Northeast Fisheries Science Center Reference Document 07-06

The 2005 Assessment of Acadian Redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine-Georges Bank Region

by Ralph K. Mayo[1], Jon K.T. Brodziak[2], John M. Burnett[1], Michele L. Traver[1], and Laurel A. Col[1]

[1]National Marine Fisheries Serv., 166 Water St., Woods Hole MA 02543-1026
[2]National Marine Fisheries Serv., 2570 Dole St., Honolulu HI 96822-2396

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

April 2007

Northeast Fisheries Science Center Reference Documents

This series is a secondary scientific series designed to assure the long-term documentation and to enable the timely transmission of research results by Center and/or non-Center researchers, where such results bear upon the research mission of the Center (see the outside back cover for the mission statement). These documents receive internal scientific review, and most receive copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these documents.

All documents issued in this series since April 2001, and several documents issued prior to that date, have been copublished in both paper and electronic versions. To access the electronic version of a document in this series, go to *http://www.nefsc.noaa.gov/nefsc/publications/*. The electronic version is available in PDF format to permit printing of a paper copy directly from the Internet. If you do not have Internet access, or if a desired document is one of the pre-April 2001 documents available only in the paper version, you can obtain a paper copy by contacting the senior Center author of the desired document. Refer to the title page of the document for the senior Center author's name and mailing address. If there is no Center author, or if there is corporate (*i.e.*, non-individualized) authorship, then contact the Center's Woods Hole Laboratory Library (166 Water St., Woods Hole, MA 02543-1026).

This document's publication history is as follows: manuscript submitted for review February 23, 2007; manuscript accepted through technical review March 19, 2007; manuscript accepted through policy review April 9, 2007; and final copy submitted for publication April 9, 2007. This document may be cited as:

Mayo RK, Brodziak JKT, Burnett JM, Traver ML, Col LA. 2007. The 2005 assessment of Acadian redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine/Georges Bank Region. U.S. Dep. Commer., *Northeast Fish. Sci. Cent. Ref. Doc*. 07-06; 32 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

TABLE OF CONTENTS

List of Tables

List of Figures

ABSTRACT

A comprehensive analysis of the stock dynamics of Acadian redfish (*Sebastes fasciatus* Storer) in the Gulf of Maine/Georges Bank region off the Northeast coast of the United States between 1934 and 2004 is presented. The status of the Gulf of Maine/Georges Bank Acadian redfish stock is provided, and estimates of fishing mortality and spawning stock biomass in 2004 are provided. Precision estimates of the 2004 fishing mortality and spawning stock biomass estimates are also given. This assessment updates the analyses in the 2001 assessment of the Gulf of Maine/Georges Bank Acadian redfish stock reviewed at the 33rd Northeast Regional Stock Assessment Workshop (SAW 33) (NEFSC 2001b; Mayo *et al.* 2002). The analyses presented herein were recently reviewed at the 2005 Groundfish Assessment Review Meeting (GARM) (NEFSC 2005).

The 2005 assessment is based on several sources of information, including: (a) the age composition of USA 1969–1985 commercial landings; (b) Northeast Fisheries Science Center spring and autumn research vessel survey data; and (c) standardized USA commercial fishing effort data. Information on total landings is available since the inception of the fishery in the mid 1930s, and a measure of commercial catch per unit of effort was derived for most of the period when the directed fishery operated (1942–1989). Trends in total biomass and exploitable biomass are illustrated, and additional information on the age structure of the stock is presented, including the age composition of the commercial landings (1969–1985) and an index of the age composition of the stock based on research vessel survey data (1975–2004). Fishery-dependent and fishery-independent information are integrated using an age-structured biomass dynamics model to generate estimates of instantaneous fishing mortality, stock biomass, and recruitment on an annual basis from 1934 through 2004.

Acadian redfish have supported a substantial domestic fishery in the Gulf of Maine and the Georges Bank (Great South Channel) regions off the northeast coast of the United States (Northwest Atlantic Fisheries Organization [NAFO] Subarea 5) since the 1930s, when the development of freezing techniques enabled a widespread distribution of the frozen product throughout the country. Landings rose rapidly from less than 100 metric tons (mt) in the early 1930s to over 20,000 mt in 1936, peaked at 56,000 mt in 1942, then declined throughout the 1940s and 1950s. Landings from the Gulf of Maine increased during the 1970s, but have been declining throughout the 1980s and 1990s. Since the mid 1990s, landings from this stock have remained at their lowest level since the directed fishery commenced in the 1930s.

Fishing mortality in 2004 is estimated at 0.00239, a substantial decline from 2001. Spawning stock biomass increased from 124,400 mt in 2001 to 175,800 mt in 2004. The estimate of the 2000 spawning stock biomass based on the present assessment is within 5% of the estimate obtained from the 2001 assessment.

Spawning stock biomass in 2004 was 175,800 mt, 74% of SSB_{MSY} (236,700 mt) and F in 2004 is estimated at 0.002, well below F_{MSY} (0.04). Thus, the stock is not overfished and overfishing is not occurring.

INTRODUCTION

Three species of *Sebastes* are common in the Northwest Atlantic. The Acadian redfish, *S. fasciatus* Storer (Robins *et al.* 1991a), and the deepwater redfish, *S. mentella* Travin, are virtually indistinguishable from each other based on external characteristics. Both species are considered beaked redfish based on the presence of a prominent symphyseal tubercle on the anterior mandible (Klein-MacPhee and Collette 2002). The third species, the golden redfish, *S. norvegicus* Ascanius (formerly *S. marinus*; see Robins *et al.* 1991b) can be distinguished from the beaked redfishes based on external characteristics, notably a greatly diminished symphyseal tubercle.

