Introduction

This document presents a summary of the 2022 simulation and 2024 benchmark stock assessments for red drum. This two-part assessment process was recommended by the Commission's Assessment Science Committee and Red Drum Stock Assessment Subcommittee (SAS) to address uncertainties experienced in previous assessments.

The simulation assessment evaluated the performance of several assessment methods for assessing simulated populations with red drum life history characteristics and the available monitoring datasets. The results of the simulation assessment served as guidance for methods used in the 2024 benchmark assessment. The benchmark assessment represents the latest and best information on the status of Atlantic coast red drum stocks and provides the scientific basis for continued management of the species. The simulation and benchmark assessments were peer-reviewed by independent panels of scientific experts through the Commission's peer review process and the Southeast Data, Assessment, and Review (SEDAR) process, respectively. The Commission's Sciaenids Management Board (Board), which oversees red drum management, accepted the assessments for management use in May 2022 (simulation assessment) and October 2024 (benchmark assessment).

Management Overview

Red drum are managed solely by the Commission through Amendment 2 to the Interstate Fishery Management Plan for Red Drum and Addendum I. The Amendment requires states to implement recreational creel and size limits to achieve the fishing mortality target, including a maximum size limit of 27 inches, and maintain existing commercial regulations. The fishing mortality (F) target is defined as the fishing mortality rate necessary to achieve a 40% static spawning potential ratio ($SPR_{40\%}$), or the fishing mortality rate that would reduce spawning stock biomass (SSB) to 40% of an unfished population. The Amendment also defines an overfishing threshold as the fishing mortality necessary to achieve $SPR_{30\%}$.

A harvest moratorium and Presidential Executive Order prevents any harvest or sale of red drum from federal waters (3 – 200 miles from shore). Addendum I includes current information on red drum habitats needed for each life stage (egg, larval, juvenile, sub-adult and adult) and identifies habitats of concern which are especially important as spawning and nursery areas.

The red drum population along the Atlantic coast is divided into two management areas, or stocks, a northern stock (New Jersey to North Carolina) and a southern stock (South Carolina to Florida). The stock units are based on differences in life history traits between the two stocks (such as growth rates and maximum observed ages) and information from genetic and tagging studies indicating red drum rarely move between the two regions.

What Data Were Used?

Assessments used both fishery-dependent and -independent data, including information on red drum biology and life history. Fishery-dependent data come from recreational and commercial fisheries, while fishery-independent data are collected through scientific research and surveys.

The same datasets were used in both assessments, but for different purposes. During the simulation assessment, data were used to create a model, called the operating model (OM), that could simulate red drum-like populations of fish. The OMs used red drum datasets and published literature to determine how fish in the simulated populations grow, interact with fisheries, reproduce, and die through time. Two separate OMs were developed to account for the differences between the two red drum stocks. The OMs were structured to sample datasets from their simulated populations that matched the types of available red drum datasets (e.g., fishery catches, fishery-independent indices of abundance). These simulated datasets were then used in stock assessment models, to determine how well the models could estimate key characteristics of the simulated populations.

During the 2024 benchmark assessment, the simulated datasets sampled by the OMs were replaced with observed datasets and the assessment models were used to estimate stock characteristics for the actual red drum stocks along the Atlantic coast. A fishing year of September-August was adopted in place of a January-December calendar year during the benchmark assessment to better match the assessment model structure to red drum life history (i.e., red drum spawning/birth peaking in September at the start of the fishing year). Datasets included information through August 2023. However, 2023 data were preliminary or incomplete, so were only used within the model, and not used to inform stock status.

