampled in April, May, and June from the commercial gill net fisheries in the Delaware Bay from 2009-2012. These months were chosen as they encompass the time of year when greater than 80 percent of the commercial harvest (personal communication DE-DFW) occur. All fish were measured for total length to the nearest millimeter. Sample sizes of biological samples are in Table 4 and the length frequency of black drum sampled is in Figure 2. Total weight (kg), gonad weight (g), and sex were recorded. Sagittal otoliths were removed and placed in envelopes with sample number, location, date, fishery, and gear type. One otolith was chosen randomly from each pair and processed for age determination. Otoliths were thin sectioned on a Hillquist high speed saw and mounted on microscope slides. Slides were viewed at 24X magnification.

4.1.2.1.4 Gill Net Catch Estimation Methodology

Sample weight for each 1mm length bin sampled each year was calculated by applying the weight-at-length from the DE-DFW length-weight relationship (section 6.1.1.1) to the frequency sampled. Catch-at-length was calculated by applying the proportion of the sample weight in each 1mm bin to the total gill net landings in weight and dividing by the weight-at-length from the length-weight relationship. An age-length key was developed by pooling all coast wide age-length samples over all years due to a lack of available samples, particularly for older fish (Table 5 and

Table 6). The coast wide age-length key was applied to catch-at-length to estimate catch-at-age. Information on changes in length-at-age with time and length-at-age by gear and area is lost by such coarse pooling of age samples. Catch-at-age for the DE gill net fishery was developed to provide a general sense of the age composition and not for direct use in assessment models.

4.1.2.2 Trends

4.1.2.2.1 Landings

Delaware landings averaged 5,245 lbs. /year between 1950 and 2012. On average, Delaware landings have accounted for 2% of the annual coastwide landings. There was no harvest reported in 18 of 28 years from 1950-1977. There has been an increasing trend in harvest in recent years averaging 31,377 lbs. /year between 2007 and 2012 and ranging from 9,708-49,744 lbs. Delaware landings have accounted for an average of 13% of annual coastwide landings during this period (range of 2-26%).

Delaware commercial fishermen primarily target black drum with drift gill nets that have mesh sizes of 10 to 12 inches. Incidental catches are made with anchored gill nets, fykes, and hook and line; however, these landings comprise a very low proportion of annual landings and, due to the number of participants, are confidential. Like the recreational fishery, harvesters are targeting spawning aggregations during the spring months.

4.1.2.2.2 Catch-at-Length/Weight/Age

The majority of the gill net landings fall between age-5 and age-15 (Table 7 and Figure 3). A large year class (2001) appears to move through the fishery from 2009-2011. A second relatively large year class (2005) appears to move through the fishery from 2010-2012.

4.1.2.2.3 Commercial Discards

No black drum commercial discard data is collected in Delaware.

4.1.2.2.4 Catch Rates

No catch rates were developed from Delaware commercial data.

4.1.3 Maryland

4.1.3.1 Data Collection

4.1.3.1.1 Landings

Maryland Department of Natural Resources (MDDNR) has a mandatory reporting system for commercial fishermen. Catch in pounds, days fished, area fished and amount and type of gear used were reported by month prior to 2006. A daily trip log was phased in from 2002 to 2005 with all fishermen using the daily log beginning in 2006. Effort data is only available for 1980–1984, 1990 and 1992–2008. Landings prior to 1981 are from NMFS.

4.1.3.1.2 Discards

No black drum commercial discard data are collected in Maryland.

4.1.3.1.3 Biological Sampling

Commercial pound nets were sampled in the Chesapeake Bay and in the mouths of its major tributaries from the Patuxent River south to the Potomac River. Sampling locations varied each year depending on where the cooperating fishermen's nets were set. The survey has been conducted every year from 1993 to 2012. Each site was generally sampled once every two weeks, weather and fisherman's schedule permitting. The commercial fishermen set all nets sampled as part of their regular fishing routine. Net soak time and manner in which they were fished were consistent with the fishermen's day-to-day operations. All black drum were measured to the nearest mm total length from each net when possible. Black drum were not frequently encountered in the survey, with only 121 samples taken through the time series. Lengths throughout the time series have ranged from 244 to 1330 mm TL, and averaged 878 mm TL.

4.1.3.1.4 Catch Estimation Methodology

No black drum catch-at-length, weight, or age has been developed due to poor biological sampling in Maryland commercial fisheries.

4.1.3.2 Trends

4.1.3.2.1 Landings

Maryland landings averaged 11,015 lbs. /year between 1950 and 2012. On average, Maryland landings have accounted for 4% of the annual coastwide landings. Landings exhibited high interannual variability with no apparent trend and reached a maximum of 99,950 lbs. in 1997 (32% of the coastwide harvest). Landings decreased significantly following the closure of the Maryland portion of the Chesapeake Bay to commercial black drum fishing in 1999, averaging 830 lbs./year from 1999-2012. Maryland landings did not exceed 1% of the annual coastwide landings during any of these years. Maryland landings were dominated by pound nets until the Chesapeake Bay closure. Landings have been from bycatch in the ocean trawl, gill net, and hook and line fisheries since 1998.

4.1.3.2.2 Catch-at-Length/Weight/Age

No black drum catch-at-length, weight, or age has been developed due to poor biological sampling in Maryland commercial fisheries.

4.1.3.2.3 Commercial Discards

No black drum commercial discard data are collected in Maryland.

4.1.3.2.4 Catch Rates

No catch rates were developed from Maryland commercial data. Changes in reporting method and sources, as well as the reliance of fishermen reporting their effort consistently and correctly, make the effort data unreliable for calculating CPUEs.

4.1.4 Virginia

4.1.4.1 Data Collection

4.1.4.1.1 Landings

The Virginia Marine Resources Commission (VMRC) began collecting voluntary reports of commercial landings from seafood buyers in 1973. Virginia implemented the Mandatory Reporting Program (MRP) in 1993, for all licensed commercial fishermen. The MRP is a complete census of all commercial harvest and landings in Virginia in a daily trip-level format. All commercial harvesters must report all species caught and retained. Data collected from the mandatory reporting program are considered reliable starting in 1994, the year after the pilot year of program.

4.1.4.1.2 Discards

No black drum commercial discard data are collected in Virginia.

4.1.4.1.3 Biological Sampling

The VMRC Biological Sampling Program was initiated in 1989 to collect fishery-dependent biological information to support assessment and management activity within the state and coastwide. Virginia began collecting biological samples from the commercial black drum fishery in 1998 including lengths, weights, and hard parts. Ageing work has been conducted by the Center for Quantitative Fisheries Ecology at Old Dominion University. A variable number of black drum from commercial fisheries have been available to the Biological Sampling Program over the years, with no samples in 2011, and as many as 210 samples in 1997 (Table 8). Length frequencies of black drum sampled in the commercial gill net and pound net fisheries are in
Figure 4.

4.1.4.1.4 Catch Estimation Methodology

No black drum catch-at-length, weight, or age has been developed due to poor biological sampling in Virginia commercial fisheries.

4.1.4.2 Trends

4.1.4.2.1 Landings

Virginia has been a primary contributor to black drum landings averaging 103,033 lbs. /year and 34% of the coastwide annual harvest from 1950-2012. There were four periods of relatively stable harvest levels. The greatest harvest was from 1950-1971, averaging 171,545 lbs. /year and 44% of the annual coastwide harvest. Average harvest then decreased significantly to 27,764 lbs. /year and 15% of the coastwide landings from 1972-1985. Average harvest then increased to 116,012 lbs. /year (46% of the coastwide landings) from 1986-1994 before decreasing to 71,348 lbs./year (31% of the coastwide landings) from 1995-2012. In 1987 there was a minimum size limit of 16 inches. In 1993 a limited entry permit was created for commercial harvest directed at black drum, there were less than 100 permits issued. All other commercial license holders are allowed to possess and sell one black drum per day. Since 2002, a commercial quota of 120,000 pounds has been in place in order to cap landings. Landings have only exceeded 100,000 pounds once since the quota was put in place, reaching 113,858 pounds in 2003. In 2004 the limited entry fishery was lowered to just 84 individuals. Virginia landings were dominated by pound nets from 1950 – 1982 (averaged 52% of Virginia annual landings) followed by primarily gill net landings from 1983-2012 (averaged 81% of the Virginia annual landings).

4.1.4.2.2 Catch-at-Length/Weight/Age

No black drum catch-at-length, weight, or age has been developed due to poor biological sampling in Virginia commercial fisheries.

4.1.4.2.3 Commercial Discards

No black drum commercial discard data are collected in Virginia.

4.1.4.2.4 Catch Rates

No catch rates were developed from Virginia commercial data.

4.1.5 North Carolina

4.1.5.1 Data Collection

4.1.5.1.1 Landings

Prior to 1978, NOAA Fisheries collected commercial landings data for North Carolina. Port agents would conduct monthly surveys of the state's major commercial seafood dealers to determine the commercial landings for the state. Starting in 1978, the NCDMF entered into a cooperative program with NOAA Fisheries to maintain the monthly surveys of North Carolina's major commercial seafood dealers and to obtain data from more dealers. The North Carolina Trip Ticket Program (NCTTP) was initiated on January 1, 1994, due to a decrease in cooperation in reporting under the voluntary NOAA Fisheries/North Carolina Cooperative Statistics Program, as well as an increase in demand by fisheries managers for complete and accurate trip-level commercial harvest statistics. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e., trips, licenses, participants, vessels) in a given fishery that was not available prior to 1994 and provides a much more detailed record of North Carolina's seafood harvest. All fish dealers in North Carolina must file a form (trip ticket) documenting all transfers of fish from the fishermen to the dealer. These forms include geographical as well as gear and catch information.

4.1.5.1.2 Discards

There is an observed program operated by NC DMF, though there is no reliable discard data for black drum collected in this program. Black drum are not a target species of this program and identification issues are likely to bias any black drum discard data.

4.1.5.1.3 Biological Sampling

Biological samples (lengths, aggregate weights) were obtained from the NCDMF commercial fisheries dependent sampling programs (P400s). Black drum lengths were collected at local fish houses by gear, market grade and area fished. Individual fish were measured (mm, centerline length-CL) and total weight (0.1 kg) of all fish measured in aggregate was obtained. Subsequent to sampling a portion of the catch, the total weight of the catch by species and market grade was obtained for each trip, either by using the trip ticket weights or some other reliable estimate.

4.1.5.1.3.1 Estuarine Gill Net Sampling

Sampling of the estuarine gill net fishery was initiated by the NCDMF in April 1991 to determine relative abundance, age, size, and composition of species taken in the Pamlico Sound area. Two modes of sampling were included in the project: at-sea sampling and fish house sampling as catches are unloaded to the seafood dealer. Most sampling was conducted at the fish house after fishermen landed and graded their catch. In 1994, at-sea and fish house sampling of estuarine gill nets was expanded to include all other areas within North Carolina.

4.1.5.1.3.2 Flounder Pound Net Fishery

Flounder pound net catches were typically sampled at fish houses late-August through early-December, based on availability of landings and when the season was open. Since most flounder pound net catches are culled at the fishing site, random stratified (graded) samples were collected. For each species, a representative number of random basket samples (50 lb.) were obtained from each size category (jumbo, large, medium, small, etc.), with more samples for larger fish.

4.1.5.1.3.3 Long Haul Seine Fishery

During the fishing season (April-November), long haul catches were sampled at the fish house where the catch was landed. Samples may be either graded or ungraded catches (sorted by market category) For each economically important (marketable) species, as many random samples (usually 50 lb. cartons) as possible were obtained from each market category.

4.1.5.1.3.4 Ocean Gill Net Fishery

Traditional, anchored, and runaround ocean gill net catches were sampled at the fish house where the catch was landed. For all gear types, the captain or crew members were interviewed, when available, to obtain information including area and depth fished, days at sea, gear(s) used including mesh size and length of gill nets. Random samples of culled catches were taken to ensure adequate coverage of all species in the catches.

4.1.5.1.3.5 Winter Trawl Fishery

Winter trawl catches were sampled at the fish house where the catch was landed. When available, the vessel's captain or a crew member was interviewed to obtain information on area and depth fished, number and duration of tows, days on the fishing grounds, and gear(s) used (including head rope length, body mesh size, and tail bag mesh size). To ensure adequate coverage of all sizes and species in the catches, and since some culling already has taken place at sea, stratified random samples of the graded catch were taken.

4.1.5.1.4 Catch Estimation Methodology

Biological sample data from NCDMF Program 400s is used to expand the number of individuals, aggregate weight, and length frequencies of each species in a sample to represent the species quantities in the sampled catch (trip ticket). Expansion was accomplished by matching at the market grade level biological fish house sample data (mean weight or length data) to the corresponding trip ticket market grade harvest. For example, the total length frequency of a species within a catch was derived by expanding the length frequency of the individuals measured in the subsample of a market grade (culled samples) to the total market category weight of that species in the sampled trip. Length frequencies were developed from 1994-2012 by fishery.

4.1.5.2 Trends

4.1.5.2.1 Landings

North Carolina has been the other primary contributor to black drum landings, particularly in recent years. Landings averaged 71,628 lbs. /year from 1950-2012 and accounted for 25% of the annual coastwide landings on average. Landings fluctuated from 1950-1967, averaging 68,828 lbs. /year and 19% of the annual coastwide landings in weight. Landings then decreased to relatively low levels from 1968-1992, averaging 31,011 lbs. /year and 15% of coastwide landings. Average landings then increased significantly to 124,920 lbs. /year from 1993-2012 (43% of annual coastwide landings). This period includes the two highest annual harvests in the time series, 497,479 lbs. in 2002 (90% of the annual coastwide harvest) and 301,998 lbs. in 2008 (75% of the annual coastwide harvest).

Black drum are primarily caught as bycatch in several North Carolina commercial fisheries including the sciaenid pound net, estuarine gill net, haul seine, and summer flounder trawl fisheries. Landings since the early 1990s have been dominated by gill nets, followed by pound nets. Trawls and haul seines were major gears in some years prior to the early 1990's, but only contributed minor landings after the early 1990s. Pound nets had the highest percentage of trips landing black drum (22.8%), followed by large mesh gill net (20.9%), haul seine (15.8%), float gill net (12.5%), and small mesh gill net (11.5%). Black drum landings have increased in both the pound net and gill net fisheries since the early 1990s. Black drum were most abundant in the fall (October and November) and winter (February); however, they are landed year around.

4.1.5.2.2 Catch-at-Length/Weight/Age

Catches-at-length for each fishery are in Table 9 - Table 13.

4.1.5.2.3 Commercial Discards

No black drum commercial discard estimates are available from North Carolina.

4.1.5.2.4 Catch Rates

No catch rates were developed from North Carolina commercial data.

4.1.6 South Carolina

4.1.6.1 Data Collection

4.1.6.1.1 Landings

Commercial landings of black drum in South Carolina were collected by the NMFS through the early 1980s. In the mid-1980s, South Carolina instituted a wholesale dealer reporting system, which is part of the NMFS Trip Interview Program (TIP). Black drum landed as bycatch from the shrimp trawl fishery are also reported through the wholesale dealer reporting system.

While there have been reported commercial landings for black drum, there have been only limited directed commercial fisheries for black drum in South Carolina. Some of these commercial landings are attributable to bycatch from other fisheries kept for sale.

4.1.6.1.2 Discards

No black drum commercial discard data are collected in South Carolina.

4.1.6.1.3 Biological Sampling

South Carolina port agents collect lengths and otoliths from a number of species as part of their commercial fisheries monitoring program. Black drum are not currently one of the species where biological samples are taken.

4.1.6.1.4 Catch Estimation Methodology

No black drum catch-at-length, weight, or age has been developed, as no biological samples have been collected from South Carolina commercial fisheries.

4.1.6.2 Trends

4.1.6.2.1 Landings

Landings in South Carolina have averaged 1,351 lbs. /year from 1950-2012 with a range of 0-13,400 lbs. /year. South Carolina landings have not exceeded 1% of the coastwide landings since 1985. There have been no reported landings in South Carolina in 13 of 19 years from 1994-2012. Most recent landings are from hook and line gears. Landings prior to 1995 were from trawls, gill nets, haul seine, and hook and line gears.

4.1.6.2.2 Catch-at-Length/Weight/Age

No black drum catch-at-length, weight, or age has been developed, as no biological samples have been collected from South Carolina commercial fisheries.

4.1.6.2.3 Commercial Discards

No black drum commercial discard data are collected in South Carolina.

4.1.6.2.4 Catch Rates

No catch rates were developed from South Carolina commercial data.

4.1.7 Georgia

4.1.7.1 Data Collection

4.1.7.1.1 Landings

Georgia began collecting commercial landings data in 1989 and implemented the trip ticket program in 2001. Via the trip tickets, harvesters and dealers provide effort, area, gear, pounds, and value for all trips unloading product in Georgia. Trip-level tickets are submitted to the Department each month and data are then shared with ACCSP and NMFS.

4.1.7.1.2 Discards

No black drum commercial discard data are collected in Georgia.

4.1.7.1.3 Biological Sampling

No black drum biological samples have been collected in Georgia commercial fisheries.

4.1.7.1.4 Catch Estimation Methodology

No black drum catch-at-length, weight, or age has been developed, as no biological samples have been collected from Georgia commercial fisheries.

4.1.7.2 Trends

4.1.7.2.1 Landings

Georgia's black drum landings for the years 1999-2012 are confidential. Landings in Georgia have averaged 925 lbs. /year. Georgia landings have not exceeded 1% of coastwide annual landings since 1980. Georgia landings have been dominated by hook and line gears, with occasional landings in trawls and gill nets prior to 1990.

4.1.7.2.2 Catch-at-Length/Weight/Age

No black drum catch-at-length, weight, or age has been developed, as no biological samples have been collected from Georgia commercial fisheries.

4.1.7.2.3 Commercial Discards

No black drum commercial discard data are collected in Georgia.

4.1.7.2.4 Catch Rates

No catch rates were developed from Georgia commercial data.

4.1.8 Florida

4.1.8.1 Data Collection

4.1.8.1.1 Landings

Florida commercial landings of black drum from 1986-2012 are collected through the Marine Fisheries Trip Ticket Program (http://myfwc.com/research/saltwater/fishstats/commercial-fisheries/wholesale-retail-dealers/). Landings prior to 1986 are from NMFS.

4.1.8.1.2 Discards

No black drum commercial discard data are collected in Florida.

4.1.8.1.3 Biological Sampling

The federal Trip Interview Program contains a small amount of data on the sizes of black drum landed by the commercial fishery in Florida. Commercial landings were sampled for lengths of black drum since 1992 and weights since 2000 (Figure 5). Sample sizes varied from 1 to 140 fish (average = 34 fish/year) measured each year.

4.1.8.1.4 Catch Estimation Methodology

No black drum catch-at-length, weight, or age has been developed due to poor biological sampling in Florida commercial fisheries.

4.1.8.2 Trends

4.1.8.2.1 Landings

The fisheries for black drum in Florida are relatively small and strictly regulated.

Florida was a major contributor to commercial landings prior to regulations implemented in the late 1980s and 1990s. During the period 1950-78, the commercial fishery landings on the Atlantic coast of Florida fluctuated (standard deviation = 28,800 lbs.) around an average of about 97,000 lbs. /year. Florida landings accounted for an average of 36% of the coastwide landings during this time period. After a period of years when landings declined to an averaged almost 68,000 lbs. (1979-87; 34% of coastwide landings on average), landings declined quickly before leveling off below 20,000 lbs. landed each year after 1994. Florida landings accounted for an average of 6% of coastwide annual landings from 1995-2012. These changes occurred at the same time as regulations were enacted (July 1989) that required a "restricted species" endorsement for fishermen landing black drum, a commercial vessel limit of 500 lbs. /day, a 14 in minimum size limit and a ban on the commercial landings, possession, or sale of black drum larger than 24 inches total length. Commercial gear information indicates that commercial gill-nets and hook-and-line gears were used for most landings of black drum prior to 1995. The prohibition of the use of entangling gear within state waters sharply curtailed the gill-net landings after 1995, when cast-net landings surged as a replacement to gill-net gear.

4.1.8.2.2 Catch-at-Length/Weight/Age

No black drum catch-at-length, weight, or age has been developed due to poor biological sampling in Florida commercial fisheries.

4.1.8.2.3 Commercial Discards

No black drum commercial discard data are collected in Florida.

4.1.8.2.4 Catch Rates

Though commercial catch rates can be calculated from the Florida trip ticket data, their utility as indices of abundance was judged to be low given the changes in the gears used in the fishery and regulations on sizes and trip limits. Furthermore, when black drum were landed they usually only made up a small proportion of the total landings from all species in that trip indicating that this is mostly bycatch fishery.

4.1.9 Potential Biases, Uncertainty, and Measures of Precision

Commercial landings from 1887-1949 are considered highly uncertain and were compiled to enable use of catch-based assessment methods that require the assumption that the stock being modeled is at unfished conditions in the beginning of the stock removals time series (section 6.1.5). There was limited gear information for these landings and the landings may not be comprehensive.

Dockside survey landings collected by NMFS on a monthly basis likely underestimate harvest in some years. Black drum may not have been reported to the species level, but rather to generic categories of landings. Commercial catch in Florida is most likely underrepresented, especially in early years, because black drum were often landed as ‘miscellaneous fish’ or ‘industrial fish’. Landings of the generic term “drum” (not specifying whether red drum or black drum) were not used in this assessment and may further confound total annual landings.

4.2 Recreational

4.2.1 MRFSS/MRIP

4.2.1.1 Survey Description

The main source of information on recreational fishing for Black Drum is the Marine Recreational Information Program (MRIP), which was formerly the Marine Recreational Fisheries Statistical Survey (MRFSS). In 2005, the National Academy of Sciences’ Natural Research Council was commissioned to review the MRFSS and provide recommendations for improving recreational fishing estimates. A major finding of the Council was that intercept methods resulted in a non-representative sample of recreational anglers and their catch-per-trip was not accounted for in the estimation methodology, resulting in potentially biased catch estimates and overestimated precision (MRIP website). Interviewers were instructed to maximize the number of intercepts made and site selection was at the interviewer’s discretion. Interviewers were more likely to obtain intercepts from high pressure sites and disregard low pressure sites and the catch-per-trip at the low pressure sites was not adequately represented. The Council’s review contributed to the implementation of the MRIP and a new estimation methodology. MRIP uses the same basic data as MRFSS but implements a new catch estimate methodology that better matches the sampling design used in the dockside intercept survey. The MRIP methodology is intended to account for possible differences in catch rates due to factors such as activity at fishing sites and time of day.

MRFSS/MRIP contain estimates for number of trips anglers are taking, the total amount of fish harvested (numbers or weight), total amount discarded, catch rates, and for this species only some sparse biological information. The survey is conducted coastwide and usually by state agency employees or contractors. In MRFSS/MRIP, anglers that fish from private boats and from shore are sampled using random dockside intercepts and telephone calls. During a dockside intercept, anglers are interviewed about their trip and the catch is counted, measured, and weighed. Angler access points are randomly selected in proportion to their expected fishing activity. To estimate effort, coastal households are randomly called and anglers are interviewed about the fishing trips taken during the previous 2 months. Similarly, a for-hire telephone survey is used to collect trip information directly from for-hire operators. Angler participation in MRIP surveys is voluntary. For details in addition to the description provided here, visit the NOAA recreational fisheries statistics website (www.st.nmfs.noaa.gov/recreational-fisheries).

Angler Catch Surveys (dockside intercepts) are interviews of anglers intercepted at public fishing access sites (e.g., marinas, piers) that collect information on the catch and fishing trip (see example questionnaire here http://www.st.nmfs.noaa.gov/Assets/recreational/pdf/append_a.pdf). Sampling is stratified by state, mode of fishing, and wave (bimonthly period) and is conducted continuously during the sampled wave. Recreational fishing estimates are provided for four major modes of fishing: private boats (including rentals), shoreline (e.g., pier, jetty, etc.), charter boats, and headboats (party boats). Each shoreline angler is treated as being on an independent fishing trip whereas boat modes are treated as fishing parties under the assumption that all anglers on a boat are fishing the same. Sampling is conducted in six waves, each wave being two consecutive calendar months starting with wave 1 (January and February) and ending with wave 6 (November and December). Sampling is conducted during all six waves in Florida (except wave 1 in 1981) and during waves 2-6 in Georgia to New Jersey (with the exception of pilot studies during some years in GA and NC). Prior to 1993 sampling was divided evenly between the two months in a wave. Beginning in 1993, sampling was divided proportional to expected fishing pressure during each month. There are a minimum of 30 intercepts in each stratum for the shore and private boat modes and at least 45 intercepts in each stratum for the party and charter boat modes (to account for clustering effect). Sampling beyond the minimum is allocated proportional to expected fishing pressure in each stratum based on the previous three year period. The number of Black Drum caught is recorded as harvested fish observed by the interviewer in whole form (type A), fish reported as harvested by the angler but not observed by the interviewer (bait, filleted, discarded dead) (type B1), and fish released alive (type B2).

Effort data are collected with the Coastal Household Telephone Survey (CHTS). The CHTS is a stratified random digit dialing telephone survey that includes only households in coastal counties (generally counties within 25-50 miles of coastline, depending on state). The CHTS is stratified by county and wave. Sampling is conducted over a two week period at the end of each wave (last week of the wave and first week of the next wave) and is allocated proportional to county population. Information is collected on the number of trips in the previous wave and details about those trips (see example CHTS questionnaire http://www.st.nmfs.noaa.gov/Assets/recreational/pdf/append_a.pdf) . Outliers in effort (number of trips during the particular wave) recorded from telephone surveys are reduced to the 95th percentile of the distribution of effort for the last five years for the particular stratum being sampled.

Evaluation of the CHTS indicated that for-hire modes were being underrepresented due to the nature of these fisheries (out of state clients, etc.). Beginning in 2005, angler effort on charter boats and headboats has been sampled through the For-Hire Survey (FHS) and several overlapping sampling programs. The CHTS was replaced by the FHS for charter boats and headboats (the CHTS is still used for private boats and shoreline modes). The FHS is also a random dial telephone survey that uses a vessel directory as a sampling frame. Other overlapping programs include the Vessel Trip Report (VTR) Program for New Jersey through Virginia (census logbook), the Southeast Headboat Survey (since 1986) for North Carolina though Florida (census logbook), and state census logbook programs in South Carolina, Florida, and Maryland.

4.2.1.2 Catch Estimation Methods

Data from both the telephone and dockside intercept surveys are used to estimate harvest, the number of fish released alive, and length frequencies of the harvest. Total catch is estimated by combining the catch per trip from dockside intercepts with number of trips from the telephone survey. Effort data from the CHTS and FHS are combined with U.S. Bureau of Census data on population size to estimate the total number of trips per stratum. Questions and responses from the Angler Catch Surveys are used to develop correction factors (ratio estimators) for non-coastal county anglers, anglers in households without telephones, and charter boat anglers fishing from boats not included in the FHS. The number of trips, catch, harvest and numbers released alive are divided into the three areas (inland coastal waters, state waters within 3 miles, and offshore waters beyond 3 miles) based on the primary areas fished during trips as reported by anglers during Angler Catch Surveys. The estimated number of trips in each stratum is multiplied by the Black Drum catch per trip for each catch type from the Angler Catch Surveys in each stratum to obtain total stratum estimates. Catch is summed across strata for total number of Black Drum caught (A+B1+B2), harvested (A+B1), and released alive (B2). Mean weight of Black Drum from intercepted fish (A1) for each stratum is multiplied by the number of harvested (A+B1) Black Drum in the stratum to obtain total weight estimates of harvest. The mean weight of type B1 fish in each stratum is assumed to be the same as type A fish in the stratum. The three main steps for calculating coastwide recreational harvest in numbers and weight from 1950 to 2012 are detailed in the following sections. They are 1) obtain average weights for strata where no fish were measured and estimate harvest in weight, 2) estimate weight of dead discards, 3) calibrate MRFSS data to MRIP estimates, and 4) extend the MRFSS data back to 1950. Steps 1 and 2 were not required to estimate historic harvest in numbers.

4.2.1.3 Missing Harvest Estimates in Weight

Prior to MRIP estimates in 2004, some MRFSS estimates at the strata level have no harvest estimates in weight and positive harvest estimates in numbers (Table 15). This occurred if all intercepted, harvested fish for the stratum were type B1 (unavailable harvest) or if interviewers were unable to obtain weight measurements for type A fish. When no weight measurement was taken for a given stratum (e.g. year/state/wave/mode/area) the harvest in weight was not calculated for that stratum and not included in the coastwide total. There were two imputation options considered to develop weight estimates for strata where they were unavailable: (1) apply a length-weight relationship to the catch-at-length, and sum catch-at-weight for total harvest in weight or (2) borrow weight observations from surrounding strata and apply the mean of borrowed observations to the harvest estimate in numbers. Option one would have required borrowing length observations from surrounding strata as well. Borrowing weight observations (option 2) was selected because this option would better capture any deviations from a static length-weight relationship. A decision tree was developed to provide an objective method of borrowing weight observations from surrounding strata (Appendix 1). Borrowing was based on expected similar size compositions in surrounding strata due to biology (e.g., migration of large, mature fish to the Delaware Bay in waves 2-4) and management (i.e., similar state regulations). Once the desired sample size of weight observations (n≥10) was obtained, the mean weight was applied to the harvest in numbers to develop harvest estimates in weight for the respective strata. In extreme cases like New Jersey (Table 15), weights were borrowed across all waves, many years, and two or more states. New weight estimates in years with missing weight estimates were as high as 127,069 lbs. in Florida 1990, 90,723 lbs. in Maryland 1984, and 87,723 lbs. in Virginia 1999 with a total of 524,055 lbs. coastwide from 1981-2003 (Table 16). New MRIP methods of imputation using length-weight relationships have been used for addressing missing harvest weight estimates and there are no strata with missing estimates from 2004-2012. There was an error discovered in MRIP data processing of length-weight information from the Angler Catch Surveys for 2004-2012 estimates. Estimates were corrected and reloaded to the MRIP query site on March 19, 2014. Corrected estimates were queried from MRIP and MRFSS estimates were recalibrated with the corrected estimates. The error did not affect harvest number estimates or released alive estimates.

4.2.1.4 Weight of Dead Discards

MRFSS and MRIP estimates released alive fish in numbers only. Weight estimates of released alive fish are necessary to derive total weight of black drum that are assumed to die post-release for catch-based and production models considered in the assessment. Biological samples were not collected from fish released alive until 2005 and, since 2005, sample sizes of length samples have been small and of little utility in estimating length frequencies and weight of released black drum (Table 17).

In the South Atlantic, the mean weight of fish released alive during all years was assumed to be the same as the mean weight of fish harvested during pre-regulatory periods. This is based on the assumption that anglers did not target specific sizes for harvest when there were no regulations. In states with slot limits, few fish greater than 600mm TL have been harvested during either pre-regulatory periods or periods with slot limits implemented, so slot limits are assumed to have little effect on mean weight estimates of fish released alive. There have been no regulations in NC during the assessed period and anglers are assumed not to have targeted specific sizes for harvest, but rather indiscriminately harvested and released fish of the same size. The mean weights of harvested fish sampled during pre-regulatory periods for each state in the South Atlantic (Table 18) were applied to number estimates of fish released alive to obtain total weight estimates of all released alive fish.

When broken down by wave period, regulations in Mid-Atlantic states are assumed to have little effect on the size composition of black drum released alive. The life history of black drum was assumed to control the approximate size of discarded fish in the Mid-Atlantic states. Black drum in the Mid-Atlantic during waves 2-3 are known to be almost exclusively large, mature fish and there are assumed to be negligible releases due to size limits (16 inch minimum). Black drum in the Mid-Atlantic states from waves 5-6 are known to be almost exclusively YOY fish of the same year class. Any fish released alive during these waves would be approximately the same size as fish harvested. Wave 4 is a transition period from mature fish to YOY fish, so mean weights were calculated separately for this wave. Mean weights of harvested fish sampled during waves 2-3, 4, and 5-6 over all years for each Mid-Atlantic state (Table 18) were calculated and applied to the corresponding estimates of released alive fish in numbers. The mean weight for fish released alive in NJ in waves 5-6 was borrowed from DE due to low sample size (n = 3). The mean weight for fish released alive in MD in waves 5-6 was borrowed from VA due to no available samples.

Total weight estimates of released alive fish estimated in MRFSS/MRIP are in Table 19. There are no data or studies providing discard mortality rates for black drum, so the SASC assumed a discard mortality rate equal to the recreational discard mortality rate for red drum (0.08; SEDAR 2009).

4.2.1.5 MRIP/MRFSS Calibration

MRFSS data were available from 1981 to 2012, after which only MRIP estimates are made. MRIP methodology was applied to raw MRFSS data for the period 2004-2012. Following the recommendations of the MRFSS/MRIP Calibration Working Group, MRFSS estimates for harvest (weight and number) and released alive (number) prior to 2004 were calibrated to MRIP estimates (2004-2012) using the ratio of mean catches from the overlapping time period. The variance is adjusted similarly, but accounts for the additional uncertainty from the estimate of the calibration factor (Salz et al. 2012). As the estimates are reduced to a finer geographic scale, precision decreases. Therefore, coastwide estimates were used in the calibration.

The ratio of MRIP harvest weight estimates to MRFSS harvest weight estimates is 1.031. Calibrated harvest weight estimates increased by 3.1% ranging from 8,590-55,946 lbs. (Table 20). The ratio of MRIP harvest number estimates to MRFSS harvest number estimates is 0.870. Calibrated harvest number estimates decreased by 13% ranging from 9,295-77,628 fewer fish (Table 21). The ratio of MRFSS released alive estimates to MRIP released alive estimates is 1.025. Calibrated released alive estimates increased by 2.5% ranging from 11-10,565 more fish (Table 22).

4.2.1.6 Historical Estimates of Recreational Harvest and Releases

The data-poor methods being considered for this stock assessment require a complete catch history from at least 1950, however recreational harvest data are only available since 1981. Previous estimates of historic recreational catch have been based on human population from the U.S. Census (e.g. Florida Spotted Seatrout, Murphy et al. 2011) or coastwide estimates of saltwater anglers and days spent saltwater fishing from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) (South Atlantic Spanish mackerel, Brennan and Fitzpatrick 2012). The human population method assumes that the number of anglers is proportional to the total coastal population and does not account for periods when recreational fishing expanded faster (or slower) than human population. The FHWAR method applied to Spanish mackerel uses coastwide estimates of saltwater fishing effort and assumes that the rate of expansion in saltwater angling was the same across the entire region. Here, we combined information from the FHWAR survey with historical fishing license data to estimate historical recreational harvest and releases in each year and state from 1950-1980.

Historic fishing license data were available in the USFWS National Fishing License Reports (http://wsfrprograms.fws.gov/Subpages/LicenseInfo/Fishing.htm) from 1958-2013 for each state. No data were available in 1960 and only Georgia was available in 1959. These reports provide values for the number of certified paid fishing license holders (participants) in each state, where a license holder is one individual regardless of the number of licenses purchased. The reports do not differentiate between saltwater and freshwater anglers. The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) provides data about the state in which these activities occurred, the number of trips taken, days of participation, type of trip, and expenditures. The survey was conducted 1991, 1996, 2001, 2006, and 2011 by the Census Bureau for the U.S. Fish and Wildlife Service. An estimate of the percentage of anglers in each state that fish in saltwater is provided in these reports (%saltwater). This percentage was extrapolated linearly between years when the survey was not conducted. Prior to 1991, the %saltwater was only available nationally and only every five years from 1955-1985. These national percentages were used to extrapolate back the statewide estimates. The total number of license holders from the USFWS Historic Fishing License data was then adjusted by the percent estimates from the FHWAR surveys to get the total number of saltwater participants by year and state. Lastly, CPUE was calculated for each year and state from 1981-2012 by dividing the MRFSS/MRIP harvest and released alive estimates by the total number of saltwater participants. The number of saltwater participants was then multiplied by the 1981-1985 average CPUE in each state to estimate historical harvest and releases since 1950.

On average over the last 10 years, Florida had the highest number of saltwater anglers followed by North Carolina, Virginia, South Carolina, Maryland, New Jersey, Georgia, and Delaware (Table 23). The number of participants accelerated faster in Florida from 1950 to mid-1970s than in any other state (Figure 6). The total number of saltwater anglers for the entire region (FL-NJ) increased sharply from 1950-1975, driven largely by growth in Florida, then declined until about the mid-1980s and has since continued a pattern of steady expansion. The recreational harvest from 1950-1980 followed the same pattern and suggests that recreational harvest during the mid-1970s was as high as during the 1980s and most of the 1990s (Figure 7, Table 24, Table 25). Recreational releases were low due to low release estimates in the early 1980s and never exceed 10,000 fish from 1950-1980 (Table 28). This method uses direct estimates of the number of saltwater anglers each year and in each state to account for the different patterns of effort that occurred across the region since 1950.

4.2.1.7 Recreational Harvest

Recreational fisheries have been the primary source of harvest from the Black Drum stock. Annual commercial landings only exceeded annual recreational harvest once in the last 63 years (1954) (Table 26, Figure 8). On average, recreational harvest is 4.2 times larger than commercial harvest. The mean coastwide recreational harvest in numbers from 1950-2012 is 213,513 fish (Table 24, Figure 9). There has been no harvest north of New Jersey. Harvest increased steadily from 1950-1975 driven primarily by a steady increase in saltwater fishing participants in Florida used to estimate the historical recreational harvest (Table 24, Figure 6). Harvest then declined to a time series minimum of 62,358 fish in 1981. This was the first official year of the MRFSS and there was no wave 1 sampling in Florida. Harvest increases to 1980s peaks of 338,410 fish in 1986 and 311,731 fish in 1987 before declining near the time series low in 1989 and 1990. Harvest then fluctuated around an increasing trend to the time series high of 789,214 fish in 2008. Recent harvest decreased to numbers similar to those estimated in the early 2000s, averaging 363,182 fish from 2009-2012.

Coast wide harvest in weight follows a similar trend as harvest in numbers. Mean harvest in weight from 1950-2012 is 1,004,614 lbs. /year (Table 18, Figure 10). The harvest increased steadily from 1950-1974 before declining to time series lows of 307,719 lbs. in 1981 and 284,514 lbs. in 1982, the first two years of the MRFSS. There was a 1980s peak in harvest weight in 1983 at 1,830,967 lbs. There was not a corresponding peak in harvest numbers, indicating harvest of more larger, older fish in 1983 relative to surrounding years. There was a decline in annual harvest weight from 1987-1990. Harvest then fluctuated around an increasing trend, hitting a time series high of 5,217,281 lbs. in 2008. Harvest in 2009 was also relatively high at 3,173,841 lbs. The harvest peaks in 2008 and 2009 are much more pronounced than peaks in harvest numbers, indicating harvest of larger fish during these years. Annual harvest decreased to an average of 1,248,763 lbs. /year from 2010-2012. Harvest in 2012 was the smallest harvest in weight (744,266 lbs.) since 1998.

South Atlantic harvest has dominated coastwide recreational harvest in weight and numbers during most years from 1981-2012, averaging 694,405 lbs. /year (Figure 11). From 1980-2000 harvest averaged 469,862 lbs., declining from 586,347 lbs. in 1984 to 180,861 lbs. in 1990. From 1991-1999 landings were rather constant around a mean of 587,127 lbs. with a spike in 2000 to 1,761,413 lbs. and 1,701,337 lbs. in 2008. Other years where harvest was high in the South Atlantic were 2001, 2003, 2010, and 2011.

There was no harvest estimated in the Mid-Atlantic during waves 2-3 for the first two years of the MRFSS. Harvest weight then increased to relatively high levels from 1983-1987, averaging 437,907 lbs. /year harvested in the Mid-Atlantic (Figure 12). Harvest decreased to variable, but low levels from 1988-2002, averaging 84,313 lbs. /year with four years of no estimated harvest (1988, 1990, 1993, and 1994). Harvest increased to the highest average of the time series (1,243,630 lbs. /year) from 2004-2010, exceeding South Atlantic harvest (in weight) in four of these seven years (2004, 2006, 2008, and 2009). Harvest decreased to a mean of 65,957 lbs. from 2011-2012. Mid-Atlantic harvest during waves 4-6 has been relatively small, averaging 62,122 lbs. /year, and likely includes some mature fish. Since 2004 recreational landings in New Jersey have averaged about 800,000 lbs. /year whereas prior that the average was just 24,431 lbs. /year indicating possible growth of the fishery or expansion of the species.

Harvest weight in 2008 and 2009 was 182% and 71% greater than the next greatest harvest (1,853,044 lbs. in 2000), respectively. These estimates were driven primarily by wave 3 estimates in New Jersey and secondarily by wave 3 estimates in Virginia. New Jersey harvest in wave 3 of 2008 (2,795,940 lbs.) and 2009 (1,393,633) accounts for 54% and 44% of the entire annual harvest, respectively. Virginia harvest in wave 3 of 2008 (497,913 lbs.) and 2009 (1,031,219 lbs.) accounts for 10% and 32% of the entire annual harvest, respectively. In New Jersey 129 and 70 fish (type A and B1) were intercepted during wave 3 in 2008 and 2009 respectively. The average number of fish observed during wave 3 intercepts for all other years (2004-2011) was just 14 fish (Table 27). Similarly in Virginia, 34 and 22 fish were intercepted during 2008 and 2009 respectively whereas the average for other years was only 5 fish. Therefore, the high estimated harvest during these years is driven by a few intercepted trips that caught large numbers of Black Drum. These estimates were anomalies for these states and similar peaks were not observed in other states during these years (Figure 13). Though PSEs exceed the recommended MRIP threshold of 20, they are relatively low compared to PSEs for Black Drum estimates at this level of detail. The SAS discussed these peaks at length. There was also a peak in the South Atlantic in 2008 and anecdotal evidence suggested that Black Drum were abundant during those years. Without objective information contradicting these estimates that originate from actual intercepts, the SAS decided that they should not be adjusted.

4.2.1.8 Discards

Historical estimates of released alive fish gradually increased from 1950-1977, averaging 5,385 fish/yr. (Table 28, Figure 14). The number of released alive fish then declines to a time series low of 428 fish in 1982. Numbers of released alive fish then increases steadily to a time series high of 892,610 fish in 2008. The relatively large peak of fish released alive in 2008 mirrors the large peak of fish harvested during the same year in New Jersey (Figure 15). This peak is driven by the New Jersey wave 5 estimate (222,679 fish, 25% of the annual estimate) and reflects a large year class spawned by the mature fish available in New Jersey that were harvested in relatively high numbers during wave 3. These released alive fish indicate regulatory discards that did not meet the NJ minimum size limit of 16 inches. Numbers released alive then decrease and fluctuate around a mean of 393,520 fish/year from 2009-2012.

Weight of released alive fish follows the same increasing trend ranging from 930 lbs. in 1982 to 6,624,806 lbs. in 2008 with a mean of 1,026,519 lbs. (Table 28, Figure 14). The large peak in weight of fish released alive in 2008 mirrors the peaks in number released alive and harvest of fish. However, the peak in number of fish released alive in 2007 is not as pronounced as the weight of fish released alive, indicating releases of primarily larger fish during that year.

Catch and release fishing was a small component of the recreational fisheries in the 1980s and early 1990s when there were few regulations, then shifted to a major component of the recreational fisheries starting in the late 1990s. From 1981-1996, the ratio of fish released alive to fish harvested averages 0.36 and the number of fish released alive does not exceed the number harvested during any of these years (Figure 16). The number of fish released alive surpasses the number harvested for the first time in 1997 and only falls below the number harvested during 4 of the next 15 years (2000, 2003, 2005, and 2011). The ratio of fish released alive to fish harvested averages 1.11 from 1997-2012.

4.2.1.9 Proportional Standard Error

The proportional standard error (PSE) is provided with MRFSS and MRIP estimates as a measure of precision. The PSE is the percentage of the standard error relative to the catch estimate and is useful for comparing precision of catch estimates of different magnitudes. A PSE value greater than 50 indicates a very imprecise estimate. In general, precision decreased going from south to north. Florida was the only state that had a PSEs less than 50 in all years for harvest in numbers

(Table 29). PSEs were greater than 50 for almost all years in Virginia, Maryland, Delaware, and New Jersey. Harvest estimates in weight (A+B1 lbs) were even less precise than numbers, reflective of the poor sample sizes of weight (Table 30). The precision on discarded fish (B2) was also very high for most years and states (Table 31).

4.2.1.10 MRFSS/MRIP Index Standardization Methods

4.2.1.10.1 Cluster Analysis to Subset Trips

The MRFSS and MRIP were designed to estimate total catch and effort of recreational anglers, not species abundance. However, catch rates (CPUE) from the MRFSS and MRIP Angler Catch Surveys can be used to track trends in relative abundance, but only a subset of the intercepted "trips" will be informative of Black Drum relative abundance. Only trips on which Black Drum could have been caught should be considered for an index of relative abundance. Trips that had no chance of catching Black Drum are not informative and will negatively bias the index (underestimate relative abundance). The intercepted trips from the Angler Catch Surveys were subset to trips that were assumed to be informative of Black Drum abundance using a cluster analysis to identify closely associated species (Shertzer and Williams). We also performed a species association analysis using the logistic regression approach of Stephens and MacCall (2004) but opted instead for the cluster analysis because the logistic regression does not select for trips with no associating species (i.e. those that only caught Black Drum) and non-convergence when separating the Mid-Atlantic into two time periods. The assumption of these species association methods is that species caught on the same trips as Black Drum cohabitate and species rarely or never caught on the same trips as Black Drum do not cohabitate. If anglers caught species that cohabitate with Black Drum, they were fishing in Black Drum habitat and could have caught Black Drum making that trip an informative trip for Black Drum relative abundance.

The cluster analysis was applied to six geographic regions based on expected changes in species compositions: the Florida Keys to Brevard County (Southeast Florida), Volusia County to the Florida border (Northeast Florida), Georgia and South Carolina, North Carolina, and Virginia to New Jersey (Mid-Atlantic). The Mid-Atlantic region was further broken into two periods, waves 2-3 and waves 4-5 based on expected changes in Black Drum size structure, species associations, and fisher behavior. It was important to analyze the species associations by these regions because the cluster analysis is heavily influenced by the large number of intercepts in Florida (and to a lesser degree North Carolina) causing the associations to be non-representative of northern states. Another option with a break at Cape Hatteras (New Jersey to Cape Hatteras and Cape Hatteras through Georgia) was considered, but the relatively large number of trips in North Carolina heavily influenced the Mid-Atlantic species associations.

Trips from 1982-2012 were included in the analyses. Wave one sampling did not occur in Florida in 1981, so 1981 trips were not included in the analyses to maintain consistency of waves sampled over each year. Prior to applying the subsetting methods, the trips were filtered to exclude trips that were not likely to have occurred in Black Drum habitat. Black drum were rarely captured offshore in any regions (Table 32), therefore trips fishing in area 2 (ocean > 3 mi) were excluded. Any modes or waves that accounted for less than 5% of the trips that caught Black Drum in one of the regions were excluded from the analyses (Table 33 and Table 34). Catch records that could not be identified to species were also excluded. Rare species that were not caught in at least 1%

of all trips for each region were excluded from the analyses. If Black Drum did not occur in 1% of the trips, the percentage of trips that caught Black Drum was used as the threshold for retaining species in the analyses. After filtering, there were 450,585 trips used in the analyses (Table 35).

The methodology of Shertzer and Williams (2008) was used to develop clusters of species associated with Black Drum. The intercept data were transformed into a matrix of number caught where each row is a species and each column is a trip and converted to a similarity matrix using the Morisita similarity index. Hierarchical cluster analysis with average linkage method was then applied and the number of clusters was determined either by observing the scree plots and evaluating species groupings (Figure 17). All trips that captured Black Drum or any of the species in its cluster were retained for standardization. The number of clusters ranged between 4 and 8 and the number of member species with Black Drum ranged from 6 to 16 (Table 35). Based on these clusters 196,798 trips were selected for development of a standardized index.

4.2.1.10.2 Index Standardization

The delta method was used to develop standardized indices (Lo et al. 1992) using the data subset by the cluster analysis. The delta method uses two GLMs, one to model positive observations of the response variable (CPUE) and a second binomial GLM to model the proportion of observations that are positive. The final index is the product of the year effects from the two GLMs. The assumed distribution of the positive observations is the lognormal distribution.

The response variable is the sum of type A CPUE (type A catch/A angler hours fished) and type B CPUE (type B catch/B angler hours fished) for each trip. Type A catch is catch available for the interviewer to look at and type A anglers are anglers that contributed to this catch. Type B catch is catch that is unavailable for the interviewer to look at and type B anglers are anglers that contributed to this catch. The species association methods assume that any anglers on a selected trip were able to catch black drum. The total number of anglers that caught type B fish for a given trip are summed (regardless of species they caught) and used as a measure of effort.

Explanatory variables considered for both GLMs were area, mode, wave, and state. Model selection was completed by dropping each explanatory variable from the base model and excluding explanatory variables that resulted in a lower AIC when excluded from the model.

The subsetting method used to develop the index does have caveats that should be considered. The species association methods assume that species caught together cohabitate. Anglers may fish multiple habitats/areas in a given trip. The area variable only indicates where the majority of fishing occurred. If anglers often fish multiple habitats during a trip, the species associations may be confounded. The species association methods ignore any trips that did not catch any fish. If there are many trips that fish in Black Drum habitat and often do not catch any fish (74% of targeted Black Drum trips did not catch any Black Drum), these would not be accounted for and the index of relative abundance would be biased. Changes in regulations, species abundance, and/or angler behavior could all affect the accuracy of these methods. For example, if abundance of a species closely associated with Black Drum decreases, that species may not be intercepted as often which could cause a decline in the number of zero trips selected for Black Drum even though the angler is fishing the same habitat.

There are also caveats with the MRFSS/MRIP design that should be considered. There is no way to account for angler experience when standardizing the index. MRFSS interviewers were instructed to visit sites where they were more likely to get the most interviews. Sites with less use were less likely to be visited by interviewers. If sites with less use had experienced different catch rates of Black Drum, this would not be accounted for unless the intercepted trips were weighted. Site-use weights are only available for 2004-2012. There have been no nighttime intercepts during the time series used for the index. If Black Drum catch rates differ at night, the index developed from daytime catch rates could be biased. However, if daytime catch rates are consistently proportional to nighttime catch rates, this may not be a concern.

Defining an accurate unit of effort may also be difficult due to the design of the MRFSS/MRIP. The number of Black Drum per trip could be used as the response variable and the number of anglers could be used as an explanatory variable. However, numbers of anglers contributing to type A catch and type B catch cannot be combined because of the potential for overlap. The response variable used for the indices does not account for additional anglers that did not catch any fish. The assumption that must be made to use this response variable is that the proportion of anglers that caught no Black Drum is consistent from year to year. Another potential measure of effort is the party variable (total number of anglers on a trip) which was recorded for boat modes starting in 1991. The tradeoff in having a more accurate effort measure would have been a loss of nine complete years of data (1982-1990) and data from four shore modes from 1991-2012.

4.2.1.10.3 Recreational Catch Rates

Three indices were developed from MRFSS/MRIP intercept data. A coast wide index was developed to provide an aggregate trend of stock wide abundance for use in production models. Based on assumptions informed by black drum life history, two additional indices were developed to provide trends of different components of the stock. CPUE in waves 2-3 in Mid-Atlantic states was assumed to reflect abundance of the mature component of the stock. CPUE in all waves in the south Atlantic was assumed to reflect the immature component of the stock.

4.2.1.10.3.1 Coast Wide MRFSS/MRIP Index

NJ/DE and MD/VA were collapsed into levels due to few observations relative to the other states. Modes 2 (jetty, breakwater, breachway) and 3 (bridge, causeway) and modes 6 (head boat) and 7 (charter boat) were also collapsed. Modes 2-3 are listed in figures below as “Shore Other” and modes 6-7 are listed as “For Hire” (Figure 18 and Figure 19). No explanatory variables were dropped from either the positive observation model (Table 36 and

) or proportion positive model (Table 38 and Table 39). The model summary is in The MRFSS/MRIP coast wide index is variable and shows a slightly increasing trend over the time series (Figure 20). The index increases from 1982 to 1985 and then declines to lowest value in 1990. The index increased sharply from 1990 to 1995 where it remains flat but variable with drops in 1996 and 2005. Recreational CPUE was highest in 2011, 2008, and 2007.

Residuals for the positive observation model are normally distributed for each factor and by year (Figure 21). Diagnostic plots indicate that variance is constant, errors are normally distributed, and there are no observations with extremely high leverage or influence (Figure 22).

4.2.1.10.3.2 MRFSS/MRIP Mature Index

The MRFSS/MRIP mature index was limited to 1995 – 2012 due to lack of positive black drum trips prior to 1995. Area, state, and wave were excluded from the final positive observation model

and Table 42) and wave was excluded from the proportion positive model (Table 43 and Table 44). The index shows a declining trend from 1997 to 2000 and then increases drastically to 2006 (Figure 25). The index then becomes highly variable, including the time series highs in 2008 and 2009. The index becomes relatively flat near the time series mean from 2010-2012. Residuals for the positive observation model are normally distributed for each factor and by year (Figure 23). Diagnostic plots indicate that variance is constant, errors are normally distributed, and there are no observations with extremely high leverage or influence (Figure 24).

4.2.1.10.3.3MRFSS/MRIP South Atlantic Index

No explanatory variables were excluded from the positive observation model (Table 45 and Table 46) and area was excluded from the proportion positive model (Table 47 and Table 48). The MRFSS/MRIP south Atlantic index followed the same trend as the MRFSS/MRIP coast wide index (Figure 26), showing how heavily the coast wide index is influenced by south Atlantic data. Residuals for the positive observation model are normally distributed for each factor and by year (Figure 27). Diagnostic plots indicate that variance is constant, errors are normally distributed, and there are no observations with extremely high leverage or influence (Figure 28).

4.2.1.11 Biological Sampling

Length and weight measurements are obtained from type-A fish encountered during Angler Catch Surveys to develop harvest length frequencies and harvest estimates in weight. The proportions of Black Drum measured for length in 1 cm length bins for the respective stratum are applied to the total number of Black Drum harvested in the stratum to obtain length frequencies of the harvest. Length measurements are fork length to the nearest mm and weight measurements are to the nearest 0.1 kg. There has been poor MRFSS/MRIP biological sampling of Black Drum in the Mid-Atlantic from VA to NJ (Table 14 and Table 15), which is particularly concerning for Black Drum fisheries that may have 60+ year classes. Few state/year/wave combinations where harvest was estimated have at least ten length or weight samples. Beginning in 2005, length measurements were obtained from type B1 and B2 fish encountered during at-sea sampling of headboats. Only 68 Black Drum have been sampled for lengths during at-sea sampling with almost all of them (n=53) from South Carolina in 2006 and 2007. No other state/year combination had more than 3 length observations on B1 and B2 fish. No age samples are taken in Angler Catch Surveys. Age samples are collected in the Southeast Headboat Survey, but no Black Drum were intercepted in this survey (1986-2012).

Biological samples from the recreational fishery, consisting of mostly length and weight measurements, were collected coastwide during MRFSS/MRIP intercepts and also through freezer programs and other fisheries dependent monitoring (i.e. tournaments) conducted at the state level. These programs are described in the following sections. Overall, there was poor coverage prior to about the mid-1990s when MRFSS began taking more samples and various state programs started. Since 1981 MRFSS collected a total of 9,921 length measurements and 9,202 weight measurements. Other biological sampling occurring from Georgia to Delaware has produced 4,680 lengths and 1,437 weights, since 1989 (Table 49 and Table 50). Georgia has been archiving otoliths since 1998 from their carcass recover project but none have been read. Only the Virginia biological sampling and freezer projects and the Delaware recreational biosampling projects have generated ages from Black Drum caught recreationally. Recreational length samples available from state sampling programs could be used to supplement MRFSS and MRIP biosampling, but the temporal and spatial coverage is limited. Length samples were available in all waves from the Georgia freezer program and South Carolina SFS, freezer, and tournament sampling. North Carolina length measurements were only taken during waves 3-5 and only since 2008. VMRC sampling includes length samples from 1999-2002 and 2007-2012 with 94% of freezer samples collected in wave 3. DE DFW biological sampling includes length samples from 2008-2012 all during wave 3.

4.2.1.12 MRFSS/MRIP Length Frequency

Black Drum caught by recreational anglers in the South Atlantic were mostly between 17 and 70 cm (straight fork length) whereas those caught in the mid-Atlantic were often larger than 70 cm (Figure 29). This is representative of a trophy fishery for large Black Drum that move into Mid-Atlantic regions seasonally to spawn. Poor coverage and small sample sizes of observed lengths in the Mid-Atlantic states result in unreliable catch-at-length, but do allow for inferences about the general size composition. MRIP length frequencies for Mid-Atlantic harvest indicate a shift in the length composition occurring around wave 4 (Figure 30). Harvest during waves 2-3 has been primarily mature fish (>600 mm TL) migrating to the Mid-Atlantic to spawn. The harvest then shifts to primarily young-of-year fish (<350 mm TL) utilizing estuaries as nursery habitat before migrated to the South Atlantic during their first fall. The lack of immature fish age-1 to approximately age-4 in the Mid-Atlantic has been noted by Jones and Wells (1998) and reflected in observed lengths of harvested fish. MRFSS length frequencies in the Mid-Atlantic reflect different size compositions available, most notably in wave 2 and wave 6. These size compositions contradict the known biology of Black Drum and are likely a result of small sample size. For example, wave 2 available catch-at-length in all Mid-Atlantic states from 1981-2003 is based on 1 sampled fish that was 11 inches FL.

Length frequencies from fish sampled in the MRFSS and MRIP indicate that harvest in the South Atlantic has been primarily immature fish (Figure 29). Only 5% of all South Atlantic harvest estimated by the MRFSS and MRIP was greater than 600mm TL(table 51), which falls at about 44% maturity on the maturity schedule.

Black Drum caught in Georgia and South Carolina were similar in size while North Carolina anglers landed slightly smaller fish (Figure 31). Larger fish are landed in Florida compared to other South Atlantic states. As noted above, length information is poor in the Mid-Atlantic regions where few Black Drum are intercepted on an annual basis. However, it is clear that larger fish are targeted in New Jersey and Virginia than other states, again reflecting trophy fisheries for this species.

4.2.1.13 MRFSS/MRIP Average Length and Weight

Average size and weight was highly variable across the entire coast. In the South Atlantic average size increased from 1980-1990 from about 13 to 15 inches due to size limits put in place by various states (Figure 32). Average weight has varied between 1.5-3.0 lbs over the entire time period. Only Florida showed a steady increasing trend in both size and weight. In South Carolina mean length and weight dropped considerably from 17 inches in 2002 to 10 inches from 2005-2007 but has since increased to larger fish. In the Mid-Atlantic, mean length and weight has been highly variable and the variability can likely be attributed to poor sample sizes, especially north of Virginia. In general, longer and heavier fish were caught in the Mid-Atlantic than South Atlantic, indicative of directed trophy fisheries. Mean length in the Mid-Atlantic ranges between 10 and 40 inches and weight between 0 and 40 pounds with no trend in either.

4.2.1.14 Potential Biases and Caveats

Pulse fisheries tend to lead to less precise catch and effort estimates (MRIP manual). Black drum fisheries in the Mid-Atlantic (VA-NJ) for mature, spawning fish occur primarily during waves 3-4 (Figure 30) and can be considered pulse fisheries. Table 14 and Table 15 illustrate the sparse biological sampling and patchy estimates in the Mid-Atlantic. Several state sampling programs indicate recreational harvest of Black Drum in strata where MRFSS or MRIP have estimated no harvest. The harvest weight is a small percentage of the coast wide harvest for any given year (Table 52), but this is a minimum collected during efforts that can be very limited (e.g., DE DFW tournament sampling, MD DNR Charter Boat Logbooks, VMRC Citation Program) and further supports concerns with MRFSS and MRIP data.

MRFSS and MRIP Anger Catch surveys have not been conducted during nighttime hours. There have been antidotal reports of relatively large scale Black Drum recreational fisheries during nighttime hours. If catch rates during nighttime fishing are not the same as catch rates of intercepted daytime fishing trips, estimates will be biased.

4.2.2 Georgia DNR Marine Sportfish Carcass Recovery Project

In the fall of 1997 the Georgia Department of Natural Resources (DNR) initiated the Marine Sportfish Carcass Recovery Project. This project takes advantage of the fishing efforts of hundreds of anglers by turning filleted fish carcasses that anglers would normally discard into a source of much needed data on Georgia's marine sportfish. Chest freezers are placed near the fish cleaning stations at 17 locations along coastal Georgia. Each freezer is marked with an identifying sign and a list of target fish species. Cooperating anglers place the filleted carcasses, with head and tail intact, in a bag, drop in a completed angler information card, and then place the bag in the freezer. Each fish is identified to species, the fish length is measured, sex is determined when possible, and the otoliths are removed. Currently, all Black Drum otoliths are in storage and have not been aged. The number of Black Drum collected by the Carcass Recovery Project ranged from 9 in 2005 to 158 in 2008 with an average of 48 fish collected each year and a total of 669 collected since the project began. These fish ranged in size from 219-1140 mm TL with an average of 402 mm TL.

4.2.3 South Carolina State Finfish Survey

The State Finfish Survey (SFS) collects finfish intercept data in South Carolina through a non-random intercept survey at public boat landings along the SC coast. The SFS focuses on known productive sample sites and targets primarily private boat mode. The survey is conducted year-round (January- December) using a questionnaire and interview procedure similar to those of MRFSS. Implemented in 1988, the State Finfish Survey (SFS) was designed to address specific data gaps, within the MRFSS, as identified by SCDNR staff. These data gaps included the lack of length data from species of concern to the SCDNR and the lack of seasonal and area-specific catch frequencies. Another concern was the lack of catch and effort data from private boat anglers, which make up a majority of the angling trips in South Carolina coastal waters. These data gaps were initially addressed by interviewing inshore anglers targeting red drum and spotted seatrout at specific sample locations. Since 2002, more emphasis has been placed on acquiring length data from all finfish retained by anglers, canvassing at additional sampling locations, and interviewing all private fishing boats within all SC coastal areas. Broadening the scope of the survey may decrease some of the bias associated with the previous SFS protocol. Sampling is conducted at public and selected private (with owner's permission) boat landings from January through December using a questionnaire and interview protocols similar to those of the MRFSS. However, the SFS questionnaire focuses on vessel surveys rather than individual angler surveys and primarily targets private boats. Interviews are obtained from cooperative anglers at each sampling site. If an angler is unwilling to participate; they can decline to be interviewed. Assigned Creel Clerks interview as many anglers as time allows at any given site. The sampling schedule is determined by "needs assessments" of the SCDNR Marine Resources Division and creel clerks. Individual Creel Clerks are assigned to a sampling region and will determine their daily sampling schedules based on local conditions (i.e. weather, landing closures, or events), additional job duties, and research and management initiatives. Attempts are made to assess all sampling sites equally, and individual creel clerks randomly rotate between all sampling locations within their region. Creel clerks will remain at landings with fishing activity. If landings have little or no fishing activity creel clerks will move on to alternative sampling locations in close proximity.

The SC-State Finfish Survey (SFS) is a fishery dependent intercept survey designed to collect primarily catch/effort data and length measurements of selected species taken by private boat anglers in South Carolina waters and federal waters off the state. The SFS has been collecting measurement and intercept data on Black Drum since 1988. The SFS has collected information on 3,612 Black Drum from 1988-2012 with measurements taken for 1,480 specimens. The mean number per intercept for the entire time period was 2 fish with a range of 1-5 fish. In addition to length data, the creel clerks began taking otoliths for aging and sexing Black Drum beginning in 2009. In 2013, the SCDNR took over responsibility for running the NMFS Marine Recreational Information Program (MRIP) in the state. Since the SFS program duplicates the same effort of the creel clerks as the MRIP survey, the two surveys will not be reported separately after 2013. The exception to this will be wave 1 (January – February) where the MRIP survey has not historically sampled in South Carolina, where the SFS will still sample separately for these two months.

4.2.4 South Carolina Freezer Program

An additional fishery dependent sampling program run by the SCDNR Inshore Fisheries group was a fish wrack collection program where carcasses of Black Drum were obtained from voluntary contributions of fish "wracks" (the remains of fish after filleting). The samples were collected using freezers for anglers to place the fish wracks in with corresponding catch information at their convenience. A minimum of four freezers were maintained at locations convenient for anglers throughout the Charleston area where fish wracks could be dropped off. Additional freezers were located at retail tackle shops in Georgetown and Hilton Head, South Carolina from 2002 to 2004, but had to be removed due to changes in management at the collection locations or non-participation by anglers. Anglers recorded the date and location of where the fish were caught and included this information with the fish wracks. Only length measurements (total and standard) were taken for freezer fish since total weight could not be obtained. Sex and maturity were determined through gross morphological examination and otoliths were removed for aging. Histological samples were not taken since the specimens had been frozen and cellular integrity of the gonad tissue was compromised. The species collected for the freezer fish program included Red Drum, Spotted Seatrout, Sheepshead, Black Drum, and Southern Flounder. Specimens have been collected monthly from January 1996 through the present.

4.2.5 South Carolina Tournament Sampling

The Inshore Fisheries group of the Marine Resources Division of the SCDNR samples inshore estuarine recreational fishing tournaments during the spring, summer and fall months, typically sampling a minimum of six fishing tournaments held in the Charleston, S.C. area. The purpose of sampling the tournaments was to gain supplemental fishery dependent data on many of the recreationally important species sampled in the group's fishery independent surveys. The group has been collecting this supplemental tournament data since 1986. Species that were typically observed were red drum (*Sciaenops ocellatus*), Black Drum (*Pogonias cromis*), Sheepshead (*Archosaurgus probatocephalus*), Spotted Seatrout (*Cynoscion nebulosus*), Bluefish (*Pomatomus saltatrix*), and Southern Flounder (*Paralichthys lethostigma*). Data obtained included length, weight, sex and gonad condition, and otoliths were removed for age determination. Small pieces of tissue from gonads were taken for histological confirmation of sex and maturity and whole ovaries were taken from Sheepshead and Spotted Seatrout for fecundity estimates.

4.2.6 North Carolina DMF Program 930 for Age and Growth Data

Collection of Black Drum otoliths for age and maturity information by the North Carolina Division of Marine Fisheries (DMF) began in the Wilmington Region office in 2008 and Division wide in 2011. Otoliths are collected monthly from commercial, recreational, and NCDMF fishery independent catches. Otoliths were removed from fish caught throughout state estuarine and coastal waters. Black drum from various recreational and commercial fisheries were sampled monthly to obtain otoliths. Length, weight, and sex (if possible) were recorded for individual fish. When possible, gonads were staged macroscopically using proper maturity schedules. Otoliths (sagittae) were excised from all fish and stored dry. Dorso-ventral sections of the left sagitta were made through the core to the nucleus perpendicular to the anterior-posterior plane with a Hillquist thin-sectioning machine. Sections were mounted on slides with ultra-violet curing glue. All sections were read from a high resolution monitor coupled to a video camera mounted on a microscope. Sectioning of otoliths for aging were conducted at the DMF Aging Lab in Morehead City. Ages were assigned based on a January 1 birth date. Depositions of annular rings occur between November and January and are complete by April and June. Age estimation was determined by counting the opaque zones (annuli) from the core to the outer otolith edge and recording the appearance of the margin as opaque or translucent using the MARMAP-SCDNR edge type codes. From 2008 to 2011, 60 Black Drum captured by recreational anglers in NC or by NC DMF fisheries independent hook and line sampling were measured for length, weight, and maturity. These ranged from 200-841 mm TL with an average of 337 mm TL and weighed between 0.1 and 8.4 kg. Of those, 33 were aged between 0 and 1 years old and 3 fish were 2 or older.

4.2.7 Virginia MRC Recreational Assessment Program

The Virginia Marine Resources Commission (VMRC) Biological Sampling Program (also known as the Stock Assessment Program) has been collecting length, weight, sex, and age information from thirteen primary species since 1998. Fish are processed either by VMRC staff or the Age and Growth lab at Old Dominion University, Center for Quantitative Fisheries Ecology. The Marine Sportfish Collection Project began in 2007 and chest freezers, bags, and information cards were placed at high activity fishing facilities so that fishermen could donate freshly filleted carcasses with head and tail intact. Bags are collected by the VMRC staff and processed for biological information. Participating anglers receive a shirt, hat, or tape measure as incentive to donate carcasses. When the project began in 2007, freezers where placed at three bait and tackle shops and by 2010 freezers were seven locations across Capeville, Hampton, Poquoson, Norfolk, and Virginia Beach. Additional samples are obtained directly from select regional fishing tournaments which VMRC staff provides technical support.

4.2.8 Maryland Charterboat Logbooks

Maryland charter boat captains have been required to maintain daily logs of where they fish, how many fish of each species they harvest, how many they release and how many anglers participated since 1993. The data includes charter and head boats licensed in Maryland and each entry is for a single day, so they may include more than one trip.

A geometric mean is calculated from the charter boat log data. No indication of target species is recorded, so the catch per unit effort includes only trips in which black drum were captured. The number of anglers was used as effort and the number of black drum harvested was used as catch. The annual GM of black drum harvested per angler was calculated for 1993-2012.

Reported charter boat harvest and effort declined from 1994 to 1999, increased through 2002 and then generally declined through 2007 (Table 53). Effort declined in 2009 and 2010 while harvest increased both years. The geometric mean harvest per angler has decreased significantly through the time series ($r^2 = 0.68$, $p<0.001$) from a high of 0.45 fish per angler in 1993 to the time series low of 0.14 fish per angler in 2008, before increasing slightly in both 2009 and remaining relatively stable through 2012 (Figure 33).

4.2.9 Delaware Recreational Biosampling

Mature Black Drum were sampled in April, May, and June from the commercial and recreational fisheries in the Delaware Bay. These months were chosen as they encompass the time of year when greater than 80 percent of the commercial harvest (personal communication DE-DFW) and greater than 90 percent of the recreational harvest occur (DE-DFW unpublished data). All fish were measured for total length to the nearest millimeter. Total weight (kg), gonad weight (g), and sex were recorded. Sagittal otoliths were removed and placed in envelopes with sample number, location, date, fishery, and gear type. One otolith was chosen randomly from each pair and processed for age determination. Otoliths were thin sectioned on a Hillquist high speed saw and mounted on microscope slides. Slides were viewed at 24X magnification.

5 FISHERY-INDEPENDENT DATA SOURCES

The SASC evaluated 28 fishery independent data sources representing various life stages, geographical, and temporal scales (Table 54). It was determined in prior data review sessions

(ASMFC 2011), that one of the major challenges of conducting a coast wide assessment would be the lack of targeted black drum information. Many monitoring programs collect information on black drum, but few programs adequately encounter black drum, especially adult fish, to calculate a reliable index of abundance. Of the 28 sources reviewed, only eight were considered reliable for tracking abundance. Biological samples from several other sources were used for estimating life history parameters.

5.1 Index Standardization

The fishery-independent surveys that encounter black drum were not designed to specifically target black drum, but rather to target higher profile species (e.g., red drum) or multiple species. Indices of relative abundance (I) developed from survey catch rates (CPUE) are assumed to be directly related to population abundance (N) through a catchability coefficient in Equation 1:

Equation 1:

$$It = qNt$$

where *It* is the index value (relative abundance, CPUE) for year *t*, *N* is the abundance in year *t*, and *q* is the survey catchability coefficient relating abundance to the index. The catchability coefficient is assumed constant for all years in the index. Changes in catchability over time will violate this assumption and lead to biased abundance estimates (Hilborn and Walters 1992). The lack of black drum-specific survey designs may not account for factors affecting black drum catchability that change over time (e.g., temporal factors, environmental factors, etc). If these factors are not accounted for, changes in catchability will erroneously appear as changes in abundance.

Catch rates for all fishery-independent surveys were modeled with generalized linear models (GLM) as a function of year and explanatory variables that were believed to affect catchability. Changes in catch rates due to a year effect reflect changes in abundance and are standardized by adjusting the year effect for effects of explanatory variables (GLM coefficients) that contribute to changes in catchability. A decision tree (Appendix 2) was developed to objectively standardize each survey index based on approaches described in Maunder and Punt (2004) and ASMFC (2012). Note that zero-inflated GLMs were considered for several of the fishery-independent surveys, but tended to be highly sensitive to model configurations in stepwise variable selection and often failed to converge. Final standardized indices are summarized in Table 55 and provided with SEs in each of the survey-specific sections below.

5.2 Surveys

5.2.1 PSEG Seine Survey

PSEG's Baywide Beach Seine Survey was initiated in 1995 to complement the NJDEP seine survey, providing sampling beyond the geographical boundaries of the respective study area to more fully characterize target species abundance and distribution patterns within the estuary. To enhance compatibility with the results being generated from the existing agency sampling program, the sampling gear and deployment procedures for the Baywide Beach Seine Survey were developed following the methods described in Baum (1994), and through personal communications with subsequent NJDEP principal investigators.

5.2.1.1 Survey Methods

Beach seine sampling was conducted during daylight once per month in June and November, and twice per month during July through October. Daylight is defined as the period one hour after sunrise to one hour before sunset. Samples were taken at 40 fixed stations in the Delaware Bay and lower River. Sampling at all stations was conducted within the period of two hours before to two hours after high slack water specific to that particular location.

Seine hauls were taken with a 100 x 6-ft (30.5 x 1.8-m) bagged haul seine with a 1/4-inch (6.25 mm) nylon mesh, identical to the gear employed by NJDEP in the beach seine program conducted upstream of the present study. The seine is set perpendicularly from shore, by boat, until the bag is reached, at which time the remainder of the net is set in an arc-like fashion back to shore. The direction of the set was chosen relative to prevailing tidal current, wind and surf conditions to produce the most effective net deployment. The standard sampling effort was a single haul at each station.

5.2.1.2 Biological Sampling

With each collection, finfish were identified to the lowest practical taxonomic level (usually species), counted, and measured. A subsample of 100 specimens of each target species was measured to the nearest mm. Fork length (FL) was measured for all species with emarginated or forked caudal fins; for other species, total length (TL) was measured.

5.2.1.3 Standardized Index of Abundance

A YOY index of abundance from 1995-2012 was developed from this survey. Length data was only available for about half the black drum caught in the time series, but only 4 of 692 fish were greater than 300mm TL, so all data are assumed to track YOY abundance. Stations were collapsed into two areas, the DE side of the bay and the NJ side of the bay, to incorporate this variable as a factor in the GLM. Stations where no black drum were captured during the time series were excluded from the data set. A negative binomial GLM was used to develop the index of abundance (Figure 36). The unit of effort was black drum caught per net set. Year, month, and area were included in the final GLM as factors. Figure 37 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 1.16. The standardized index showed high interannual variability, with no clear trend over the time series (Figure 38).

5.2.2 Delaware Finfish Trawl Surveys

The Delaware Division of Fish and Wildlife (DEDFW) operates two finfish trawl surveys, one for juvenile finfish and one for adult finfish.

5.2.2.1 Survey Methods

5.2.2.1.1 Juvenile Survey

The Delaware Division of Fish and Wildlife has conducted a 16-foot bottom trawl survey in the Delaware Estuary for juvenile finfish since 1980. The survey uses a 4.9-m semi-balloon otter trawl, consisting of a 5.2-m headrope and a 6.4-m footrope with a 3.8-cm stretch-mesh number 9 thread body. A 1.3-cm knotless stretch-mesh liner is inserted in the cod-end. The net is equipped with 30.5-cm x 61-cm doors constructed of 1.9-cm marine plyboard doors with 1.3-cm x 5.1-cm shoes. The doors are towed via bridle warps of 30-m no-lay line. Tows are made against current for ten minutes. The survey is conducted monthly at 39 fixed stations in the Delaware Estuary (Delaware waters) from April through October.

5.2.2.1.2 Adult Survey

The Division also conducted a 30-foot trawl survey in the Delaware Bay from 1966-71, 1979-84, and 1990 - present. The net used has a 9.3-m headrope and a 12.0-m footrope. It is comprised of 7.6-cm stretch-mesh in the wings and body, with a (5.1-cm) stretch-mesh cod-end. The net is attached to the trawl doors with 12.0-m leglines. The doors were 1.37-m x 0.71-m and were constructed of 1.9-cm virgin pine lumber, with 5.1-cm x 1.9-cm milled steel shoe bottom runners. Tows are made using the 19-m R/V First State, which tows for twenty minutes against the current. Sampling was conducted from March through December at 9 fixed stations on the Delaware side of the Delaware Bay.

5.2.2.2 Biological Sampling

5.2.2.2.1 Juvenile Survey

The catch from each tow is sorted and counted by species, with a sub-sample of 30 individuals being measured. Only juvenile black drum were caught in this survey with the length of black drum caught ranged from 45 to 760 mm, with a mean of 173 mm. Only 2 black drum (0.2%) caught during the survey were > 285mm TL. No other biological information was taken as part of this survey.

5.2.2.2.2 Adult Survey

The catch from each tow is sorted, counted and weighed by species, and a sub-sample of 50 being measured. No aging of black drum occurred as part of this survey. Juvenile black drum were present in this survey, with adult occurring at a rare frequency. The range of black drum captured were from 105 to 999 mm, with a mean of 204 mm. Only 23 black drum (0.8%) caught during the survey were > 285mm TL. No other biological information was taken as part of this survey.

5.2.2.3 Standardized Index of Abundance

5.2.2.3.1 Juvenile Survey

The SASC decided to subset the survey data to the years 1990-2012 due to a vessel change in 1990. Black drum with a length greater than 300mm TL were excluded to develop a YOY index, due to very low and sporadic catches of fish greater than 300mm (only 3 black drum were caught in these months). Tows that occurred in April through July were excluded due to low catch and stations where no black drum were caught during the time series were also excluded. A negative binomial GLM was used to standardize the survey index (Figure 39). The unit of effort was black drum caught per tow. Year and surface water temperature were included in the final GLM as factors. Figure 40 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 1.21.The standardized index showed high interannual variability, with low relative abundance from 2009-2012 (Figure 41). There was no trend over the time series.

5.2.2.3.2 Adult Survey

The SASC decided to subset the survey data to the years 1990-2012. Catch rates in the first year of the survey (1966) were extremely high and there was concern that factors other than abundance contributed to the peak. There were also breaks in sampling in the 1980s and the survey continued in 1990 with a new vessel. Black drum with a length greater than 300mm TL were excluded to develop a YOY index, due to very low and sporadic catches of fish greater than 300mm. Tows that occurred in January through July were excluded due to low catch and stations where no black drum were caught during the time series were also excluded. Following the standardization decision tree, a negative binomial GLM was used to develop a standardized index (Figure 42). The unit of effort was black drum caught per tow. Year and month were included in the GLM as factors. Figure 43 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter was 1.22. The standardized index showed extreme interannual variability, with stable, but low relative abundance from 2009-2012 (Figure 44). There was no trend over the time series.

5.2.3 Maryland Coastal Bays Seine Survey

5.2.3.1 Survey Methods

The Maryland DNR has conducted the Coastal Bays Fisheries seine survey in Maryland's Coastal Bays since 1972, sampling with a standardized protocol since 1989. Seining sampled the shallow regions of the Coastal Bays frequented by juvenile fishes.

A 30.5 m X 1.8 m X 6.4 mm mesh (100 ft X 6 ft X 0.25 in. mesh) bag seine was used at 18 fixed sites in depths less than 1.1 m (3.5 ft.) along the shoreline. A 15.24 m (50 foot) version of the previously described net was used at site S019 due to it is restricted sampling area. However, some sites necessitated varying this routine to fit the available area and depth. GPS coordinates were taken at the start and stop points as well as an estimated percent of net open. Other site parameters recorded include: depth, bottom substrate, SAV percent coverage, dominate SAV type, water temperature, salinity, dissolved oxygen, secchi depth and tide state.

Shore beach seine sampling was conducted at 19 fixed sites once per month in June and September from 1993 – 2012, and in July or August and September prior to 1993.

5.2.3.2 Biological Sampling

Fishes and invertebrates were identified, counted, and measured for total length (TL) in millimeters. At each site, a sub-sample of the first 20 fish (when applicable) of each species were measured and the remainder counted. A total of 480 black drum were captured in the survey from 1989 – 2012 (years with standardized sampling methodology), with annual catches ranging from zero (for three years) to 77. Black drum lengths from 1989 - 2012 ranged from 26 to 461 mm TL, and mean TL length was 155 mm. Only 9 specimens exceeded 250mm TL.

5.2.3.3 Standardized Index of Abundance

An index was developed from 1989-2012 that is assumed to track YOY abundance due to the lack of fish greater than 250mm TL. Standardized sampling did not occur until 1989 so no samples prior to that year were used. Only samples collected in September were used since 93% all of black drum were caught in that month. Samples from stations where no black drum were caught during the time series were also excluded. A negative binomial GLM was used to standardize the survey index (Figure 45). The unit of effort was black drum caught per net set. Year and bay were included in the final GLM as factors. Figure 46 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 0.82. The standardized index showed high interannual variability, with no clear trend over the time series (Figure 47).

5.2.4 North Carolina Independent Gill Net Survey

2.3.5.1 Survey Methods

The North Carolina Division of Marine Fisheries (NCDMF) independent gill net study (Program 915) started in 1998 on the New, Neuse, Pamlico and Pungo river systems (River Independent Gill Net Survey (RIGNS). Sampling in Pamlico Sound (The Pamlico Sound Independent Gill Net Survey (PSIGNS)) was initiated in May of 2001. Sampling in the RIGNS was dropped after 2000 and resumed in 2003 to present. The PSIGNS has sampled continuously since 2001. Sampling in the Cape Fear and New river systems began in April 2008. The goals of the program are to provide CPUE data for coastal fishes, to supplement age, growth, and reproduction studies, to evaluate catch rates and species distribution for use in management plans, and to characterize habitat use.

The NCDMF Pamlico District, Southern District, and Wanchese field office conduct the project operations within their respective boundaries. The Wanchese office covers the Outer Banks area and the Pamlico District office covers Hyde County bays and adjacent areas of Pamlico Sound. The Pamlico District is also responsible for covering the areas in the Pamlico, Pungo, and Neuse River systems. The Southern District is responsible for covering the Cape Fear River and the New River. For all offices, a stratified random sampling design is used, based on area and water depth. Each region is overlaid with a one-minute by one-minute grid system (equivalent to one square nautical mile) and delineated into shallow (<6 feet) and deep (>6 feet) strata using bathymetric data from NOAA navigational charts and field observations.

Floating gill nets are used to sample shallow strata while sink nets are fished in deep strata. Each net gang consists of 30-yard segments of 3, 3 ½, 4, 4 ½, 5, 5 ½, 6, and 6 ½ inch stretched mesh, for a total of 240 yards of nets combined. Catches from an array of gill nets comprised a single sample and two samples (one shall, one deep), totaling 480 yards of gill nets fished, are completed in each field trip. Nets are deployed parallel or perpendicular to the shore based on the strata and common fishing techniques for the area. Gear was typically deployed within an hour of sunset and fished the following morning with effort made to keep all soak times within 12 hours. The 12-hour soak time allowed for uniform effort and kept the study in compliance with the terms and conditions mandated by the Section 7 permit issued by the U.S. Fish and Wildlife Service. The soak times in the Southern District were further modified due to interactions with sea turtles in June 2007. Soak times were reduced to four hours soak times starting two hours before sunset.

The reduced soak times are used from April to September. These actions were taken to minimize interactions with endangered and threatened sea turtles.

Samples were collected from February 15-December 15 each year. The period of December 16 through February 14 is not sampled due to low catch rates and safety concerns associated with fewer daylight hours and cold water and air temperatures occurring during that period. The catch from the gang of nets comprises a single sample. Each of the sampling areas within each region is sampled twice a month. Within a month, with the exception of Region 1 in June through August, 32 core samples are completed (8 areas x twice a month x 2 samples) for the Pamlico Sound and the same number completed in the Pamlico, Neuse and Pungo river systems. For the southern area (New and Cape Fear rivers) 12 samples are completed, comprised of 8 from New River (2 areas-upper and lower x twice a month x 2 samples-shallow and deep) and 4 from Cape Fear (1 area x twice a month x 2 shallow samples).

Data in the Cape Fear and New river systems limited to 2008 and soak times are reduced to four hours from April to September in these systems. Due to the limited soak times and short time series the Cape Fear and New River samples will be dropped from the analysis. In the Pamlico Sound, 94 of the deep water grids (25% of sampling area) were eliminated in 2005. Sampling area was again reduced by 15% in the Pamlico Sound in 2011 when Dare County Area 1 was eliminated.

5.2.4.1 Biological Sampling

Each collection of fish per mesh size (30-yard net) was sorted into individual species groups. All species groups were enumerated and an aggregate weight (nearest 0.01 kilogram (kg)) was obtained for most species, including damaged (partially eaten or decayed) fish. Physical and environmental conditions including surface and bottom water temperature (oC), salinity (ppt), dissolved oxygen (mg/L), bottom composition, and a qualitative assessment of sediment size were recorded upon retrieval of the nets on each sampling trip. Catch rates of target species were calculated annually and expressed as an overall catch per unit effort (CPUE) along with corresponding length class distributions. The overall CPUE gives an estimate of abundance showing availability of black drum to the study, while the length distribution shows the size structure of each species for a given year. The overall CPUE was defined as the number of black drum captured per sample and was further expressed as the number of a species of fish at length per sample, with a sample being one array of nets. Due to disproportionate sizes of each strata and region, the final CPUE estimate was weighted. The length frequency distribution for black drum was weighted by strata and number caught to determine the contribution of each size class to the final weighted CPUE. The total area of each region by strata was quantified using the one-minute by one-minute grid system and then used to weight the observed catches for calculating the abundance indices.

Caudal length was converted to total length using a conversion factor from the North Carolina 930 program. Length ranged from 110 mm to 825 mm with only 13 fish caught that were greater than 600 mm total length.

5.2.4.2 Standardized Index of Abundance

The SASC decided to develop an index of abundance from river and sound net sets. This limited the time series to 2003-2012 due to a break in sampling in rivers from 2000-2002, but covered a larger spatial scale. This index is assumed to track abundance of immature fish <600mm TL, due to the lack of fish captured above this size. Samples collected after December 15 and before February 14 were excluded from the data set (no sampling during these times after 2002).

The unit of effort was number of black drum per net set hour, a continuous response variable, so the delta method (Lo et al. 1992; section 4.2.1.10.2) was used to develop an index. The positive observation model was a lognormal GLM with year and region as factors. Residuals plots are in Figure 49 and show no patterns in the residuals. The dispersion parameter is 0.65. The proportion positive model was a binomial model with year, month, and region as factors. Residual plots are in Figure 50 and show no patterns in residuals. The dispersion parameter is 0.89. The standardized index showed high interannual variability, with no clear trend over the time series (Figure 51).

5.2.5 South Carolina Trammel Net Survey

5.2.5.1 Survey Methods

The South Carolina Trammel Net Survey was initiated in November 1990 and is still ongoing. It uses a stratified random sampling protocol covering seven different strata within four major estuarine systems. Not all strata have been sampled equally over the entire time period and different strata have been added over the years of the survey. The strata include the ACE Basin (AB) (1994-present), Ashley River (AR) (1990-present), Charleston Harbor (CH) (1990-present), Lower Wando River (LW) (1990-present), White Banks/Muddy Bay area (MB) (1997-present), Cape Romain Harbor (RH) (1991-present), and Winyah Bay (WB) (2001-present), with approximately 30 sites in each stratum. Sites are selected at random without replacement and sampled monthly during early to late ebb tide using a trammel net that is 184 m long and 2.1 m deep with 177-mm outer mesh and 63-mm inner mesh. Each net is set close to shore (<2 m depth) by a fast moving boat and the enclosed section of water is then vigorously disturbed on the surface for 10 minutes before retrieving the net.

5.2.5.2 Biological Sampling

Fish are collected in a live well until the net has been completely hauled, after which they are counted, measured for total length and standard length to the nearest millimeter, tagged and released alive.

5.2.5.3 Standardized Index of Abundance

The SASC decided to develop an index from 1994-2012 because time series covers a greater spatial scale and is only three years shorter than an index developed from data that covers only the Charleston area from 1991-2012. This index is assumed to track abundance of immature fish less than 600mm, due to lack of larger fish capture during the time series. A negative binomial GLM was used to standardize the survey index (Figure 52). The unit of effort was black drum caught per net set. Year, system, and month were included in the final GLM as factors. Figure 53 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 1.58. The standardized index showed high interannual variability, with no clear trend over the time series (Figure 54). There was a relatively high peak in 1999. The index does show a decreasing trend since 2008.

5.2.6 Georgia Marine Sport Fish Population Health Survey

5.2.6.1 Survey Methods

The Marine Sport Fish Population Health Survey consists of random stratified trammel net sampling conducted in selected Georgia estuaries. The survey began in March of 2003. The primary purpose of the survey is to collect timely and relevant data on the age structure, abundance, and habitat preferences of red drum and spotted sea trout. Data collected are used to create long term uninterrupted indices of abundance, monitor trends in populations and determine the efficacy of current management practices. Age analysis and determination is conducted on spotted sea trout and red drum, the first and second most frequently targeted sport fish in coastal Georgia. Although the primary objective of this survey is to gather data on selected recreationally valuable species, all finfish, rays, skates and sharks collected during sampling are identified and measured.

The survey area currently consists of two Georgia estuarine systems: Wassaw Sound Estuary and Altamaha River Estuary. The Wassaw Sound Estuary is located in Chatham County and is bordered by the city of Savannah. The northern portion of Wassaw Sound Estuary exhibits moderate variability in salinity and water temperature due to influence from the Savannah River. The Wassaw Sound Estuary was divided up into four regions or quadrants. The majority of land surrounding the Altamaha River Estuary is undeveloped and managed by the state of Georgia and the federal government as wildlife management areas and national wildlife refuges. The Altamaha River Estuary lies within the northern and southern portions of Glynn and McIntosh counties. Due to fresh water influence of the Altamaha River, salinity and water temperature are highly variable in this estuary. The Altamaha River Estuary was divided up into three regions: Doboy Sound in the northern part of the estuary; the Altamaha River proper along the main channel of the river; and the Hampton River in the southern part of the estuary.

Each estuary (i.e. Wassaw, Altamaha, the southern portions of Doboy Sound and the Hampton River Estuary) is over-laid with a geo-referenced 0.65 sq km series of grids. GADNR personnel then ground-truth each grid and determine if there is a location that is conducive to deploying a trammel net, a gillnet, or both gear types along an uninterrupted length of stream bank. A sampling event consists of a single net set. The net is deployed in a half circle along the shore by boat. Net deployment is done against the tidal current. Immediately after deployment, the net is actively fished by making two to three passes with the boat in the area enclosed by the net. After the last pass is made, the net is retrieved starting with the end that was first set out.