Visual separation of Acadian redfish and deepwater redfish can be accomplished reliably by counting the number of soft rays in the anal fin (Ni 1982) and internal examination of the passage of the extrinsic gas bladder musculature between the second, third, and fourth ventral ribs (Ni 1981; see Hallacher 1974). The two species can also be distinguished genetically by the genotype at the malate dehydrogenase locus (*MDH-A**) (Payne and Ni 1982; McGlade *et al*. 1983). In general, deepwater redfish are predominant in the northernmost reaches of the Northwest Atlantic, extending from the Gulf of St. Lawrence and the Grand Banks of Newfoundland across the North Atlantic to European waters. (See Atkinson 1987 for a general review.) Acadian redfish and deepwater redfish co-occur in the Gulf of St. Lawrence and the Laurentian Channel, where introgressive hybridization occurs between the two species (Roques *et al*. 2001), and on the Grand Banks and the Flemish Cap. Morphometric studies have shown that within the Gulf of St. Lawrence, deepwater redfish have a more fusiform body shape than Acadian redfish (Valentin *et al.* 2002). Deepwater redfish are less prominent in the more southerly regions of the Scotian Shelf and appear to be virtually absent from the Gulf of Maine, where Acadian redfish appear to be the sole representative of the genus *Sebastes* (Sevigny *et al*. 2003).

Acadian redfish are long-lived, exhibit ovoviviparous reproduction, and are characterized by low fecundity and a low natural mortality rate. The testes of the males ripen in the autumn and mating occurs in late autumn and early winter (Kelly and Wolf 1959; Pikanowski *et al*. 1999). Fertilization of the ripe eggs is delayed until spring and larval extrusion generally occurs from late spring through July and August, as incubation requires between 45 and 60 days (Kelly *et al.* 1972; Kelly and Wolf 1959). Generally, between 15,000 and 20,000 extruded larvae are produced per female during each spawning cycle (Kelly *et al.* 1972).

Acadian redfish have supported a substantial domestic fishery in the Gulf of Maine and the Georges Bank (Great South Channel) regions off the northeast coast of the United States (Northwest Atlantic Fisheries Organization [NAFO] Subarea 5) since the 1930s, when the development of freezing techniques enabled a widespread distribution of the frozen product throughout the country. Landings rose rapidly from less than 100 metric tons (mt) in the early 1930s to over 20,000 mt in 1936, peaked at 56,000 mt in 1942, then declined throughout the 1940s and 1950s (Table 1, Figure 1). As landings declined in local waters, fishing effort began to expand to the Scotian Shelf and the Gulf of St. Lawrence (NAFO Subarea 4), and finally to the Grand Banks of Newfoundland (NAFO Subarea 3). This expansion continued throughout the 1940s and early 1950s, culminating in a peak USA catch of 130,000 mt in 1952. By the mid 1950s, redfish stocks throughout the Northwest Atlantic were heavily exploited (Atkinson 1987), and total landings began to decline in all Subareas. Landings from the Gulf of Maine increased temporarily during the 1970s, but have been declining throughout the 1980s and 1990s. Since the mid 1990s, landings from this stock have remained at their lowest level since the directed fishery commenced in the 1930s.

United States commercial fisheries for Acadian redfish are managed under the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan (FMP). Under this FMP, redfish are included in a complex of 15 groundfish species managed by time/area closures, gear restrictions, minimum size limits, and – since 1994 – by direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5, 7, and 13 to the FMP. Amendment 9 established initial biomass rebuilding targets (Anon. 1998) and defined control rules which specify target fishing mortality rates and corresponding rebuilding time horizons. Amendment 13 implemented formal rebuilding plans within specified time frames based on revised biomass and fishing mortality targets derived by the Working Group on Re-evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002b). The goal of the management program is to reduce fishing mortality to levels which will allow stocks within the complex to initially rebuild above minimum biomass thresholds, then to attain and remain at or near target biomass levels.

The dynamics of this stock have been evaluated using a variety of techniques including production models (Schaefer 1954, 1957; Pella and Tomlinson 1969; Fox 1975), yield per recruit (Thompson and Bell 1934; Beverton and Holt 1957), and virtual population analysis (VPA). A preliminary production model estimate suggested a long-term potential yield of between 14,000 and 20,000 mt, depending on model formulation (Mayo 1975, 1980). A yield per recruit analysis performed with M=0.05 and a partial recruitment of 50% at age 6 and full recruitment at ages 9 and older indicated F_{MAX} at 0.13 and $F_{0.1}$ at 0.06 (Mayo 1993). VPA, which was first performed on this stock using catch at age data from 1969–1980, indicated that age 9+ fishing mortality rates (in the range of 0.18 to 0.28 throughout most of the 1970s) were accompanied by a 62% decline in exploitable biomass (ages 5+) between 1969 and 1980 (Mayo *et al.* 1983). A subsequent analysis which included additional catch at age data through 1983 indicated that, although F had begun to decline from a maximum value of 0.28 in 1979 to 0.17 in 1983, exploitable biomass had been reduced by 75% from the 1969 level by 1984 (NEFC 1986). The VPA was discontinued after 1986, but further declines in redfish landings since then suggest that F is now likely to be rather low (at or below M), rendering the convergence of VPAs unlikely.

An index-based assessment of this stock was presented at the 15th Northeast Regional Stock Assessment Workshop (SAW) in December 1992 (Mayo 1993; NEFSC 1993a, 1993b) and an interim assessment was reviewed by the Northern/Southern Demersal Working Group in August 2000 (NEFSC 2001a). However, the index-based results were not relevant to the then existing biological reference points (see Anon. 1998). The initial peer review of an age-based dynamics model assessment for this stock (Mayo *et al*. 2002) occurred at the 33rd Northeast Regional SAW in June 2001 (NEFSC 2001b), and an updated index assessment was reviewed at the Groundfish Assessment Review Meeting (GARM) in October 2002 (NEFSC 2002a; Mayo and Col 2002). The present age-based dynamics model assessment was reviewed at the second GARM in August 2005 (NEFSC 2005; Mayo *et al*. 2005).