Life History

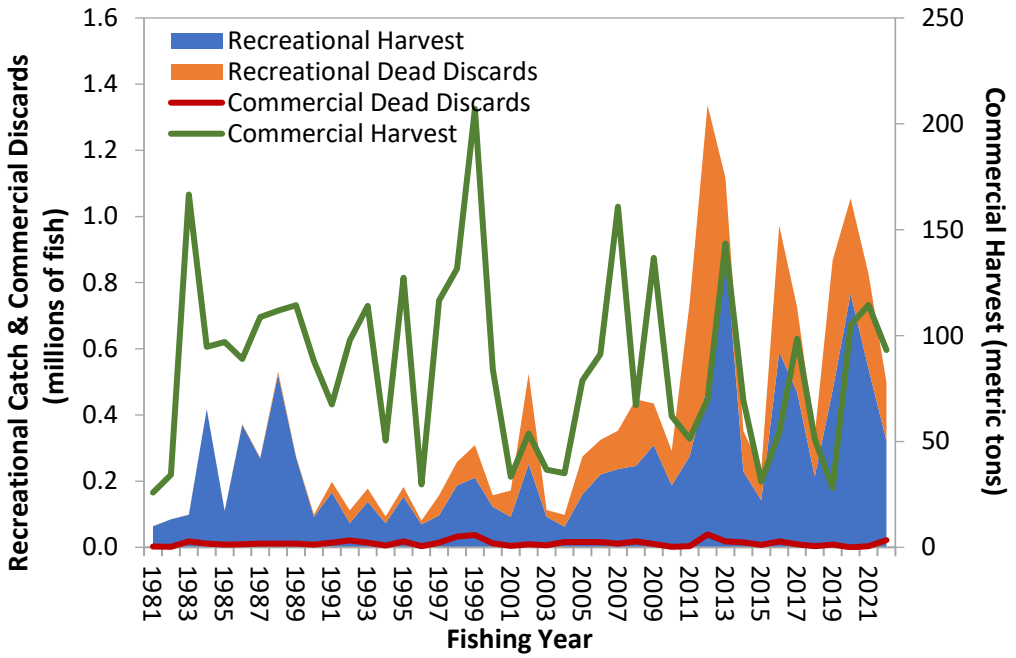
While red drum on the Atlantic coast may be encountered from Massachusetts to Key West, Florida, they are most common south of the Chesapeake Bay. Adult red drum spawn in the late summer and fall in nearshore waters, and juveniles are most abundant in estuarine waters and inlets. Depending on the area, males mature between ages 2 and 4 at a size of 24 - 26 inches total length. Females mature between ages 3 and 5 at a size of 30 – 33 inches total length. After maturing, red drum spend less time in estuaries and more time in ocean waters. As a result of this life history pattern and regulations restricting the harvest of larger fish, there is limited information on the adult portion of the stocks. The maximum age observed for red drum is 62 and 41 years old in the northern and southern stocks, respectively. Natural mortality was estimated during the assessments based on red drum growth and longevity, with smaller fish at the youngest ages estimated to have higher mortality due to natural causes (e.g., predation). Fish from the northern stock were estimated to have lower natural mortality relative to fish from the southern stock, explaining the older ages observed in the northern stock.

Recreational Data

Red drum fisheries are predominately recreational. Recreational catch information is collected by the Marine Recreational Information Program (MRIP). Total recreational removals in both stocks were high in the 1980s, declined to lower levels in 1990s, and increased through the 2000s and 2010s. Removals in the northern stock have increased to time series highs in recent years, while removals in the southern stock have increased to levels similar to time series highs observed in the early 1980s. The northern stock accounts for fewer removals than the southern stock, with most of these removals coming from North Carolina followed by Virginia. Very few removals come from states north of Virginia. Florida has accounted for the majority of southern stock removals, followed by South Carolina and Georgia.