Trammel net surveys are conducted in the Altamaha River Estuary and the Wassaw Sound Estuary from September to November. A total of 75 trammel nets are set for each estuary region each year; 25 stations are sampled each month. The Altamaha River Estuary stations are selected from a pool of 64 total stations using a random stratified station design. The Wassaw Sound Estuary stations are selected from a pool of 38 stations using a random stratified station design. No stations are sampled more than one time each month. All sampling occurs during the last three hours of ebb tide and only during daylight hours.

Currently the trammel net is 300 ft long by 7 ft deep. The two outer panels have 14 in stretch mesh, and the inner panel has 2.75 in stretch mesh. The net has a one-inch diameter float rope and a 165 lb lead line. A 25 lb anchor chain is attached to each end of the lead line, and a large bullet float is attached to each end of the float line. After a net comparison study in 2007, the trammel net length was reduced from 600 ft to 300 ft long.

5.2.6.2 Biological Sampling

All fish caught in the net are placed in a floating mesh holding pen. After the net is fully retrieved, all catch is measured (FL mm), and released.

Immediately after deployment, the net is actively fished by making two to three passes with the boat in the area enclosed by the net. After the last pass is made, the net is retrieved starting with the end that was first set out. All fish caught in the net are placed in a floating mesh holding pen. After the net is fully retrieved, all catch is measured (FL mm), and released. The caudal lengths were converted to total length using a conversion factor from North Carolina's 930 program, and ranged from 180 mm to 711 mm.

5.2.6.3 Standardized Index of Abundance

An index was developed from 2003-2012 and is assumed to track YOY abundance due to the lack of fish greater than 300mm TL captured during the time series. The data was subset to samples in September-November due to lack of catch in other months sampled. The unit of effort was number of black drum per 300 feet of net width, a continuous response variable, so the delta method was used to develop an index (Figure 55). The positive observation model was a lognormal GLM with Year and sound as factors. Residuals plots are in Figure 56 and show no patterns in the residuals. The dispersion parameter is 0.53. The proportion positive model was a binomial model with year, month, and sound as factors. Residual plots are in Figure 57 and show no patterns in residuals. The dispersion parameter is 1.06. The standardized index showed stable relative abundance aside from peaks in 2007 and 2009 (Figure 58).

5.2.7 Florida Fishery-Independent Monitoring Seine Survey

5.2.7.1 Survey Methods

Fishery-independent surveys of Florida's inshore fish species have been conducted using seines since 1989 in the northern Indian River area, since 1997 in the southern Indian River Lagoon area, and since 2001 in the St. Johns River/Nassau Sound area.

These surveys utilize a stratified random design with 21.3-m seines used since the survey's inception in the northern Indian River Lagoon and St. Johns/Nassau Sound areas and with 183-m bag seines used since 1997 in both Indian River Lagoon areas and since 2001 in the St. Johns/ Nassau Sound area (Fisheries-Independent Monitoring Staff 2008).

The sizes of fish captured by the 183-m haul seine was similar between the Northeast Florida and Southern Indian River regions with most fish ranging in size from about 150-350 mm SL and very few fish larger than 500 mm. In the Northern Indian River lagoon, many fish as large as 1,000 mm SL were captured. This is believed to be due to the Merritt Island National Wildlife Refuge which has been closed for over 50 years since the development of the Kennedy Space Center and is known to produce world record sized fish outside the reserve (Roberts *et al.* 2001). This 'spillover' of large fish is observed by comparing the length distributions of fish from zones in the Indian River Lagoon where zone D is the closed area, zone E is adjacent to the refuge followed by zones C and H being further away.

5.2.7.2 Standardized Index of Abundance

A recruit (<101 mm SL) abundance index using the 21.3-m seine data could not be developed from the data because very few black drum of these sizes were caught in these surveys. In the St. Johns River/Nassau Sound area, less than 10 recruits were caught each year during the May-November recruitment. In the northern Indian River Lagoon, less than 10 black drum recruits were caught each year during all months and none were caught in the southern Indian River Lagoon.

The SASC decided to develop four indices from the seine survey data. Net sets are independently allocated within the sampling areas of northeast Florida (NE FL), Northern Indian River Lagoon (N IR), and Southern Indian River Lagoon (S IR). Further, the N IR index included larger fish that were not observed in the S IR or Northeast Florida. The group discussed concern that these larger fish in N IR may not be representative of the coastwide adult population and, therefore, an index including these adult black drum would not be appropriate to use for a coastwide assessment. These larger fish could be resident fish utilizing a marine preserve in close proximity to the N IR. The group decided to include fish <600mm in the data set used to develop indices. This would allow comparison and monitoring of the FL indices with the South Carolina (SC) trammel and North Carolina gill net indices that are assumed to track the relative abundance of the same size classes of black drum.

Northeast Florida Index

An index was developed from 2001-2012. A negative binomial GLM was used to standardize the survey index (Figure 59). The unit of effort was black drum caught per net set. Year, month, and zone were included in the final GLM as factors. Figure 60 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 1.22. The standardized index shows interannual variability, with a declining trend over the time series (Figure 61).

N IR Immature Index

An index was developed from 1997-2012. A negative binomial GLM was used to standardize the survey index (Figure 62). The unit of effort was black drum caught per net set. Year, month, and zone were included in the final GLM as factors. Figure 63 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 1.35. The standardized index shows interannual variability, with no clear trend (Figure 64). There is an extremely large peak in 2012. The sharp increase of CPUE is believed to be real, although there is currently no explanation. Drastic environmental changes have been taking place inside this estuary over the last few years including massive blooms of micro and macro algae, fish kills, and mammal and bird deaths. It is possible that potential predators and/or competitors of juvenile black drum were negatively impacted by such changes thereby increasing the survival of young-of-year and juvenile black drum. It should also be noted that the Indian River Lagoon was hit by multiple tropical storms in 2004 and 2005 during the period of peak recruitment of black drum. This could have altered their distribution, catchability, and/or abundance leading to the low catch rates during those years.

S IR Index

An index was developed from 1997-2012. A negative binomial GLM was used to standardize the survey index (Figure 65). The unit of effort was black drum caught per net set. Year, zone, and bottom structure were included in the final GLM as factors. Figure 66 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 1.25. The standardized index shows an increasing trend until 2003 followed by a decreasing trend until 2006 (Figure 67). The index shown no trend from 2006-2012

N IR Mature Index

An index was developed from 1997-2012. A negative binomial GLM was used to standardize the survey index (Figure 68). The unit of effort was black drum caught per net set. Year and month were included in the final GLM as factors. Figure 69 shows the diagnostic quantile residual plots. There were no patterns in residuals. The dispersion parameter is 1.05. The standardized index shows no clear trend over the time series (Figure 70). There is a large peak in 2002.

6 METHODS

6.1 Background

The SASC determined several assessment methods were appropriate for black drum given the available data. Coast wide biological samples were used in life history analyses to provide information on the life history of black drum and provide required parameters for potential assessment methods. Life history parameters were used in yield per recruit and spawning potential per recruit analyses. Indices of relative abundance were evaluated for potential use as indicators of stock condition. Removal time series were used in addition to life history parameters in three similar catch-based methods. These methods included a method developed by Martell and Froese (2012) referred to through the remainder of this document as the Catch-MSY method, Depletion-Based Stock Reduction Analysis (DB-SRA; Dick and McCall, 2011), and Depletion-Corrected Average Catch (DCAC; McCall, 2009). Surplus production and age-structured production models were also attempted given the available time series of removals and an index of aggregate abundance assumed to reflect the abundance of the entire stock unit.

Several major limitations precluded the development of some traditional assessment methods. Catch curves were considered for estimating mortality. However, there has not been adequate biological sampling of the black drum fisheries in the Mid-Atlantic to develop reliable catch-at-length or catch-at-age. Delaware gill net catch-at-age does track a large age class (Figure 3), but only includes four years of data in a relatively small fishery. In the south Atlantic, catch curves were developed from the SC Trammel survey. However, black drum emigrate from survey and fishery areas in the south Atlantic as they mature. The SASC was concerned that mortality estimates from the south Atlantic would be biased without accounting for unknown emigration rates.

A traditional catch-at-age model was not attempted due to poor biological sampling, particularly in Mid-Atlantic fisheries and Florida commercial fisheries. There are fisheries that harvest large, mature fish and harvest in some of these fisheries has been increasing in recent years. Assuming a large plus-group would not be informative of the stock structure and size. In addition, there are no indices of abundance tracking the mature portion of the stock.

6.1.1 Life-History Analysis

Six biological sampling data sets were used to estimate various life history estimates for black drum. Fishery-dependent data sets included biological sampling in recreational and commercial fisheries in Delaware (DE-DFW) and Virginia (VMRC). Fishery-independent data sets included biological sampling during the NEAMAP survey (NEAMAP) and CHESMMAP survey (CHESMMAP). North Carolina (NCDMF) and South Carolina (SCDNR) biological sampling data sets included both fishery-dependent and fishery-independent samples.

6.1.1.1 Growth

Growth parameters were estimated using total length versus weight and for length at age using the von Bertalanffy growth equation. Not all data sources could be used for both growth estimates as available data was not always appropriate for both of the growth estimates. Length versus weight was estimated using a 2 parameter non-linear regression in the form:

$$Wt = a * TL^b$$

Where Wt = weight, TL = total length, a = y-intercept, and b = slope (growth coefficient). There were six data sets used to estimate the length vs. weight regressions. All regressions were run for males and females separately and for the combined group for each data set. The data sets used for length versus weight were DE-DFW, NEAMAP, CHESMMAP, VMRC, NCDMF, and SCDNR. The results for each of the regressions are available in Table 56. Size at age was estimated using the von Bertalanffy growth equation in the form:

$$L_t = L_\infty (1 - e^{-k(t-t_o)})$$

Where L_t = length at time t, L_∞ = asymptotic length, k = growth coefficient, and t_o = theoretical age at length zero. All von Bertalanffy (VOB) estimates were performed using Growth II (Pisces Conservation Ltd.). There were five data sets suitable for VOB estimates: DE-DFW, CHESMMAP, VMRC, NCDMF, and SCDNR. In addition, parameters were estimated for all data sets combined. All of the data sets (except NCDMF and combined data sets) were processed for VOB parameters by sex as well as for the combined groups and significance between the sexes was tested using a X^2 test for differences in the residual sum of squares from each regression (Greenwood and Nikulin, 1996). The results for each data set can be seen in Table 57. Combined data sets are plotted against the combined data set von Bertalanffy growth curve in Figure 71. There was not a significant difference ($p > 0.05$) between asymptotic length (L) in any of the data sets, however there was a significant difference ($p = 0.001$) in the growth coefficient (k) between DE-DFW and all the other data sets. The reason for this was the DE-DFW data did not contain any fish younger than age 3, while the other data sets all contained younger ages. Since the greatest amount of growth in black drum occurs during the first 3 years, this resulted in k values an order of magnitude less compared to the other data sets that was reflecting the slower growth rates after age 3.

6.1.1.2 Maturity

Size and age at maturity was estimated using a logistic regression on the SCDNR, VMRC, and CHESMMAP data sets. The analysis was run for each data set individually by sex, however, the maturity parameters used in the final assessment model were from the composite data of all three data sets for length and from SCDNR and VMRC data for age at maturity. The regression parameters for each data set and the composite can be seen in Table 58. The length distributions by data set indicated that the CHESMMAP was primarily younger immature fish with only a few older mature fish. This was the reason for the difference in the maturity curve for CHESMMAP data while the composite model was driven primarily by the VMRC and SCDNR data sets which had very similar maturity curves (Figure 72). The estimated length at 50% maturity was 675 mm total length with full maturity being reached at approximately 850 mm total length.

Both males and females reached 50% maturity at approximately age 4 with full maturity occurring at age 7 (Figure 73). Given their age range, black drum appear to mature relatively early and can have many years, if not decades of reproductive potential.

6.1.1.3 Mortality

Natural mortality was estimated using Hoenig (1983) and Hewitt and Hoenig (2005) methods using the von Bertalanffy parameters from the age and growth estimates. For the Hoenig (1983) estimates natural mortality ranged from 0.063 to 0.091 depending on the data set, while the Hewitt and Hoenig (2005) estimates were only slightly lower with a range of 0.0448-4.0652 (Table 59). The low levels of natural mortality reflect the long life span used in the estimates. Only one data set (SCDNR) was suitable for catch curve analysis, while all of the others did not have either enough specimens from different years or year classes or did not have enough older fish in the dataset. In the catch curve analysis for the SCDNR data set there were 18 year-classes from 1990 to 2007. Mortality levels ranged from 0.122 to 0.973 with a mean of 0.820 (Table 60). The 1998 year-class (which was exceptionally large in South Carolina) had the lowest mortality level because it was present for the longest period of time in the data series. The range without that year-class for mortality was 0.638 to 0.973, with a long term mean value of 0.861 that was only slightly higher than the mean value for the entire data set.

6.1.2 Trend Analysis

There was at least one fishery-independent index of relative abundance from each state except New Jersey and Virginia considered in the assessment. The only fishery-dependent indices considered were developed from MRFSS/MRIP intercept data from the full range of the black drum stock. Available indices represented several size classes of black drum, primarily immature fish less than 600 mm TL.

6.1.2.1 Spearman's Correlation

Associations between these indices were evaluated with Spearman's rank analysis (Spearman, 1904). Spearman's rank analysis is a non-parametric test for a monotonic relationship between two variables. Each index value is ranked relative to the other values and the rankings are compared to the ordered rankings of another index. Spearman's rho, the association statistic, is more robust to outliers than Pearson's correlation coefficient due to a conversion of each index value to an ordered rank (Croux and Dehon, 2010). Spearman's rho requires the less restrictive assumption of a monotonic relationship, as opposed to the assumed linear relationship for the Pearson's correlation coefficient. Statistical significance is determined by the p-value relative to a selected alpha level. A two-tailed test was completed to test for positive or negative associations, so a 0.1 alpha level was selected. The strength of the association is determined by the Spearman's rho with a value of -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association.

Indices were grouped based on similar size compositions for the analysis. Fishery-independent indices in the Mid-Atlantic region (MD Seine index, DE 16ft and 30ft Trawl indices, PSEG Seine index) and GA (GA Trammel index) included only YOY fish (<350mm TL) and were evaluated in pairwise comparisons. Fishery-independent indices in the south Atlantic encounter primarily immature fish (<600 mm TL). The NC Gill Net index, SC Trammel index, NE FL Seine index, N IR FL Immature Seine index, S IR FL Seine index, and MRFSS/MRIP South Atlantic index are referred to as immature indices and were evaluated in pairwise comparisons. The MRFSS/MRIP Mature index and N IR FL Mature Seine index are referred to as the mature indices and were compared in pairwise comparisons. Mature indices were lagged from 3-10 years to compare to YOY indices and from 1-10 years to compare to immature indices to identify associations attributable to YOY/immature fish recruiting to mature indices after maturing. Associations were evaluated between non-lagged mature and immature/YOY indices to identify variations in YOY abundance attributable to variations in mature abundance. A final comparison was between immature and YOY indices to identify associations attributable to YOY fish recruiting to the south Atlantic after their first fall.

6.1.2.2 Mann-Kendall Analysis

The Mann-Kendall test was performed to evaluate trends in the computed indices. The Mann-Kendall test is a non-parametric test for monotonic trend in time-ordered data (Gilbert 1987). The test was applied to the following indices: MD Seine index, DE 16ft and 30ft Trawl indices, PSEG Seine index, GA Trammel index, NC Gill Net index, SC Trammel index, NE FL Seine index, IR FL Seine index, and coast wide MRFSS/MRIP index described in sections 4 and 5 of this report. Trends were considered statistically significant at $\alpha = 0.05$.

6.1.3 Per-Recruit Analyses

6.1.3.1 Model Description

An equilibrium yield and spawner per recruit analysis was completed based on life history datasets combined for males and females and pooled across all sources coastwide. The equilibrium spawner per recruit analysis is an age-structured model capable of illustrating the relationship between spawning potential ratio (SPR), minimum size limits, and exploitation rates. This approach uses survivorship (net probability of surviving to each age) along with age schedules of size, weight, mortality, fecundity, maturity, and harvest vulnerability to calculate equilibrium incidence functions (Botsford 1981, Walters and Martell 2004). The incidence functions represent the sum over ages of some quantity (i.e. fecundity, vulnerable biomass) times survivorship, thereby capturing the cumulative effects of fishing and natural mortality on animals as they age. These functions depend on age schedules of survival and life history characteristics on a per-capita basis and do not rely on population size. The survivorship to age a in the fished condition, $S_{f,a}$, is given by:

$$S_{f,0} = 1, \text{ and } S_{f,a} = S_{f,a-1} \cdot e^{-M} \cdot (1 - U v_{a-1}) \text{ for } a > 0.$$

Where M is the instantaneous natural mortality rate, U is the annual exploitation rate for fully vulnerable fish, and v_a is the relative vulnerability of an average age-a fish to harvesting.

Removing the term for exploitation rate provides the survivorship schedule in an unfished condition ($S_{0,a}$).

Size at age was modeled using the von Bertalanffy growth function and converted to weight using the standard length-weight conversion equation. Natural mortality was assumed to be age-specific based on the Lorenzen equation and scaled so that the average M, weighted by vulnerability at age, is equal to the Hoenig (1983) estimate based on maximum age. The probability of a fish being mature is a logistic relationship with age (or length if desired). Relative fecundity at age was assumed to be equal to the difference between weight at age and the weight at maturity. As the only concern for this analysis was the ratio of eggs per recruit in fished and unfished states, the actual numbers of eggs produced by a recruit throughout its lifetime was not estimated. Rather, a relative fecundity schedule was used with a simplifying assumption that the number of eggs produced is proportional to body weight in excess of the weight at maturity.

The vulnerability to harvest schedule (v_a) was assumed to follow the logistic function where fish at the size limit were 50% vulnerable to harvest with the steepness parameter equal to 10% of the size limit. To account for the probability of being captured and discarded before reaching the minimum size limit, or after leaving the upper limit of a slot, we included a vulnerability to capture schedule (c_a) along with a discard mortality rate. The c_a was also assumed to follow a logistic function where fish at the size of first capture were 50% vulnerable to capture and a steepness parameter equal to 10% of the size of first capture. To include discards of caught and released fish, the survivorship equation was modified to:

$$S_{f,0} = 1, \text{ and } S_{f,a} = S_{f,a\text{-}1} \cdot e^{-M} \cdot (1\text{-}Uv_{a\text{-}1}) \cdot ((1\text{-}Uc_{a\text{-}1}\text{-}Uv_{a\text{-}1}) \cdot M_{discard}) \text{ for } a > 0.$$

Reference points are calculated using several incidence functions. The vulnerable biomass per recruit (BPR_v) is calculated as the sum over ages of the product of body weight at age (w_a), vulnerability to harvest at age (v_a), and survivorship at age in the fished condition ($S_{f,a}$). Equilibrium yield-per-recruit (*YPR*) is equal to the exploitation rate *u* times BPR_v. Spawning biomass per recruit in the fished condition ($SBPR_f$) is the sum over ages of maturity at age (m_a), w_a, and $S_{f,a}$. Spawning biomass per recruit in the unfished condition ($SBPR_0$) is calculated using $S_{0,a}$. Similarly, eggs pre recruit in the fished (EPR_f) and unfished (EPR_0) conditions can be calculated by using the relative fecundity schedule (f_a) instead of m_a.

The SPR was calculated simply as the ratio of eggs-per-recruit in the unfished conditioned (EPR_o) to that in the fished condition (EPR_f). Eggs per recruit in the fished and unfished conditions were calculated as the sum over ages of relative fecundity times survivorship with and without fishing. Alternatively, an SPR ratio can be calculated using the ratio of $SBPR_f$ to $SBPR_0$. Lastly, the fishing mortality rate (F_{SPR}) that results in target SPR (SPR_{target}) which is usually defined by management but assumed to be 0.4 in this case was solved.

This model was developed in an excel spreadsheet using life history parameters estimated by combining all available biological datasets (DE-DFW, NEAMAP, CHESMMAP, VMRC, NCDMF, and SCDNR) (Table 61). Parameter schedules are in Figure 74. Equilibrium YPR and SPR was calculated using a minimum size limit of 16 inches with size at first capture assumed to be 10 inches and a discard mortality rate of 0.08.

6.1.4 Catch-MSY

6.1.4.1 Model Description

The Catch-MSY method was developed by Martell and Froese (2012) and was inspired by the stock reduction analyses (SRA) of Kimura and Tagart (1982) and Kimura et al. (1984). Martell and Froese note that the strong negative correlation between maximum population increase rate (r) and stock carrying capacity (K) limit the possible combinations of these parameters that produce positive biomass estimates that do not exceed carrying capacity, given a time series of removals from the stock. Biomass in the first year of the time series (B_1) is the product of the assumed K parameter and assumed relative biomass in the first year (B_1/K) (

Equation 2).

Equation 2:

$$B_1 = K * B_1/K$$

Biomass in each subsequent year is estimated with a deterministic production model parameterized with the r and K parameters. A Pella-Tomlinson (1969) production model (

Equation 3) was used for black drum,

Equation 3:

$$B_t = B_{t-1} + \frac{r}{p} * B_{t-1} * \left(1 - \left(B_t - \frac{1}{K}\right)^p\right) - R_{t-1} - 1$$

where B_t is current biomass, B_{t-1} is biomass in the previous year, p is a shape parameter (see below), and R_{t-1} are the removals from the previous year.

Several authors since the 1950s (Pella and Tomlinson 1969, Fox 1970, Maunder 2003) suggest that biomass producing MSY relative to K (B_{MSY}/K) equal to 0.5, and hence the Schaefer (1954) production function, may not be an appropriate assumption. The Pella-Tomlinson production model is parameterized with an additional parameter, p, controlling the shape of the production curve, allowing for peak productivity below, at, or above 0.5K. The shape parameter is a function of B_{MSY}/K (Equation 4) and can be solved for iteratively by specifying the B_{MSY}/K parameter.

Equation 4:

$$\frac{B_{MSY}}{K} = \left(\frac{1}{p+1}\right)^{1/p}$$

To further narrow the plausible r and K combinations, assumptions are made about the relative biomass range in the terminal year of the time series (B_n/K) based on data or expert opinion. If the estimated terminal biomass does not fall within the assumed range of terminal biomass, or if any biomass estimates exceed carrying capacity or are non-positive, the r and K combination in the model is considered implausible. Plausible r and K combinations are used to derive MSY reference points in

Equation 5 - Equation 9.

Equation 5:

$$MSY = r * K * \left(\frac{1}{1+p}\right)^{\left(\frac{1}{p}\right)+1}$$

Equation 6:

$$B_{MSY} = K * \left(\frac{1}{1+p}\right)^{\frac{1}{p}}$$

Equation 7:

$$F_{MSY} = r * \left(\frac{1}{1+p}\right)$$

Equation 8:

$$U_{MSY} = \frac{F_{MSY}}{F_{MSY} + M} * (1 - \exp(-M - F_{MSY}))$$

Equation 9:

$$OFL = B_n * U_{MSY}$$

B_1/K, r, K, and B_{MSY}/K parameters are drawn from specified prior distributions to account for some uncertainty and a specified number of model iterations are run. Parameters and reference points from accepted iterations are output in probability distributions. The model was coded in the R software language, version 3.0.2 for Windows (R Development Core Team 2013). The code is a modification to code developed by John Wiedenmann (Rutgers University) for the ASMFC Data-Poor Stock Assessment Training Workshop (2012).

6.1.4.1.1 Input Data

The time series of removals used in the model was 1950-2012 (Table 2). Relative biomass in 1950 (B_{1950}/K) was drawn from a uniform distribution with bounds of 0.85 and 0.99. Minor depletion in 1950 was assumed based on low removals prior to 1950. The relative biomass range in 2012 (B_{2012}/K) was assumed to be 0.656-0.856. Depletion in 1993 was assumed to be 10% and depletion from 1994-2012 was assumed to be 16% based on declines in the SC Trammel index for a total depletion from unfished conditions of 24.4% (B_{2012}/K = 0.756). The average coast wide removals from 1994-2012 increased 75% relative to the average removals from 1950-1993. The 2009-2012 average relative abundance from the SC Trammel index declined 16% from the 1994-1997 average relative abundance.

Due to concerns with the accuracy and precision of the stock removals (see section 4.1.9 and 4.2.1.14), observation error was incorporated in the model. Annual commercial landing estimates were drawn from a uniform distribution. Commercial landing reporting is designed to be a census, so the total landings recorded was used as a lower bound. The upper bound was assumed to be 50% greater than the total landings recorded and this is intended to address unknown dead discards, unreported landings, and black drum in unclassified landings. This is the equivalent to assuming up to one third of commercial removals may not have been reported in a given year. There is no commercial discard data for black drum, though there are anecdotal reports of discards that can be quite high (personal communication, NCDMF). Recreational harvest estimates were drawn from normal distributions with a mean set as the available point estimate and a standard deviation derived from the available PSE. The average PSE from 1981-1985 was used as the annual PSE for recreational harvest estimated with the historical method (1950-1980; section 4.2.1.6). Recreational release estimates in weight were drawn from normal distributions with a mean set as the available point estimate and a standard deviation derived from the PSE for recreational release estimates in numbers. The PSEs for weight and number estimates were assumed to be the same. Dead recreational discards were calculated as the product of the assumed recreational discard mortality rate (0.08) and the recreational release estimates in weight. Normal distributions truncated with a lower limit of zero were assumed for recreational harvest and release estimates.

A uniform distribution with bounds of 0.16 and 0.5 was used to draw the r parameter (Figure 75). Patrick et al. (2009) used empirical relationships between life history attributes and a survey of stocks landed in U.S. fisheries to rank stock productivity. Five life history parameters for black drum were ranked as indicative of either low (1), moderate (2), or high (3) productivity using the ranking scheme in Patrick et al. 2009 (Table 62). The Brody growth coefficient (k) from the coast wide growth curve (0.13, section 6.1.1.1) ranked moderate, the asymptotic length (L_{inf}) from the coast wide growth curve (117 cm) ranked moderate, fecundity (37.67 million ova; Nieland and Wilson 1993) ranked high, the age at approximately 50% maturity on the coast wide maturity schedule (4; section 6.1.1.2) ranked moderate, and the maximum age (67, VMRC) ranked low. The average ranking (2) suggested moderate r (0.16-0.5, Table 63).

The K parameter was also drawn from a uniform distribution with a lower bound equal to the maximum observed removals (5.76 million lbs. in 2008) and an upper bound 100 times greater than the maximum observed removals (Figure 75). These are default bounds in Martell and Froese (2012). K is known to be greater than the maximum observed removals or the stock would be extinct. The upper bound corresponds to a maximum removal of only 1% of the stock. A stock would not likely need to be assessed and managed if annual removals have never exceeded 1% of the stock, so these bounds are assumed to capture the true carrying capacity for an exploited stock like black drum.

Thorson et al. (2012) provide a prior distribution for the $SB_{MSY}/SB0$ parameter (mean = 0.35, sd = 0.12) for order Perciformes that was used as a proxy for the black drum B_{MSY}/K parameter. A truncated beta distribution with a lower limit of 0.2 and an upper limit of 0.8 was used to exclude unrealistically skewed production curves (Figure 75).

Ten thousand iterations were run for all model configurations (base and sensitivity).

6.1.4.1.2 Assumptions, Limitations, and Biases

The Catch-MSY method is a production-based method and many of the assumptions of standard production models apply. The productivity parameters are assumed constant throughout the time series. A related assumption is that the entire stock is lumped biomass. This assumption may result in biased biomass estimates if there have been significant changes in the age-structure of the black drum stock over the time series, as processes that contribute to productivity (natural mortality, fecundity, etc.) would likely change as well. The stock is assumed to respond immediately to changes in biomass and there is no lag between production and recruitment to the exploitable biomass. The SAS felt this was a valid assumption because YOY fish are captured coast wide and age-1 through age-4 fish that are unavailable to the Mid-Atlantic fisheries are assumed to immigrate immediately to the South Atlantic and become vulnerable to those fisheries. There may be a portion of the mature stock that is not fully vulnerable to the fisheries, depending on the proportion that migrate to the Mid-Atlantic, and this portion will not be captured in exploitable biomass estimates.

The model does not incorporate any process error and the stock is assumed not to deviate from the deterministic production dynamics. There was no information to inform specification of the magnitude of stochastic process error for black drum.

MSY reference point estimates are highly dependent on the lower limit of r and the upper limit of K (Martell and Froese 2012). These limits must be specified carefully to capture all plausible r and K combinations. Higher values of r cause more drastic increases in biomass and estimates are more likely to exceed carrying capacity, resulting in more accepted r values and a central value towards the lower bound. The larger the upper limit on K is relative to the removals, the lower the central r value will be due to the negative correlation between the parameters.

The MSY estimates are also dependent on the assumed depletion in the end of the time series. The lower limit of the MSY distribution is dependent on the lower limit of the assumed depletion and the upper limit of the MSY distribution is dependent on the upper limit of the assumed depletion and the range of K values (Martell and Froese 2012). The assumed depletion for black drum was based on the SC trammel index which captures very few mature fish (>600mm), but is conducted at the center of the stock distribution, covers a relatively large geographical area, and covers a long time series.

The authors validated this method by applying it to U.S. and international stocks with independent MSY estimates from “data-rich” assessment methods. A bias was detected applying this method to lightly exploited stocks. Stocks that are lightly exploited do not contain enough information in the catch history for the model to narrow the range of plausible r and K combinations. The larger K is relative to the removals, the wider the range of r values that could have sustained the relatively small removals. It is not clear if observed removals were sustained due to a large K and low r or a smaller K and higher r. This may not be clear unless the removal time series contains contrast due to depletion and rebuilding.

The authors also found that Catch-MSY tended to overestimate K relative to the K estimate from independent data-rich assessments. Similarly, r estimates from the Catch-MSY method tended to be underestimated relative to $2*F_{MSY}$. These biases lead to precautionary estimates because they result in higher biomass thresholds and lower fishing mortality thresholds than estimated with the data-rich assessments (Martell and Froese 2012). Precautionary estimates are a favorable quality of methods for data-poor stocks with highly uncertain input parameters and data.

6.1.4.1.3 Sensitivity Analysis

The K parameter was difficult to specify and the prior distribution was broad due to a one-way removal time series that may not contain information on maximum productivity. To limit the prior distribution on K to a more realistic range, the upper bound of the uniform distribution was reduced to the highest plausible K value (100 million lbs.) corresponding to the lower bound of the r distribution (0.16) in the base configuration. This limit was suggested by Martell and Froese (2012) as a more informative limit given the better information used to specify the r parameter.

Sensitivity to the bounds of the r parameter was evaluated with two configurations using the default r bounds suggested by Martell and Froese (2012). Black drum life-history traits indicate low, moderate, and even high productivity and the SASC had difficulties specifying this parameter. The first sensitivity configuration assumed moderate productivity with bounds on the uniform distribution at 0.2 and 1. The second sensitivity configuration assumed low productivity with bounds on the uniform distribution at 0.05 and 0.5.

The assumed shape of the production curve was evaluated with two sensitivity configurations. The first maintained a Pella-Tomlinson production function, but increased the mean of B_{MSY}/K to 0.4, the mean of pooled orders in the Thorson et al. (2012) meta-analysis. The traditional Schaefer production function with B_{MSY}/K equal to 0.5 was assumed for a second sensitivity configuration.

The relative biomass in the first and last years are major assumptions for this method. Bounds on the relative biomasses where changed to defaults developed by Martell and Froese (2012) based on the magnitude of removals observed at the beginning and end of the time series to test sensitivity to relative biomass assumptions. These bounds were much broader than those assumed in the base configuration (B_{1950}/K = 0.5-0.9, B_{2012}/K = 0.01-0.4). Three additional sensitivity configurations were evaluated by decreasing the bounds of terminal relative biomass from 0.756-0.956 to 0.456-0.656 by 0.1. Sensitivity to assumed relative biomass in the first year of the time series was evaluated by extending the time series back to 1900 and assuming an unfished stock. This sensitivity configuration mirrors the depletion assumptions made for the DB-SRA method (section 7.4).

Stochastic deviations were incorporated in the model to evaluate sensitivity to process error (Equation 10). Lognormal deviations on the log scale were drawn from a normal distribution with a mean of 0 and sd of 0.05.

Equation 10:

$$B_t = (B_{t-1} + \frac{r}{p} * B_{t-1} * \left(1 - \left(B_t - \frac{1}{K}\right)^p\right) - R_{t-1} - 1) * \mathbf{exp}(\boldsymbol{dev})$$

Commercial data reporting shifted from monthly level reports to trip level reports from NC to NJ in 1994 and is assumed to have become more reliable. The upper bound of the uniform prior distribution for commercial landings values from 1950-1993 was increased to two times the reported landings, assuming up to 50% of annual commercial removals may not have been reported during these years. The upper bound for 1994-2012 remained at one and a half times the reported landings.

A second sensitivity configuration was conducted to evaluate the effects of historic data. The time series was shortened to 1982, the first complete year MRFSS recreational harvest and release estimates are available. Recreational estimates prior to 1981 were made with several simplifying assumptions and did not include uncertainty estimates. The relative biomass in 1982 (B_{1982}/K) was not changed from the base run (B_{1950}/K).

The effects of the anomalous MRIP estimates in 2008 and 2009 were evaluated by setting the estimates in these years equal to the mean of two years before and two years after these estimates (2006, 2007, 2011 and 2010).

6.1.5 Depletion-Based Stock Reduction Analysis (DB-SRA)

6.1.5.1 Model Description

Similar to the Catch-MSY method, DB-SRA was inspired by SRA. SRA estimates unfished recruitment (R0) necessary to have sustained an observed time series of removals resulting in recent stock biomass levels, whereas, DB-SRA estimates carrying capacity (K) necessary to have sustained an observed time series of removals resulting in recent stock biomass levels.

Natural mortality (M), the ratio of fishing mortality corresponding to MSY and natural mortality (F_{MSY}/M), biomass corresponding to MSY relative to carrying capacity (B_{MSY}/K), and biomass in a recent year relative to carrying capacity (B_r/K) are leading parameters used to derive MSY reference points and are based on data, meta-analysis, or expert opinion. F_{MSY} is derived from the product of F_{MSY}/M and M (Equation 11). Exploitation corresponding to MSY (U_{MSY}) is derived with Equation 12.

Equation 11:

$$F_{MSY} = \frac{F_{MSY}}{M} * M$$

Equation 12:

$$U_{MSY} = \left(\frac{F_{MSY}}{M + F_{MSY}}\right) * (1 - \exp(-(M + F_{MSY})))$$

The only additional parameter necessary to derive reference points is K. The first year of the removal time series is assumed to be the first year of exploitation and, therefore, the stock is assumed to be at unfished conditions (i.e., K) in the beginning of the first year. An initial K parameter is specified and stock biomass is projected forward in each subsequent year with a production model and the time series of removals. K is then solved for iteratively conditional on the assumed B_r/K and specified bounds around K. If the absolute difference between the estimated B_r/K and assumed B_r/K is not within a specified range (tolerance), or if any biomass estimates are non-positive, the model is considered implausible and is rejected. If the model is accepted, the parameters are used to derive MSY reference points with Equation 13 - Equation 15.

Equation 13:

$$B_{MSY} = K * \left(\frac{B_{MSY}}{K}\right)$$

Equation 14:

$$MSY = B_{MSY} * U_{MSY}$$

Equation 15:

$$OFL = U_{MSY} * B_t$$

As described in section 6.1.4.1, a Pella-Tomlinson production model was assumed the most appropriate production function for black drum. The Pella-Tomlinson production function used in DB-SRA was reparameterized by Fletcher (1978; Equation 16).

Equation 16:

$$P = g * MSY * \left(\frac{B_{t-a}}{K}\right) - g * MSY * \left(\frac{B_{t-a}}{K}\right)^n$$

The parameter controlling the shape of the production curve (n) is related to the leading parameter B_{MSY}/K in Equation 17 and is solved for iteratively conditional on the B_{MSY}/K parameter. The nuisance parameter, g, is related to n in Equation 18 and is derived after solving for n. MSY is derived with Equation 19 and is solved once K is solved.

Equation 17:

$$if\ n = 1, \frac{B_{MSY}}{K} = \exp(-1)$$
$$if\ n \neq 1, \frac{B_{MSY}}{K} = n^{\left(\frac{1}{1-n}\right)^2}$$

Equation 18:

$$g = \frac{n^{\frac{n}{n-1}}}{n-1}$$

Equation 19:

$$MSY = U_{MSY} * \frac{B_{MSY}}{K} * K$$

The production function was hybridized with a Schaefer production function to address excessive production estimates at low biomasses of highly skewed Pella-Tomlinson production curves, as noted by Fletcher (1978). The hybridized production function estimates production with a Pella-

Tomlinson-Fletcher production function at biomasses above a specified biomass (B_{join}) and a Schaefer production function at biomasses below B_{join}. The optimal B_{join} is dependent on the shape of the production curve (i.e., B_{MSY}/K) and recommendations by Dick and McCall (2011,

Equation 20) were used for specifying B_{join}. The recommendations result in a hybridized production function that estimates production for low biomass levels similar to a Beverton-Holt stock-recruitment relationship.

Equation 20:

$$if\,\frac{B_{MSY}}{K} < 0.3, \frac{B_{join}}{K} = \frac{0.5B_{MSY}}{K};$$

$$if\;0.3 < \frac{B_{MSY}}{K} > 0.5, \frac{B_{join}}{K} = 0.75\left(\frac{B_{MSY}}{K}\right) - 0.075$$

$$if\,\frac{B_{MSY}}{K} > 0.5, use\;PTF\;for\;all\;biomass\;estimates$$

Biomass was estimated using a delay-difference model in the original method developed by Dick and McCall (Equation 21) that requires an additional age-at-maturity parameter (a). Black drum are known to recruit to exploitable biomass before age-at-maturity. Therefore, biomass was estimated in this analysis using a traditional production model with no lag between production and recruitment by setting the age-at-maturity (a) equal to one.

Equation 21:

$$B_t = B_{t-1} + P(B_{t-a}) - R_{t-1}$$

Uncertainty of leading parameters is addressed by drawing the parameters from a prior distribution and running a specified number of model iterations. MSY reference points from each plausible iteration are output in probability distributions. The model was coded in the R software language, version 3.0.2 for Windows (R Development Core Team 2013). The code is a modification to code developed by John Wiedenmann (Rutgers University) for the ASMFC Data-Poor Stock Assessment Training Workshop (2012).

6.1.5.2 Input Data

Removals from 1900-2012 were used in the analysis (Table 2). The time series of black drum removals was extended back to 1900 to address the assumption of an unfished stock in the first year. There were sporadic commercial landings prior to 1900 (Figure 1), but these landings were small and are considered highly uncertain. There were no recreational harvest estimates from 1900-1949. Recreational harvest estimates were extrapolated from 1949 back to 1900 (Table 2) using an exponential regression of the recreational harvest estimates from 1950-1975 (Figure 76). A linear regression was considered as well ($R^2 = 0.923$), but the exponential regression resulted in a better fit ($R^2 = 0.973$). The average PSE from 1981-1985 was assumed for recreational harvest from 1900-1949. Recreational discards were assumed to be zero from 1900-1949. Removals from 1950-2012 were treated the same as for the Catch-MSY method (section 6.1.4.1.1).

Natural mortality was drawn from a lognormal distribution with expectation equal to the Hoenig (1983) natural mortality estimate (0.063) and a CV equal to 0.53 (Figure 77). MacCall's (2009) analysis of Hoenig's fish mortality estimates resulted in a standard error (σ^2) of 0.50 for ln(Z). This standard error corresponds to a CV of the lognormal distribution equal to 0.53 (Johnson et al. 1994;

Equation 22).

Equation 22:

$$CV = (\exp(\sigma^2) - 1)^{\frac{1}{2}}$$

Zhou et al. (2012) modelled the relationship between F_{MSY} and life history parameters at the class and order level. Their model with M and class as explanatory variables had a lower DIC than their model with M, class, and order as explanatory variables. The coefficient for natural mortality as an explanatory variable of F_{MSY} for teleosts is 0.87 with a sd of 0.06. The ratio of F_{MSY}/M for black drum was drawn from a normal distribution with a mean of 0.87 and sd of 0.06 (Figure 77).

~~The B_r/K parameter was drawn from a truncated beta distribution with a mean of 0.756, an assumed CV of 0.2, and bounds of 0.01 and 0.99 (Figure 77). The mean was based on the SC Trammel index and assumptions based on removals prior to this survey (see section 6.1.4.1.1)[3].~~ The B_r/K parameter was drawn from a uniform distribution with bounds of 0.5-0.9 (Figure 97). This parameter represents depletion from unfished conditions. The biomass (B_r) does not have to be from the terminal year in the time series, but rather a recent year in the time series. There was not better information for an alternative recent year, so the terminal year biomass (B_{2012}) was assumed in this analysis.

The B_{MSY}/K parameter was specified the same as in the Catch-MSY method based on the Thorson et al. (2012) meta-analysis. The distribution was a truncated beta distribution with a mean of 0.35, sd of 0.12, lower bound of 0.2, and upper bound of 0.8 (Figure 77).

Ten thousand iterations were run for each model configuration (base and sensitivity). The tolerance for accepting iterations based on the absolute difference between the estimated B_{2012}/K and assumed B_{2012}/K was set at 0.01. The initial K value was 10 times the maximum observed removals and bounds were the maximum observed removals and 100 times the maximum observed removals.

6.1.5.3 Assumptions, Limitations, and Biases

The same production theory assumptions that apply to the Catch-MSY method apply to DB-SRA. The model does not incorporate any process error and the stock is assumed not to deviate from the deterministic production dynamics.

[3] The peer review panel recommended that an uninformative, uniform distribution with bounds of 0.5-0.9 be used for the Br/K parameter. This was accepted for the final preferred DB-SRA configuration.

The primary limitation of this method is that the stock must be unfished in the beginning of the time series. The K parameter serves two purposes, as a productivity parameter and as the initial condition of the stock.

The leading parameters can be highly subjective and directly influence the reference point estimates. An analysis by Wetzel and Punt (2011) found that DB-SRA was most sensitive to overly optimistic relative biomass (depletion) specifications in a recent year. As discussed for the Catch-MSY method, this parameter is difficult to specify and can result in biased estimates if incorrectly specified.

6.1.5.4 Sensitivity Runs

Sensitivity to the assumed relative biomass in 2012 was evaluated by assuming five different mean values decreasing from 0.9 to 0.5 by 0.1. There was data available to inform the relative depletion, supporting a non-uniform distribution. However, there were several assumption made about this data. To evaluate the assumption of a beta distribution, the distribution was changed to a uniform distribution with the same bounds assumed in the Catch-MSY analysis (0.656-0.856).

Wetzel and Punt (2011) found that DB-SRA is robust to misspecification of the natural mortality parameter for some life histories, but can be sensitive for other life histories especially when M is greater than the true value. Sensitivity to M was evaluated by assuming M estimated with Hewitt and Hoenig's (2005) method and assuming M equal to the estimate in Jones and Wells (1998). The Hewitt and Hoenig estimate (0.045) is less than the Hoenig (1983) estimate and the Jones and Wells estimate (0.08) is greater than the Hoenig estimate. The same CV (0.50) from McCall (2009) was assumed for both alternative M estimates.

Sensitivity to the F_{MSY}/M parameter was evaluated by setting the mean and CV to 0.92 and 0.1, respectively. These parameters were from the Zhou et al. (2012) model including the order Perciformes as an explanatory variable.

To evaluate the assumption of no lag between production and recruitment, a delay-difference model was configured with age-at-maturity set at 4 (≈50% maturity on the coast wide maturity schedule, section 6.1.1.2).

The assumed shape of the production curve was evaluated by increasing the mean of B_{MSY}/K to 0.4, the mean value when pooling orders as an explanatory variable in the Thorson et al. (2012) meta-analysis.

The effects of the anomalous MRIP estimates in 2008 and 2009 were evaluated by setting the estimates in these years equal to the mean of two years before and two years after these estimates (2006, 2007, 2011 and 2010).

Sensitivity to extrapolated recreational harvest from 1900-1949 was evaluated by assuming no recreational harvest from 1900-1949.

Assumed bounds for the commercial landings prior distribution were also evaluated due to changes in reporting. The upper bound for 1900-1993 was increased to two times the reported landings.

The upper limit of the K parameter was evaluated with new information from the Catch-MSY method. The upper limit was set at 100 million pounds, the maximum value corresponding to the lower limit of the r parameter in the Catch-MSY method.

6.1.6 Depletion-Corrected Average Catch (DCAC)

6.1.6.1 Model Description

DCAC was developed by McCall (2009) and expands on the potential-yield formula ().

Equation 23) of Alverson and Pereyra (1969) and Gulland (1970). The underlying theory is that if a stock has been exploited without a decline in abundance the average annual removals during exploitation are sustainable. However, in the more realistic scenario where exploitation has led to a decline in abundance, a portion of the average removals, termed the windfall harvest (W), is not sustainable and causes the decline in abundance. The windfall harvest must be accounted for in the average removals to estimate a reasonable yield (i.e., not extremely precautionary) that is likely to be sustainable (Y_{sust}).

Equation 23:

$$Y_{pot} = 0.5MK$$

The original potential yield formula is based on traditional production assumptions of B_{MSY}/K equal to 0.5 and F_{MSY} equal to M. Under these assumptions, the windfall harvest resulting in a reduction in biomass from K to the biomass corresponding to MSY (B_{MSY}) is equal to 0.5K. After this windfall harvest, the stock is at B_{MSY} and Y_{pot} is a sustainable annual yield. The windfall harvest relative to annual potential yield (W/Y_{pot}), or correction term, is equal to the number of years of sustainable yield that has already been removed in the windfall harvest. Adding the correction term to the number of years in the removal time series and averaging the removals accounts for harvest that was unsustainable and results in a sustainable yield (Equation 24). As windfall harvest increases, the sustainable yield decreases and vice versa. If there has been no windfall harvest (i.e., $W/Y_{pot} = 0$), the sustainable yield is equal to the average removals.
Equation 24:

$$Y_{sust} = \frac{\Sigma R}{n + \left(\frac{W}{Y_{pot}}\right)}$$

The potential yield formula can be modified to assume any B_{MSY}/K value and any relationship between F_{MSY} and M. A multiplier, c, is applied to M so any relationship between F_{MSY} and M can be assumed (Equation 25). The c parameter is equivalent to F_{MSY}/M.

Equation 25:

$$Y_{pot} = \left(\frac{B_{MSY}}{K}\right) cMK = \left(\frac{B_{MSY}}{K}\right) * \left(\frac{F_{MSY}}{M}\right) MK$$

McCall also modifies the windfall harvest equation so that any changes in biomass can be incorporated into the sustainable yield equation with a delta parameter (Δ), not just a reduction in biomass from K to B_{MSY}. The delta parameter is the assumed change in biomass from the initial year in the time series to the terminal year in the time series relative to K (Equation 26).

Equation 26:

$$\Delta = (B_1 - B_t)/K$$

The correction term is updated with the modified

Equation 27. Prior distributions for each input parameter (Δ, B_{MSY}/K, M, c) are specified and a specified number of iterations of Y_{sust} are run with the observed removals over n years. The Y_{sust} from all iterations are output in probability distributions.

Equation 27:

$$\frac{W}{Y_{pot}} = \frac{\Delta K}{\left(\frac{B_{MSY}}{K}\right) cMK} = \frac{\Delta}{\left(\frac{B_{MSY}}{K}\right) cM}$$

The model was coded in the R software language, version 3.0.2 for Windows (R Development Core Team 2013). The code is a modification to code developed by Jeff Brust (NJDFW) for the ASMFC Data-Poor Stock Assessment Training Workshop (2012).

6.1.6.2 Input Data

The time series of removals was 1950-2012 (n = 63) for consistency with the Catch-MSY method (Table 2). Removals were treated the same as in the Catch-MSY and DB-SRA methods before summation and incorporate observation error.

The M and c (F_{MSY}/M) parameters were specified as described for the DB-SRA method. The B_{MSY}/K parameter was specified as described for the Catch-MSY and DB-SRA methods. Prior distributions are in Figure 78.

The depletion delta was developed with the same assumptions used for Catch-MSY and DB-SRA and was drawn from a beta distribution (Figure 78). The black drum fishery has developed over the time series according to the removal time series and it is assumed that the delta is not negative (i.e., increase in biomass from 1950-2012). Relative biomass in 1950 (B_{1950}/K) was assumed to be 0.92 based on relatively minor removals prior to 1950. This value is the central value in the assumed B_{1950}/K range for the Catch-MSY method (0.85-0.99). Relative biomass in 2012 was assumed to be 0.756 based on the SC trammel survey index. These relative biomasses correspond to a mean depletion delta of 0.164 (Equation 28). The sd of the depletion delta was 0.028 which corresponds to an assumed CV of 0.20.

Equation 28:

$$\Delta = \frac{B_{1950} - B_{2012}}{K} = \frac{0.92 - 0.756}{1} = 0.164$$

Ten thousand iterations were completed for each model configuration (base and sensitivity).

6.1.6.3 Assumptions, Limitations, and Biases

The removals are summed overall years in the time series, so any consistent bias in annual removals (e.g., non-reporting) will be carried through to the sustainable yield estimate (McCall 2009). This was addressed by incorporating observation error into removals, though there could still be a systematic bias that was not captured in the observation error.

This method is recommended for stocks with M greater than ≈0.2. As M increases, the correction term approaches zero (M is in the denominator of the correction term) and the yield estimate approaches the average catch. Sustainable yield would tend to be overestimated. Black drum M is assumed to be much less than 0.2.

The sustainable yield estimate is not equal to MSY, but is rather a high yield that is not likely to exceed MSY. By rule, the Y_{sust} will be less than MSY. The sustainable yield estimate is appropriate for average biomass levels during the time series modeled. If the stock has been severely depleted in recent years, the Y_{sust} estimate may not be applicable depending on the typical biomasses in the earlier years (Martell and Froese 2012).

Similar to DB-SRA, DCAC can be sensitive to overly optimistic depletion assumptions and the F_{MSY}/M and M parameters for some life-histories. Assuming a lower depletion will result in a lower sustainable yield estimate (Wetzel and Punt 2011).

6.1.6.4 Sensitivity Analysis

Sensitivity to M was evaluated by assuming M estimated with Hewitt and Hoenig’s (2005) method and assuming M equal to the estimate in Jones and Wells (1998). The Hewitt and Hoenig estimate (0.045) is less than the Hoenig (1983) estimate in the base configuration and the Jones and Wells estimate (0.08) is greater than the Hoenig estimate. The same CV from McCall (2009) was assumed for both sensitivity configurations.

Sensitivity to the assumed dynamics of the production curve was evaluated by increasing the B_{MSY}/K parameter to 0.4, the value for pooled orders in the Thorson et al. (2012) meta-analysis.

Sensitivity to the F_{MSY}/M parameter was evaluated by setting the mean and CV to 0.92 and 0.1, respectively. These parameters were from the Zhou et al. 2012 model including the order Perciformes as an explanatory variable.

Due to the nature of averages, sensitivity to the time series of removals selected was evaluated by shortening the time series to 1982. This limits the time series to years with external recreational estimates.

Sensitivity to the assumed error around the commercial landings prior to improvements in commercial reporting (1950-1993) was evaluated by increasing the upper bound on the uniform distribution to two times the reported landings.

The effects of the anomalous MRIP estimates in 2008 and 2009 were evaluated by setting the estimates in these years equal to the mean of two years before and two years after these estimates (2006, 2007, 2011 and 2010).

Four alternative depletion assumptions were evaluated by decreasing the terminal relative biomass by 0.1 in four sensitivity configurations.

6.1.7 Surplus Production and Age-Structured Production Models

Several attempts were made to estimate MSY reference points and determine stock status with a surplus production model (ASPIC; Prager 1994) and an age-structured production model (ASMFC 2005). However, several model configurations failed to converge and model estimates of biomass and fishing mortality from configurations that converged on a solution were biologically unrealistic given the time series of removals and general understanding of historical black drum exploitation. Relative biomass was estimated at extremely low levels in the 1980s and never recover during the time series. Several model parameters were estimated at bounds when freely estimated and resulted in other parameters being estimated at bounds when fixed. There was only one index of abundance that indexed black drum from the entire stock unit, the MRFSS/MRIP index. The available fishery-independent indices were limited spatially relative to the stock range and only covered fractions of the stock age structure. The trend analyses suggested that fishery-independent indices were reflective of localized abundance and did not indicate associated trends across the stock range (section 7.1.1). The MRFSS/MRIP index increases from the early 1990s to a time series high in 2008, despite increasing removals during the same period (Figure 79). These trends are contradictory to expected trends in a developing fishery, where increases in removals would lead to declines in abundance. The SAS was more confident in the removal time series and felt that these analyses provide little support for the MRFSS/MRIP index being a reliable index of stock abundance.

7 RESULTS

7.1 Trend Analysis

7.1.1 Spearman's Correlation

7.1.1.1 YOY Index Association

There were positive associations between all indices from the Delaware Bay (PSEG Seine index, DE 16ft and 30ft Trawl indices; Table 64). All associations exceeded a Spearman's Rho of 0.5. The MD Seine index was positively associated with the PSEG Seine index (Spearman's Rho = 0.61), but not associated with the DE Trawl indices. There were not associations between the GA Trammel index and Mid-Atlantic YOY indices. This lack of association is not surprising due to the distance separating the survey areas.

7.1.1.2 Immature Index Association

There were positive associations between the N IR FL Immature and S IR FL Seine indices, the S IR FL and NC Gill Net indices, the SC Trammel and MRFSS/MRIP South Atlantic indices, the NC Gill Net and MRFSS/MRIP South Atlantic indices, and the SC Trammel and NC Gill Net indices (Table 65). There were negative associations between the NE FL Seine and N IR FL Immature Seine indices and the NE FL Seine and MRFSS/MRIP South Atlantic indices.

7.1.1.3 Mature Index Association

There was no significant association between the mature indices (Table 66).

7.1.1.4 Lagged Mature and YOY Index Association

There are positive associations between the MD Seine index and the MRFSS/MRIP Mature index lagged by 6, 8, 9, and 10 years (Table 67). The only significant associations between the lagged N IR FL Mature Seine index and YOY indices were negative (Table 68). The N IR FL Mature Seine index was negatively associated with the MD Seine index when lagged by 3 years, the DE 16ft Trawl index when lagged by 3, 5, or 10 years, and the DE 30ft Trawl index when lagged by 5 or 10 years.

7.1.1.5 Lagged Mature and Immature Index Association

The MRFSS/MRIP South Atlantic index was positively associated with the MRFSS/MRIP Mature index lagged from 5 to 10 years (Table 69). The MRFSS/MRIP Mature index was positively associated with the NE FL Seine index when lagged by 3 years, the SC Trammel index when lagged by 6 years, and the N IR FL Immature index when lagged by 10 years. The MRFSS/MRIP Mature index was negatively associated with the S IR FL Seine index when lagged by 4 years and the NE FL Seine index when lagged by 8 years. The N IR FL Mature Seine index was positively associated with the MRFSS/MRIP South Atlantic index when lagged by 1 year, but negatively associated when lagged by 2 or 3 years (Table 70). The N IR FL Mature Seine index was positively associated with the NC Gill Net index when lagged by 1 year, the NE FL Seine index when lagged by 2 years, the SC Trammel index when lagged by 9 years, and the S IR FL Seine index when lagged by 10 years. The N IR FL Mature Seine index was negatively associated with the NE FL Seine index when lagged by 8 years.

7.1.1.6 Mature and YOY Indices

The N IR FL Mature Seine index was positively associated with the GA Trammel index and the MRFSS/MRIP Mature index was negatively associated with the MD Seine index (Table 71).

7.1.1.7 Mature and Immature Indices

The SC Trammel index was positively associated with the N IR FL Mature Seine index (Table 72). No other immature and mature indices were associated.

7.1.1.8 Immature and YOY Indices

The MD Seine index was positively associated with the MRFSS/MRIP South Atlantic index (Table 73). No other YOY and Immature indices were associated.

7.1.2 Mann-Kendall Analysis

The Mann-Kendall test was applied to the full time series of a total of ten indices (Table 65). A significant increasing trend was detected in the coast wide MRSS/MRIP index. When the Mann-Kendall test was applied to only the final ten years of each index, no trend was evident in nine of the indices, but in this configuration, the FL IR Seine index was the only one with a negative trend (Table 75).

7.2 Per Recruit Analyses

With a 16 inch minimum size limit, the exploitation rate that results in a SPR_{target} of 0.4 ($U_{SPR0.4}$) is 0.047. The exploitation rate that maximizes YPR (U_{MSY}) is 0.089 (Figure 80). As the minimum size limit is increased, the exploitation rates to achieve SPR_{target} of 0.4 also increases (Figure 81). Because more age classes are protected by regulations, those that are legal can be fished harder. It is important to remember that annual exploitation rate in this analysis represents the proportion of the stock harvested each year, which is different from instantaneous fishing mortality rate F.

There are a number of simplifying assumptions made by this simple per-recruit model. A major assumption is made that the age structure of the population has attained equilibrium, implying that recruitment is constant; what happens to one cohort as it ages is representative of what happens to all cohorts. It also assumes that natural mortality and growth are constant with stock size (i.e. no density dependent effects). It is also assumed that the vulnerability schedule follows a logistic curve. In reality, we know very little about the selectivity patterns of black drum as they may vary by location, season, and fishery.

Despite these (unrealistic) assumptions, the per-recruit analysis provides some estimate of sustainable exploitation rates given the life history of the species and ages/sizes available to the fishery. It is intended to be a supplement to the data poor methods used in this assessment that rely more heavily on historical removals than biological characteristics of the species.

7.3 Catch-MSY

7.3.1 Parameter Estimates

About six percent of all model iterations (567 of 10,000) were accepted for parameter estimates. The distribution of K parameters from accepted iterations is skewed to the right with a median of 53.25 million pounds, a minimum of 24.51, and a maximum of 109.93 (Figure 82). The distribution of r parameters is also skewed to the right with a median of 0.28, minimum of 0.16, and maximum of 0.50 (Figure 82). The accepted r and K combinations are in Figure 83. The median of the B_{MSY}/K distribution is 0.41 with a minimum of 0.32 and a maximum of 0.48 (Figure 82). The distribution is not highly skewed.

The median of the terminal biomass distribution (B_{2012}) is 41.75 million pounds with a minimum of 16.60 and a maximum of 94.06 (Figure 82).

7.3.2 Reference Points

7.3.2.1 MSY

The median MSY estimate is 3.46 million pounds (Figure 84). The minimum and maximum of the MSY distribution are 2.01 and 5.72, respectively. The distribution was not highly skewed in either direction. Removals exceeded the median MSY estimate in 2008 and came within 100,000 pounds of the median MSY estimate in 2009 (Figure 85, Table 76). All other years of removals were at least 1.32 million pounds below the median MSY estimate.

7.3.2.2 OFL

The median OFL estimate is 4.74 million pounds (Figure 84). The minimum and maximum of the OFL distribution are 2.37 and 8.75, respectively. The distribution was not highly skewed in either direction. The OFL estimate is greater than the MSY estimate due to assumed biomass in the terminal year that is greater than B_{MSY}/K. The removals in 2012 (R_{2012}) were 3.65 million pounds below the median OFL estimate.

7.3.2.3 B_{MSY}

The median B_{MSY} estimate is 27.87 million pounds (Figure 84). The minimum and maximum of the B_{MSY} distribution are 12.15 and 57.86, respectively. The distribution is skewed to the right.

7.3.2.4 F_{MSY}

The median F_{MSY} estimate is 0.123 (Figure 84). The minimum and maximum of the F_{MSY} distribution are 0.059 and 0.277, respectively. The distribution is skewed to the right.

7.3.2.5 U_{MSY}

The median of the U_{MSY} distribution is 0.113 with a minimum of 0.055 and a maximum of 0.234 (Figure 84).

7.3.3 Sensitivity Analysis

Sensitivity of the median MSY and OFL estimates to data inputs and parameter specification is summarized in Table 76 and Table 77. Changes to the accepted r and K parameters are summarized in Table 78.

The K parameter was difficult to specify and the prior distribution was broad due to a one-way removal time series that may not contain information on maximum productivity. To limit the prior distribution on K to a more realistic range, the upper bound of the uniform distribution was reduced to the highest plausible K value (100 million lbs.) corresponding to the lower bound of the r distribution (0.16) in the base configuration. This limit was suggested by Martell and Froese (2012) as a more informative limit given the better information used to specify the r parameter.

- The median MSY estimate increased by 1% to 3.51 million pounds and the median OFL estimate increased by 2% to 4.83 million pounds. These increases are due partly to a 2% decrease in the K parameter and associated increase (4%) in the r parameter, indicating a smaller, more productive stock.

Sensitivity to the bounds of the r parameter was evaluated with two configurations using the default r bounds suggested by Martell and Froese (2012). Black drum life-history traits indicate low, moderate, and even high productivity and the SASC had difficulties specifying this parameter. The first sensitivity configuration assumed moderate productivity with bounds on the uniform distribution at 0.2 and 1. The second sensitivity configuration assumed low productivity with bounds on the uniform distribution at 0.05 and 0.5.

- Changes in the bounds of the prior distribution for r resulted in expected changes to the MSY and OFL estimates. Assuming moderate productivity increased the central value of the uniform prior distribution for r from 0.33 to 0.6, increased the median accepted r value by 55% to 0.43, increased the median MSY estimate by 7% to 3.71 million pounds, and increased the median OFL estimate by 1% to 4.78 million pounds. Assuming low productivity decreased the central value of the uniform prior distribution for r to 0.275, decreased the median accepted r value by 38% to 0.17, decreased the median MSY estimate by 12% to 3.04 million pounds, and decreased the median OFL estimate by 11% to 4.22 million pounds.

The assumed shape of the production curve was evaluated with two sensitivity configurations. The first maintained a Pella-Tomlinson production function, but increased the mean of B_{MSY}/K to 0.4, the mean of pooled orders in the Thorson et al. (2012) meta-analysis. The traditional Schaefer production function with B_{MSY}/K equal to 0.5 was assumed for a second sensitivity configuration.

- Increasing the assumed B_{MSY}/K value increased the median MSY and OFL estimates. Assuming a value of 0.4 resulted in increases to the median MSY and OFL estimates by 3% and 6% to 3.58 and 5.04 million pounds, respectively. Assuming Schaefer production dynamics resulted in increases to the median MSY and OFL estimates by 8% and 15% to 3.75 and 5.44 million pounds, respectively.

The relative biomass in the first and last years are major assumptions for this method. Bounds on the relative biomasses where changed to defaults developed by Martell and Froese (2012) based on the magnitude of removals observed at the beginning and end of the time series to test sensitivity to relative biomass assumptions. These bounds were much broader than those assumed in the base configuration (B_{1950}/K = 0.5-0.9, B_{2012}/K = 0.01-0.4). Three additional sensitivity configurations were evaluated by decreasing the bounds of terminal relative biomass from 0.756-0.956 to 0.456-0.656 by 0.1. Sensitivity to assumed relative biomass in the first year of the time series was evaluated by extending the time series back to 1900 and assuming an unfished stock. This sensitivity configuration mirrors the depletion assumptions made for the DB-SRA method (section 6.1.5).

- Assuming a less depleted stock results in increases of the median MSY and OFL estimates due primarily to a larger K estimate, while assuming a more depleted stock results in decreases of the median MSY and OFL estimates due primarily to a smaller K estimate. The median accepted r values changed relatively little for each of the sensitivity configurations, increasing from 1-8%. The default terminal depletion bounds used by Martell and Froese (2012) suggest a relatively depleted black drum stock (0.01-0.4), which the SASC does not believe reflects the true condition of the stock based on knowledge of historical exploitation and the available removal data. Assuming these default bounds decrease the median MSY and OFL estimates by 57% and 87% to 1.50 and 0.62 million pounds, respectively. The median accepted K value decreases by 57% to 22.71 million pounds. Increasing the bounds for the B_{2012}/K distribution to 0.756-0.956 resulted in increases of the median MSY and OFL estimates by 144% and 187% to 8.45 and 13.58 million pounds, respectively. The median accepted K value increased 131% to 123.26 million pounds. The magnitude of the changes for this sensitivity configuration relative to the other depletion sensitivity configurations was concerning. Decreasing the bounds to 0.556-0.756 resulted in decreases of the median MSY and OFL estimates by 26% and 34% to 2.57 and 3.11 million pounds, respectively. The median accepted K value decreased by 26% to 39.18 million pounds. Decreasing the bounds to 0.456-0.656 further decreased the median MSY and OFL estimates to 2.07 and 2.09 million pounds, respectively. Note that as assumed depletion approaches B_{MSY}/K, the median OFL estimate approaches the median MSY estimate.

- Assuming the stock is at unfished conditions in 1900 resulted in increases to the median MSY and OFL estimates by 1% and 3% to 3.50 and 4.86 million pounds, respectively. These negligible changes appear to support precise depletion assumptions between the DB-SRA, Catch-MSY, and DCAC methods.

Stochastic deviations were incorporated in the model to evaluate sensitivity to process error (Equation 10). Lognormal deviations on the log scale were drawn from a normal distribution with a mean of 0 and sd of 0.05.

- Stochastic process error resulted in decreases of the median MSY and OFL estimates by 15% and 23% to 2.93 and 3.64 million pounds, respectively. It is important to note that deviations are random and depending on the model iterations, estimates are likely to fluctuate around the base configuration estimates. The distribution of lognormal deviations exp(dev) with a sd(dev) equal to 0.05 and mean of 0 is in Figure 86. These deviations are multiplied by the estimated annual biomass.

Commercial data reporting shifted from monthly level reports to trip level reports from NC to NJ in 1994 and is assumed to have become more reliable. The upper bound of the uniform prior distribution for commercial landings values from 1950-1993 was increased to two times the reported landings, assuming up to 50% of annual commercial removals may not have been reported during these years. The upper bound for 1994-2012 remained at one and a half times the reported landings.

- Assuming greater error in commercial reporting prior to trip level reporting resulted in increases in the median MSY and OFL estimates by 3% and 5% to 3.57 and 4.98 million pounds, respectively.

A second sensitivity configuration was conducted to evaluate the effects of historic data. The time series was shortened to 1982, the first complete year MRFSS recreational harvest and release estimates are available. Recreational estimates prior to 1981 were made with several simplifying assumptions and did not include uncertainty estimates. The relative biomass in 1982 (B_{1982}/K) was not changed from the base run (B_{1950}/K).

- Limiting the data series to the time frame when external recreational estimates are available resulted in a negligible decrease in the median OFL estimate by 1% to 4.79 million pounds and no change to the median MSY estimate.

The effects of the anomalous MRIP estimates in 2008 and 2009 were evaluated by setting the estimates in these years equal to the mean of two years before and two years after these estimates (2006, 2007, 2011 and 2010).

- Adjusting the MRIP estimates in 2008 and 2009 resulted in a decrease of the median MSY and OFL estimates by 25% to 2.59 and 3.57 million pounds, respectively. Reducing the removals while holding all other inputs constant indicated a smaller stock. The median accepted K value decreased by 24% to 40.28 million pounds.

7.4 DB-SRA

7.4.1 Parameter Estimates

Based on the recommendations by the peer review to use an uninformative, uniform distribution for the depletion parameter, the results of the final preferred DB-SRA model are highlighted in yellow below.

~~About ninety two percent of all model iterations (9,161 of 10,000) were accepted for parameter estimates. Rejected iterations tended to estimate large values of K, resulting in large terminal biomass estimates that did not match the assumed relative terminal biomass. The correlation between these three parameters in apparent in the high concentration of rejected values at the upper ends of the distributions (Figure 87-Figure 89). The K distribution is skewed to the right with a median of 162.05, a minimum of 22.58, and a maximum of 575.54. The median of the terminal biomass (B_{2012}) distribution is 120.69 million pounds with a minimum of 7.86 and a maximum of 566.70. There were no other patterns in rejected parameter values (Figure 90-Figure 92). No annual biomass estimates from accepted runs fell below B_{join} so all biomass estimates were made with a Pella-Tomlinson model.~~

Almost all model iterations (9,976 of 10,000) were accepted for parameter estimates. Rejected iterations tended to estimate large values of K, resulting in large terminal biomass estimates that did not match the assumed relative terminal biomass. The correlation between these three parameters in apparent in the high concentration of rejected values at the upper ends of the distributions (Figure 98-Figure 100). The K distribution is skewed to the right with a median of 135.20, a minimum of 23.09, and a maximum of 575.53. The median of the terminal biomass (B_{2012}) distribution is 90.78 million pounds with a minimum of 12.40 and a maximum of 514.97. There were no other patterns in rejected parameter values (Figure 101-Figure 103). No annual biomass estimates from accepted runs fell below B_{join} so all biomass estimates were made with a Pella-Tomlinson model.

7.4.2 Reference Points

7.4.2.1 MSY

~~The median MSY estimate is 2.60 million pounds with a minimum of 0.48 and a maximum of 28.98 (Figure 93). Removals exceeded the median MSY estimate in 2008 and 2009, but no other years (Figure 94).~~

The median MSY estimate is 2.12 million pounds with a minimum of 0.43 and a maximum of 8.83 (Figure 104).

7.4.2.2 OFL

~~The median OFL estimate is 5.50 million pounds with a minimum of 0.24, and a maximum of 76.30. The distribution is skewed to the right (Figure 93). Removals in 2012 were 4.41 million pounds below the median OFL estimate.~~

The median OFL estimate is 4.12 million pounds with a minimum of 0.56, and a maximum of 38.53. The distribution is skewed to the right (Figure 104).

7.4.2.3 B_{MSY}

~~The median of the B_{MSY} distribution is 57.24 million pounds with a minimum of 9.65, and a maximum of 390.51. The distribution is skewed to the right (Figure 93).~~

The median of the B_{MSY} distribution is 47.26 million pounds with a minimum of 11.35, and a maximum of 229.28. The distribution is skewed to the right (Figure 104).

7.4.2.4 F_{MSY}

~~The median of the F_{MSY} distribution is 0.049, with a minimum of 0.008, and a maximum of 0.279. The distribution is skewed to the right (Figure 93).~~

The median of the F_{MSY} distribution is 0.048, with a minimum of 0.008, and a maximum of 0.279. The distribution is skewed to the right (Figure 104).

7.4.2.5 U_{MSY}

~~The median of the U_{MSY} distribution is 0.047. The distribution is skewed to the right with a minimum of 0.008 and a maximum of 0.212 (Figure 93). The median estimate is equal to the $U_{SPR0.4}$ estimate (0.047) from the per recruit analysis, suggesting a more conservative U_{MSY} than the per recruit analysis (0.089).~~

The median of the U_{MSY} distribution is 0.046. The distribution is skewed to the right with a minimum of 0.008 and a maximum of 0.212 (Figure 104). The median estimate is close to the $U_{SPR0.4}$ estimate (0.047) from the per recruit analysis, suggesting a more conservative U_{MSY} than the per recruit analysis (0.089).

7.4.3 Sensitivity Analysis

Sensitivity of the median MSY and OFL estimates to data inputs and parameter specification is summarized in Table 80.

Sensitivity to the assumed relative biomass in 2012 was evaluated by assuming five different mean values decreasing from 0.9 to 0.5 by 0.1. The assumed distribution was also evaluated by changing the distribution from a beta distribution to a uniform distribution with the same bounds assumed in the catch-MSY analysis (0.656-0.856).

- MSY and OFL estimates increased when relative biomass was assumed greater than that in the base configuration and decreased when relative biomass was assumed less. The median MSY estimate decreased from 2.91 (12%) for the highest assumed relative biomass (0.9) to 1.36 (-48%) for the lowest assumed relative biomass (0.5). The median OFL estimate decreased from 6.29 (14%) to 1.84 (-67%). Assuming a normal distribution resulted in negligible increases (1%) in the MSY and OFL estimates.

Wetzel and Punt (2011) found that DB-SRA is robust to misspecification of the natural mortality parameter for some life-histories, but can be sensitive for other life-histories especially when M is greater than the true value. Sensitivity to M was evaluated by assuming M estimated with Hewitt and Hoenig's (2005) method and assuming M equal to the estimate in Jones and Wells (1998). The Hewitt and Hoenig estimate (0.045) is less than the Hoenig (1983) estimate and the Jones and Wells estimate (0.08) is greater than the Hoenig estimate. The same CV (0.50) from McCall (2009) was assumed for both alternative M estimates.

- Alternate M values resulted in changes to the median MSY and OFL estimates of similar absolute magnitude (≈11-16%). A lower natural mortality suggests a less productive stock and a decrease in median MSY (2.20) and OFL (4.64) and a greater natural mortality suggests a more productive stock leading to greater median MSY (2.87) and OFL (6.10) estimates.

Sensitivity to the Fmsy/M parameter was evaluated by setting the mean and CV to 0.92 and 0.1, respectively. These parameters were from the Zhou et al. 2012 model including the order Perciformes as an explanatory variable.

- Assuming a higher Fmsy/M value results in a slight increase (3%) of the median MSY and OFL estimates to 2.66 and 5.64, respectively.

To evaluate the assumption of no lag between production and recruitment, a delay-difference model was configured with age-at-maturity set at 4 (≈50% maturity on the coast wide maturity schedule, section 6.1.1.2).

- A delay-difference with an age-at-maturity of 4 resulted in slightly greater (4%) median MSY (2.71) and OFL (5.75) estimates.

The shape of the production curve was evaluated by increasing the mean of B_{MSY}/K to 0.4, the mean value when pooling orders in the Thorson et al. (2012) meta-analysis.

- Increasing the location of B_{MSY}/K on the growth curve results in a negligible decrease (1%) in the median MSY estimate to 2.57 and a 12% decrease in the median OFL estimate to 4.85. The alternative B_{MSY}/K results in current biomass closer to B_{MSY} and a lower OFL.

The effects of the anomalous MRIP estimates in 2008 and 2009 were evaluated by setting the estimates in these years equal to the mean of two years before and two years after these estimates (2006, 2007, 2011 and 2010).

- Adjusting the 2008 and 2009 MRIP estimates decreases the median MSY and OFL estimates by 12% to 2.29 and 4.86, respectively. Lower removals resulting in the same relative biomass suggest a less productive or smaller stock.

Sensitivity to extrapolated recreational harvest from 1900-1949 was evaluated by assuming no recreational harvest from 1900-1949.

- Assuming extrapolated recreational harvest from 1900-1949 had little effect on the MSY and OFL estimates. The median MSY estimate did not change and the median OFL estimate increases by 1% (≈50,000 lbs).

Commercial data reporting shifted from monthly level reports to trip level reports from NC to NJ in 1994 and is assumed to have become more reliable. The upper bound of the uniform distribution used to draw commercial landings values from 1950-1993 was increased to two times the reported landings, assuming up to 50% of annual commercial removals may not have been reported during these years. The bound for years from 1994-2012 remained at 1.5 times the reported landings.

- Assuming greater error in commercial landings prior to 1994 resulted in 2% and 1% increases in the MSY and OFL estimates to 2.64 and 5.58, respectively.

The upper limit of the K parameter was evaluated with new information from the Catch-MSY method. The upper limit was set at 100 million pounds, the maximum value corresponding to the lower limit of the r parameter in the Catch-MSY method.

- Decreasing the upper limit of the carrying capacity resulted in a 31% decrease of the median MSY estimate to 1.80 and a 54% decrease of the median OFL estimate to 2.53. The median K estimate decreased by 53% to 76.64 million pounds indicating a smaller stock than the base configuration.

7.5 DCAC

7.5.1 Correction Term (W/Y_{pot})

The median of the correction term distribution is 9.31. The distribution is skewed to the right with a minimum of 1.20 and a maximum of 93.46 (Figure 95).

7.5.2 Reference Point

7.5.2.1 Sustainable Yield (Y_{sust})

The median of the sustainable yield distribution is 1.20 million pounds. The distribution is skewed to the left with a minimum of 0.57 and a maximum of 1.40 (Figure 95). The uncorrected average catch is 1.31 million pounds. The removals exceeded the median sustainable yield estimate in 29 of 63 years, including every year from 2000-2011 (Figure 96, Table 81). Removals in 2012 fall about 100,000 lbs. below the median sustainable yield estimate

7.5.3 Sensitivity Analysis

Sensitivity of the median sustainable yield estimate to data inputs and parameter specification is summarized in Table 82.

Sensitivity to M was evaluated by assuming M estimated with Hewitt and Hoenig's (2005) method and assuming M equal to the estimate in Jones and Wells (1998). The Hewitt and Hoenig estimate (0.045) is less than the Hoenig (1983) estimate in the base configuration and the Jones and Wells estimate (0.08) is greater than the Hoenig estimate. The same CV (0.50) from McCall (2009) was assumed for both sensitivity configurations.

- The median sustainable yield estimate increased slightly (4%) to 1.25 million pounds when M was increased to the Jones and Wells (1998) estimate (0.08). The change of the median sustainable yield was the same in magnitude (-4%), but was a decrease to 1.15 million pounds when M was decreased to the Hewitt and Hoenig (2005) estimate (0.045). M is in the denominator of the correction term, so these changes are a result of decreasing and increasing the correction term, respectively.

Sensitivity to the assumed dynamics of the production curve was evaluated by increasing the B_{MSY}/K parameter to 0.4, the value for pooled orders in the Thorson et al. (2012) meta-analysis.

- Assuming an increase in the B_{MSY}/K parameter resulted in a slight increase (3%) of the median sustainable yield estimate to 1.23 million pounds.

Sensitivity to the F_{MSY}/M parameter was evaluated by setting the mean and CV to 0.92 and 0.1, respectively. These parameters were from the Zhou et al. 2012 model including the order Perciformes as an explanatory variable.

- Increasing the F_{MSY}/M parameter decreases the correction term and resulted in a greater sustainable yield estimate. The median sustainable yield estimate increased slightly (2%) to 1.22 million pounds.

Due to the nature of averages, sensitivity to the time series of removals selected was evaluated by shortening the time series to 1982. This limits the time series to years with external recreational estimates.

- The uncorrected average removals over the shortened time series increased to 1.50 million pounds. However, the median sustainable yield estimate did not change. The assumed depletion delta was not changed from the base configuration.

Sensitivity to the assumed error around the commercial landings prior to improvements in commercial reporting (1950-1993) was evaluated by increasing the upper bound on the uniform distribution to two times the reported landings.

- Assuming greater error around the commercial landings from 1950-1993 resulted in a slight increase (5%) of the median sustainable yield estimate to 1.26 million pounds.

The effects of the anomalous MRIP estimates in 2008 and 2009 were evaluated by setting the estimates in these years equal to the mean of two years before and two years after these estimates (2006, 2007, 2011 and 2010).

- The uncorrected average removals decreased to 1.22 million pounds and the median sustainable yield estimate decreased by 6% to 1.12 million pounds.

Four alternative depletion assumptions were evaluated by decreasing the terminal relative biomass by 0.1 in four sensitivity configurations.

- Assuming different depletion levels while all other inputs remain constant will change the correction term in the same direction (positive or negative) as the new assumed depletion relative to the assumed base depletion. A depletion delta of 0.064 indicates that less of the stock has been depleted than in the base configuration and the median sustainable yield estimate increased by 10% to 1.32 million pounds. The other three assumed depletion deltas, 0.264, 0.364, and 0.464, indicated that more of the stock had been depleted than the base assumption and resulted in decreases of the median sustainable yield estimates to 1.13 (-6%), 1.05 (-12%), and 0.99 (-17%) million pounds, respectively. The decreases from the base estimate were about 6%, or approximately 70,000 pounds, with each additional 10% stock depletion.

8 DISCUSSION

8.1 Stock Status

The per recruit analyses completed for black drum are useful for estimating reference points based on age-structured dynamics and changes in reference points due to potential management scenarios. However, the lack of stock-wide fishing mortality or abundance estimates precludes the use of these analyses to determine black drum stock status. These analyses will be particularly useful in future assessments when data limitations are addressed and fishing mortality and/or abundance can be estimated.

The catch-based methods used in the assessment were designed to estimate catch reference points, not stock condition estimates to make stock status determination. The estimates are directly controlled by subjective depletion parameters that are informed by little if any data. The methods do not fit estimates to any external abundance data and may not be rigorous enough to determine stock status with any certainty. Inferences can be made into general stock condition, given the inputs, particularly assumed depletion inputs, are accurate. The only methods attempted that did fit to abundance data, surplus and age-structured production models, failed to produce stable or realistic estimates. The SASC's confidence in abundance data reflective of the entire stock was diminished following these analyses and highlights the need for comprehensive abundance data.

Further complicating the SASC's ability to determine stock status was the lack of data indicating fluctuations in the condition of the black drum stock due to exploitation and the stock's response to varying conditions. Relatively strong data sources for black drum are fishery-independent indices of relative abundance for YOY and immature fish and the removals. Mann-Kendall trend analysis detected no trends in any of the fishery-independent indices (except for the IR FL Seine index when shortened to 2003-2012) and the removal time series is a one-way trip reflective of a developing fishery. The SASC could not determine a reference point for an index indicator to trigger concern for the stock. ~~No stock status determination was made for the black drum stock[4].~~ Based on the DB-SRA results, black drum life history, indices of abundance, and history of exploitation, the black drum stock is not overfished and not experiencing overfishing.

8.2 Catch Reference Points

The SASC selected the DB-SRA method as the preferred method for estimating catch reference points. DCAC does not incorporate the removals into a population dynamics process, but rather modifies the average removals based on the assumed depletion level. If exploitation has changed significantly during any part of the time series, the sustainable yield may not correspond to the current stock condition (MacCall 2009). In addition, the reference point estimated with DCAC is not equal to MSY, but rather a lower yield. The Catch-MSY method may perform poorly for lightly exploited stocks and result in imprecise estimates. The smaller the removals are relative to K, the less informed the model will be in estimating the r and K combination. A greater range of r and K can sustain relatively small removals and the intervals around the r and K parameters, and therefore the reference points, will be broad (Martell and Froese 2012). The SASC also had difficulty specifying the r parameter and agreed it was more subjective than the alternate parameters required for DB-SRA (F_{MSY}/M, M). The ranking scheme used to specify r resulted in low to high productivity rankings and selection of associated life history attributes was subjective. DB-SRA parameters are more defined through available meta-analyses.

DB-SRA estimates two catch reference points that have been provided in the results section, MSY and OFL. The SASC assumed the black drum stock was not overfished in 2012 (i.e., $B_{2012} > B_{MSY}$) due to light exploitation and minor decreases in the SC Trammel index and, therefore, the OFL will be greater than MSY. As detected in the sensitivity analysis, the DB-SRA method is sensitive to assumed inputs for black drum, particularly the depletion assumptions. Due to uncertain inputs and the nature of data poor methods, the SASC recommends the more precautionary MSY estimate as a catch reference point for black drum. ~~The median MSY estimate is 2.60 million pounds with~~

[4] During the peer review, the assessment team and review panel agreed that the stock was not overfished and overfishing was not occurring. This stock status determination was based on the DB-SRA results, black drum life history, indices of abundance, and history of exploitation. See the peer review report.

~~an interquartile range of 1.76-4.10 million pounds.~~ The median MSY estimate from the final preferred DB-SRA configuration accepted at the peer review workshop is 2.12 million pounds with an interquartile range of 1.60 – 3.05 million pounds. The catch reference points may further be limited by the one-way removal time series observed for black drum. If the stock has not reached levels of maximum productivity, the data may not be informative of overall maximum productivity and the reference points may only correspond to observed exploitation, which is assumed to be relatively low. For a data-poor stock, this precautionary approach is favorable.

9 RESEARCH RECOMMENDATIONS

The SASC recommends that new benchmark stock assessments be completed for the black drum stock every five years. The stock is believed to be relatively lightly exploited and black drum are an extremely long-lived species. At any given time there may be 60+ year classes in the stock. The SASC is hopeful that some high priority research recommendations will be addressed prior to the next benchmark stock assessment and will enable the development of more comprehensive assessment methods that can better inform stock status.

HIGH PRIORITY

- Age otoliths that have been collected and archived.
- Collect information to characterize the size composition of fish discarded in recreational fisheries.
- Collect information on the magnitude and sizes of commercial discards. Obtain better estimates of bycatch of black drum in other fisheries, especially juvenile fish in south Atlantic states.
- Increase biological sampling in commercial fisheries to better characterize the size and age composition of commercial fisheries by state and gear.
- Increase biological sampling in recreational fisheries to better characterize the size and age composition by state and wave.
- Obtain estimates of selectivity-at-age for commercial fisheries by gear, recreational harvest, and recreational discards.
- Continue all current fishery-independent surveys and collect biological samples for black drum on all surveys.
- Develop fishery-independent adult surveys. Consider long line and purse seine surveys. Collect age samples, especially in states where maximum size regulations preclude the collection of adequate adult ages.

MODERATE PRIORITY

- Conduct reproductive studies, including: age and size-specific fecundity, spawning frequency, spawning behaviors by region, and movement and site fidelity of spawning adults.
- Conduct a high reward tagging program to obtain improved return rate estimates. Continue and expand current tagging programs to obtain mortality and growth information and movement at size data.
- Improve sampling of night time fisheries.
- Conduct studies to estimate catch and release mortality rates in recreational fisheries.

- Collect genetic material (i.e., create “genetic tags”) over a long time span to obtain information on movement and population structure, and potentially estimate population size.
- Obtain better estimates of harvest from the black drum recreational fishery (especially in states with short seasons).

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11 TABLES

Table 1. 2014 state regulations for black drum.

State	Recreational		Commercial			Notes
	Size limit	Bag limit	Size limit	Trip Limit	Annual Quota	
ME->NY	-	-	-	-	-	
NJ	16" min	3/person/day	16" min	10,000 lbs	65,000 lbs	
DE	16" min	3/person/day	16" min	10,000 lbs	65,000 lbs	
MD	16" min	1/person/day 6/vessel (Bay)	16" min		1,500 lbs Atlantic Coast	Ches Bay closed to commercial harvest
VA	16" min	1/person/day	16" min	1/person/day*	120,000 lbs	*without Black Drum Harvesting and Selling permit
NC	14" min 25" max	10/person/day	14" min 25" max	500 lbs		
SC	14" min 27" max	5/person/day	14" min 27" max	5/person/day		Commercial fishery primarily bycatch
GA	10" min	15/person/day	10" min	15/person/day		
FL	14" min 24" max	5/person/day	14" min 24" max	500 lbs/day		One fish >24" allowed for recreational fishers

Table 2. Commercial landings (lbs.), recreational harvest (lbs.), recreational harvest PSE, recreational released alive (lbs.), recreational release alive PSE for number estimates, assumed recreational dead discards (lbs.), and total removals (lbs.) by year input in catch-based methods.