The potential for Acadian redfish to return to conditions observed in the 1960s is limited in part by their combination of slow growth and low fecundity. Even at relatively low levels of F (0.03–0.05), restoration of the 1969 age structure is not likely to occur except under extremely favorable recruitment conditions over several decades (Mayo 1987). The recent appearance of just such favorable recruitment during the past decade suggests that restoration of age structure is underway.

THE FISHERY

Trends in Catch and Effort

Landings of Acadian redfish from Subarea 5 from 1934 through 2004 are given in Table 1 and illustrated in Figure 1. This fishery has been prosecuted almost exclusively by large (>150 gross registered tons) otter trawlers fishing out of Maine and Massachusetts ports. Landings by domestic vessels rose rapidly from less than 100 mt in the early 1930s to over 20,000 mt in 1936, peaked at 56,000 mt in 1942, then declined throughout the 1940s and 1950s. Although Acadian redfish have been harvested primarily by domestic vessels, distant water fleets took considerable quantities for a brief period during the early 1970s (Table 1, Figure 1), at times accounting for 25-30% of the total Subarea 5 redfish catch. The distant water fleet effort, combined with increased domestic fishing effort, resulted in a brief increase in total catch to about 20,000 mt during the early 1970s. With the declaration of exclusive economic zones (EEZ) by the USA and Canada in 1977, USA vessels could no longer access redfish stocks on the Scotian Shelf and the Grand Banks. The fishery for Acadian redfish was then restricted almost exclusively to the Gulf of Maine except for a small portion of the Scotian Shelf off Southwest Nova Scotia. Landings from the Gulf of Maine increased temporarily during the late 1970s, but declined throughout the 1980s and have averaged less than 500 mt per year during the 1990s and the early part of the 21st century.

Commercial catch per unit effort (CPUE) indices from 1942–1989 for directed redfish trips, standardized by vessel tonnage class as described by Mayo *et al*. (1979), are listed in Table 1 and illustrated in Figure 2. The resulting calculated fishing effort values were derived by dividing total annual landings by the directed CPUE index. Directed CPUE has declined steadily from about 6 tons per standard day fished during the late 1960s to less than 2 tons per day fished after 1980 (Table 1, Figure 2). This decline is consistent with the 60–70% decline in exploitable biomass estimated by previous VPAs (Mayo *et al*. 1983; NEFC 1986). Total fishing effort, after nearly tripling between 1969 and 1979 (coincident with the highest estimates of fishing mortality [NEFC 1986]), appeared to stabilize during the mid 1980s before declining markedly through 1989.

Traditionally, the directed fishery for redfish in the Gulf of Maine was prosecuted by vessels using otter trawls with relatively small mesh in the range of 70–80 mm. After the 1980s, under domestic management plans, minimum mesh size regulations were imposed on vessels fishing for the major demersal species off the New England coast, including Acadian redfish. In 1977, following implementation of the Magnuson Fishery Conservation and Management Act, the minimum allowable mesh size increased from 114 to 130 mm; by 1994 the minimum mesh size had increased to 152 mm. These mesh restrictions, combined with low biomass and truncated size and age structure of the redfish stock, have effectively eliminated the prosecution of a fishery since the mid 1980s.

Age Composition of the 1969–1985 Landings

Estimates of the number of fish landed at age were derived from biological sampling data collected in the ports during the period 1969 through 1985 (Table 2, Figure 3). With the sharp decline in landings during the 1980s, ageing of commercial samples was discontinued after 1985. For the period 1969–1985, however, estimates of numbers landed at age were derived by applying quarterly age/length keys, separately by sex, to the estimated numbers landed at length by sex. The overall age composition was then obtained by addition of the estimates by sex.

Landings at age and mean weight at age matrices based on all available commercial length and age data from 1969 through 1985 are given in Table 3. The sharp discontinuity in the age structure of the population created by infrequent recruitment after the 1960s can be inferred from the age composition of the landings; this is in contrast to a more uniform age structure in the 1970s resulting from a series of moderate year classes produced in the 1950s and 1960s. The most striking feature is the singular presence of the 1971 year class advancing through the fishery since 1976, followed by the entrance of the 1978 year class during 1983–1985. By the early 1980s the fishery had become dependent on a few relatively strong year classes and recruitment appeared to have diminished considerably.

BOTTOM TRAWL SURVEY RESULTS

Bottom trawl surveys have been conducted by the Northeast Fisheries Science Center (NEFSC) in the Gulf of Maine/Georges Bank region since autumn 1963 and spring 1968 (Azarovitz 1981). The NEFSC spring and autumn bottom trawl survey data were analyzed to evaluate trends in total and exploitable abundance and biomass of Acadian redfish, and trends in the age composition of the population.

Trends in Total Abundance and Biomass

Abundance (stratified mean number per tow) and biomass (stratified mean weight per tow) indices were calculated from NEFSC spring and autumn surveys based on strata encompassing the Gulf of Maine and portions of the Great South Channel (strata 24, 26–30, 36–40; Tables 4 and 5; Figures 4 and 5). Trends in total abundance and biomass are similar in both spring and autumn surveys. Relative abundance of redfish has declined sharply in both survey series, from peak levels over of 100 fish per tow in the late 1960s and early 1970s to generally between 10 and 30 fish per tow during the mid 1980s through mid 1990s. The decline in biomass has been of the same order. Both series suggest a slight increase in abundance and biomass between the mid 1980s and 1990s followed by a sharp increase in autumn 1996 and spring 1997, and relative stability at these higher levels during the past decade.