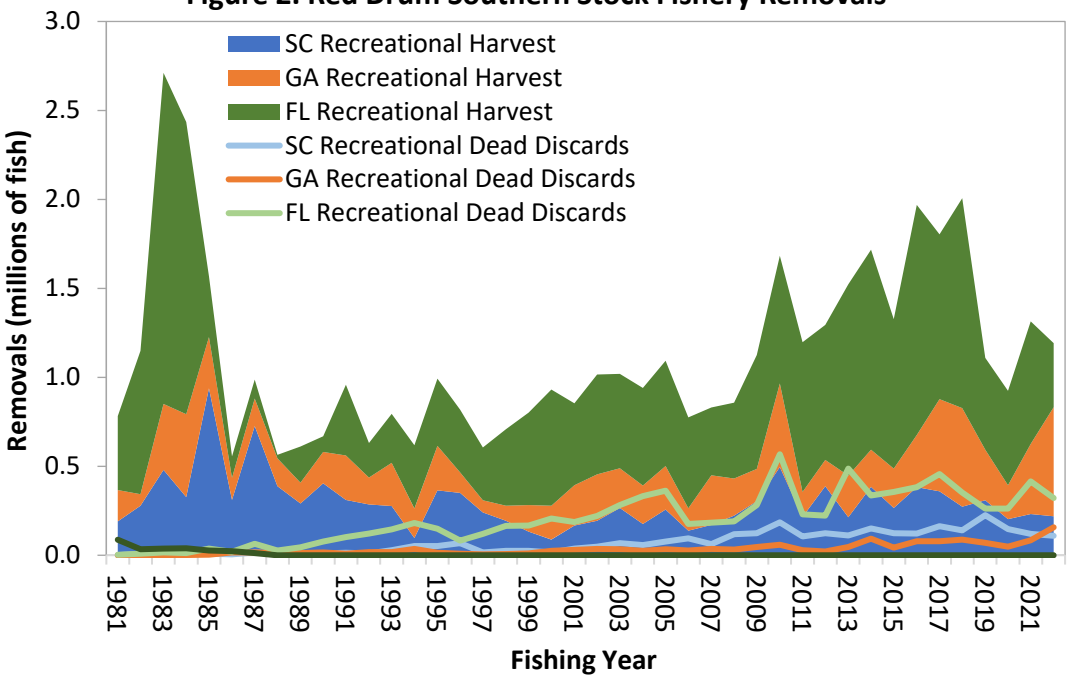
Based on several studies of survival rates for fish caught by hook and line and consistent with previous red drum assessments, the current assessments assumed 8% of fish discarded in recreational fisheries died after release. In both the northern and southern stocks, anglers have released an increasingly large percentage of their catch, accounting for less than 2% of total removals in the early 1980s to greater than 30% in the 2020s. Due to slot limit regulations, the majority of fish harvested by anglers are immature sub-adults (ages 1-3). Discard mortality affects all ages caught and released in recreational fisheries.

Figure 1. Red Drum Northern Stock Fishery Removals



Size data from harvested fish collected by MRIP were also used in the assessment models to describe size compositions of red drum harvested in recreational fisheries and inform model estimates of fishery selectivity. Size data are not collected by MRIP from discarded fish. As a result, the assessments relied on limited data from angler releases of tagged fish and reporting through citizen science-based phone applications. Characterizing sizes of discarded fish remains a primary source of uncertainty in red drum assessments as released catch, including adults in targeted trophy fisheries, have accounted for growing proportions of fishery removals. Fish carcasses from harvested fish donated to freezer programs along the coast have provided age data from otoliths (ear bones that accrue rings through time like those found in trees) paired with length measurements that are used in stock assessment models to estimate growth rates. As with size data collected from harvested fish, these carcass donations primarily inform growth of sub-adult fish.

Figure 2. Red Drum Southern Stock Fishery Removals



Commercial Data

Historically, there were small commercial fisheries for red drum in both stocks. Prior to 1988, commercial landings in the southern stock mostly came from Florida's gillnet and hook and line fisheries, but were still small in magnitude relative to recreational harvest. Since 1988, there have been negligible commercial landings from the southern stock, as South Carolina and Florida (and Georgia later on) enacted regulations preventing commercial harvest of red drum.