Year	Commercial Landings (lbs.)	Recreational Harvest (lbs.)	Recreational Harvest PSE	Recreational Released Alive (lbs.)	Recreational Released Alive Number PSE	Recreational Dead Discards (lbs.)	Total Removals (lbs.)
1887	100,065	0	0	0	0	0	**100,065**
1888	86,000	0	0	0	0	0	**86,000**
1889	228,000	0	0	0	0	0	**228,000**
1890	228,000	0	0	0	0	0	**228,000**
1891	0	0	0	0	0	0	**0**
1892	0	0	0	0	0	0	**0**
1893	0	0	0	0	0	0	**0**
1894	0	0	0	0	0	0	**0**
1895	10,900	0	0	0	0	0	**10,900**
1896	0	0	0	0	0	0	**0**
1897	380,600	0	0	0	0	0	**380,600**
1898	0	0	0	0	0	0	**0**
1899	0	0	0	0	0	0	**0**
1900	0	72,832	21.2	0	0	0	**72,832**
1901	58,330	75,592	21.2	0	0	0	**133,922**
1902	187,520	78,457	21.2	0	0	0	**265,977**
1903	0	81,430	21.2	0	0	0	**81,430**
1904	453,080	84,517	21.2	0	0	0	**537,597**
1905	0	87,720	21.2	0	0	0	**87,720**
1906	0	91,045	21.2	0	0	0	**91,045**
1907	0	94,495	21.2	0	0	0	**94,495**
1908	0	98,077	21.2	0	0	0	**98,077**
1909	0	101,794	21.2	0	0	0	**101,794**
1910	0	105,652	21.2	0	0	0	**105,652**
1911	0	109,656	21.2	0	0	0	**109,656**
1912	0	113,812	21.2	0	0	0	**113,812**
1913	0	118,126	21.2	0	0	0	**118,126**
1914	0	122,603	21.2	0	0	0	**122,603**
1915	0	127,249	21.2	0	0	0	**127,249**
1916	0	132,072	21.2	0	0	0	**132,072**
1917	0	137,078	21.2	0	0	0	**137,078**
1918	536,332	142,273	21.2	0	0	0	**678,605**
1919	0	147,665	21.2	0	0	0	**147,665**
1920	60,680	153,262	21.2	0	0	0	**213,942**
1921	68,809	159,071	21.2	0	0	0	**227,880**
1922	0	165,100	21.2	0	0	0	**165,100**
1923	61,454	171,357	21.2	0	0	0	**232,811**

1924	0	177,852	21.2	0	0	0	**177,852**
1925	253,330	184,592	21.2	0	0	0	**437,922**
1926	35,540	191,588	21.2	0	0	0	**227,128**
1927	98,113	198,850	21.2	0	0	0	**296,963**
1928	140,937	206,386	21.2	0	0	0	**347,323**
1929	148,933	214,208	21.2	0	0	0	**363,141**
1930	98,689	222,327	21.2	0	0	0	**321,016**
1931	214,139	230,753	21.2	0	0	0	**444,892**
1932	107,235	239,499	21.2	0	0	0	**346,734**
1933	123,059	248,576	21.2	0	0	0	**371,635**
1934	126,500	257,997	21.2	0	0	0	**384,497**
1935	72,000	267,776	21.2	0	0	0	**339,776**
1936	252,700	277,924	21.2	0	0	0	**530,624**
1937	196,500	288,458	21.2	0	0	0	**484,958**
1938	288,300	299,391	21.2	0	0	0	**587,691**
1939	26,300	310,738	21.2	0	0	0	**337,038**
1940	9,900	322,515	21.2	0	0	0	**332,415**
1941	16,800	334,738	21.2	0	0	0	**351,538**
1942	32,200	347,425	21.2	0	0	0	**379,625**
1943	0	360,593	21.2	0	0	0	**360,593**
1944	33,800	374,259	21.2	0	0	0	**408,059**
1945	243,800	388,444	21.2	0	0	0	**632,244**
1946	94,000	403,166	21.2	0	0	0	**497,166**
1947	184,900	418,447	21.2	0	0	0	**603,347**
1948	192,100	434,306	21.2	0	0	0	**626,406**
1949	81,900	450,766	21.2	0	0	0	**532,666**
1950	269,400	492,568	21.2	13,030	102.5	1,042	**763,010**
1951	332,700	507,920	21.2	13,437	102.5	1,075	**841,695**
1952	239,800	523,272	21.2	13,843	102.5	1,107	**764,179**
1953	291,600	538,624	21.2	14,249	102.5	1,140	**831,364**
1954	554,700	553,976	21.2	14,655	102.5	1,172	**1,109,848**
1955	260,200	569,328	21.2	15,061	102.5	1,205	**830,733**
1956	311,600	584,680	21.2	15,467	102.5	1,237	**897,517**
1957	286,700	600,032	21.2	15,873	102.5	1,270	**888,002**
1958	138,800	615,385	21.2	16,280	102.5	1,302	**755,487**
1959	345,400	658,962	21.2	16,980	102.5	1,358	**1,005,720**
1960	339,100	674,900	21.2	17,385	102.5	1,391	**1,015,391**
1961	393,500	654,192	21.2	18,209	102.5	1,457	**1,049,149**
1962	597,400	690,539	21.2	20,406	102.5	1,632	**1,289,571**
1963	528,900	688,555	21.2	19,919	102.5	1,594	**1,219,049**
1964	281,700	733,423	21.2	21,302	102.5	1,704	**1,016,827**
1965	401,500	783,861	21.2	23,160	102.5	1,853	**1,187,214**
1966	664,100	819,474	21.2	24,508	102.5	1,961	**1,485,535**
1967	392,500	864,234	21.2	25,459	102.5	2,037	**1,258,771**
1968	453,600	918,188	21.2	27,142	102.5	2,171	**1,373,959**
1969	286,300	916,837	21.2	25,396	102.5	2,032	**1,205,169**

1970	228,400	933,971	21.2	25,674	102.5	2,054	**1,164,425**
1971	316,200	1,048,601	21.2	29,508	102.5	2,361	**1,367,162**
1972	187,076	1,093,397	21.2	30,772	102.5	2,462	**1,282,935**
1973	170,096	1,171,110	21.2	32,291	102.5	2,583	**1,343,789**
1974	188,044	1,268,956	21.2	35,267	102.5	2,821	**1,459,821**
1975	319,911	1,226,382	21.2	34,678	102.5	2,774	**1,549,067**
1976	188,653	1,156,437	21.2	32,807	102.5	2,625	**1,347,715**
1977	176,969	1,150,828	21.2	33,746	102.5	2,700	**1,330,497**
1978	174,465	1,034,724	21.2	29,702	102.5	2,376	**1,211,565**
1979	165,345	1,101,653	21.2	31,361	102.5	2,509	**1,269,507**
1980	141,397	1,029,900	21.2	28,809	102.5	2,305	**1,173,602**
1981	241,603	307,719	14.0	6,344	122.1	508	**549,830**
1982	221,878	284,514	28.0	930	160.8	74	**506,466**
1983	195,235	1,830,967	19.2	7,199	95.8	576	**2,026,778**
1984	162,611	738,024	23.9	47,321	73.9	3,786	**904,421**
1985	121,857	946,233	20.8	34,623	60.1	2,770	**1,070,860**
1986	346,246	1,228,939	16.7	123,268	50.1	9,861	**1,585,046**
1987	245,421	882,893	21.3	90,196	47.5	7,216	**1,135,530**
1988	294,404	478,464	20.3	110,116	56.9	8,809	**781,677**
1989	140,276	485,681	25.7	41,524	49.4	3,322	**629,279**
1990	201,132	335,563	36.7	96,974	39.3	7,758	**544,453**
1991	245,665	657,047	19.5	306,783	34.2	24,543	**927,255**
1992	210,156	849,920	17.8	117,389	29.7	9,391	**1,069,467**
1993	252,520	443,637	15.0	226,619	27.3	18,130	**714,287**
1994	292,933	720,497	15.4	257,816	22.4	20,625	**1,034,055**
1995	270,728	878,155	20.5	462,139	19.9	36,971	**1,185,854**
1996	312,442	703,886	20.2	602,757	23.3	48,221	**1,064,549**
1997	313,802	640,413	15.2	429,670	23.0	34,374	**988,589**
1998	134,509	677,024	18.5	735,718	20.8	58,857	**870,390**
1999	335,231	818,453	11.5	507,930	16.0	40,634	**1,194,318**
2000	240,184	1,853,044	13.7	567,436	20.1	45,395	**2,138,623**
2001	184,993	1,410,905	12.9	945,515	18.3	75,641	**1,671,539**
2002	555,506	859,311	14.1	787,602	21.6	63,008	**1,477,825**
2003	289,312	1,643,324	16.2	733,961	16.3	58,717	**1,991,353**
2004	162,661	1,566,705	34.6	797,094	23.1	63,768	**1,793,134**
2005	130,243	1,318,521	19.7	758,093	14.8	60,647	**1,509,411**
2006	221,212	1,580,160	28.6	1,637,040	15.0	130,963	**1,932,335**
2007	292,579	1,408,391	15.9	1,629,792	14.5	130,383	**1,831,353**
2008	404,690	5,217,281	14.7	1,671,308	16.1	133,705	**5,755,676**
2009	285,262	3,173,841	23.2	1,081,249	23.6	86,500	**3,545,603**
2010	207,898	1,489,802	14.5	1,134,273	13.4	90,742	**1,788,442**
2011	188,359	1,512,221	18.9	1,032,739	15.3	82,619	**1,783,199**
2012	238,163	744,266	12.4	1,401,612	12.8	112,129	**1,094,558**

Table 3. Coast wide commercial landings by gear from 1887-2012.

Year	Gear							
	Gill Net	Fixed Net	Seine	Trawl	Hook and Line	Other Gears	Not Coded	Not Available
1887	0	0	0	0	0	0	0	100,065
1888	0	0	0	0	0	0	0	86,000
1889	0	0	0	0	0	0	0	228,000
1890	0	0	0	0	0	0	0	228,000
1891	0	0	0	0	0	0	0	0
1892	0	0	0	0	0	0	0	0
1893	0	0	0	0	0	0	0	0
1894	0	0	0	0	0	0	0	0
1895	10,300	0	600	0	0	0	0	0
1896	0	0	0	0	0	0	0	0
1897	0	0	0	0	0	0	0	380,600
1898	0	0	0	0	0	0	0	0
1899	0	0	0	0	0	0	0	0
1900	0	0	0	0	0	0	0	0
1901	0	0	0	0	0	0	0	58,330
1902	0	0	0	0	0	0	0	187,520
1903	0	0	0	0	0	0	0	0
1904	0	0	0	0	0	0	0	453,080
1905	0	0	0	0	0	0	0	0
1906	0	0	0	0	0	0	0	0
1907	0	0	0	0	0	0	0	0
1908	0	0	0	0	0	0	0	0
1909	0	0	0	0	0	0	0	0
1910	0	0	0	0	0	0	0	0
1911	0	0	0	0	0	0	0	0
1912	0	0	0	0	0	0	0	0
1913	0	0	0	0	0	0	0	0
1914	0	0	0	0	0	0	0	0
1915	0	0	0	0	0	0	0	0
1916	0	0	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0
1918	52,450	0	447,072	0	36,300	510	0	0
1919	0	0	0	0	0	0	0	0
1920	0	55,180	0	0	5,500	0	0	0
1921	0	67,659	1,150	0	0	0	0	0
1922	0	0	0	0	0	0	0	0
1923	41,840	0	6,214	0	12,400	0	1,000	0
1924	0	0	0	0	0	0	0	0
1925	1,200	252,130	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	35,540

1927	44,050	2,920	7,293	2,500	41,350	0	0	0
1928	76,391	3,936	39,122	2,835	18,653	0	0	0
1929	3,800	73,250	400	0	1,237	0	0	70,246
1930	1,000	71,154	0	120	500	0	0	25,915
1931	0	197,825	0	880	0	0	0	15,434
1932	0	63,566	0	169	0	0	0	43,500
1933	0	122,480	0	579	0	0	0	0
1934	0	37,500	0	0	0	0	0	89,000
1935	0	64,600	7,000	400	0	0	0	0
1936	22,500	13,600	30,500	400	0	0	0	185,700
1937	13,200	54,600	60,300	0	0	0	0	68,400
1938	10,700	133,300	90,900	100	0	0	0	53,300
1939	0	0	0	0	0	0	0	26,300
1940	0	0	0	0	0	0	0	9,900
1941	0	0	0	0	0	0	0	16,800
1942	0	0	0	0	0	0	0	32,200
1943	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	33,800
1945	0	0	0	0	0	0	0	243,800
1946	0	0	0	0	0	0	0	94,000
1947	0	0	0	0	0	0	0	184,900
1948	0	0	0	0	0	0	0	192,100
1949	0	0	0	0	0	0	0	81,900
1950	64,000	66,100	101,100	30,900	7,300	0	0	0
1951	49,100	64,900	180,900	22,800	15,000	0	0	0
1952	36,900	29,700	154,600	16,700	1,900	0	0	0
1953	51,300	54,200	154,100	17,200	14,800	0	0	0
1954	98,000	199,500	120,200	31,100	105,900	0	0	0
1955	76,800	64,800	42,300	21,100	55,200	0	0	0
1956	55,400	106,300	44,200	59,500	46,200	0	0	0
1957	26,600	79,800	81,800	26,500	72,000	0	0	0
1958	12,000	55,600	43,300	9,000	18,900	0	0	0
1959	7,700	165,600	115,800	25,200	31,100	0	0	0
1960	7,900	79,400	130,900	50,000	70,900	0	0	0
1961	13,400	177,200	75,000	54,900	73,000	0	0	0
1962	15,700	285,100	149,600	110,500	36,500	0	0	0
1963	22,900	301,900	108,400	60,300	35,200	200	0	0
1964	29,900	39,500	124,900	54,400	33,000	0	0	0
1965	91,100	69,700	60,000	133,200	47,500	0	0	0
1966	168,300	321,900	113,600	29,900	30,400	0	0	0
1967	208,800	71,100	73,000	8,400	31,200	0	0	0
1968	136,700	257,100	24,500	4,100	31,200	0	0	0
1969	108,500	104,700	16,300	8,500	47,300	1,000	0	0
1970	117,800	39,900	21,200	13,000	36,500	0	0	0
1971	133,000	66,200	34,700	47,200	35,100	0	0	0
1972	32,191	11,970	27,873	50,642	64,400	0	0	0

1973	43,403	6,561	17,465	26,567	75,600	500	0	0
1974	46,454	29,174	16,715	28,601	67,100	0	0	0
1975	48,673	27,094	125,892	16,352	101,900	0	0	0
1976	60,945	5,515	9,554	34,939	77,700	0	0	0
1977	81,862	8,594	12,777	8,736	65,000	0	0	0
1978	6,974	15,820	4,687	21,968	33,725	91,291	0	0
1979	17,975	13,533	1,692	55,781	10,892	65,472	0	0
1980	10,223	19,704	9,422	44,498	2,134	55,416	0	0
1981	8,066	67,940	7,960	75,531	962	81,144	0	0
1982	3,692	32,842	2,061	99,558	1,000	82,725	0	0
1983	83,787	25,206	3,178	7,404	3,407	72,253	0	0
1984	58,413	29,144	2,609	7,429	9,997	54,942	77	0
1985	41,095	7,217	24,202	6,920	230	39,719	2,474	0
1986	226,286	9,275	26,163	4,861	7,896	0	71,765	0
1987	93,746	39,768	4,052	15,498	5,381	50	86,926	0
1988	107,318	36,026	16,490	35,101	1,922	3,228	94,319	0
1989	47,931	16,876	10,239	16,291	14,711	0	34,228	0
1990	70,029	34,449	38,253	25,597	11,828	326	20,650	0
1991	150,330	40,618	1,903	8,490	19,123	2,898	22,303	0
1992	179,179	6,627	3,403	2,866	11,583	312	6,186	0
1993	109,275	33,409	7,291	83,576	14,417	143	4,409	0
1994	226,111	19,230	2,121	3,413	12,183	1,252	28,622	0
1995	177,522	48,859	15,348	10,876	13,030	1,728	3,367	0
1996	225,216	33,982	8,419	15,352	12,968	3,395	13,111	0
1997	112,226	21,930	23,164	45,405	7,708	4,035	99,335	0
1998	101,280	9,271	1,479	3,943	14,945	2,451	1,141	0
1999	174,976	31,927	101,634	6,175	13,739	6,588	193	0
2000	146,598	20,401	11,576	37,204	20,721	3,509	176	0
2001	118,953	18,832	4,794	11,849	27,839	2,674	53	0
2002	231,859	264,278	17,065	20,475	14,593	7,236	0	0
2003	204,086	36,766	16,296	8,356	20,276	3,411	123	0
2004	106,532	20,225	2,206	13,651	14,435	2,955	2,658	0
2005	99,138	5,982	2,477	8,709	11,430	2,383	124	0
2006	137,610	38,962	12,826	16,767	12,316	2,291	440	0
2007	221,674	25,812	15,485	10,542	14,332	4,625	108	0
2008	269,320	80,336	11,824	8,550	22,880	11,184	596	0
2009	223,172	26,574	8,617	1,854	16,041	8,652	352	0
2010	158,280	13,450	4,607	3,708	21,519	5,661	673	0
2011	147,510	11,917	2,796	1,274	20,786	2,149	1,928	0
2012	175,254	38,542	1,889	2,464	12,840	5,823	1,374	0

Table 4. Sample size of length samples obtained from Delaware gill net fisheries during DE DFW biological sampling in commercial fisheries.

Year	n
2009	63
2010	84
2011	59
2012	21
Total	227

Table 5. Sample size of coast wide age samples by year obtained from various biological sampling programs. Green cells are those with at least 10 samples, yellow cells are those with 5-9 samples, and red cells are those with <5 samples.

Age	**Year Collected**													
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
0	8	26	36	0	0	0	8	20	53	5	0	0	17	19
1	0	21	28	0	0	0	13	12	22	9	6	28	23	18
2	0	0	15	0	0	0	0	4	7	4	2	13	31	6
3	0	1	0	0	0	0	0	2	2	6	3	8	1	5
4	0	3	0	0	0	0	2	1	1	3	1	3	0	3
5	0	0	0	0	0	0	4	0	0	0	4	2	1	0
6	0	0	0	0	0	0	0	1	0	1	0	3	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	2	1
8	0	0	0	0	0	0	1	0	1	1	0	0	0	0
9	0	0	0	0	0	0	0	0	0	2	1	1	0	0
10	0	0	0	0	0	0	0	1	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	2	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	1
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19	0	0	0	0	0	0	1	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	1	0	0	0	0
21	0	1	0	0	0	0	1	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	1	0	0	0	0

23	0	0	0	0	0	0	1	0	0	0	0	1	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	1	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	1	1	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0

65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Age	**Year Collected**													
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
0	4	9	8	18	24	3	24	7	58	153	84	19	50	36
1	36	81	17	110	17	5	5	26	11	12	20	21	59	10
2	8	30	22	21	73	8	14	3	15	4	21	1	11	5
3	2	4	15	24	5	28	10	3	3	5	7	15	5	0
4	1	5	5	15	5	5	1	3	0	3	11	3	27	0
5	0	3	4	5	2	1	0	0	0	1	0	24	2	0
6	1	2	5	1	0	0	3	2	3	6	2	0	28	2
7	1	3	2	3	0	0	0	2	0	17	8	11	0	6
8	0	1	0	0	0	1	1	0	0	5	55	8	1	1
9	0	4	1	1	0	0	0	0	0	9	8	77	5	2
10	0	4	1	3	0	0	0	0	0	4	22	7	41	0
11	1	4	8	2	0	0	0	0	0	0	20	22	6	2
12	0	0	1	2	0	1	0	0	2	9	2	16	1	1
13	3	0	3	2	0	0	0	0	0	8	7	1	9	0
14	2	4	1	1	0	0	0	0	0	2	9	3	3	0
15	3	5	6	0	0	0	0	0	0	2	1	5	1	0
16	0	3	5	4	0	0	0	0	1	3	3	1	0	0
17	1	0	2	4	0	0	0	0	0	4	3	4	0	1
18	2	0	1	0	0	0	0	0	0	8	0	3	4	0
19	2	2	2	1	0	1	0	0	0	3	4	2	1	0
20	2	1	4	0	0	0	1	0	0	4	5	2	1	0
21	3	2	0	2	0	0	0	0	0	2	1	3	0	0
22	1	4	1	0	0	0	0	0	0	8	0	2	3	0
23	3	0	3	2	0	0	0	0	0	8	2	0	1	2
24	7	5	1	0	0	0	0	0	1	4	6	4	0	0
25	11	1	3	0	0	0	0	0	0	2	2	1	1	1
26	2	4	1	1	0	0	0	0	0	0	0	1	1	0
27	4	2	7	3	0	0	0	0	0	3	1	0	0	0
28	18	4	1	3	0	0	0	0	0	3	2	1	0	1
29	5	5	1	0	2	0	0	0	0	3	2	1	0	0
30	6	5	3	0	0	0	0	0	0	1	1	0	0	0
31	25	3	5	3	0	0	0	0	1	1	1	1	1	0
32	8	9	3	1	1	0	0	0	2	6	0	2	0	0
33	8	2	8	3	0	0	0	0	0	9	1	0	0	0
34	6	1	3	1	0	0	0	1	1	8	3	1	2	0
35	10	3	3	5	0	0	0	0	1	0	2	3	2	0
36	3	5	1	0	0	1	0	0	0	7	1	3	0	2

37	3	5	6	1	0	0	0	0	0	11	0	0	3	0
38	5	3	2	3	0	0	0	0	0	10	4	2	1	0
39	9	3	4	1	0	0	0	0	3	10	5	3	1	0
40	4	0	5	0	0	0	0	0	1	21	6	5	7	0
41	3	0	1	0	0	0	0	1	1	6	4	3	1	1
42	0	0	1	2	0	0	0	0	5	2	0	6	1	0
43	2	0	0	0	0	0	0	0	4	7	1	1	3	1
44	2	1	1	0	0	0	0	0	3	6	0	1	0	0
45	1	1	0	1	0	1	0	1	1	8	4	1	0	0
46	0	1	1	0	0	0	0	0	1	5	3	2	1	0
47	4	1	0	0	0	0	0	0	4	8	2	1	0	0
48	2	0	0	0	0	0	0	0	2	1	0	1	0	1
49	0	1	0	1	0	0	0	0	1	6	3	1	0	0
50	1	0	0	2	0	0	0	0	1	1	4	0	3	0
51	2	2	1	1	0	0	1	0	0	3	0	3	2	0
52	0	0	0	0	0	0	0	1	0	1	1	0	1	0
53	0	0	0	0	0	0	0	0	0	0	1	0	0	0
54	2	0	0	0	0	0	0	0	1	4	0	0	0	0
55	0	1	0	0	1	0	0	1	1	0	1	1	0	0
56	0	0	0	0	0	0	0	0	0	2	1	0	0	0
57	0	0	0	0	0	0	0	0	1	1	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	1	0
61	0	0	1	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	1	0	1	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 6. Total Coastwide age samples by gear, total length (mm), year, and age.

Gear	n	Total Length (mm)	n	Total Length (mm)	n	Year	n	Age	n	Age	n
Cast nets	3	**75-99**	3	**725-749**	30	1985	8	**0**	689	**34**	27
Gill net	898	**100-124**	6	**750-774**	38	1986	52	**1**	610	**35**	29
Try net	5	**125-149**	3	**775-799**	38	1987	81	**2**	318	**36**	23
Trawl	334	**150-174**	33	**800-824**	83	1988	0	**3**	154	**37**	29
Dredge	2	**175-199**	90	**825-849**	77	1989	0	**4**	101	**38**	30
Seine	3	**200-224**	172	**850-874**	71	1990	0	**5**	53	**39**	39
Pound net	263	**225-249**	206	**875-899**	64	1991	31	**6**	60	**40**	49
Stop net	111	**250-274**	133	**900-924**	59	1992	41	**7**	56	**41**	21
Rotenone	1	**275-299**	81	**925-949**	51	1993	87	**8**	76	**42**	17
Trammel net	115	**300-324**	73	**950-974**	46	1994	35	**9**	111	**43**	19
Hand line	402	**325-349**	73	**975-999**	37	1995	17	**10**	83	**44**	14
Hook and line	1189	**350-374**	80	**1000-1024**	40	1996	59	**11**	65	**45**	19
Spears and gigs	6	**375-399**	90	**1025-1049**	45	1997	76	**12**	37	**46**	14
		400-424	112	**1050-1074**	63	1998	54	**13**	34	**47**	20
		425-449	140	**1075-1099**	76	1999	229	**14**	25	**48**	7
		450-474	111	**1100-1124**	102	2000	240	**15**	24	**49**	13
		475-499	83	**1125-1149**	88	2001	180	**16**	20	**50**	12
		500-524	52	**1150-1174**	126	2002	253	**17**	19	**51**	15
		525-549	61	**1175-1199**	85	2003	130	**18**	19	**52**	4
		550-574	55	**1200-1224**	89	2004	55	**19**	19	**53**	1
		575-599	42	**1225-1249**	71	2005	60	**20**	21	**54**	7
		600-624	34	**1250-1274**	36	2006	51	**21**	15	**55**	6
		625-649	35	**1275-1299**	23	2007	130	**22**	20	**56**	3
		650-674	41	**1300-1324**	8	2008	440	**23**	23	**57**	2
		675-699	32	**1325-1349**	5	2009	358	**24**	28	**58**	0
		700-724	37	**1350-1374**	1	2010	299	**25**	22	**59**	0
						2011	291	**26**	11	**60**	1
						2012	75	**27**	20	**61**	1
								28	35	**62**	0
								29	19	**63**	0
								30	16	**64**	2
								31	41	**65**	0
								32	32	**66**	0
								33	31	**67**	1

Table 7. Catch-at-age (numbers) in Delaware commercial gill net fishery from 2009-2012.

Age	2009	2010	2011	2012
3	0	0	7	0
4	0	7	17	0
5	0	154	12	0
6	0	0	211	20
7	34	112	0	82
8	215	83	23	9
9	54	783	84	9
10	136	75	624	0
11	152	168	111	20
12	20	91	23	9
13	23	7	120	0
14	89	15	40	0
15	9	46	9	0
16	13	13	0	0
17	15	28	0	14
18	0	20	76	0
19	16	9	13	0
20	29	6	9	0
21	0	21	0	0
22	0	0	16	0
23	5	0	13	27
24	27	15	0	0
25	7	6	7	14
26	0	0	4	0
27	5	0	0	0
28	10	0	0	14
29	10	2	0	0
30	5	0	0	0
31	0	0	8	0
32	0	2	0	0
33	2	0	0	0
34	0	0	0	0
35	2	2	19	0
36	2	7	0	27
37	0	0	20	0
38	10	2	4	0
39	2	6	0	0
40	18	2	43	0
41	2	7	4	14
42	0	18	8	0

43	0	6	9	14
44	0	7	0	0
45	4	0	0	0
46	2	7	4	0
47	1	0	0	0
48	0	0	0	14
49	1	7	0	0
50	4	0	11	0
51	0	11	31	0
52	0	0	0	0
53	0	0	0	0
54	0	0	0	0
55	1	7	0	0
56	2	0	0	0

Table 8. Sample sizes of black drum length samples collected by year and gear from commercial fisheries in the VMRC Biological Sampling Program.

Year	Gill Net	Pound Net	Commercial Hook and Line	Other Gears	Total
1998	77	6	1	0	**84**
1999	191	5	0	4	**200**
2000	110	12	0	0	**122**
2001	104	46	5	0	**155**
2002	39	26	17	2	**84**
2003	4	21	0	0	**25**
2004	0	29	0	0	**29**
2005	11	13	0	0	**24**
2006	2	4	0	3	**9**
2007	3	6	0	0	**9**
2008	0	9	0	0	**9**
2009	1	25	0	1	**27**
2010	23	11	1	0	**35**
2011	0	0	0	0	**0**
2012	20	15	0	0	**35**
Total	**1112**	**425**	**24**	**12**	**1573**

Table 9. Catch-at-length in numbers by 10mm length bin in the NC Estuarine gill net fishery from 1994-2012.

Centerline Length (mm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
180	.	.	.	.	.	.	.	.	.	.	.	.	45	0	19	.	.	34	.
190	.	.	.	.	.	.	.	.	.	.	.	.	45	0	63	.	.	34	36
200	.	.	.	.	.	.	.	.	66	.	.	.	171	108	340	.	.	351	108
210	.	.	.	.	.	.	.	.	1029	.	.	.	759	176	721	82	121	593	431
220	.	.	.	.	.	645	.	195	2077	73	.	53	1007	497	1784	356	202	1117	478
230	.	.	.	.	.	645	1326	390	2218	146	.	260	708	565	1172	218	105	2715	649
240	.	.	.	.	.	1901	497	1171	2227	158	.	630	1419	1729	2129	726	291	1604	997
250	.	.	.	.	.	1290	1436	1268	3143	661	.	1215	1306	2521	5216	1336	488	1385	1203
260	.	.	.	.	.	645	221	488	2330	231	.	964	1486	2034	1529	1573	286	946	1809
270	.	.	.	.	.	.	.	1105	2564	284	.	576	722	1365	1691	526	202	193	720
280	.	.	.	447	.	1766	.	.	1908	126	.	240	527	769	263	174	81	83	642
290	.	.	.	.	.	1631	.	.	1776	85	.	.	353	413	401	27	40	83	765
300	.	.	.	.	.	171	.	.	1916	381	77	.	238	184	501	46	.	77	278
310	.	.	.	.	.	171	.	.	1411	.	.	.	270	84	1043	550	.	17	435
320	.	.	.	.	.	672	110	98	1579	.	.	.	997	81	1035	230	22	.	413
330	.	.	.	.	.	341	110	127	1682	.	560	.	909	59	1485	196	65	17	341
340	283	.	.	.	.	2187	351	127	2257	85	.	51	878	133	2357	247	275	133	615
350	.	.	.	.	.	986	582	227	2664	254	462	235	1623	292	2425	394	127	210	905
360	424	.	37975	447	.	512	1044	713	4205	1747	385	183	2396	494	3555	1474	299	466	1337
370	424	.	2277	1341	435	3712	2288	1883	7314	908	616	256	3866	871	4800	1090	358	699	1634
380	707	.	3416	894	435	4886	3221	941	8566	1289	1078	375	3107	2786	6566	2303	415	882	3017
390	990	.	3416	1788	658	5735	3193	2529	8953	3041	1232	192	3025	3763	7786	2996	441	932	2667
400	565	.	1139	1565	658	4284	1710	1200	8682	4361	924	452	2026	4173	7261	3770	777	1071	2025
410	283	.	2277	1978	1093	5463	2382	649	6734	2506	462	375	2129	3994	10186	2861	1011	737	2154
420	.	10285	3416	1341	658	1184	3138	1461	5551	4233	385	171	1299	2880	5985	2786	1217	834	1399

430	141	.	.	.	224	171	1077	1200	4271	3412	231	535	643	1972	4185	2319	695	351	763
440	.	.	1139	430	224	341	858	1136	1645	2999	.	416	623	1113	2831	1711	455	294	529
450	.	.	1139	2151	447	672	596	293	1514	2690	529	249	70	708	1287	1409	549	194	341
460	.	.	.	.	.	.	561	780	1542	2034	342	132	35	520	617	1189	166	127	641
470	.	.	1139	.	112	.	351	1266	336	2490	265	181	135	449	363	1237	345	77	303
480	.	.	.	.	.	.	231	488	468	2495	77	154	205	284	155	778	152	.	428
490	.	.	.	.	435	.	120	195	.	1206	77	130	.	319	218	578	237	11	297
500	.	.	.	.	112	.	285	617	.	1034	265	.	103	375	103	310	40	71	270
510	.	.	.	.	112	.	476	195	.	323	154	30	.	144	6	136	147	27	85
520	.	.	.	.	.	.	.	.	.	389	529	.	.	137	107	285	124	.	108
530	.	.	.	.	.	.	.	.	.	336	606	51	.	123	194	191	168	11	36
540	.	.	.	.	.	.	120	.	.	73	265	.	.	.	138	119	83	11	207
550	.	.	.	.	.	171	.	.	.	124	265	30	35	31	56	115	60	11	36
560	.	.	.	.	.	.	.	127	.	.	265	51	103	.	64	.	99	11	36
570	.	.	.	.	.	.	.	.	66	158	.	.	.	18	51	27	292	.	375
580	.	.	.	.	.	.	.	.	.	.	265	30	.	41	44	46	154	.	49
590	.	.	.	.	.	.	.	98	.	.	77	.	.	.	50	130	72	.	49
600	.	.	.	.	.	.	.	.	.	.	.	.	.	15	.	46	40	.	.
610	.	.	.	.	.	.	.	.	.	.	265	30	.	.	.	92	84	.	.
620	.	.	.	.	.	.	.	.	.	.	.	51	.	.	.	.	42	.	.
630	.	.	.	.	.	.	.	.	168	.	.	.	.	.	.	27	65	.	.
640	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22	.	.
650	.	.	.	.	.	.	.	.	.	.	.	30	.	.	.	46	22	.	.
660	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	92	.	.	.
670	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20	.	.
680	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22	.	.
700	.	.	.	.	.	.	.	.	.	.	.	71	.	.	.	.	22	.	.
710	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15	.	20	.	.
820	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	46	.	.	.
1210	.	.	.	.	.	.	.	.	.	.	.	.	35	.	.	27	.	.	.
1250	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.

1270	.	.	.	.	.	.	.	.	.	.	.	.	.	15	6	.	.	.	.

Table 10. Catch-at-length in numbers by 10mm length bin in the NC long haul seine net fishery from 1994-2012.

Centerline Length (mm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
150	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.
170	.	.	.	.	.	.	.	.	.	.	.	.	11	.	.	.	.	.	.
180	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.
200	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.
210	.	.	.	.	.	5	51	.	.	.	4	.	.	38	.	.	.	.	.
220	.	.	.	.	.	56	51	.	3	.	.	.	24	76	.	.	.	.	.
230	.	.	.	.	.	30	19	.	29	.	15	.	39	378	.	.	2	12	.
240	.	.	.	.	.	78	51	.	12	.	.	.	25	636	.	.	9	3	.
250	.	.	199	.	.	92	57	3	17	20	4	.	9	491	.	.	21	.	.
260	.	.	.	.	.	31	38	.	80	.	4	.	131	273	52	.	24	.	.
270	.	.	419	569	.	24	.	.	332	.	4	.	266	120	35	.	24	46	.
280	.	.	942	.	.	15	.	25	275	.	4	.	439	.	191	.	11	46	.
290	.	.	381	.	.	21	.	.	608	55	22	85	290	55	.	.	2	9	4
300	.	.	99	.	.	7	70	3	952	20	.	.	553	84	.	.	4	7	.
310	.	.	99	.	.	19	24	12	850	114	4	.	384	71	242	.	.	42	.
320	82	.	490	.	.	79	5	.	942	.	.	.	509	86	329	2	9	.	.
330	.	.	303	.	.	82	68	3	1240	.	.	.	369	56	331	.	94	.	.
340	.	.	947	.	.	185	128	3	357	129	.	.	493	39	488	.	18	42	.
350	82	.	492	.	.	148	221	.	329	35	.	.	251	154	591	.	18	42	.
360	82	.	235	91	.	156	229	.	494	20	.	.	291	60	475	.	.	48	.
370	82	.	136	43	.	122	373	19	323	151	.	.	410	66	487	.	4	.	10
380	82	.	179	661	.	76	520	.	258	35	.	.	259	170	543	10	2	.	.
390	.	.	.	.	.	42	267	.	25	52	.	.	173	154	346	.	24	.	.

400	.	.	.	661	11	39	280	.	30	12	.	.	113	144	225	.	.	.	34
410	.	.	.	3439	11	14	153	4	23	261	15	.	.	108	90	.	.	.	34
420	.	.	.	.	32	.	38	27	7	52	.	85	15	241	.	186	.	.	72
430	.	.	.	91	.	12	19	25	8	212	.	.	.	195	38	20	.	.	.
440	.	.	.	50	.	.	.	74	.	575	.	.	.	247	.	95	.	9	19
450	.	.	.	569	69	.	.	74	.	360	.	17	.	205	.	145	.	.	.
460	.	.	.	25	11	7	9	84	.	410	.	.	62	235	.	12	.	3	.
470	.	.	.	.	22	.	.	18	8	673	.	34	.	186	.	196	.	42	.
480	.	.	.	.	.	.	.	48	.	268	.	.	.	219	35	221	.	49	.
490	.	.	.	.	43	.	.	42	.	417	.	.	.	204	.	135	.	3	.
500	.	.	.	.	.	.	.	.	8	700	4	34	.	23	35	43	.	84	.
510	.	.	.	.	.	.	5	.	8	196	.	.	.	58	35	43	.	84	.
520	.	.	.	.	.	.	.	16	.	131	.	17	.	83	.	96	5	88	.
530	.	.	.	.	.	.	.	.	.	131	.	.	.	.	.	96	72	.	5
540	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	138	82	.	.
550	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	178	88	.	.
560	.	.	.	.	.	.	.	.	.	.	122	.	.	.	.	.	99	42	.
570	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	85	36	.	.
580	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	135	27	.	.
590	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15	.	.
600	.	.	.	.	.	.	.	.	.	.	.	.	.	.	35	93	.	.	.
610	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.
620	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.
630	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27	.	.
710	.	.	.	.	.	.	60	.	.	.	.	.	.	.	.	.	.	.	.

Table 11. Catch-at-length in numbers by 10mm length bin in the NC ocean gill net fishery from 1994-2012.

Centerline Length (mm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
180	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	578
190	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19	145
200	.	.	.	.	.	.	65	.	.	.	.	.	.	41	.	.	.	298	289
210	.	1701	.	.	.	.	259	.	.	.	.	.	.	83	.	.	.	993	289
220	.	4536	.	.	.	.	65	.	.	14	.	.	175	.	.	15	.	979	145
230	.	2835	.	.	.	.	.	.	.	14	.	154	.	.	.	.	.	728	.
240	.	2835	.	.	.	.	.	.	.	93	.	159	.	41	.	.	.	320	.
250	.	567	.	.	.	.	.	.	.	64	.	239	.	.	.	.	.	95	.
260	.	.	.	.	.	.	.	.	.	64	.	239	.	41	7	.	.	3	.
270	.	.	.	.	.	173	.	1339	.	78	.	244	.	41	22	.	.	4	.
280	.	.	.	.	.	.	.	31	.	7	.	5	.	41	7	.	.	2	.
290	.	.	1534	.	.	.	.	.	.	7	.	.	.	83	.	.	.	.	.
300	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	145
320	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36	.	.	.	.
330	.	.	.	.	.	.	.	.	.	.	.	.	25	.	29	.	.	.	.
340	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36	.	.	.	145
350	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.	.	.	.
360	.	.	.	.	.	.	.	.	.	.	.	.	12	.	65	.	.	.	.
370	.	.	.	.	.	.	65	.	.	.	.	5	.	.	65	.	.	.	.
380	.	.	.	.	.	.	.	.	.	.	.	.	.	67	22	33	.	.	.
390	.	.	.	.	.	.	.	31	.	.	.	.	12	.	22	30	.	.	.
400	.	.	.	7064	.	.	.	.	.	.	.	.	.	.	14	.	.	.	.
410	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	145
420	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14	30	.	.	.
430	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	.	357	.	.
440	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	48	.	.	.

450	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15	.	.	.
460	.	.	.	.	.	.	.	.	.	31	.	.	.	.	.	.	.	.	.
470	.	.	.	.	.	.	.	.	.	.	.	.	.	108	.	30	.	.	.
480	.	.	.	.	.	.	.	.	.	.	.	.	.	83	14	45	.	.	.
490	.	.	.	.	.	.	.	.	.	31	.	.	.	67	.	45	.	.	.
500	.	.	.	.	.	.	.	.	.	.	.	.	.	41	.	.	.	.	.
520	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15	.	.	.
530	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15	.	.	.
560	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.
570	.	.	.	.	.	.	.	.	.	.	.	.	.	124	.	.	.	.	.
580	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	357	.	.
610	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.
710	.	.	.	.	.	.	.	.	.	.	.	.	31	.	.	.	.	.	.
740	.	.	.	.	.	.	.	.	.	.	.	.	31	.	.	.	.	.	.
750	.	.	.	.	.	.	65	.	.	.	.	.	31	.	.	.	.	.	.
760	.	.	.	.	.	.	.	.	.	.	.	.	31	.	.	.	.	.	.
770	.	.	.	.	.	.	.	.	.	.	.	.	31	.	.	.	.	.	.
790	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	.	.	.
810	.	.	.	.	.	.	.	.	.	.	.	.	31	.	.	.	.	.	.
820	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	.	.	.
830	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	33	.	.	.
840	.	.	.	.	.	.	.	.	.	.	41	.	.	.	.	.	.	.	.
860	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.
890	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	.	.	.
910	.	.	.	.	.	.	.	31	.	.	.	.	.	.	.	.	.	.	.
920	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	33	.	.	.
940	.	.	.	.	.	.	.	.	.	.	41	.	.	.	.	.	.	.	42
1210	.	.	.	.	.	117	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 12. Catch-at-length in numbers by 10mm length bin in the NC ocean trawl fishery from 1994-2012.

Centerline Length (mm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
210	.	.	.	.	.	.	.	.	.	.	.	41	.	.	.	.	.	.	.
220	.	.	.	.	.	.	.	.	.	.	.	49	.	.	.	.	.	.	.
230	.	.	47	.	.	.	.	102	.	9	.	65	.	39	5	.	.	.	.
240	.	.	.	.	.	.	.	102	.	.	.	49	29	96	.	.	.	.	.
250	.	.	.	.	.	.	6	408	.	32	.	16	.	58	.	.	.	.	.
260	.	.	.	.	.	.	.	102	.	.	.	278	.	39	.	.	.	.	.
270	.	.	.	.	.	.	.	102	.	.	28	25	.	50	.	.	.	.	.
280	.	.	47	.	.	.	.	.	.	.	.	.	.	19	.	.	.	.	.
290	.	.	.	.	.	.	6	.	.	.	.	8	.	.	.	.	.	.	.
300	.	.	.	.	.	.	.	.	.	16	.	.	.	19	.	.	.	.	.
320	.	.	.	.	.	.	.	.	37	32	.	.	.	.	.	.	.	.	.
330	.	.	.	.	.	.	.	.	46	.	.	.	.	.	.	.	.	.	.
350	.	.	.	.	.	.	2	.	.	16	.	.	.	.	.	.	.	.	.
360	.	.	.	.	.	.	.	12	.	16	.	.	.	.	.	.	.	.	.
370	.	.	.	.	.	.	10	.	.	32	.	.	.	.	.	.	.	.	.
380	.	.	.	.	.	.	19	.	.	34	.	.	.	.	.	.	.	.	.
390	.	.	.	.	11	.	73	71	21	34	.	.	.	.	.	.	.	.	.
400	.	.	47	.	11	.	23	12	21	82	.	.	.	.	.	.	.	.	.
410	.	.	44	293	11	.	25	121	.	9	.	.	.	.	.	.	.	.	.
420	.	.	.	.	11	.	31	36	42	50	.	.	.	.	71	.	.	.	.
430	.	.	.	.	.	.	38	20	19	107	.	.	.	.	.	.	.	.	.
440	.	.	44	.	.	.	21	.	.	107	.	.	.	.	76	.	.	.	.
450	.	.	47	.	.	82	23	.	.	50	.	.	.	.	5	191	.	.	.
460	.	.	.	96	.	.	14	.	26	146	.	.	.	.	.	.	.	.	.
470	.	.	47	.	.	.	6	31	.	85	.	.	40	556	5	.	.	.	.
480	.	.	.	.	.	.	.	24	2	25	.	.	.	.	11	.	.	.	.

490	.	.	.	.	.	.	8	.	7	.	.	.	.	.	5	.	.	.	.
500	.	.	.	.	.	.	18	12	.	.	.	.	.	12	16	.	.	.	.
510	.	.	.	.	11	.	6	12	2	27	.	.	.	.	.	.	.	.	.
520	.	.	.	.	11	.	6	24	9	32	.	.	.	.	5	.	.	.	.
530	.	.	.	.	.	.	15	36	8	.	.	.	.	.	.	.	.	.	.
540	.	.	.	.	33	.	6	36	11	.	.	.	.	.	.	.	.	.	.
550	.	.	.	.	.	.	2	.	38	.	19	.	.	.	.	.	.	.	.
560	.	.	33	.	22	.	8	36	13	.	28	.	.	.	5	.	.	.	.
570	.	.	.	.	.	.	12	67	14	.	.	.	.	.	.	.	.	.	.
580	.	.	.	.	11	.	4	.	15	.	.	.	.	.	.	.	.	.	.
590	.	.	.	.	22	.	2	.	8	.	97	.	.	.	.	.	.	.	.
600	.	.	.	.	11	.	4	.	9	.	.	.	.	.	.	.	.	.	.
610	.	.	.	.	.	.	2	.	9	.	.	.	.	.	.	.	.	.	.
620	.	.	.	.	.	.	5	.	11	.	.	.	.	.	.	.	.	.	.
630	.	.	.	.	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.
640	.	72	.	.	.	.	.	.	19	.	.	.	.	.	.	.	.	.	.
650	.	.	.	.	.	.	.	.	11	.	.	.	.	.	608	.	.	.	.
660	.	.	.	.	.	.	.	.	24	.	.	.	.	.	.	.	.	.	.
670	.	.	.	.	.	.	.	.	37	.	.	.	.	.	.	.	.	.	.
680	.	.	.	.	.	.	5	.	6	.	4	.	.	.	.	.	.	.	.
690	.	.	.	.	.	.	.	.	14	.	.	.	.	.	.	.	21	.	.
700	.	.	.	.	.	.	.	.	6	8	.	.	29	.	.	40	.	.	.
710	.	.	.	.	.	.	8	.	23	.	.	.	.	.	.	.	.	.	.
720	.	.	.	.	.	.	2	.	.	8	.	.	.	.	.	.	.	.	.
730	.	.	.	.	.	.	2	.	2	8	.	.	.	.	.	.	.	.	.
740	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
750	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.
760	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
770	.	.	.	.	.	.	.	12	.	.	.	.	.	.	71	.	.	.	.
810	.	.	.	.	.	.	.	.	.	.	.	.	.	12	.	.	.	.	.
870	.	.	.	.	.	.	.	.	.	.	.	.	40	.	.	.	.	.	.

1080	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1130	.	.	.	.	.	.	.	.	.	.	.	.	.	24	.	.	.	.	.
1240	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12	.	.
1250	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.	.	.	.	.

Table 13. Catch-at-length in numbers by 10mm length bin in the NC pound net fishery from 1994-2012.

Centerline Length (mm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
210	.	.	.	.	.	.	.	.	.	.	80	.	.	.	.	.	.	.	.
220	.	493	.	.	49	14	13	30	.	.	.	.	.	18	11	.	37	.	34
230	.	1082	.	.	.	180	13	91	.	.	.	.	.	9	11	.	.	46	103
240	.	2125	.	.	.	.	13	152	.	.	.	.	17	46	.	.	37	61	82
250	.	4869	78	.	49	126	25	243	.	.	80	.	17	128	23	23	73	88	.
260	.	3877	51	.	49	42	.	152	130	.	.	.	122	186	21	.	84	144	72
270	.	1589	44	.	98	28	47	243	186	.	172	.	136	558	.	.	121	114	20
280	.	1120	1542	60	555	14	.	.	64	.	172	.	161	111	34	17	121	81	22
290	.	1381	.	.	.	53	.	.	218	.	.	.	167	27	23	.	37	47	10
300	.	565	.	.	.	84	13	30	367	.	.	.	52	46	46	.	37	75	49
310	.	684	.	.	.	42	32	30	331	.	.	.	120	9	57	11	.	24	10
320	.	97	.	.	.	358	47	.	729	.	80	.	426	.	340	.	.	.	25
330	.	303	120	178	.	373	92	.	2583	.	343	.	487	9	836	.	11	.	142
340	.	.	125	60	.	607	297	61	2258	.	80	.	2190	9	1079	.	11	3	92
350	.	.	241	529	.	901	722	121	4898	.	432	17	1946	9	1775	34	.	.	133
360	.	.	509	356	.	1208	736	294	4436	.	252	.	1519	9	1621	11	22	6	259
370	.	.	482	589	.	761	437	243	8365	211	513	.	3267	19	2135	.	.	3	332
380	.	.	751	654	.	1053	630	628	10095	211	340	.	1825	47	3459	11	11	6	448
390	.	.	607	295	.	1150	648	495	9303	.	492	.	2021	27	2282	.	34	25	569
400	.	125	859	358	.	642	632	415	12800	.	409	.	1413	45	2578	23	45	6	748

410	.	15	789	.	.	475	292	418	12439	.	160	.	756	57	1840	.	95	25	456
420	.	.	576	178	.	316	388	597	11465	83	328	9	701	47	2235	138	89	20	588
430	.	.	252	475	49	190	284	214	10176	.	.	17	216	53	1619	23	106	45	239
440	.	15	545	.	.	138	178	152	6043	166	88	26	29	36	821	68	56	31	162
450	.	.	.	.	.	65	127	152	6605	129	.	20	19	53	594	11	89	28	172
460	.	.	53	.	.	42	89	152	2668	249	.	9	27	46	493	34	89	20	104
470	.	.	77	60	.	14	82	30	1053	129	160	17	78	87	227	34	78	26	171
480	.	.	.	.	.	.	13	99	870	212	80	9	42	49	87	51	128	20	44
490	.	.	.	.	.	.	47	.	279	.	.	.	10	36	76	11	39	9	10
500	.	.	.	.	.	.	38	.	.	.	.	.	.	85	73	79	39	35	25
510	.	.	.	60	.	.	13	69	24	646	.	12	.	36	.	102	11	26	25
520	.	15	.	.	.	.	106	.	.	.	.	.	.	27	77	157	46	.	.
530	.	.	.	.	49	.	110	30	.	129	.	36	10	36	34	190	11	.	22
540	.	.	.	60	.	.	13	.	35	240	.	17	.	18	121	162	.	.	.
550	.	.	.	60	.	.	106	.	503	.	80	17	.	45	135	51	22	7	.
560	.	.	.	235	.	.	13	61	.	.	.	20	.	18	23	116	95	.	.
570	.	.	.	60	.	.	13	.	.	.	160	9	.	.	30	209	11	.	5
580	.	.	.	175	49	.	13	.	.	.	.	23	.	.	11	90	11	.	5
590	.	.	.	120	.	.	.	.	.	.	.	12	.	9	.	21	45	3	.
600	.	.	.	.	49	.	.	69	.	.	183	23	.	.	16	17	22	3	.
610	.	.	.	.	49	.	.	.	.	.	.	26	.	.	11	115	22	26	10
620	.	.	.	.	113	.	.	.	.	.	.	17	.	9	11	.	.	.	.
630	.	.	.	.	.	.	.	30	93	83	.	17	.	.	.	11	22	.	.
640	.	.	.	.	.	.	.	.	50	.	.	.	.	.	11	11	.	3	.
650	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	23	.	.	22
660	.	.	.	.	.	.	.	30	.	.	.	9	69	.	.	.	22	.	10
670	.	.	25	.	.	.	.	.	.	.	.	9	.	.	11	.	11	.	.
680	.	.	.	.	.	.	.	30	.	.	.	17	.	.	.	.	.	.	21
690	.	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	39	3	.
700	.	.	.	.	.	.	.	.	.	.	.	26	.	.	.	.	.	.	.
710	.	.	.	.	.	.	.	.	.	.	.	12	.	.	.	.	.	.	.

720	.	.	.	.	.	.	.	.	.	.	.	17	.	.	.	.	11	3	.
730	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.
740	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10
750	.	.	.	.	.	.	.	.	.	.	.	.	16	.	.	.	11	.	32
760	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	46	.	.
770	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22	3	5
790	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.
810	.	.	.	.	.	.	.	.	.	.	.	9	.	.	.	.	.	.	.
830	.	.	.	.	.	.	.	.	.	.	.	.	10	.	11	.	.	3	.
910	.	.	.	.	.	.	.	.	.	.	.	9	.	.	.	.	.	.	.
1070	.	.	.	.	.	28	.	.	.	.	.	.	.	.	.	.	.	.	.
1110	.	.	.	.	.	.	.	.	.	.	.	9	.	.	.	.	.	.	.
1150	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
1160	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	.	.
1180	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	28	.	.
1190	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
1200	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	.	.	.	.

Table 14. Number of Black Drum length measurements taken in MRFSS/MRIP intercepts by year, wave, and state. Gray cells indicate periods where there were no landings estimates (no Black Drum were intercepted). Green cells are those with at least 10 measurements, and red cells are those with less than 10 that require filling.

	Florida						Georgia						South Carolina					
Year	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1981	NA	1	NA	3	9	6	NA	NA	2	6	NA	NA	NA	0	NA	0	3	NA
1982	4	1	39	4	8	2	NA	NA	3	NA	7	3	NA	1	2	1	6	NA
1983	5	7	6	5	17	24	NA	NA	3	3	4	7	NA	0	NA	1	2	NA
1984	10	11	13	4	26	48	NA	1	0	7	5	5	NA	NA	NA	1	NA	12
1985	3	4	9	13	18	14	NA	1	3	6	5	56	NA	NA	NA	2	0	2
1986	3	4	15	25	5	13	10	11	19	32	40	22	NA	0	1	2	7	1

1987	9	20	12	3	18	7	14	29	17	48	47	16	NA	NA	4	6	3	4
1988	3	5	10	2	14	16	5	2	9	16	5	7	NA	7	5	2	0	1
1989	1	NA	NA	2	1	7	14	7	30	11	21	13	NA	3	8	7	1	2
1990	1	1	2	1	0	4	NA	1	NA	2	NA	1	NA	0	0	3	NA	2
1991	5	NA	9	5	1	30	NA	0	0	0	3	2	NA	NA	1	1	NA	1
1992	7	5	5	7	8	7	NA	3	7	3	3	17	NA	4	NA	0	10	6
1993	5	7	15	6	7	17	NA	1	3	6	4	2	NA	NA	1	4	9	2
1994	29	8	2	5	10	32	NA	4	2	9	2	6	NA	2	2	0	NA	1
1995	8	5	2	9	3	4	NA	1	3	6	3	6	NA	1	3	0	5	5
1996	3	12	4	6	9	15	NA	NA	1	1	0	NA	NA	10	5	3	20	2
1997	0	9	1	4	5	21	NA	2	2	0	1	1	NA	4	6	8	9	39
1998	13	25	1	11	4	39	NA	0	NA	3	3	NA	NA	1	4	6	6	4
1999	25	34	17	16	36	49	NA	0	0	1	0	6	NA	NA	0	12	5	27
2000	17	45	17	10	20	29	NA	3	9	1	23	8	NA	NA	4	17	17	2
2001	28	16	23	22	67	20	NA	1	2	11	2	2	NA	2	1	0	NA	3
2002	9	6	8	14	26	14	NA	2	9	1	30	1	NA	0	6	2	2	5
2003	14	11	10	11	12	37	NA	7	19	35	16	1	NA	2	5	5	0	9
2004	3	8	9	8	46	16	NA	2	16	0	5	11	NA	NA	3	1	2	9
2005	16	19	8	3	4	23	NA	2	5	7	4	0	NA	0	5	1	1	10
2006	15	9	10	8	20	13	NA	8	5	2	10	7	NA	NA	1	2	7	165
2007	14	24	15	9	16	37	NA	3	13	14	36	13	NA	4	63	33	4	9
2008	42	23	10	17	43	50	NA	16	8	26	50	12	NA	10	7	7	17	9
2009	44	40	20	14	14	20	NA	3	8	5	17	4	NA	11	6	4	6	2
2010	36	31	14	12	18	27	NA	3	45	9	7	12	NA	4	24	2	3	5
2011	10	5	14	12	18	23	NA	NA	0	5	4	8	NA	1	4	3	3	2
2012	9	10	2	10	15	14	NA	4	2	4	9	6	NA	0	3	3	7	4

Table 14. Continued.

Year	North Carolina 1	2	3	4	5	6	Virginia 1	2	3	4	5	6	Maryland 1	2	3	4	5	6
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	10	NA	NA	NA	NA	NA	5	15	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	3	NA	NA	NA
1985	NA	NA	NA	NA	0	2	NA	NA	28	1	NA	NA	NA	NA	4	8	NA	NA
1986	NA	NA	NA	NA	3	2	NA	NA	38	NA	2	NA	NA	NA	NA	1	NA	NA
1987	NA	NA	2	12	31	0	NA	NA	29	NA	NA	NA	NA	NA	NA	0	NA	NA
1988	NA	NA	NA	15	1	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	1	NA	NA	NA	NA	1	1	1	NA	NA	NA	13	NA	NA	NA
1990	NA	NA	0	4	1	1	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	3	1	18	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	3	1	3	0	NA	NA	14	NA	NA	1	NA	NA	NA	NA	NA	NA
1993	NA	NA	1	2	19	39	NA	NA	NA	NA	1	1	NA	NA	NA	NA	NA	NA
1994	NA	NA	54	38	14	15	NA	NA	NA	0	3	NA	NA	NA	NA	NA	NA	NA
1995	NA	1	4	16	145	224	NA	0	1	NA	4	NA	NA	NA	0	NA	NA	NA
1996	NA	5	38	60	110	126	NA	NA	3	1	1	NA	NA	NA	NA	NA	NA	NA
1997	NA	12	35	72	20	5	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	3	52	82	30	NA	NA	2	NA	1	0	NA	NA	NA	NA	0	NA
1999	NA	4	33	72	95	44	NA	NA	NA	NA	0	NA	NA	NA	1	NA	NA	NA
2000	NA	3	50	68	31	26	NA	NA	1	NA	1	NA	NA	NA	NA	1	NA	NA
2001	NA	0	11	30	82	50	NA	NA	NA	NA	2	NA	NA	NA	NA	NA	NA	NA
2002	NA	17	24	51	80	47	NA	NA	NA	2	3	NA	NA	NA	NA	1	0	NA
2003	NA	10	56	26	72	34	NA	1	5	1	5	NA	NA	NA	NA	0	2	NA
2004	NA	3	39	14	36	42	NA	NA	NA	NA	2	NA	NA	NA	1	1	NA	NA
2005	0	0	5	4	18	62	NA	NA	5	NA	1	NA	NA	NA	NA	NA	NA	NA
2006	NA	1	22	25	34	24	NA	NA	1	NA	NA	NA	NA	NA	2	NA	NA	NA
2007	NA	3	13	10	30	135	NA	NA	4	NA	4	4	NA	NA	NA	NA	NA	NA
2008	NA	3	42	32	126	162	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

2009	0	6	8	17	92	68	NA	NA	12	1	2	NA	NA	NA	NA	NA	NA	NA
2010	1	7	62	31	71	87	NA	NA	1	0	2	NA	NA	NA	NA	0	NA	NA
2011	NA	2	14	1	260	290	NA	NA	0	2	1	3	NA	NA	NA	NA	NA	NA
2012	1	17	40	47	50	82	NA	NA	1	NA	1	NA	NA	NA	NA	NA	NA	NA

Table 14. Continued

	Delaware						New Jersey					
Year	1	2	3	4	5	6	1	2	3	4	5	6
1981	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	13	NA	NA	NA	1	NA	NA	NA
1987	NA	NA	NA	NA	3	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	1	6	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	8	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	21	NA	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1996	NA	NA	1	NA	1	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	1	1	NA	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
2001	NA	NA	NA	NA	1	NA	NA	0	4	3	NA	NA
2002	NA	NA	3	8	NA	NA	NA	NA	0	2	NA	NA
2003	NA	NA	NA	NA	NA	NA	NA	NA	2	1	NA	NA

2004	NA	NA	1	NA	NA	NA	NA	NA	14	NA	NA	NA
2005	NA	NA	1	1	1	NA	NA	2	8	0	NA	NA
2006	NA	NA	NA	8	1	NA	NA	32	8	1	NA	NA
2007	NA	NA	1	NA	4	1	NA	NA	4	NA	1	NA
2008	NA	NA	4	11	NA	NA	NA	NA	65	2	0	NA
2009	NA	NA	29	NA	NA	NA	NA	2	40	NA	NA	NA
2010	NA	NA	4	2	NA	NA	NA	NA	10	NA	NA	NA
2011	NA	NA	6	NA	1	NA	NA	NA	8	1	2	NA
2012	NA	NA	12	NA	1	NA	NA	5	1	NA	NA	NA

Table 15. Number of Black Drum weight measurements taken in MRFSS/MRIP intercepts by state, year, and wave. Gray cells indicate periods where there were no landings estimates (no Black Drum were intercepted). Green cells are those with at least 10 measurements, and red cells are those with less than 10 that require filling.

	Florida						Georgia						South Carolina					
Year	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1981	NA	1	NA	6	11	6	NA	NA	2	6	NA	NA	NA	0	NA	0	3	NA
1982	4	1	39	4	7	2	NA	NA	3	NA	8	3	NA	1	2	1	6	NA
1983	5	7	6	5	17	23	NA	NA	3	3	4	7	NA	0	NA	1	2	NA
1984	7	11	13	4	26	48	NA	1	0	9	5	5	NA	NA	NA	1	NA	12
1985	4	4	9	12	18	14	NA	1	3	6	4	56	NA	NA	NA	2	0	2
1986	3	5	14	25	5	12	10	10	19	32	40	22	NA	1	1	2	7	2
1987	9	20	12	4	18	8	14	28	17	39	47	16	NA	NA	4	3	4	4
1988	3	6	10	2	14	16	5	2	9	16	5	7	NA	1	3	2	1	1
1989	1	NA	NA	3	1	5	14	7	30	11	21	13	NA	1	2	2	2	2
1990	1	1	0	1	1	4	NA	1	NA	2	NA	1	NA	0	0	0	NA	1
1991	5	NA	9	5	1	35	NA	0	1	0	3	0	NA	NA	1	1	NA	1
1992	7	5	5	13	8	7	NA	5	7	3	6	19	NA	4	NA	1	9	6
1993	5	9	15	6	7	19	NA	1	3	6	4	5	NA	NA	1	4	7	2
1994	29	8	2	5	10	32	NA	2	2	9	2	6	NA	2	2	0	NA	1
1995	8	6	2	11	3	3	NA	1	3	8	3	6	NA	1	3	0	4	5
1996	6	15	3	9	10	15	NA	NA	5	2	0	NA	NA	10	5	3	21	1
1997	0	8	1	4	5	26	NA	1	3	0	1	1	NA	4	6	8	8	39
1998	12	25	1	11	6	39	NA	0	NA	3	3	NA	NA	1	4	6	6	4
1999	27	33	17	16	33	44	NA	0	0	1	0	6	NA	NA	0	12	5	26
2000	16	44	17	10	19	32	NA	1	9	1	16	8	NA	NA	3	16	17	2
2001	27	15	23	21	64	20	NA	1	3	10	2	2	NA	3	2	0	NA	3
2002	9	6	8	13	26	14	NA	2	4	1	30	1	NA	0	6	1	2	5
2003	14	11	10	15	12	37	NA	5	11	35	15	1	NA	2	5	5	0	9
2004	4	7	9	6	46	16	NA	2	16	0	5	6	NA	NA	1	3	3	9
2005	15	18	8	1	4	23	NA	2	5	6	4	0	NA	0	5	1	3	10

2006	15	7	8	7	20	13	NA	8	2	2	10	7	NA	NA	1	2	7	166
2007	11	17	12	9	16	34	NA	3	13	13	36	13	NA	4	63	33	4	9
2008	41	23	10	16	42	45	NA	15	8	26	50	12	NA	10	5	7	17	9
2009	42	41	18	14	14	17	NA	3	8	5	17	4	NA	11	6	4	6	2
2010	35	31	12	11	18	27	NA	3	45	9	7	11	NA	4	24	2	3	5
2011	8	5	14	12	12	23	NA	NA	0	5	4	8	NA	1	6	1	2	2
2012	9	8	2	10	15	14	NA	4	2	4	9	5	NA	0	2	3	7	4

Table 15. Continued.

	North Carolina						Virginia						Maryland					
Year	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	2	NA	NA	NA	NA	NA	3	9	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	0	NA	NA	NA
1985	NA	NA	NA	NA	1	3	NA	NA	5	1	NA	NA	NA	NA	4	7	NA	NA
1986	NA	NA	NA	NA	3	2	NA	NA	9	NA	2	NA	NA	NA	NA	1	NA	NA
1987	NA	NA	0	7	31	0	NA	NA	3	NA	NA	NA	NA	NA	NA	0	NA	NA
1988	NA	NA	NA	13	1	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	2	NA	NA	NA	NA	1	1	1	NA	NA	NA	3	NA	NA	NA
1990	NA	NA	0	4	1	1	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	3	1	18	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	3	1	3	0	NA	NA	4	NA	NA	0	NA	NA	NA	NA	NA	NA
1993	NA	NA	1	2	19	34	NA	NA	NA	NA	1	1	NA	NA	NA	NA	NA	NA
1994	NA	NA	52	36	14	15	NA	NA	NA	0	3	NA	NA	NA	NA	NA	NA	NA
1995	NA	1	4	16	135	168	NA	0	1	NA	4	NA	NA	NA	4	NA	NA	NA
1996	NA	5	27	55	68	37	NA	NA	3	1	1	NA	NA	NA	NA	NA	NA	NA
1997	NA	6	28	71	17	5	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	3	52	82	30	NA	NA	2	NA	1	0	NA	NA	NA	NA	0	NA
1999	NA	2	33	70	94	44	NA	NA	NA	NA	0	NA	NA	NA	1	NA	NA	NA
2000	NA	5	50	68	31	26	NA	NA	2	NA	1	NA	NA	NA	NA	1	NA	NA

2001	NA	0	11	28	81	50	NA	NA	NA	NA	2	NA	NA	NA	NA	NA	NA	NA
2002	NA	16	24	48	79	47	NA	NA	NA	2	3	NA	NA	NA	NA	1	0	NA
2003	NA	10	54	24	71	34	NA	1	5	1	5	NA	NA	NA	NA	0	0	NA
2004	NA	3	38	15	36	42	NA	NA	NA	NA	2	NA	NA	NA	0	1	NA	NA
2005	0	0	5	4	18	61	NA	NA	4	NA	1	NA	NA	NA	NA	NA	NA	NA
2006	NA	1	22	25	34	24	NA	NA	1	NA	NA	NA	NA	NA	0	NA	NA	NA
2007	NA	3	13	10	30	133	NA	NA	4	NA	3	4	NA	NA	NA	NA	NA	NA
2008	NA	3	42	31	121	157	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	0	6	7	17	91	67	NA	NA	0	1	2	NA	NA	NA	NA	NA	NA	NA
2010	1	6	59	19	62	87	NA	NA	1	1	2	NA	NA	NA	NA	0	NA	NA
2011	NA	2	14	1	256	290	NA	NA	0	2	1	3	NA	NA	NA	NA	NA	NA
2012	1	17	31	28	49	81	NA	NA	1	NA	1	NA	NA	NA	NA	NA	NA	NA

Table 15. Continued.

	Delaware						New Jersey					
Year	1	2	3	4	5	6	1	2	3	4	5	6
1981	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	13	NA	NA	NA	1	NA	NA	NA
1987	NA	NA	NA	NA	3	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	1	6	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	8	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	20	NA	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

1996	NA	NA	0	NA	1	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	1	1	NA	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
2001	NA	NA	NA	NA	1	NA	NA	0	6	0	NA	NA
2002	NA	NA	3	8	NA	NA	NA	NA	0	2	NA	NA
2003	NA	NA	NA	NA	NA	NA	NA	NA	1	1	NA	NA
2004	NA	NA	1	NA	NA	NA	NA	NA	2	NA	NA	NA
2005	NA	NA	1	1	1	NA	NA	3	6	0	NA	NA
2006	NA	NA	NA	8	1	NA	NA	32	8	0	NA	NA
2007	NA	NA	1	NA	4	1	NA	NA	0	NA	1	NA
2008	NA	NA	4	12	NA	NA	NA	NA	6	2	0	NA
2009	NA	NA	19	NA	NA	NA	NA	0	4	NA	NA	NA
2010	NA	NA	4	2	NA	NA	NA	NA	3	NA	NA	NA
2011	NA	NA	6	NA	1	NA	NA	NA	4	1	2	NA
2012	NA	NA	0	NA	0	NA	NA	4	0	NA	NA	NA

Table 16. Estimated harvest in pounds by year and state from MRFSS data 1981-2003 where no harvest estimates were made because no fish were measured in a particular strata.

Year	DE	FL	GA	MD	NC	NJ	SC	VA	total
1981	77,861	0	0	0	0	0	3,039	0	80,900
1982	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0
1984	0	0	0	90,723	0	0	0	0	90,723
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	0	0	4,858	0	0	0	0	4,858
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	1,654	0	1,654
1990	0	127,069	6,050	0	234	0	691	0	134,045
1991	0	0	3,674	0	0	0	0	0	3,674
1992	0	0	0	0	0	0	0	21,001	21,001
1993	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	2,916	2,916
1995	0	0	0	0	0	0	0	13,898	13,898
1996	0	0	0	0	0	0	0	0	0
1997	0	10,977	0	0	0	0	0	0	10,977
1998	0	0	0	5,469	0	0	0	2,552	8,021
1999	0	0	0	0	0	0	0	87,723	87,723
2000	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	61,832	0	0	61,832
2002	0	0	0	0	0	0	1,831	0	1,831
2003	0	0	0	0	0	0	0	0	0

Table 17. Sample size of black drum length samples collected during MRIP at-sea headboat sampling.

Year	Number of Length Observations
2005	1
2006	18
2007	36
2008	3
2009	4
2010	5
2012	1

Table 18. Mean weights used to calculate total weight of MRFSS/MRIP released alive fish (B2).

State / Waves	Years	Mean Weight (lbs.)	n
NJ waves 2-3	1981-2012	23.92	81
NJ wave 4	1981-2012	7.59	6
NJ waves 5-6	1981-2012	33.29	3
DE waves 2-3	1981-2012	36.29	40
DE wave 4	1981-2012	2.75	33
DE waves 5-6	1981-2012	0.89	63
MD waves 2-3	1981-2012	37.82	15
MD wave 4	1981-2012	43.72	20
MD waves 5-6	1981-2012	NA	0
VA wave 2-3	1981-2012	29.87	52
VA wave 4	1981-2012	20.14	12
VA waves 5-6	1981-2012	5.68	46
NC	1981-2012	1.52	4145
SC	1981-2006	2.17	598
GA	1981-1997	1.53	686
FL	1981-1988	2.02	500

Table 19. Total weight (lbs.) of coast wide released alive fish estimated in MRFSS/MRIP.

Year	Coast Wide Released Alive (B2) Total Weight (lbs.)
1981	6,344
1982	930
1983	7,199
1984	47,321
1985	34,623
1986	123,268
1987	90,196
1988	110,116
1989	41,524
1990	96,974
1991	306,783
1992	117,389
1993	226,619
1994	257,816
1995	462,139
1996	602,757
1997	429,670
1998	735,718
1999	507,930
2000	567,436
2001	945,515
2002	787,602
2003	733,961
2004	797,094
2005	758,093
2006	1,637,040
2007	1,629,792
2008	1,671,308
2009	1,081,249
2010	1,134,273
2011	1,032,739
2012	1,401,612

Table 20. Total harvest (A+B1) in pounds and PSE from uncalibrated and calibrated MRFSS.

Year	MRFSS Harvest Estimate (lbs.)	MRFSS Harvest Estimate PSE	Calibrated Harvest Estimate (lbs.)	Calibrated Harvest Estimate PSE	Harvest Estimate Change (lbs.)
1981	298,429	12.0	307,719	14.0	9,290
1982	275,924	25.7	284,514	28.0	8,590
1983	1,775,688	17.2	1,830,967	19.2	55,279
1984	715,742	21.8	738,024	23.9	22,282
1985	917,665	18.8	946,233	20.8	28,568
1986	1,191,836	14.7	1,228,939	16.7	37,103
1987	856,237	19.3	882,893	21.3	26,656
1988	464,019	18.3	478,464	20.3	14,445
1989	471,018	23.5	485,681	25.7	14,663
1990	325,432	34.0	335,563	36.7	10,131
1991	637,210	17.5	657,047	19.5	19,837
1992	824,260	15.8	849,920	17.8	25,660
1993	430,243	13.0	443,637	15.0	13,394
1994	698,744	13.4	720,497	15.4	21,753
1995	851,642	18.5	878,155	20.5	26,513
1996	682,635	18.2	703,886	20.2	21,251
1997	621,078	13.2	640,413	15.2	19,335
1998	656,584	16.5	677,024	18.5	20,440
1999	793,743	9.3	818,453	11.5	24,710
2000	1,797,098	11.7	1,853,044	13.7	55,946
2001	1,368,308	10.8	1,410,905	12.9	42,597
2002	833,367	12.1	859,311	14.1	25,944
2003	1,593,710	14.2	1,643,324	16.2	49,614

Table 21. Total harvest (A+B1) in numbers and PSE from uncalibrated and calibrated MRFSS.

Year	MRFSS Harvest Estimate	MRFSS Harvest Estimate PSE	Calibrated Harvest Estimate	Calibrated Harvest Estimate PSE	Harvest Estimate Change
1981	71,653	20.9	62,358	25.1	-9,295
1982	193,589	21.7	168,477	26.0	-25,112
1983	263,184	16.6	229,044	20.2	-34,140
1984	266,085	15.9	231,569	19.4	-34,516
1985	231,241	18.5	201,245	22.3	-29,996
1986	388,851	19.1	338,410	23.0	-50,441
1987	358,195	19.9	311,731	23.9	-46,464
1988	156,165	13.6	135,908	16.8	-20,257
1989	91,074	21.6	79,260	25.9	-11,814
1990	88,671	20.8	77,169	25.0	-11,502
1991	204,056	15.5	177,586	18.9	-26,470
1992	217,019	9.8	188,868	12.6	-28,151
1993	160,409	9.4	139,601	12.1	-20,808
1994	187,912	9.9	163,536	12.7	-24,376
1995	387,910	13.7	337,591	16.9	-50,319
1996	251,171	10.5	218,590	13.3	-32,581
1997	174,281	11.4	151,674	14.3	-22,607
1998	181,009	9.9	157,529	12.7	-23,480
1999	307,337	10.6	267,470	13.4	-39,867
2000	479,861	9.0	417,614	11.7	-62,247
2001	387,161	9.4	336,939	12.1	-50,222
2002	332,400	10.3	289,282	13.1	-43,118
2003	598,438	14.5	520,810	17.8	-77,628

Table 22. Total number of fish released alive (B2) in numbers and PSE from uncalibrated and calibrated MRFSS.

Year	MRFSS Released Alive Estimate	MRFSS Released Alive Estimate PSE	Calibrated Released Alive Estimate	Calibrated Released Alive Estimate PSE	Released Alive Estimate Change
1981	3,308	75.9	3,392	122.1	84
1982	417	100.0	428	160.8	11
1983	3,684	59.5	3,777	95.8	93
1984	11,303	45.8	11,589	73.9	286
1985	16,490	37.2	16,908	60.1	418
1986	61,095	30.9	62,642	50.1	1,547
1987	45,487	29.3	46,639	47.5	1,152
1988	55,393	35.2	56,796	56.9	1,403
1989	22,134	30.5	22,695	49.4	561
1990	48,516	24.1	49,745	39.3	1,229
1991	148,944	20.9	152,716	34.2	3,772
1992	58,353	18.0	59,831	29.7	1,478
1993	105,052	16.5	107,713	27.3	2,661
1994	113,527	13.3	116,402	22.4	2,875
1995	173,550	11.7	177,945	19.9	4,395
1996	130,729	13.9	134,040	23.3	3,311
1997	165,728	13.7	169,925	23.0	4,197
1998	261,169	12.3	267,784	20.8	6,615
1999	260,274	9.1	266,866	16.0	6,592
2000	287,928	11.8	295,220	20.1	7,292
2001	417,130	10.6	427,695	18.3	10,565
2002	306,309	12.8	314,067	21.6	7,758
2003	307,738	9.3	315,532	16.3	7,794

Table 23. Estimated number of saltwater participants in each state from 1950-2013 based on USFWS fishing license data and FHWAR census.

Year	DE	FL	GA	MD	NJ	NC	SC	VA
1950	5,926	265,900	58,689	45,387	80,422	95,637	44,789	130,062
1951	6,110	274,187	60,518	46,801	82,928	98,618	46,185	134,116
1952	6,295	282,475	62,347	48,216	85,435	101,598	47,581	138,169
1953	6,480	290,762	64,176	49,630	87,941	104,579	48,977	142,223
1954	6,665	299,049	66,006	51,045	90,448	107,560	50,373	146,277
1955	6,849	307,337	67,835	52,459	92,954	110,541	51,769	150,330
1956	7,034	315,624	69,664	53,874	95,461	113,521	53,165	154,384
1957	7,219	323,911	71,493	55,289	97,968	116,502	54,561	158,438
1958	7,403	332,199	73,322	56,703	100,474	119,483	55,957	162,491
1959	7,895	365,676	83,528	56,631	179,199	77,808	58,865	150,237
1960	8,087	374,577	84,808	58,010	183,561	79,702	60,298	153,894
1961	8,702	414,720	87,064	58,511	104,646	113,602	64,063	142,102
1962	8,196	391,199	89,882	73,867	103,705	112,338	69,651	148,620
1963	7,332	399,699	99,412	69,019	107,664	112,518	77,411	152,512
1964	8,372	418,956	104,567	74,949	113,146	129,586	79,839	161,955
1965	8,120	442,416	117,125	82,622	116,827	143,987	86,452	172,459
1966	7,952	453,819	131,537	88,934	119,166	149,296	79,277	182,655
1967	8,911	493,510	120,220	90,285	121,613	160,514	103,793	191,333
1968	8,650	496,090	114,606	100,562	141,187	167,869	105,401	206,204
1969	9,776	521,289	114,150	86,776	149,627	175,485	118,824	217,011
1970	6,699	562,752	118,638	85,161	145,519	176,272	88,347	232,996
1971	8,196	705,592	126,846	92,728	158,116	176,823	94,301	233,635
1972	6,456	731,204	130,360	97,156	158,416	181,544	101,932	252,805
1973	10,093	772,865	134,834	101,476	173,348	199,445	107,716	272,907
1974	11,735	834,392	144,253	112,040	174,222	217,449	117,847	295,247
1975	11,581	870,670	149,037	104,120	191,718	220,220	123,102	248,908
1976	11,199	821,995	144,075	97,919	172,519	207,841	128,982	233,888
1977	11,160	739,438	133,881	113,261	154,994	190,099	121,552	242,880

Year	DE	FL	GA	MD	NJ	NC	SC	VA
1978	11,236	667,847	128,013	96,774	132,414	183,570	116,870	226,124
1979	11,414	716,261	132,393	101,510	150,084	183,452	116,626	242,359
1980	11,935	588,882	129,388	99,517	145,920	175,120	116,110	247,867
1981	12,909	581,532	142,225	87,394	150,357	179,784	122,976	279,302
1982	13,155	563,339	124,649	88,698	160,509	179,074	113,596	287,828
1983	13,819	607,404	130,869	88,414	158,133	182,963	115,678	266,607
1984	14,143	649,083	138,965	92,488	166,822	125,261	108,849	259,888
1985	14,497	684,301	142,115	168,257	170,086	170,115	115,252	277,734
1986	15,568	687,402	142,018	267,153	174,162	170,657	113,209	292,186
1987	14,895	645,483	137,284	261,254	181,873	164,443	97,684	292,464
1988	15,991	644,860	131,507	271,691	185,196	152,247	104,500	293,088
1989	15,980	632,557	125,219	195,314	183,184	161,918	108,359	233,749
1990	16,372	693,183	117,966	416,966	190,422	165,753	108,705	235,724
1991	18,370	731,261	117,930	459,474	185,774	170,443	106,321	237,249
1992	18,431	775,458	125,913	340,235	179,001	184,647	117,195	249,572
1993	17,753	745,297	129,800	334,743	181,118	202,442	123,896	273,545
1994	20,004	777,864	136,200	351,490	174,618	209,046	149,579	290,893
1995	19,991	791,477	142,395	374,674	176,954	243,362	160,257	298,034
1996	21,154	770,610	151,340	359,309	169,755	251,122	170,785	290,376
1997	19,114	782,742	127,550	232,858	167,124	253,050	182,696	296,726
1998	17,233	806,434	108,233	234,467	159,826	257,454	192,441	278,159
1999	16,137	935,546	96,422	223,613	126,737	315,623	199,857	264,757
2000	14,652	925,380	79,597	211,863	123,355	323,887	200,097	256,100
2001	13,487	871,024	59,975	204,808	128,548	351,919	217,396	246,155
2002	13,772	846,377	66,677	215,623	123,193	341,942	217,542	241,153
2003	12,834	796,720	68,861	207,467	121,697	310,993	196,827	230,220
2004	15,019	815,838	77,563	223,609	126,615	314,028	211,385	248,650
2005	13,947	767,444	79,255	215,011	125,031	284,526	191,176	237,267
2006	14,997	933,356	86,736	210,065	128,758	283,825	199,235	254,140
2007	15,579	1,008,471	92,073	177,450	123,494	290,660	196,328	266,515
2008	16,269	1,057,003	90,769	158,516	122,676	302,977	198,856	283,067

Year	DE	FL	GA	MD	NJ	NC	SC	VA
2009	17,856	1,085,113	93,441	158,725	123,630	388,134	205,280	328,299
2010	18,198	1,079,780	96,030	139,472	132,777	450,868	202,744	289,357
2011	70,484	1,059,224	95,167	136,889	136,530	470,477	208,585	305,352
2012	72,078	1,140,376	96,648	141,931	144,352	478,201	250,580	306,960
2013	67,736	1,066,988	105,798	134,786	140,387	491,486	223,108	303,023

Table 24. Historical recreational landings of Black Drum (numbers, A+B1) by state from 1950-1980 estimated using USFWS fishing license data and FHWAR census (1950-1980), MRFSS (1981-2003), and MRIP (2004-2012).

Year	DE	FL	GA	MD	NJ	NC	SC	VA	total
1950	320	60,450	5,565	2,328	1,045	1,662	4,815	4,339	80,524
1951	330	62,334	5,739	2,400	1,077	1,714	4,965	4,474	83,033
1952	340	64,219	5,912	2,473	1,110	1,766	5,115	4,609	85,543
1953	350	66,103	6,086	2,545	1,142	1,817	5,265	4,745	88,053
1954	360	67,987	6,259	2,618	1,175	1,869	5,415	4,880	90,563
1955	370	69,871	6,432	2,690	1,207	1,921	5,565	5,015	93,072
1956	380	71,755	6,606	2,763	1,240	1,973	5,715	5,150	95,582
1957	390	73,639	6,779	2,836	1,272	2,025	5,865	5,286	98,092
1958	400	75,523	6,953	2,908	1,305	2,076	6,015	5,421	100,601
1959	427	83,134	7,921	2,904	2,327	1,352	6,328	5,012	109,405
1960	437	85,157	8,042	2,975	2,384	1,385	6,482	5,134	111,997
1961	470	94,284	8,256	3,001	1,359	1,974	6,887	4,741	120,971
1962	443	88,936	8,523	3,788	1,347	1,952	7,487	4,958	117,435
1963	396	90,869	9,427	3,540	1,398	1,955	8,321	5,088	120,995
1964	453	95,247	9,916	3,844	1,470	2,252	8,582	5,403	127,165
1965	439	100,580	11,106	4,237	1,517	2,502	9,293	5,753	135,429
1966	430	103,173	12,473	4,561	1,548	2,594	8,522	6,093	139,394
1967	482	112,196	11,400	4,630	1,580	2,789	11,157	6,383	150,617
1968	468	112,782	10,868	5,158	1,834	2,917	11,330	6,879	152,235
1969	528	118,511	10,824	4,450	1,943	3,050	12,773	7,240	159,320
1970	362	127,938	11,250	4,368	1,890	3,063	9,497	7,773	166,140
1971	443	160,411	12,028	4,756	2,054	3,073	10,137	7,794	200,696
1972	349	166,234	12,361	4,983	2,058	3,155	10,957	8,434	208,531
1973	546	175,705	12,786	5,204	2,251	3,466	11,579	9,104	220,642
1974	634	189,693	13,679	5,746	2,263	3,779	12,668	9,850	238,312
1975	626	197,940	14,132	5,340	2,490	3,827	13,233	8,304	245,893
1976	605	186,875	13,662	5,022	2,241	3,612	13,865	7,803	233,684
1977	603	168,106	12,695	5,809	2,013	3,304	13,066	8,103	213,699
1978	607	151,830	12,139	4,963	1,720	3,190	12,563	7,544	194,556
1979	617	162,837	12,554	5,206	1,949	3,188	12,537	8,085	206,974

Year	DE	FL	GA	MD	NJ	NC	SC	VA	total
1980	645	133,878	12,269	5,104	1,895	3,043	12,481	8,269	177,585
1981	1,307	47,839	3,190				7,521	2,501	62,357
1982		150,049	7,366			1,464	9,597		168,476
1983		156,382	8,587	11,582	2,054		23,638	26,802	229,044
1984		209,277	12,392	1,667			6,592	1,641	231,569
1985	99	142,483	33,797	815		4,522	14,629	4,900	201,246
1986	12,710	225,549	47,900	4,933	2,435	16,272	18,370	10,241	338,410
1987	821	202,856	35,151	2,627		36,242	23,800	10,235	311,731
1988		93,375	18,733			9,184	13,549	1,066	135,907
1989		32,133	34,082	3,728		343	7,941	1,034	79,261
1990	1,483	45,900	14,122			1,838	13,096	731	77,170
1991	1,949	134,139	28,456			7,582	4,457	1,003	177,586
1992		148,984	16,554			6,855	11,836	4,639	188,867
1993	3,295	74,617	18,046			28,009	14,043	1,590	139,600
1994		92,482	15,886			46,425	7,515	1,228	163,536
1995		48,811	21,806	3,537		237,087	23,301	3,050	337,592
1996	179	67,268	5,847			117,424	24,397	3,475	218,590
1997	358	58,040	8,700			46,218	37,798	560	151,674
1998	359	97,823	4,680	565		39,008	12,247	2,847	157,529
1999	621	106,799	4,849	460		101,307	44,382	9,054	267,472
2000	1,039	205,273	54,512	839		98,520	55,075	2,357	417,614
2001	1,205	180,649	11,627		6,947	125,397	10,069	1,044	336,939
2002	2,884	58,330	20,081	2,922	4,783	171,629	24,695	3,957	289,282
2003		119,395	38,207	1,878	13,775	237,608	100,000	9,948	520,811
2004	320	94,967	18,568	2,351	15,152	97,262	18,384	2,485	249,489
2005	1,303	103,462	20,355		19,998	75,924	83,874	9,439	314,355
2006	11,462	66,415	20,080	701	42,070	92,956	93,364	1,556	328,604
2007	4,152	144,434	50,670		21,095	209,372	96,494	21,697	547,914
2008	6,973	175,195	91,777		74,982	359,702	54,490	26,097	789,216
2009	1,151	126,384	15,610		35,782	92,058	18,578	21,535	311,098
2010	1,450	127,214	69,547	2,731	8,593	122,709	33,178	730	366,152
2011	918	236,625	10,590		8,590	211,396	13,660	30,386	512,165
2012	111	74,596	19,134		526	139,363	28,006	1,577	263,313

Table 25. Historical recreational landings of Black Drum (1,000 lbs, A+B1) by state from 1950-1980 estimated using USFWS fishing license data and FHWAR census (1950-1980), MRFSS (1981-2003), and MRIP (2004-2012).

Year	DE	FL	GA	MD	NJ	NC	SC	VA	Total
1950	18.4	148.8	7.9	125.8	36.3	1.9	12.0	141.6	492.6
1951	19.0	153.4	8.1	129.7	37.4	1.9	12.4	146.0	507.9
1952	19.6	158.0	8.4	133.6	38.5	2.0	12.8	150.4	523.3
1953	20.2	162.7	8.6	137.5	39.7	2.0	13.1	154.8	538.6
1954	20.7	167.3	8.8	141.5	40.8	2.1	13.5	159.2	554.0
1955	21.3	171.9	9.1	145.4	41.9	2.2	13.9	163.6	569.3
1956	21.9	176.6	9.3	149.3	43.1	2.2	14.3	168.0	584.7
1957	22.5	181.2	9.6	153.2	44.2	2.3	14.6	172.5	600.0
1958	23.0	185.8	9.8	157.2	45.3	2.3	15.0	176.9	615.4
1959	24.6	204.6	11.2	157.0	80.9	1.5	15.8	163.5	659.0
1960	25.2	209.6	11.4	160.8	82.8	1.6	16.2	167.5	674.9
1961	27.1	232.0	11.7	162.2	47.2	2.2	17.2	154.7	654.2
1962	25.5	218.9	12.0	204.7	46.8	2.2	18.7	161.8	690.5
1963	22.8	223.6	13.3	191.3	48.6	2.2	20.8	166.0	688.6
1964	26.0	234.4	14.0	207.7	51.0	2.5	21.4	176.3	733.4
1965	25.3	247.5	15.7	229.0	52.7	2.8	23.2	187.7	783.9
1966	24.7	253.9	17.6	246.5	53.8	2.9	21.3	198.8	819.5
1967	27.7	276.1	16.1	250.2	54.9	3.1	27.8	208.3	864.2
1968	26.9	277.5	15.4	278.7	63.7	3.3	28.3	224.4	918.2
1969	30.4	291.6	15.3	240.5	67.5	3.4	31.9	236.2	916.8
1970	20.8	314.8	15.9	236.0	65.7	3.4	23.7	253.6	934.0
1971	25.5	394.7	17.0	257.0	71.3	3.4	25.3	254.3	1,048.6
1972	20.1	409.1	17.5	269.3	71.5	3.5	27.3	275.2	1,093.4
1973	31.4	432.4	18.1	281.2	78.2	3.9	28.9	297.0	1,171.1
1974	36.5	466.8	19.3	310.5	78.6	4.2	31.6	321.4	1,269.0
1975	36.0	487.1	20.0	288.6	86.5	4.3	33.0	270.9	1,226.4
1976	34.8	459.9	19.3	271.4	77.8	4.0	34.6	254.6	1,156.4

Year	DE	FL	GA	MD	NJ	NC	SC	VA	Total
1977	34.7	413.7	17.9	313.9	69.9	3.7	32.6	264.4	1,150.8
1978	35.0	373.6	17.2	268.2	59.7	3.6	31.3	246.1	1,034.7
1979	35.5	400.7	17.7	281.3	67.7	3.6	31.3	263.8	1,101.7
1980	37.1	329.4	17.3	275.8	65.8	3.4	31.1	269.8	1,029.9
1981	80.3	114.8	7.9				6.7	98.0	307.7
1982		261.6	6.5			2.8	13.6		284.5
1983		339.2	7.0	621.9	71.3		63.5	728.1	1,831.0
1984		566.1	32.8	93.5			5.6	39.9	738.0
1985	0.1	482.3	38.8	45.3		4.0	65.2	310.6	946.2
1986	3.3	340.5	54.2	226.8	107.2	64.1	25.3	407.6	1,228.9
1987	0.6	237.2	47.3	5.0		53.1	62.9	476.7	882.9
1988		266.7	29.7			82.0	62.8	37.3	478.5
1989		135.2	46.1	199.0		2.2	47.3	55.8	485.7
1990	2.5	237.3	59.6			4.1	23.7	8.4	335.6
1991	1.4	441.6	103.1		0.0	10.9	14.3	85.7	657.0
1992		500.4	31.0			20.7	31.2	266.6	849.9
1993	1.2	336.8	27.7			32.5	44.4	1.1	443.6
1994		499.7	102.9			95.6	16.3	5.9	720.5
1995		329.8	55.4	153.8		234.7	68.9	35.7	878.2
1996	4.2	340.7	8.9	0.0		178.3	71.0	100.8	703.9
1997	11.7	203.5	29.2	0.0		161.9	196.8	37.3	640.4
1998	16.0	380.0	19.6	5.6		105.7	53.3	96.8	677.0
1999	2.3	444.1	12.4	8.8		176.1	84.3	90.5	818.5
2000	6.6	1,068.5	194.8	17.7		267.7	285.2	12.5	1,853.0
2001	0.4	931.4	33.5	0.0	233.9	194.1	17.3	0.3	1,410.9
2002	6.1	240.4	25.7	10.6	9.8	489.4	62.4	15.0	859.3
2003	0.0	552.4	139.3	12.7	220.9	366.8	251.5	99.7	1,643.3
2004	2.6	412.0	58.0	20.9	809.3	221.9	30.2	11.9	1,566.7
2005	25.9	520.9	46.5	0.0	519.6	63.2	59.0	83.3	1,318.5
2006	23.6	452.5	33.1	25.2	792.9	162.9	63.0	26.8	1,580.2

Year	DE	FL	GA	MD	NJ	NC	SC	VA	Total
2007	14.8	576.0	84.5	0.0	202.4	220.5	71.5	238.7	1,408.4
2008	19.8	817.8	244.4	0.0	2,998.2	524.1	115.0	497.9	5,217.3
2009	43.0	464.7	30.2	0.0	1,435.9	121.0	42.8	1,036.3	3,173.8
2010	76.3	516.4	169.3	48.2	251.6	305.5	114.3	8.2	1,489.8
2011	15.8	867.7	19.5	0.0	126.6	151.4	46.8	284.3	1,512.2
2012	2.9	315.8	59.3	0.0	13.7	244.0	103.1	5.5	744.3

Table 26. Coastwide recreational (A+B1) and commercial harvest of Black Drum in pounds from 1950-2012.