Trends in Exploitable Abundance and Biomass

Indices of exploitable abundance and biomass were derived by applying a series of mesh selection ogives to the time series of bottom trawl survey data. First, a catch-weighted average mesh size was calculated for each year from 1964–1993. The average mesh size increased from 2.5–3 in (64–76 mm) during the 1960s to about 5.5 in (140 mm) during the late 1980s and early 1990s (Figure 6), then to 6–6.5 in (152–165 mm) at present. Five periods were identified and data from early mesh selection studies (Clark 1963; Clay 1979; McKone 1979; Nikeshin *et al.* 1981) were used to construct mesh selectivity curves based on estimates of alpha and beta derived by fitting logistic curves to published data.

These selectivity factors (alpha and beta) were applied to the NEFSC spring and autumn survey data to ‘filter out’ those fish that would not have been retained by the approximate mesh size in use by the commercial fleets during each period. The same stratified mean calculations of abundance and biomass were performed on the 'filtered' data as for the total abundance and biomass indices.

During the 1960s, most of the population of redfish was above the size that would be retained by the 2.5–3 in (64–76 mm) mesh used by the commercial fleets. During the late 1990s and early 2000s, most of the population of redfish was below the size that would be retained by the 5.5–6 in (140–152 mm) mesh used by the commercial fleets. Thus, recent increases in total abundance and biomass are not reflected in the exploitable component of the stock under the present management regulations (Figures 7 and 8). At present the portion of the total biomass stock that is exploitable is very small compared to the earlier periods (Table 6).

Age Composition Indices

Stratified mean indices of abundance at age were calculated from NEFSC autumn survey data from 1975 through 2004 and from NEFSC spring survey data from 1975 through 1990 with some exceptions. The survey otolith collection is routinely aged to the maximum possible age. For this analysis, all ages greater than 50 years were binned at 50+. As the autumn survey has provided the most consistent set of abundance and biomass indices, priority was given to ageing of the autumn survey otolith collection. Annual age compositions from all available spring and autumn surveys are depicted in Figure 9, and the composite age distribution from the autumn survey is illustrated in Figure 10. The age composition data clearly illustrate recruitment patterns and changes in age structure of the population. In 1975, the population still appeared to exhibit a relatively broad age structure. The 1971 year class is prominently featured in 1975, followed by the 1978 year class in the early 1980s; these two year classes continued to dominate the demographics of the population through the 1980s.

More recently, the 1985 and 1992 year classes appear most prominent. Despite this improvement in recent recruitment, the age structure of the population during the late 1990s and early 2000s remains severely truncated compared to 1975 and earlier.

Accuracy and Precision of Survey Ages

For Acadian redfish, age-reader precision was estimated once from second readings of random subsamples from the NEFSC 2004 autumn bottom trawl survey. The precision level was 89% agreement, with a total CV of 1.0%, between first and second readings (Figure 11), indicating a moderate level of consistency in age determinations for this long-lived species.

ESTIMATION OF FISHING MORTALITY AND STOCK SIZE

Population dynamics model

In this section, an age-structured assessment model is developed for redfish. Age-structured population dynamics of redfish were modeled in a standard manner using forward-projection methods for statistical catch-at-age analyses (Fournier and Archibald 1982; Methot 1990; Ianelli and Fournier 1998; Restrepo and Legault 1998). The age-structured model (RED) employed at the last peer review of this assessment in 2001 (SAW 33) was updated with NEFSC spring and autumn bottom trawl survey biomass indices and NEFSC autumn bottom trawl survey age compositions through 2004. The population dynamics model is briefly described below and a full description of the age-structured model is provided in Mayo *et al*. 2002.

The age-structured model is based on forward projection of population numbers at age. This modeling approach is based on the principle that population numbers through time are determined by recruitment and total mortality at age through time. The population numbers at age matrix $N=(N_{y,a})_{YxA}$ has dimensions Y by A, where Y is the number of years in the assessment time horizon and A is the number of age classes modeled. The oldest age (A) comprises a plus-group consisting of all fish age A and older. The time horizon for redfish is 1934–2004 (Y=71). The number of age classes is 26, representing ages 1–26+. Input data to the model includes the total landings (1934–2004), commercial CPUE index (1942–1989), commercial landings at age (1969–1985), NEFSC spring and autumn total biomass indices, and the autumn survey age composition (1975–2004).

Forward Projection Model Results

Fishing mortality on Acadian redfish has generally remained quite low compared to many other species. Average fully recruited fishing mortality (ages 9+) remained between 0.05 and 0.15 from the 1940s through the 1960s even as landings also declined (Figure 12). Fishing mortality increased substantially during the 1970s and early 1980s, peaking at 0.29 in 1979 and 1982. These results are very similar to those obtained using VPA during the early 1980s (Mayo *et al*. 1983, NEFSC 1986). With the subsequent disappearance of the directed fishery, fishing mortality declined sharply, reaching extremely low levels during the 1990s and 2000s.

The spawning stock biomass of redfish declined from over 500,000 mt in the early 1940s, shortly after exploitation commenced, to 120,000–130,000 mt between 1957 and 1971 (Figure 13). Spawning biomass declined further to very low levels of less than 30,000 mt during most of the 1980s and early 1990s before increasing to almost 180,000 mt in 2004. The estimate of the 2000 spawning stock biomass based on the present assessment is within 5% of the estimate obtained from the 2001 assessment.

Recruitment at age 1 remained relatively constant for about two decades from the mid 1940s through the mid 1960s, averaging about 60 million fish (Figure 13). Following this period of relative stability, strong or moderate year classes appeared infrequently until the 1990s, when moderate to strong year classes once again appeared on a more regular basis. The largest year classes in the almost 60-year series are the 1971 (246 million fish at age 1) and 1992 (281 million fish at age 1) cohorts. Survival ratios (recruits per unit of spawning biomass) also illustrate the relatively high survival of the dominant 1971 and 1992 year classes, as well as the moderate 1978 and 1989 year classes (Figure 14).