In the northern stock, commercial fisheries still land red drum, but as limited bycatch in fisheries directed at other species. Commercial landings have been variable with no discernible trend. North Carolina has accounted for 96% of northern stock commercial landings during the assessment time period, mostly from gillnets. North Carolina provided on-board observer data and trip reports that were used to estimate the number of red drum discarded from the gillnet fishery; most fish were discarded dead, and for those fish discarded alive, the assessment assumed a 5% discard mortality rate. Commercial discards make up a small proportion of removals from the northern stock.

Biological samples were taken from commercial catch in Virginia, North Carolina, and Florida (historically), though only consistently in North Carolina. Fish were measured and weighed, and otoliths were collected to be aged. As with recreational catch, size measurements were used to develop length composition data for assessment models that describe the sizes of fish removed by commercial fisheries and inform model estimates of fishery selectivity. Commercial fisheries are generally managed with similar slot size limits as recreational fisheries resulting in landings of primarily sub-adult fish. Ages paired with length measurements were used in assessment models to estimate growth and provide information on year class strength.

Fishery-Independent Data

Both red drum assessments used fishery-independent surveys from North Carolina to Florida to provide information on trends in relative abundance for different life stages, including young-of-year, sub-adults, and adults. In the northern stock, the assessment used three fishery-independent surveys, all from North Carolina: a seine survey that catches young-of-year, a gillnet survey that catches sub-adults, and a longline survey that catches adults. Indices have generally been variable with no discernible trends.

In the southern stock, the assessment used eight fishery-independent surveys. Three surveys catch young-of-year, one each from South Carolina, Georgia, and Florida. Three surveys, two from South Carolina and one from Florida, catch primarily sub-adult red drum. Two surveys, one from South Carolina and one from Georgia, use longlines to catch adults. Two of the South Carolina surveys, the young-of-year survey and one of the sub-adult surveys, provide historical abundance information, but were discontinued in the 1990s. Indices have generally shown declines in recent years.

Biological sampling conducted during these surveys was used to develop composition data for assessment models that described the size or age composition of fish caught so the models could track abundance and mortality of age classes caught by the surveys.

Tagging Data

In additional to using angler-reported lengths of tagged fish to characterize size compositions of fish discarded in recreational fisheries, tagging data were used in supplemental analyses during the assessment. The tagging

programs providing these data are cooperative efforts between management agencies and recreational anglers. In some cases, red drum are tagged by both agency personnel and trained recreational anglers. Recaptures of tagged fish, primarily by recreational anglers, are reported and were provided for the assessment. These tag-recapture histories are used to estimate mortality through time.

A red drum being captured for sampling as part of the Red Dum Longline Survey © Bryan Frazier, SC DNR

What Models Were Used?

Simulation Assessment

The simulation assessment used the two types of models described in the data section above: (1) OMs to simulate populations and sample datasets from the simulated populations, and (2) assessment models to estimate population characteristics of interest (e.g., total abundance, fishing mortality) for the simulated populations from the sampled datasets. The key to the simulation assessment process is that, by simulating populations, the true population characteristics are known and therefore how well assessment models estimate these population characteristics can be determined. This feature is not available in a traditional benchmark stock assessment for a stock with unknown population characteristics. Given high uncertainty in past red drum assessments and components of the stocks that are difficult to verify with available data (mature adult abundance and mortality, discarding selectivity), this simulation process was appealing to provide guidance on methods to apply in the subsequent benchmark stock assessment.

The simulation assessment included three different assessment models that were believed to be suitable for the types of data available for red drum stock assessments, a traffic light analysis (TLA), a statistical catch-at-age model (SCA), and an integrated assessment model using Stock Synthesis (SS). A TLA was used as a way to incorporate multiple data sources (both fishery-independent and -dependent) into easily understood metrics for management advice. The TLA is often used for data-limited species, or species that are not assessed on a frequent basis. The name comes from assigning a color (red, yellow, or green) to categorize population and fishery metrics relative to levels of these metrics observed during a defined reference period. Population metrics selected in the simulation assessment included young-of-year recruitment and adult abundance measured by fishery-independent surveys and fishery performance (fishery harvest divided by abundance of slot-sized fish) as a measure of fishing mortality. If the metrics are red, the TLA would indicate the stock is in poor condition and should be addressed with management action.