Year	Recreational Harvest (lbs)	Commercial Harvest (lbs)	Total Harvest (lbs)
1950	492,568	269,400	761,968
1951	507,920	332,700	840,620
1952	523,272	239,800	763,072
1953	538,624	291,600	830,224
1954	553,976	554,700	1,108,676
1955	569,328	260,200	829,528
1956	584,680	311,600	896,280
1957	600,032	286,700	886,732
1958	615,385	138,800	754,185
1959	658,962	345,400	1,004,362
1960	674,900	339,100	1,014,000
1961	654,192	393,500	1,047,692
1962	690,539	597,400	1,287,939
1963	688,555	528,900	1,217,455
1964	733,423	281,700	1,015,123
1965	783,861	401,500	1,185,361
1966	819,474	664,100	1,483,574
1967	864,234	392,500	1,256,734
1968	918,188	453,600	1,371,788
1969	916,837	286,300	1,203,137
1970	933,971	228,400	1,162,371
1971	1,048,601	316,200	1,364,801
1972	1,093,397	187,076	1,280,473
1973	1,171,110	170,096	1,341,206
1974	1,268,956	188,044	1,457,000
1975	1,226,382	319,911	1,546,293
1976	1,156,437	188,653	1,345,090
1977	1,150,828	176,969	1,327,797

Year	Recreational Harvest (lbs)	Commercial Harvest (lbs)	Total Harvest (lbs)
1978	1,034,724	174,465	1,209,189
1979	1,101,653	165,345	1,266,998
1980	1,029,900	141,397	1,171,297
1981	307,719	241,603	549,322
1982	284,514	221,878	506,392
1983	1,830,967	195,235	2,026,202
1984	738,024	162,611	900,635
1985	946,233	121,857	1,068,090
1986	1,228,939	346,246	1,575,185
1987	882,893	245,421	1,128,314
1988	478,464	294,404	772,868
1989	485,681	140,276	625,957
1990	335,563	201,132	536,695
1991	657,047	245,665	902,712
1992	849,920	210,156	1,060,076
1993	443,637	252,520	696,157
1994	720,497	292,933	1,013,430
1995	878,155	270,728	1,148,883
1996	703,886	312,442	1,016,328
1997	640,413	313,802	954,215
1998	677,024	134,509	811,533
1999	818,453	335,231	1,153,685
2000	1,853,044	240,184	2,093,228
2001	1,410,905	184,993	1,595,898
2002	859,311	555,506	1,414,816
2003	1,643,324	289,312	1,932,636
2004	1,566,705	162,661	1,729,366
2005	1,318,521	130,243	1,448,764
2006	1,580,160	221,212	1,801,372
2007	1,408,391	292,579	1,700,970

Year	Recreational Harvest (lbs)	Commercial Harvest (lbs)	Total Harvest (lbs)
2008	5,217,281	404,690	5,621,971
2009	3,173,841	285,262	3,459,103
2010	1,489,802	207,898	1,697,700
2011	1,512,221	188,359	1,700,580
2012	744,266	238,163	982,429

Table 27. Number of type A and B1 fish recorded on intercepts made in New Jersey, by wave, from 2004-2011. Years and waves with unusually high numbers of Black Drum observed that cause spike in estimated harvest are highlighted.

Year	wave 2	wave 3	wave 4	wave 5	wave 6	total
	New Jersey					
2004	0	13	0	0		13
2005	3	14	6	7		30
2006	77	13	1	0		91
2007	0	12	1	5		18
2008	0	129	3	58		190
2009	4	70	1	22		97
2010	0	16	0	16		32
2011	0	13	1	3		18
	Virginia					
2004	0	9	1	17	0	27
2005	0	8	6	13	0	27
2006	0	2	0	11	0	13
2007	0	6	2	17	22	47
2008	0	34	4	1	0	39
2009	1	22	1	9	0	33
2010	0	2	13	15	0	30
2011	0	5	9	25	7	46

Table 28. Coastwide estimates of number and weight of Black Drum released alive (type B2) from 1950-2012.

Year	Estimate	Released Alive (B2) Numbers	PSE	Released Alive (lbs)
1950	Historical Method	3,009	NA	12,163
1951	Historical Method	3,102	NA	12,542
1952	Historical Method	3,196	NA	12,921
1953	Historical Method	3,290	NA	13,300
1954	Historical Method	3,384	NA	13,679
1955	Historical Method	3,477	NA	14,058
1956	Historical Method	3,571	NA	14,437
1957	Historical Method	3,665	NA	14,817
1958	Historical Method	3,759	NA	15,196
1959	Historical Method	4,129	NA	15,898
1960	Historical Method	4,224	NA	16,276
1961	Historical Method	4,596	NA	17,091
1962	Historical Method	4,490	NA	18,994
1963	Historical Method	4,642	NA	18,600
1964	Historical Method	4,874	NA	19,870
1965	Historical Method	5,216	NA	21,581
1966	Historical Method	5,419	NA	22,808
1967	Historical Method	5,758	NA	23,733
1968	Historical Method	5,780	NA	25,220
1969	Historical Method	5,987	NA	23,738
1970	Historical Method	6,266	NA	24,046
1971	Historical Method	7,588	NA	27,735
1972	Historical Method	7,873	NA	28,914
1973	Historical Method	8,296	NA	30,351
1974	Historical Method	8,960	NA	33,125
1975	Historical Method	9,294	NA	32,688
1976	Historical Method	8,840	NA	30,936
1977	Historical Method	8,092	NA	31,581
1978	Historical Method	7,365	NA	27,852
1979	Historical Method	7,826	NA	29,421
1980	Historical Method	6,711	NA	26,907

Year	Estimate	Released Alive (B2) Numbers	PSE	Released Alive (lbs)
1981	Calibrated MRFSS	3,392	122.09	6,344
1982	Calibrated MRFSS	428	160.76	930
1983	Calibrated MRFSS	3,777	95.80	7,199
1984	Calibrated MRFSS	11,589	73.86	49,554
1985	Calibrated MRFSS	16,908	60.11	55,156
1986	Calibrated MRFSS	62,642	50.07	123,745
1987	Calibrated MRFSS	46,639	47.52	95,193
1988	Calibrated MRFSS	56,796	56.92	110,116
1989	Calibrated MRFSS	22,695	49.43	41,524
1990	Calibrated MRFSS	49,745	39.27	105,287
1991	Calibrated MRFSS	152,716	34.21	325,683
1992	Calibrated MRFSS	59,831	29.65	117,389
1993	Calibrated MRFSS	107,713	27.31	307,930
1994	Calibrated MRFSS	116,402	22.35	276,624
1995	Calibrated MRFSS	177,945	19.91	683,140
1996	Calibrated MRFSS	134,040	23.28	599,635
1997	Calibrated MRFSS	169,925	22.97	484,098
1998	Calibrated MRFSS	267,784	20.82	838,435
1999	Calibrated MRFSS	266,866	16.03	532,730
2000	Calibrated MRFSS	295,220	20.06	579,256
2001	Calibrated MRFSS	427,695	18.25	1,674,553
2002	Calibrated MRFSS	314,067	21.59	2,129,937
2003	Calibrated MRFSS	315,532	16.32	962,249
2004	MRIP	299,672	23.10	811,441
2005	MRIP	274,519	14.80	1,502,470
2006	MRIP	376,009	15.00	2,684,223
2007	MRIP	669,818	14.50	2,322,351
2008	MRIP	892,610	16.10	6,624,806
2009	MRIP	399,924	23.60	3,173,140
2010	MRIP	465,820	13.40	1,825,018
2011	MRIP	326,477	15.30	1,969,868
2012	MRIP	381,857	12.80	1,828,571

Table 29. PSE for total harvest (A+B1) of Black Drum in numbers, by year and state from uncalibrated MRFSS (1981-2003) and MRIP (2004-2012).

Year	DE	FL	GA	MD	NJ	NC	SC	VA
1981	100.0	25.4	52.7				45.3	100.0
1982		24.2	38.7			63.5	29.6	
1983		21.8	42.3	24.0	74.3		57.6	31.2
1984		17.3	36.9	100.0			55.1	100.0
1985	100.0	19.2	67.6	37.7		38.7	72.2	38.6
1986	88.7	27.4	20.2	66.4	37.6	61.9	32.4	30.0
1987	58.8	29.8	15.0	100.0		23.5	35.3	31.0
1988		17.4	24.2			60.8	36.9	58.4
1989		47.1	22.2	37.3		45.3	24.7	55.4
1990	67.7	27.4	55.4			35.4	46.0	100.0
1991	45.8	19.5	26.9		0.0	33.1	41.2	100.0
1992		11.9	21.7			28.3	28.1	34.0
1993	46.6	13.3	24.4			19.9	29.9	78.3
1994		13.5	25.4			19.9	23.9	56.8
1995		22.7	30.7	69.1		18.3	43.3	41.8
1996	74.4	25.1	43.3	0.0		11.8	25.8	57.7
1997	73.7	17.4	49.5	0.0		17.8	27.7	100.1
1998	100.0	13.3	40.7	99.5		17.6	34.9	58.8
1999	100.0	10.2	43.4	99.8		21.9	26.8	72.8
2000	73.3	11.6	24.9	100.1		18.2	33.2	58.2
2001	61.5	11.0	27.4	0.0	44.9	18.8	64.2	99.7
2002	72.4	12.8	37.0	66.4	61.7	15.4	29.8	46.1
2003	0.0	12.7	20.9	69.5	72.8	27.2	33.4	30.5
2004	88.1	25.1	29.9	71.3	64.9	19.0	34.9	63.3
2005	82.4	23.2	34.2	0.0	47.3	27.0	62.7	60.1
2006	83.1	23.1	35.6	105.4	53.7	21.5	32.3	79.7
2007	53.2	15.1	27.8	0.0	69.8	22.3	26.4	46.7
2008	68.0	13.9	23.3		26.7	20.6	27.8	48.7
2009	47.3	21.9	29.4		33.5	22.8	30.7	43.0
2010	80.3	13.3	37.0	99.6	51.0	20.5	34.9	67.8

2011	68.2	30.7	49.3	0.0	50.1	18.0	33.9	40.5
2012	46.6	19.8	33.3	0.0	89.4	15.9	38.5	74.9

Table 30. PSE for total harvest (A+B1) of Black Drum in pounds, by year and state from uncalibrated MRFSS (1981-2003) and MRIP (2004-2012).

Year	DE	FL	GA	MD	NJ	NC	SC	VA
1981	0	23	61				67	0
1982		28	44			114	35	
1983		24	46	28.8	77.1		64	32.5
1984		25	39	0			53	0
1985	0	24	50	38.6		52	64	40.5
1986	88.7	27	24	0	51.4	65	36	34.1
1987	58.8	26	21	0		30	36	32.4
1988		23	27			66	45	0
1989		60	23	37.4		82	56	14.3
1990	64.5	40	91			66	73	100
1991	48	21	69		0	30	54	0
1992		18	21			33	30	39.1
1993	47.3	16	27			25	33	70.9
1994		17	39			19	35	74
1995		30	33	72.2		17	47	97.4
1996	90	29	44	0		16	31	71.2
1997	0	21	54	0		20	32	0
1998	100	15	47	0		26	40	92.1
1999	0	12	43	0		18	33	0
2000	84.8	14	51	0		19	41	59.8
2001	62.1	13	33	0	39.3	21	43	99.8
2002	80.3	15	36	70.6	27.7	19	41	51.4
2003	0	15	26	68.2	80.3	19	36	37
2004	86.8	29	32	85.4	65	23	44	70
2005	101	24	32	0	41.8	33	42	66.9
2006	82.2	23	37	105	55	22	29	79.5
2007	68.6	19	27	0	62.9	19	26	57.6
2008	51.6	16	28		23.1	27	38	51.5
2009	46.5	22	29		36.3	20	28	49.2
2010	95	14	35	99.6	51.6	35	41	66

2011	66.6	30	41	0	67.6	18	38	20.6
2012	57	21	37	0	93.2	18	39	102

Table 31. PSE for total live releases (B2) of Black Drum in numbers, by year and state from uncalibrated MRFSS (1981-2003) and MRIP (2004-2012).

Year	DE	FL	GA	MD	NJ	NC	SC	VA
1981		100.0	100.0					
1982							100.0	
1983		71.9	94.8					
1984		53.2		100.0			100.0	
1985		46.9	46.4	71.6				
1986		39.2	37.5	100.0		100.0	74.8	
1987	100.0	34.7	41.4			72.7	100.0	
1988		40.6	46.7			100.0	79.4	
1989		47.2	44.1			100.0	56.9	
1990	79.1	26.6	71.2			100.0	100.0	
1991	100.0	22.5	62.9		100.0	43.9		
1992		20.0	31.0			100.0		
1993	55.8	19.1	62.2			30.4	56.9	75.3
1994		14.8	55.0			46.6	56.5	55.1
1995		18.9	70.8	100.0		16.8	62.2	30.8
1996		24.3	100.0	100.0		19.0	46.7	37.1
1997		18.2	100.0	100.0		20.5	50.5	45.4
1998	61.1	16.2	70.2			17.2	51.1	43.0
1999		12.5	43.4			13.3	31.2	82.4
2000		13.4	32.2			23.5	45.6	100.0
2001	70.9	16.7	36.0	100.0	52.1	15.6	46.6	33.9
2002	47.0	16.3	30.7	43.8	49.8	24.0	36.4	56.0
2003	46.1	15.1	26.3		100.0	14.9	96.4	31.0
2004	98.7	40.2	61.8			40.1	44.9	40.9
2005	60.2	23.3	38.1	72.5	76.4	25.6	54.7	56.1
2006	98.1	21.9	53.8		75.9	25.4	31.3	42.2
2007	41.6	22.6	33.5	96.4	52.8	27.0	36.6	51.2
2008	61.7	18.0	33.5		52.6	24.8	32.3	34.6
2009	78.7	21.3	40.1		80.7	28.5	26.8	58.7
2010	96.8	20.2	40.5	63.9	85.4	20.6	27.7	49.7

2011	109.2	26.7	52.3	78.8	85.9	20.8	36.3	45.8
2012	43.7	19.7	43.7	94.1	60.2	20.0	34.3	62.7

Table 32. Percentage of intercepted trips that caught Black Drum by area in each region. Areas that did not account for > 5% of positive Black Drum trips (shaded) were excluded.

Area	Mid-Atl	NC	GA & SC	NE FL	SE FL
Ocean <= 3 mi	12%	68%	21%	18%	32%
Ocean > 3 mi	3%	1%	5%	1%	1%
Inland	85%	31%	74%	81%	66%

Table 33. Percentage of trips that caught Black Drum by mode in each region. Modes that did not account for > 5% of positive Black Drum trips (shaded) were excluded.

Mode	Mid-Atl	NC	GA & SC	NE FL	SE FL
Pier, dock	11%	30%	14%	16%	13%
Jetty, breakwater, breachway	3%	0%	1%	3%	17%
Bridge, causeway	1%	5%	1%	5%	6%
Other man-made	1%	0%	0%	0%	2%
Beach or bank	6%	36%	2%	6%	5%
Head boat	8%	0%	2%	0%	0%
Charter boat	24%	1%	14%	1%	1%
Private/Rental boat	48%	28%	65%	68%	56%

Table 34. Percentage of trips that caught Black Drum by wave in each region. Waves that did not account for ≥ 5% of positive Black Drum trips (shaded) were excluded.

Wave	Mid-Atl	NC	GA & SC	NE FL	SE FL
1	0%	0%	1%	12%	25%
2	5%	3%	11%	15%	17%
3	47%	11%	17%	14%	10%
4	14%	17%	20%	13%	9%
5	31%	36%	26%	22%	15%
6	3%	33%	27%	24%	23%

Table 35. Number of trips in each region used in cluster analysis, number of clusters, number of species in the Black Drum cluster, and number of trips that caught one or more of the member species and thus retained for standardization.

	SEFL	NEFL	GA & SC	NC	Mid-Atl waves 2-3	Mid-Atl waves 4-5
number of trips after filtering	80,449	41,097	46,076	116,876	56,905	109,182
number of clusters	8	6	5	4	5	8
number of species in BD cluster	10	7	7	7	16	6
number of trips selected	47,805	14,242	25,955	30,040	43,696	35,060

Table 36. Results of excluding each explanatory variable considered in the full positive model for the coast wide MRFSS/MRIP index.

Variable Excluded	Df	Deviance	AIC	Scaled Deviance	Pr(>Chi)
<none>	NA	8057.935	27710.86	NA	NA
YEAR	30	8174.745	27807.52	156.6593678	4.37E-19
AREA_X	1	8061.195	27713.27	4.402237445	0.035892
MODE_F	4	8115.768	27780.71	77.84367477	4.99E-16
ST	5	8071.164	27718.72	17.85554197	0.003133
WAVE	5	8140.975	27812.46	111.6004353	1.88E-22

Table 37. Model fit summary and coefficient estimates for the final positive model for the coast wide MRFSS/MRIP index.

```
Call:
glm(formula = FinalPosForm, family = gaussian, data = trips_pr_pos,
    na.action = na.exclude)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.9866  -0.5604  -0.0744   0.5038   5.6550

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)   -1.480657   0.142589 -10.384  < 2e-16 ***
YEAR1983      -0.010901   0.153521  -0.071 0.943393
YEAR1984       0.208819   0.156215   1.337 0.181334
YEAR1985       0.086818   0.151800   0.572 0.567388
YEAR1986       0.459330   0.137449   3.342 0.000835 ***
YEAR1987       0.268558   0.136263   1.971 0.048763 *
YEAR1988       0.265734   0.151050   1.759 0.078565 .
YEAR1989       0.284350   0.156193   1.820 0.068711 .
YEAR1990       0.167374   0.163038   1.027 0.304634
YEAR1991       0.325834   0.144131   2.261 0.023799 *
YEAR1992       0.320559   0.137976   2.323 0.020182 *
YEAR1993       0.285726   0.136723   2.090 0.036657 *
YEAR1994       0.227216   0.134182   1.693 0.090420 .
YEAR1995       0.394463   0.130518   3.022 0.002515 **
YEAR1996       0.337062   0.130060   2.592 0.009566 **
YEAR1997       0.400972   0.134114   2.990 0.002798 **
YEAR1998       0.372299   0.130452   2.854 0.004327 **
YEAR1999       0.434516   0.127457   3.409 0.000654 ***
YEAR2000       0.420593   0.128542   3.272 0.001071 **
YEAR2001       0.480096   0.128275   3.743 0.000183 ***
YEAR2002       0.507506   0.128713   3.943 8.10e-05 ***
YEAR2003       0.421559   0.127809   3.298 0.000976 ***
YEAR2004       0.352275   0.129302   2.724 0.006451 **
YEAR2005       0.338528   0.131298   2.578 0.009941 **
YEAR2006       0.463820   0.129132   3.592 0.000330 ***
YEAR2007       0.561182   0.127092   4.416 1.02e-05 ***
YEAR2008       0.472935   0.126150   3.749 0.000178 ***
YEAR2009       0.484052   0.128320   3.772 0.000163 ***
YEAR2010       0.498569   0.127337   3.915 9.08e-05 ***
YEAR2011       0.570860   0.127031   4.494 7.07e-06 ***
```

```
YEAR2012           0.503261   0.127665   3.942 8.13e-05 ***
AREA_XOcean <=3 mi.  0.052504   0.025074   2.094 0.036290
*
MODE_FFor Hire      -0.309496   0.053221  -5.815 6.22e-09 ***
MODE_FPier/Dock      0.088804   0.028008   3.171 0.001525 **
MODE_FPrivate Boat  -0.100432   0.031969  -3.142 0.001685
**
MODE_FShore Other    0.008669   0.042450   0.204 0.838191
STFL               -0.022652   0.056445  -0.401 0.688204
STGA               -0.096970   0.057874  -1.676 0.093855 .
STMD/VA            -0.086736   0.066998  -1.295 0.195486
STNC                0.023768   0.056972   0.417 0.676547
STSC                0.036717   0.061713   0.595 0.551878
WAVE2              -0.108263   0.045423  -2.383 0.017168 *
WAVE3              -0.096430   0.042676  -2.260 0.023867 *
WAVE4              -0.111265   0.042636  -2.610 0.009077 **
WAVE5              -0.151731   0.040130  -3.781 0.000157 ***
WAVE6               0.074594   0.039790   1.875 0.060859 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 0.7434205)

    Null deviance: 8548.0  on 10884  degrees of freedom
Residual deviance: 8057.9  on 10839  degrees of freedom
AIC:
27711

Number of Fisher Scoring iterations: 2
```

Table 38. Results of excluding each explanatory variable considered in the full proportion positive model for the coast wide MRFSS/MRIP index.

Variable Excluded	Df	Deviance	AIC	Scaled Deviance	Pr(>Chi)
<none>	NA	73860.11	73952.11	NA	NA
YEAR	30	74797.43	74829.43	937.3173	8.49E-178
AREA_X	1	73870.7	73960.7	10.58876	0.001138
MODE_F	4	74573.26	74657.26	713.1512	4.95E-153
ST	5	78540.51	78622.51	4680.396	0
WAVE	5	74219.47	74301.47	359.361	1.69E-75

Table 39. Model fit summary and coefficient estimates for the final proportion positive model for the coast wide MRFSS/MRIP index.

```
Call:
glm(formula = FinalBinForm, family = binomial(link = "logit"),
    data = trips_pr, na.action = na.exclude)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.0047  -0.3912  -0.2744  -0.1308   3.4313

Coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)      -4.45269    0.16585 -26.848  < 2e-16
***
YEAR1983          0.61450    0.18139   3.388 0.000705
***
YEAR1984          0.40338    0.18651   2.163 0.030560
*
YEAR1985          0.17432    0.18033   0.967 0.333719
YEAR1986          1.00255    0.16421   6.105 1.03e-09
YEAR1987          0.69254    0.16262   4.259 2.06e-05
YEAR1988          0.17959    0.17977   0.999 0.317804
YEAR1989         -0.16219    0.18502  -0.877 0.380698
YEAR1990         -0.29368    0.19348  -1.518 0.129039
YEAR1991         -0.14057    0.17137  -0.820 0.412052
YEAR1992          0.30007    0.16433   1.826 0.067840
YEAR1993          0.16444    0.16273   1.011 0.312250
YEAR1994          0.24496    0.15958   1.535 0.124780
YEAR1995          0.45123    0.15487   2.914 0.003572
YEAR1996          0.89441    0.15472   5.781 7.44e-09
***
YEAR1997          0.36391    0.15958   2.280 0.022585
*
YEAR1998          0.58553    0.15524   3.772 0.000162
***
YEAR1999          0.96278    0.15172   6.346 2.21e-10
***
YEAR2000          0.79164    0.15305   5.173 2.31e-07
***
YEAR2001          0.87501    0.15266   5.732 9.95e-09
***
YEAR2002          0.63365    0.15297   4.142 3.44e-05
***
YEAR2003          0.99608    0.15207   6.550 5.75e-11
***
YEAR2004          0.68760    0.15383   4.470 7.82e-06
***
```

```
YEAR2005           0.41536    0.15599   2.663 0.007751
**
YEAR2006           0.66409    0.15350   4.326 1.52e-05
***
YEAR2007           0.93219    0.15129   6.161 7.21e-10
***
YEAR2008           1.23166    0.15031   8.194 2.52e-16
***
YEAR2009           0.77747    0.15277   5.089 3.59e-07
***
YEAR2010           0.70053    0.15151   4.624 3.77e-06
***
YEAR2011           0.78415    0.15095   5.195 2.05e-07
***
YEAR2012           0.41200    0.15173   2.715 0.006622
**
AREA_XOcean <=3 mi. -0.09155    0.02820  -3.246 0.001170 **
MODE_FFor Hire      -0.71873    0.06074 -11.833  < 2e-16 ***
MODE_FPier/Dock     -0.15510    0.03551  -4.368 1.26e-05 ***
MODE_FPrivate Boat  -0.84747    0.03690 -22.965  < 2e-16 ***
MODE_FShore Other   -0.27465    0.05139  -5.345 9.05e-08 ***
STFL              1.79208    0.06216  28.828  < 2e-16 ***
STGA               2.24518    0.06650  33.760  < 2e-16
***
STMD/VA            -0.03039    0.07568  -0.402 0.688016
STNC               2.50788    0.06176  40.604  < 2e-16 ***
STSC              1.81980    0.06938  26.228  < 2e-16 ***
WAVE2              -0.16865    0.05451  -3.094 0.001974
WAVE3              -0.16422    0.05125  -3.204 0.001355
WAVE4              -0.26007    0.05079  -5.121 3.05e-07
***
WAVE5              -0.09105    0.04833  -1.884 0.059566 .
WAVE6               0.29245    0.04782   6.116 9.61e-10
***
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’
1
(Dispersion parameter for binomial family taken to be 1)
    Null deviance: 84155  on 196609  degrees of freedom
Residual deviance: 73860  on 196564  degrees of freedom
AIC:
73952
Number of Fisher Scoring iterations: 7
```

Table 40. Coast wide MRFSS/MRIP standardized index of catch per unit effort.

Year	Standardized Index	SE	Var	CV	Lower 95% CI	Upper 95% CI	n
1982	0.00786	0.00149	2.23E-06	0.18992	0.00539	0.01145	1928
1983	0.01404	0.00273	7.46E-06	0.19446	0.00955	0.02065	2947
1984	0.01431	0.00265	7.04E-06	0.18540	0.00991	0.02067	1658
1985	0.01019	0.00158	2.49E-06	0.15486	0.00749	0.01386	4306
1986	0.03250	0.00483	2.33E-05	0.14853	0.02419	0.04367	3615
1987	0.02002	0.00367	1.35E-05	0.18344	0.01391	0.02880	3452
1988	0.01220	0.00238	5.66E-06	0.19493	0.00829	0.01795	2763
1989	0.00890	0.00186	3.47E-06	0.20931	0.00588	0.01347	3945
1990	0.00699	0.00117	1.38E-06	0.16803	0.00501	0.00976	3753
1991	0.00952	0.00148	2.19E-06	0.15540	0.00699	0.01297	5054
1992	0.01454	0.00219	4.78E-06	0.15036	0.01078	0.01960	4893
1993	0.01232	0.00179	3.19E-06	0.14504	0.00923	0.01644	4599
1994	0.01257	0.00168	2.83E-06	0.13381	0.00963	0.01641	6275
1995	0.01812	0.00243	5.90E-06	0.13406	0.01387	0.02366	6710
1996	0.02601	0.00376	1.41E-05	0.14443	0.01951	0.03467	5814
1997	0.01677	0.00228	5.20E-06	0.13598	0.01279	0.02198	6321
1998	0.02015	0.00257	6.58E-06	0.12734	0.01564	0.02597	6862
1999	0.03059	0.00399	1.59E-05	0.13047	0.02359	0.03967	7547
2000	0.02570	0.00331	1.10E-05	0.12874	0.01989	0.03322	8015
2001	0.02950	0.00381	1.45E-05	0.12907	0.02281	0.03815	8594
2002	0.02415	0.00308	9.48E-06	0.12747	0.01873	0.03113	9266
2003	0.03115	0.00405	1.64E-05	0.13008	0.02404	0.04036	8577
2004	0.02175	0.00294	8.62E-06	0.13498	0.01663	0.02846	8443
2005	0.01655	0.00215	4.64E-06	0.13018	0.01277	0.02144	7981
2006	0.02380	0.00299	8.93E-06	0.12558	0.01853	0.03056	8310
2007	0.03377	0.00411	1.69E-05	0.12162	0.02650	0.04303	9171
2008	0.04075	0.00510	2.60E-05	0.12521	0.03176	0.05230	8900

2009	0.02703	0.00340	1.15E-05	0.12560	0.02105	0.03472	8383
2010	0.02551	0.00318	1.01E-05	0.12475	0.01989	0.03270	9557
2011	0.02967	0.00372	1.38E-05	0.12540	0.02311	0.03809	9169
2012	0.01928	0.00442	1.95E-05	0.22919	0.01226	0.03031	9806

Table 41. Results of excluding each explanatory variable considered in the full positive observation model for the MRFSS/MRIP mature index.

Variable Excluded	Df	Deviance	AIC	Scaled Deviance	Pr(>Chi)
<none>	NA	129.7886	661.9409	NA	NA
YEAR	17	148.4036	668.9536	41.01277	0.00093
AREA_X	1	130.5656	661.7672	1.826373	0.176557
MODE_F	4	135.2759	666.6121	12.67122	0.012999
ST	3	130.8843	658.5132	2.572368	0.462354
WAVE	1	130.0056	660.452	0.51115	0.474641

Table 42. Model fit summary and coefficient estimates for the final positive observation model for the MRFSS/MRIP mature index.

```
Call:
glm(formula = FinalPosForm, family = gaussian, data =
trips_pr_pos,
    na.action = na.exclude)


Deviance Residuals:
     Min       1Q    Median       3Q      Max
-2.02015  -0.33703  -0.08784   0.35649   2.36662


Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.992660   0.473864  -4.205  3.5e-05 ***
YEAR1996     0.526169   0.415879   1.265  0.20684
YEAR1997    -0.442856   0.413225  -1.072  0.28476
YEAR1998    -0.048523   0.381608  -0.127  0.89891
YEAR1999    -1.470245   0.736886  -1.995  0.04697 *
YEAR2000    -1.731182   0.557852  -3.103  0.00211 **
YEAR2001     0.305841   0.376949   0.811  0.41784
YEAR2002     0.997290   0.483664   2.062  0.04012 *
YEAR2003    -0.028758   0.334238  -0.086  0.93150
YEAR2004     0.051433   0.323594   0.159  0.87383
YEAR2005    -0.024070   0.309205  -0.078  0.93801
YEAR2006     0.372302   0.301036   1.237  0.21721
YEAR2007     0.346791   0.355808   0.975  0.33056
YEAR2008     0.304780   0.294620   1.034  0.30179
YEAR2009     0.155692   0.292962   0.531  0.59553
YEAR2010     0.051433   0.320042   0.161  0.87244
YEAR2011    -0.059625   0.322450  -0.185  0.85343
YEAR2012    -0.006837   0.328125  -0.021  0.98339
```

```
MODE_F5      0.184749   0.443444   0.417  0.67727
MODE_F6      0.347946   0.389994   0.892  0.37305
MODE_F7      0.271643   0.389082   0.698  0.48565
MODE_F8      0.572533   0.383966   1.491  0.13704
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’
1
(Dispersion parameter for gaussian family taken to be 0.4636057)

    Null deviance: 158.30  on 305  degrees of freedom
Residual deviance: 131.66  on 284  degrees of freedom
AIC: 656.33
Number of Fisher Scoring iterations: 2
```

Table 43. Results of excluding each explanatory variable considered in the full proportion positive model for the MRFSS/MRIP mature index.

Variable Excluded	Df	Deviance	AIC	Scaled Deviance	Pr(>Chi)
<none>	NA	2964.081	3018.081	NA	NA
YEAR	17	3088.541	3108.541	124.4607	2.17E-18
AREA_X	1	3052.583	3104.583	88.50213	5.08E-21
MODE_F	4	3079.412	3125.412	115.3311	5.30E-24
ST	3	3082.887	3130.887	118.8063	1.39E-25
WAVE	1	2964.423	3016.423	0.342701	0.558274

Table 44. Model fit summary and coefficient estimates for the final proportion positive model for the MRFSS/MRIP mature index.

```
Call:
glm(formula = FinalBinForm, family = binomial(link = "logit"),
    data = trips_pr, na.action = na.exclude)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.6354  -0.1541  -0.0921  -0.0631   4.1833

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -8.578769   0.700052 -12.254  < 2e-16 ***
YEAR1996    -0.160699   0.580755  -0.277  0.78201
YEAR1997    -0.296758   0.608183  -0.488  0.62559
YEAR1998    -0.009251   0.559311  -0.017  0.98680
YEAR1999    -1.691980   1.081744  -1.564  0.11779
```

```
YEAR2000    -1.258776   0.818676  -1.538  0.12415
YEAR2001    -0.325936   0.530353  -0.615  0.53884
YEAR2002    -1.133721   0.709103  -1.599  0.10986
YEAR2003     0.120204   0.491053   0.245  0.80662
YEAR2004     0.315584   0.477013   0.662  0.50824
YEAR2005     0.752436   0.457514   1.645  0.10005
YEAR2006     1.181710   0.447811   2.639  0.00832 **
YEAR2007     0.060329   0.512283   0.118  0.90625
YEAR2008     1.316486   0.438413   3.003  0.00267 **
YEAR2009     1.383870   0.436199   3.173  0.00151 **
YEAR2010     0.541356   0.474491   1.141  0.25390
YEAR2011     0.686776   0.476911   1.440  0.14985
YEAR2012     0.710326   0.474112   1.498  0.13408
AREA_X5      1.921367   0.259539   7.403 1.33e-13 ***
MODE_F5      1.766300   0.591274   2.987  0.00281 **
MODE_F6      1.146069   0.526032   2.179  0.02935 *
MODE_F7      2.457455   0.517848   4.746 2.08e-06 ***
MODE_F8      0.921118   0.510605   1.804  0.07124 .
ST24        -0.752104   0.386252  -1.947  0.05151 .
ST34         1.318460   0.173192   7.613 2.68e-14 ***
ST51         0.154680   0.186774   0.828  0.40758
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’
1

(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 3434.2  on 30947  degrees of freedom
Residual deviance: 2964.4  on 30922  degrees of
freedom
AIC: 3016.4


Number of Fisher Scoring iterations: 9
```

Table 45. Results of excluding each explanatory variable considered in the full positive observation model for the MRFSS/MRIP South Atlantic index.

Variable Excluded	Df	Deviance	AIC	Scaled Deviance	Pr(>Chi)
<none>	NA	7595.735	25961.84	NA	NA
YEAR	30	7707.582	26050.28	148.4418	1.27E-17
AREA_X	1	7600.664	25966.43	6.587278	0.010271
MODE_F	5	7650.114	26024.28	72.44222	3.18E-14
ST	3	7605.824	25969.32	13.47852	0.003708
WAVE	5	7684.486	26069.81	117.9663	8.46E-24

Table 46. Model fit summary and coefficient estimates for the final positive observation model for the MRFSS/MRIP South Atlantic index.

```
Call:
glm(formula = FinalPosForm, family = gaussian, data =
trips_pr_pos,
    na.action = na.exclude)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.0781  -0.5702  -0.0731   0.5135   5.6836

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.33845    0.12901 -10.375  < 2e-16 ***
YEAR1983    -0.01224    0.17730  -0.069 0.944963
YEAR1984     0.19433    0.15762   1.233 0.217626
YEAR1985     0.08776    0.15907   0.552 0.581171
YEAR1986     0.41470    0.14133   2.934 0.003351 **
YEAR1987     0.27634    0.13796   2.003 0.045190 *
YEAR1988     0.27235    0.15216   1.790 0.073507 .
YEAR1989     0.29834    0.15906   1.876 0.060729 .
YEAR1990     0.17906    0.16506   1.085 0.278020
YEAR1991     0.32919    0.14604   2.254 0.024211 *
YEAR1992     0.32299    0.13931   2.318 0.020445 *
YEAR1993     0.26130    0.13794   1.894 0.058219 .
YEAR1994     0.22843    0.13527   1.689 0.091306 .
YEAR1995     0.41083    0.13172   3.119 0.001820 **
YEAR1996     0.34042    0.13110   2.597 0.009426 **
YEAR1997     0.42804    0.13536   3.162 0.001570 **
YEAR1998     0.38211    0.13153   2.905 0.003680 **
YEAR1999     0.44050    0.12819   3.436 0.000592 ***
YEAR2000     0.43831    0.12932   3.389 0.000703 ***
YEAR2001     0.48428    0.12925   3.747 0.000180 ***
YEAR2002     0.49193    0.12992   3.786 0.000154 ***
YEAR2003     0.43393    0.12888   3.367 0.000763 ***
YEAR2004     0.36053    0.13052   2.762 0.005751 **
YEAR2005     0.31580    0.13324   2.370 0.017800 *
YEAR2006     0.44556    0.13041   3.417 0.000637 ***
YEAR2007     0.58011    0.12803   4.531 5.94e-06 ***
YEAR2008     0.46233    0.12715   3.636 0.000278 ***
YEAR2009     0.48773    0.12980   3.757 0.000173 ***
```

```
YEAR2010     0.50795    0.12834   3.958 7.62e-05 ***
YEAR2011     0.60056    0.12801   4.691 2.75e-06 ***
YEAR2012     0.52092    0.12864   4.049 5.18e-05 ***
AREA_X5     -0.06797    0.02654  -2.561 0.010443 *
MODE_F2     -0.25104    0.05874  -4.274 1.94e-05 ***
MODE_F3      0.02691    0.04982   0.540 0.589025
MODE_F5     -0.08836    0.02861  -3.088 0.002018 **
MODE_F7     -0.32006    0.06201  -5.162 2.50e-07 ***
MODE_F8     -0.18576    0.02887  -6.434 1.29e-10 ***
ST13        -0.08519    0.03285  -2.593 0.009520 **
ST37         0.03268    0.02513   1.300 0.193494
ST45         0.04715    0.03660   1.288 0.197712
WAVE2       -0.11603    0.04612  -2.516 0.011893 *
WAVE3       -0.09340    0.04393  -2.126 0.033519 *
WAVE4       -0.12506    0.04344  -2.879 0.004000 **
WAVE5       -0.18201    0.04076  -4.466 8.07e-06 ***
WAVE6        0.05756    0.04019   1.432 0.152145
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1
(Dispersion parameter for gaussian family taken to be 0.7513091)
    Null deviance: 8028.8  on 10154  degrees of freedom
Residual deviance: 7595.7  on 10110  degrees of
freedom
AIC:
25962
Number of Fisher Scoring iterations: 2
```

Table 47. Results of excluding each explanatory variable considered in the full proportion positive model for the MRFSS/MRIP mature index.

Variable Excluded	Df	Deviance	AIC	Scaled Deviance	Pr(>Chi)
<none>	NA	65525.82	65615.82	NA	NA
YEAR	30	66408.62	66438.62	882.8005	2.53E-166
AREA_X	1	65526.88	65614.88	1.056306	0.304059
MODE_F	5	66325.56	66405.56	799.7408	1.32E-170
ST	3	66186.61	66270.61	660.787	6.68E-143
WAVE	5	65884	65964	358.1812	3.03E-75

Table 48. Model fit summary and coefficient estimates for the final proportion positive model for the MRFSS/MRIP mature index.

```
Call:
glm(formula = FinalBinForm, family = binomial(link = "logit"),
    data = trips_pr, na.action = na.exclude)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.9884  -0.4475  -0.3648  -0.3011   2.8224

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.82594    0.15276 -18.500  < 2e-16 ***
YEAR1983     0.06470    0.21091   0.307 0.759035
YEAR1984     0.37876    0.18794   2.015 0.043869 *
YEAR1985     0.10231    0.18916   0.541 0.588598
YEAR1986     0.87987    0.16907   5.204 1.95e-07 ***
YEAR1987     0.62450    0.16449   3.797 0.000147 ***
YEAR1988     0.20398    0.18098   1.127 0.259718
YEAR1989    -0.13877    0.18832  -0.737 0.461186
YEAR1990    -0.22331    0.19586  -1.140 0.254220
YEAR1991    -0.13934    0.17365  -0.802 0.422306
YEAR1992     0.30836    0.16586   1.859 0.062998 .
YEAR1993     0.11921    0.16403   0.727 0.467381
YEAR1994     0.25102    0.16082   1.561 0.118549
YEAR1995     0.38752    0.15623   2.480 0.013120 *
YEAR1996     0.88725    0.15601   5.687 1.29e-08 ***
YEAR1997     0.35748    0.16106   2.220 0.026448 *
YEAR1998     0.56466    0.15650   3.608 0.000309 ***
YEAR1999     0.97841    0.15260   6.412 1.44e-10 ***
YEAR2000     0.82416    0.15399   5.352 8.70e-08 ***
YEAR2001     0.88735    0.15390   5.766 8.12e-09 ***
YEAR2002     0.57617    0.15442   3.731 0.000190 ***
YEAR2003     0.99593    0.15341   6.492 8.48e-11 ***
YEAR2004     0.65673    0.15530   4.229 2.35e-05 ***
YEAR2005     0.30271    0.15833   1.912 0.055898 .
YEAR2006     0.58197    0.15510   3.752 0.000175 ***
YEAR2007     0.90933    0.15244   5.965 2.44e-09 ***
YEAR2008     1.18664    0.15153   7.831 4.85e-15 ***
YEAR2009     0.67847    0.15455   4.390 1.13e-05 ***
YEAR2010     0.66193    0.15269   4.335 1.46e-05 ***
YEAR2011     0.74455    0.15205   4.897 9.74e-07 ***
```

```
YEAR2012     0.36039    0.15281   2.358 0.018350 *
MODE_F2     -0.46763    0.06931  -6.747 1.51e-11 ***
MODE_F3      0.21613    0.05833   3.705 0.000211 ***
MODE_F5      0.20306    0.03641   5.577 2.45e-08 ***
MODE_F7     -0.94757    0.07067 -13.408  < 2e-16 ***
MODE_F8     -0.66099    0.02784 -23.747  < 2e-16 ***
ST13         0.55547    0.03912  14.198  < 2e-16 ***
ST37         0.66597    0.02845  23.410  < 2e-16 ***
ST45         0.07459    0.04336   1.720 0.085404 .
WAVE2       -0.16054    0.05510  -2.914 0.003571 **
WAVE3       -0.16337    0.05230  -3.123 0.001788 **
WAVE4       -0.25408    0.05123  -4.959 7.07e-07 ***
WAVE5       -0.09889    0.04869  -2.031 0.042238 *
WAVE6        0.29496    0.04787   6.162 7.19e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1

(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 69220  on 117972  degrees of freedom
Residual deviance: 65527  on 117929  degrees of freedom
AIC:
65615

Number of Fisher Scoring iterations: 5
```

Table 49. Number of Black Drum measured for length (mm TL) from recreational fisheries each year and wave by various state-run biological sampling programs from Georgia to Delaware.

Year	GA	SC SFS	SC Freezer	SC Tourn.	NC 930	VMRC Freezer	VMRC Tourn.	DE DFW	DE Tourn.	total
1989		1								1
1990		4		6						10
1991		9		16						25
1992		19		6						25
1993		31		8					6	45
1994		6		19					8	33
1995		10	1	8					8	27
1996		21	37	19					21	98
1997			51	25					35	111
1998	34	102	17	13					23	189
1999	20	191	25	23		15			17	291
2000	26	81	104	41		55			19	326
2001	30	120	31	15		1			6	203
2002	38	295	123	40		8			11	515
2003	68	183	55	34					18	358
2004	21	129	14	28					23	215
2005	9	69	14	22					19	133
2006	10	135	4	29					26	204
2007	23	71	5	22		2	38		2	163
2008	158	106	2	10	14	162	64	34	66	616
2009	58	64	7	18	3	36	31	94	75	386
2010	157	34	13	14	7	50	13	82	33	401
2011	16	29	9	15	36	16	17	68	19	225
2012		49	3	7		16			5	80
Wave										
1	11	77	22							110

2	59	168	28	15		8			1	279
3	100	300	114	152	2	340	163	278	412	1,861
4	172	243	97	224	7	10			21	774
5	204	442	164	33	51	3			6	903
6	122	529	90	14						755
total	668	1,759	515	438	60	361	163	278	440	4,680
min TL	219	102	247	232	196	525	745	620	380	
max TL	1,140	839	1,210	1,225	820	1,346	1,350	1,280	750	
mean TL	402	391	438	551	329	1,010	1,137	890	483	
median TL	397	387	431	488	271	1,030	1,175	848	480	

Table 50. Number of Black Drum measured for weight (kg) from recreational fisheries each year by various state-run biological sampling programs from Georgia to Delaware.

Year	SC Tourn.	NC Prog 930	VA BSP & Freezer Program	DE DFW Biological Sampling	DE Tournament Sampling	total
1990	6				7	13
1991	16				2	18
1992	6				3	9
1993	8				6	14
1994	19				8	27
1995	8				8	16
1996	18				21	39
1997	25				35	60
1998	12				23	35
1999	23		2		17	42
2000	40		13		19	72
2001	13		1		6	20
2002	40		2		11	53
2003	33				18	51
2004	24				23	47
2005	18				19	37
2006	28				26	54
2007	22		39		2	63
2008	10	14	78	34	66	202
2009	18	3	33	94	75	223
2010	8	7	19	52	33	119
2011	8	36	19	68	19	150
2012	7	60	1		5	73
total	410	120	207	248	452	1437
min wt (kg)	0.18	0.10	5.45	5.18	15.42	
max wt	31.50	8.40	86.90	34.20	45.36	
mean wt	4.09	0.86	52.20	12.74	29.64	
median wt	1.93	0.20	58.00	10.55	29.03	

Table 51. Percent of fish harvested during the MRFSS and MRIP, assuming 600 mm total length as a cutoff for maturity.

Estimation Methodology	MRFSS 1981-2003	MRIP 2004-2012
Immature Fish	95	95
Mature Fish	5	5

Table 52. Other harvest recorded by various sampling programs and the percentage of those harvest to the coastwide MRFSS/MRIP estimate.

Year	MRFSS/MRIP estimate (lbs)	DE Tourn.	MD Charter Logbook	VA Tourn.	% of MRFSS/MRIP estimate
1981	307,719			1,305	0.42%
1982	284,514			5,270	1.85%
1983	1,830,967			21,853	1.19%
1984	738,024	80		6,418	0.88%
1985	946,233			5,340	0.56%
1986	1,228,939	391		18,282	1.52%
1987	882,893			8,065	0.91%
1988	478,464	54		2,263	0.48%
1989	485,681			5,587	1.15%
1990	335,563	432		4,118	1.36%
1991	657,047	101		1,361	0.22%
1992	849,920	187		3,670	0.45%
1993	443,637	360	42,843	3,257	10.47%
1994	720,497	479	42,976	3,264	6.48%
1995	878,155	576	30,781	2,548	3.86%
1996	703,886	1,392	17,616	3,421	3.19%
1997	640,413	2,337	23,434	4,840	4.78%
1998	677,024	1,496	9,147	4,851	2.29%
1999	818,453	1,030	5,874	0	0.84%
2000	1,853,044	1,334	6,104	0	0.40%
2001	1,410,905	379	8,258	366	0.64%
2002	859,311	757	7,663	0	0.98%
2003	1,643,324	1,146	5,482	93	0.41%
2004	1,566,705	1,589	6,838	671	0.58%
2005	1,318,521	1,218	6,392	525	0.62%
2006	1,580,160	1,662	9,247	167	0.70%
2007	1,408,391	128	3,956	1,347	0.39%
2008	5,217,281	4,305	4,641	743	0.19%
2009	3,173,841	4,822	8,168	250	0.42%

2010	1,489,802	2,277	5,045	333	0.51%
2011	1,512,221	1,239	5,245	171	0.44%
2012	744,266	324	1,765	169	0.30%

Table 53. Number of black drum reported as harvested and released and the number of anglers and trips capturing black drum from Maryland charter boat logs, 1993-2012.

Year	Number Harvested	Number Released	Number of Anglers	Number of Trips
1993	812	40	1,549	269
1994	832	1	1,574	275
1995	613	1483	1,722	294
1996	499	3	1,320	208
1997	491	231	1,381	203
1998	354	7	816	117
1999	146	23	718	115
2000	319	524	1,245	156
2001	318	13	1,224	186
2002	432	24	2,165	300
2003	905	16	1,476	236
2004	242	6	1,660	251
2005	252	0	1,431	223
2006	208	19	1,600	229
2007	104	13	733	105
2008	149	0	1,218	203
2009	220	10	1,144	170
2010	509	1	852	119
2011	335	6	1034	173
2012	101	0	630	105

Table 54. Fishery-independent data sources reviewed for the assessment. Each data sources was reviewed for d abundance (Develop Index?) and for use in life history parameter estimates (Use Biological Samples?). A su excluding each data source from consideration in the assessment is included.

Data Source	**Location**	**Gear**	**Years Available**	**Develop Index?**	**Use Biological Samples?**	**Length**	**Individual Weight**	**Age**	**Sex**	**Maturit**
NJDEP Striped Bass Recruitment Survey	Delaware River	beach seine	1980-2012	N	N	Y	N	N	N	N
NJDEP Delaware Bay Trawl Survey	Delaware Bay	16ft otter trawl	1991-2012	N	N	Y	N	N	N	N
NJDEP Ocean Trawl Survey	NY Harbor to DE Bay	two-seam trawl	1988-2012	N	N	Y	N	N	N	N
DEDFW 16ft Bottom Trawl Surveys	Delaware Estuary	16ft otter trawl	1980-2012	Y	N	Y	N	N	N	N
DEDFW 30ft Bottom Trawl Surveys	DE side of Delaware Bay	30ft otter trawl	1966-71, 1979-84, 1990-2012	Y	N	Y	N	N	N	N
PSEG Beach Seine Survey	Delaware Bay	beach seine	1995-2012	Y	N	Y	N	N	N	N

PSEG Juvenile Trawl Survey	Delaware Bay	trawl	2000-2012	N	N	Y	N	N	N	N	Only 1 black drum captured in 6 of 12 years. Only length data collected.
MD DNR Juvenile Striped Bass Survey	Upper Chesapeake Bay and tributaries	beach seine	1955-2012	N	N	Y	N	N	N	N	Sampling not in black drum habitat. 41 years with no catch. 138 black drum captured in 56 years of sampling. Only length data collected.
MD DNR Blue Crab Trawl Survey	Chesapeake Bay and tributaries	otter trawl	1989-2012	N	N	Y	N	N	N	N	14 of 23 years had zero catch, 92 total caught. Only length data collected.
MD DNR Costal Bays Seine Survey	Maryland costal bays	beach seine	1972-2012	Y	N	Y	N	N	N	N	Index only. Only length data collected.
MD DNR Costal Bays Trawl Survey	Maryland costal bays	trawl	1972-2012	N	N	Y	N	N	N	N	9 of 23 years had zero catch; 101 total caught. Only length data collected.
ChesMMAP	Chesapeake Bay	shrimp trawl	2002-2012	N	Y	Y	Y	Y	Y	Y	Life history estimates only. More than 25 black drum encountered in only 1 year (2011, 44 of which were in one tow). Very few positive tows from 2010-2012.
VIMS Striped Bass Seine Survey	Chesapeake Bay	seine	1967-1973, 1980-2012	N	N	Y	N	N	N	N	No black drum encountered in 30 of 40 years. Only length data collected.
VIMS Juvenile Trawl Survey	Chesapeake Bay and tributaries	trawl	1955-2012	N	N	Y	N	N	N	N	Catches few black drum. No black drum encountered in 24 of 58 years. Only length data collected.

NC DMF River Independent Gill Net Survey (Program 915)	4 NC river systems	gill net	1998-2000, 2003-2012	Y	Y	Y	Y	Y	Y	Y	NA
NC DMF Pamlico Sound Trawl Survey (Program 195)	Pamlico Sound	trawl	1990-2012	N	N	Y	N	N	N	N	No black drum encountered in 13 of 22 years sampled. Only length data collected.
SC DNR Rotenone Sampling Program	mouth of small estuarine creeks	rotenone, mesh stop net	1986-1993	N	Y	Y	Y	Y	Y	Y	Life history estimates only. Short time series, inconsistent sampling.
SC DNR Stop Net Program	4 estuarine systems	stop net	1990-1994 (limited in 95,96,98)	N	Y	Y	Y	Y	Y	Y	Life history estimates only. Not sampling preferred habitat, short time series, inconsistent sampling.
SC DNR Trammel Net Program	4 major estuarine systems	trammel net	1990-2012	Y	Y	Y	Y	Y	Y	Y	NA
SC DNR Electroshock Monitoring Program	5 estuarine river systems	electrofishing	2001-2012	N	Y	Y	Y	Y	Y	Y	Life history estimates only. Not sampling preferred habitat.
GA DNR Ecological Monitoring Survey	6 estuaries (creek/river, sounds, near-shore ocean)	shrimp trawl	2003-2012	N	N	Y	N	N	N	N	Only 16 caught in ≈4500 trawls. Only length data collected.

GA DNR Marine Sport Fish Population Health Gill Net Survey	Wassaw Sound Estuary, Altamaha River Estuary	gill net	2003-2012	N	N	Y	N	N	N	N	6 years with no catch in Wassaw. Only 1 year with more than 9 fish captured in Altamaha (26 in 2008). Short time series. Only length data collected.
GA DNR Marine Sport Fish Population Health Trammel Net Survey	Wassaw Sound Estuary, Altamaha River Estuary	trammel net	2003-2012	Y	N	Y	N	N	N	N	Index only. Only length data collected.
FL FWC FIM Seine Survey	Northeast Florida and Indian River Lagoon	183m bag seine	1997-2012	Y	N	Y	N	N	N	N	Index only. Only length data collected.
NEAMAP	near shore Atlantic waters, Martha's Vineyard to Cape Hatteras	trawl	2007-2012	N	Y	Y	Y	Y	Y	Y	Life history estimates only. Adults encountered sporadically, short time series.
SEAMAP	near shore Atlantic waters, Cape Hatteras south to FL	trawl	1989-2012	N	N	Y	N	N	N	N	127 black drum caught in 13,514 tows over 22 years. Only length data collected.

NEFSC Fall Bottom Trawl Survey	Federal Atlantic waters	trawl	1975-2012	N	N	Y	N	N	N	N	23 of 38 years had zero catch; 266 total caught. Only length data collected.
NEFSC Spring Bottom Trawl Survey	Federal Atlantic waters	trawl	1975-2012	N	N	Y	N	N	N	N	33 of 38 years had zero catch; 8 total caught. Only length data collected.

Table 55. Summary of fishery-independent indices developed with GLMs. Phi is the overdispersion parmeter

Survey	**Years**	**Life History Stage**	**Unit Effort**	**Distribution**	**Explanatory Variables**	**Phi**
MD Seine	1989-2012	YOY	net set	Negative Binomial	Year, Bay	0.82
DE 16ft Trawl	1990-2012	YOY	tow	Negative Binomial	Year, Surface Temperature	1.21
DE 30ft Trawl	1990-2012	YOY	tow	Negative Binomial	Year, Month	1.22
PSEG Seine	1995-2012	YOY	net set	Negative Binomial	Year, Month, Area	1.16
GA Trammel	2003-2012	YOY	300ft net width fished	Delta-Lognormal	Lognormal (Year, Sound); Binomial (Year, Month, Sound)	Lognormal(0.53); Binomial (1.06)
N IR FL Immature Seine	1997-2012	Immature	net set	Negative Binomial	Year, Zone, Month	1.35
S IR FL Seine	1997-2012	Immature	net set	Negative Binomial	Year, Zone, Bottom Structure (Present/Absent)	1.25
NE FL Seine	2001-2012	Immature	net set	Negative Binomial	Year, Zone, Month	1.22
SC Trammel	1994-2012	Immature	net set	Negative Binomial	Year, System, Month	1.58
NC Gill Net	2003-2012	Immature	net set hour	Delta-Lognormal	Lognormal (Year, Region); Binomial (Year,Month, Region)	Lognormal (0.65); Binomial (0.89)

N IR FL Mature Seine	1997-2012	Mature	net set	Negative Binomial	Year, Month	1.05

Table 56. Length versus weight regressions ($W_t = a * TL^b$) parameters by data set and sex for black drum.

Data Source	Sex	Num	a	b	r^2	p-value
DE DFW Biological Data	Combined	412	2.74100E-08	2.9392	0.911	0.0019
	Male	289	1.14947E-09	3.3941	0.869	0.0432
	Female	123	7.44590E-09	3.1249	0.953	0.0001
NEAMAP Data	Combined	198	1.02734E-07	2.7298	0.976	<0.0001
	Male	122	8.92395E-07	2.7454	0.965	<0.0001
	Female	25	2.73900E-12	4.2290	0.966	<0.0001
ChesMMAP	Combined	134	4.32325E-07	2.5311	0.976	<0.0001
	Male	75	3.17386E-04	2.5700	0.978	0.004
	Female	26	1.50301E-04	2.6868	0.970	0.004
VMRC Data	Combined	1069	7.46988E-04	2.9996	0.922	<0.0001
	Male	311	1.12476E-04	2.9430	0.948	<0.0001
	Female	256	2.90648E-04	2.8076	0.949	<0.0001
NC DMF Data	Combined	560	3.18366E-05	2.8977	0.996	<0.0001
	Male	168	1.48365E-05	3.0257	0.985	<0.0001
	Female	159	4.81565E-05	2.8334	0.964	<0.0001
SCDNR Data	Combined	785	7.28438E-06	3.1145	0.981	<0.0001
	Male	232	6.80530E-06	3.1257	0.986	<0.0001
	Female	274	6.81110E-06	3.1241	0.972	<0.0001

Table 57. Von Bertalanffy growth equation parameters by data set and sex for black drum.

Data Source	Sex	Num	L_∞	K	t_o	T_{max}	AIC
DE DFW Biological Data	Combined	466	1206.7	0.0678	-8.7272	57	6754.4
	Male	317	1190.5	0.0724	-7.8809	55	4228.1
	Female	149	1239.4	0.0603	-10.1768	57	1874.3
ChesMMAP	Combined	135	1169.3	0.1710	-1.2183	55	1665.7
	Male	75	1143.7	0.2895	1.6878	45	906.8
	Female	26	1160.3	0.1911	-1.0535	55	291.3
VMRC Data	Combined	1069	1178.3	0.1299	-2.0795	67	16618.2
	Male	359	1177.5	0.1323	-1.8282	64	9035.7
	Female	580	1177.9	0.1357	-1.8366	67	5616.1
NC-DMF*	Combined		1201.3	0.1356	-1.6406	60	3716.6
SCDNR Data	Combined	1161	1136.8	0.1517	-1.7516	46	15489.4
	Male	401	1122.1	0.1507	-1.7714	34	5687.8
	Female	464	1161.3	0.1441	-1.9343	46	6933.6
Mean Values (from surveys)			1178.48	0.131192	-3.08344		
All Data Sets Combined (calculated)	Combined	2986	1170.1	0.1300	-2.0023	67	48726.3
*Model does not fit with separate sexes, only 2 specimens > age 6 (22,60)							

Table 58. Logistic maturity parameters by data set and for composite model.

	Estimate			Regression Parameter Estimates				
Data Set	**Variable**	**Sex**	**Number**	**a**	**b**	X^2	r^2	**AIC**
SCDNR	Length	Combined	994	-16.429	0.024	543.10	0.642	205.10
		Male	463	-18.310	0.027	258.50	0.716	79.04
		Female	531	-16.039	0.023	288.70	0.587	125.50
	Age	Combined	917	-15.735	4.044	537.50	0.444	81.40
		Male	427	-11.807	2.986	217.60	0.399	47.40
		Female	490	-114.739	28.875	324.80	0.485	31.50
CHESMMAP	Length	Combined	134	-18.295	-1.552	131.86	0.626	4.00
		Male*	108	*model failed to converge				
		Female	26	-18.053	0.027	30.30	0.688	9.15
VMRC	Length	Combined	855	-14.583	0.022	436.70	0.400	112.10
		Male	508	-13.941	0.021	221.10	0.353	58.02
		Female	347	-15.398	0.024	210.01	0.454	57.90
	Age	Combined	823	-3.494	0.844	372.40	0.364	165.40
		Male	495	-2.424	0.574	169.90	0.290	102.20
		Female	328	-9.494	2.558	217.60	0.485	45.01
Composite Model	Length	Combined	1973	-16.213	0.024	2,413.40	0.704	328.70
		Male	1079	-16.880	0.025	1,362.50	0.717	136.90
		Female	904	-16.060	0.023	1,043.50	0.685	192.50
	Age	Combined	1873	-7.307	1.781	2262.8	0.701	325.2
		Male	1029	-5.507	1.221	1230.1	0.697	200.3
		Female	844	-15.134	3.996	1065.5	0.717	85.2

Table 59. Natural mortality estimates for black drum by data set for the Atlantic coast of the United States.

						Hoenig (1983)	Hewitt & Hoenig (2005)		
Data Set	T_{max}	L_{inf}	K	$Z_{score\ (Catch\ Curve)}$	M	N-Estimate	N-Estimate	F_{est} (F = M - N)	NOTES
DE DFW Biological Data	57	1206.7	0.0678	*		0.0740	0.0526		Data distribution not appropriate for catch curve analysis
ChesMMAP	55	1169.3	0.1710	*		0.0767	0.0545		Not enough data points for adequate catch curve analysis
NC-DMF	60	1201.3	0.1356	*		0.0703	0.0500		Only 2 specimens greater than age 6 (22,60)
VMRC Data	67	1178.3	0.1299	*		0.0630	0.0448		Catch freq. by age not appropriate for catch curve
SCDNR Data	46	1136.8	0.1517	1.34954	0.9115	0.0917	0.0652	0.8198	
				*not applicable for catch curve estimate					

Table 60. Catch curve analysis of SCDNR black drum data by year-class.

SCDNR Data set: Year-Class Specific Catch Curve Data with Z-estimate and M: Model fit using 2-parameter Exp Equ						
*model fit using 3 parameter Exp Eq.						
	Number of					
Year-Class	**Years Present**	**a**	**b (Z)**	**r^2**	**p-value**	**M**
1990	7	20.057	1.80804	0.528	0.021	0.969
1991	9	108.756	0.81027	0.957	0.002	0.814
1992	12	1257.07	0.35302	0.994	0.019	0.638
1993	7	18.761	1.74685	0.871	0.004	0.959
1994	7	27.883	1.29341	0.907	0.004	0.902
1995	7	-2.9643	1.93499	0.752	0.016	0.973
1996	8	80.722	0.79322	0.942	0.079	0.786
1997	8	103.074	0.82772	0.985	0.002	0.795
1998*	5	36.413	-1.16391	0.572	0.020	0.122
1999	7	265.217	0.83719	0.979	0.001	0.797
2000	6	501.99	0.61979	0.998	0.000	0.731
2001	5	260.604	1.21091	0.938	0.014	0.887
2002	4	28.014	1.87913	0.287	0.127	0.969
2003	4	31.335	1.52586	0.378	0.109	0.936
2004	4	57.15	0.74281	0.881	0.019	0.771
2005	4	52.229	1.25776	0.989	0.017	0.895
2006	6	23.134	1.301468	0.948	0.000	0.905
2007	5	50.451	1.31221	0.958	0.001	0.905
						Mean = 0.820
1998 was an exceptionally large year-class in SC						

Table 61. Life history parameters used to define schedules of lengths, weight, and maturity at age for the equilibrium per-recruit analysis.

Parameter	Coastwide Combined Sex
Age_{max}	67
L_{inf} (mm TL)	1170
K	0.130
t_o	-2.002
LW a	8.907E-06
LW b	3.080
$L50_{mat}$ (mm TL)	613
L_{mat} a	-11.649
L_{mat} b	0.019
A_{mat} a	-7.307
A_{mat} b	1.781

Table 62. Ranking of productivity relationship to black drum life history parameters based on ranking scheme in Patrick et al. (2009). A life history parameter value indicative of low stock productivity was ranked 1, a value indicative of moderate productivity was ranked 2, and a value indicative of high productivity was ranked 3.

Life History Parameter	Black Drum Estimate	Productivity Relationship	Black Drum Rank
K	0.13	moderate	2
Fecundity	37.67 million ova	high	3
tmax	67	low	1
tmat	4	moderate	2
Lmax	117	moderate	2
		Mean =	**2**

Table 63. Low, moderate, and high stock productivity ranges suggested by Patrick et al. (2009).

Productivity	low	mod	high
r value	1	2	3

Ranking	<0.16	0.16-0.5	>0.5

Table 64. Spearman's rho (ρ), p-value, and sample size for pairwise YOY indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association. P-values in red indicate ties in rankings within indices and are not exact.

YOY Indices	GA Trammel			MD Seine			DE 30ft Trawl			DE 16ft Trawl		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
MD Seine	0.13	0.73	10									
DE 30ft Trawl	0.39	0.27	10	0.15	0.49	23						
DE 16ft Trawl	0.45	0.19	10	0.37	**0.08**	23	0.75	**0.00**	23			
PSEG Seine	0.19	0.61	10	0.61	0.01	18	0.59	0.01	18	0.69	**0.00**	18

Table 65. Spearman's rho (ρ), p-value, and sample size for pairwise immature indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association.

Immature Indices	NE FL Seine			N IR FL Immature Seine			S IR FL Seine			SC Trammel			NC Gill Net		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
N IR FL Immature Seine	-0.52	**0.09**	12												
S IR FL Seine	-0.26	0.42	12	0.49	**0.06**	16									
SC Trammel	-0.12	0.72	12	-0.16	0.56	16	0.32	0.23	16						
NC Gill Net	-0.14	0.71	10	0.48	0.17	10	0.71	**0.03**	10	0.56	0.10	10			
MRFSS/MRIP South Atlantic	-0.58	**0.05**	12	0.29	0.28	16	0.23	0.40	16	0.52	**0.02**	19	0.59	**0.08**	10

Table 66. Spearman's rho (ρ), p-value, and sample size for pairwise mature indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association.

Mature Indices	N IR FL Mature Seine		
	ρ	p-value	n
MRFSS/MRIP Mature	-0.28	0.30	16

Table 67. Spearman's rho (ρ), p-value, and sample size for pairwise lagged MRFSS/MRIP mature index and YOY indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association. P-values in red indicate ties in rankings within indices and are not exact.

Lagged MRFSS/MRIP Mature Index and YOY Indices	GA Trammel			MD Seine			DE 30ft Trawl			DE 16ft Trawl			PSEG Seine		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
MRFSS/MRIP Mature 3 year lag	-0.07	0.91	7	-0.06	0.81	18	0.05	0.84	18	0.17	0.49	18	0.00	0.99	15
MRFSS/MRIP Mature 4 year lag	0.26	0.66	6	0.01	0.97	18	-0.18	0.47	18	0.03	0.90	18	0.12	0.68	14
MRFSS/MRIP Mature 5 year lag	-0.70	0.23	5	0.29	0.25	18	0.10	0.69	18	0.15	0.54	18	0.20	0.52	13
MRFSS/MRIP Mature 6 year lag	-0.40	0.75	4	0.41	**0.09**	18	-0.12	0.65	17	0.20	0.45	17	-0.01	0.99	12

MRFSS/MRIP Mature 7 year lag	1.00	0.33	3	0.36	0.15	17	0.14	0.60	16	0.32	0.22	16	0.38	0.25	11
MRFSS/MRIP Mature 8 year lag	1.00	1.00	2	0.52	**0.04**	16	0.08	0.77	15	0.24	0.39	15	0.39	0.26	10
MRFSS/MRIP Marture 9 year lag	NA	NA	1	0.51	**0.05**	15	0.10	0.73	14	0.28	0.33	14	-0.47	0.21	9
MRFSS/MRIP Mature 10 year lag	NA	NA	0	0.58	**0.03**	14	0.25	0.40	13	0.43	0.15	13	0.19	0.66	8

Table 68. Spearman's rho (ρ), p-value, and sample size for pairwise lagged N IR FL Mature Seine index and YOY indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association. P-values in red indicate ties in rankings within indices and are not exact.

N IR FL Mature Seine Index and YOY Indices	GA Trammel			MD Seine			DE 30ft Trawl			DE 16ft Trawl			PSEG Seine		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
N IR FL Mature Seine 3 year lag	-0.18	0.71	7	-0.62	**0.01**	16	-0.38	0.15	16	-0.48	**0.06**	16	-0.44	0.10	15
N IR FL Mature Seine 4 year lag	-0.54	0.30	6	0.08	0.78	16	0.14	0.61	16	0.18	0.50	16	0.02	0.95	14
N IR FL Mature	-0.70	0.23	5	0.09	0.75	16	-0.52	**0.04**	16	-0.44	**0.09**	16	-0.43	0.14	13

Seine 5 year lag															
N IR FL Mature Seine 6 year lag	-0.40	0.75	4	-0.25	0.36	16	0.39	0.13	16	0.17	0.54	16	0.12	0.72	12
N IR FL Mature Seine 7 year lag	1.00	0.33	3	-0.19	0.48	16	0.15	0.57	16	0.26	0.34	16	0.31	0.36	11
N IR FL Mature Seine 8 year lag	1.00	1.00	2	-0.14	0.60	16	0.02	0.93	15	-0.08	0.77	15	0.33	0.35	10
N IR FL Mature Seine 9 year lag	NA	NA	1	0.12	0.67	15	0.19	0.52	14	0.12	0.69	14	0.20	0.61	9
N IR FL Mature Seine 10 year lag	NA	NA	0	-0.06	0.84	14	-0.81	**0.00**	13	-0.78	**0.00**	13	-0.14	0.75	8

Table 69. Spearman's rho (ρ), p-value, and sample size for pairwise lagged MRFSS/MRIP Mature index and immature indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association.

Lagged MRFSS/MRIP Mature Index and Immature Indices	NE FL Seine			N IR FL Seine			S IR FL Seine			SC Trammel			NC Gill Net			MRFSS/MRIP South Atlantic		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
MRFSS/MRIP 1 year lag	-0.41	0.21	11	0.30	0.28	15	-0.10	0.72	15	-0.10	0.69	18	-0.20	0.61	9	0.20	0.42	18

MRFSS/MRIP 2 year lag	0.10	0.79	10	0.37	0.20	14	0.02	0.95	14	0.27	0.29	17	0.29	0.50	8	0.31	0.20	18
MRFSS/MRIP 3 year lag	0.72	**0.04**	9	0.01	0.98	13	-0.13	0.67	13	0.26	0.33	16	-0.04	0.96	7	0.26	0.29	18
MRFSS/MRIP 4 year lag	0.00	1.00	8	0.03	0.92	12	-0.52	**0.08**	12	0.14	0.61	15	-0.54	0.30	6	0.39	0.11	18
MRFSS/MRIP 5 year lag	-0.54	0.24	7	0.36	0.27	11	-0.22	0.52	11	0.28	0.33	14	0.30	0.68	5	0.62	**0.01**	18
MRFSS/MRIP 6 year lag	0.71	0.14	6	-0.03	0.95	10	-0.02	0.97	10	0.63	**0.03**	13	0.60	0.42	4	0.68	**0.00**	18
MRFSS/MRIP 7 year lag	-0.10	0.95	5	0.32	0.41	9	-0.25	0.52	9	0.31	0.33	12	-1.00	0.33	3	0.69	**0.00**	18
MRFSS/MRIP 8 year lag	-1.00	**0.08**	4	-0.07	0.88	8	-0.05	0.93	8	0.10	0.78	11	-1.00	1.00	2	0.76	**0.00**	18
MRFSS/MRIP 9 year lag	0.50	1.00	3	-0.61	0.17	7	-0.07	0.91	7	0.37	0.30	10	NA	NA	1	0.80	**0.00**	18
MRFSS/MRIP 10 year lag	1.00	1.00	2	0.83	**0.06**	6	0.26	0.66	6	0.13	0.74	9	NA	NA	0	0.74	**0.00**	18

Table 70. Spearman's rho (ρ), p-value, and sample size for pairwise lagged N IR FL Mature Seine index and immature indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association.

Lagged N IR FL Mature Seine Index and Immature Indices	NE FL Seine			N IR FL Seine			S IR FL Seine			SC Trammel			NC Gill Net			MRFSS/MRIP South Atlantic		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n

N IR FL Mature Seine 1 year lag	-0.29	0.39	11	0.30	0.28	15	0.41	0.13	15	0.14	0.62	16	0.68	**0.05**	9	0.52	**0.04**	16
N IR FL Mature Seine 2 year lag	0.61	**0.07**	10	-0.35	0.21	14	0.04	0.89	14	-0.07	0.79	16	-0.29	0.50	8	-0.58	**0.02**	16
N IR FL Mature Seine 3 year lag	0.33	0.39	9	-0.42	0.15	13	-0.37	0.22	13	-0.35	0.19	16	-0.57	0.20	7	-0.46	**0.08**	16
N IR FL Mature Seine 4 year lag	-0.26	0.54	8	0.34	0.28	12	0.06	0.87	12	-0.43	0.12	15	-0.49	0.36	6	-0.26	0.34	16
N IR FL Mature Seine 5 year lag	0.04	0.96	7	0.04	0.92	11	0.20	0.56	11	-0.10	0.73	14	0.30	0.68	5	-0.03	0.91	16
N IR FL Mature Seine 6 year lag	0.09	0.92	6	0.21	0.56	10	0.20	0.58	10	0.05	0.86	13	0.60	0.42	4	-0.13	0.62	16
N IR FL Mature Seine 7 year lag	-0.10	0.95	5	-0.55	0.13	9	-0.58	0.11	9	-0.19	0.56	12	-1.00	0.33	3	-0.34	0.20	16
N IR FL Mature Seine 8 year lag	-1.00	**0.08**	4	-0.02	0.98	8	-0.26	0.54	8	0.43	0.19	11	-1.00	1.00	2	-0.09	0.73	16
N IR FL Mature Seine 9 year lag	0.50	1.00	3	0.29	0.56	7	0.50	0.27	7	0.58	**0.09**	10	NA	NA	1	-0.25	0.36	16

N IR FL Mature Seine 10 year lag	1.00	1.00	2	0.26	0.66	6	0.83	**0.06**	6	0.00	1.00	9	NA	NA	0	-0.19	0.49	16

Table 71. Spearman's rho (ρ), p-value, and sample size for pairwise mature and YOY indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association. P-values in red indicate ties in rankings within indices and are not exact.

Mature and YOY Indices	GA Trammel			MD Seine			DE 30ft Trawl			DE 16ft Trawl			PSEG Seine		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
N IR FL Mature Seine	0.60	**0.07**	10	0.24	0.37	16	-0.08	0.78	16	0.14	0.59	16	-0.14	0.60	16
MRFSS/MRIP Mature	0.44	0.20	10	-0.63	**0.01**	18	-0.21	0.41	18	-0.26	0.30	18	-0.23	0.37	18

Table 72. Spearman's rho (ρ), p-value, and sample size for pairwise mature and immature indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association.

Mature and Immature Indices	NE FL Seine			N IR FL Seine			S IR FL Seine			SC Trammel			NC Gill Net			MRFSS/MRIP South Atlantic		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
N IR FL Mature Seine	-0.50	0.10	12	-0.29	0.27	16	0.26	0.33	16	0.50	**0.05**	16	0.35	0.33	10	0.16	0.56	16
MRFSS/MRIP Mature	-0.08	0.82	12	0.37	0.16	16	0.09	0.73	16	-0.23	0.36	18	0.27	0.45	10	0.01	0.99	18

Table 73. Spearman's rho (ρ), p-value, and sample size for pairwise immature and YOY indices. P-values highlighted in yellow were significant at α = 0.1. Spearman's rho indicates the strength of the association between the indices, with -1 indicating a perfect negative association, +1 indicating a perfect positive association, and 0 indicating no association.

Immature and YOY Indices	NE FL Seine			N IR FL Seine			S IR FL Seine			SC Trammel			NC Gill Net			MRFSS/MRIP South Atlantic		
	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n	ρ	p-value	n
GA Trammel	-0.45	0.19	10	-0.01	1.00	10	0.35	0.33	10	0.27	0.45	10	-0.21	0.56	10	-0.15	0.68	10
MD Seine	-0.10	0.77	12	0.06	0.82	16	0.27	0.31	16	0.25	0.31	19	0.08	0.84	10	0.48	**0.02**	24
DE 30ft Trawl	-0.24	0.45	12	-0.11	0.68	16	0.17	0.53	16	0.14	0.58	19	0.13	0.73	10	0.17	0.43	23
DE 16ft Trawl	-0.17	0.60	12	-0.19	0.48	16	-0.03	0.92	16	0.18	0.47	19	-0.13	0.73	10	0.19	0.38	23
PSEG Seine	-0.29	0.37	12	0.22	0.40	16	0.03	0.93	16	-0.09	0.72	18	-0.15	0.68	10	0.19	0.45	18

Table 74. Results of Mann-Kendall trend analyses applied to the full time period for each index. *P*-value is the one-tailed probability for the trend test. Trend indicates the direction of the trend if a statistically significant temporal trend was detected (two-tailed test: *P*-value < α/2; α = 0.05); NS = not significant.

Index	**Available Years**	***P*-value**	**Trend**
PSEG Seine CPUE	1995–2012	0.470	NS
DE 30ft Trawl CPUE	1979–2012	0.126	NS
DE 16ft Trawl CPUE	1980–2012	0.046	NS
MD Seine CPUE	1989–2012	0.236	NS
NC Sounds and Rivers Gill Net CPUE	2003–2012	0.429	NS
SC Trammel CPUE	1994-2012	0.363	NS
GA Trammel CPUE	2003–2012	0.295	NS
FL IR Seine CPUE	1997-2012	0.081	NS
NE FL Seine CPUE	2001-2012	0.366	NS
Coast Wide MRFSS/MRIP	1982-2012	<0.001	↑

Table 75. Results of Mann-Kendall trend analyses applied to the final ten years of each index. *P*-value is the one-tailed probability for the trend test. Trend indicates the direction of the trend if a statistically significant temporal trend was detected (two-tailed test: *P*-value < α/2; α = 0.05); NS = not significant.

Index	**Available Years**	***P*-value**	**Trend**
PSEG Seine CPUE	2003–2012	0.423	NS
DE 30ft Trawl CPUE	2003–2012	0.186	NS
DE 16ft Trawl CPUE	2003–2012	0.186	NS
MD Seine CPUE	2003–2012	0.429	NS
NC Sounds and Rivers Gill Net CPUE	2003–2012	0.429	NS
SC Trammel CPUE	2003–2012	0.360	NS
GA Trammel CPUE	2003–2012	0.296	NS
FL IR Seine CPUE	2003–2012	0.024	↓
NE FL Seine CPUE	2003–2012	0.429	NS
Coast Wide MRFSS/MRIP	2003-2012	0.500	NS

Table 76. Difference between the median MSY estimate from the Catch-MSY base configuration and total observed removals.

Year	Median MSY (millions lbs.)	Total Removals (millions lbs.)	Difference (millions lbs.)
1950	3.46	0.763	2.70
1951	3.46	0.842	2.62
1952	3.46	0.764	2.70
1953	3.46	0.831	2.63
1954	3.46	1.110	2.35
1955	3.46	0.831	2.63
1956	3.46	0.898	2.57
1957	3.46	0.888	2.58
1958	3.46	0.755	2.71
1959	3.46	1.006	2.46
1960	3.46	1.015	2.45
1961	3.46	1.049	2.42
1962	3.46	1.290	2.17
1963	3.46	1.219	2.25
1964	3.46	1.017	2.45
1965	3.46	1.187	2.28
1966	3.46	1.486	1.98
1967	3.46	1.259	2.21
1968	3.46	1.374	2.09
1969	3.46	1.205	2.26
1970	3.46	1.164	2.30
1971	3.46	1.367	2.10
1972	3.46	1.283	2.18
1973	3.46	1.344	2.12
1974	3.46	1.460	2.00
1975	3.46	1.549	1.92
1976	3.46	1.348	2.12
1977	3.46	1.330	2.13
1978	3.46	1.212	2.25
1979	3.46	1.270	2.19
1980	3.46	1.174	2.29
1981	3.46	0.550	2.91
1982	3.46	0.506	2.96
1983	3.46	2.027	1.44
1984	3.46	0.904	2.56
1985	3.46	1.071	2.39
1986	3.46	1.585	1.88
1987	3.46	1.136	2.33
1988	3.46	0.782	2.68
1989	3.46	0.629	2.83
1990	3.46	0.544	2.92
1991	3.46	0.927	2.54
1992	3.46	1.069	2.39
1993	3.46	0.714	2.75

1994	3.46	1.034	2.43
1995	3.46	1.186	2.28
1996	3.46	1.065	2.40
1997	3.46	0.989	2.48
1998	3.46	0.870	2.59
1999	3.46	1.194	2.27
2000	3.46	2.139	1.33
2001	3.46	1.672	1.79
2002	3.46	1.478	1.99
2003	3.46	1.991	1.47
2004	3.46	1.793	1.67
2005	3.46	1.509	1.95
2006	3.46	1.932	1.53
2007	3.46	1.831	1.63
2008	3.46	5.756	-2.29
2009	3.46	3.546	-0.08
2010	3.46	1.788	1.68
2011	3.46	1.783	1.68
2012	3.46	1.095	2.37

Table 77. Summary of sensitivity configurations for the Catch-MSY method. Input changes from the base configuration are described. Changes of the median MSY and OFL estimates from the base median estimates are provided.

Model Configuration	Changes from Base Configuration	MSY (millions lbs.)				OFL (millions lbs.)			
		Min	Median	Median Δ from Base Configuration	Max	Min	Median	Median Δ from Base Configuration	Max
Base	NA	2.01	3.46	NA	5.72	2.37	4.74	NA	8.75
Upper Bound of K based on r Distribution	Upper Bound of K = 100 million lbs.	1.71	3.51	1%	5.72	1.91	4.83	2%	8.78
Martell and Froese (2012) Moderate Resilience	r = 0.2-1	2.24	3.71	7%	5.92	2.54	4.78	1%	8.99
Martell and Froese (2012) Low Resilience	r = 0.05-0.5	1.41	3.04	-12%	5.36	1.68	4.22	-11%	8.33
Thorson et al. (2012) Bmsy/K for Pooled Orders	Bmsy/K mean = 0.4; Bmsy/K sd = 0.14	2.08	3.58	3%	5.61	2.27	5.04	6%	8.89
Schaefer Production Function	Bmsy/K distribution = NA; Bmsy/K = 0.5	2.12	3.75	8%	5.90	2.63	5.44	15%	8.80
Martell and Froese (2012) Default Relative Biomass Bounds	B_{1950}/K bounds = 0.5-0.9; B_{2012}/K bounds = 0.01-0.4	1.11	1.50	-57%	2.17	0.03	0.62	-87%	1.36
High B_{2012}/K	B_{2012}/K bounds = 0.756-0.956	2.27	8.45	144%	16.58	2.91	13.58	187%	28.93
Moderate B_{2012}/K	B_{2012}/K bounds = 0.556-0.756	1.81	2.57	-26%	3.60	1.87	3.11	-34%	4.79
Low B_{2012}/K	B_{2012}/K bounds = 0.456-0.656	1.48	2.08	-40%	2.96	1.23	2.09	-56%	3.34
Unfished Condition Time Series	Start Year = 1900; B_{1900}/K fixed at 1	1.99	3.50	1%	5.44	2.18	4.86	3%	8.34
Arbitrary Process Error	sigma = 0.05	1.44	2.93	-15%	8.92	1.76	3.64	-23%	13.22

Increased Commercial Landings Error from 1950-1993	Upper Bound of Commercial Landings Uniform Distribution from 1950-1993 = 2*reported landings	2.05	3.57	3%	5.41	2.31	4.98	5%	8.30
MRFSS/MRIP Time Series	Start Year = 1982	1.80	3.47	0%	5.76	2.05	4.79	1%	8.70
Adjusted 2008-2009 MRIP Estimates	2008-2009 MRIP Harvest and Released Alive Estimates = Mean of 2006,2007,2010 and 2011 estimates	1.63	2.59	-25%	4.23	1.92	3.57	-25%	6.66

Table 78. Summary of sensitivity configurations for the Catch-MSY method. Input changes from the base configuration are described. Changes of the median r and K estimates from the base median estimates are provided.

Model Configuration	**Changes from Base Configuration**	**K (millions lbs.)**				**r**			
		Min	**Median**	**Median Δ from Base Configuration**	**Max**	**Min**	**Median**	**Median Δ from Base Configuration**	**Max**
Base	NA	24.51	53.25	NA	109.93	0.16	0.28	NA	0.50
Upper Bound of K based on r Distribution	Upper Bound of K = 100 million lbs.	20.82	52.07	-2%	99.99	0.16	0.29	4%	0.50
Martell and Froese (2012) Moderate Resilience	r = 0.2-1	13.09	36.62	-31%	91.92	0.20	0.43	55%	0.99
Martell and Froese (2012) Low Resilience	r = 0.05-0.5	22.62	77.07	45%	259.07	0.05	0.17	-38%	0.50
Thorson et al. (2012) Bmsy/K for Pooled Orders	Bmsy/K mean = 0.4; Bmsy/K sd = 0.14	23.79	52.16	-2%	107.35	0.16	0.28	1%	0.50
Schaefer Production Function	Bmsy/K distribution = NA; Bmsy/K = 0.5	24.12	52.41	-2%	106.90	0.16	0.27	-1%	0.50

Martell and Froese (2012) Default Relative Biomass Bounds	B_{1950}/K bounds = 0.5-0.9; B_{2012}/K bounds = 0.01-0.4	14.74	22.71	-57%	35.32	0.16	0.30	8%	0.49
High B_{2012}/K	B_{2012}/K bounds = 0.756-0.956	30.22	123.26	131%	343.30	0.16	0.28	2%	0.50
Moderate B_{2012}/K	B_{2012}/K bounds = 0.556-0.756	20.64	39.18	-26%	72.61	0.16	0.28	1%	0.50
Low B_{2012}/K	B_{2012}/K bounds = 0.456-0.656	17.92	31.75	-40%	53.52	0.16	0.28	2%	0.50
Unfished Condition Time Series	Start Year = 1900; B_{1900}/K fixed at 1	22.95	53.40	0%	117.04	0.16	0.29	3%	0.50
Arbitrary Process Error	sigma = 0.05	26.42	48.12	-10%	216.83	0.16	0.24	-14%	0.47
Increased Commercial Landings Error from 1950-1993	Upper Bound of Commercial Landings Uniform Distribution from 1950-1993 = 2*reported landings	24.60	53.21	0%	110.63	0.16	0.28	-1%	0.50
MRFSS/MRIP Time Series	Start Year = 1982	21.00	51.04	-4%	112.63	0.16	0.28	1%	0.50
Adjusted 2008-2009 MRIP Estimates	2008-2009 MRIP Harvest and Released Alive Estimates = Mean of 2006,2007,2010 and 2011 estimates	15.58	40.28	-24%	85.34	0.16	0.27	-2%	0.50

Table 79. Difference between the median MSY estimate from the DB-SRA base configuration and total observed removals.

Year	Median MSY (millions lbs.)	Total Removals (millions lbs.)	Difference (millions lbs.)
1900	2.60	0.07	2.52
1901	2.60	0.13	2.46
1902	2.60	0.27	2.33
1903	2.60	0.08	2.51
1904	2.60	0.54	2.06
1905	2.60	0.09	2.51
1906	2.60	0.09	2.51
1907	2.60	0.09	2.50
1908	2.60	0.10	2.50
1909	2.60	0.10	2.49
1910	2.60	0.11	2.49
1911	2.60	0.11	2.49
1912	2.60	0.11	2.48
1913	2.60	0.12	2.48
1914	2.60	0.12	2.47
1915	2.60	0.13	2.47
1916	2.60	0.13	2.46
1917	2.60	0.14	2.46
1918	2.60	0.68	1.92
1919	2.60	0.15	2.45
1920	2.60	0.21	2.38
1921	2.60	0.23	2.37
1922	2.60	0.17	2.43
1923	2.60	0.23	2.36
1924	2.60	0.18	2.42
1925	2.60	0.44	2.16
1926	2.60	0.23	2.37
1927	2.60	0.30	2.30
1928	2.60	0.35	2.25
1929	2.60	0.36	2.23
1930	2.60	0.32	2.28
1931	2.60	0.44	2.15
1932	2.60	0.35	2.25
1933	2.60	0.37	2.22
1934	2.60	0.38	2.21
1935	2.60	0.34	2.26
1936	2.60	0.53	2.07

1937	2.60	0.48	2.11
1938	2.60	0.59	2.01
1939	2.60	0.34	2.26
1940	2.60	0.33	2.26
1941	2.60	0.35	2.24
1942	2.60	0.38	2.22
1943	2.60	0.36	2.24
1944	2.60	0.41	2.19
1945	2.60	0.63	1.96
1946	2.60	0.50	2.10
1947	2.60	0.60	1.99
1948	2.60	0.63	1.97
1949	2.60	0.53	2.06
1950	2.60	0.76	1.83
1951	2.60	0.84	1.75
1952	2.60	0.76	1.83
1953	2.60	0.83	1.76
1954	2.60	1.11	1.49
1955	2.60	0.83	1.77
1956	2.60	0.90	1.70
1957	2.60	0.89	1.71
1958	2.60	0.76	1.84
1959	2.60	1.01	1.59
1960	2.60	1.02	1.58
1961	2.60	1.05	1.55
1962	2.60	1.29	1.31
1963	2.60	1.22	1.38
1964	2.60	1.02	1.58
1965	2.60	1.19	1.41
1966	2.60	1.49	1.11
1967	2.60	1.26	1.34
1968	2.60	1.37	1.22
1969	2.60	1.21	1.39
1970	2.60	1.16	1.43
1971	2.60	1.37	1.23
1972	2.60	1.28	1.31
1973	2.60	1.34	1.25
1974	2.60	1.46	1.14
1975	2.60	1.55	1.05
1976	2.60	1.35	1.25
1977	2.60	1.33	1.27
1978	2.60	1.21	1.38

1979	2.60	1.27	1.33
1980	2.60	1.17	1.42
1981	2.60	0.55	2.05
1982	2.60	0.51	2.09
1983	2.60	2.03	0.57
1984	2.60	0.90	1.69
1985	2.60	1.07	1.53
1986	2.60	1.59	1.01
1987	2.60	1.14	1.46
1988	2.60	0.78	1.81
1989	2.60	0.63	1.97
1990	2.60	0.54	2.05
1991	2.60	0.93	1.67
1992	2.60	1.07	1.53
1993	2.60	0.71	1.88
1994	2.60	1.03	1.56
1995	2.60	1.19	1.41
1996	2.60	1.06	1.53
1997	2.60	0.99	1.61
1998	2.60	0.87	1.73
1999	2.60	1.19	1.40
2000	2.60	2.14	0.46
2001	2.60	1.67	0.92
2002	2.60	1.48	1.12
2003	2.60	1.99	0.60
2004	2.60	1.79	0.80
2005	2.60	1.51	1.09
2006	2.60	1.93	0.66
2007	2.60	1.83	0.76
2008	2.60	5.76	-3.16
2009	2.60	3.55	-0.95
2010	2.60	1.79	0.81
2011	2.60	1.78	0.81
2012	2.60	1.09	1.50

Table 80. Summary of sensitivity configurations for the DB-SRA method. Input changes from the base configuration are described. Changes of the median MSY and OFL estimates from the base median estimates are provided.

Model Configuration	Changes from Base Configuration	MSY				OFL			
		Min	Median	Median Δ from Base Configuration	Max	Min	Median	Median Δ from Base Configuration	Max
Base	NA	0.48	2.60	NA	28.98	0.24	5.50	NA	76.30
B2012/K = 0.90	B2012/K = 0.90	0.38	2.91	12%	43.47	0.05	6.29	14%	118.68
B2012/K = 0.80	B2012/K = 0.80	0.48	2.95	14%	38.75	0.19	6.48	18%	111.58
B2012/K = 0.70	B2012/K = 0.70	0.42	2.17	-17%	20.76	0.28	4.25	-23%	62.23
B2012/K = 0.60	B2012/K = 0.60	0.36	1.65	-37%	10.07	0.27	2.72	-51%	44.83
B2012/K = 0.50	B2012/K = 0.50	0.31	1.36	-48%	5.08	0.23	1.84	-67%	20.87
B2012/K Uniform Distribution	B2012/K Distribution = Uniform; B2012/K Bounds = 0.656-0.856	0.59	2.53	-3%	6.47	0.99	5.35	-3%	25.55
Hewitt and Hoenig (2005) M	M = 0.045	0.35	2.20	-15%	20.93	0.20	4.64	-16%	70.43
Jones and Wells (1998) M	M = 0.08	0.58	2.87	11%	35.44	0.27	6.10	11%	88.26
Zhou et al. (2012) Perciformes Fmsy/M	Fmsy/M mean = 0.92; Fmsy/M cv = 0.1	0.50	2.66	3%	32.58	0.24	5.64	3%	84.40
Delay Difference Model	Age-at-Maturity = 4	0.48	2.71	4%	28.25	0.24	5.75	5%	84.15
Thorson et al. (2012) Bmsy/K for Pooled Orders	Bmsy/K = 0.4	0.49	2.57	-1%	32.90	0.22	4.85	-12%	74.12

Adjusted 2008-2009 MRIP Estimates	2008-2009 MRIP Harvest and Released Alive Estimates = Mean of 2006,2007,2010 and 2011 estimates	0.45	2.29	-12%	28.98	0.22	4.86	-12%	76.45
Assume No Recreational Harvest from 1900-1949	Recreational Harvest from 1900-1949 = 0	0.43	2.55	-2%	28.98	0.23	5.43	-1%	77.08
Increased Commercial Landings Error from 1900-1993	Upper Bound of Commercial Landings Uniform Distribution from 1900-1993 = 2*reported landings	0.50	2.64	2%	28.98	0.25	5.58	1%	76.65
Upper Bound on K from Catch-MSY	Upper Bound of K = 100 million lbs.	0.58	1.80	-31%	6.18	0.24	2.53	-54%	17.79

Table 81. Difference between the median sustainable yield (Y_{sust}) estimate from the DCAC base configuration and total observed removals.