Sensitivity Analyses

The initial version of the age-structured forward projection model (RED) was refined after 2001, and is now a component of the NOAA Fisheries Toolbox (NFT) stock assessment software, STATCAM. This version, while identical to RED in most approaches, provides for additional weighting of input data, depending on the length of the time series. Comparative runs of both models were conducted on data sets available at the previous peer review meeting (1934–2000) and at the present meeting (1934–2004) to determine whether differences in modeling approaches produced different estimates of spawning biomass and F. While both models produce very similar estimates of spawning stock biomass and fishing mortality over time (Figure 15), the STATCAM model (STATCAM 2005) is generating a higher rate of increase in SSB during the past decade than the biomass produced by the original RED model. Both models produce the same status determination for this stock, but because the results from the original RED model were used to derive the biomass reference point, the update from this model is used for current status determination.

BIOLOGICAL REFERENCE POINTS

Estimates of recruitment obtained from the age-structured biomass dynamics model reviewed at SAW 33 were used to infer the probable recruitment that could be produced by a rebuilt stock as described in NEFSC (2002b). Recruitment estimates derived by the model from the1952–1999 year classes served as the basis for evaluating trends and patterns in recruitment. The stock recruitment data suggest an increase in the frequency of larger year classes (>50 million fish) at higher biomass levels (Figure 16); therefore, recruitment estimates corresponding to the upper quartile of the SSB range served as the basis for deriving mean and median recruitment estimates. In accordance with the recommendation of the Stock Assessment Review Committee (SARC) at SAW 33, the estimate of $F_{50\%}$ (0.04) is taken as a proxy for F_{MSY}. This fishing mortality rate produces 4.1073 kg of spawning stock biomass per recruit and 0.1429 kg of yield per recruit. The resulting mean recruitment of 57.63 million fish results in an SSB_{MSY} estimate of 236,700 mt when multiplied by the SSB per recruit, and an MSY estimate of 8,235 mt when multiplied by the yield per recruit.

Reference points derived from the non parametric approach are:

MSY = 8,235mt
SS B_{MSY} = 236,700 mt
F_{MSY} = $F_{50\%}$ MSP = 0.04

CONCLUSIONS

It was determined (NEFSC 2002b) that the stock could not be rebuilt to B_{MSY} by 2009 even at F=0.0. Therefore, the rebuilding scenario invoked a 10 year plus 1 mean generation time (31 years for Acadian redfish) to achieve rebuilding. This results in an $F_{rebuild}$ = 0.013. Based on the results from the present assessment, spawning stock biomass in 2004 is estimated at 175,800 mt, 74% of B_{MSY} and F in 2004 is estimated at 0.002, well below F_{MSY}. Thus, the stock is not overfished and overfishing is not occurring.

ACKNOWLEDGMENTS

We are indebted to the 2005 Groundfish Assessment Review Meeting (GARM II) participants who provided a thorough, constructive review of this assessment.

REFERENCES

Anon. 1998. Evaluation of existing overfishing definitions and recommendations for new overfishing definitions to comply with the Sustainable Fisheries Act. Final Report, Overfishing Definition Review Panel, June 17, 1998.

Atkinson DB. 1987. The redfish resources off Canada's East coast. Proc Int Rockfish Symp., October, 1986, Anchorage Alaska. Alaska Sea Grant Rep No. 87-2, p 15-34.

Azarovitz TR. 1981. A brief historical review of the Woods Hole Laboratory trawl survey time series. In: Doubleday WG, Rivard D, eds. Bottom Trawl Surveys. Can Spec Sci Publ Fish Aquat Sci. 58:62-67.

Beverton RJ, Holt SJ. 1957. On the dynamics of exploited fish populations. Fish Invest Lond. (2)19:533 p.

Clark JR. 1963. Size selection of fish by otter trawls, Part I. Escapement of redfish through codend meshes. Int Comm Northw Atl Fish Spec Publ. No. 5, p 85-88.

Clay D. 1979. Synthesis of Selection Curves for Atlantic Redfish, *Sebastes mentella*. Northw Atlant Fish Org SCR Doc. 79/VI/113 (Revised), 7 p.

Fournier DA, Archibald CP. 1982. A general theory for analyzing catch at age data. Can J Fish Aquat Sci. 39:1195-1207.

Fox WW. 1975. Fitting the generalized stock production model by least squares and equiblibrium approximation. Fish Bull US. 73(1):23-27

Hallacher LE. 1974. The comparative morphology of extrinsic gasbladder musculature in the scorpoinfish genus *Sebastes* (Pisces: *Scorpaenidae*). Proc Calif Acad Sci., 4th Series, Vol XL, No. 3, p 59-86.

Ianelli JN, Fournier DA. 1998. Alternative age-structured analyses of NRC simulated stock assessment data. NOAA Tech Memo NMFS-F/SPO-30, p. 81-96.

Kelly GF, Earl PM, Kaylor JD, Lux FE, MacAvoy HR, McRae ED. 1972. Fishery Facts-1. Redfish. NMFS Extension Publ. No. 1.

Kelly GF, Wolf RS. 1959. Age and growth of redfish, *Sebastes marinus*, in the Gulf of Maine. Fish Bull US. 60:1-31.

Klein-MacPhee G, Collette BB. 2002. Scorpionfishes. Family Scorpaenidae. In: Collette BB, Klein-MacPhee G, eds. Bigelow and Schroeder's Fishes of the Gulf of Maine 2nd ed. Smithsonian Institution Press, Washington DC.

Mayo RK. 1975. A preliminary assessment of the redfish fishery in ICNAF Subarea 5. Int Comm Northw Atl Fish Res Doc. 75/59, 31 p.