The SCA model uses fishery catch, fishery-independent indices of abundance, age composition data, and life history inputs to estimate stock abundance, *F,* and *SPR*. This model has been used in previous red drum assessments and is structured to focus on the sub-adult components of stocks most vulnerable to fisheries, limiting its use for adult estimates including SSB, an important measurement of reproductive potential and stock status.

The SS model is similar to the SCA model structure, but includes more options for alterative structures including how composition datasets are input (length and age compositions) and more detailed tracking of mature, adult fish. The SS platform is used for many other stocks around the world and has dedicated, ongoing support. Each assessment model estimated population characteristics from the two simulated populations and their performance at estimating the true characteristic was compared to the other assessment models.

The SS assessment model performed as well or better than the other assessment models in accurately estimating key population characteristics of the simulated northern stock. This included SSB which is of note due to inability to estimate this characteristic in past red drum stock assessments. The TLA for the simulated northern stock performed relatively well for SSB and recruitment estimates, demonstrating its utility as a supplementary, alternative assessment approach. The SCA assessment model had two major flaws including reliance on historical inputs from tagging data that are no longer available and sensitivity to data weighting choices. The SS assessment model and TLA were recommended for use to assess the northern red drum stock in the next benchmark stock assessment.

The three assessment models performed more similarly for the simulated southern stock, but the simulation assessment peer review panel ultimately recommended against further pursuit of the SCA in the benchmark assessment because of limitations for further development and support of this model. As with the northern stock, the SS assessment model and TLA were recommended for use in the next benchmark stock assessment.

With the results of the simulation assessment and peer review as a guide, the SAS then transitioned to a traditional benchmark assessment using observed datasets from the actual red drum stocks in the assessment models recommended during the simulation assessment.