Year	Median Ysust (millions lbs.)	Total Removals (millions lbs.)	Difference (millions lbs.)
1950	1.20	0.76	0.44
1951	1.20	0.84	0.36
1952	1.20	0.76	0.43
1953	1.20	0.83	0.37
1954	1.20	1.11	0.09
1955	1.20	0.83	0.37
1956	1.20	0.90	0.30
1957	1.20	0.89	0.31
1958	1.20	0.76	0.44
1959	1.20	1.01	0.19
1960	1.20	1.02	0.18
1961	1.20	1.05	0.15
1962	1.20	1.29	-0.09
1963	1.20	1.22	-0.02
1964	1.20	1.02	0.18
1965	1.20	1.19	0.01
1966	1.20	1.49	-0.29
1967	1.20	1.26	-0.06
1968	1.20	1.37	-0.18
1969	1.20	1.21	-0.01
1970	1.20	1.16	0.03
1971	1.20	1.37	-0.17
1972	1.20	1.28	-0.08
1973	1.20	1.34	-0.15
1974	1.20	1.46	-0.26
1975	1.20	1.55	-0.35
1976	1.20	1.35	-0.15
1977	1.20	1.33	-0.13
1978	1.20	1.21	-0.01
1979	1.20	1.27	-0.07
1980	1.20	1.17	0.02
1981	1.20	0.55	0.65
1982	1.20	0.51	0.69
1983	1.20	2.03	-0.83
1984	1.20	0.90	0.29
1985	1.20	1.07	0.13
1986	1.20	1.59	-0.39
1987	1.20	1.14	0.06
1988	1.20	0.78	0.42
1989	1.20	0.63	0.57
1990	1.20	0.54	0.65
1991	1.20	0.93	0.27
1992	1.20	1.07	0.13
1993	1.20	0.71	0.48

1994	1.20	1.03	0.16
1995	1.20	1.19	0.01
1996	1.20	1.06	0.13
1997	1.20	0.99	0.21
1998	1.20	0.87	0.33
1999	1.20	1.19	0.00
2000	1.20	2.14	-0.94
2001	1.20	1.67	-0.47
2002	1.20	1.48	-0.28
2003	1.20	1.99	-0.79
2004	1.20	1.79	-0.59
2005	1.20	1.51	-0.31
2006	1.20	1.93	-0.73
2007	1.20	1.83	-0.63
2008	1.20	5.76	-4.56
2009	1.20	3.55	-2.35
2010	1.20	1.79	-0.59
2011	1.20	1.78	-0.58
2012	1.20	1.09	0.10

Table 82. Summary of sensitivity configurations for the DCAC method. Input changes from the base configuration are described. Changes of the median sustainable yield estimate from the base median estimate are provided.

Model Configuration	**Changes from Base Configuration**	**Ysust**			
		Min	**Median**	**Median Δ from Base Configuration**	**Max**
Base	NA	0.57	1.20	NA	1.40
Hewitt and Hoenig (2005) M	M = 0.045	0.42	1.15	-4%	1.41
Jones and Wells (1998) M	M = 0.08	0.65	1.25	4%	1.46
Thorson et al. (2012) Bmsy/K for Pooled Orders	Bmsy/K = 0.4	0.43	1.23	3%	1.45
Zhou et al. (2012) Perciformes Fmsy/M	Fmsy/M mean = 0.92; Fmsy/M cv = 0.1	0.58	1.22	2%	1.45
MRFSS/MRIP Time Series	Start Year = 1982	0.37	1.20	0%	1.64
Increased Commercial Landings Error from 1900-1993	Upper Bound of Commercial Landings Uniform Distribution from 1900-1993 = 2*reported landings	0.49	1.26	5%	1.48
Adjusted 2008-2009 MRIP Estimates	2008-2009 MRIP Harvest and Released Alive Estimates = Mean of 2006,2007,2010 and 2011 estimates	0.53	1.12	-6%	1.31
Delta = 0.064	Delta = 0.064	0.92	1.32	10%	1.46
Delta = 0.264	Delta = 0.264	0.40	1.13	-6%	1.40
Delta = 0.364	Delta = 0.364	0.39	1.05	-12%	1.42
Delta = 0.464	Delta = 0.464	0.34	0.99	-17%	1.35

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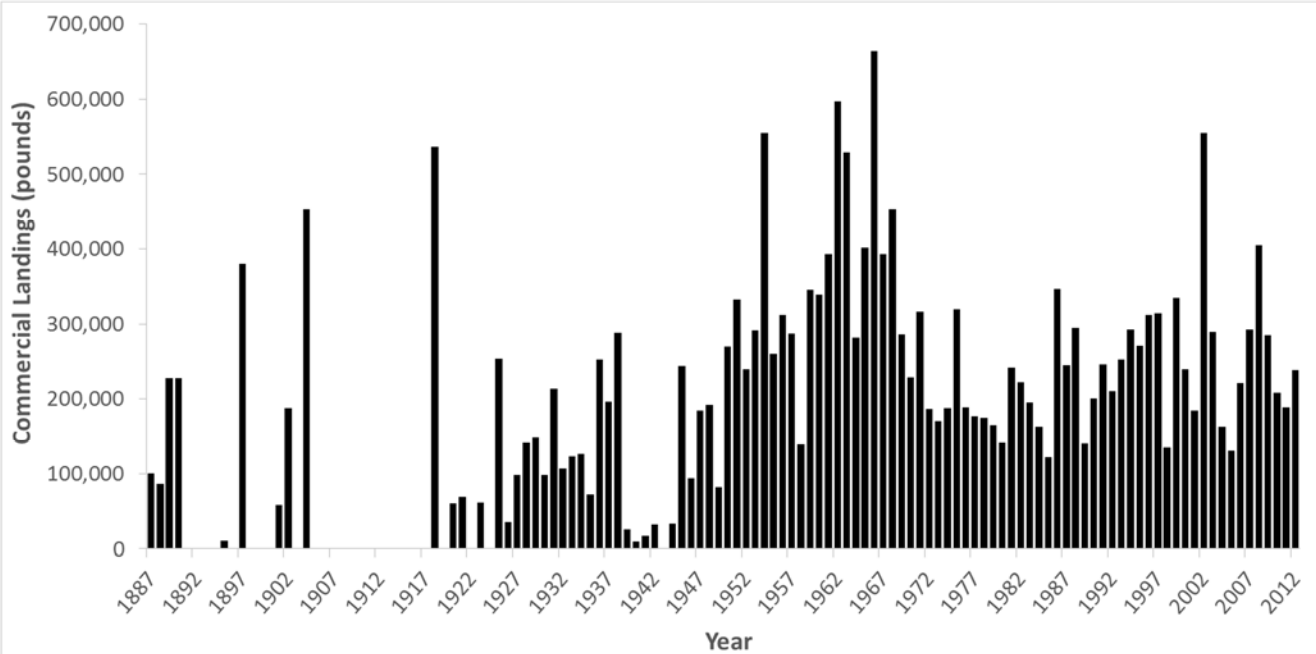


Figure 1. Coast wide commercial black drum landings from 1887-2012.

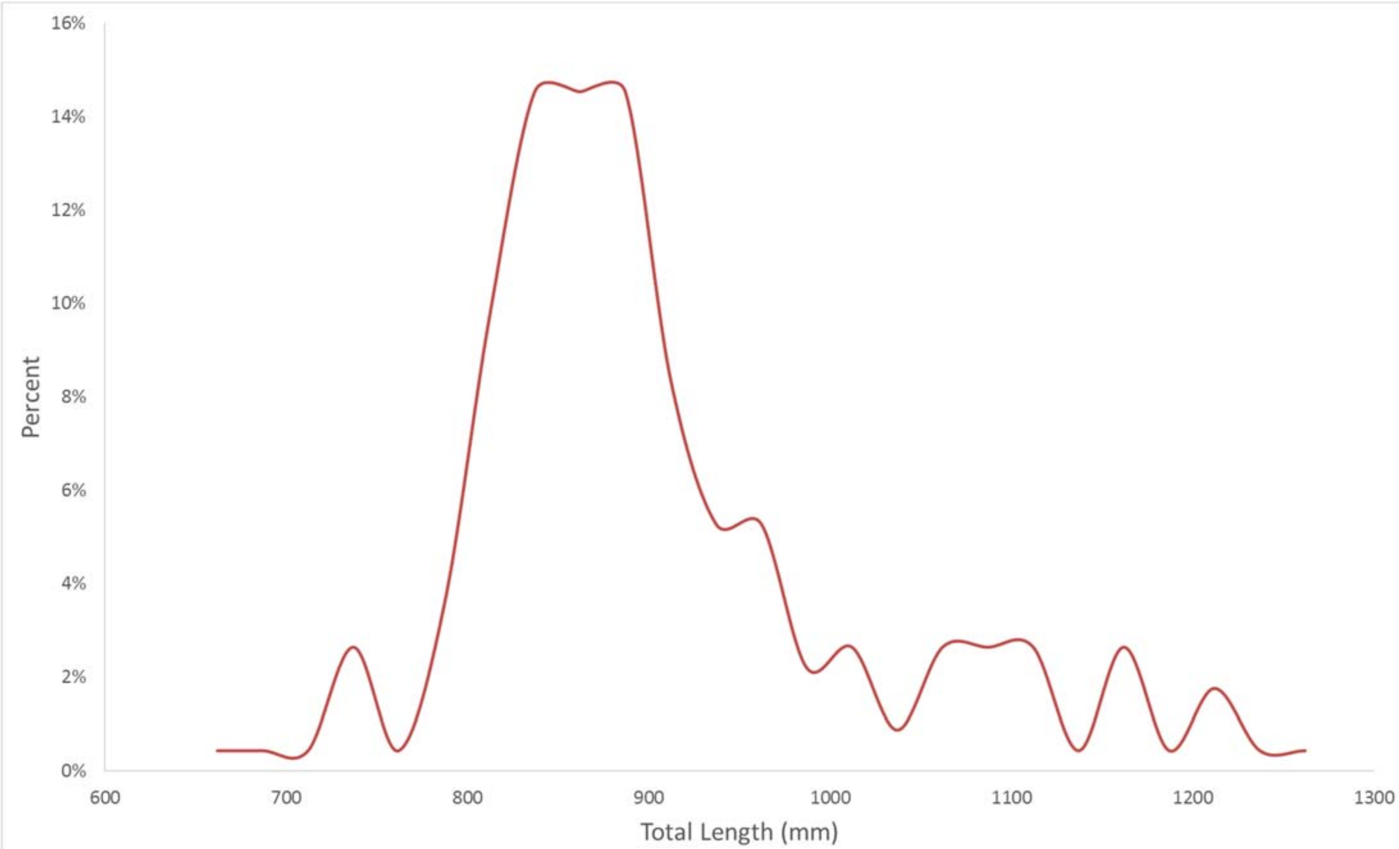


Figure 2. Length frequency of black drum sampled from Delaware gill net fisheries during DE DFW biological sampling in commercial fisheries.

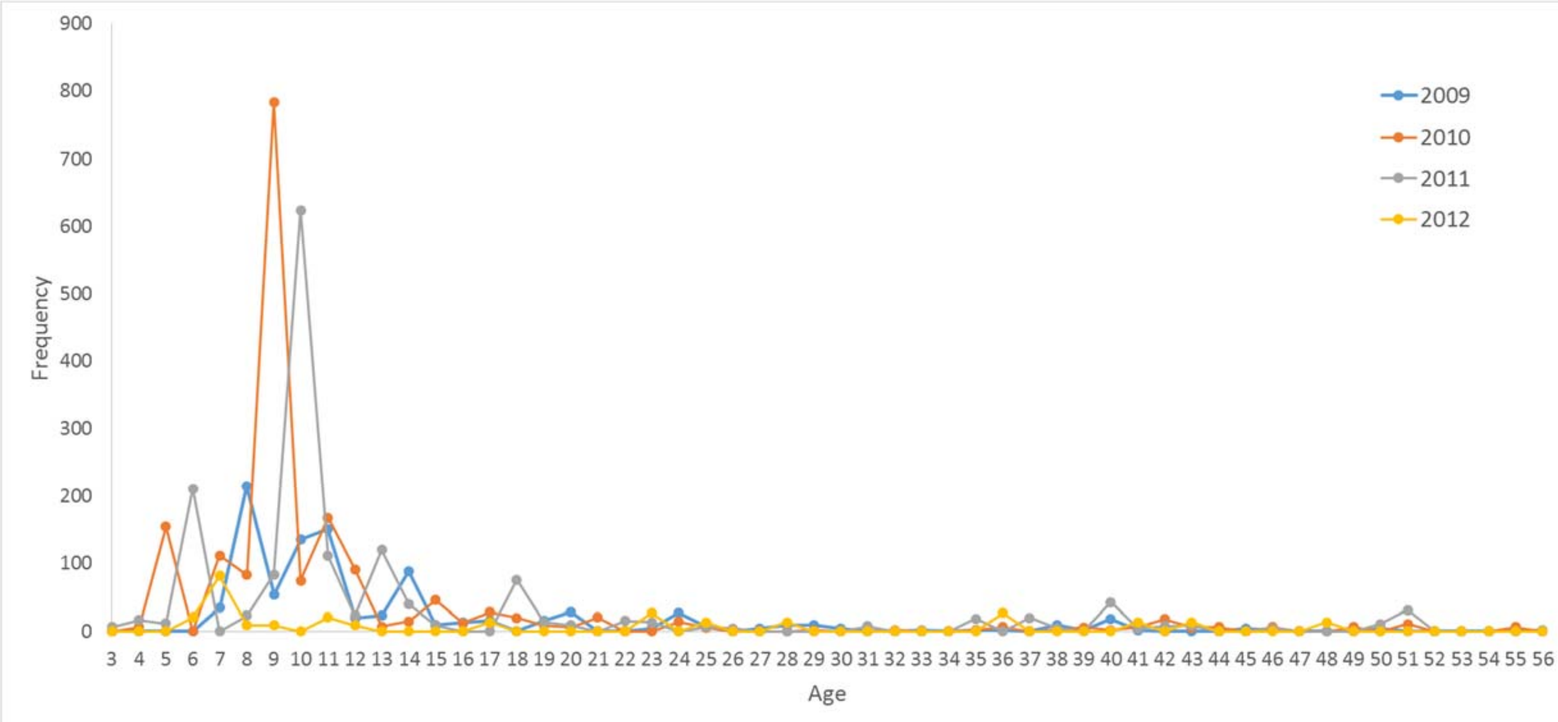


Figure 3. Catch-at-age in Delaware commercial gill net fishery from 2009-2012.

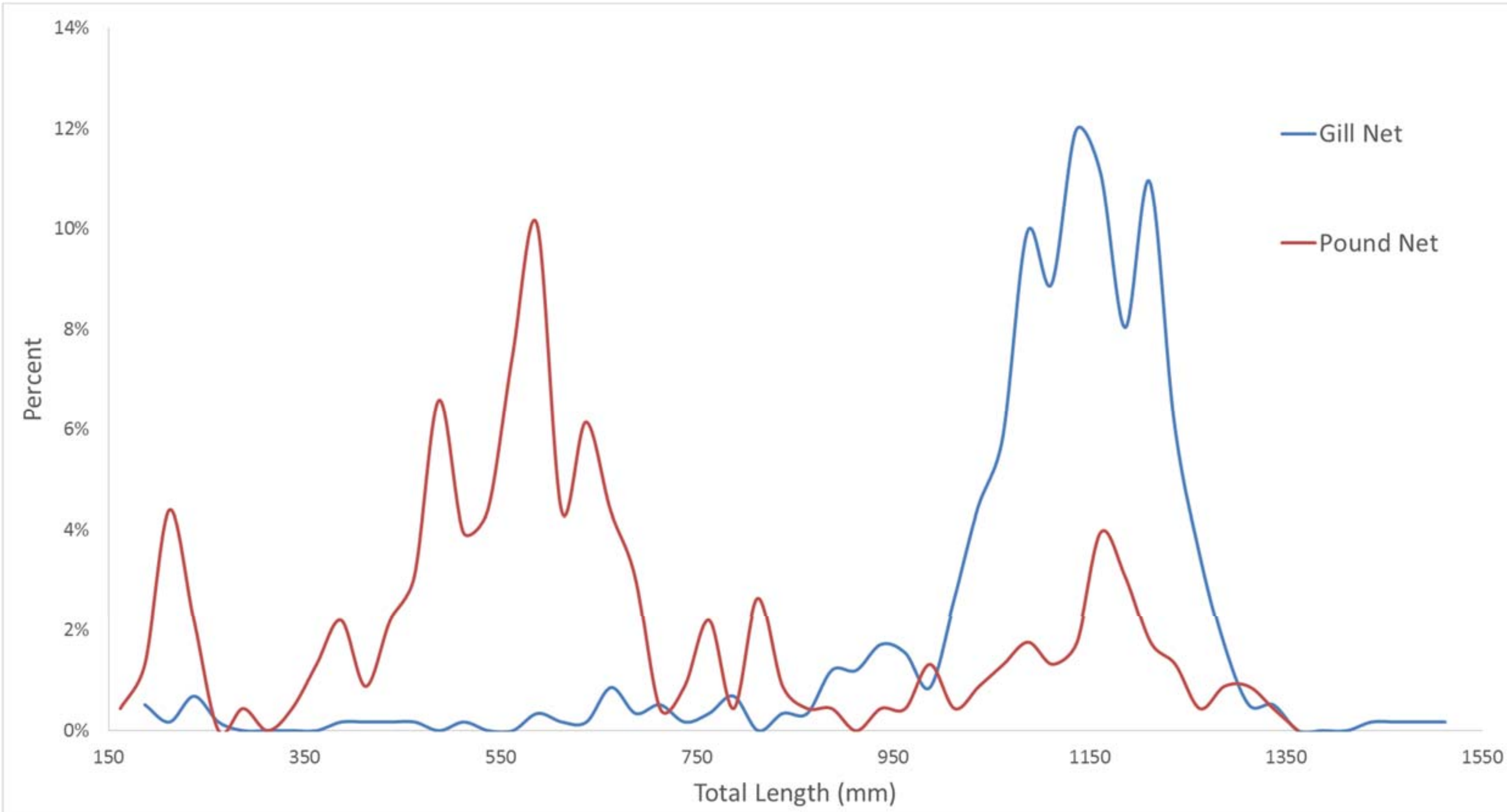


Figure 4. Length frequencies of black drum from commercial gill net and pound net fisheries sampled in the VMRC Biological Sampling Program from 1998-2012.

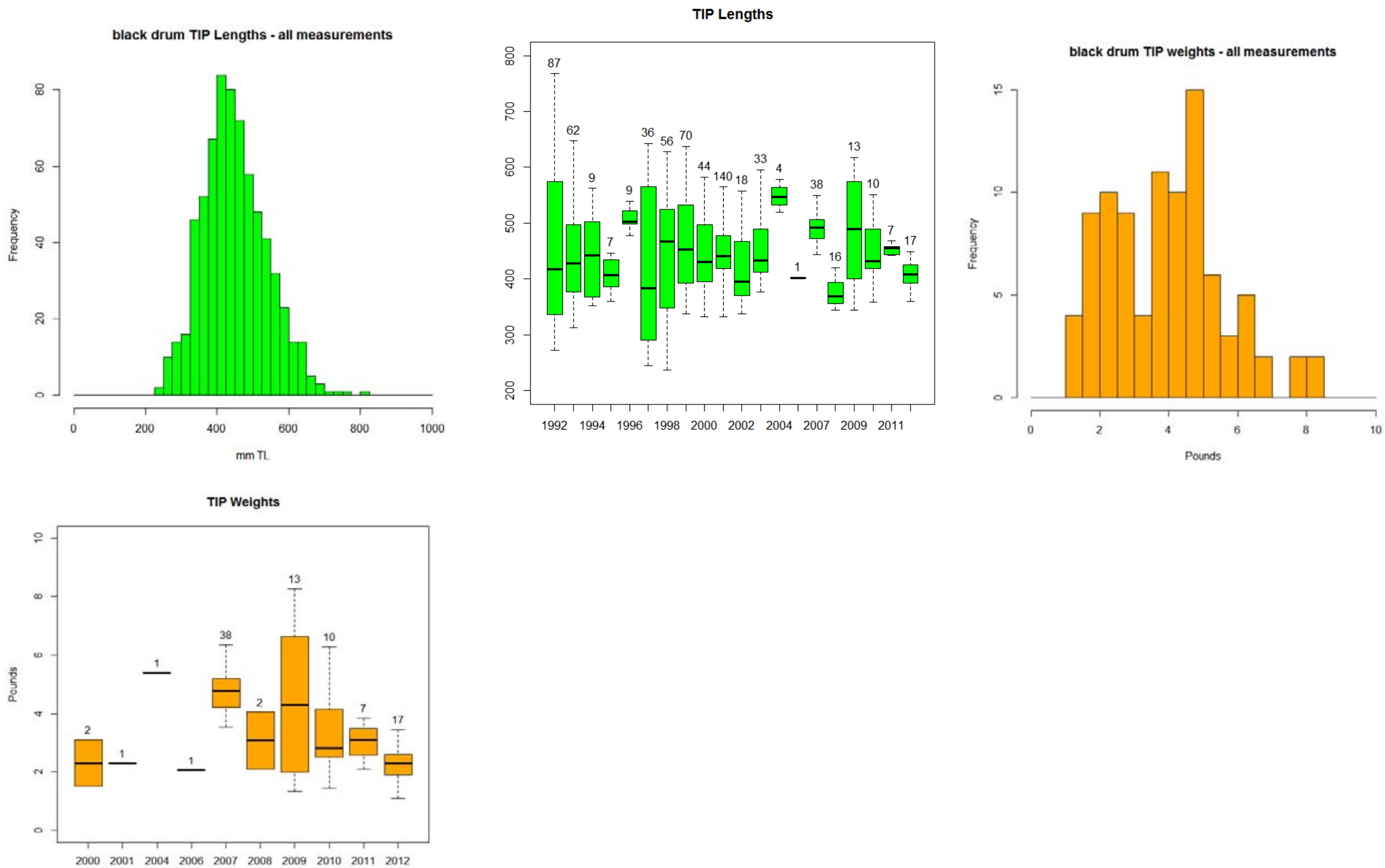


Figure 5. Distribution of lengths and weights of black drum landed by the commercial fishery and available from the TIP program. Values above boxplot indicate the number of fish measured.

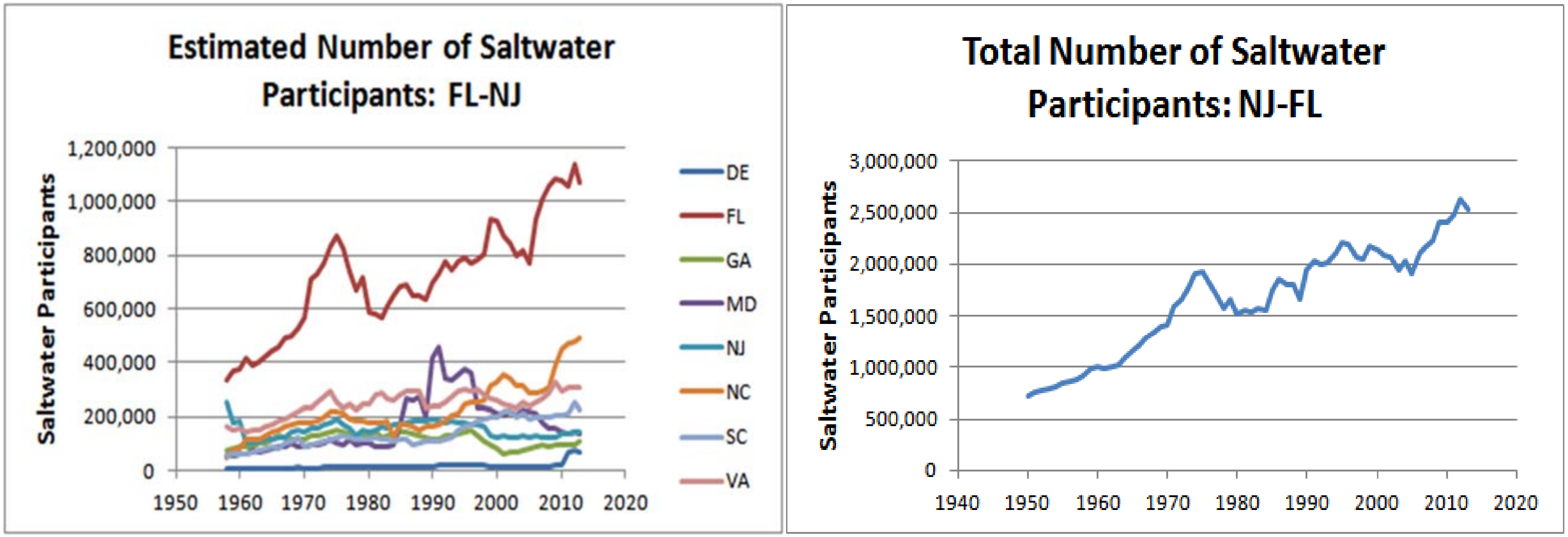


Figure 6. Estimated number of saltwater fishing participants for each state and coastwide from FL-NJ, estimated from USFWS Historical License Data and FHWAR census reports.

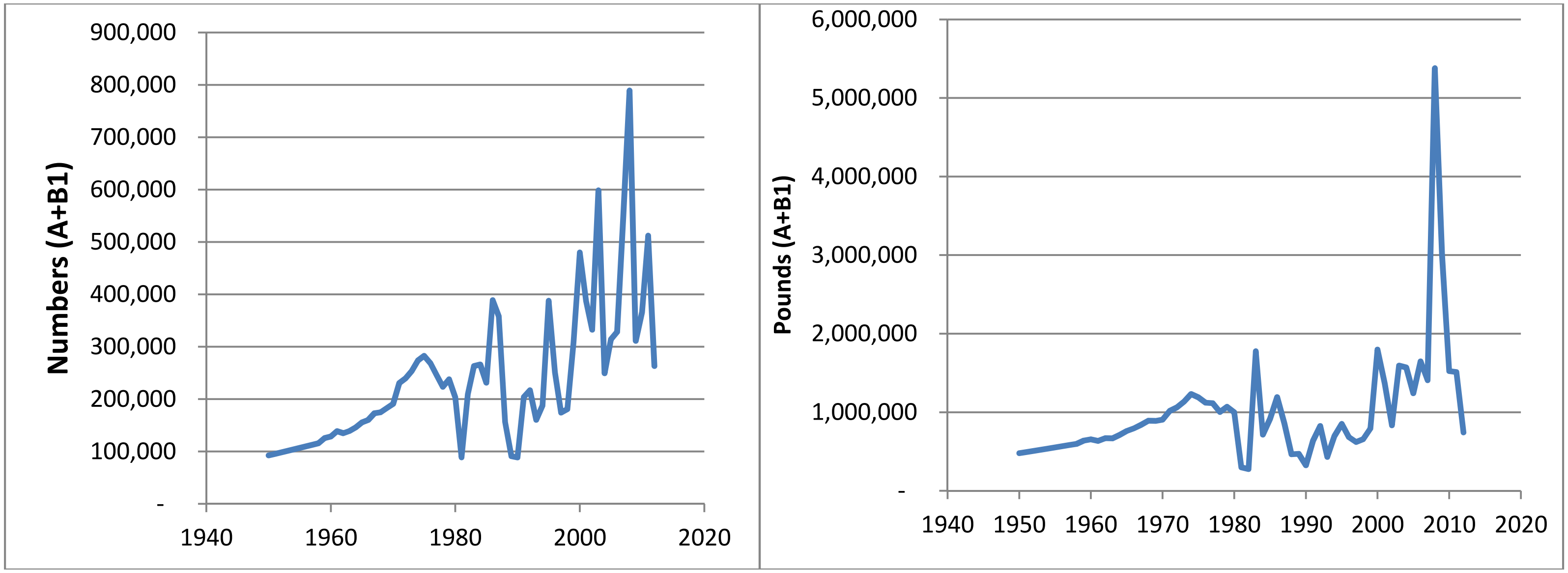


Figure 7. Estimated recreational landings (number and weight) of Black Drum on the east coast (NJ-FL) from USFWS fishing license data/FHWAR census method (1950-1980), calibrated MRFSS (1981-2003), and MRIP (2004-2012).

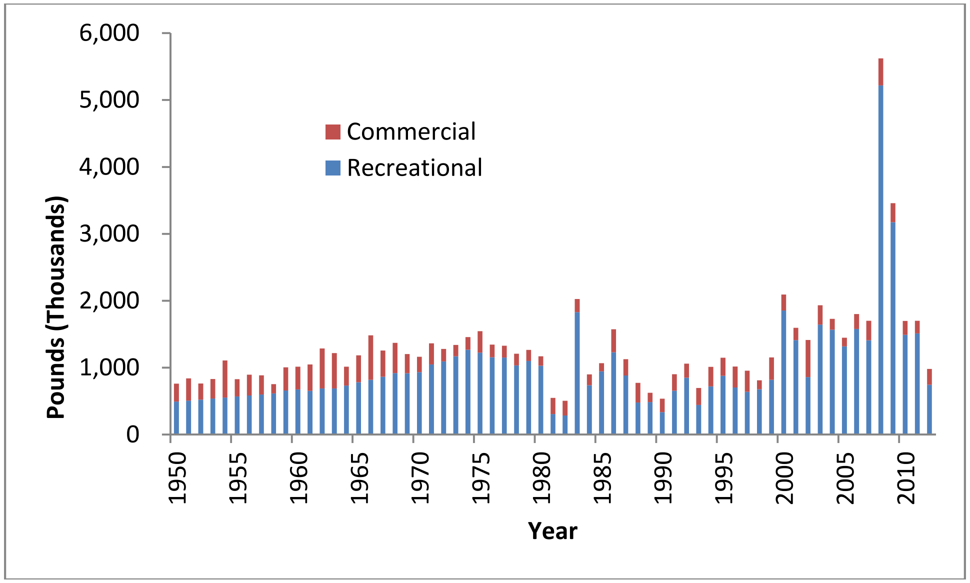


Figure 8. Commercial and recreational harvest of Black Drum (pounds) from Florida to New Jersey, 1950-2012. Recreational landings include historical estimates (1950-1980), calibrated MRFSS (1981-2003), and MRIP (2004-2012).

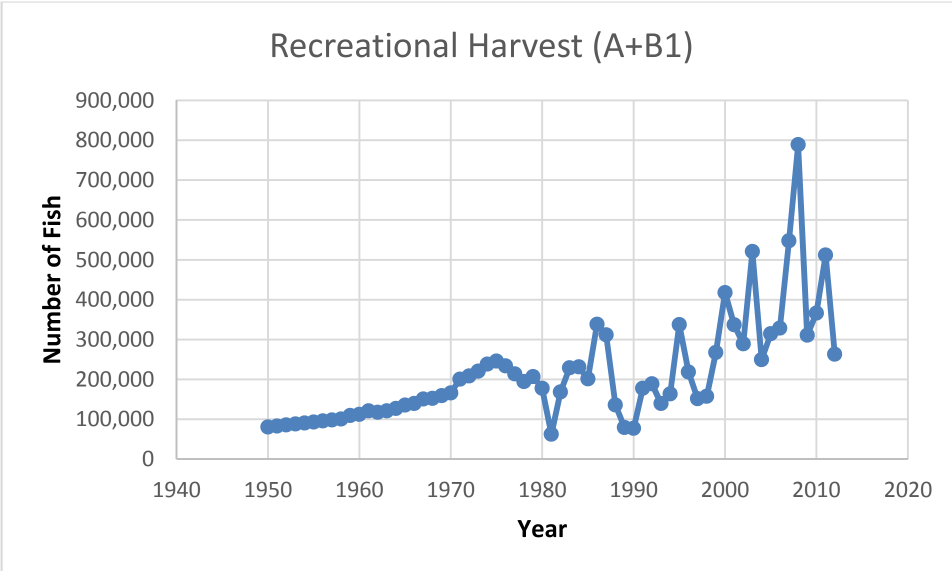


Figure 9. Commercial and recreational harvest of Black Drum (numbers) from Florida to New Jersey, 1950-2012. Recreational landings included historical estimates (1950-1980), calibrated MRFSS (1981-2003), and MRIP (2004-2012).

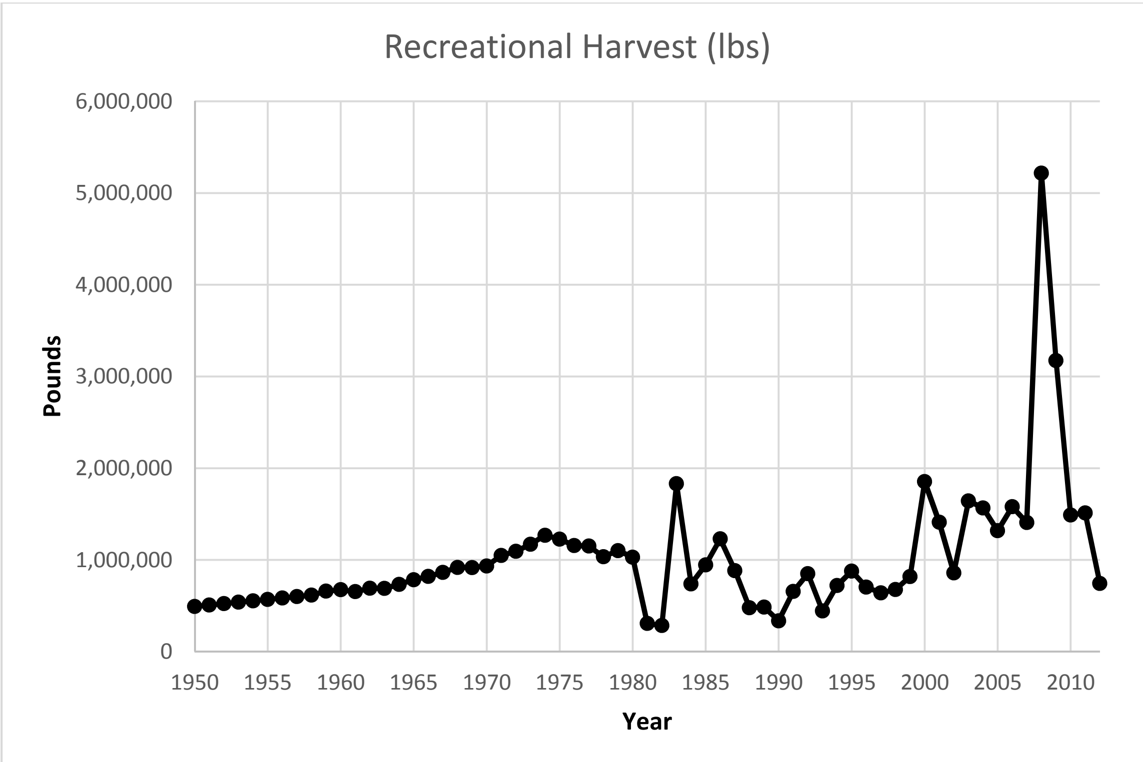


Figure 10. Estimated pounds of Black Drum harvested by recreational anglers from Florida to New Jersey, 1950-2012.

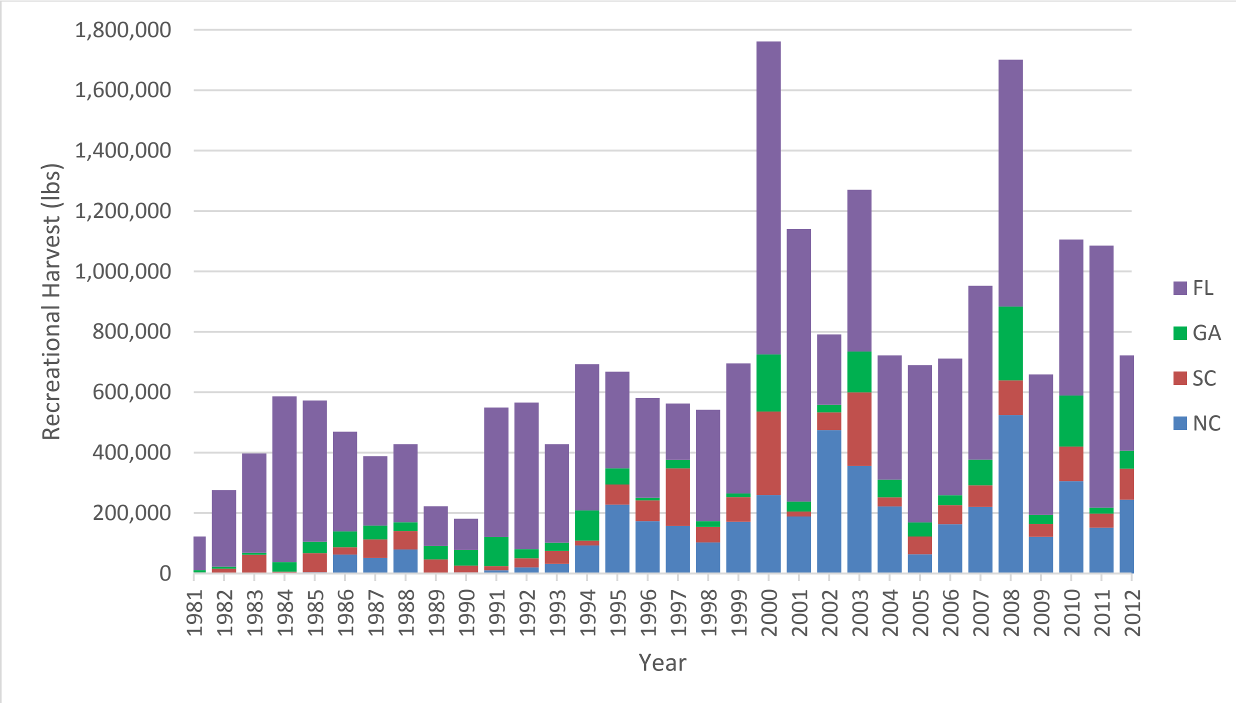


Figure 11. Recreational harvest (pounds) of Black Drum by year and state in the South Atlantic.

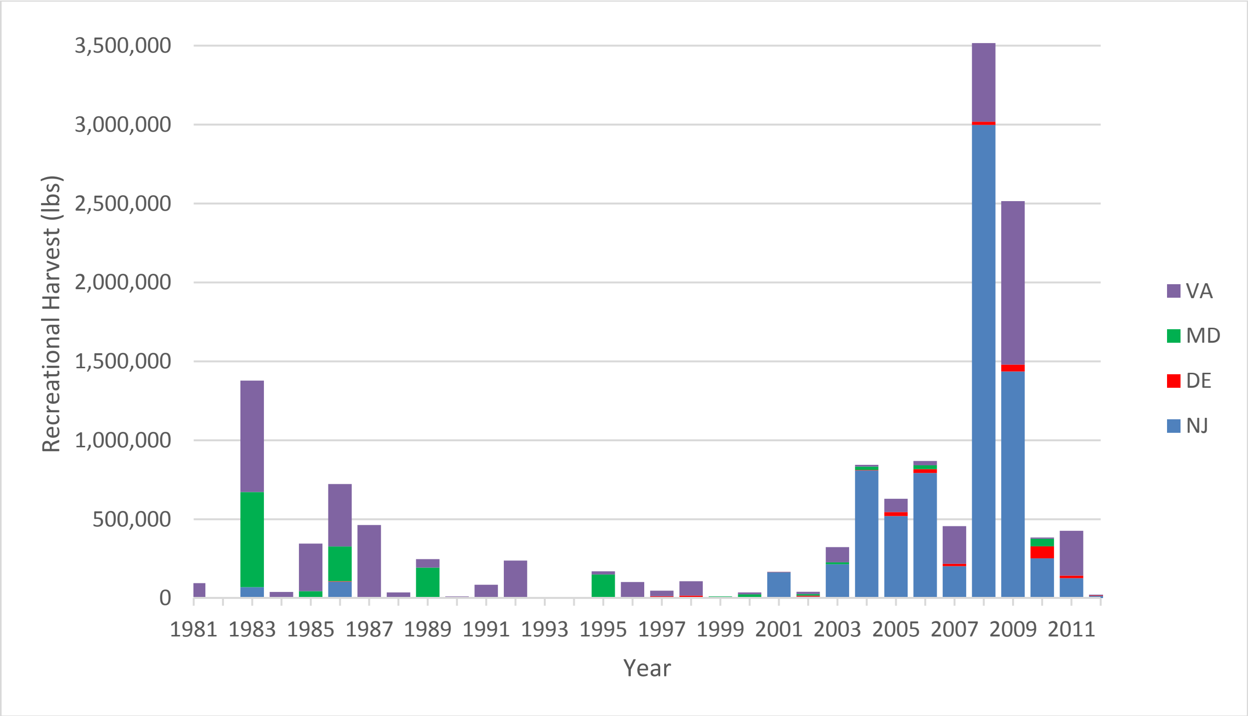


Figure 12. Recreational harvest (pounds) of Black Drum by year and state in the Mid-Atlantic.

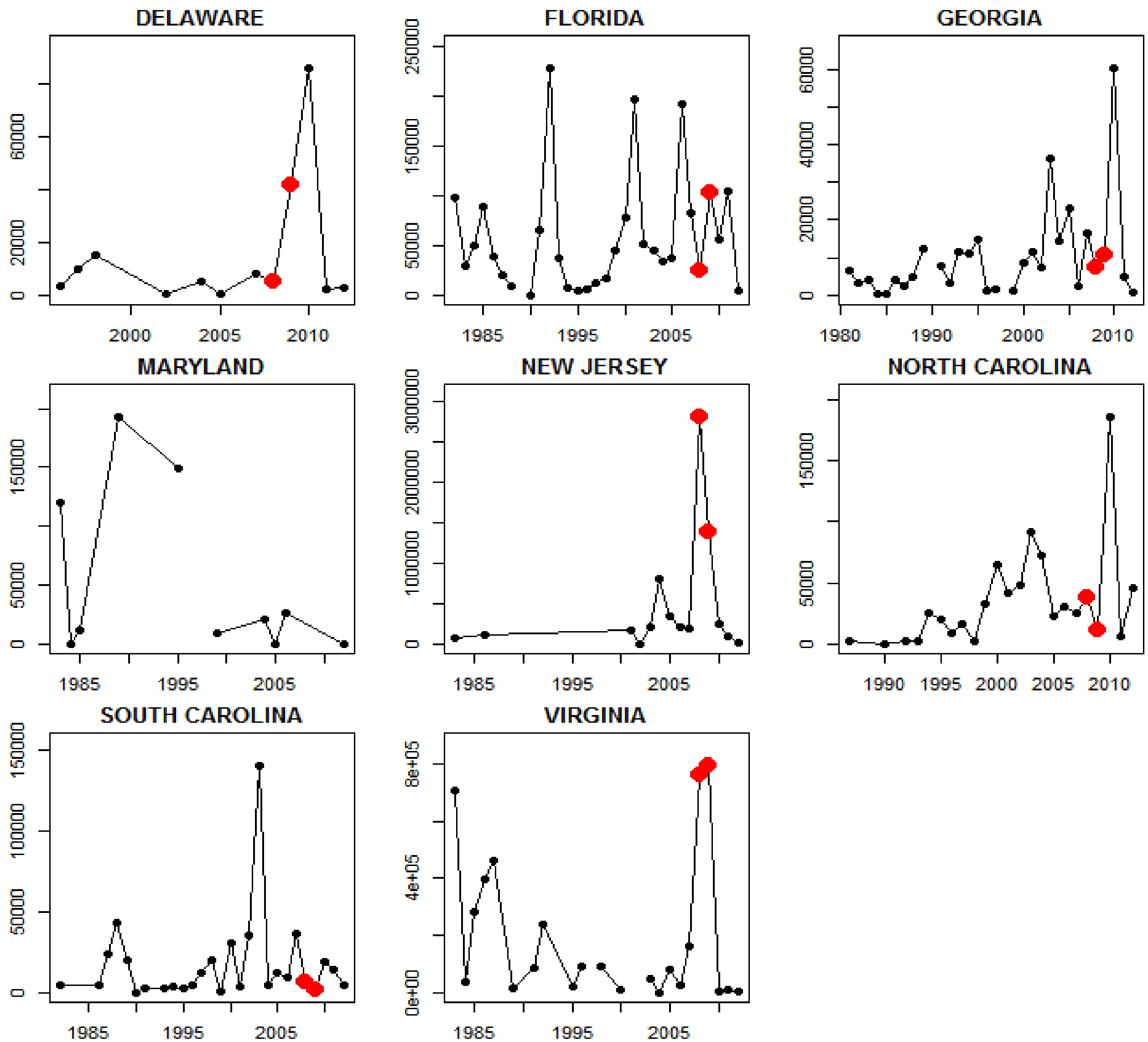


Figure 13. Wave three landings (lbs) by year and state. Red points identify 2008 and 2009 where New Jersey and Virginia had extremely high estimated landings.

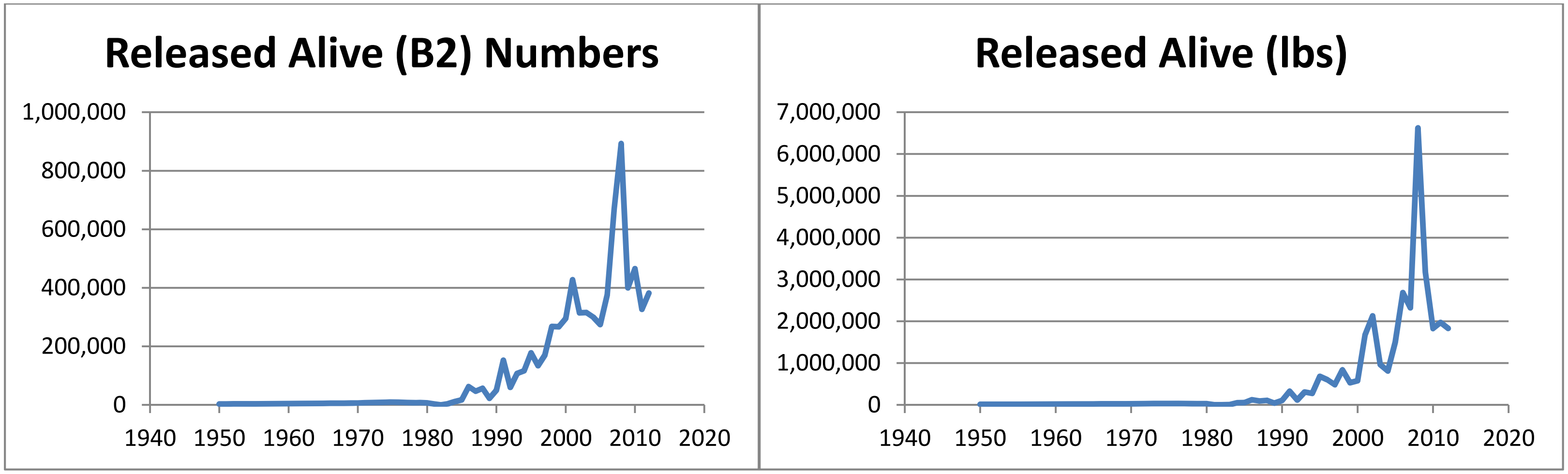


Figure 14. Estimated recreational live discards (number and weight) of Black Drum on the east coast (NJ-FL) from USFWS fishing license data/FHWAR census method (1950-1980), calibrated MRFSS (1981-2003), and MRIP (2004-2012).

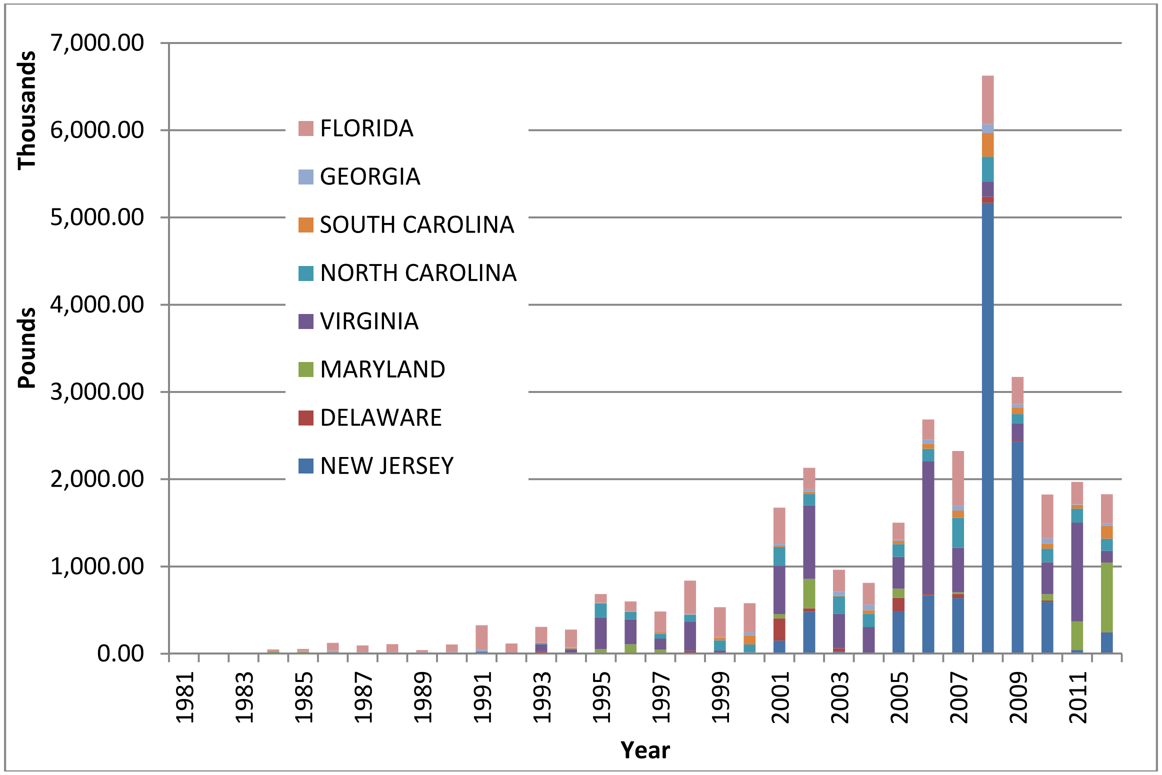


Figure 15. Estimated recreational live discards (pounds) of Black Drum by state (NJ-FL) from calibrated MRFSS (1981-2003), and MRIP (2004-2012).

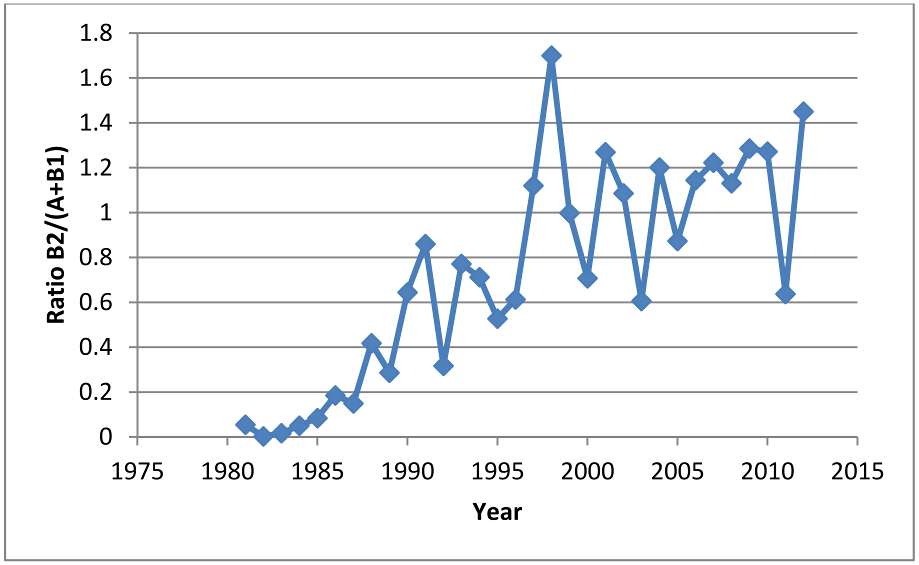
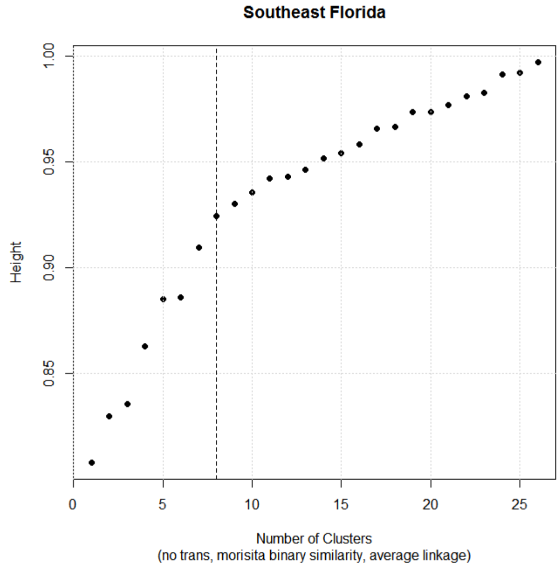
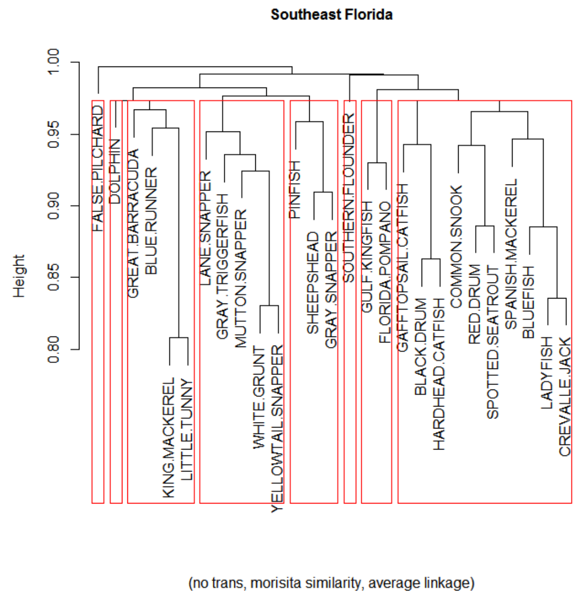
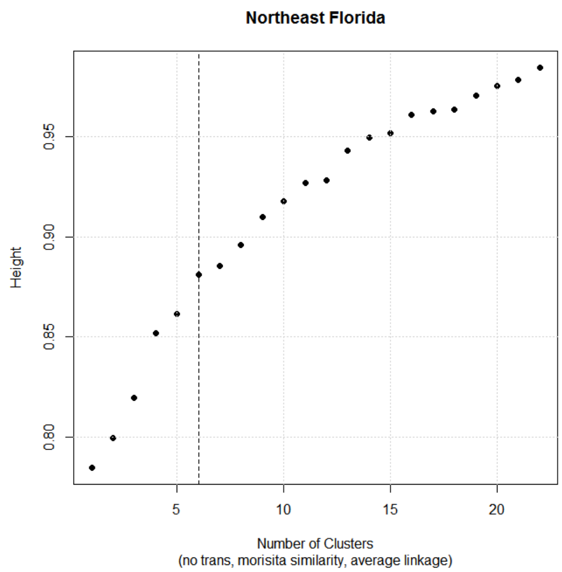
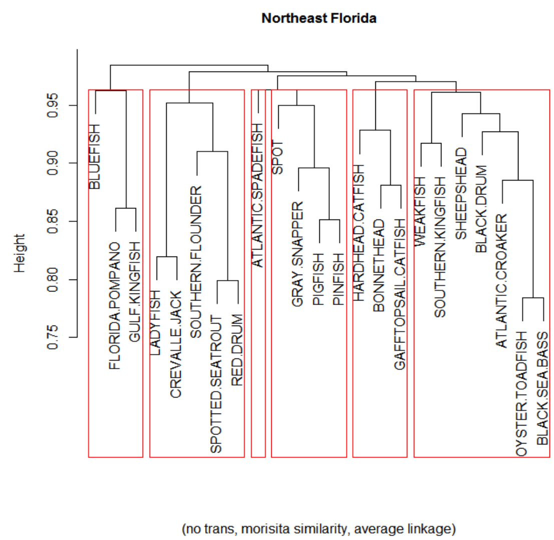


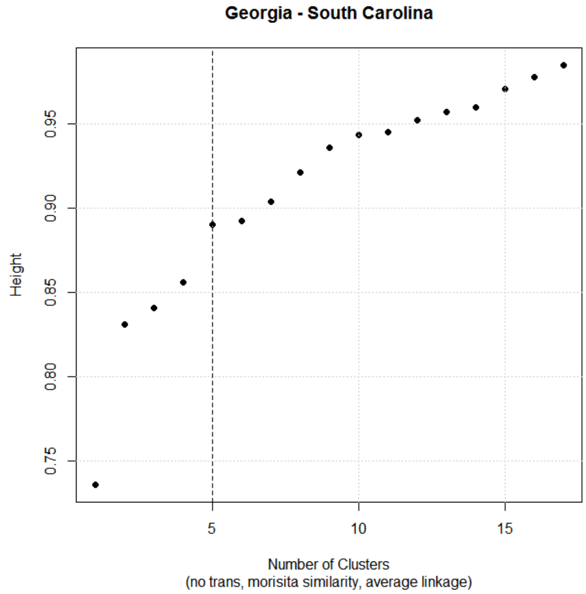
Figure 16. Ratio of coastwide number of fish released alive (B2) to number harvested (A+B1)

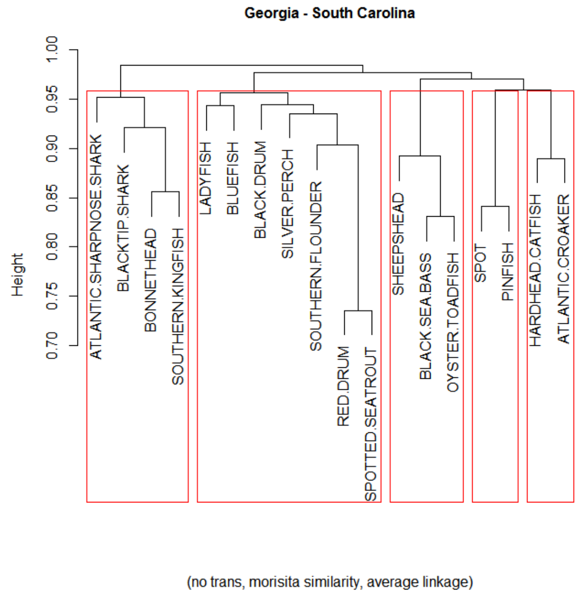

Southeast Florida
Height
Number of Clusters
(no trans, morisita binary similarity, average linkage)

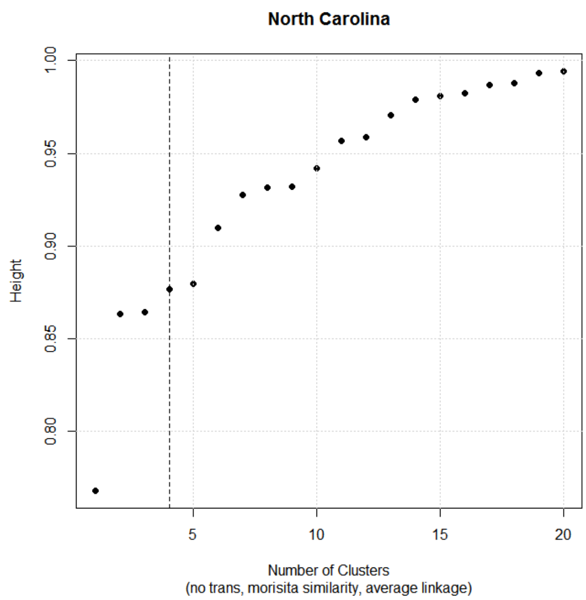

Southeast Florida
Height
FALSE.PILCHARD
DOLPHIN
GREAT.BARRACUDA
BLUE.RUNNER
KING.MACKEREL
LITTLE.TUNNY
LANE.SNAPPER
GRAY.TRIGGERFISH
MUTTON.SNAPPER
WHITE.GRUNT
YELLOWTAIL.SNAPPER
PINFISH
SHEEPSHEAD
GRAY.SNAPPER
SOUTHERN.FLOUNDER
GULF.KINGFISH
FLORIDA.POMPANO
GAFFTOPSAIL.CATFISH
BLACK.DRUM
HARDHEAD.CATFISH
COMMON.SNOOK
RED.DRUM
SPOTTED.SEATROUT
SPANISH.MACKEREL
BLUEFISH
LADYFISH
CREVALLE.JACK
(no trans, morisita similarity, average linkage)

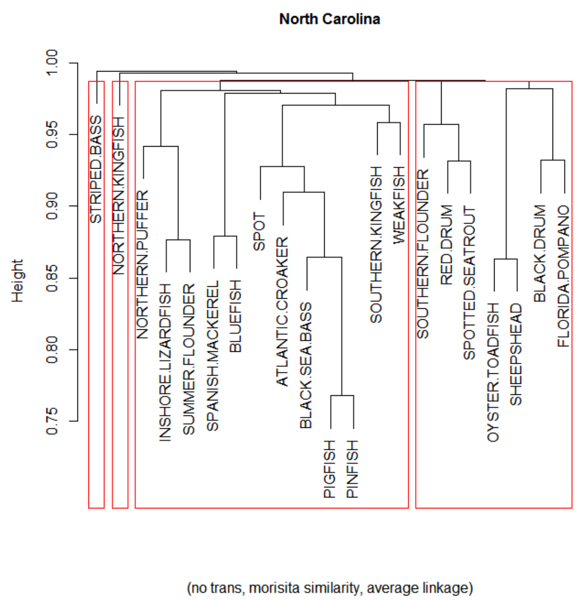

Northeast Florida
Height
Number of Clusters
(no trans, morisita similarity, average linkage)


Northeast Florida
Height
BLUEFISH
FLORIDA.POMPANO
GULF.KINGFISH
LADYFISH
CREVALLE.JACK
SOUTHERN.FLOUNDER
SPOTTED.SEATROUT
RED.DRUM
ATLANTIC.SPADEFISH
SPOT
GRAY.SNAPPER
PIGFISH
PINFISH
HARDHEAD.CATFISH
BONNETHEAD
GAFFTOPSAIL.CATFISH
WEAKFISH
SOUTHERN.KINGFISH
SHEEPSHEAD
BLACK.DRUM
ATLANTIC.CROAKER
OYSTER.TOADFISH
BLACK.SEA.BASS
(no trans, morisita similarity, average linkage)


Georgia - South Carolina
Height
0.75
0.80
0.85
0.90
0.95
5
10
15
Number of Clusters
(no trans, morisita similarity, average linkage)


Georgia - South Carolina
Height
0.70
0.75
0.80
0.85
0.90
0.95
1.00
ATLANTIC.SHARPNOSE.SHARK
BLACKTIP.SHARK
BONNETHEAD
SOUTHERN.KINGFISH
LADYFISH
BLUEFISH
BLACK.DRUM
SILVER.PERCH
SOUTHERN.FLOUNDER
RED.DRUM
SPOTTED.SEATROUT
SHEEPSHEAD
BLACK.SEA.BASS
OYSTER.TOADFISH
SPOT
PINFISH
HARDHEAD.CATFISH
ATLANTIC.CROAKER
(no trans, morisita similarity, average linkage)


North Carolina
Height
0.80
0.85
0.90
0.95
1.00
5
10
15
20
Number of Clusters
(no trans, morisita similarity, average linkage)


North Carolina
Height
0.75
0.80
0.85
0.90
0.95
1.00
STRIPED.BASS
NORTHERN.KINGFISH
NORTHERN.PUFFER
INSHORE.LIZARDFISH
SUMMER.FLOUNDER
SPANISH.MACKEREL
BLUEFISH
SPOT
ATLANTIC.CROAKER
BLACK.SEA.BASS
PIGFISH
PINFISH
SOUTHERN.KINGFISH
WEAKFISH
SOUTHERN.FLOUNDER
RED.DRUM
SPOTTED.SEATROUT
OYSTER.TOADFISH
SHEEPSHEAD
BLACK.DRUM
FLORIDA.POMPANO
(no trans, morisita similarity, average linkage)

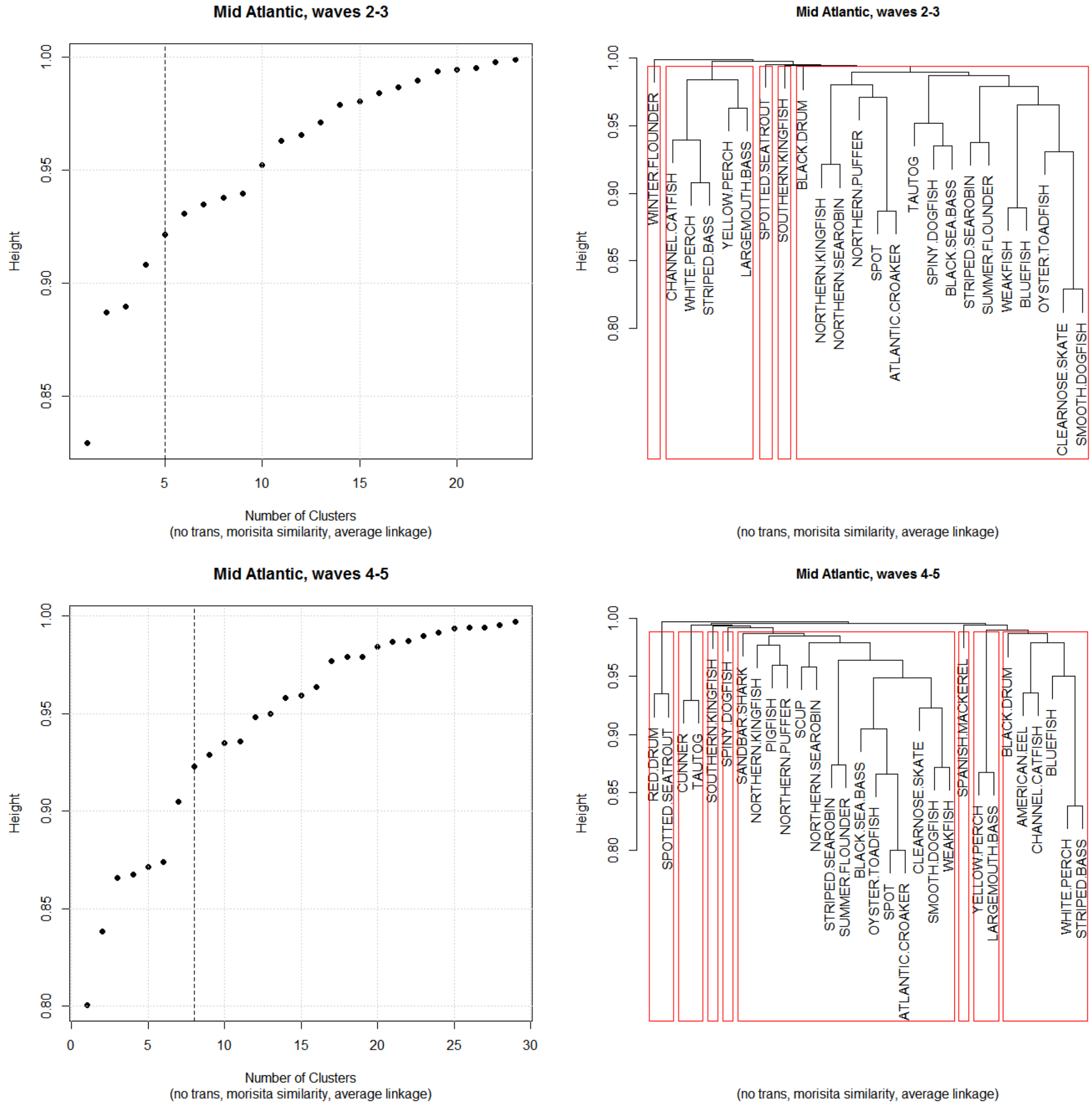


Figure 17. Scree plots and dendrograms from hierarchical cluster analyses used to identify species closely associated with Black Drum and subset intercepts accordingly. On the scree plots a vertical line identifies a breakpoint for the optimal number of clusters. Further separation beyond vertical would only increase the within-cluster similarity (height) a small amount.

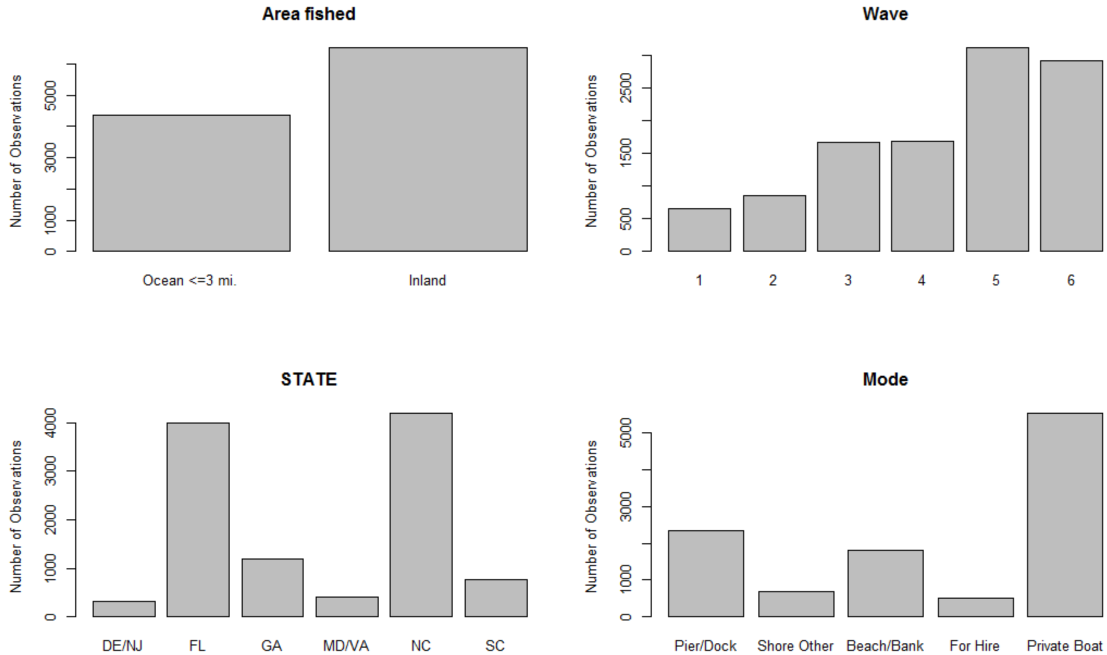


Figure 18. Number of intercepts catching Black Drum at each factor included in the GLMs.

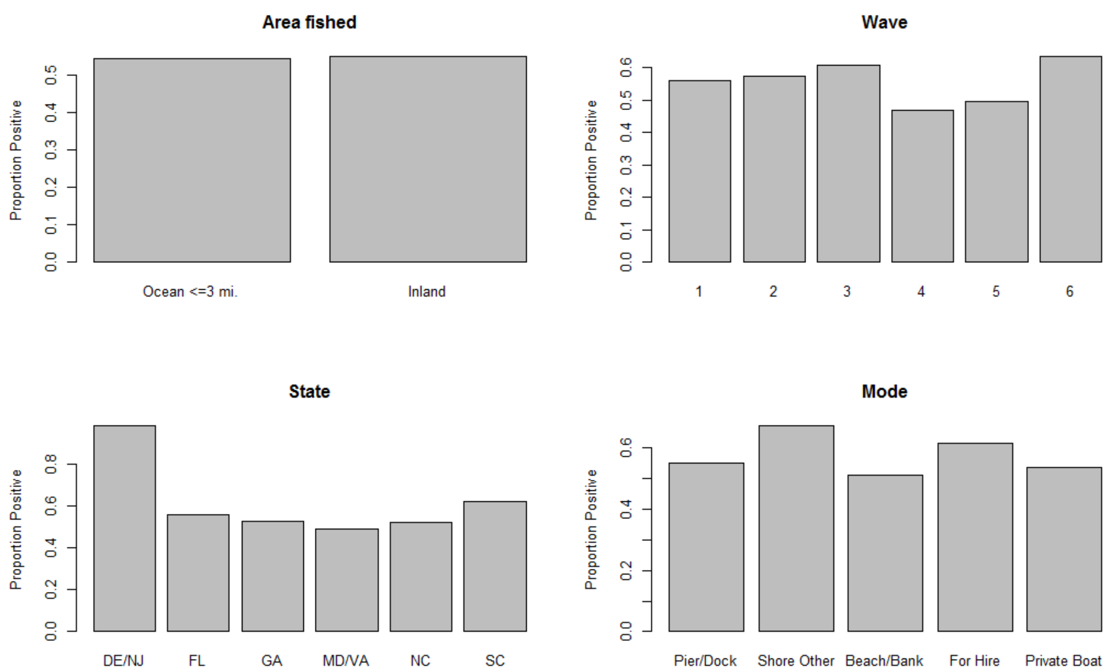


Figure 19. Proportion of subset trips that caught Black Drum for each factor included in the GLMs.

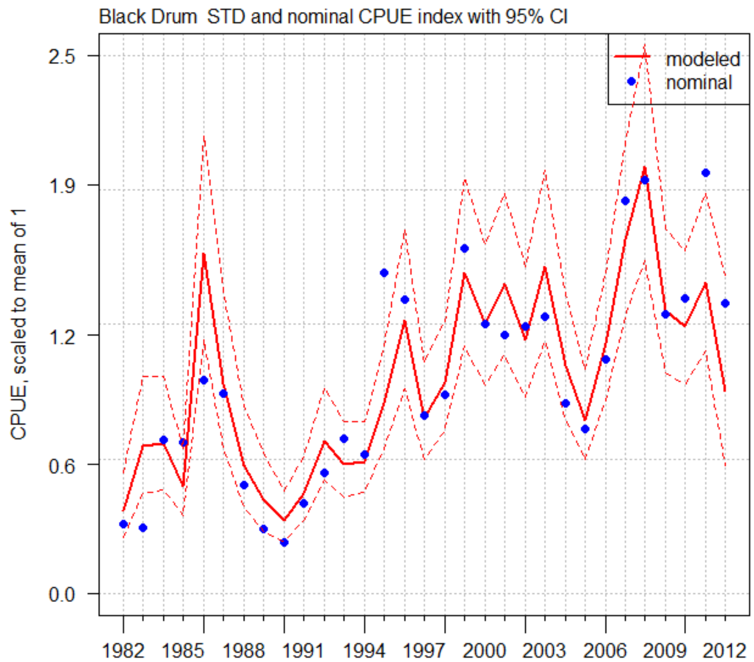


Figure 20. Standardized and nominal recreational CPUE from the coast wide MRFSS/MRIP intercept data subset by cluster analysis

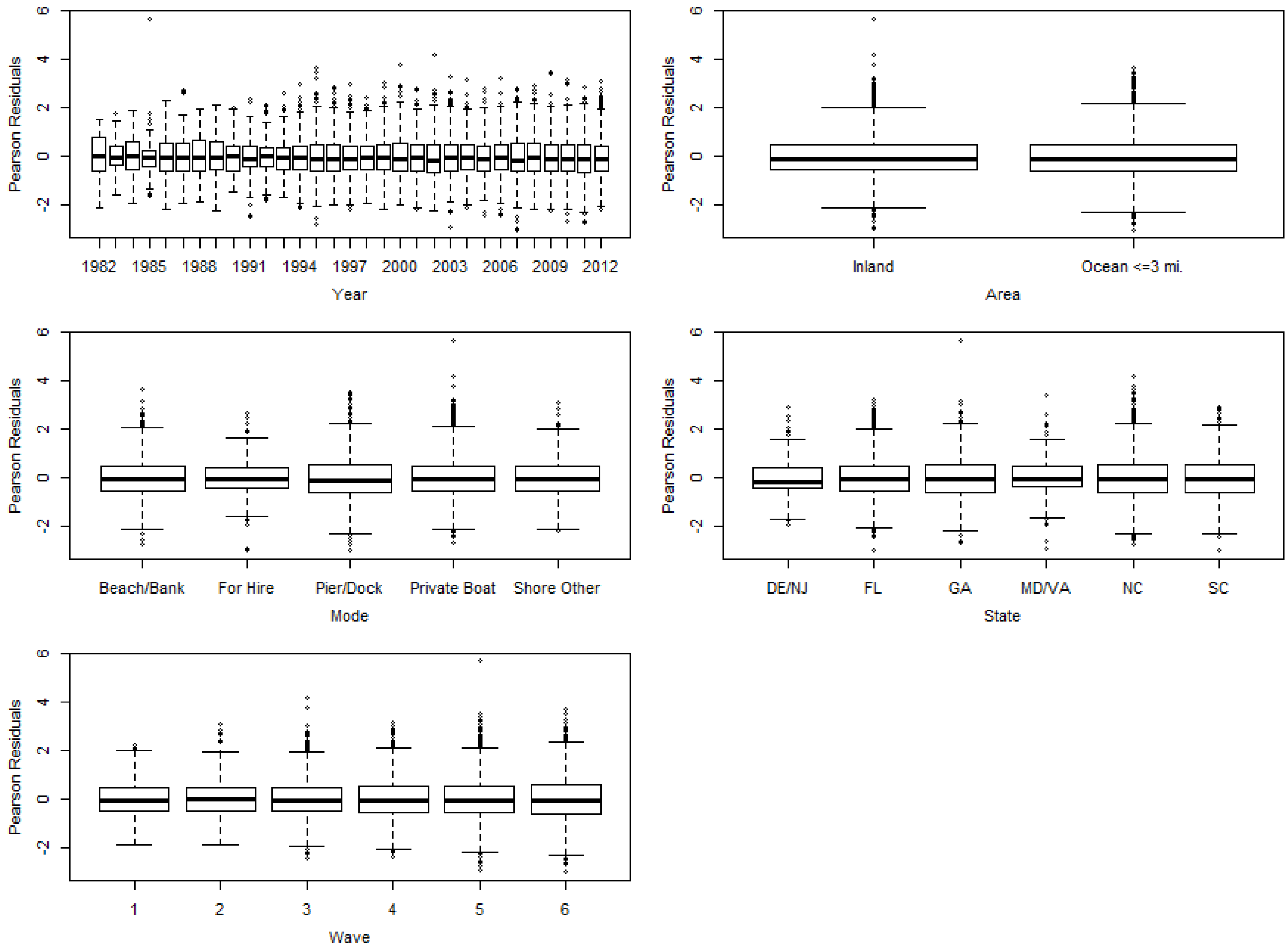


Figure 21. Coast wide MRFSS/MRIP standardized index residuals by factor for the positive observation model.

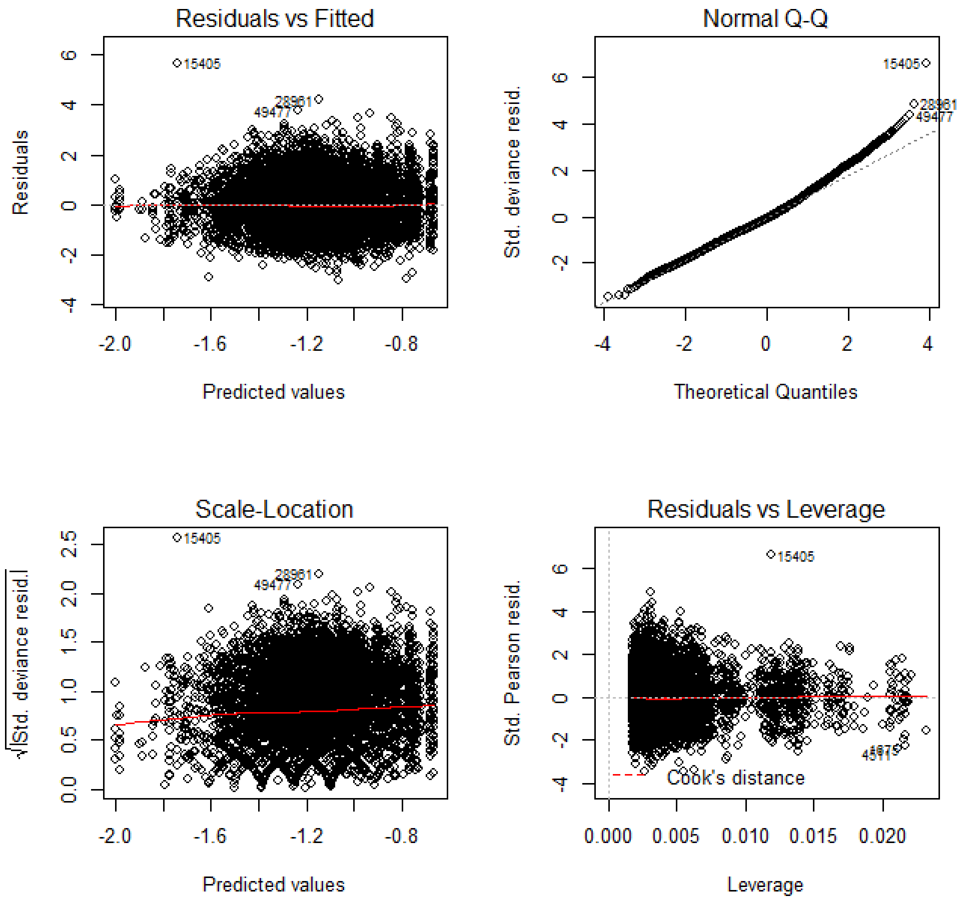


Figure 22. Model diagnostics for the coast wide MRFSS/MRIP standardized index positive observation model.

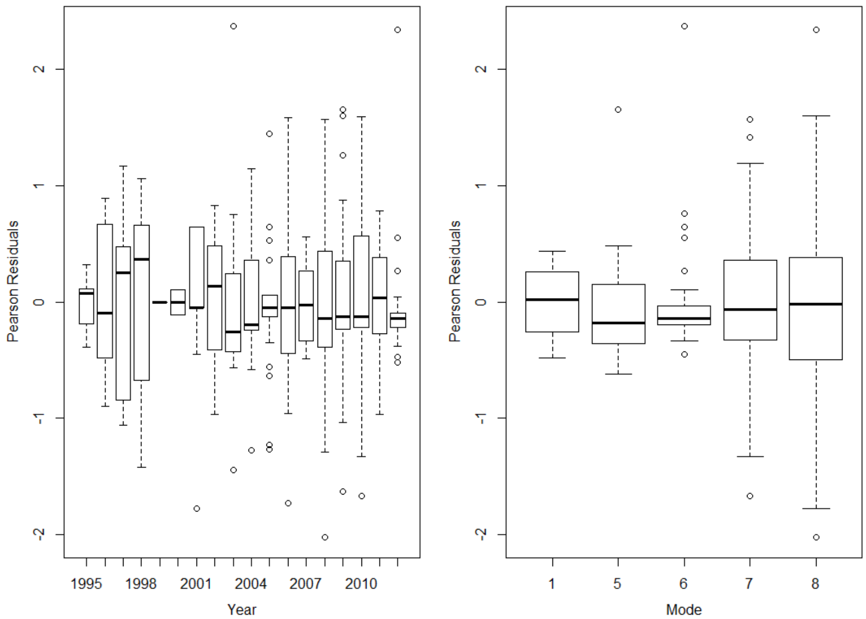


Figure 23. MRFSS/MRIP mature standardized index residuals by factor for the positive observation model.

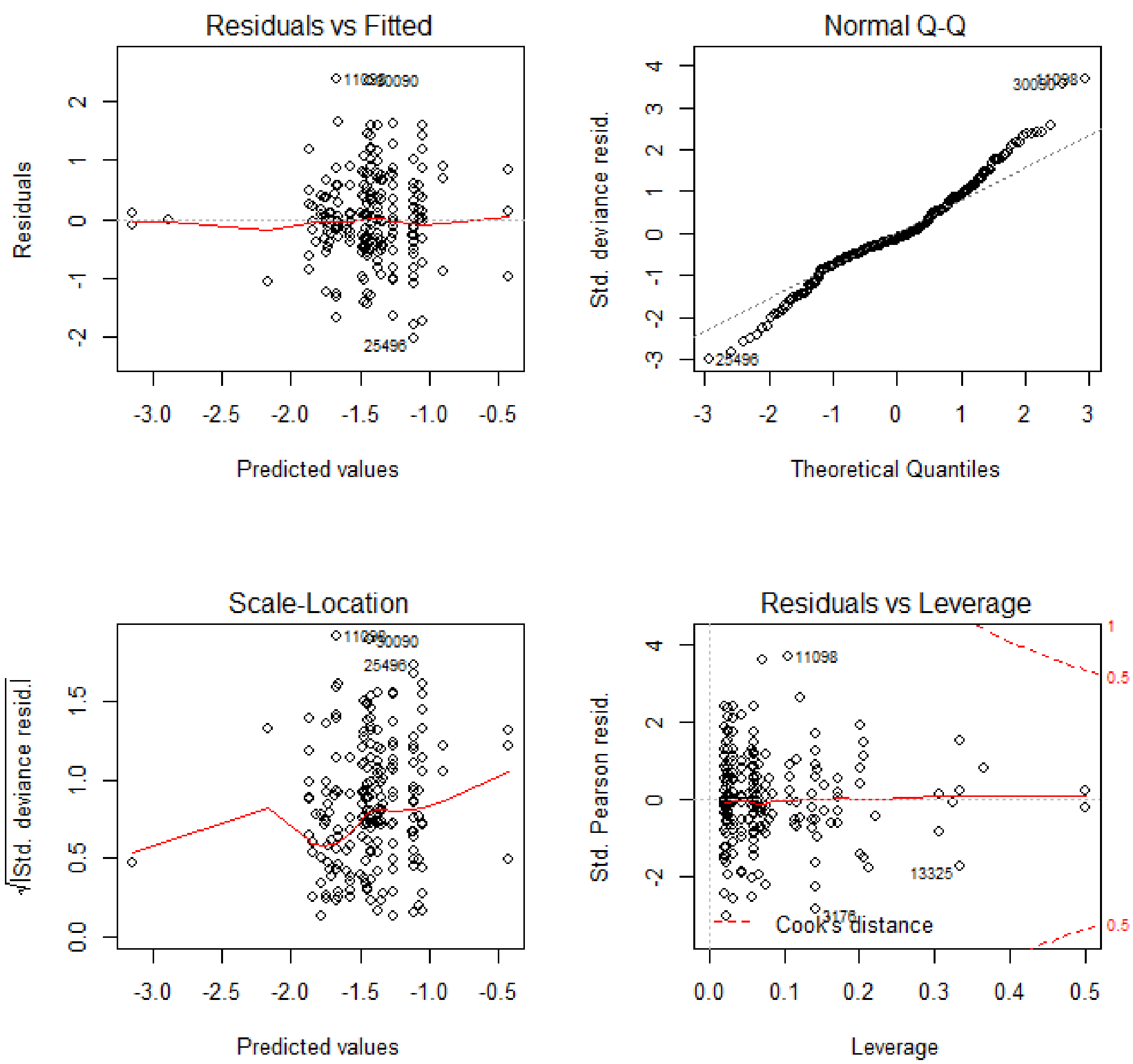


Figure 24. Model diagnostics for the MRFSS/MRIP mature standardized index positive observation model.

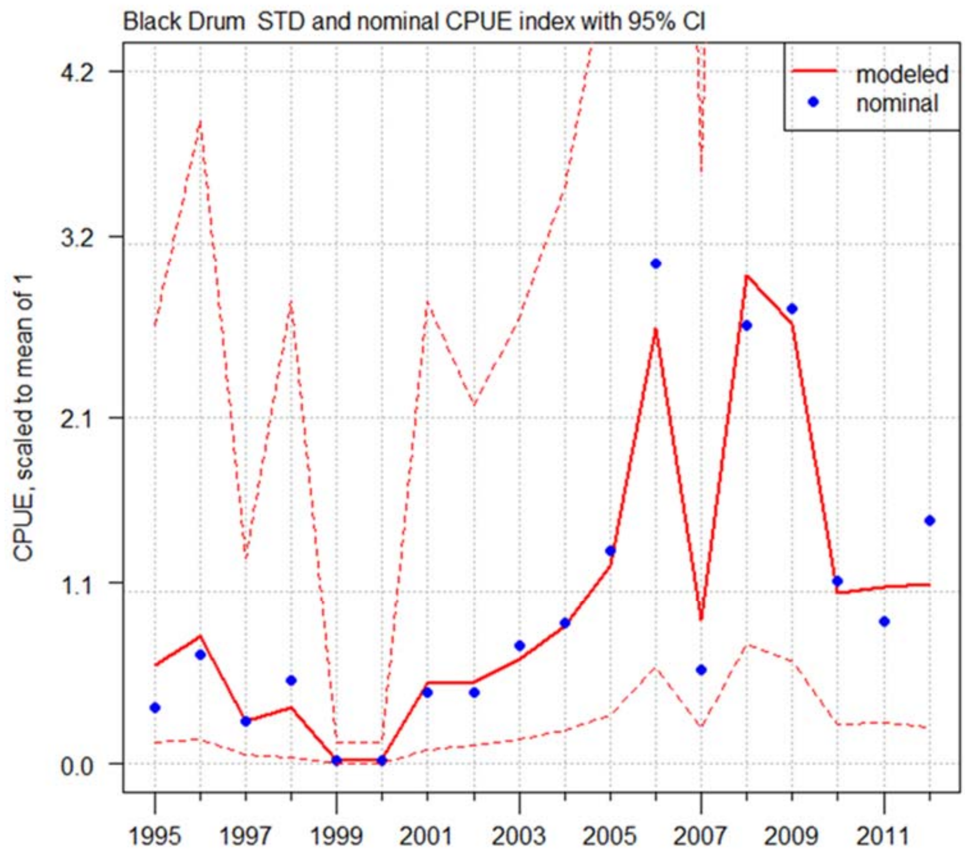


Figure 25. Standardized and nominal recreational CPUE from the MRFSS/MRIP mature intercept data subset by cluster analysis.