Mayo RK. 1980. Exploitation of redfish, *Sebastes marinus* (L.), in the Gulf of Maine-GeorgesBank Region, with particular reference to the 1971 Year-Class. J Northw Atl Fish Sci. 1:21-37.

Mayo RK. 1987. Recent exploitation patterns and future stock rebuilding strategies for Acadian redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine-Georges Bank region of the Northwest Atlantic. Proc Int Rockfish Symp, October, 1986, Anchorage Alaska. Alaska Sea Grant Report No. 87-2, p. 335-353.

Mayo RK. 1993. Historic and recent trends in the population dynamics of redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine-Georges Bank Region. Northeast Fish Sci Cent Ref Doc. 93-03, 24 p.

Mayo RK, Bevacqua B, Gifford VM, Griffin ME. 1979. An assessment of the Gulf of Maine redfish, *Sebastes marinus* (L.), stock in 1978. Northeast Fish Cent Woods Hole Lab Ref Doc. 79-20, 63 p.

Mayo RK, Brodziak JKT, Thompson M, Burnett JM, Cadrin SX. 2002. Biological characteristics, population dynamics, and current status of redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine-Georges Bank Region. Northeast Fish Sci Cent Ref Doc. 02-05, 130 p.

Mayo RK, Brodziak J, Traver M, Col L. 2005. Gulf of Maine/Georges Bank Acadian Redfish. In: Mayo RK, Terceiro M, eds. Assessment of 19 northeast groundfish stocks through 2004. 2005 Groundfish Assessment Review Meeting (2005 GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, 15-19 August, 2005. Northeast Fish Sci Cent Ref Doc. 05-13, p 372-388.

Mayo RK, Col L. 2002. Gulf of Maine-Georges Bank Acadian redfish. In: Assessment of 20 groundfish stocks through 2001, a report of the Groundfish Assessment Review Meeting (GARM), Northeast Fish Sci Cent Ref Doc. 02-16, p 265-274.

Mayo RK, Dozier U, Clark SH. 1983. An assessment of the redfish, *Sebastes fasciatus*, stock in the Gulf of Maine-Georges Bank Region. Northeast Fisheries Center Woods Hole Laboratory Reference Document 83-22, 55 p.

McGlade JM, Annand MC, Kenchington TJ. 1983. Electrophoretic identification of *Sebastes* and *Helicolenus* in the northwestern Atlantic. Can J Fish Aquat Sci. 40:1861–1870.

McKone DM. 1979. Division 3M redfish mesh assessment. Northw Atlant Fish Org SCR Doc. 79/VI/121, 7 p.

Methot RD. 1990. Synthesis model: an adaptive framework for analysis of diverse stock assessment data. Int North Pac Fish Comm Bull. 50:259-277.

NEFC. 1986. Redfish. In: Report of the Second NEFC Stock Assessment Workshop (Second SAW). Northeast Fish Cent Woods Hole Lab Ref Doc. 86-09, p 19-30.

NEFSC. 1993a. Report of the 15th Northeast Regional Stock Assessment Workshop (SAW 15). Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish Sci Cent Ref Doc. 93-06, 108 p.

NEFSC. 1993b. Report of the 15th Northeast Regional Stock Assessment Workshop (SAW 15). The plenary. Northeast Fish Sci Cent Ref Doc. 93-07, 66 p.

NEFSC. 2001a. Assessment of 19 northeast groundfish atocks through 2000. Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 30-31, 2000. Northeast Fish Sci Cent Ref Doc. 01-20, 217 p.

NEFSC. 2001b. Report of the 33rd Northeast Regional Stock Assessment Workshop (SAW 33). Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish Sci Cent Ref Doc. 01-18, 281 p.

NEFSC. 2002a. Assessment of 20 northeast groundfish stocks through 2001. Groundfish Assessment Review Meeting (GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, October 8-11, 2002. Northeast Fish Sci Cent Ref Doc. 02-16, 522 p.

NEFSC. 2002b. Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. Northeast Fish Sci Cent Ref Doc. 02-04, 254 p.

NEFSC. 2005. Assessment of 19 northeast groundfish stocks through 2004. In: Mayo RK, Terceiro M, eds. 2005 Groundfish Assessment Review Meeting (2005 GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, 15-19 August 2005. Northeast Fish Sci Cent Ref Doc. 05-13; 499 p.

Ni I-H. 1981. Separation of sharp-beaked redfish, *Sebastes fasciatus* and *S. mentella*, from Northeastern Grand Bank by morphology of extrinsic gasbladder musculature. J Northw Atl Fish Sci. 2:7-12.

Ni I-H. 1982. Meristic variation in beaked redfishes, *Sebastes mentella* and *S.fasciatus*, in the Northwest Atlantic. Can J Fish Aquat Sci. 39:1664-1685.

Nikeshin KN, Kovalenko VG, Kondratyuk YA, Gorskova AS. 1981. Selectivity of bottom and midwater codends when fishing for deepwater redfish in the Northwest Atlantic. Northw Atlant Fish Org SCR Doc. 81/IX/87, 17 p.

Payne RH, Ni I-H. 1982. Biochemical population genetics of redfishes (*Sebastes*) off Newfoundland. J Northw Atl Fish Sci. 3:169–172.

Pella JJ, Tomlinson PK. 1969. A generalized stock production model. Bull Inter-Amer Trop Tuna Comm. 13(3):419-496.

Pikanowski RA, Morse WW, Berrien PL, Johnson DL, McMillan DG. 1999. Essential fish habitat document. Redfish, *Sebastes spp*., life history and habitat characteristics. NOAA Tech Mem NMFS-NE-132, 19 p.

Restrepo VR, Legault CM. 1998. A stochastic implementation of an age-structured production model. University of Alaska Sea Grant College Program, Rep No. 98-01:435-450.