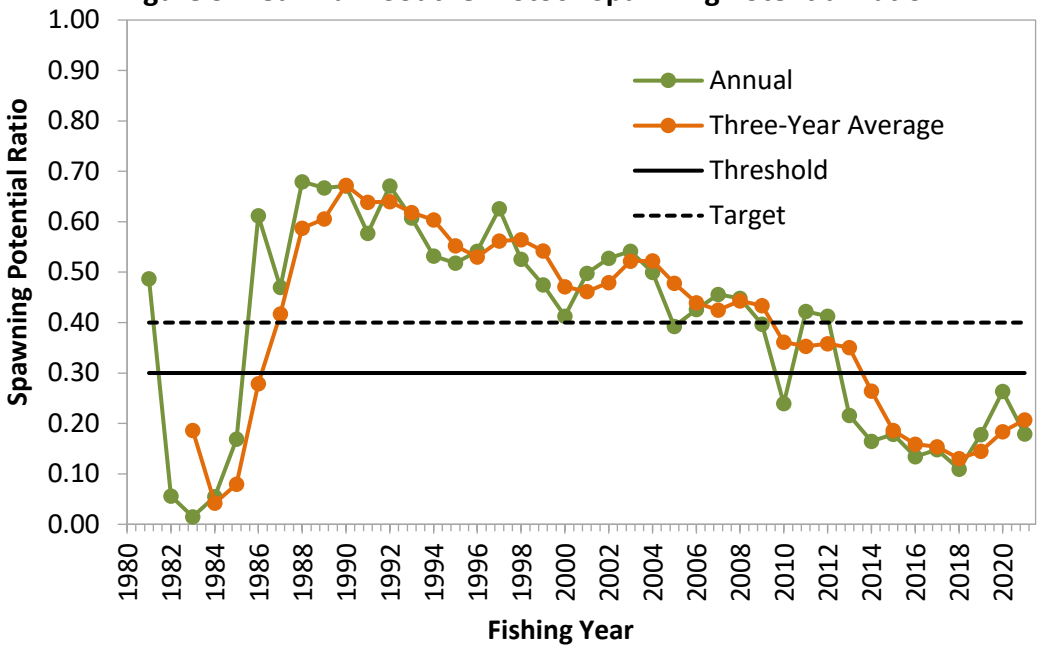
Benchmark Assessment

The SS model for the southern stock with observed datasets met criteria used to determine stable and robust estimation, while the SS model for the northern stock did not. The cause of the northern SS model's instability with observed red drum datasets is unknown and requires future research. Therefore, the SS model was used to determine stock status for the southern stock and the TLA was used to determine stock status for the northern stock. New analyses were also included in the benchmark assessment as supplementary approaches including a model using tag-recapture data for the southern stock (Cormack-Jolly-Seber Tagging Model) and the Skate data limited control rule method. These analyses were not evaluated during the simulation assessment, but were included in the benchmark assessment because they provided corroboration of trends estimated with the primary analyses used for stock status determination.

The SS model estimates annual *SPR* as well as *SSB*. *SSB* reference points have not previously been defined for red drum, but were recommended during these assessments as the *SSB* produced when fishing at the overfishing threshold (i.e., $SSB_{30\%}$, *SSB* threshold) and the fishing mortality target ($SSB_{40\%}$, *SSB* target). Stock status is determined from three-year averages of *SPR* and *SSB* at the end of the assessment time series (2019-2021 fishing years).

The reference period used for the TLA was the previous stock assessment period that had available data and was determined to not be in an overfishing state (1996-2013 for the northern stock). Using this reference period indicates how more recent years, including the last year of this benchmark assessment, compare to a period when the stock was considered to be in good condition. A framework was developed during the benchmark assessment for relating the results of the TLA to stock status determinations based on how TLA results were evaluated during the simulation assessment. The red drum adult abundance and fishery performance metrics were used to determine overfished and overfishing stock status, respectively. To relate the TLA stock status determinations to the SS stock status determinations, which consider estimates during the last three years of the assessment, the TLA identified an overfished or overfishing status if determinations for any of the last three years were red.

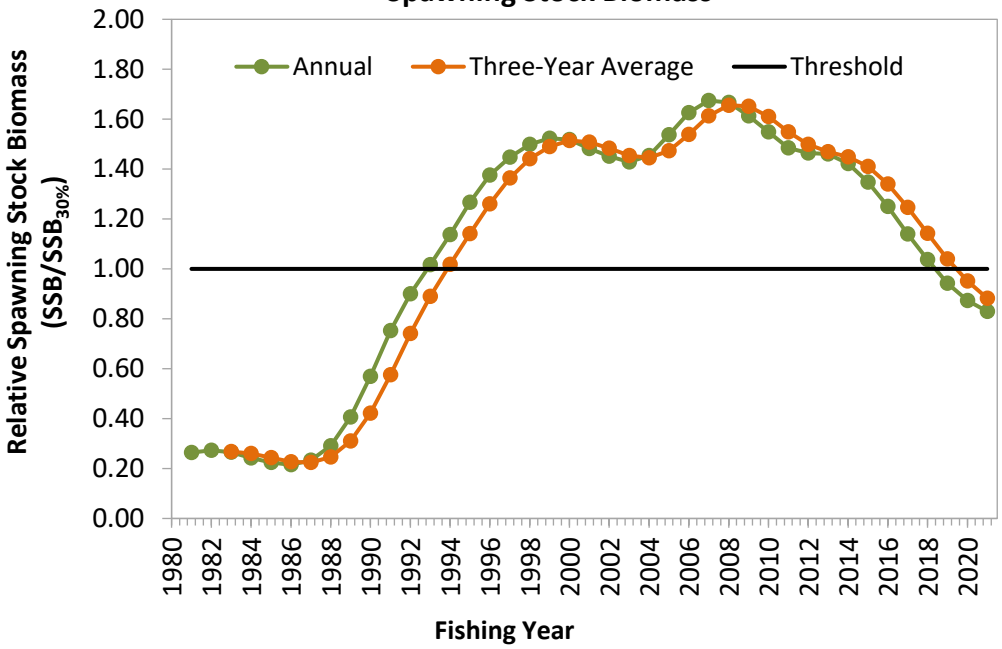
Figure 3. Red Drum Southern Stock Spawning Potential Ratio



What is the Status of the Stock?