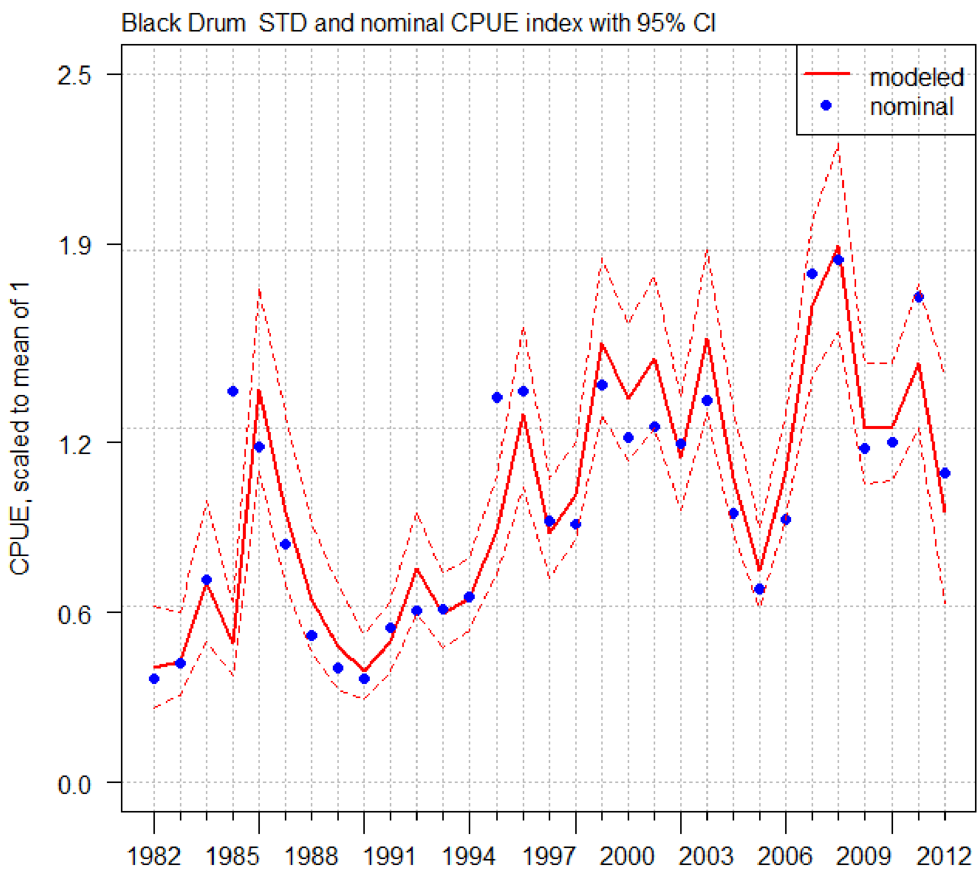


Figure 26. Standardized and nominal recreational CPUE from the MRFSS/MRIP south Atlantic intercept data subset by cluster analysis.

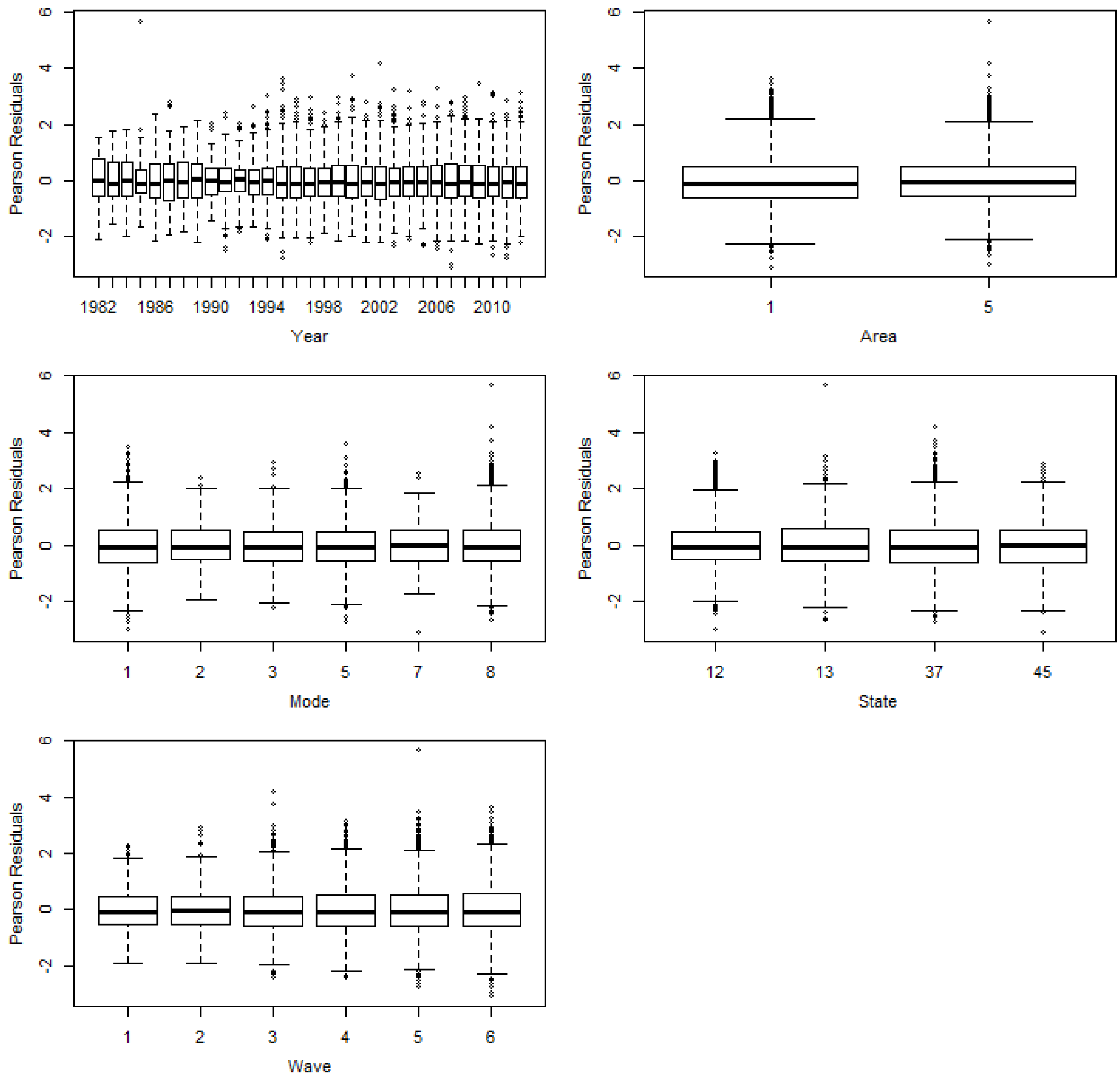


Figure 27. MRFSS/MRIP south Atlantic standardized index residuals by factor for the positive observation model.

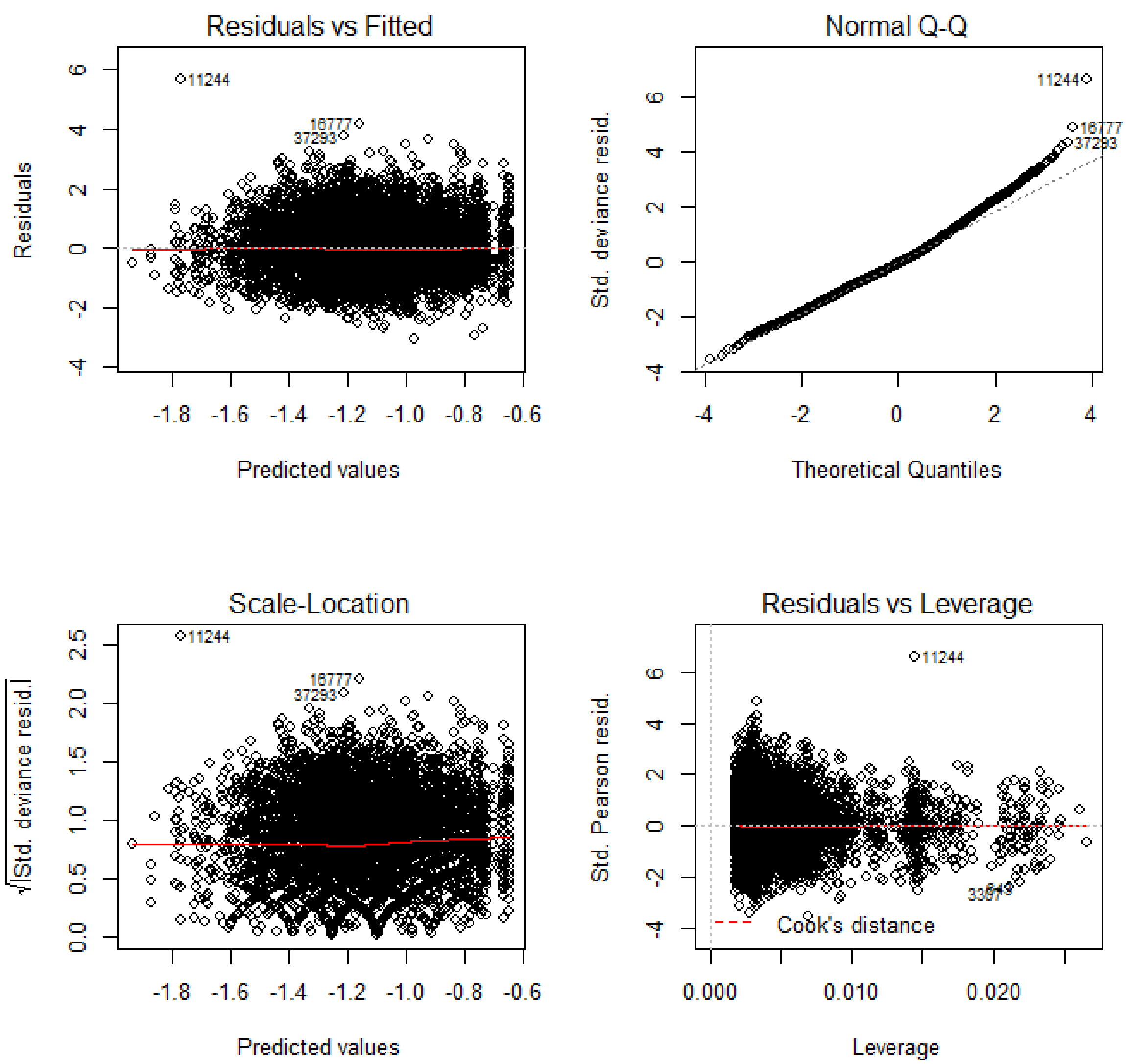


Figure 28.Model diagnostics for the MRFSS/MRIP south Atlantic standardized index positive observation model.

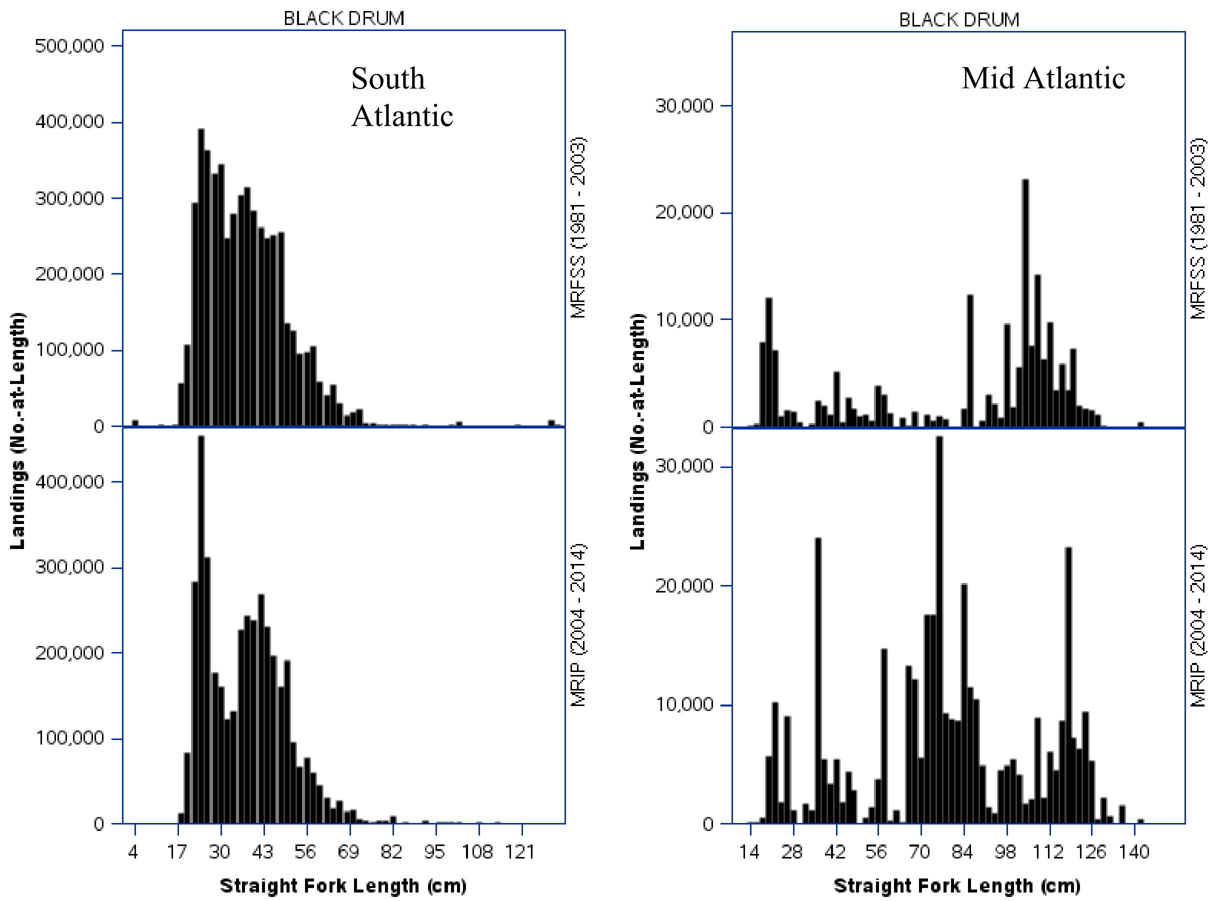


Figure 29. Length frequency distribution of total estimated recreational catch (numbers) from the South Atlantic (left) and Mid-Atlanatic (right) for all strata from MRFSS and MRIP.

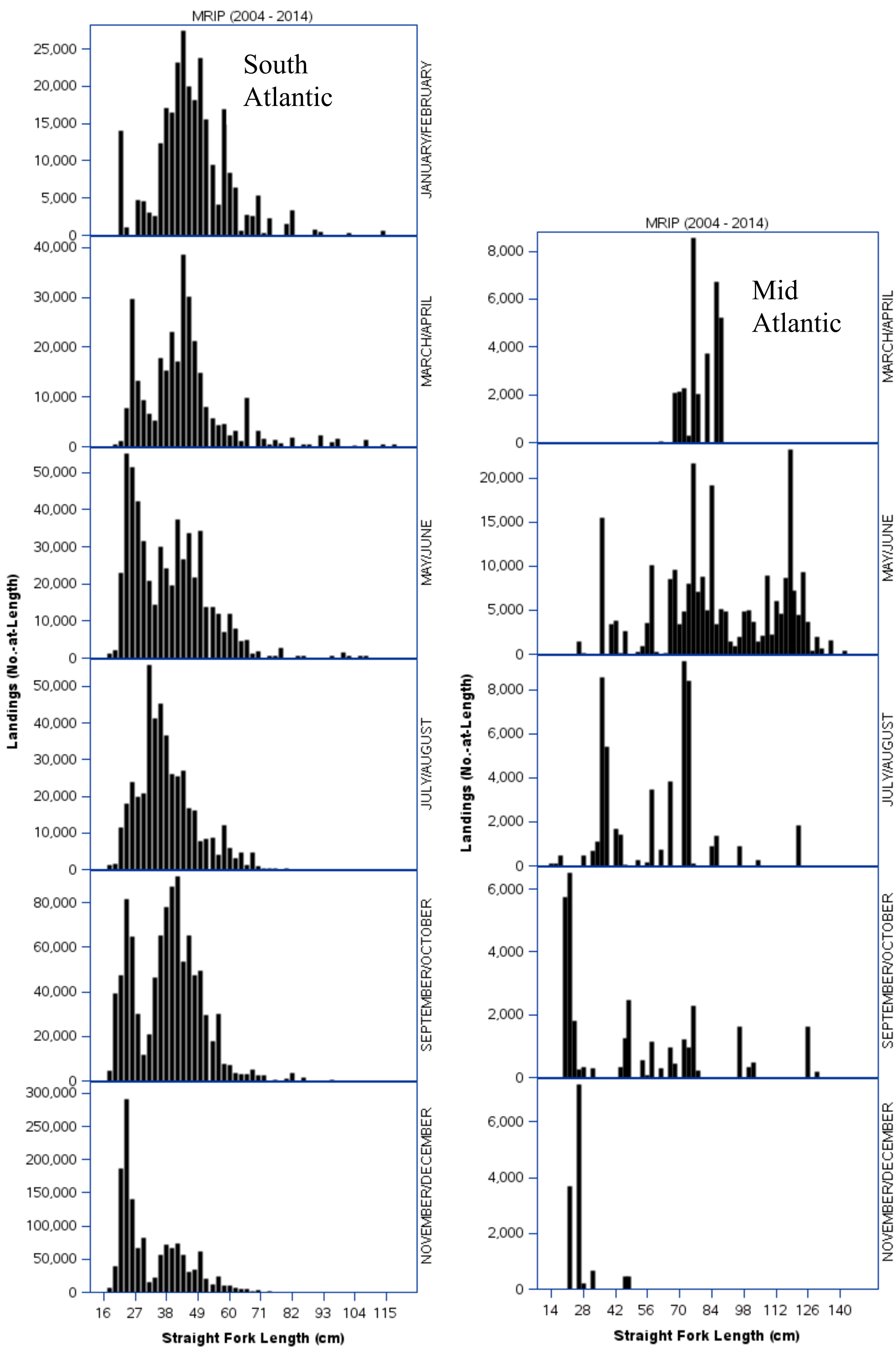


Figure 30. Length frequency distribution of total estimated recreational catch (numbers) from the South Atlantic (left) and Mid-Atlanatic (right) by wave from MRIP (2004-2012).

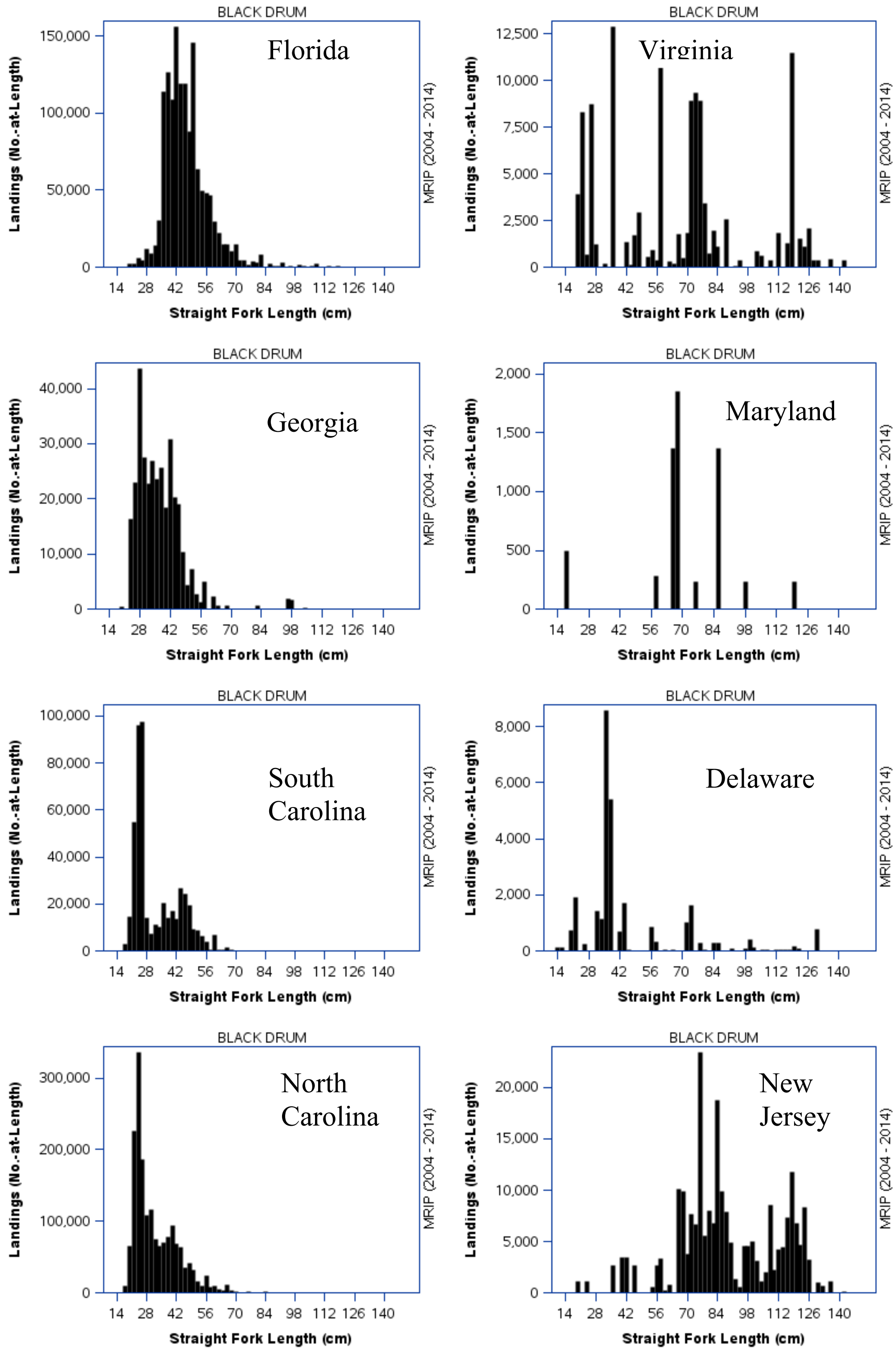


Figure 31. Length frequency distribution of total estimated recreational catch (numbers) by state from MRIP (2004-2012).

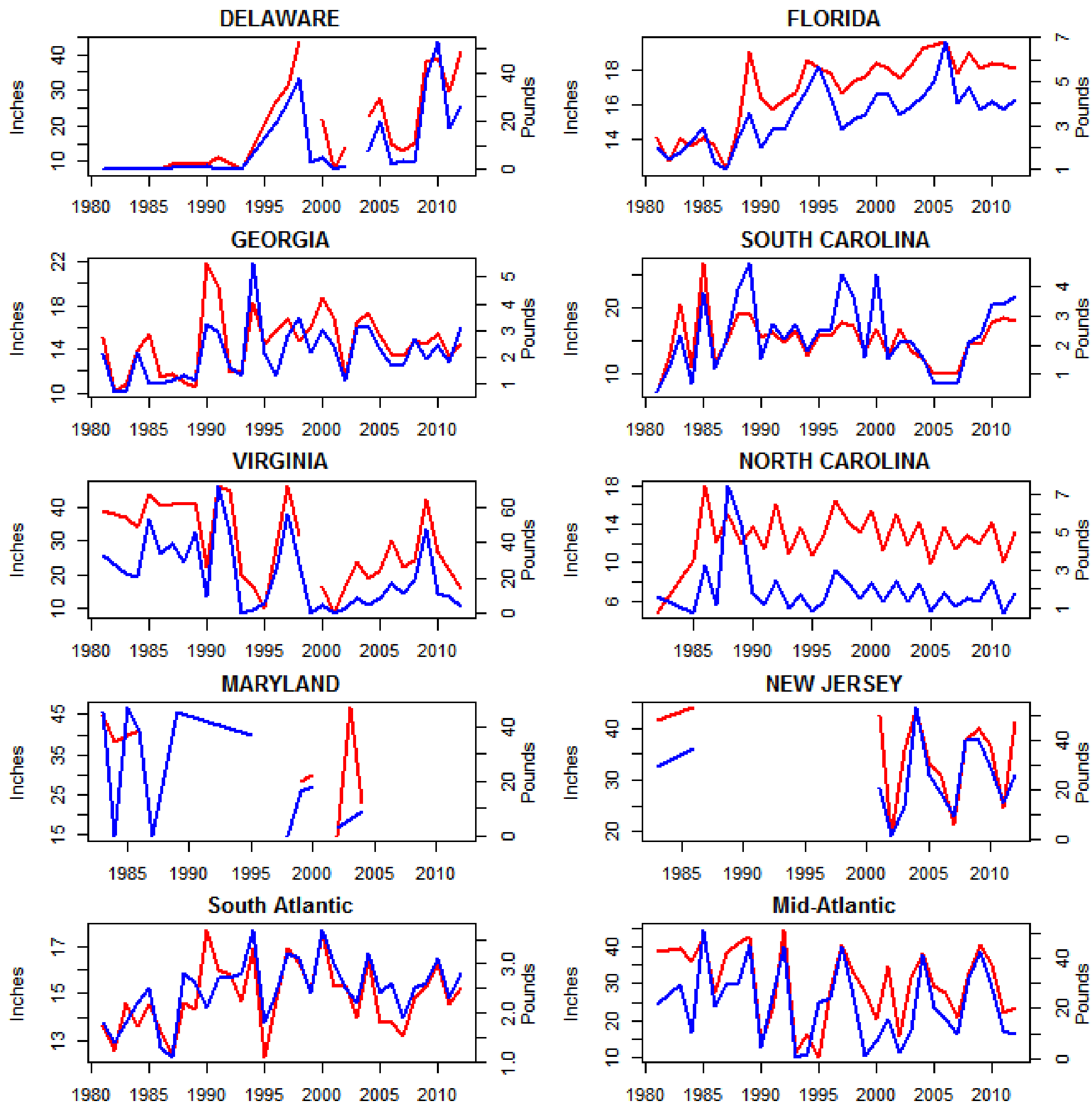


Figure 32. Average length (red) and weight (blue) of Black Drum from MRFSS/MRIP intercepts by state and region.

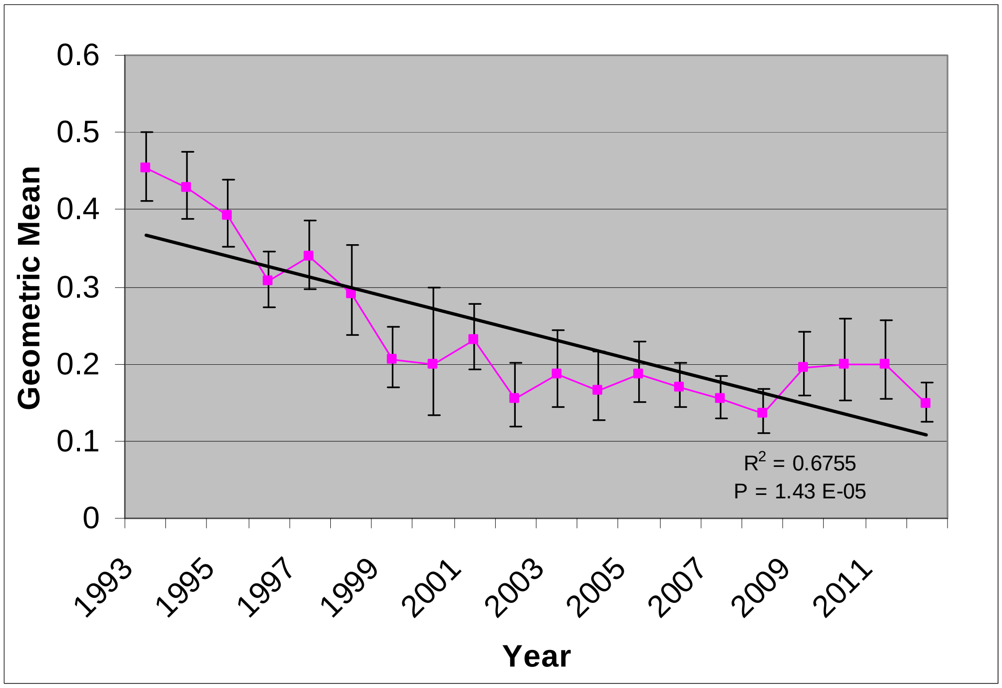


Figure 33. Maryland charter boat black drum harvest per angler CPUE, 1993-2012.

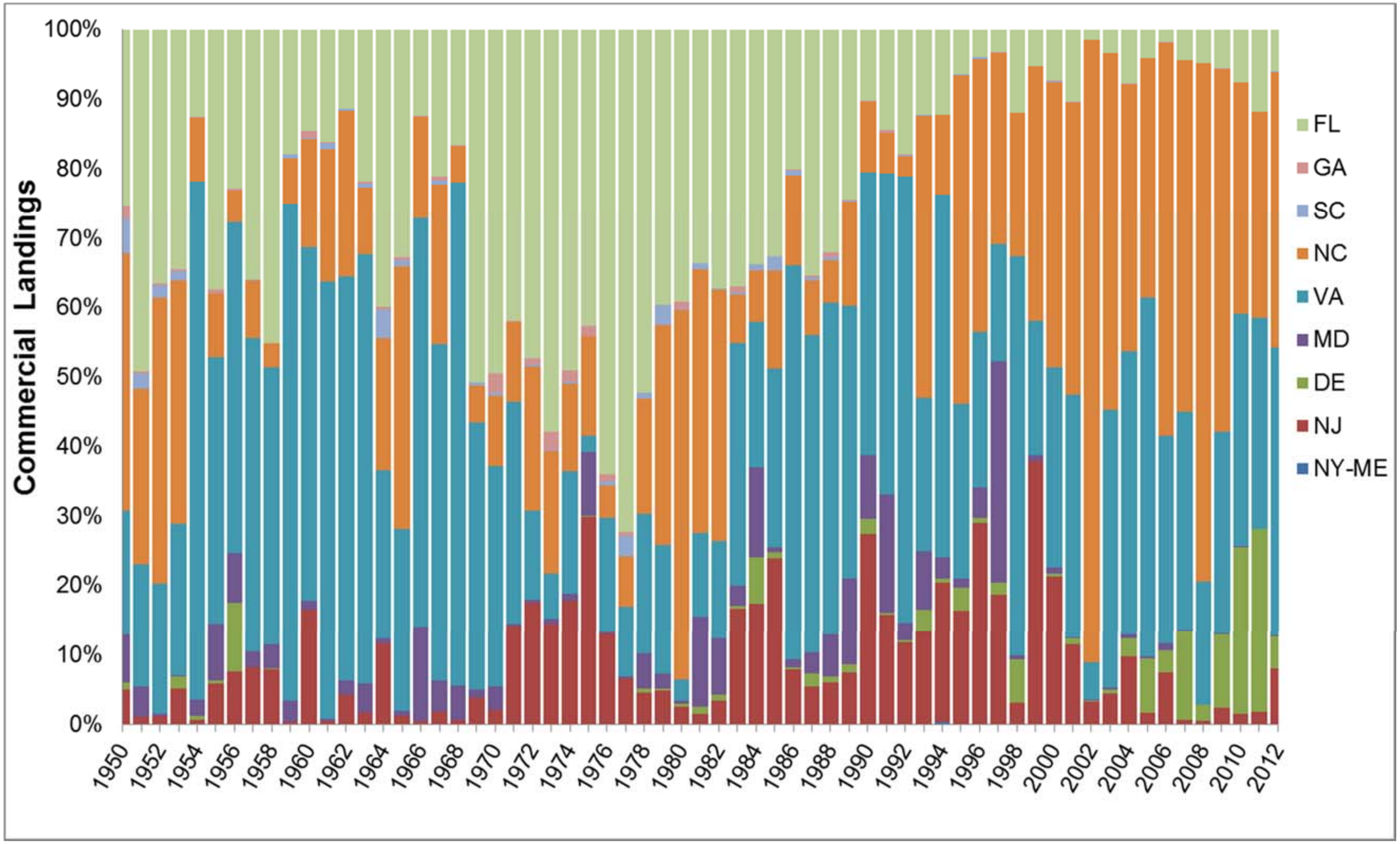


Figure 34. Coastwide Commercial Black Drum Landings, Percent Contribution By State

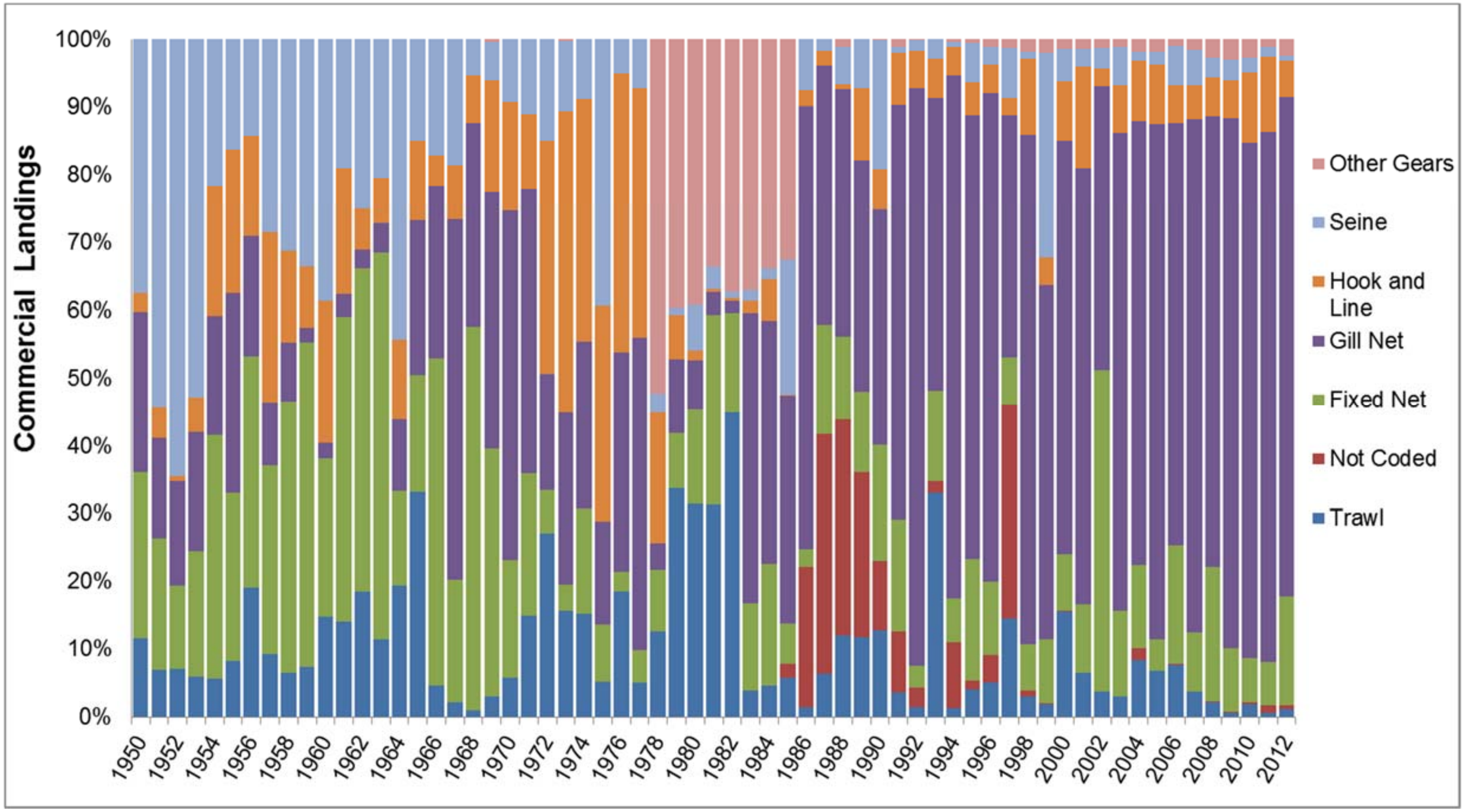


Figure 35. Coastwide Commercial Black Drum Landings, Percent Contribution By Gear, All States Combined

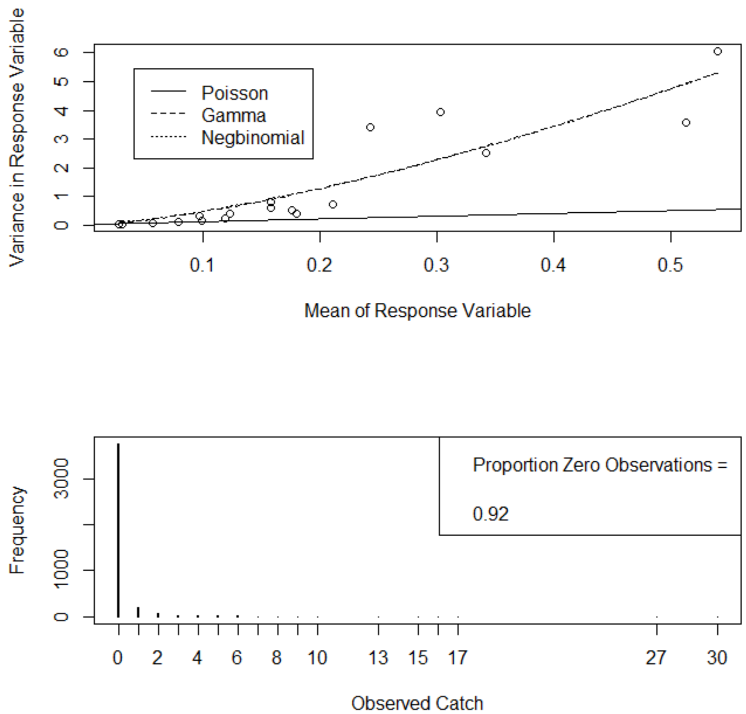
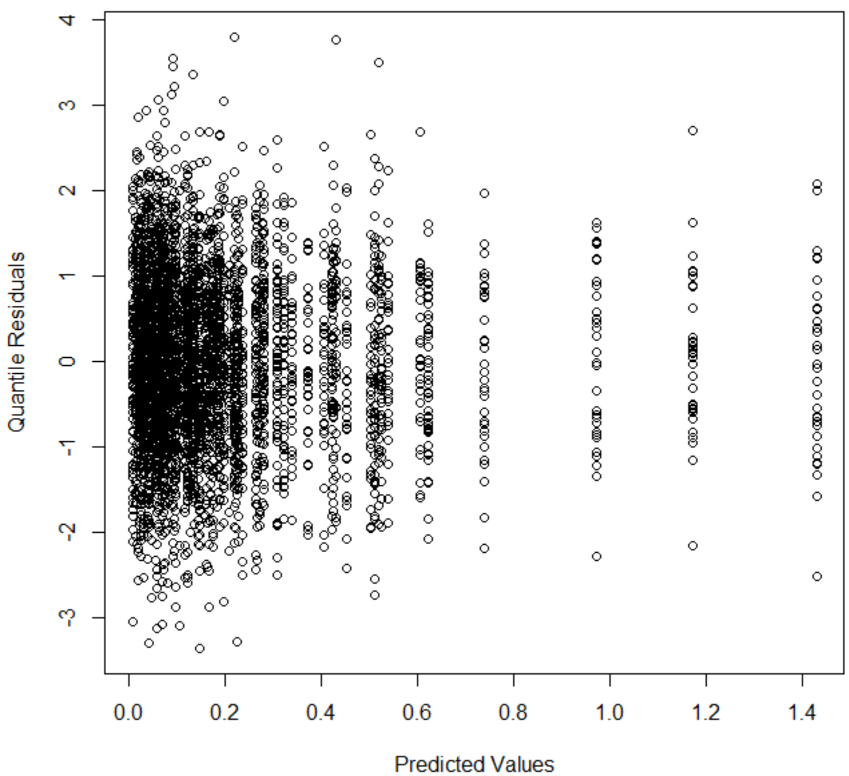
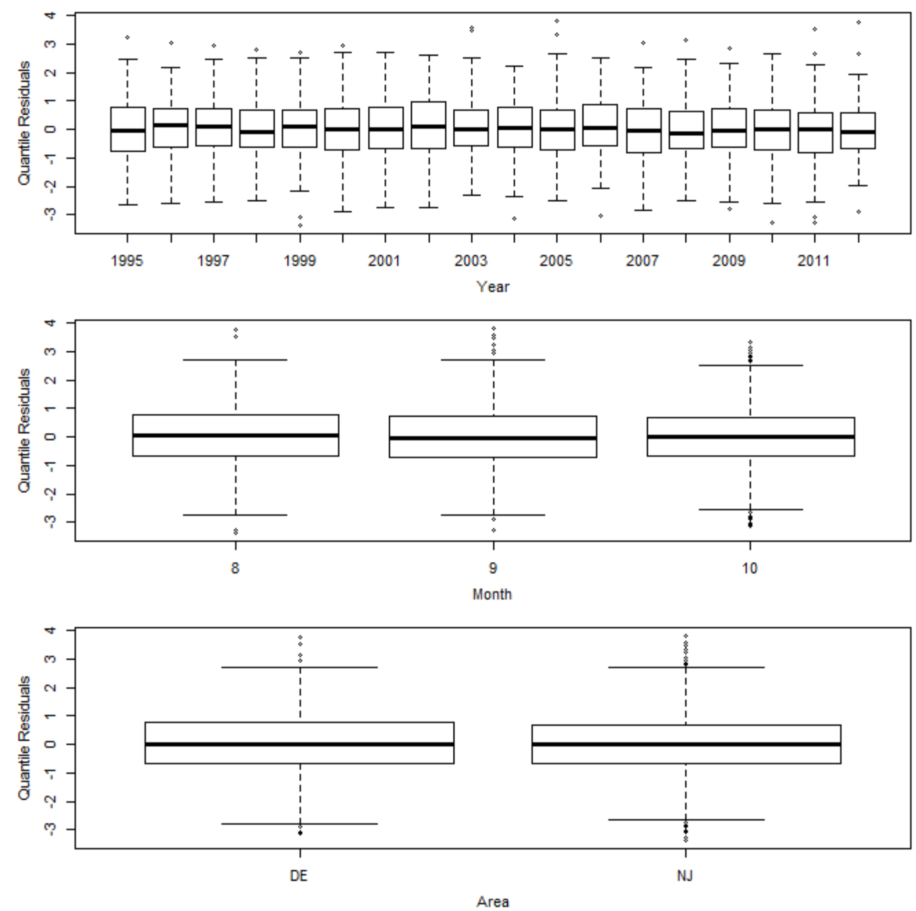


Figure 36. Distribution of the response variable and proportion of zero observations for the PSEG seine survey.



Quantile Residuals
Predicted Values



Quantile Residuals
Year
Month
Area
DE
NJ

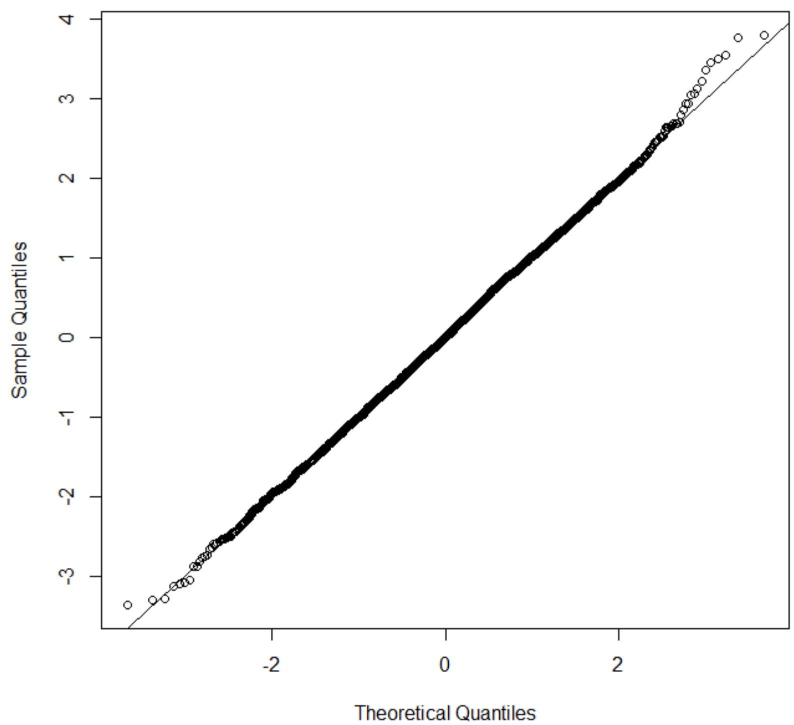


Figure 37. Diagnostic residual plots for the standardized PSEG seine index.

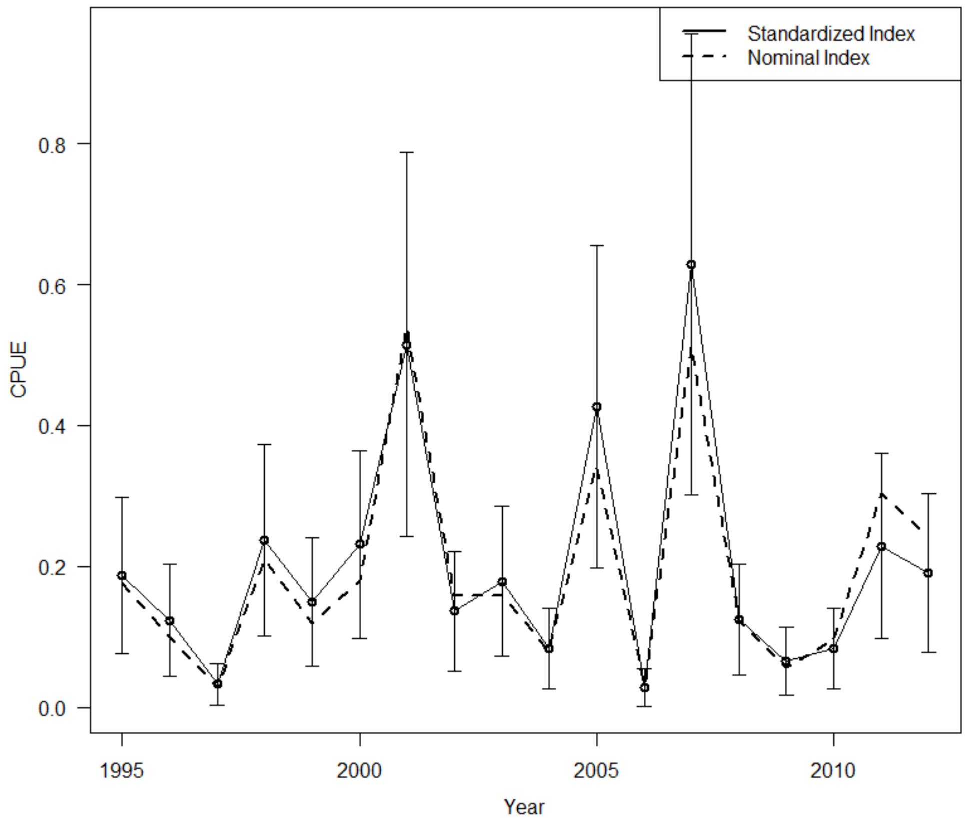


Figure 38. Standardized and nominal PSEG Seine index. Error bars represent 95% CIs of standardized index from SEs.

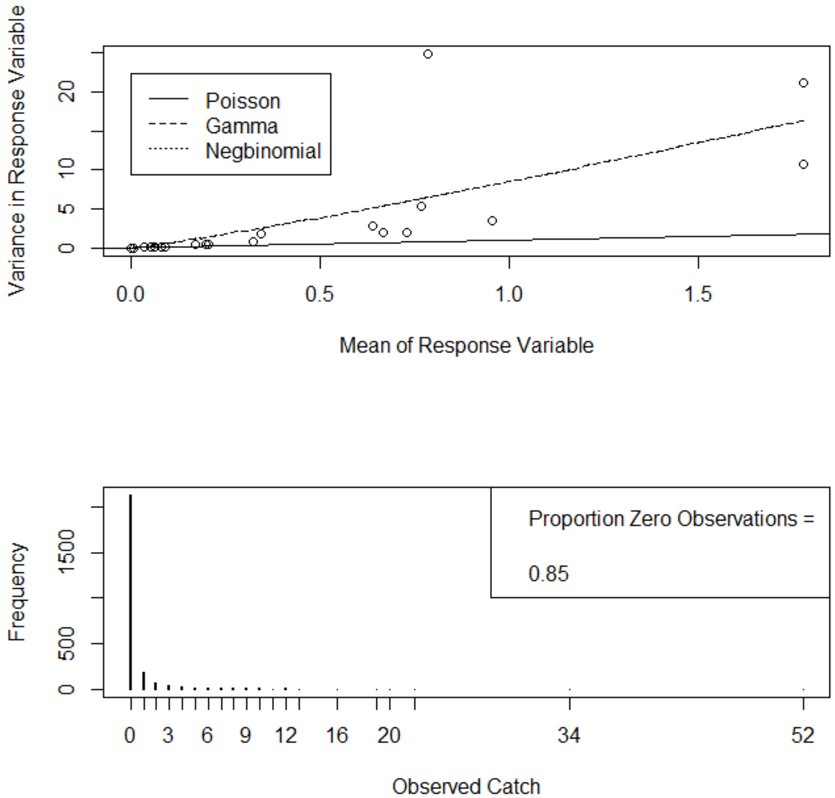
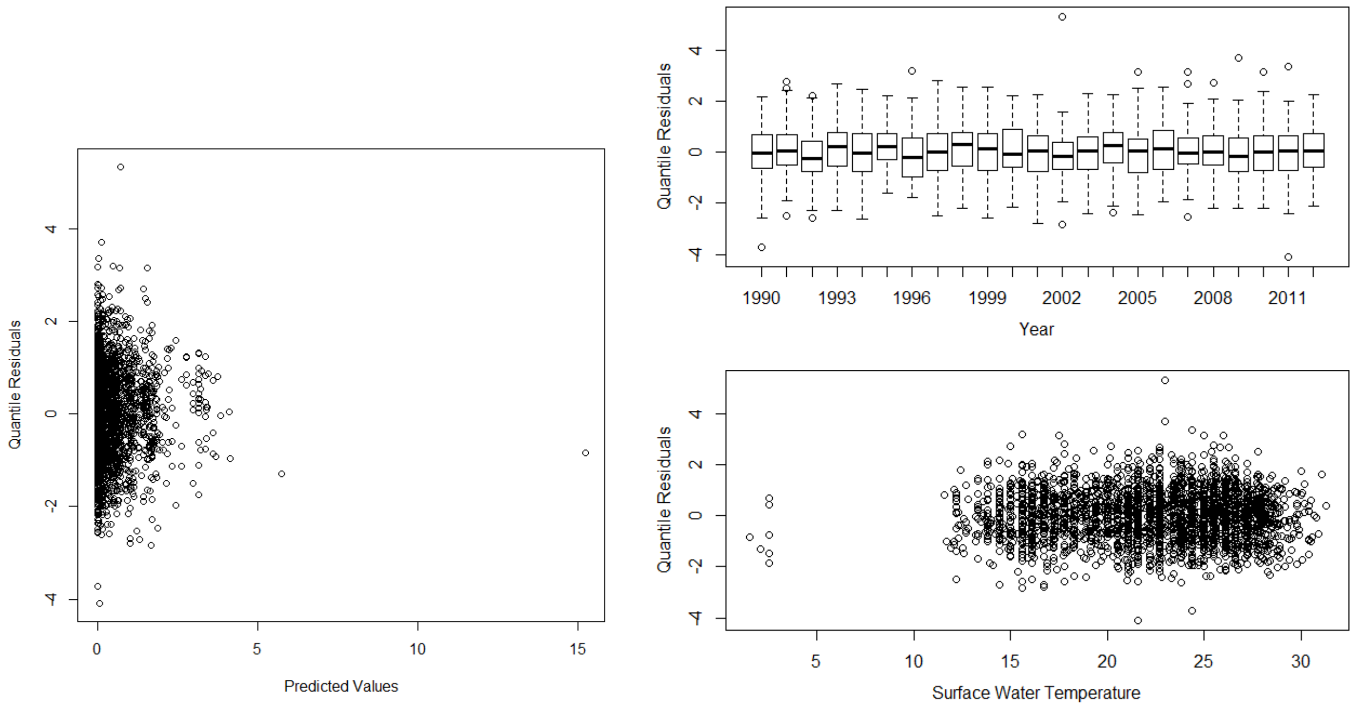


Figure 39. Distribution of the response variable and proportion of zero observations for the DE 16ft trawl survey.


Quantile Residuals
Predicted Values
Quantile Residuals
Year
Quantile Residuals
Surface Water Temperature

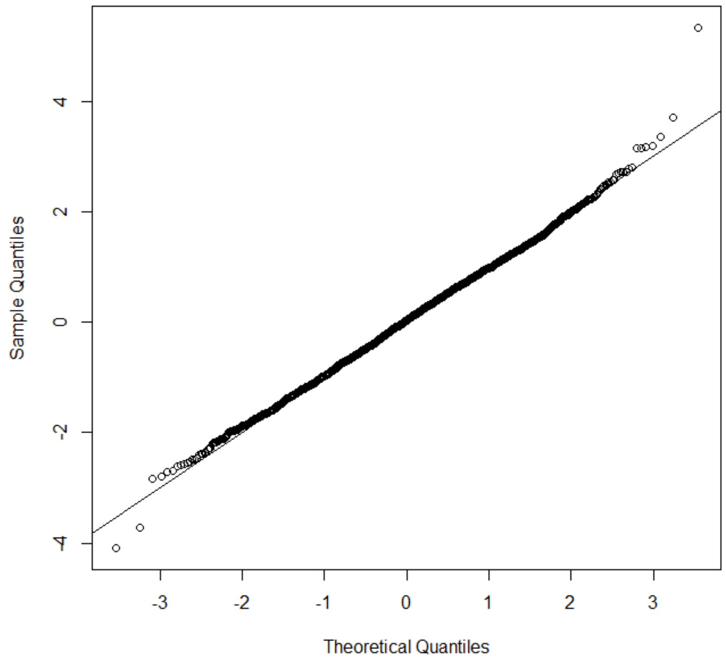


Figure 40. Diagnostic residual plots for the standardized DE 16ft trawl index.

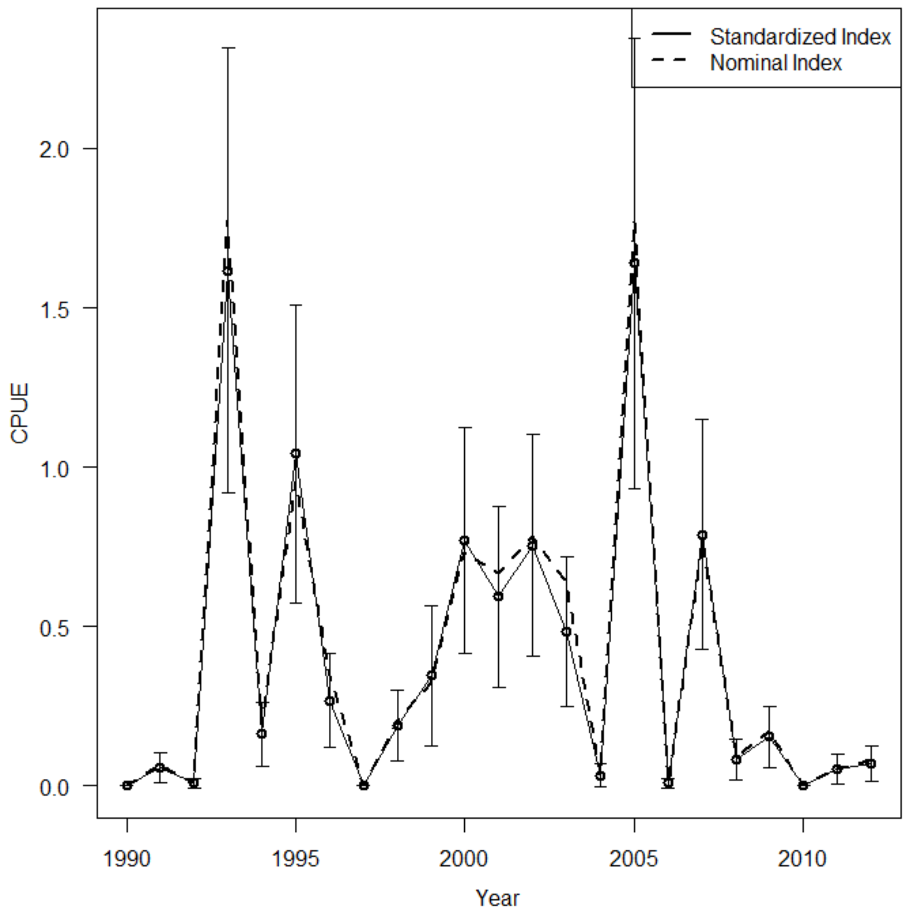


Figure 41. Standardized and nominal DE 16ft trawl index. Error bars represent 95% CIs of standardized index from SEs.

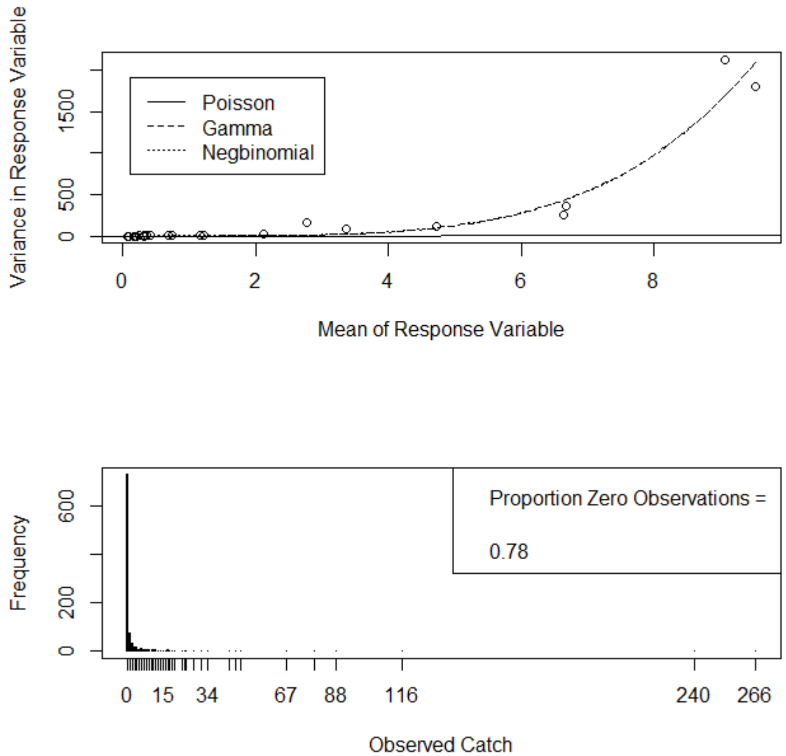
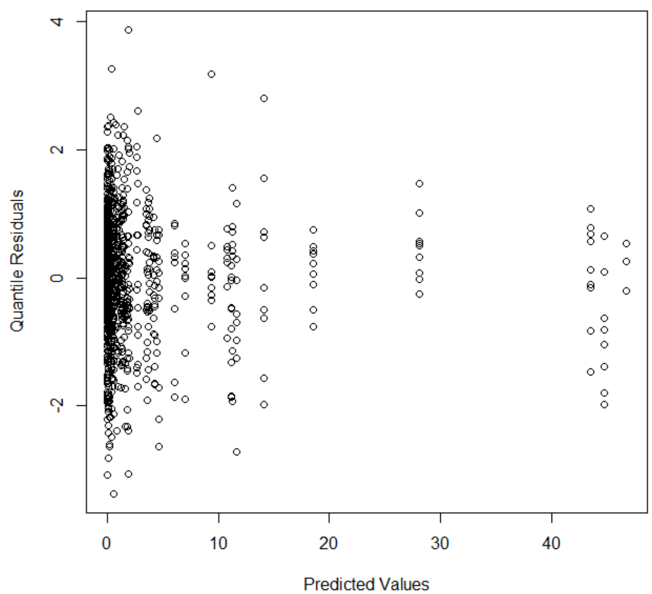
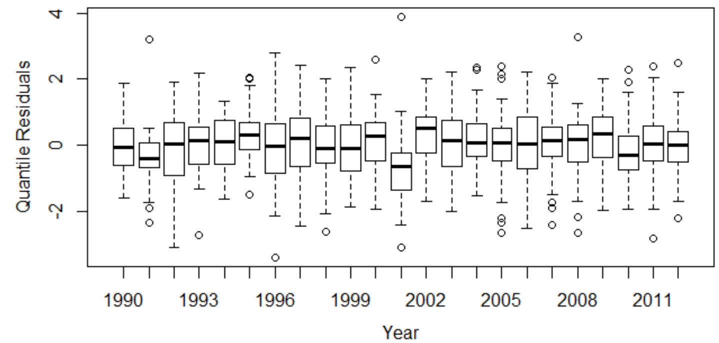
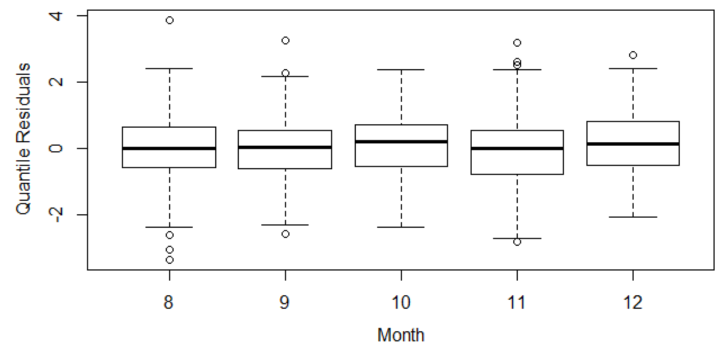


Figure 42. Distribution of the response variable and proportion of zero observations for the DE 30ft trawl survey.


Quantile Residuals
Predicted Values
0
10
20
30
40
-2
0
2
4


Quantile Residuals
Year
1990
1993
1996
1999
2002
2005
2008
2011


Quantile Residuals
Month
8
9
10
11
12

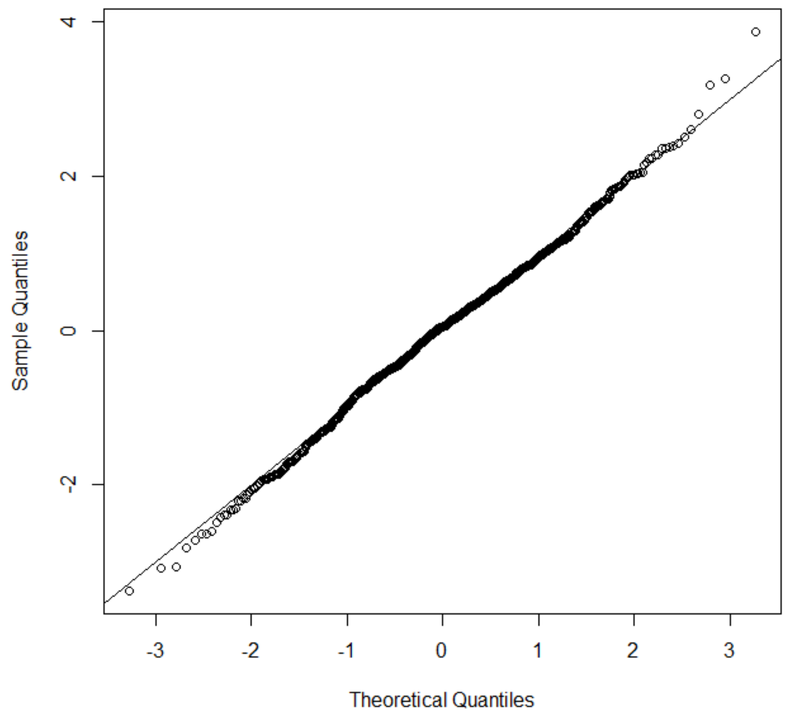


Figure 43. Diagnostic residual plots for the standardized DE 30ft trawl index.

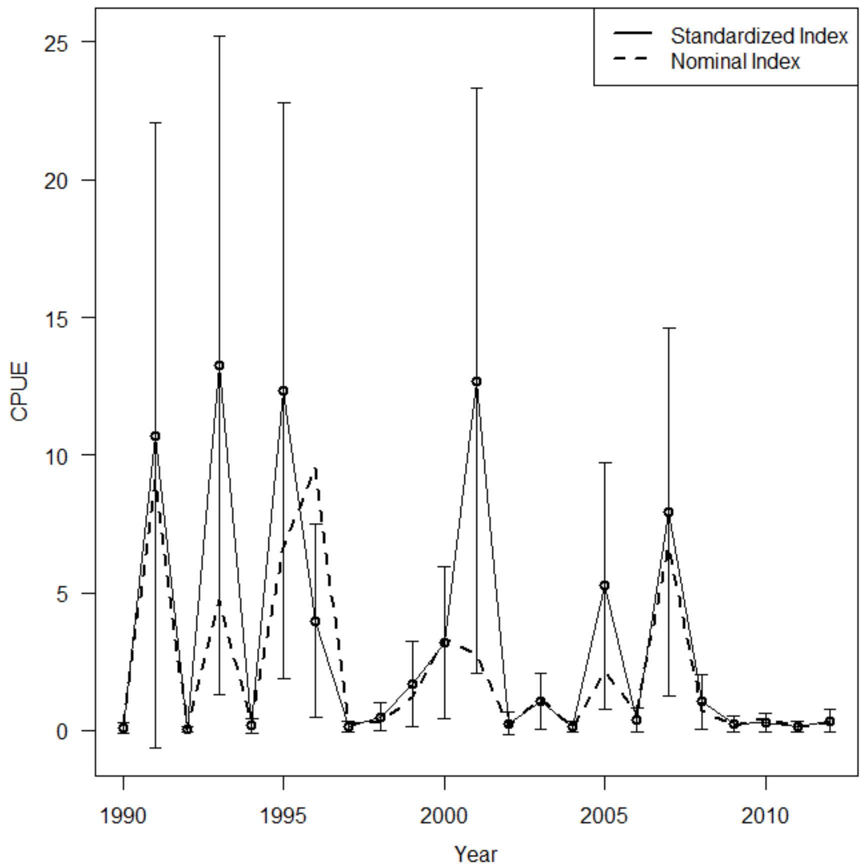


Figure 44. Standardized and nominal DE 30ft trawl index. Error bars represent 95% CIs of standardized index from SEs.

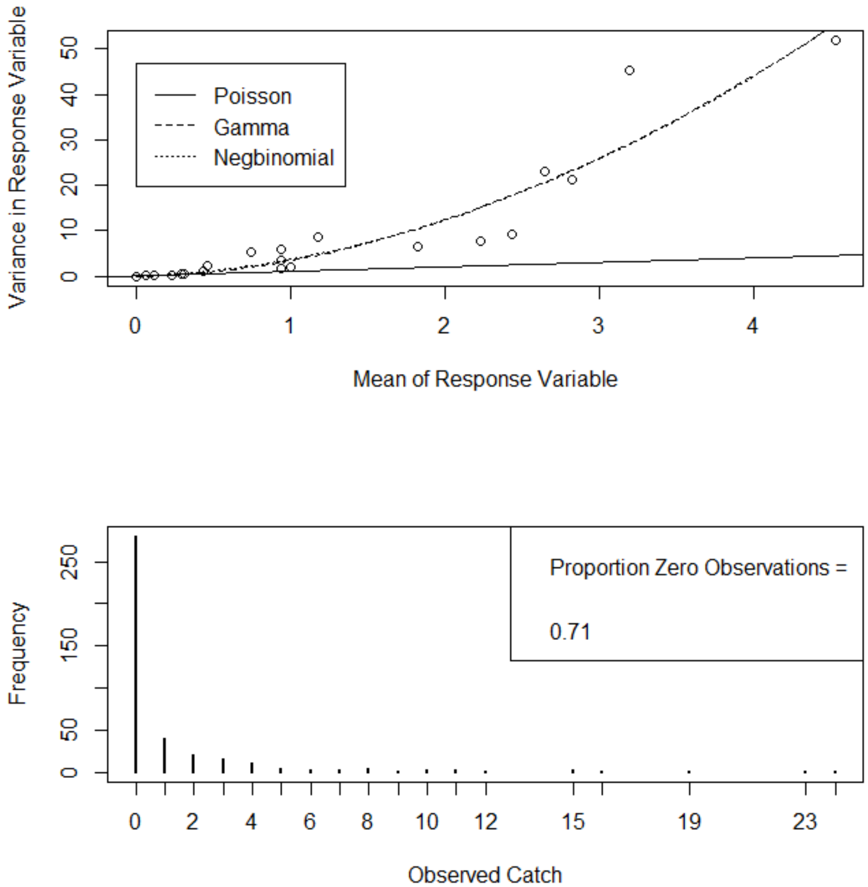
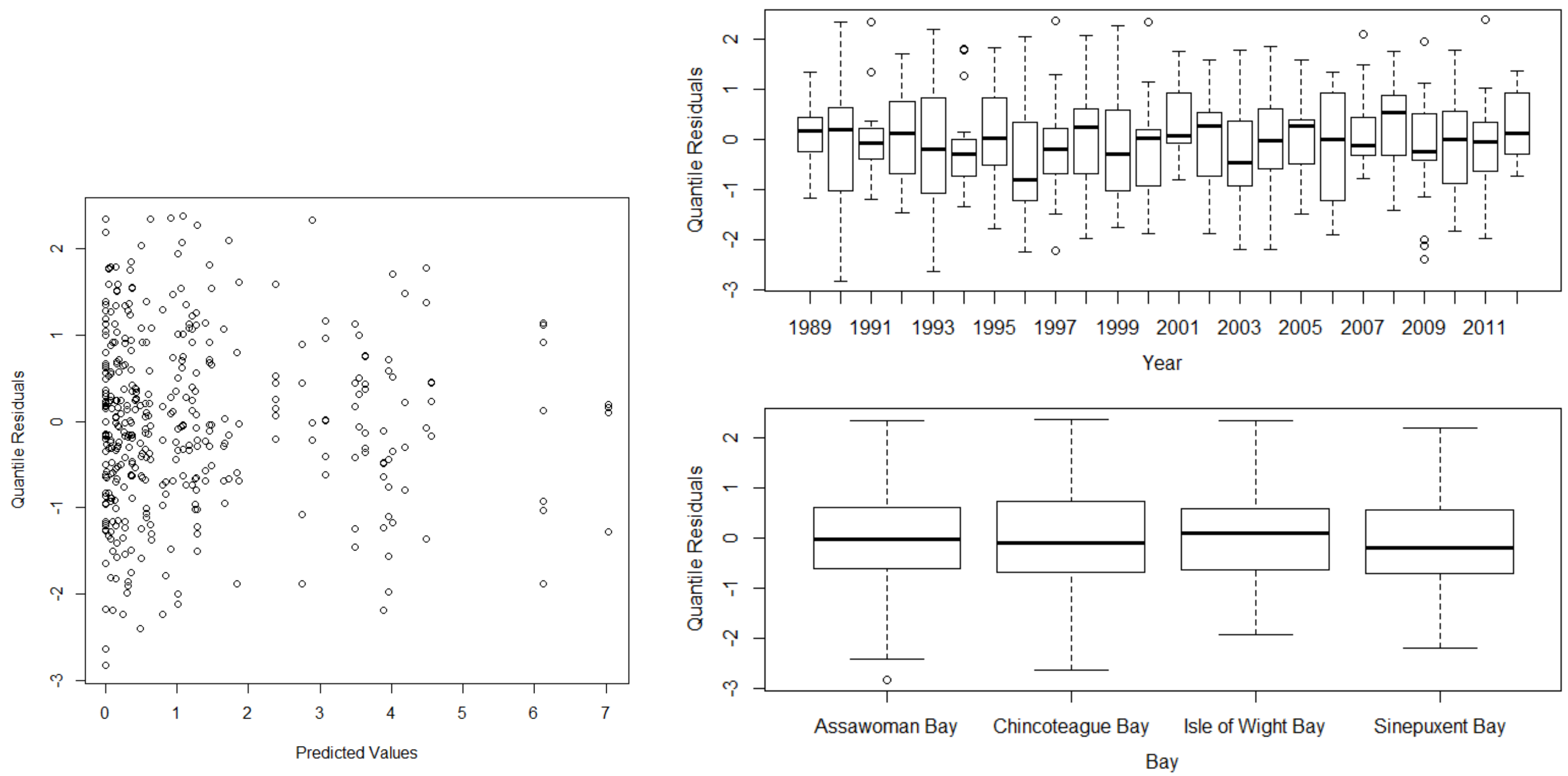


Figure 45. Distribution of the response variable and proportion of zero observations for the MD seine survey.



Quantile Residuals
Predicted Values
Quantile Residuals
Year
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Quantile Residuals
Bay
Assawoman Bay
Chincoteague Bay
Isle of Wight Bay
Sinepuxent Bay

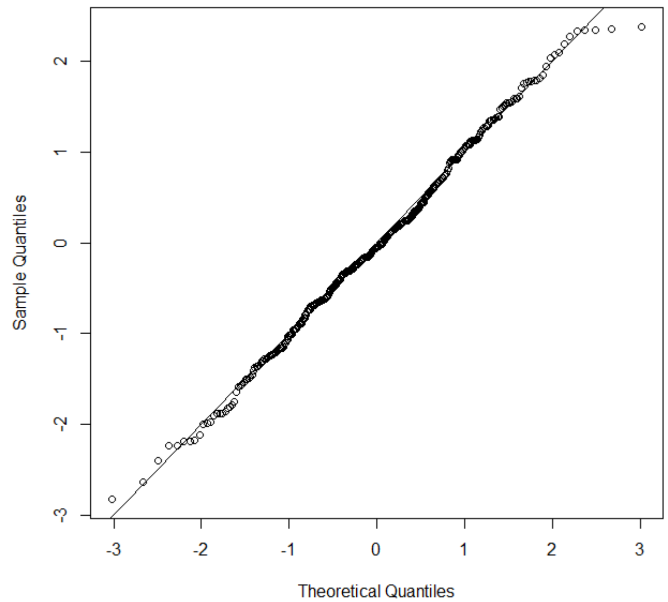


Figure 46. Diagnostic residual plots for the standardized MD seine index.

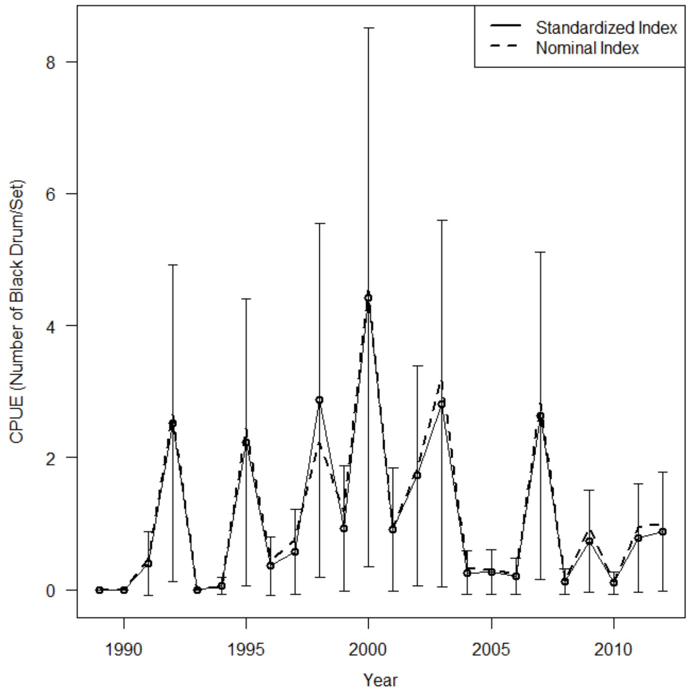


Figure 47. Standardized and nominal MD seine index. Error bars represent 95% CIs of standardized index from SEs.

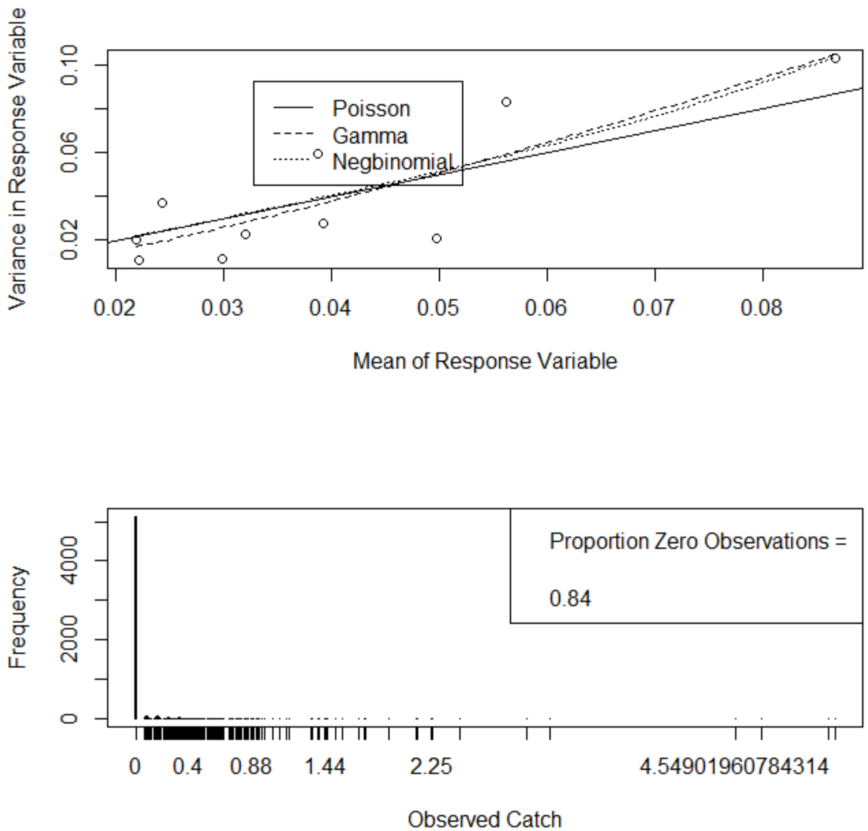
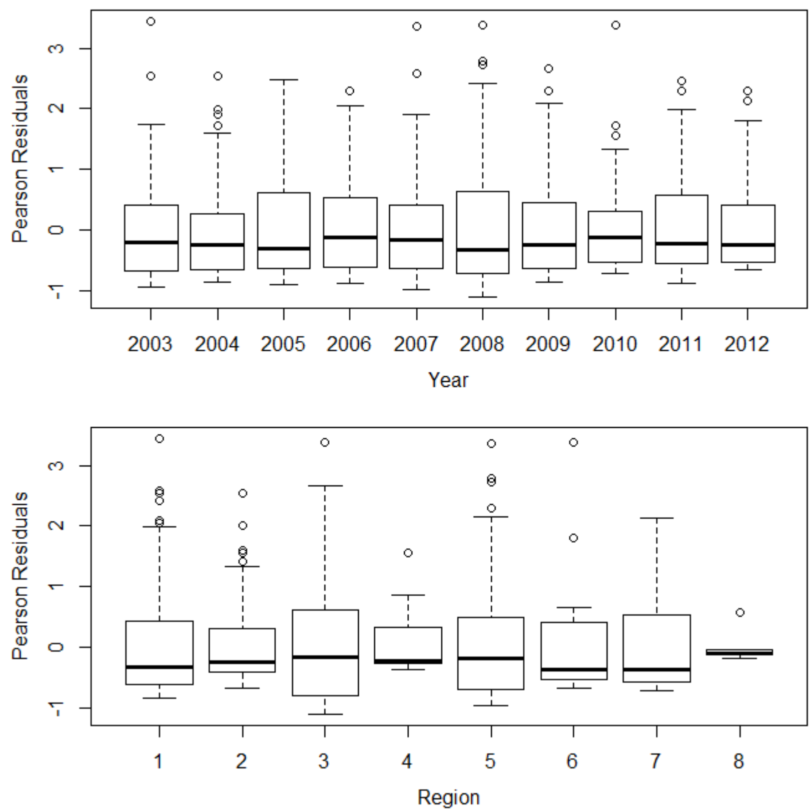


Figure 48. Distribution of the response variable and proportion of zero observations for the NC gill net survey.


Pearson Residuals
Year
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Pearson Residuals
Region
1
2
3
4
5
6
7
8

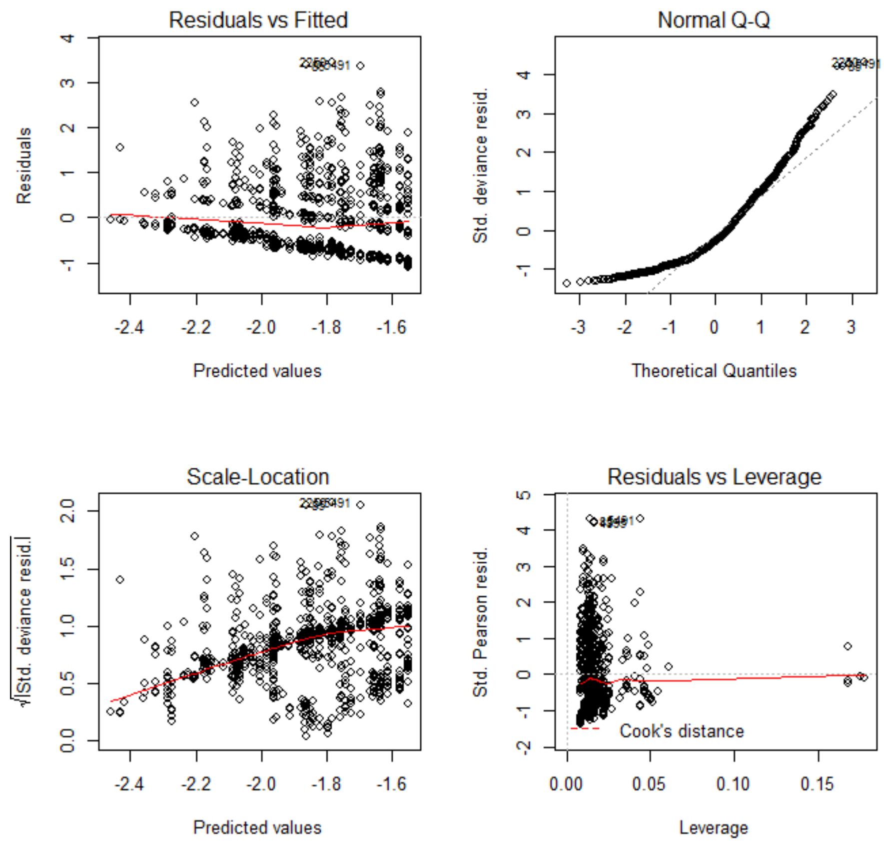
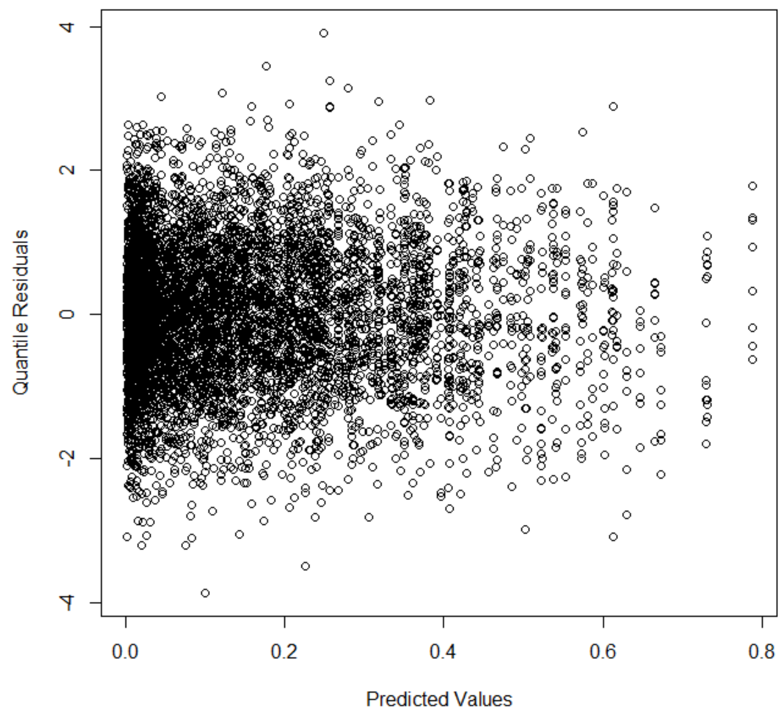
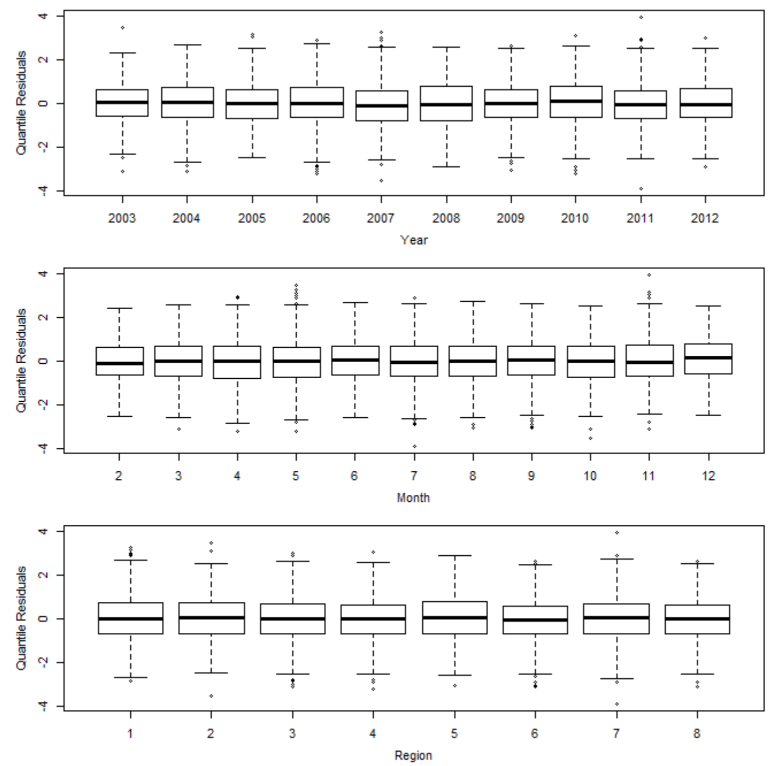


Figure 49. Diagnostic residual plots for the positive observation model used to standardize the NC gill net index.


Quantile Residuals
Predicted Values
0.0
0.2
0.4
0.6
0.8
4
2
0
-2
-4


Quantile Residuals
Year
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Month
Region

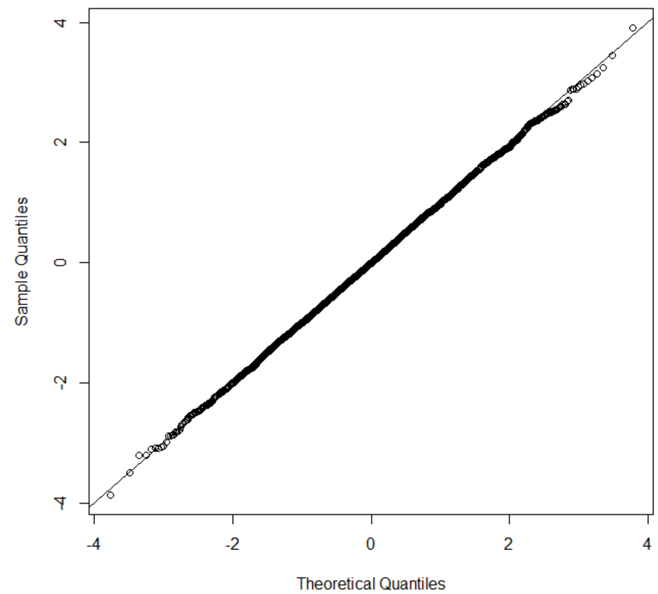


Figure 50. Diagnostic residual plots for the proportion positive model used to standardize the NC gill net index.

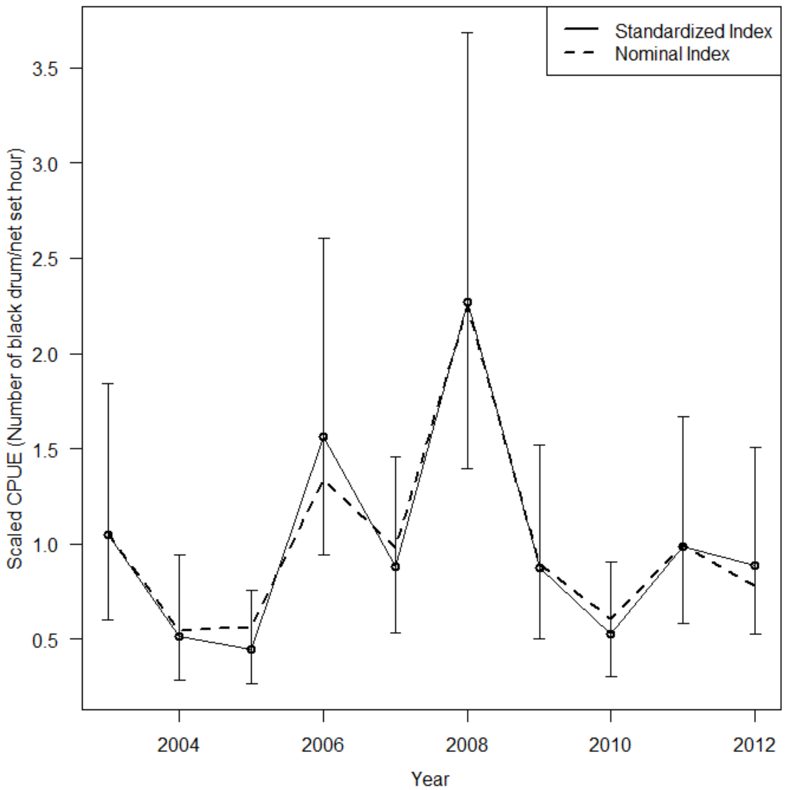


Figure 51. Standardized and nominal NC gill net index. Error bars represent 95% CIs of standardized index from SEs.