Robins CR, Bailey RM, Bond CE, Brooker JR, Lachner EA, Lea RN, Scott WB. 1991a. Common and scientific names of fishes from the United States and Canada, Fifth Edition. Amer Fish Soc Spec Publ. 20, 183 p.

Robins CR, Bailey RM, Bond CE, Brooker JR, Lachner EA, Lea RN, Scott WB. 1991b. Names of the Atlantic Redfishes, Genus *Sebastes*. Fisheries, Vol. 11, No.1, p 28-29.

Roques S, Sévigny J-M, Bernatchez K. 2001. Evidence for broadscale introgressive hybridisation between two redfish (genus *Sebastes*) in the Northwest Atlantic: a rare example in marine environment. Molec Ecol. 10:149-165.

Schaefer MB. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bull Inter-Amer Trop Tuna Comm. 1(2):25-56.

Schaefer MB. 1957. A study of the dynamics of the fishery for yellowfin tuna in the Eastern tropical Pacific ocean. Bull Inter-Amer Trop Tuna Comm. 2(6):245-285.

Sévigny J-M, Roques S, Bernatchez L, Valentin A, Parent É, Black MN, Chanut J-P, Marcogliese1 D, Arthur R, Albert E, Desrosiers B, Atkinson B. 2003. 2. Species identification and stock structure. In: Gascon D, ed. Redfish multidisciplinary research zonal program (1995-1998): final report. Can Tech Rep Fish Aquat Sci. 2462:xiii + 139 p.

STATCAM. 2005. Statistical catch at age model, version 1.3. NOAA Fisheries Toolbox. NEFSC, Woods Hole, MA. Available at http://nft.nefsc.noaa.gov/beta

Thompson WF, Bell FH. 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon yield and yield per unit of gear. Rep Int Fish (Pacific halibut) Comm. 8; 49 p.

Valentin A, Sévigny J-M, Chanut, J-P. 2002. Geometric morphometrics reveals body shape differences between sympatric redfish *Sebastes mentella, Sebastes fasdatus* and their hybrids in the Gulf of St Lawrence. J Fish Biol. 60:857-875.

Table 1. Nominal redfish catches (metric tons), actual and standardized catch per unit effort, and calculated standardized USA and total effort for the Gulf of Maine/Georges Bank redfish fishery.

Year	Nominal Catch (metric tons)			USA Catch per Unit Effort (tons per day)		Calculated Standard Effort (days fished)	
	USA	Others	Total	Actual	Standard	USA	Total
1934	519		519				
1935	7549		7549				
1936	23162		23162				
1937	14823		14823				
1938	20640		20640				
1939	25406		25406				
1940	26762		26762				
1941	50796		50796				
1942	55892		55892	6.9	6.9	8100	8100
1943	48348		48348	6.7	6.7	7216	7216
1944	50439		50439	5.4	5.4	9341	9341
1945	37912		37912	4.5	4.5	8425	8425
1946	42423		42423	4.7	4.7	9026	9026
1947	40160		40160	4.9	4.9	8196	8196
1948	43631		43631	5.4	5.4	8080	8080
1949	30743		30743	3.3	3.3	9316	9316
1950	34307		34307	4.1	4.1	8368	8368
1951	30077		30077	4.1	4.1	7336	7336
1952	21377		21377	3.5	3.4	6287	6287
1953	16791		16791	3.8	3.6	4664	4664
1954	12988		12988	3.4	3.1	4190	4190
1955	13914		13914	4.5	4.0	3479	3479
1956	14388		14388	4.4	3.8	3786	3786
1957	18490		18490	4.3	3.6	5136	5136
1958	16043	4	16047	4.4	3.6	4456	4458
1959	15521		15521	4.3	3.5	4435	4435
1960	11373	2	11375	3.8	3.0	3791	3792
1961	14040	61	14101	4.6	3.5	4011	4029
1962	12541	1593	14134	5.4	4.0	3135	3534
1963	8871	1175	10046	4.1	3.0	2957	3349
1964	7812	501	8313	4.3	2.9	2694	2867
1965	6986	1071	8057	7.0	4.4	1588	1831
1966	7204	1365	8569	11.7	6.4	1126	1339
1967	10442	422	10864	12.4	5.6	1865	1940
1968	6578	199	6777	14.7	6.1	1078	1111
1969	12041	414	12455	11.4	4.9	2457	2542
1970	15534	1207	16741	9.0	4.0	3884	4185
1971	16267	3767	20034	7.0	3.2	5083	6261
1972	13157	5938	19095	5.7	2.9	4537	6584
1973	11954	5406	17360	5.3	2.9	4122	5986
1974	8677	1794	10471	5.0	2.6	3337	4027
1975	9075	1497	10572	4.0	2.2	4125	4805
1976	10131	565	10696	4.6	2.3	4405	4650
1977	13012	211	13223	4.9	2.5	5205	5289
1978	13991	92	14083	4.8	2.4	5830	5868
1979	14722	33	14755	3.6	1.9	7748	7766
1980	10085	98	10183	3.2	1.6	6303	6364
1981	7896	19	7915	2.7	1.4	5640	5654
1982	6735	168	6903	2.7	1.5	4490	4602
1983	5215	113	5328	2.1	1.2	4346	4440
1984	4722	71	4793	1.9	1.1	4293	4357
1985	4164	118	4282	1.4	0.9	4627	4758
1986	2790	139	2929	1.0	0.6	4650	4882
1987	1859	35	1894	1.1	0.7	2656	2706
1988	1076	101	1177	0.9	0.5	2152	2354
1989	628	9	637	1.1	0.6	1047	1062
1990	588	13	601	**	**		
1991	525		525	**	**		
1992	849		849	**	**		
1993	800		800	**	**		
1994*	440		440	**	**		
1995*	440		440	**	**		
1996*	322		322	**	**		
1997*	251		251	**	**		
1998*	320		320	**	**		
1999*	353		353	**	**		
2000*	319		319	**	**		
2001*	360		360	**	**		
2002*	368		368	**	**		
2003*	361		361	**	**		
2004*	398		398	**	**		

* Preliminary

** CPUE and effort not calculated due to sharp reduction in directed redfish trips

Table 2. Commercial length and age sampling summary for Gulf of Maine/Georges Bank Acadian redfish, 1969-2000.