The assessment determined that the **northern stock** was **not overfished** and **not experiencing overfishing**. TLA determinations for the fishery performance and adult abundance metrics were yellow and green, respectively, for the last three years of the assessment. The **southern stock** was determined to be **overfished** and **experiencing overfishing**. The three-year average SSB at the end of the assessment was below the threshold and the SPR average of the last three years was less than $SPR_{30\%}$ (20.7%).

Figure 4. Red Drum Southern Stock Relative Spawning Stock Biomass



Despite the positive stock status determination for the northern stock in the last year of the assessment, fishing mortality rates have been on the rise and are approaching the fishing mortality threshold. Updates of the TLA in coming years are recommended to monitor these trends closely.

Next Steps

After accepting the benchmark assessment in October 2024, the Board tasked the Red Drum Technical Committee (TC) with providing estimates of SPRs associated with different management measures in the southern stock. The Board also tasked the TC with providing guidance on responses necessary for a yellow traffic light result and potential impacts of management measures for the northern stock. The TC will report back to the Board at the Commission's 2025 Spring Meeting in May.

Data and Research Needs

More biosampling data are needed to characterize the size of fish discarded in recreational fisheries and ages of adults caught during fishery-independent surveys. As red drum mature, sizes overlap across many age classes, making age samples far more valuable for estimating abundance and mortality of adults than length samples. Modeling analyses of tag-recapture data like the Cormack-Jolly-Seber Tagging Model applied to South Carolina data during this assessment should be expanded to other states where similar tagging programs operate (Georgia, North Carolina, and Virginia) to help supplement and verify results from traditional stock assessment models. With increasing trends in fishery removals from states north of North Carolina that historically accounted for small and intermittent catches, it became clear during this assessment that the lack of fishery-independent abundance information from these states is a growing uncertainty in assessment of the northern stock. Surveys with gears efficient at catching red drum (i.e., non-trawl) are needed in these states to determine rate of abundance expansion relative to the increasing removals.

Whom Do I Contact for More Information?

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Glossary

Age class: all of the individuals in a stock that were spawned or hatched in the same year. This is also known as the year class.

Fishing mortality: the instantaneous rate at which fish are killed by fishing, often denoted as *F*

Marine Recreational Information Program (MRIP): a national survey conducted by the National Marine Fisheries Service (NMFS), often in conjunction with state agencies, to collect information on the catch, effort, and length frequencies of marine recreational fisheries

Natural mortality: the instantaneous rate at which fish die because of natural causes (predation, disease, starvation, etc.)

Otoliths: the inner ear bones of a fish. They form rings as they grow, much like those found in trees, which can be counted to assign an age to the fish.

Recruitment: A measure of the weight or number of fish that enter a defined portion of the stock, such as the spawning stock or fishable stock.

Static spawning potential ratio (SPR): the reproductive potential (the amount of eggs or biomass that a fish could produce over its lifetime) of a fished stock compared to the reproductive potential of an unfished stock.

Statistical catch-at-age (SCA) model: an age-structured stock assessment model that works forward in time to estimate population size and fishing mortality in each year. It does not assume that the catch-at-age is known without error.

References

ASMFC. 2020. Red Drum Stock Assessment Road Map Memorandum. Atlantic States Marine Fisheries Commission, 2 p.

ASMFC. 2022. Red Drum Simulation Assessment and Peer Review Report. Atlantic States Marine Fisheries Commission, Stock Assessment Report, 522 p.

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