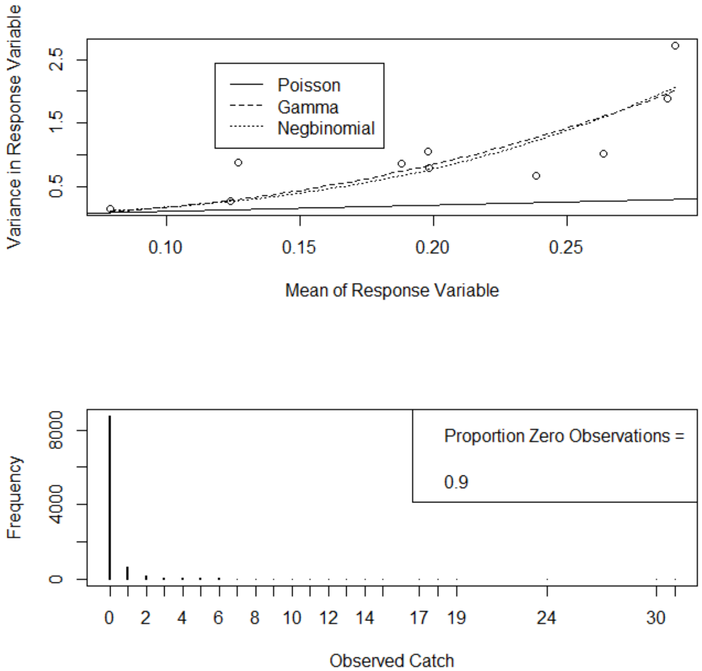
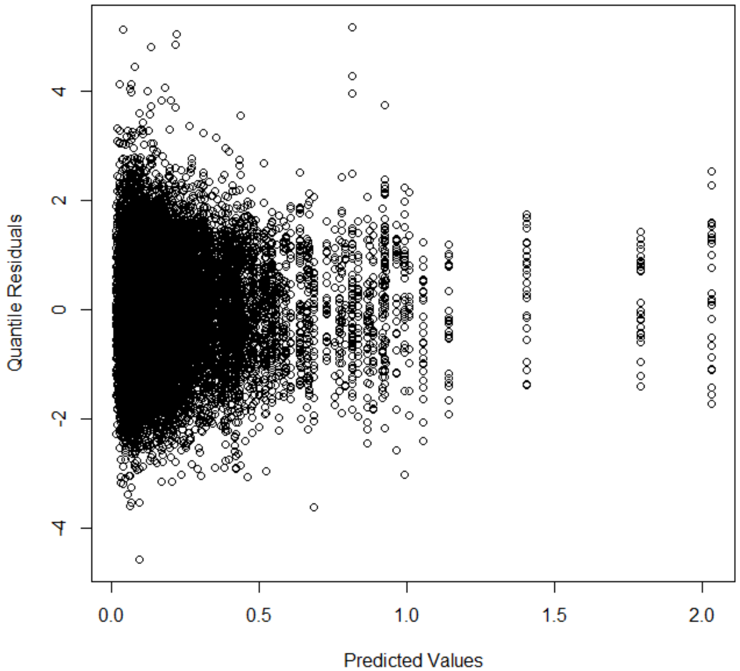
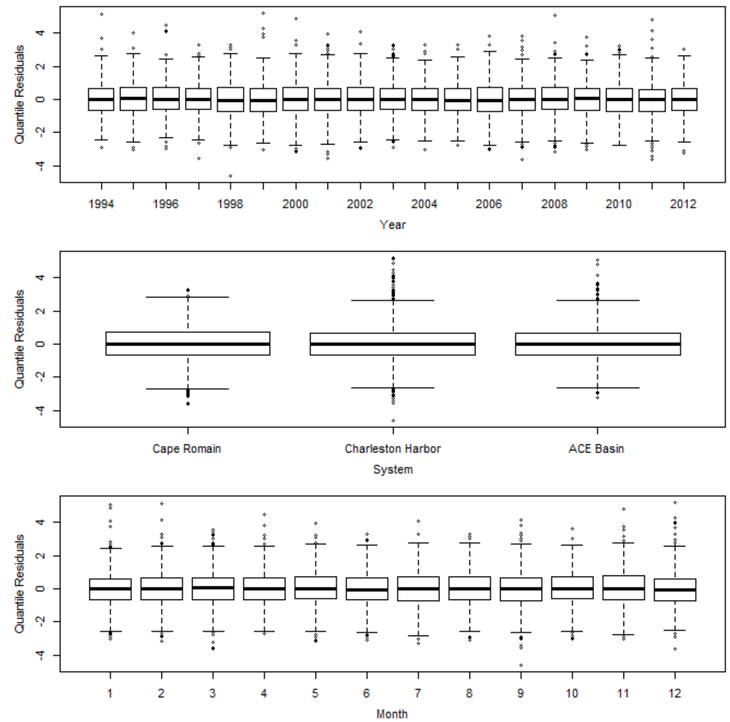


Figure 52. Distribution of the response variable and proportion of zero observations for the SC trammel net survey.


Quantile Residuals
Predicted Values
0.0
0.5
1.0
1.5
2.0
-4
-2
0
2
4


Quantile Residuals
Year
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Cape Romain
Charleston Harbor
ACE Basin
System
Month
1
2
3
4
5
6
7
8
9
10
11
12

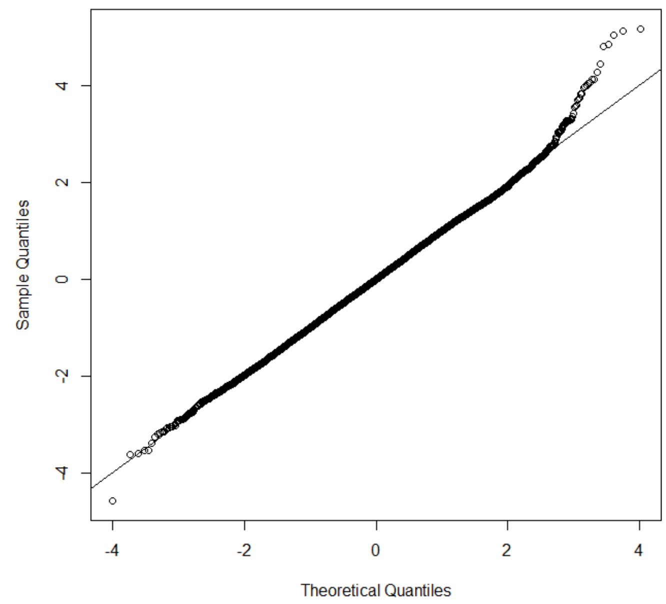


Figure 53. Diagnostic residual plots for the standardized SC trammel net index.

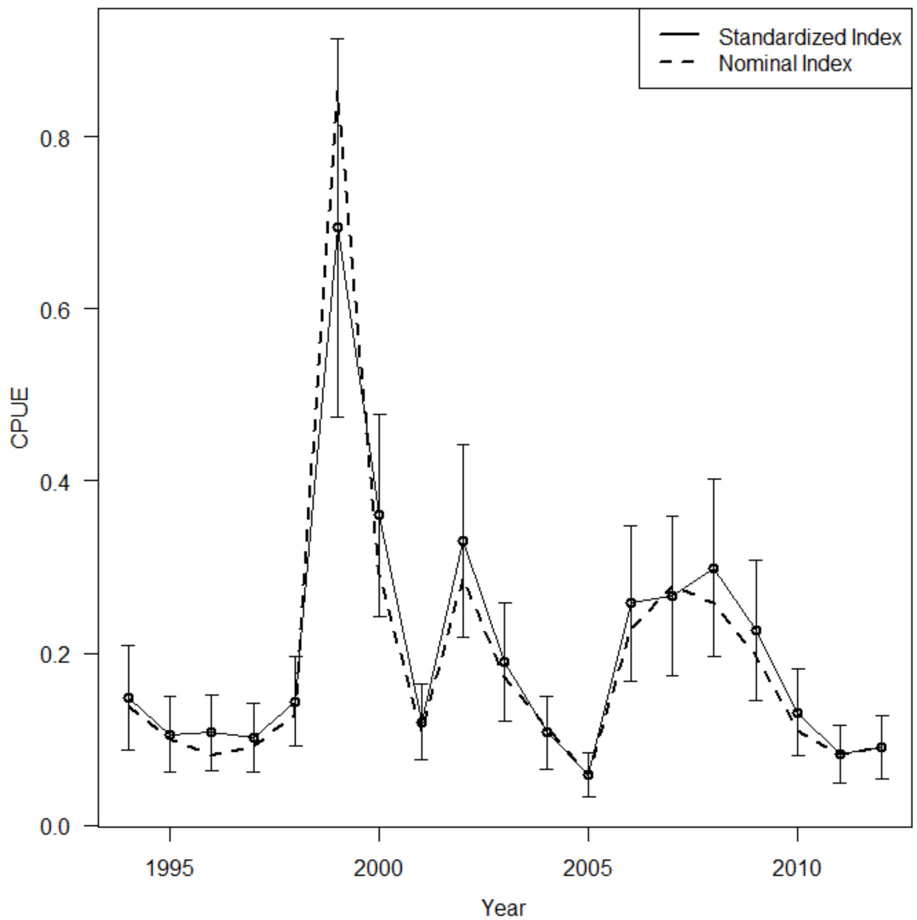


Figure 54. Standardized and nominal SC trammel net index. Error bars represent 95% CIs of standardized index from SEs.

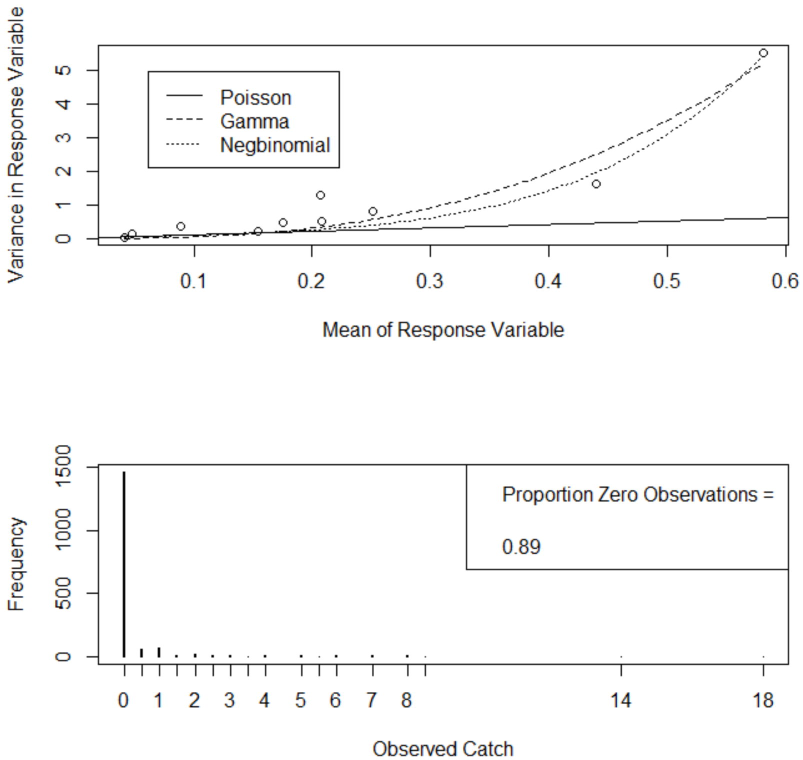


Figure 55. Distribution of the response variable and proportion of zero observations for the GA trammel net survey.

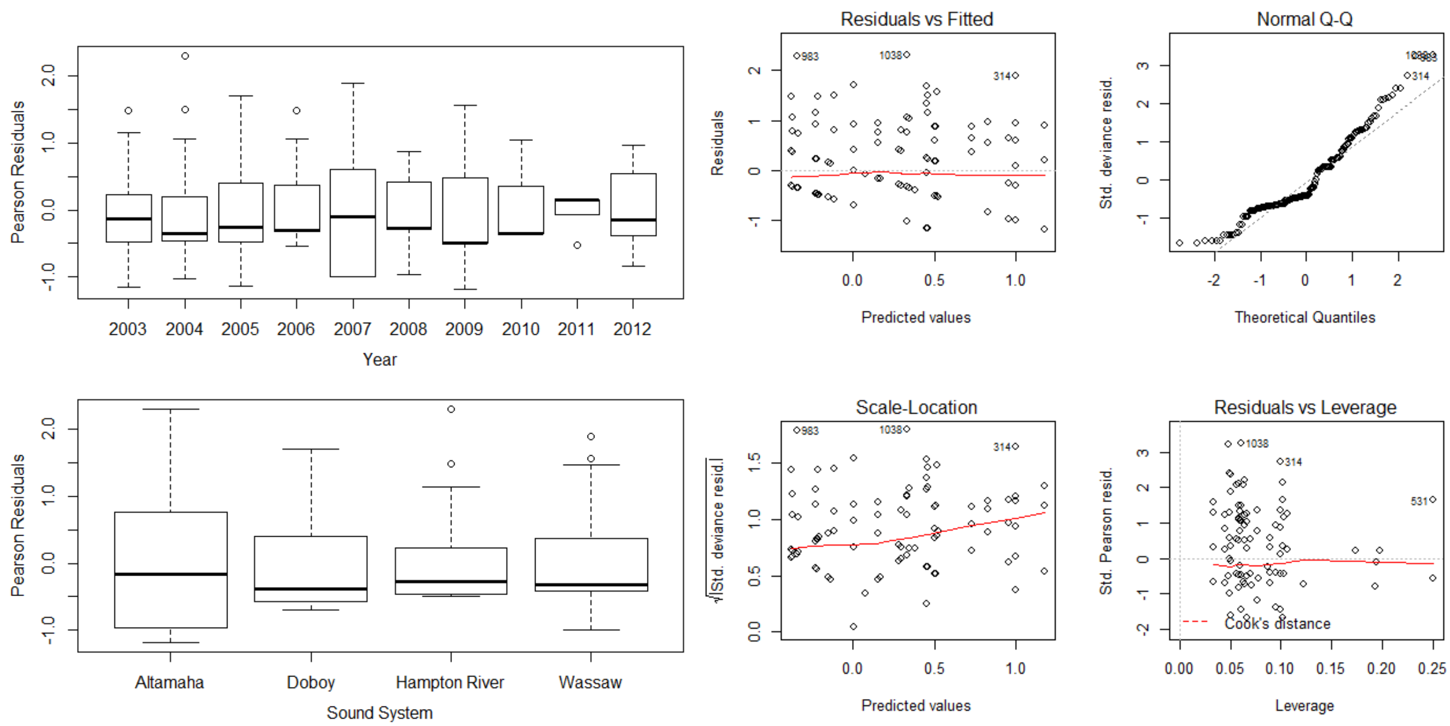
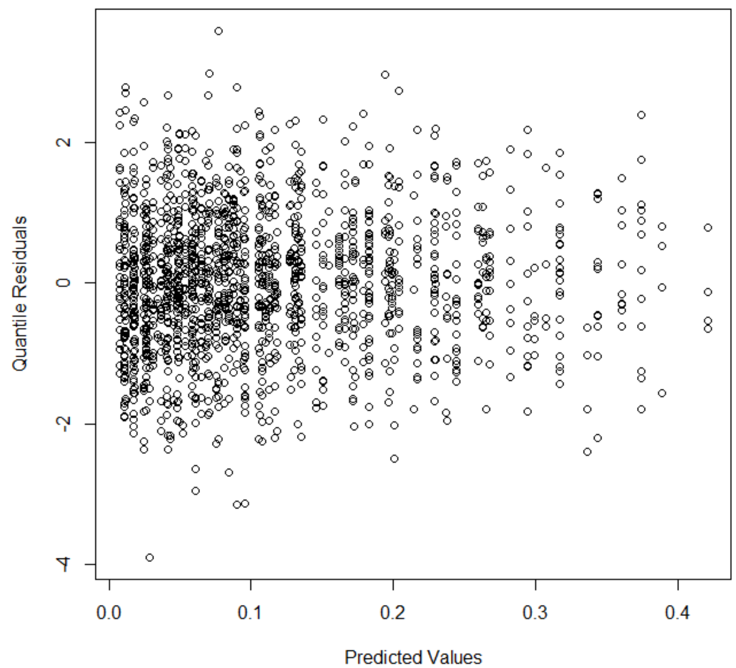
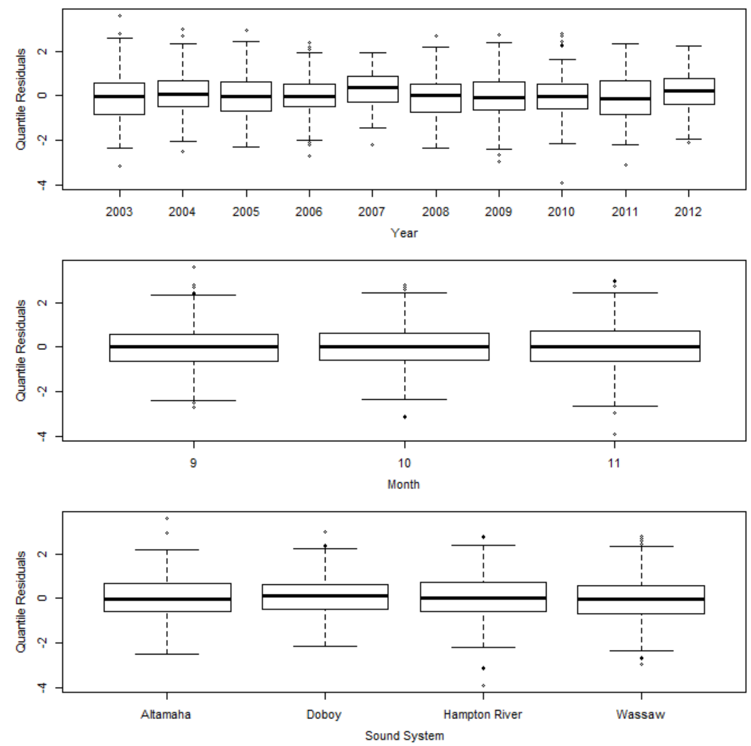


Figure 56. Diagnostic residual plots for the positive observation model used to standardize the GA trammel net index.


Quantile Residuals
Predicted Values
0.0
0.1
0.2
0.3
0.4
-4
-2
0
2


Quantile Residuals
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year
9
10
11
Month
Altamaha
Doboy
Hampton River
Wassaw
Sound System

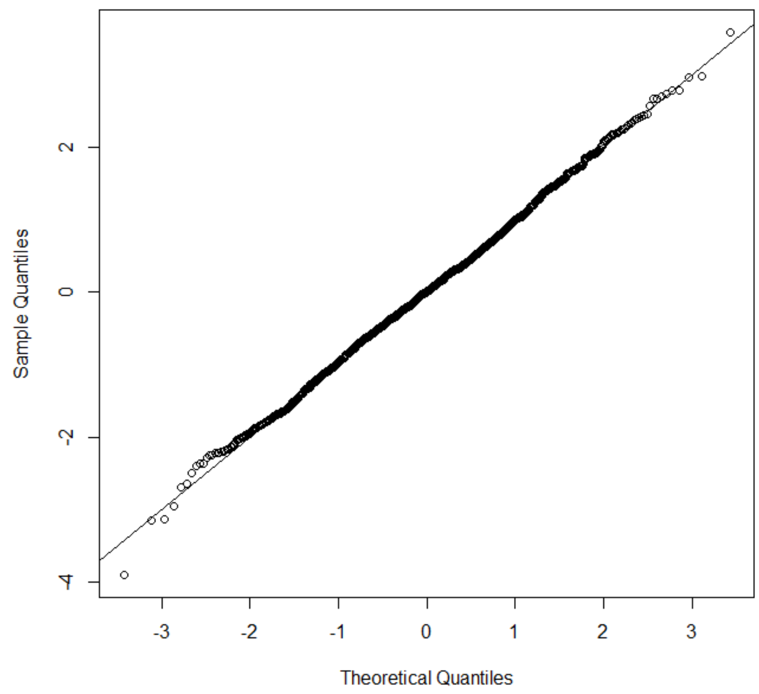


Figure 57. Diagnostic residual plots for the proportion positive model used to standardize the GA trammel net index.

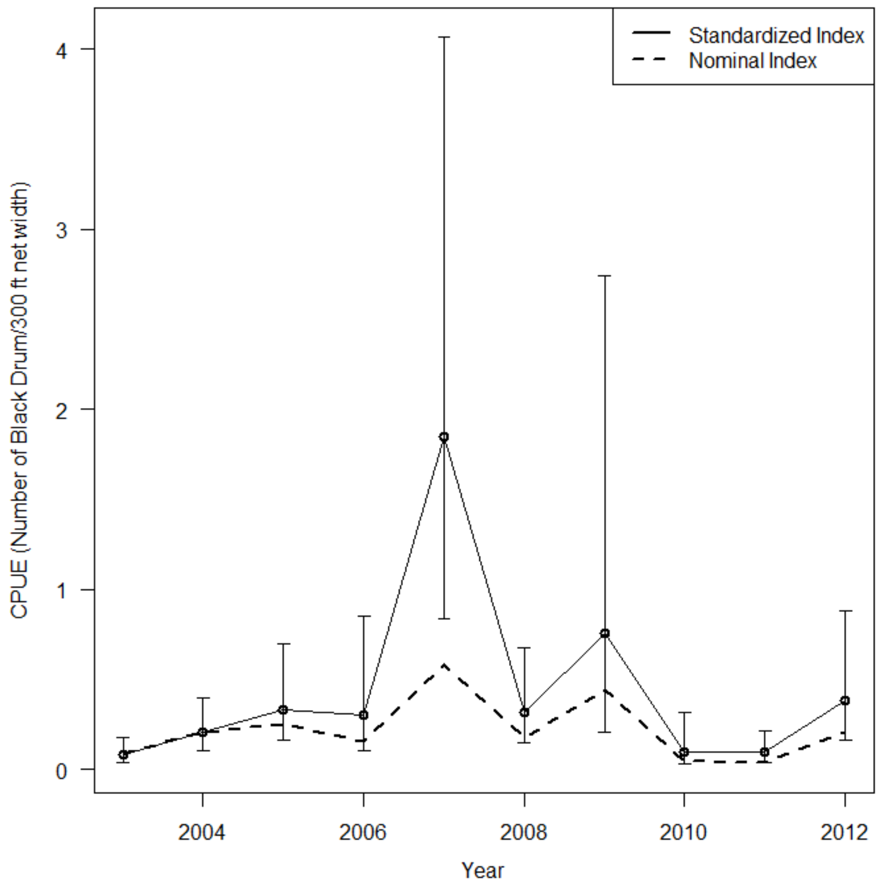
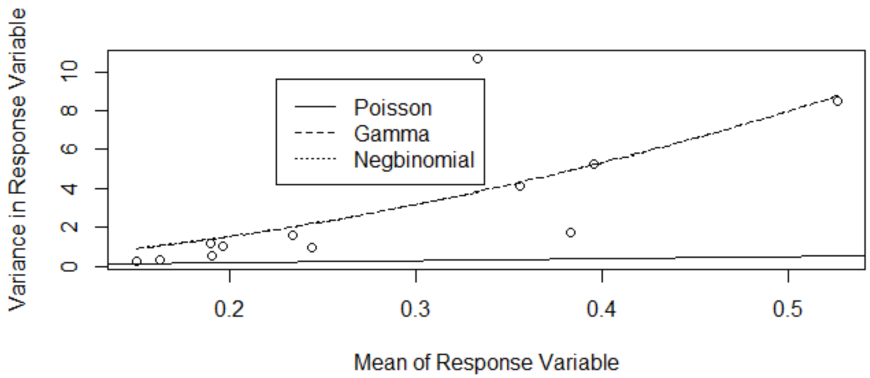


Figure 58. Standardized and nominal GA trammel net index. Error bars represent 95% CIs of standardized index from SEs.



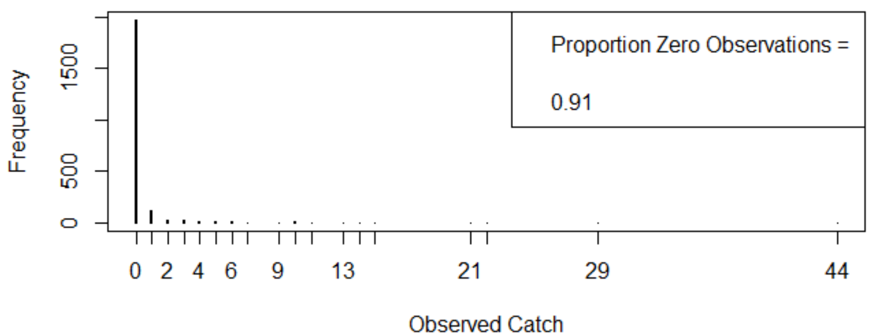
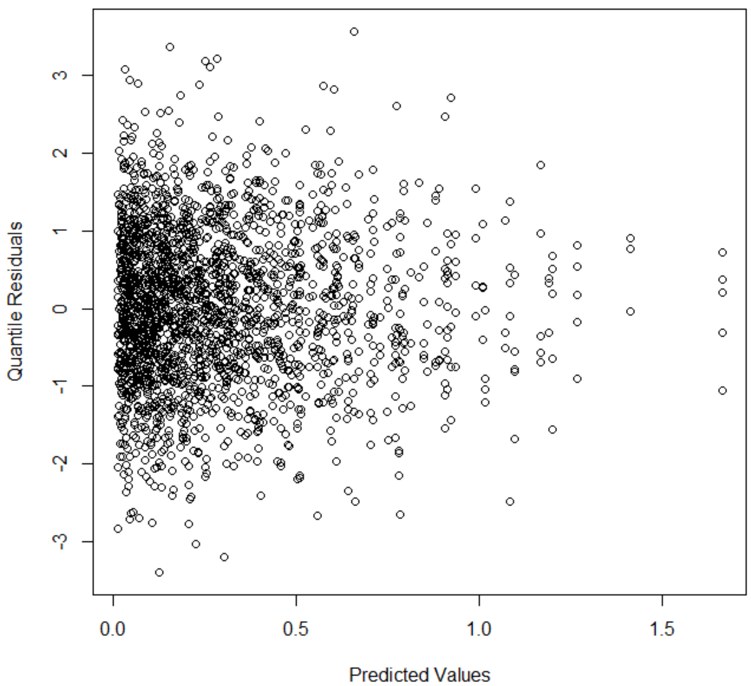
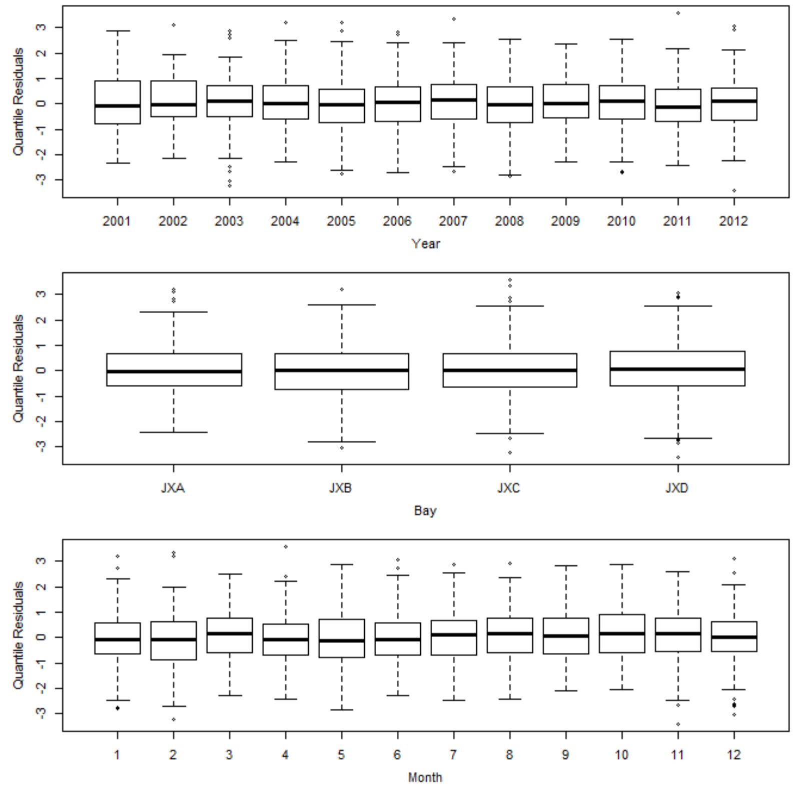


Figure 59. Distribution of the response variable and proportion of zero observations for the NE FL seine index.


Quantile Residuals
Predicted Values
0.0
0.5
1.0
1.5
-3
-2
-1
0
1
2
3


Quantile Residuals
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year
JXA
JXB
JXC
JXD
Bay
1
2
3
4
5
6
7
8
9
10
11
12
Month

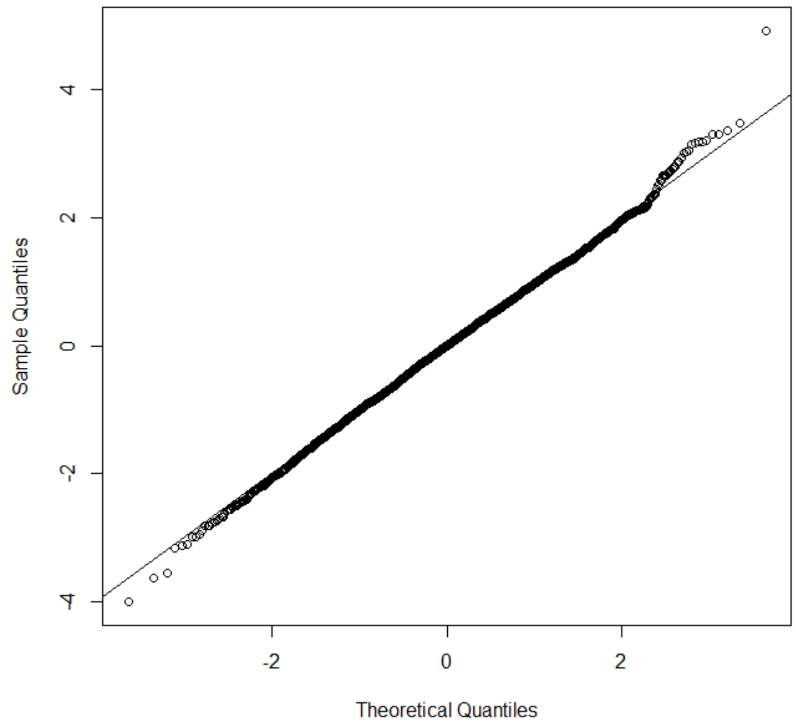


Figure 60. Diagnostic residual plots for the standardized NE FL seine index.

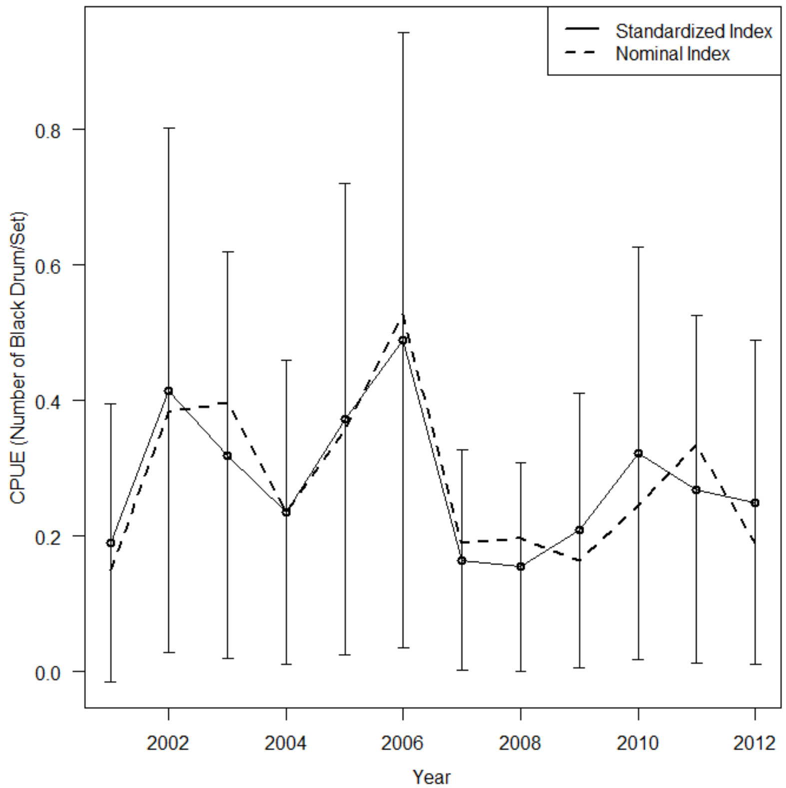


Figure 61. Standardized and nominal NE FL seine index. Error bars represent 95% CIs of standardized index from SEs.

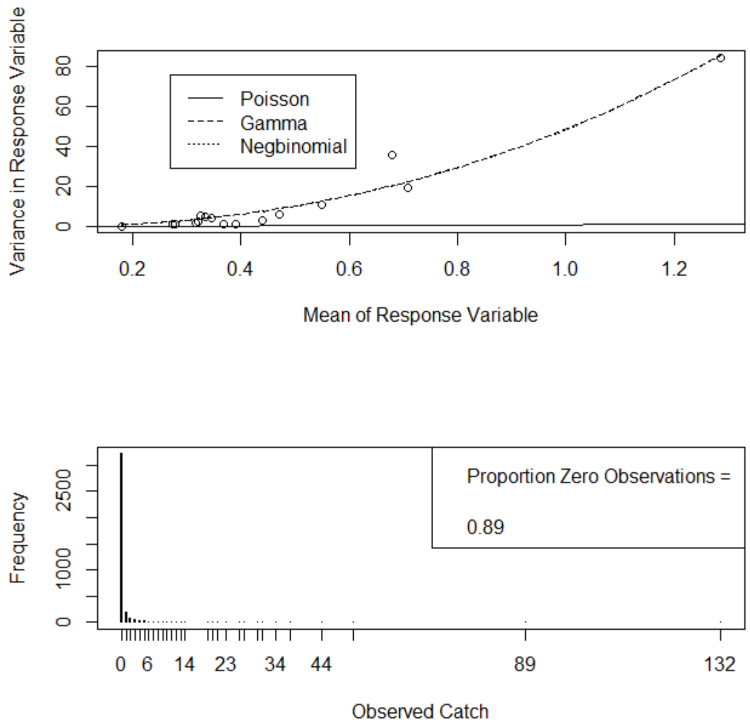
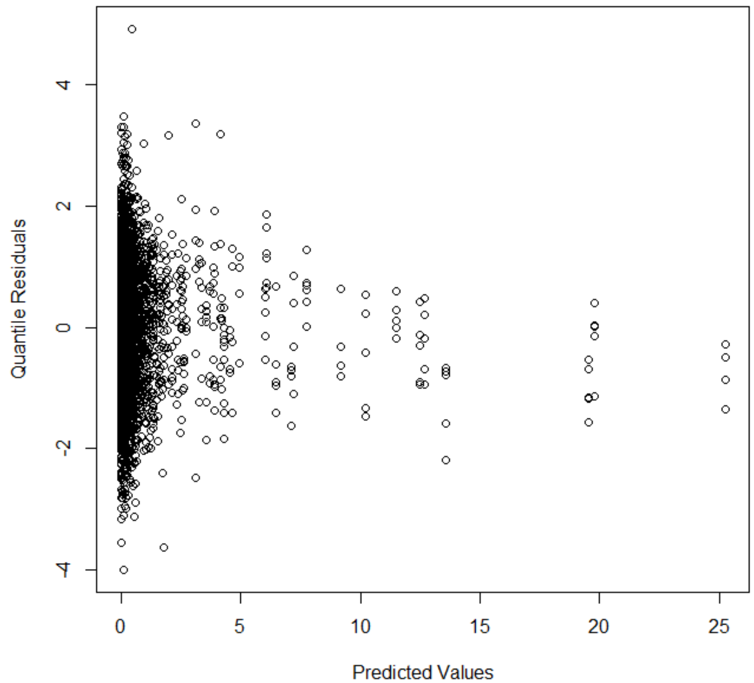
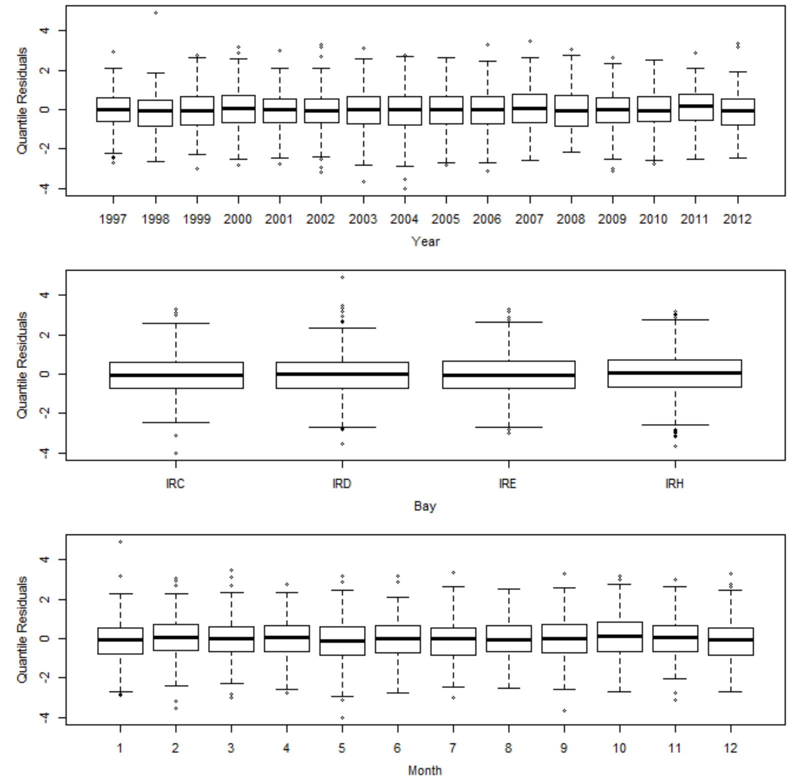


Figure 62. Distribution of the response variable and proportion of zero observations for the N IR FL Immature seine index.


Quantile Residuals
Predicted Values
4
2
0
-2
-4
0
5
10
15
20
25


Quantile Residuals
Year
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Bay
IRC
IRD
IRE
IRH
Month
1
2
3
4
5
6
7
8
9
10
11
12

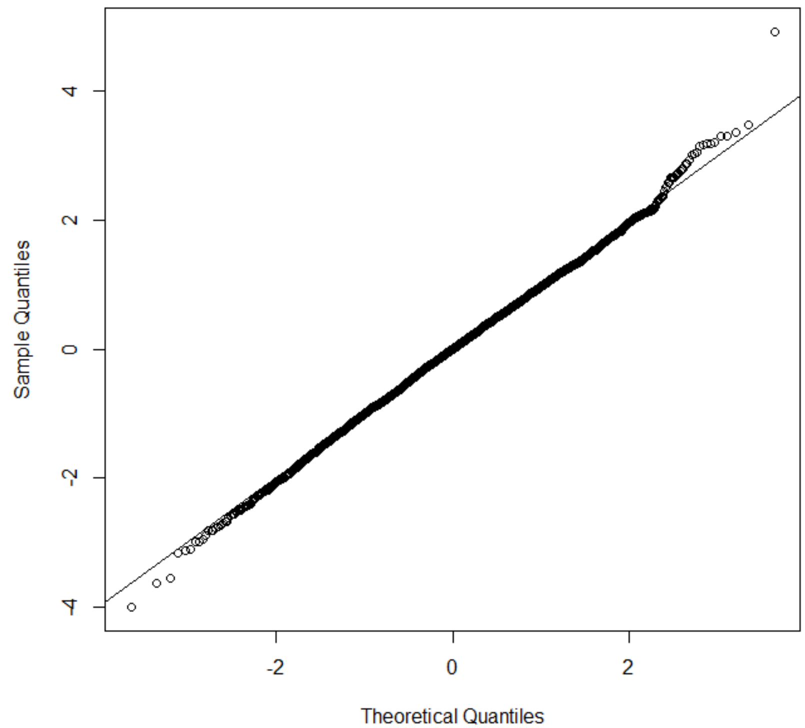


Figure 63. Diagnostic residual plots for the standardized N IR FL Immature seine index.

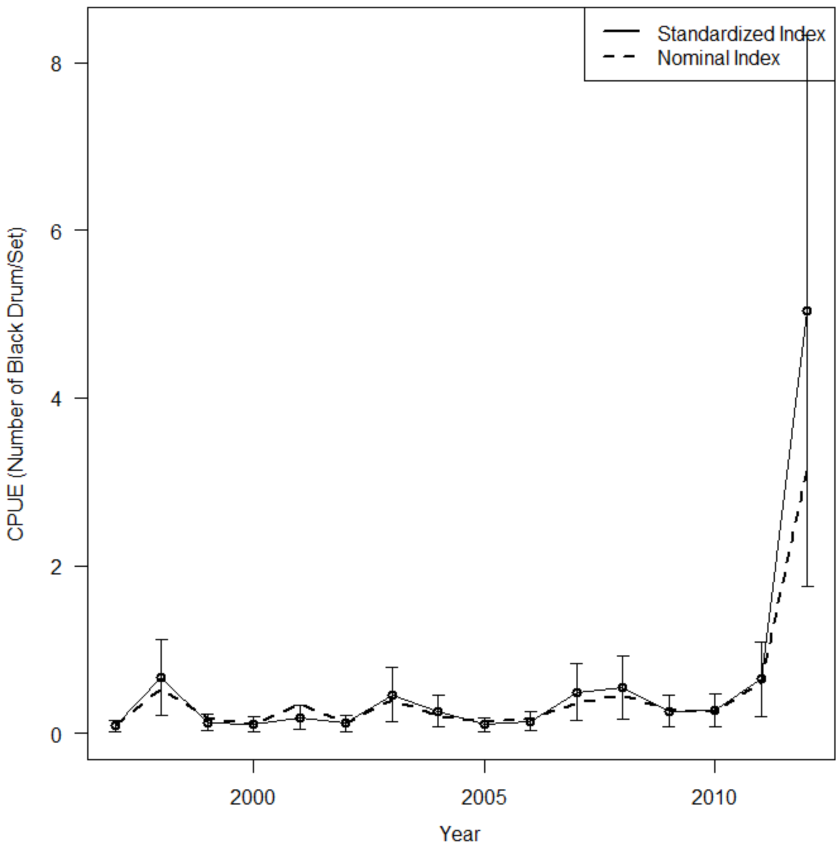


Figure 64. Standardized and nominal N IR FL Immature seine index. Error bars represent 95% CIs of standardized index from SEs.

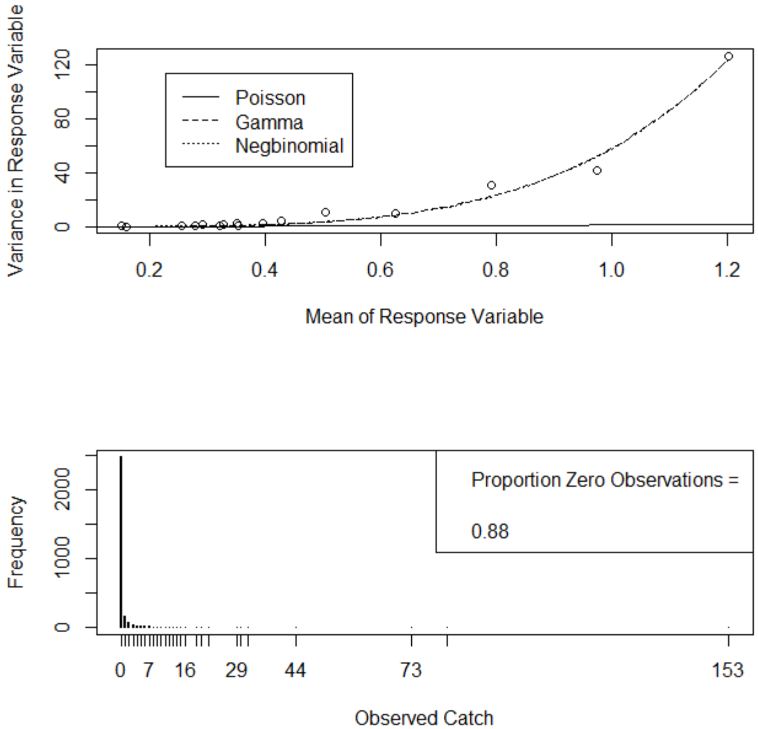
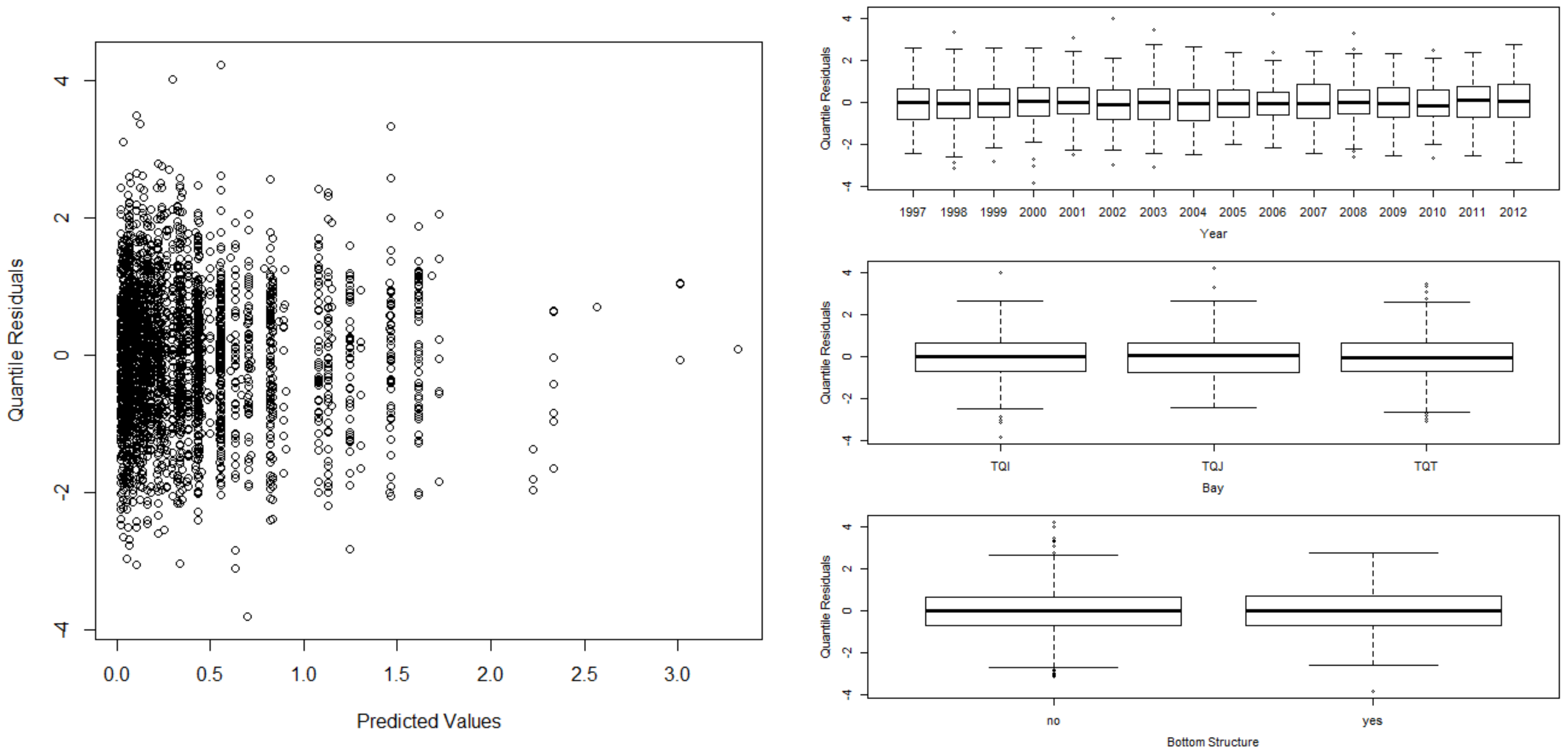


Figure 65. Distribution of the response variable and proportion of zero observations for the S IR FL seine index.


Quantile Residuals
Predicted Values
0.0
0.5
1.0
1.5
2.0
2.5
3.0
4
2
0
-2
-4
Quantile Residuals
Year
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Quantile Residuals
Bay
TQI
TQJ
TQT
Quantile Residuals
Bottom Structure
no
yes

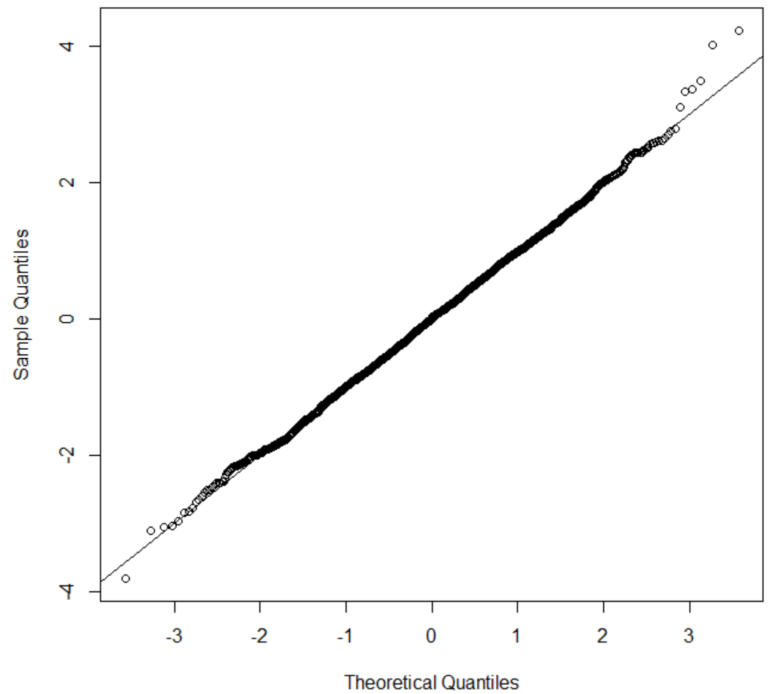


Figure 66. Diagnostic residual plots for the standardized S IR FL seine index.

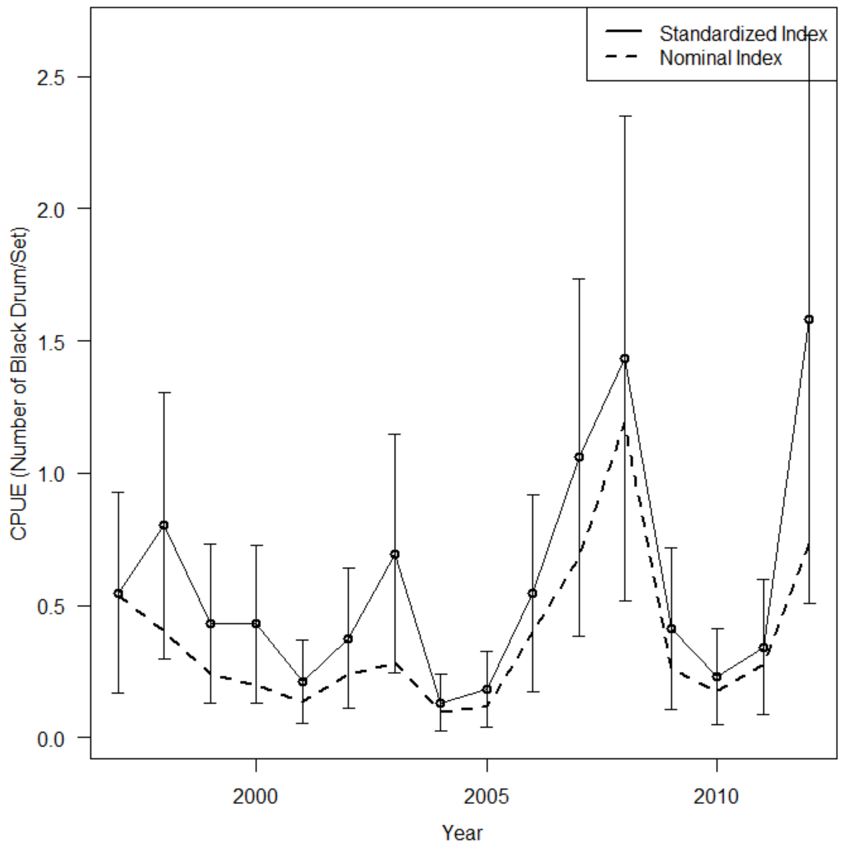


Figure 67. Standardized and nominal S IR FL seine index. Error bars represent 95% CIs of standardized index from SEs.

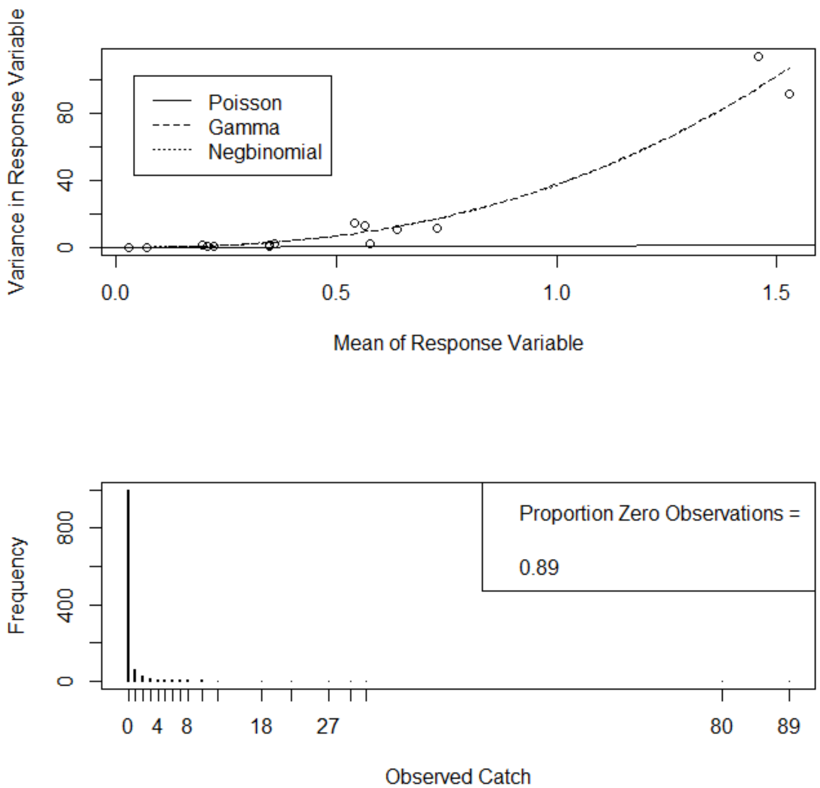
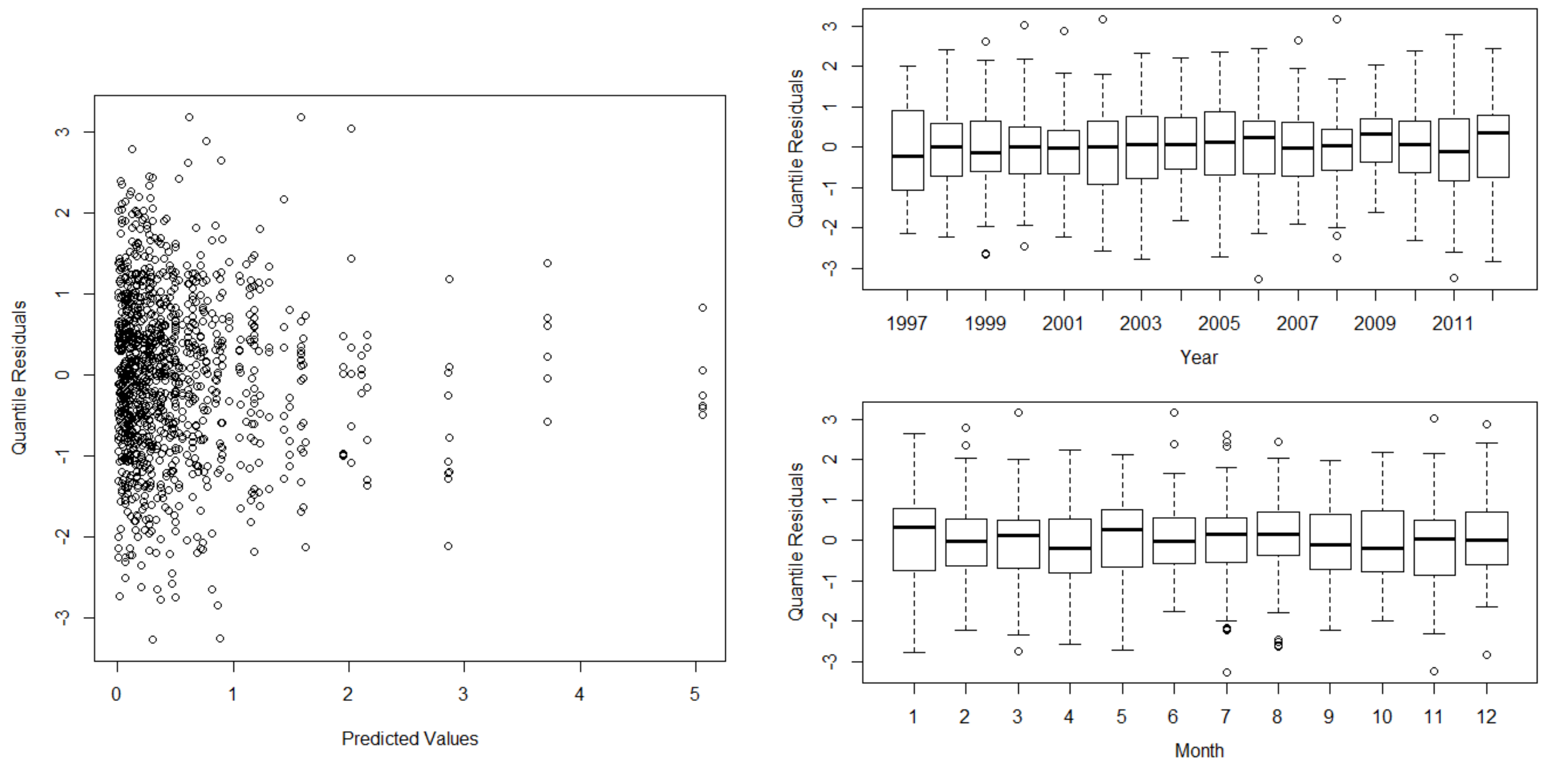


Figure 68. Distribution of the response variable and proportion of zero observations for the N IR FL Mature seine index.


Quantile Residuals
Predicted Values
Quantile Residuals
Year
1997
1999
2001
2003
2005
2007
2009
2011
Quantile Residuals
Month

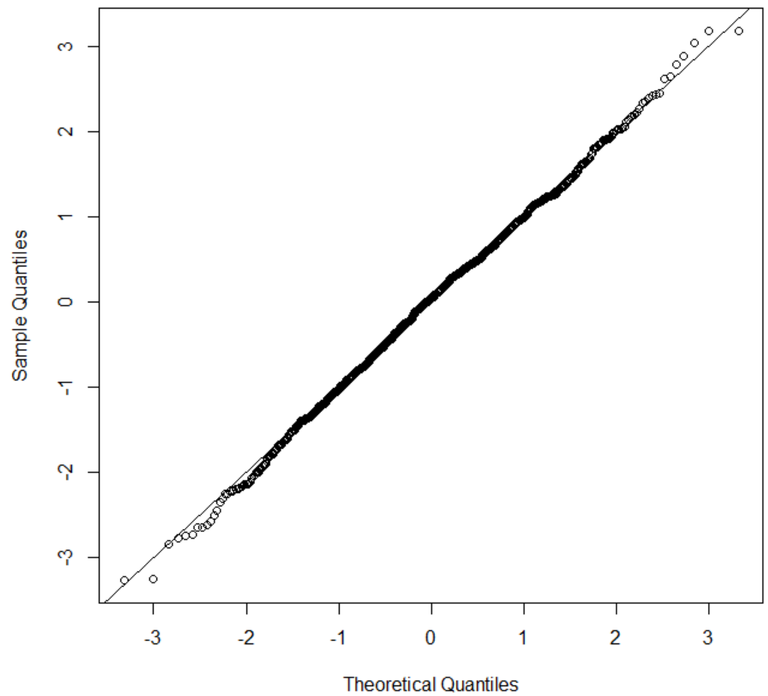


Figure 69. Diagnostic residual plots for the standardized N IR FL Mature seine index.

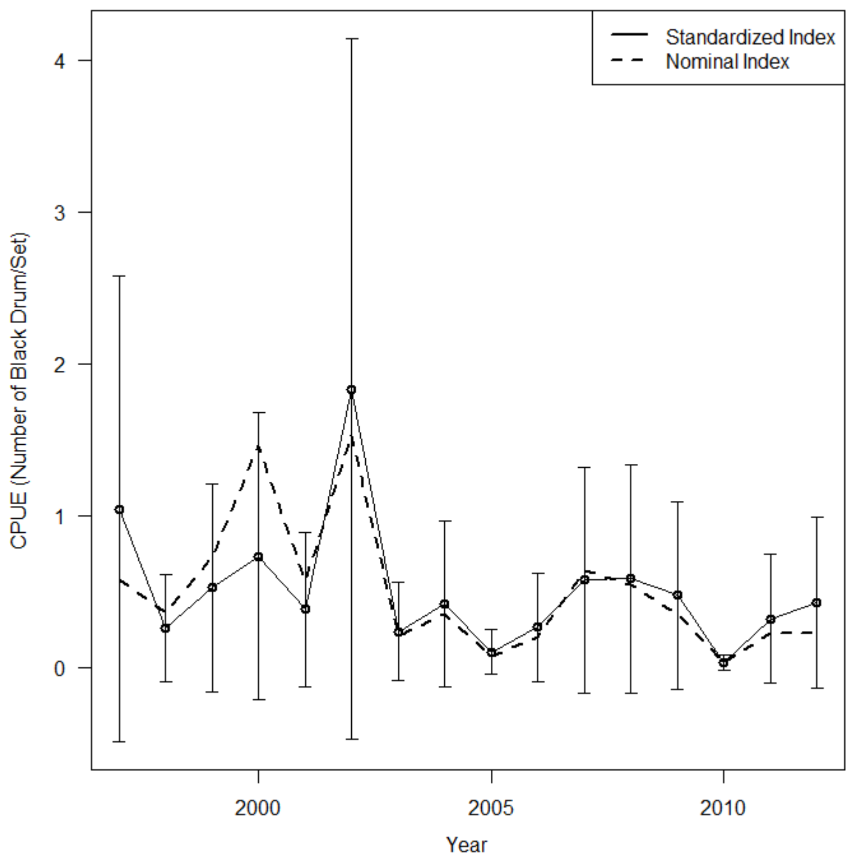


Figure 70. Standardized and nominal N IR FL Mature seine index. Error bars represent 95% CIs of standardized index from SEs.

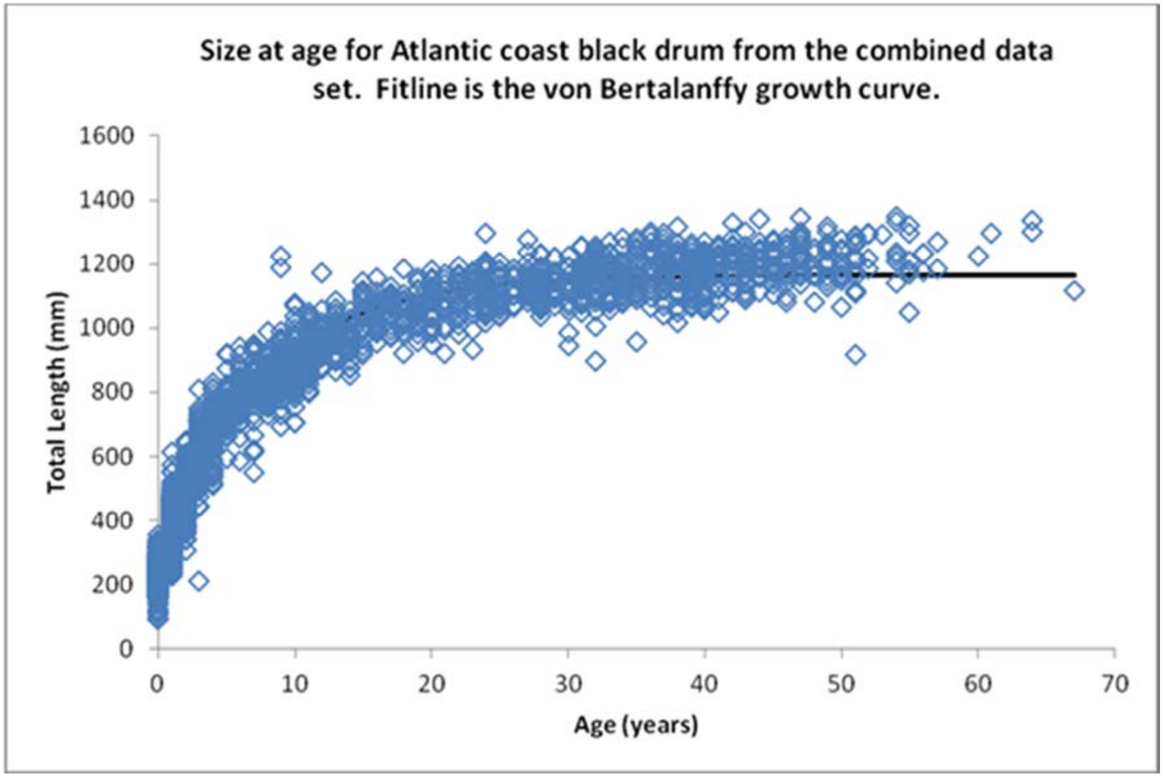


Figure 71. Combined data sets plotted against the von Bertalanffy growth curve estimated from combined data sets.

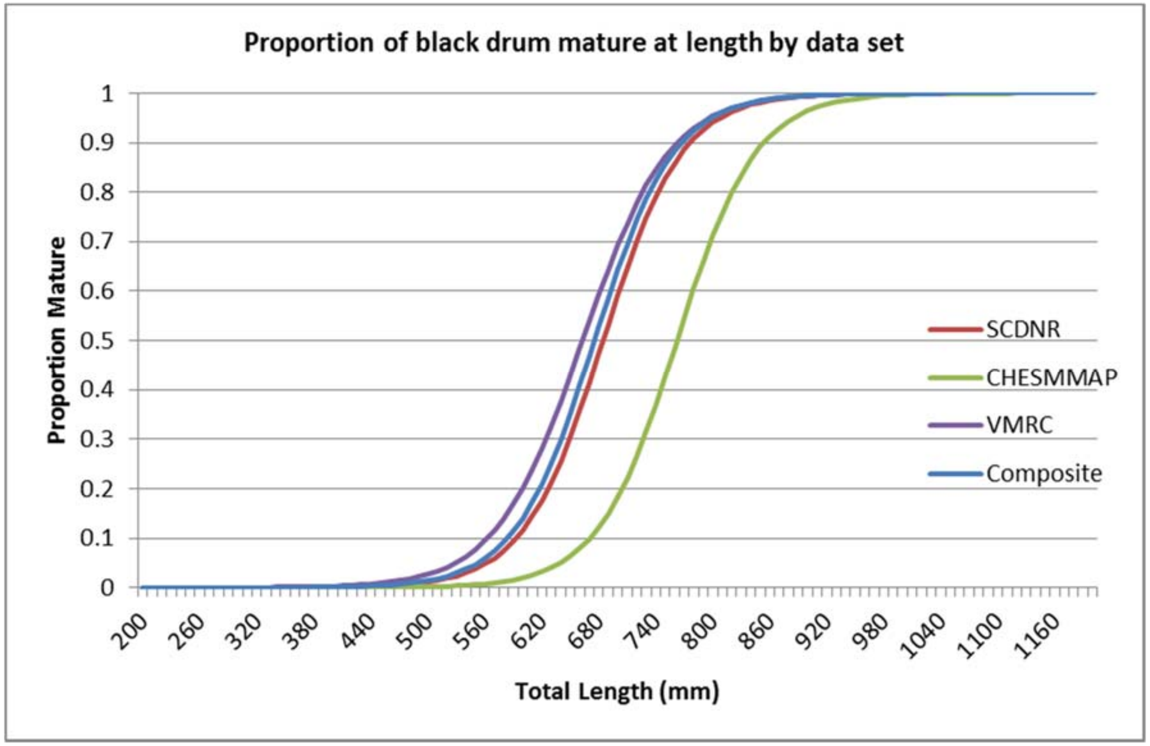


Figure 72. Proportion of black drum mature-at-length by data set.

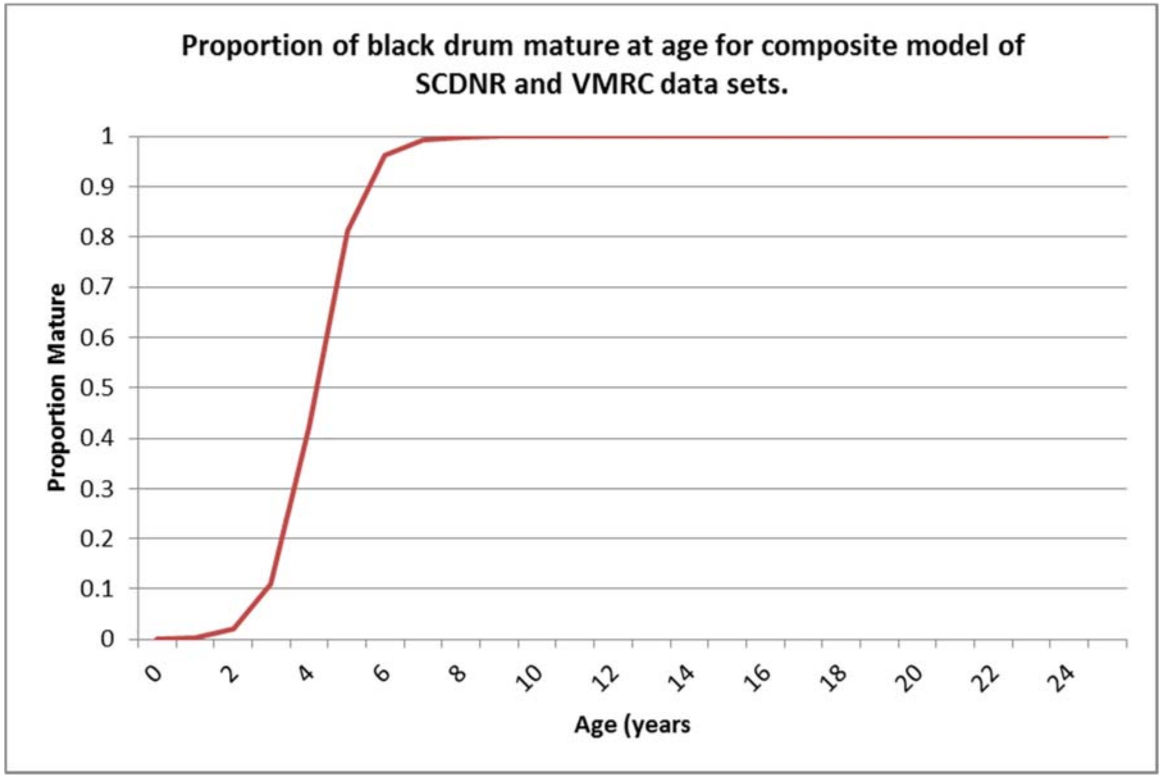


Figure 73. Proportion of black drum mature-at-age for composite model of SCDNR and VMRC data sets.

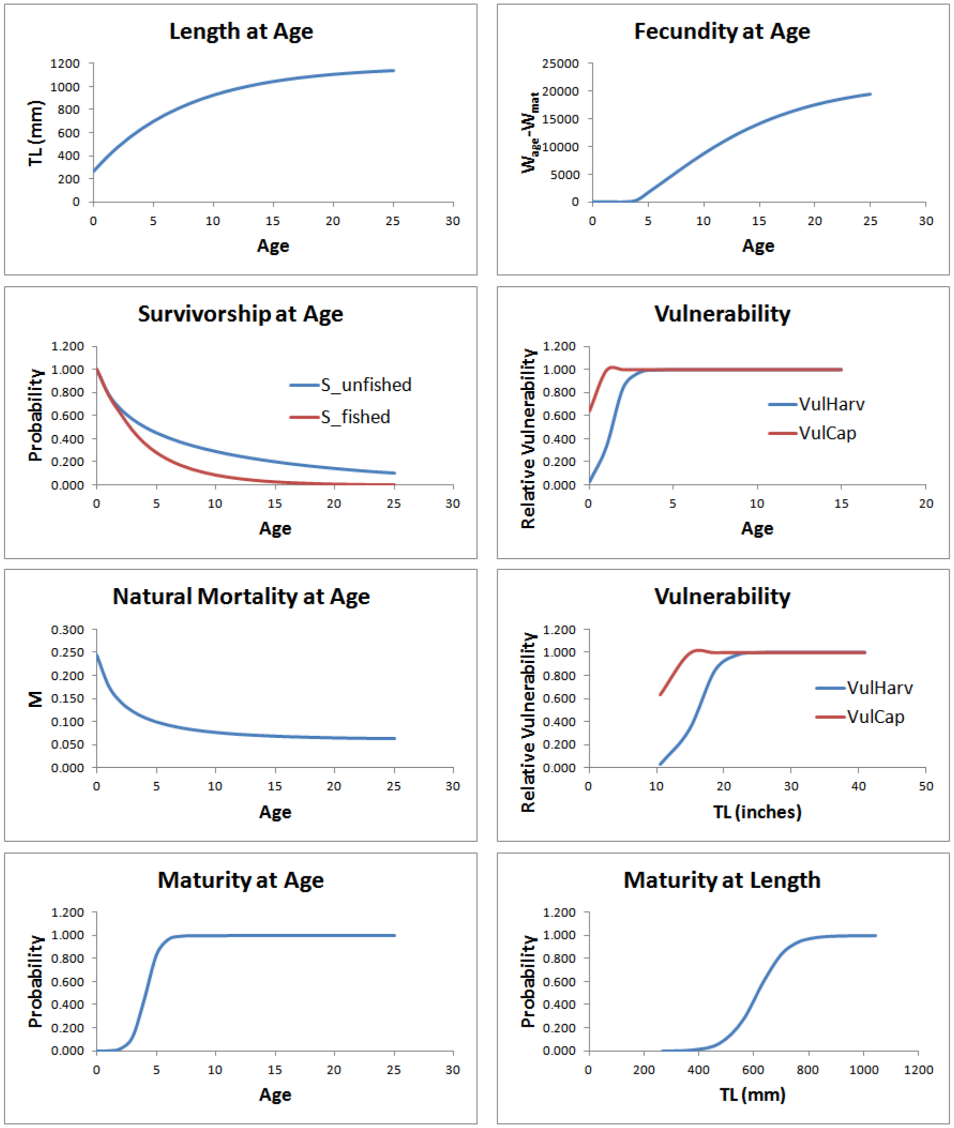


Figure 74. Age schedules of size, mortality, fecundity, maturity, vulnerability, and survivorship for black drum based on life history parameters estimated from combined coastwide data sources.

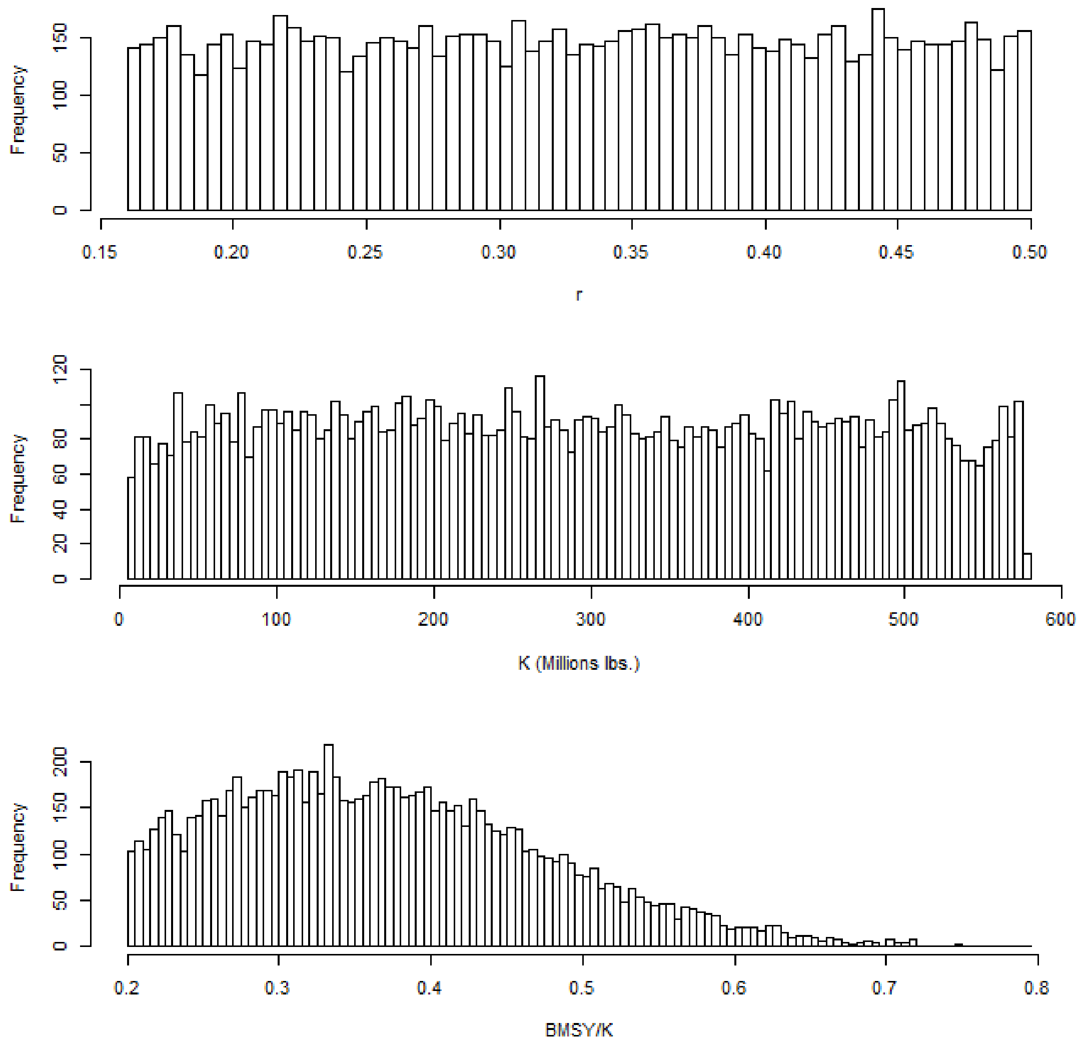


Figure 75. Catch-MSY prior distributions for input parameters r, K and BMSY/K.

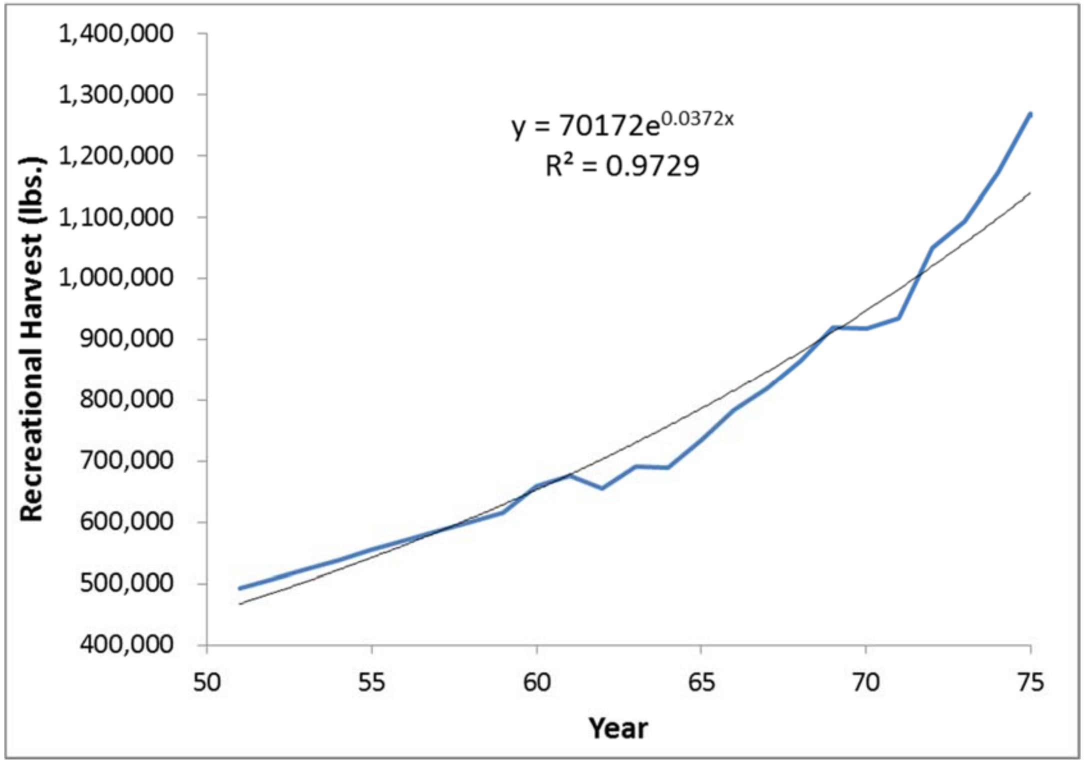


Figure 76. Exponential regression of recreational harvest estimates from 1950-1975.

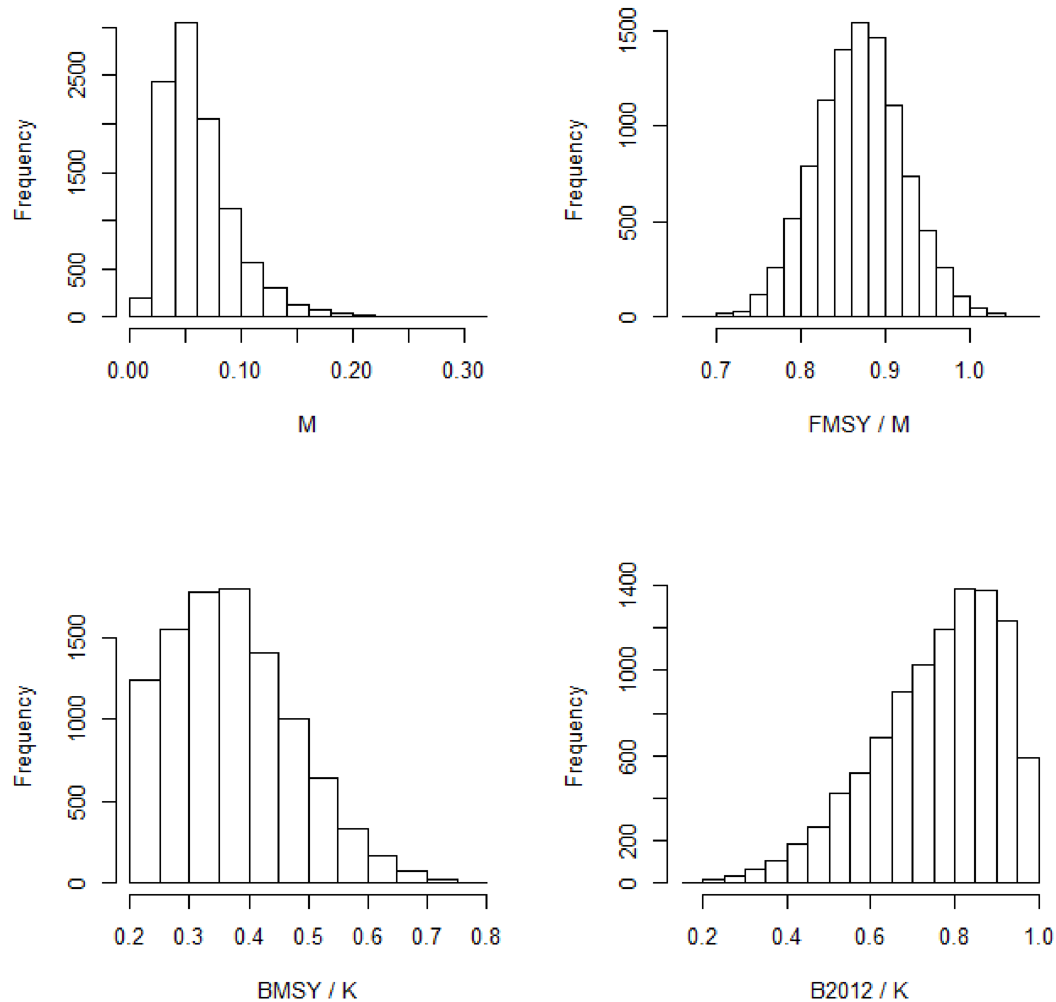


Figure 77. DB-SRA prior distributions for input parameters M, F_{MSY}/M, B_{MSY}/K, and B_{2012}/K.

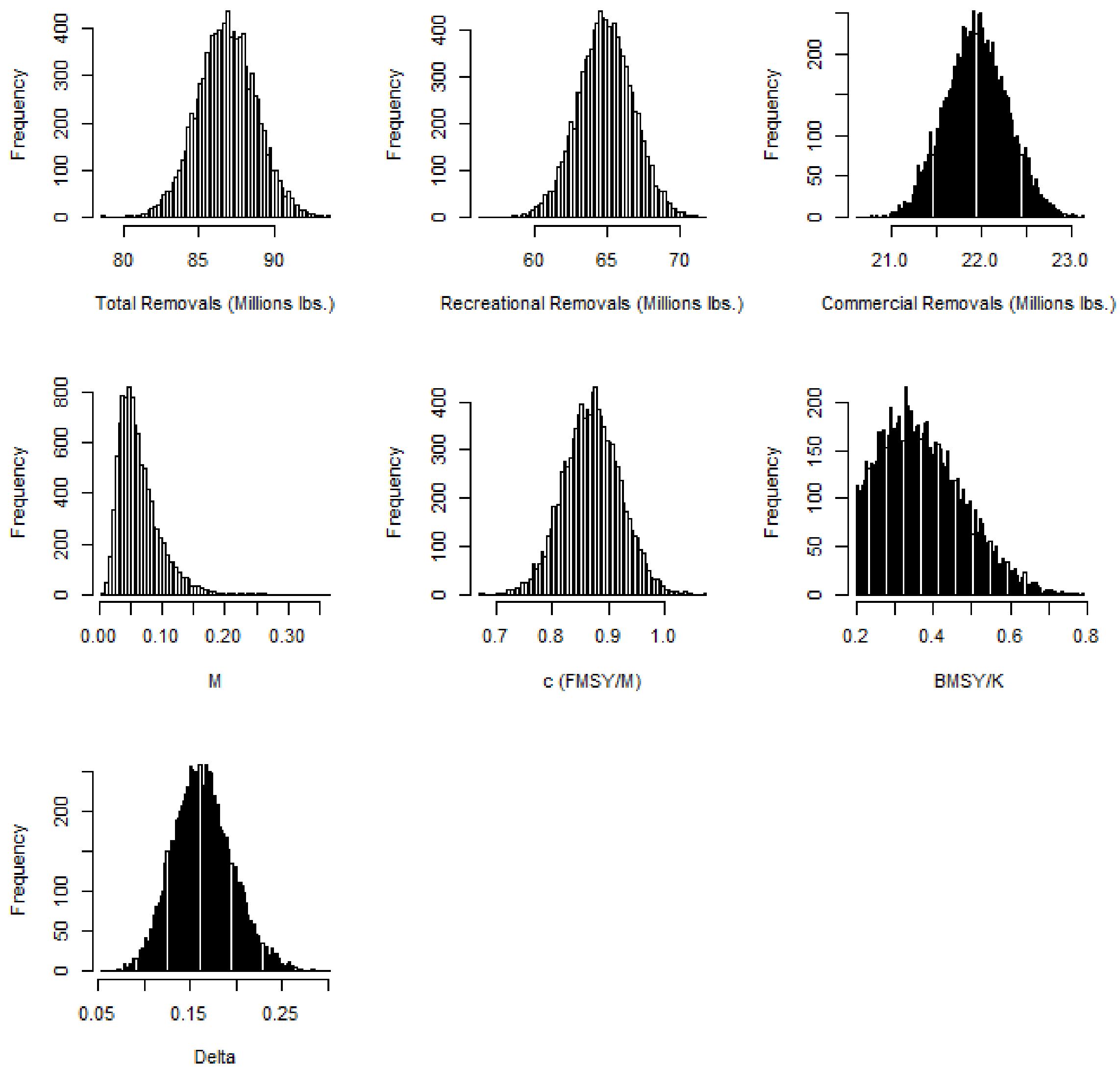


Figure 78. DCAC prior distributions for input data and parameters M, c (i.e., FMSY/M), BMSY/K, and delta.

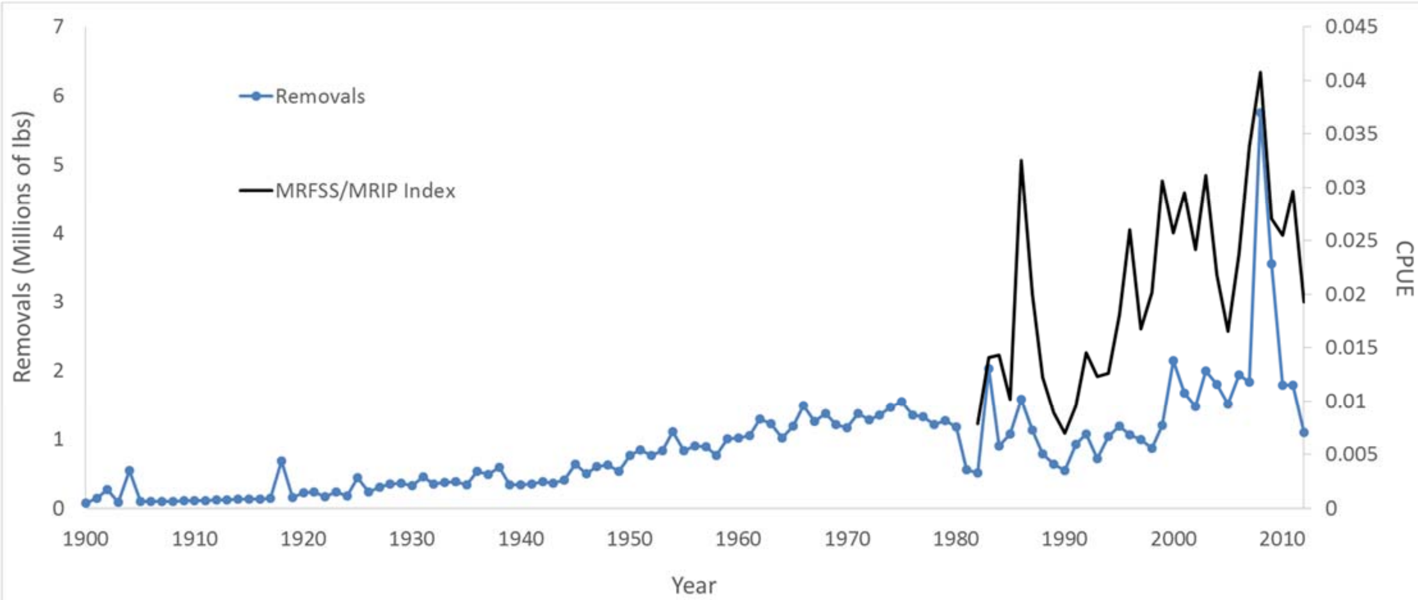


Figure 79. Total removals and the MRFSS/MRIP coast wide index of relative abundance.

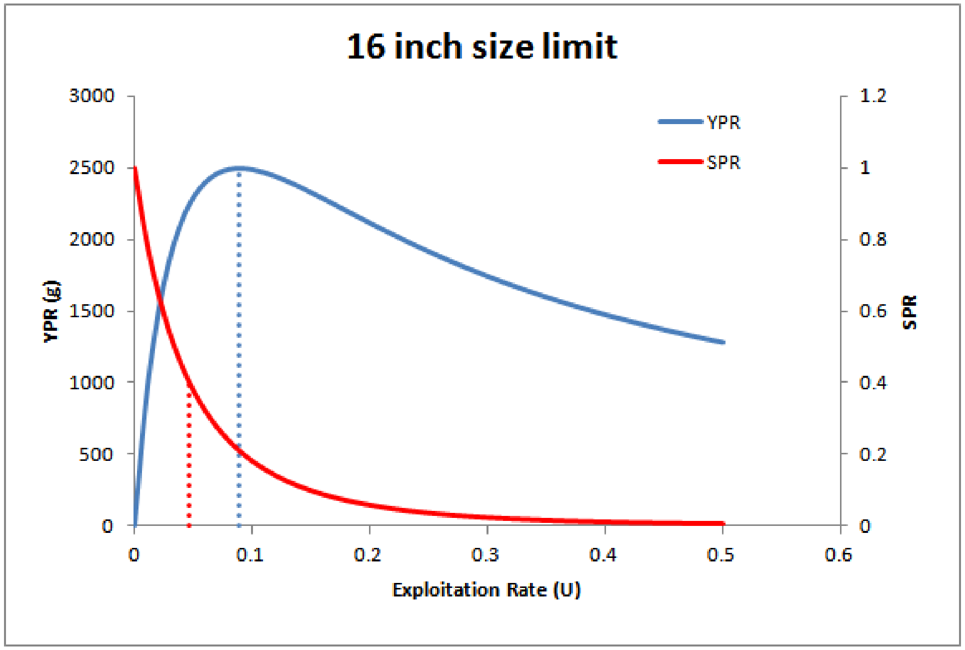


Figure 80. SPR and YPR curves for the under 16 inch minimum size limit. Vertical dotted lines indicate the exploitation rate that maximizes YPR (UMSY) and the rate that produces the target SPR of 0.4 (USPR0.4).

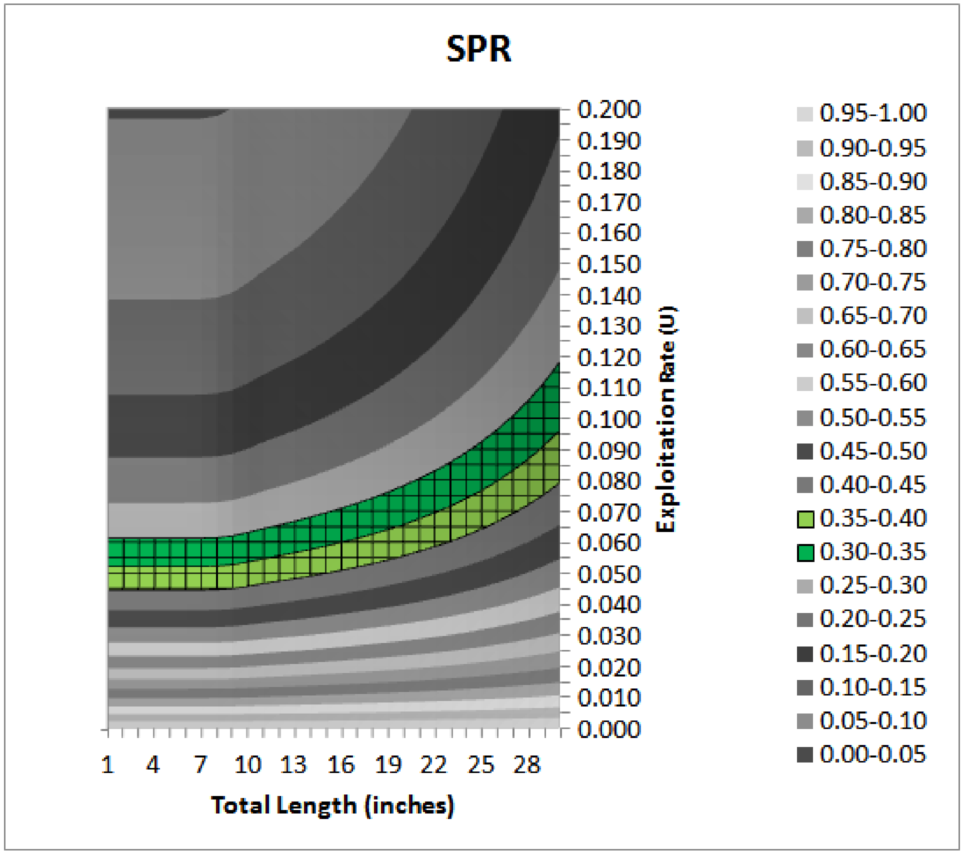


Figure 81. Isopleths plots indicating the SPR that would be achieved over a range of minimum size limits. The green shaded areas identify SPR values between 0.3 and 0.4.

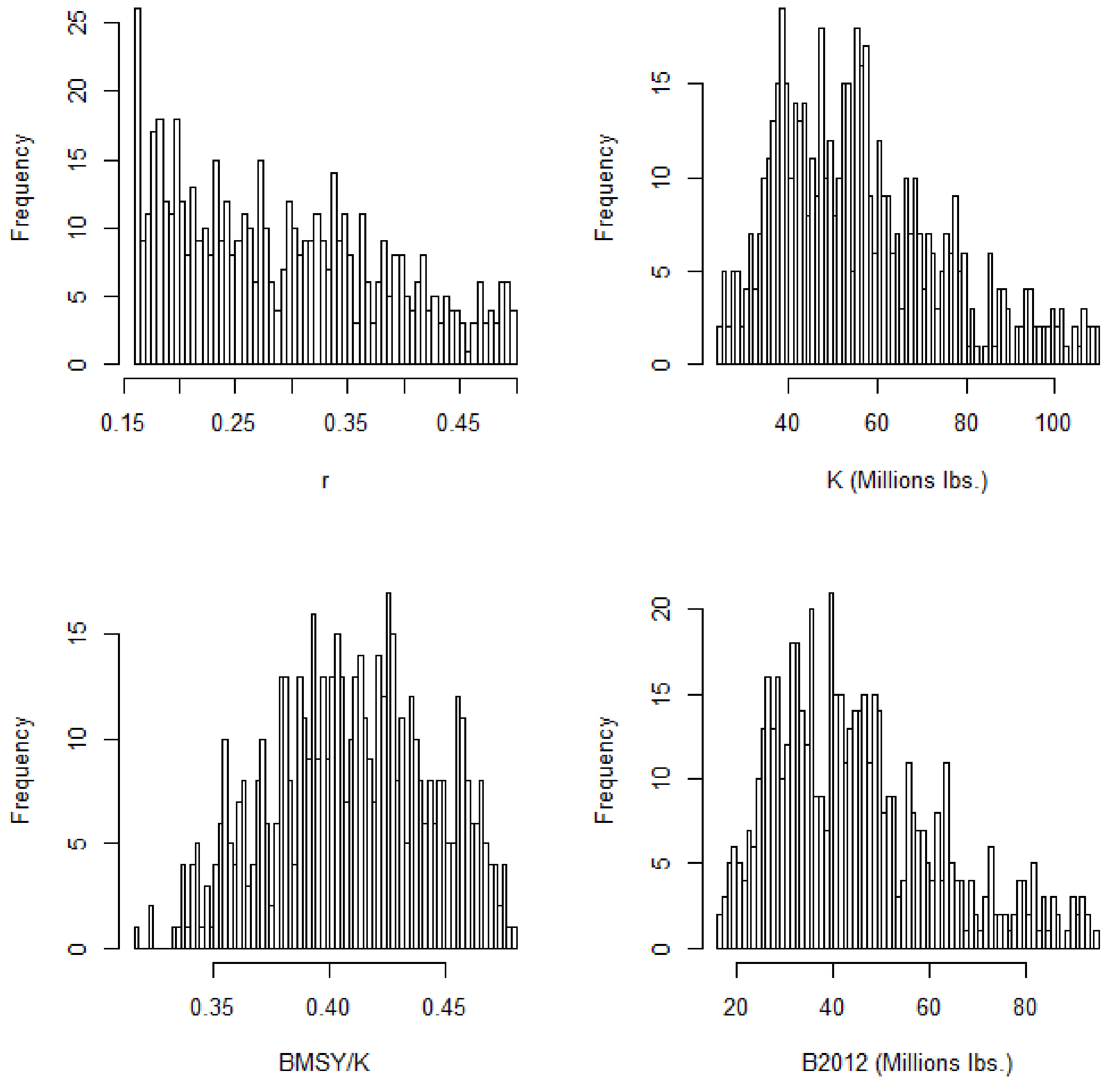


Figure 82. Distributions of input parameters and terminal biomass (B2012) from accepted runs of the Catch-MSY base configuration.

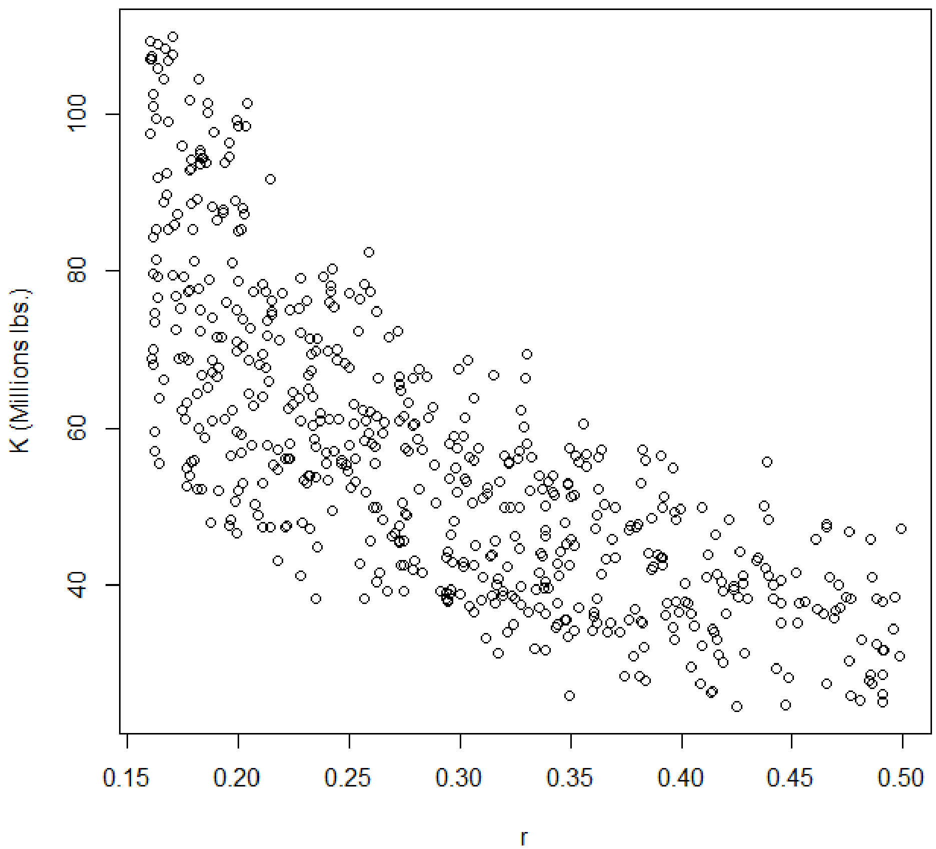


Figure 83. Accepted r and K parameter values for the Catch-MSY base configuration.

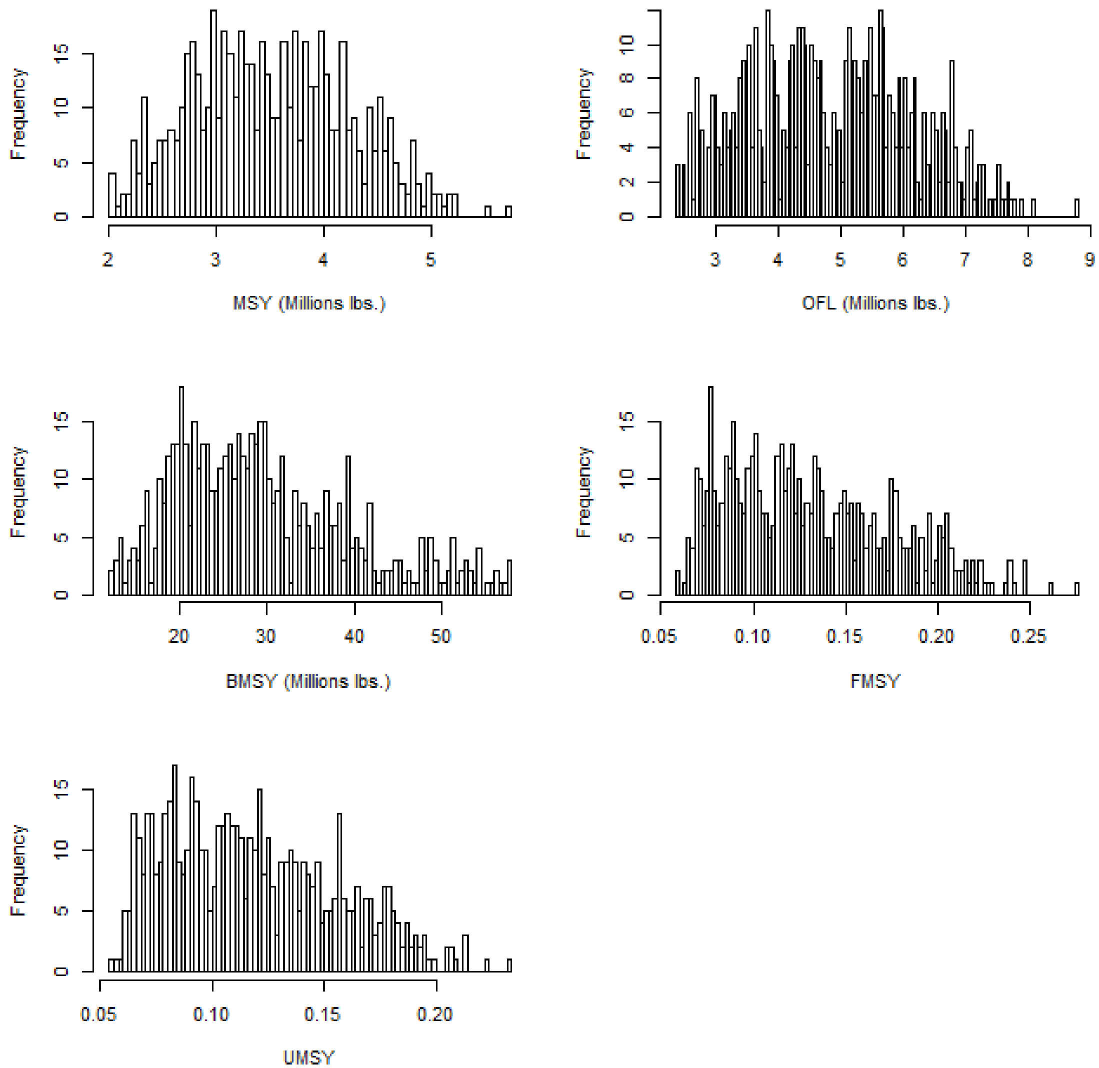


Figure 84. Reference point distributions for the Catch-MSY base configuration.

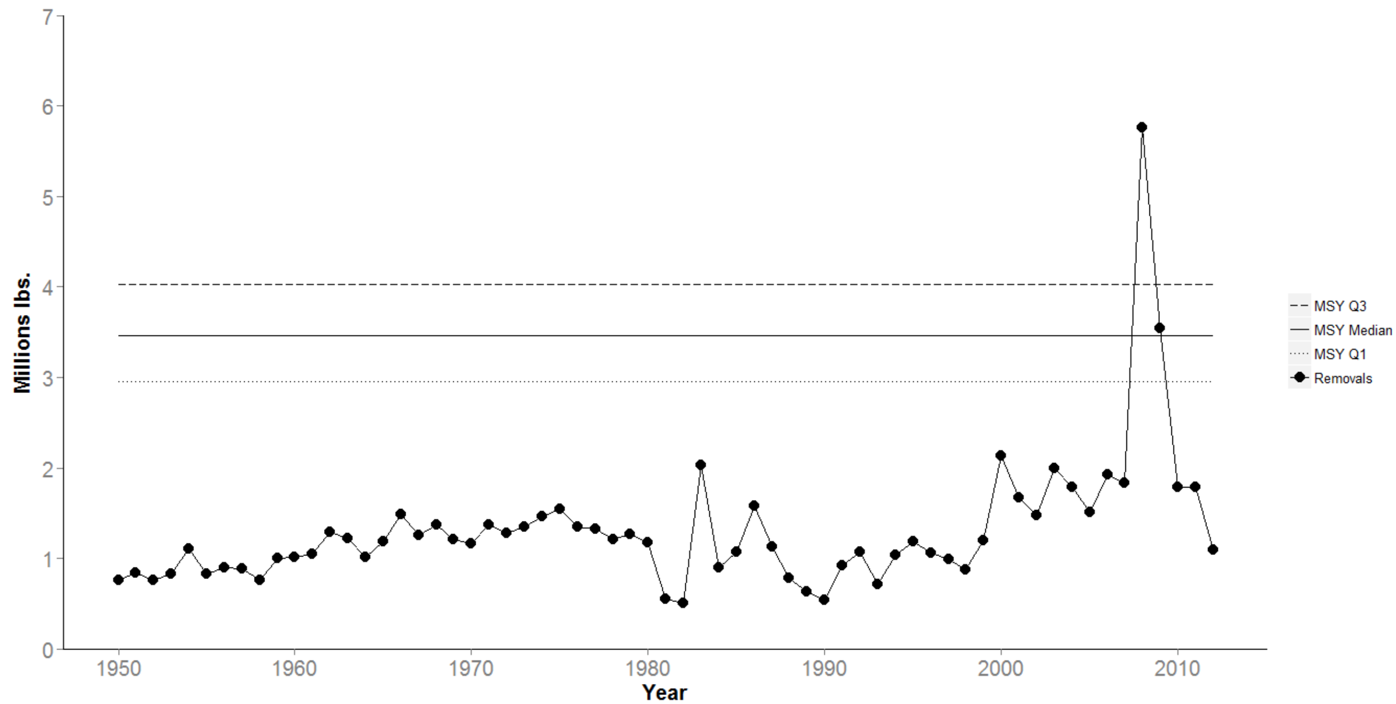


Figure 85. Observed removals and the median (3.46 million pounds) and interquartile range (2.96 – 4.03 million pounds) of the MSY estimate from the Catch-MSY base configuration.

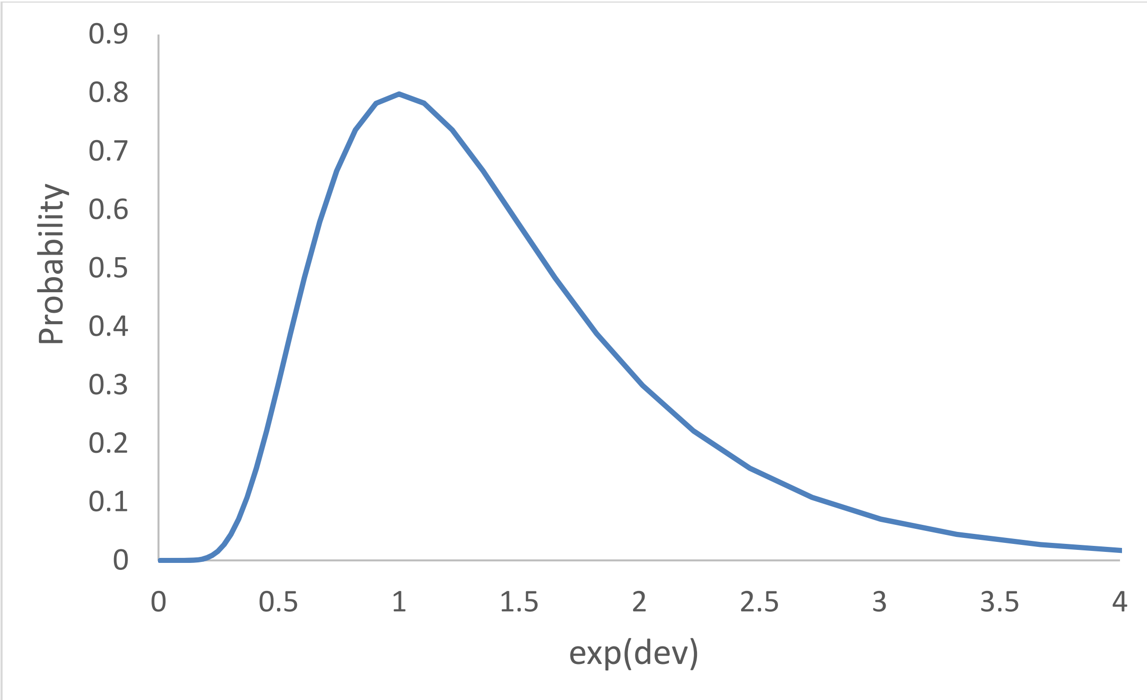


Figure 86. Distribution of lognormal deviations (exp(dev)) for Catch-MSY sensitivity configuration incorporating process error. Mean of (dev) = 0 and sd of (dev) = 0.05.

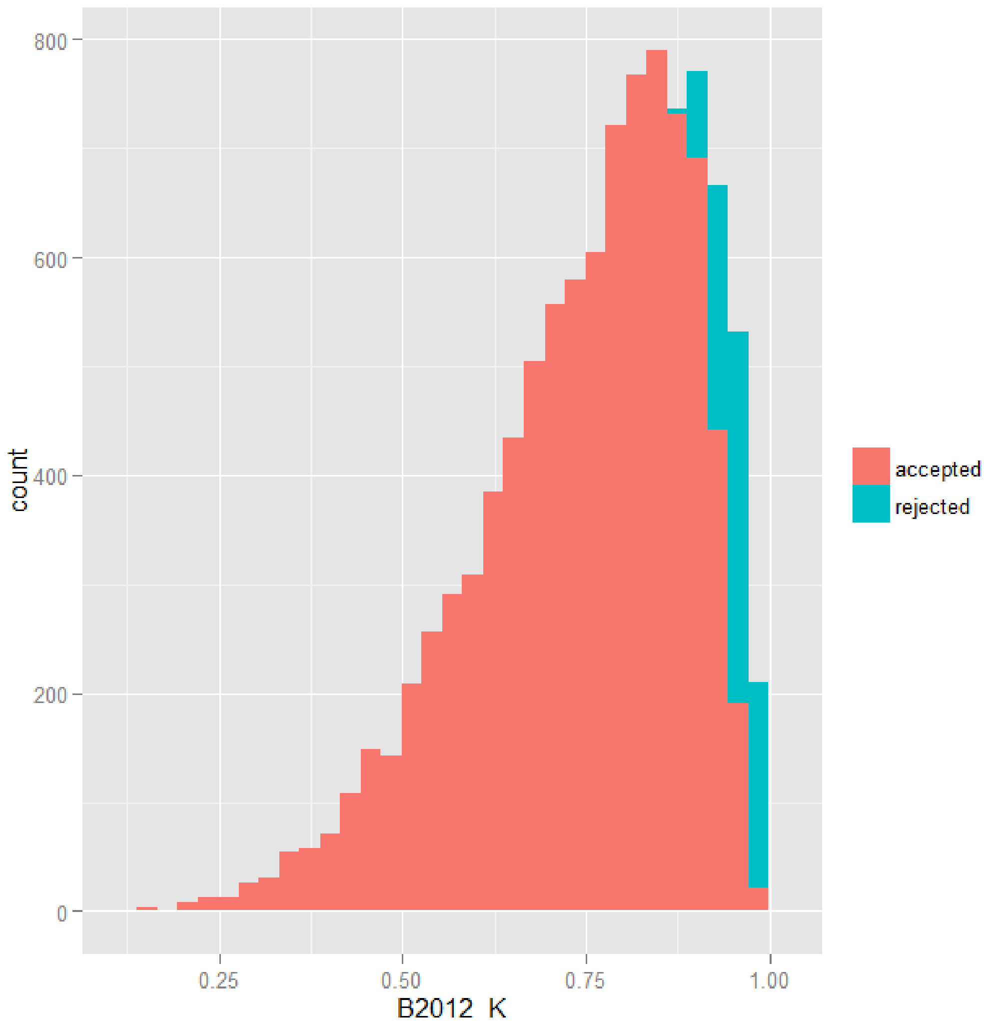


Figure 87. Stacked histogram of terminal relative biomass parameter (B2012/K) values from accepted (red) and rejected (blue) iterations of the DB-SRA base configuration.

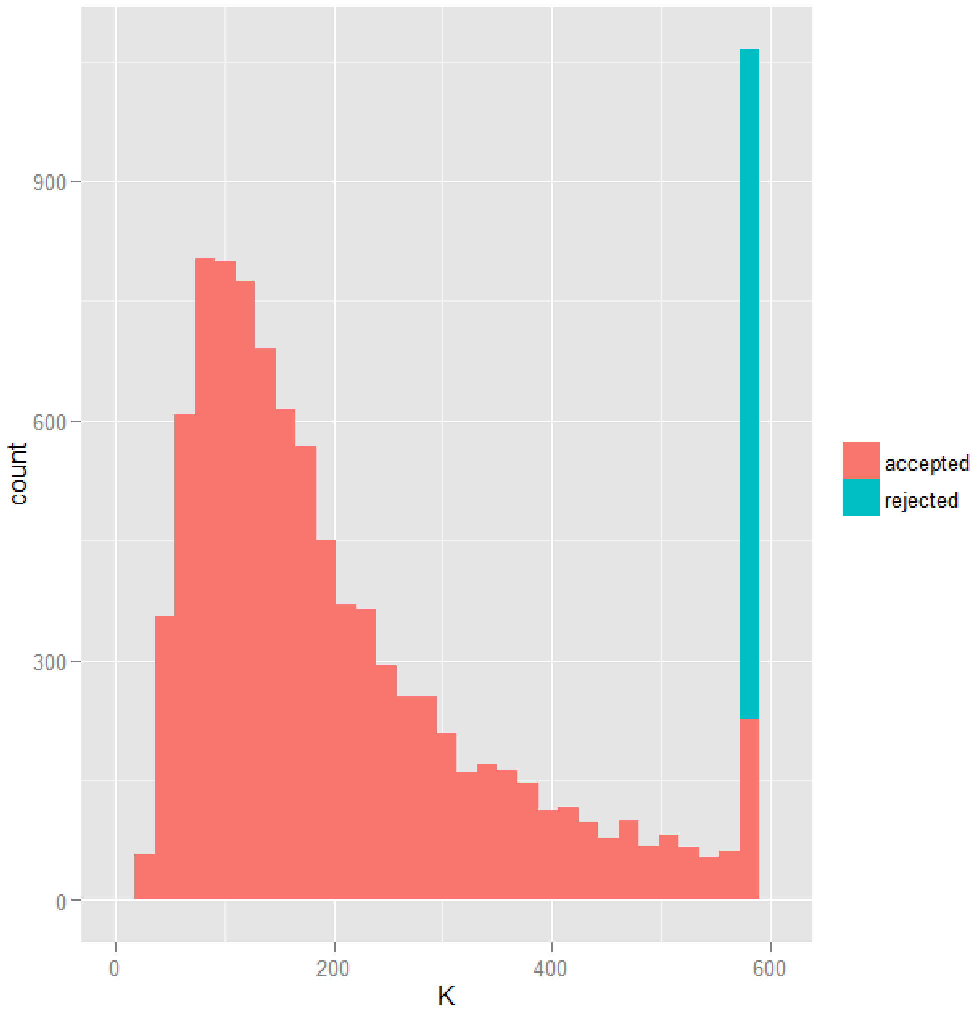


Figure 88. Stacked histogram of carrying capacity parameter (K) values from accepted (red) and rejected (blue) iterations of the DB-SRA base configuration.

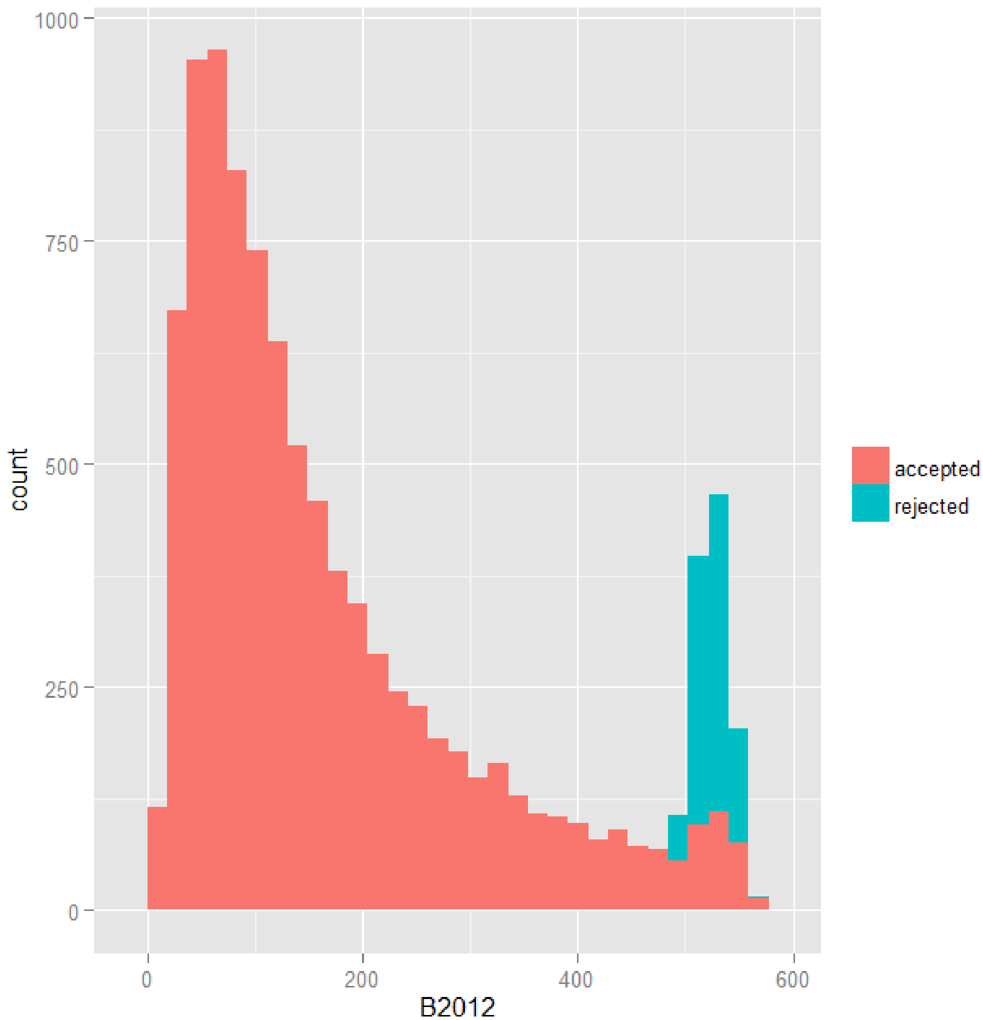


Figure 89. Stacked histogram of terminal biomass parameter (B2012) values from accepted (red) and rejected (blue) iterations of the DB-SRA base configuration.

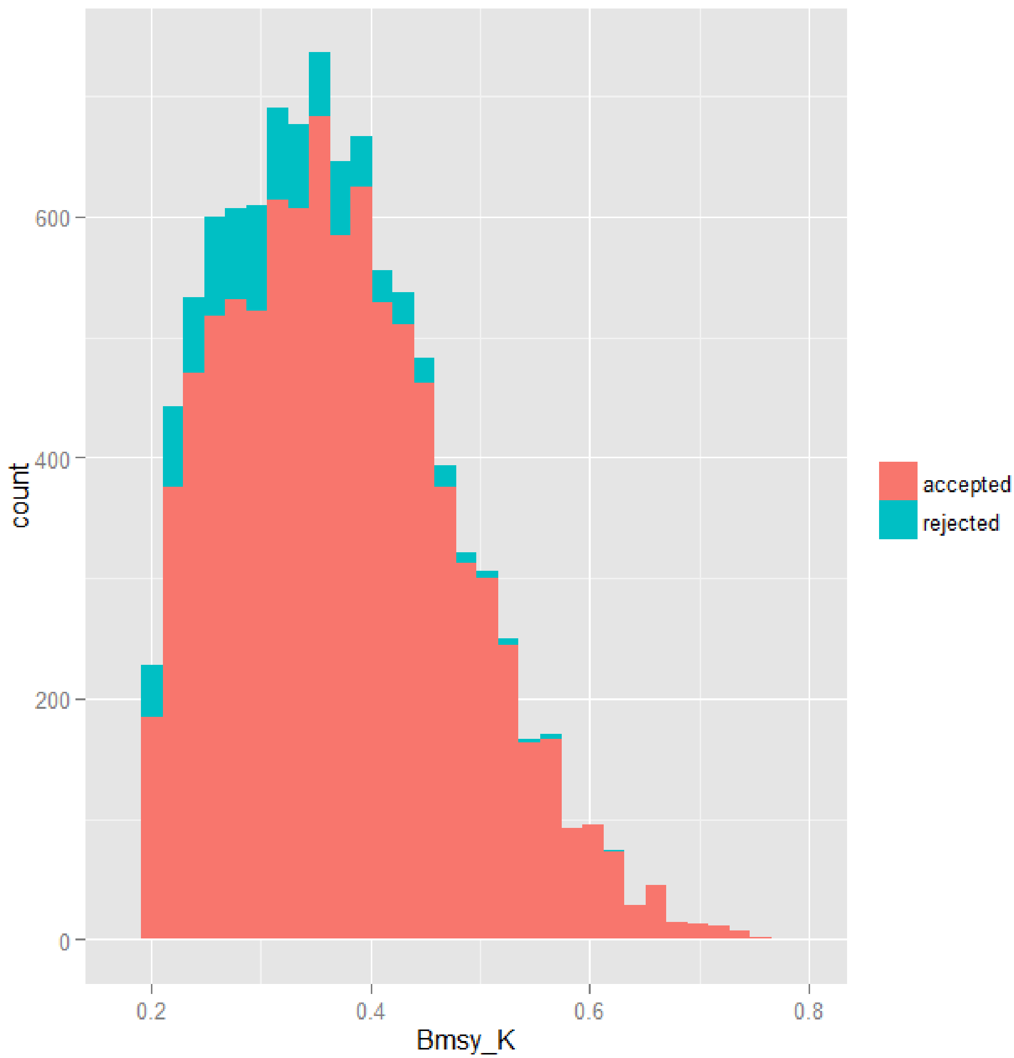


Figure 90. Stacked histogram of BMSY/K parameter values from accepted (red) and rejected (blue) iterations of the DB-SRA base configuration.

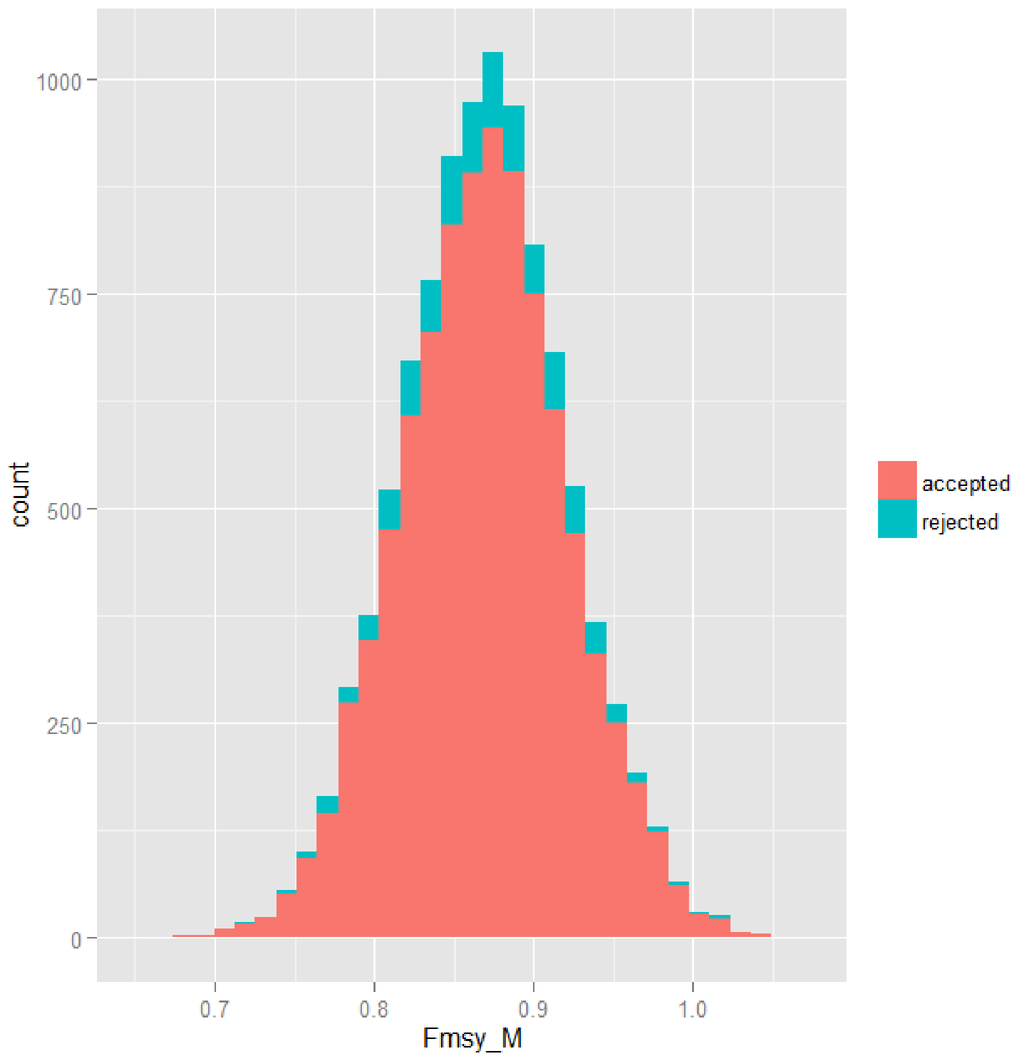


Figure 91. Stacked histogram of FMSY/M parameter values from accepted (red) and rejected (blue) iterations of the DB-SRA base configuration.

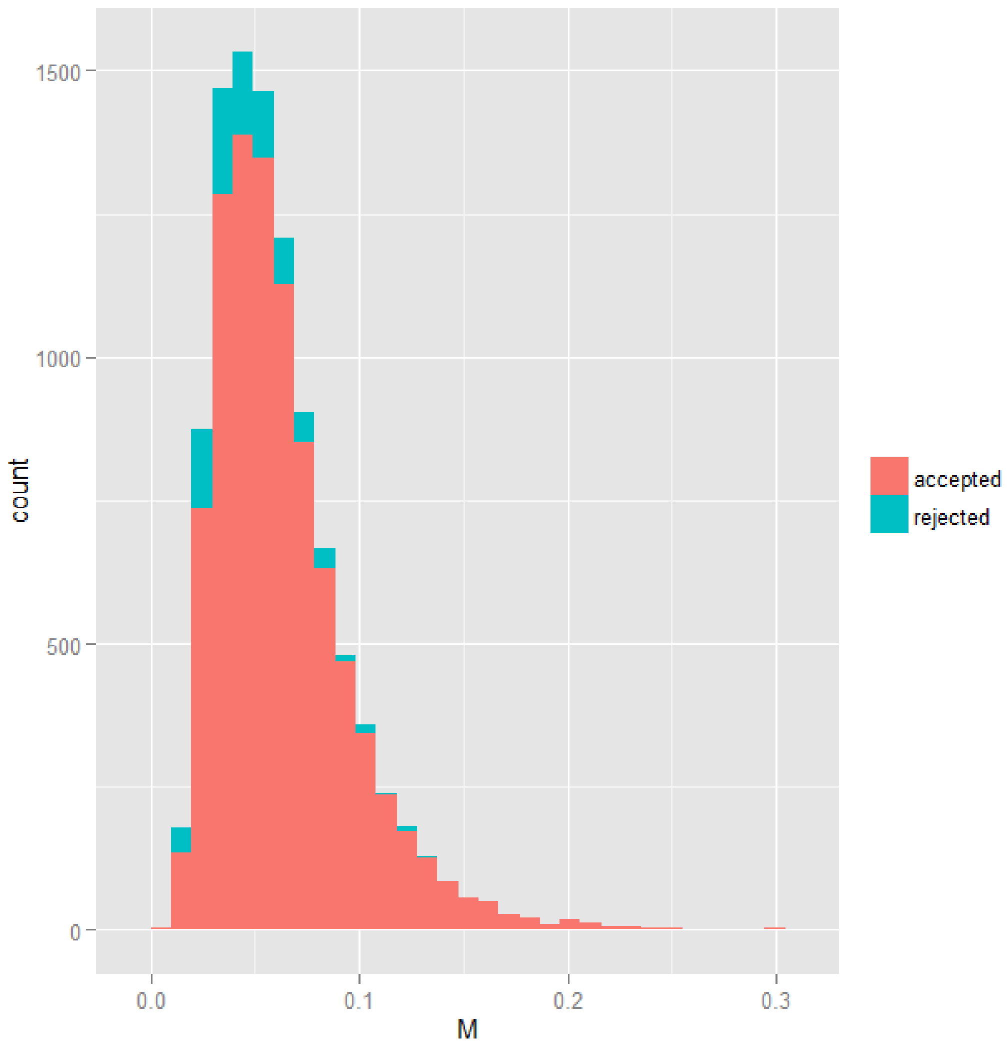


Figure 92. Stacked histogram of natural mortality parameter (M) values from accepted (red) and rejected (blue) iterations of the DB-SRA base configuration.

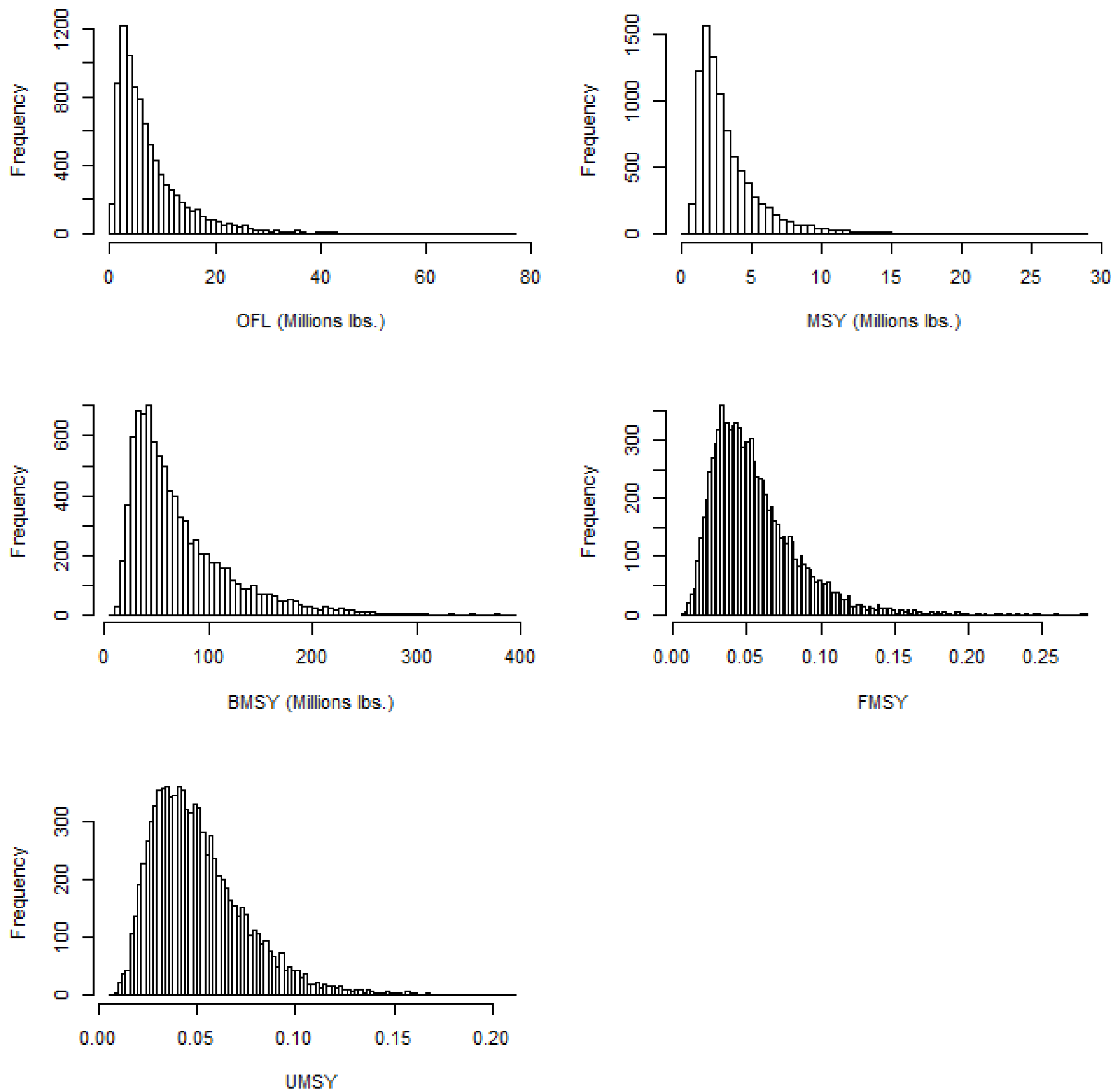


Figure 93. Reference point distributions for the DB-SRA base configuration.

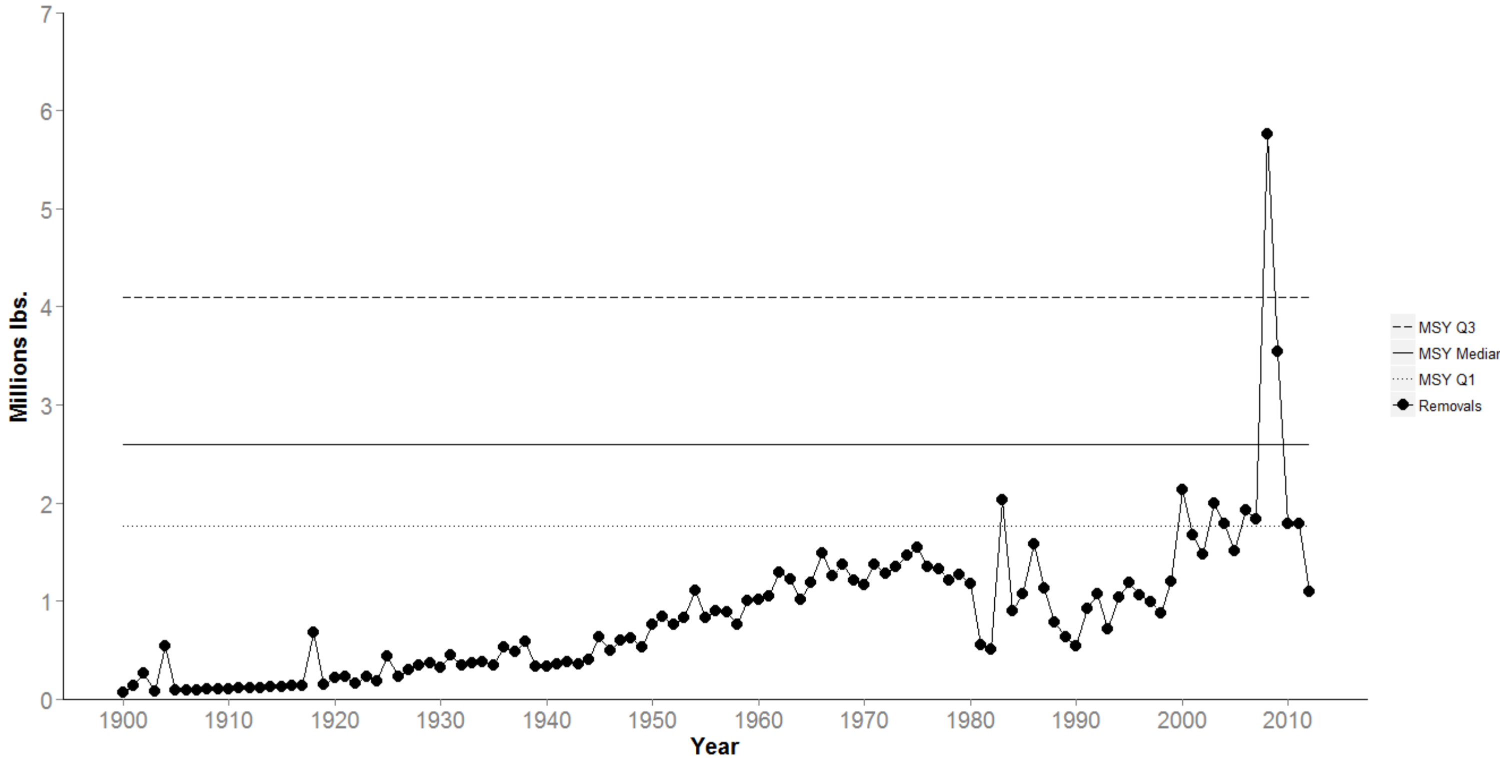


Figure 94. Observed removals and the median (2.60 million pounds) and interquartile range (1.76 – 4.10 million pounds) of the MSY estimate from the DB-SRA base configuration.

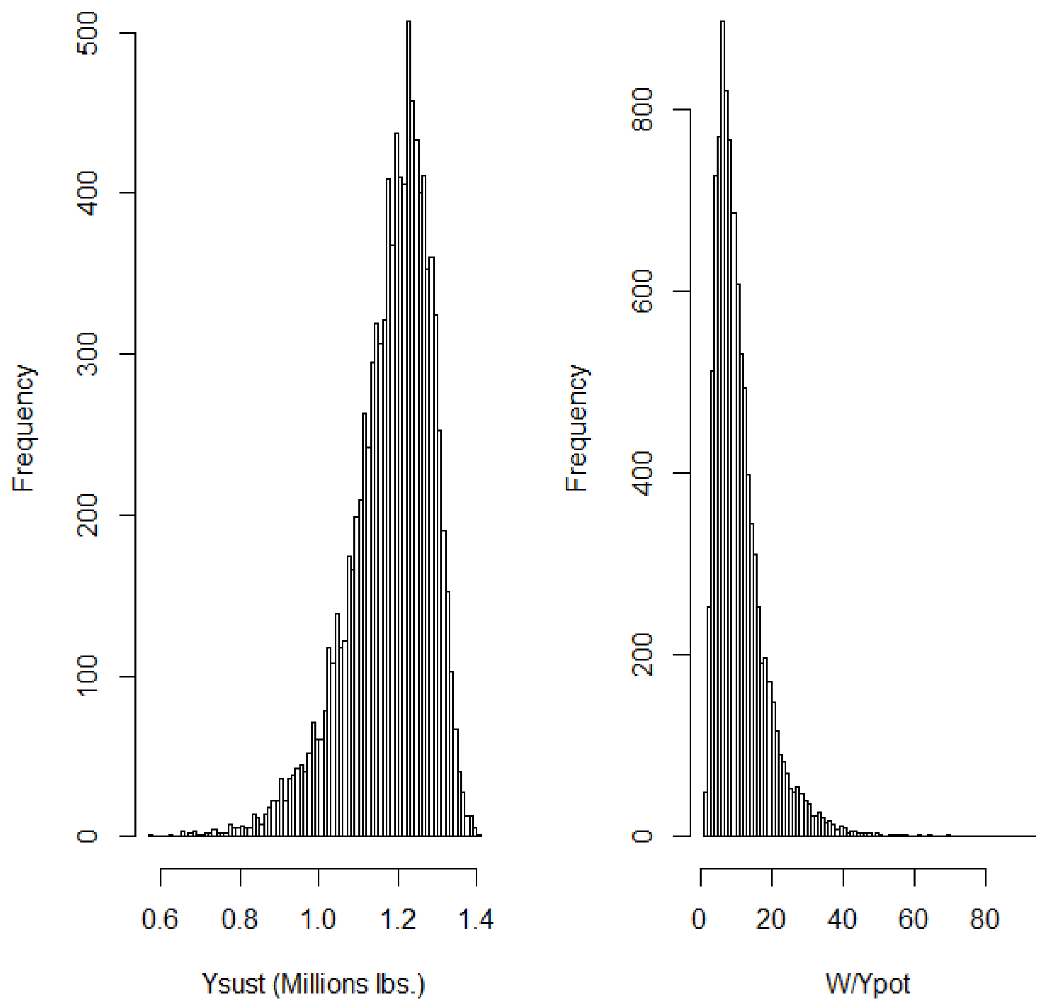


Figure 95. Distributions of the sustainable yield and correction term estimates from the DCAC base configuration.

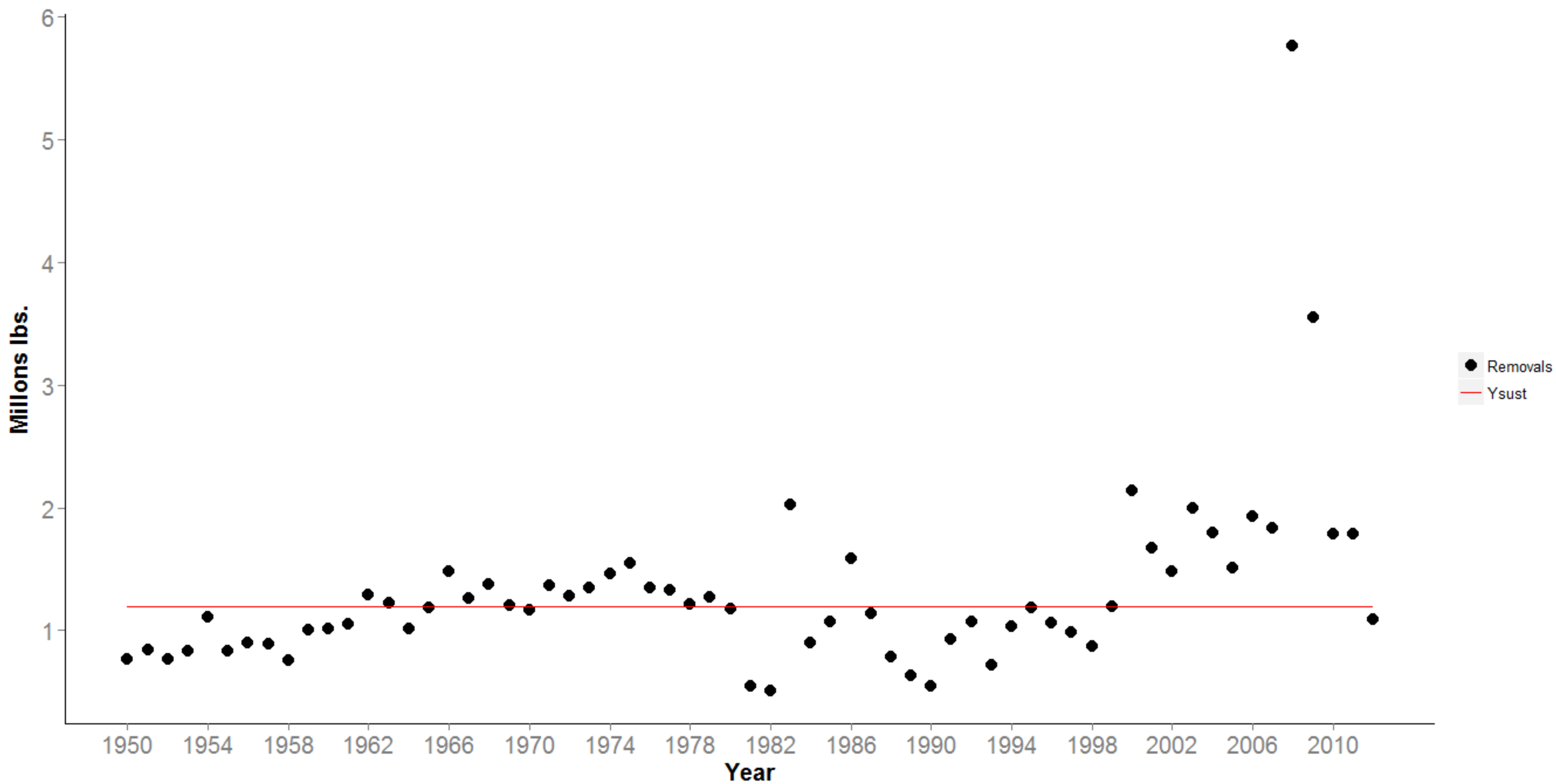


Figure 96. Observed removals and the median (1.20 million pounds) and interquartile range (1.12 – 1.25 million pounds) of the sustainable yield estimate from the DCAC base configuration.

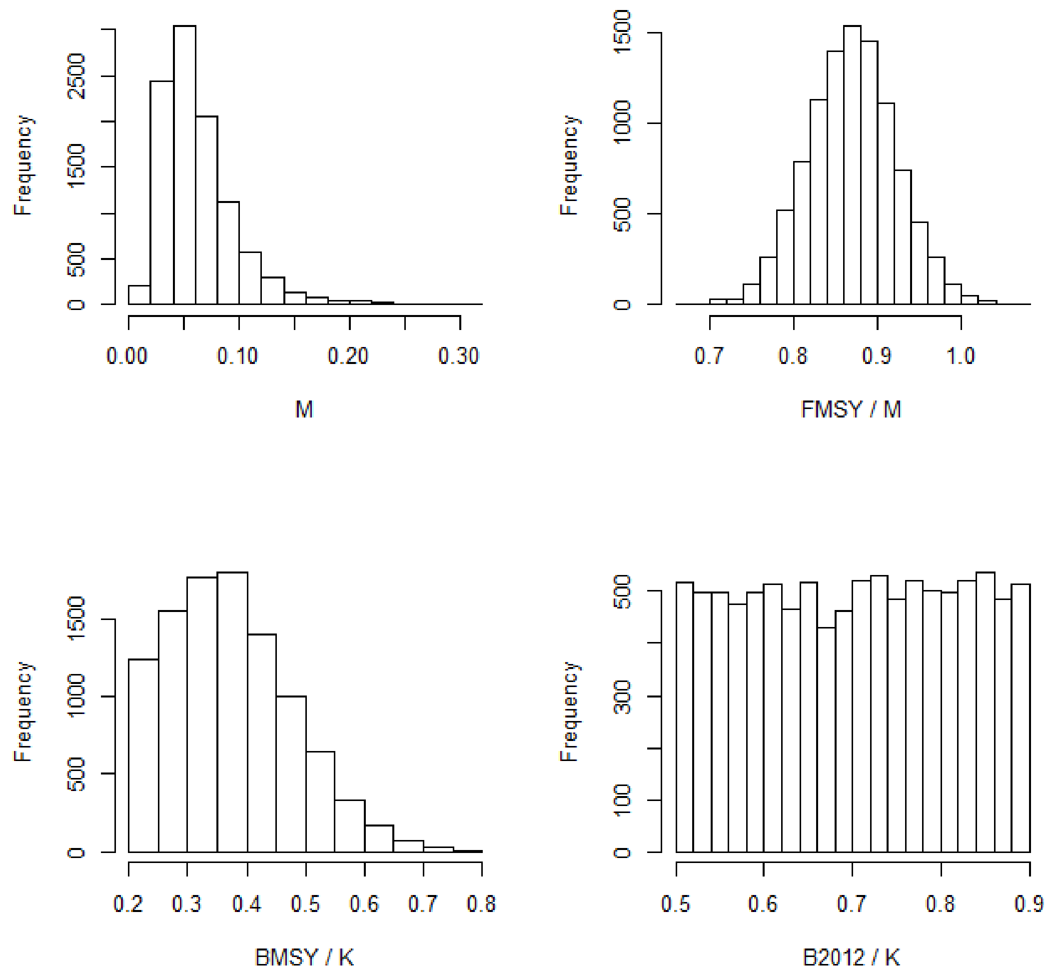


Figure 97. DB-SRA prior distributions for input parameters M, F_{MSY}/M, B_{MSY}/K, and B_{2012}/K for final preferred DB-SRA configuration.

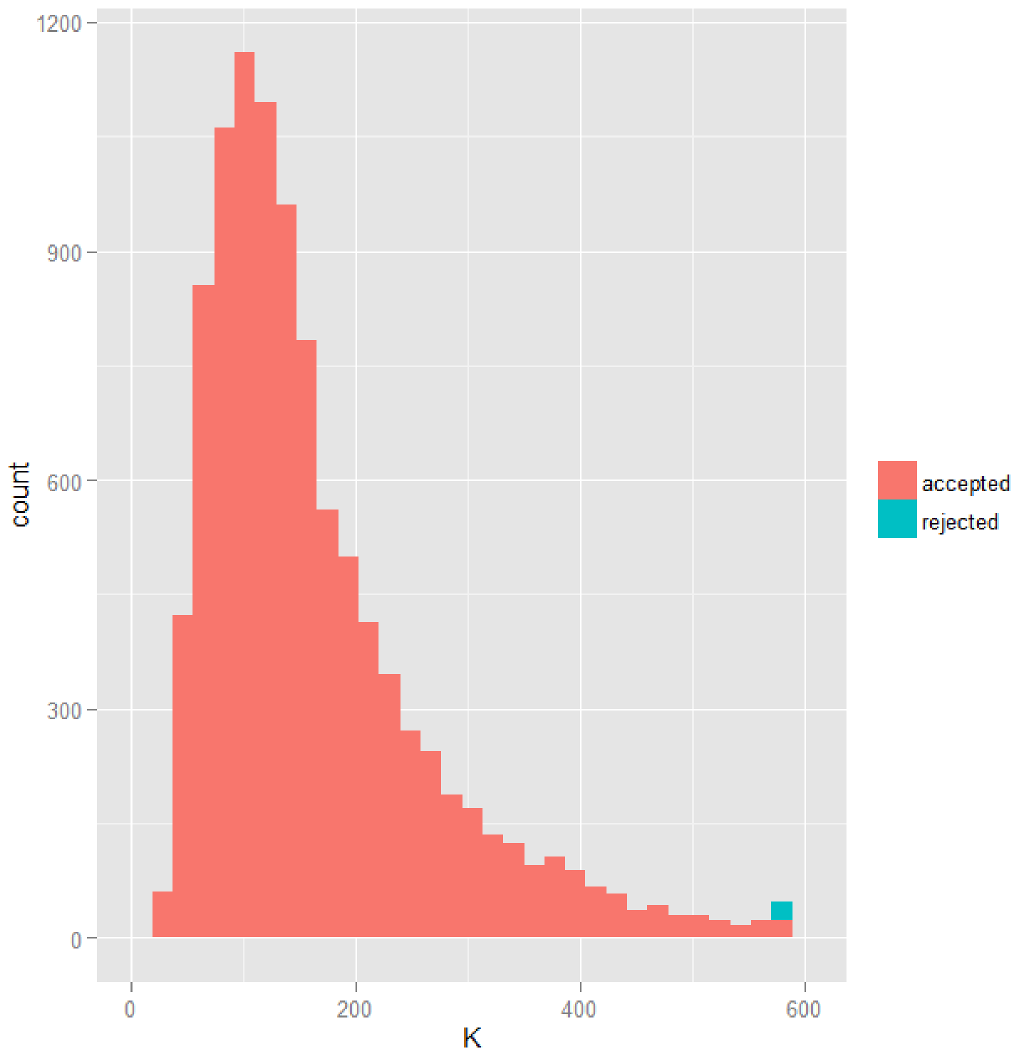


Figure 98. Stacked histogram of carrying capacity parameter (K) values from accepted (red) and rejected (blue) iterations of the DB-SRA new base configuration.

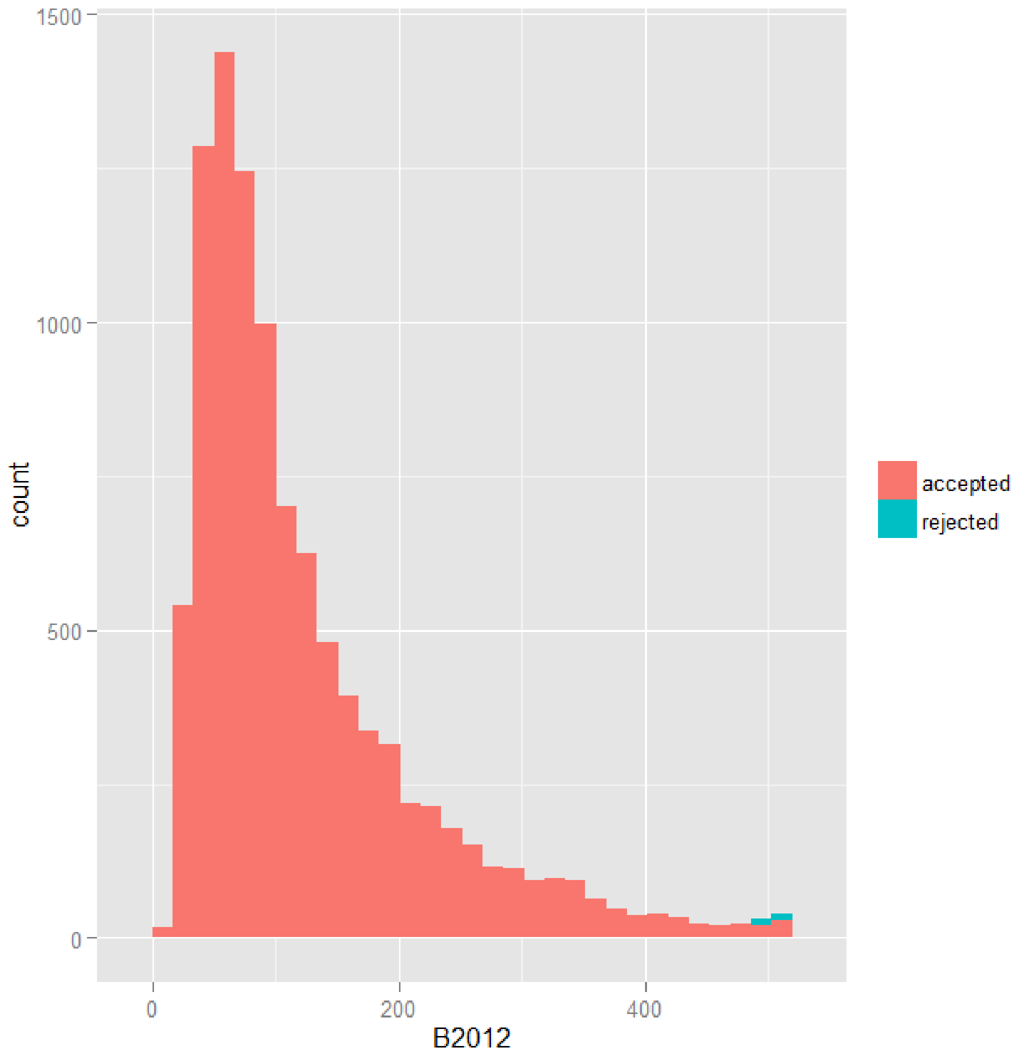


Figure 99. Stacked histogram of terminal biomass parameter (B2012) values from accepted (red) and rejected (blue) iterations of the DB-SRA new base configuration.

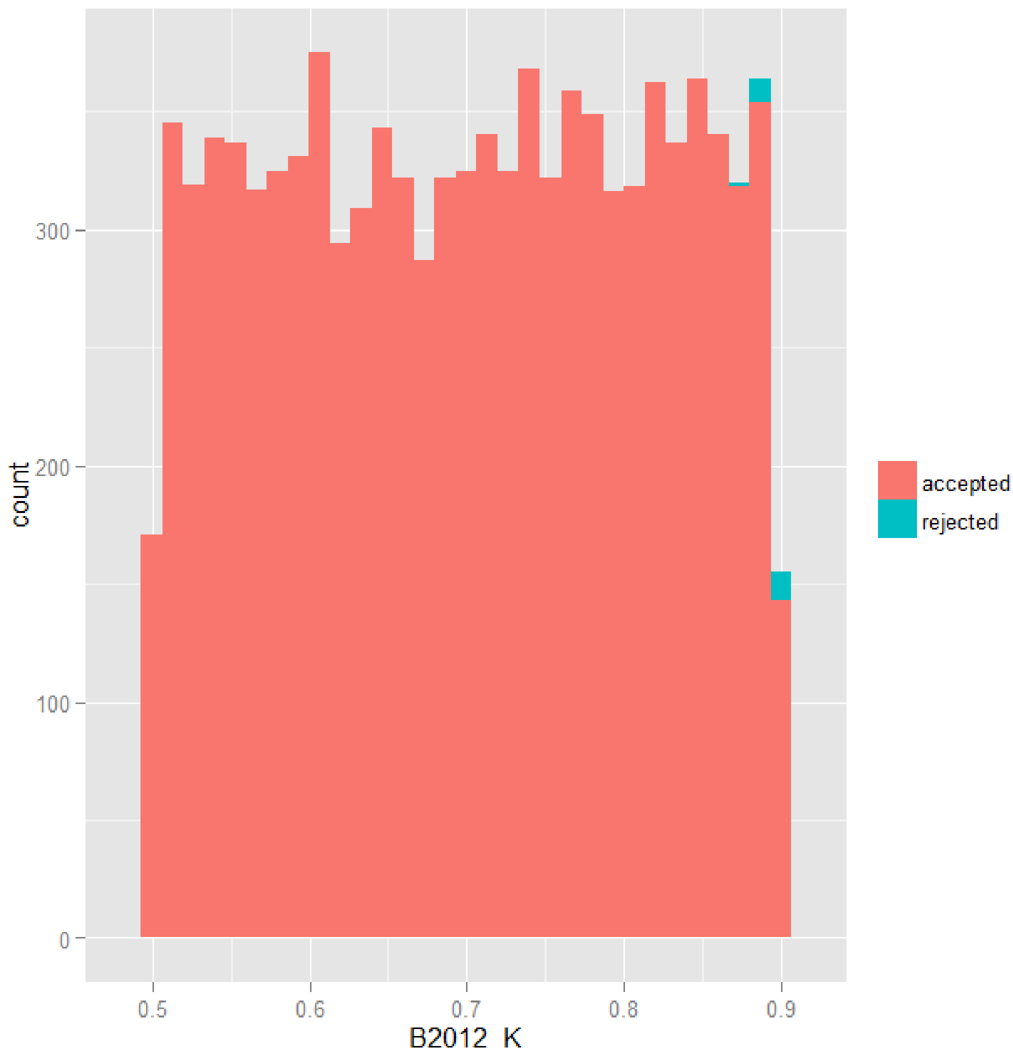


Figure 100. Stacked histogram of terminal relative biomass parameter (B2012/K) values from accepted (red) and rejected (blue) iterations of the DB-SRA new base configuration.

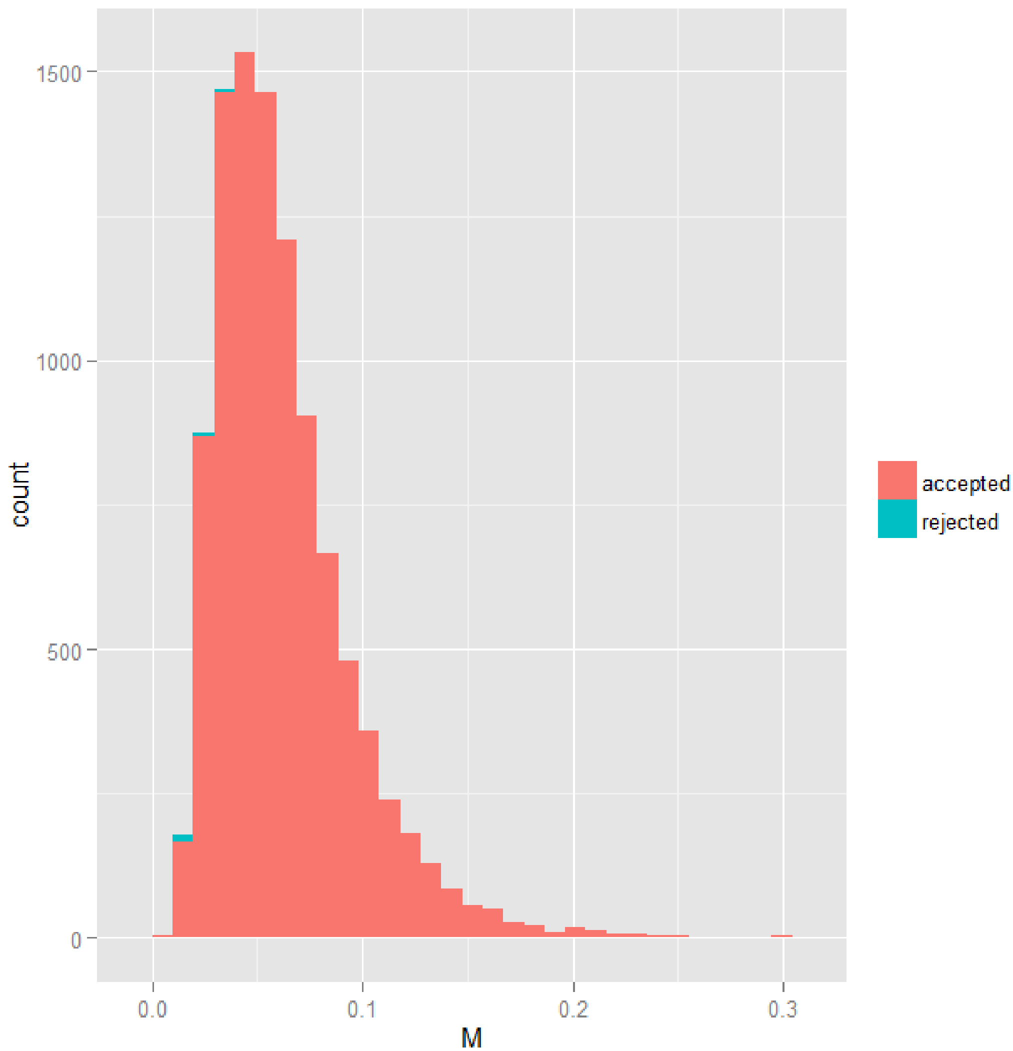


Figure 101. Stacked histogram of natural mortality parameter (M) values from accepted (red) and rejected (blue) iterations of the DB-SRA new base configuration.

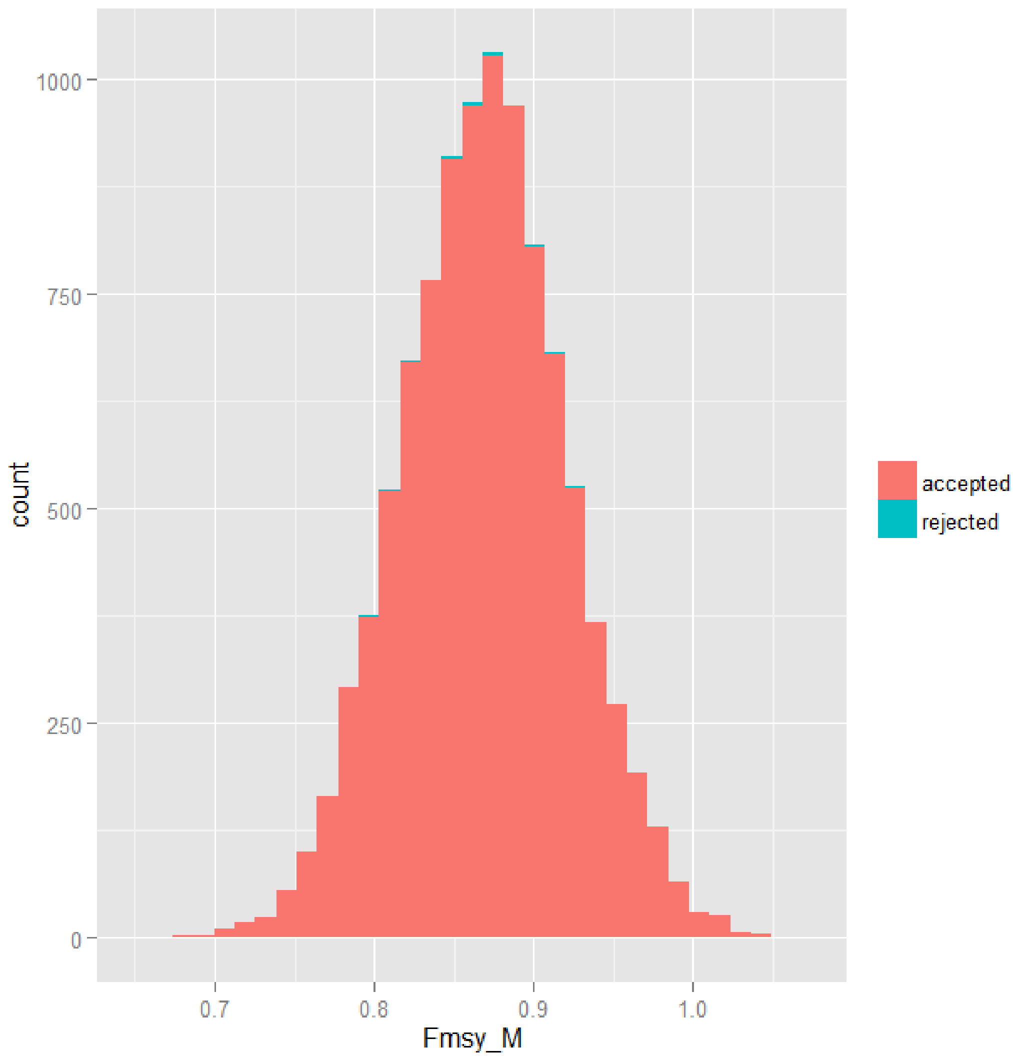


Figure 102. Stacked histogram of FMSY/M parameter values from accepted (red) and rejected (blue) iterations of the DB-SRA new base configuration.

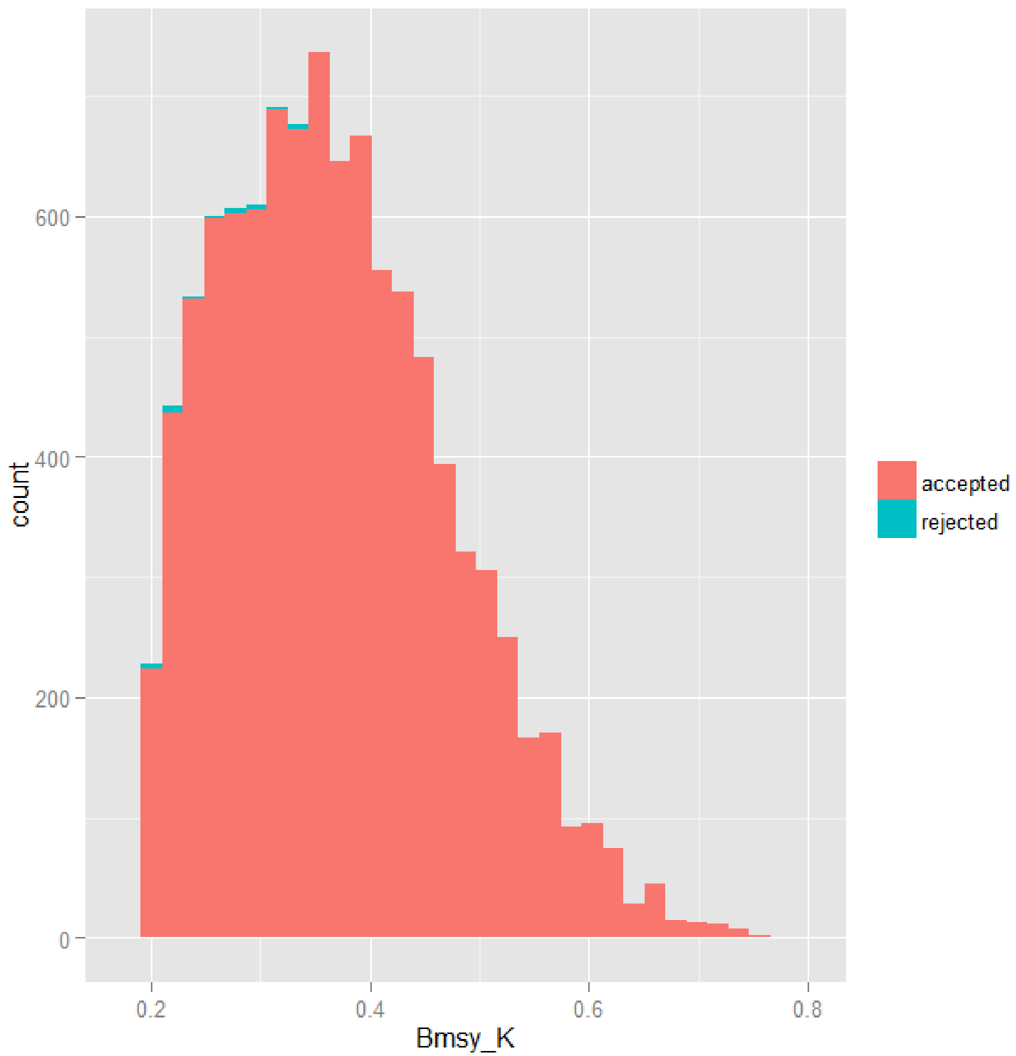


Figure 103. Stacked histogram of BMSY/K parameter values from accepted (red) and rejected (blue) iterations of the DB-SRA new base configuration.

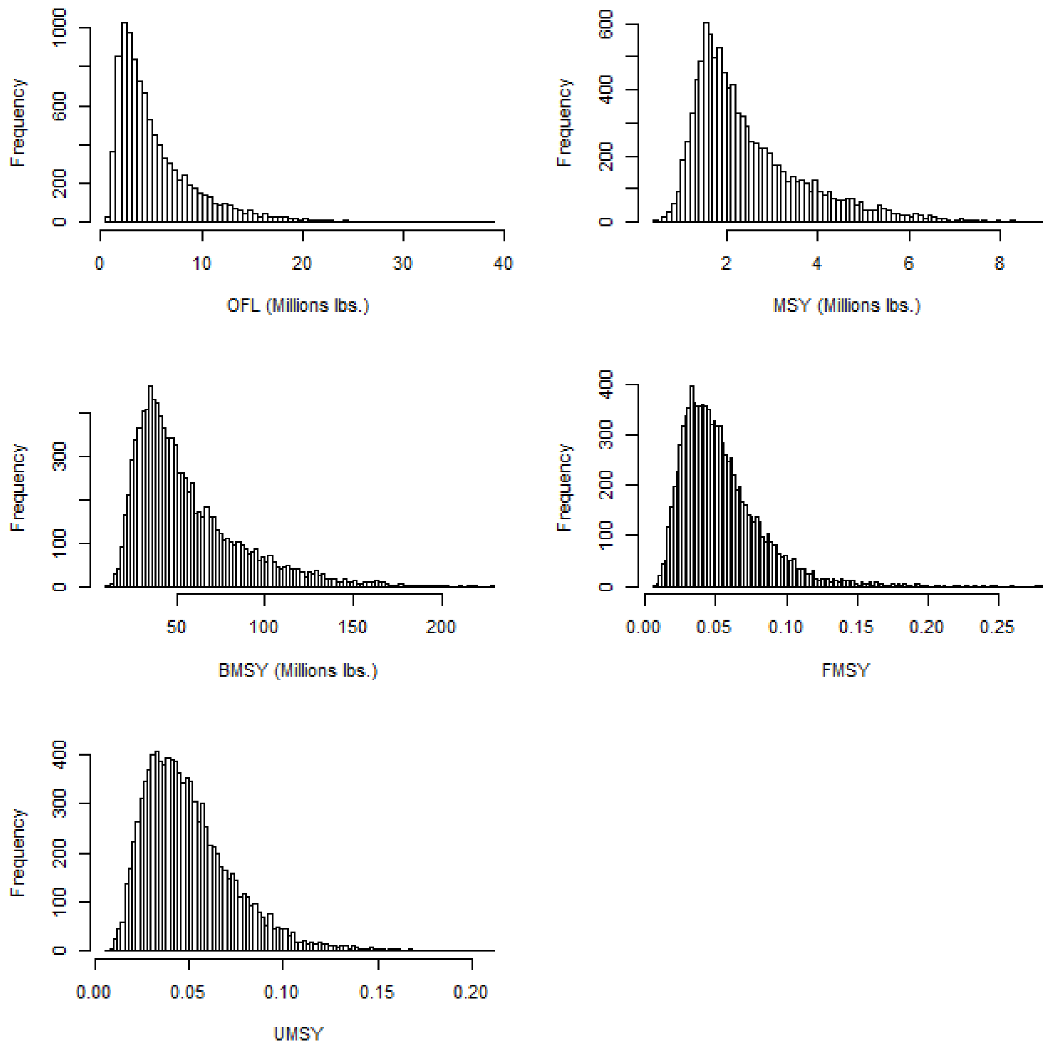


Figure 104. Reference point distributions for the DB-SRA new base configuration.

Appendix 1 Decision Tree for Filling Missing MRFSS Weights

Step 1. If there is not a weight or variance estimate for a strata, combine strata over boat modes (4-7) and shore modes (1-3) for the same year/state/wave combination.
Step 2. If there are less than 10 weight observations, collapse strata over wave 1-3 and wave 4-6 for each year/state combination.
Step 3. If there are still less than 10 weight observations, collapse over all modes for each year/state/wave grouping combinations.
Step 4. If there are still less than 10 weight observations, collapse over the year/state/wave grouping combinations based on changes in regulations outlined below.

- NJ-VA 1981-1986 (no size limit)
- VA 1987-1993 (16” minimum)
- NJ-MD 1987-1993 (no size limit)
- VA&MD 1994-2000 (16” minimum)
- NJ&DE 1994-2000 (no size limit)
- NJ,MD,VA 2001-2009 (16” minimum)
- DE 2001-2009 (no size limit)
- NJ-DE 2010-2012 (16” minimum)
- NC 1982-2012 (no size limit)
- SC-GA 1981-1997 (no size limit)
- SC 1998-2006 (no size limit)
- SC 2007-2012 (14”-27” slot)
- GA 1998-2012 (10” minimum)
- FL 1982-1988 (no size limit)
- FL 1989-2012 (14”-24” slot & 1 fish over 24” allowed)

Step 5. If there are still less than 10 weight observations, combine over preceding and proceeding years where possible. Keep combining over +1 year within the timeframes in step 4.
Step 7. If there are still less than 10 weight observations, combine over waves and go through steps 4 and 5 again.
Step 8. Apply mean weight and/or variance of weight from strata combination to the total number estimate for the stratum with missing weight and/or variance estimates.

Appendix 2 Draft Black Drum Standardizing Decision Tree

1. Complete any *a priori* filtering based on recommendations from the data contact (e.g., exclude a station where black drum have never been encountered).
2. Select the response variable.
3. Select explanatory variables that would explain variance in catch due to catchability, not abundance. Consult literature and/or expert opinion to identify variables that affect catchability. Always include year to determine year effect. Include justification for including/excluding variables in the dataset.
4. Check for outliers and unrealistic observations (e.g., depth=0) in all variables. Plot each variable (can also support making explanatory variables categorical) and visually check data for extreme outliers in response and explanatory variables. If there are outliers or unrealistic observations, check with data set contact to identify potential typos. If unrealistic observations cannot be fixed, change the observation to NA. If outlier cannot be confirmed as a typo, leave unchanged in data set.
5. Determine type of each explanatory variable (categorical or quantitative). Plot each explanatory variable and examine for obvious breaks or groupings. If breaks /groups are present, make the variable categorical and indicate the levels. Always make year a categorical variable. Confirm that there are adequate observations in each level of categorical variables (model may crash if there are not adequate observations). If there are not adequate observations, combine similar levels (e.g., combine bottom types of sand and silt, consult expert opinion or literature to combine categories). If levels cannot be logically combined, drop any levels with too few observations.
6. Check for correlation/association between potential explanatory variables. Plot each pairing of quantitative explanatory variables and calculate the variance inflation factors for all quantitative explanatory variable combinations. If the correlation coefficient is approximately 0.8 or greater and/or the variance inflation factor is approximately 10 or greater for any pair of variables, exclude the variable that is least intuitive from a biological standpoint (and/or has significantly less observations). Perform an analysis of variance on all categorical and quantitative variable combinations. If any combinations result in a significant p-value (<0.05), exclude the variable that is least intuitive from a biological standpoint (and/or has significantly less observations).
7. If sample effort varies and catch in numbers is the response variable, plot catch and effort. If catch increases proportional to effort, make effort an offset variable to be used in any models assuming a Poisson distribution (or negative binomial). If catch does not increase proportional to effort or if any other error distribution is selected, include effort as an explanatory variable.
8. Change scale of any explanatory variables that are not similar in scale to other explanatory variables (values in 1,000s for one variable compared to values in 10s for other variable).
9. Check if there are enough positive response observations per explanatory variable (model parameter). There should be 10 or more positive response observations per explanatory variable to avoid overparameterization (Peduzzi et al. 1996).

10. Examine the distribution of the response variable. Plot the annual mean of the response variable vs. the annual variance in response variable to determine relationship. If the response variable is continuous and there is a relationship between variance in catch rate and the square of the mean catch rate, select a gamma distribution. Try to avoid the lognormal distribution. If the response variable is a count and there is a linear relationship between mean catch and variance in catch, select a Poisson distribution. If there is a relationship between variance in catch and both the mean catch and the square of the mean catch, select a negative binomial distribution (Maunder and Punt 2004).
11. Plot frequencies of observed response variable. If there is a high proportion of zero observations, consider a model designed to deal with zero catches. If zero-inflation is apparent, select a zero-inflated GLM. If zero-inflation is not an issue with the data collection method, select the delta-GLM (Lo et al. 1992). If there is not a high proportion of zeros, select a standard GLM.
12. Exclude one explanatory variable at a time and rerun the model. Select the model with the lowest AIC.
13. Check for overdispersion and perform diagnostics (residual analysis) on the selected model . Plot residuals against each explanatory variable in the model. Plot residuals against the model predicted values. Overdispersion and/or patterns in residuals may be due to outliers, non-linear relationships, missing interactions, missing covariates, correlation, wrong link function, wrong error distribution, data with large variance, or zero inflation (Zuur et al. 2009). Evaluate the potential causes of overdispersion and/or residual patterns (add covariates, reconsider selected link function, etc.) and fit data to alternative model.
14. If necessary, use the Vuong's test to compare the Poisson GLM with the zero-inflated Poisson GLM or the negative binomial GLM with the zero-inflated negative binomial GLM (Vuong 1989).
15. Do back transformation for any models with upfront transformation of the response variable. Estimate mean year effects and SEs. Use bootstrapping for zero-inflated models.

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