Year	Landings (tons)	Number of Samples	Number of tons/sample	Number of Length Measurements	Number of Ages Collected	Number of Ages Available
1969	12455	14	890	3,200	?	616
1970	16741	18	930	2,300	600	461
1971	20034	34	589	7,796	963	963
1972	19095	16	1193	5,085	?	1,066
1973	17360	23	755	6,246	1,120	1,027
1974	10471	34	308	7,945	2,170	1,011
1975	10572	27	392	6,761	2,912	1,147
1976	10696	24	446	8,094	3,700	1,028
1977	13223	31	427	8,495	3,688	863
1978	14083	30	469	5,493	2,352	1,012
1979	14755	35	422	8,975	3,866	1,122
1980	10183	21	485	4,858	2,210	1,110
1981	7915	21	377	3,718	1,718	851
1982	6903	27	256	4,216	1,734	849
1983	5328	31	172	5,100	2,416	995
1984	4793	26	184	4,603	2,275	1,018
1985	4282	37	116	5,775	2,962	1,464
1986	2929	38	77	6,063	3,102	N/A
1987	1894	29	65	4,633	2,290	N/A
1988	1177	21	56	2,487	1,258	N/A
1989	637	17	37	1,921	958	N/A
1990	601	12	51	1,338	692	N/A
1991	525	10	52	1,136	?225	N/A
1992	849	11	77	1,354	?	N/A
1993	800	5	160	528	?	N/A
1994	440	2	220	226	?	N/A
1995	440	3	147	303	?	N/A
1996	322	1	322	113	?	N/A
1997	251	3	84	343	?	N/A
1998	320	0	B	0	?	N/A
1999	353	1	353	111	?	N/A
2000	319	1	319	110	?	N/A

Table 3. Total landings at age and mean weights at age for Gulf of Maine/Georges Bank redfish, 1969-1985.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26+
													Number landed (000s)													
1969	-	-	-	22	421	439	1008	6065	2513	6717	2660	3975	3287	2221	2820	1348	751	526	606	426	451	345	469	38	100	847
1970	-	-	-	-	146	4055	4048	1060	9692	3221	8351	2734	4702	2672	2302	3489	1778	1640	393	662	368	529	572	488	64	1743
1971	-	-	-	-	-	72	1941	4430	1536	7907	2767	6504	3088	4267	3680	2895	2206	2765	1347	1163	560	1048	559	282	138	2439
1972	-	-	-	-	-	-	933	3296	7401	1712	7580	2782	2884	1994	3531	2449	1205	1276	2245	734	1011	1172	718	538	1280	2874
1973	-	-	-	-	-	-	235	2463	7938	8391	2201	7337	2078	3100	2376	2024	1799	1380	864	933	411	590	426	295	289	1977
1974	-	-	308	105	-	17	8	174	1886	4724	2945	2435	1709	1115	1302	935	1454	910	640	661	589	730	271	285	250	1755
1975	-	-	4	695	72	11	-	30	124	1944	4360	2154	1932	1442	1009	1344	1360	1235	945	1116	608	887	492	294	298	1282
1976	-	-	-	196	8961	439	-	-	21	48	467	2706	3375	1702	1725	1388	1233	1166	1424	608	769	681	323	672	94	2011
1977	-	-	-	-	234	16747	311	-	-	-	81	2127	1262	4012	1823	2747	1466	1190	1064	461	706	541	117	571	1013	2157
1978	-	-	-	-	-	271	24569	215	-	34	33	182	1689	1484	2948	1748	1310	866	899	1283	895	734	500	192	530	2220
1979	-	-	-	-	25	205	849	23729	152	117	48	168	541	1228	1972	1299	1580	983	845	1008	798	594	532	538	427	2506
1980	-	-	-	-	-	132	175	1110	16900	208	44	46	217	491	830	1221	860	664	564	452	473	370	349	294	265	1308
1981	-	-	23	-	77	40	57	47	223	12380	84	22	-	44	317	364	1274	506	534	396	318	381	306	326	350	1540
1982	-	-	3	271	123	60	92	30	-	15	7268	56	32	21	128	185	582	452	840	324	501	484	301	134	104	2270
1983	-	-	-	11	1687	159	46	43	86	49	141	4959	58	106	64	42	85	319	270	551	169	224	314	195	131	1817
1984	-	-	46	11	51	6674	-	20	40	-	35	15	3571	-	44	49	34	92	210	166	324	215	144	157	162	1807
1985	-	-	27	146	33	31	3818	-	28	11	13	40	12	3202	-	25	11	101	116	260	230	187	197	142	107	1489
													Mean weight (kg)													
1969	.010	.020	.052	.113	.115	.142	.169	.195	.219	.260	.320	.339	.366	.404	.425	.473	.495	.457	.589	.497	.515	.594	.589	.705	.708	.591
1970	.010	.020	.052	.092	.172	.168	.170	.189	.221	.236	.290	.339	.356	.367	.340	.418	.427	.438	.523	.579	.505	.450	.464	.476	.345	.541
1971	.010	.020	.052	.092	.135	.172	.242	.244	.265	.304	.333	.369	.399	.437	.445	.468	.435	.449	.541	.553	.514	.544	.581	.481	.473	.540
1972	.010	.020	.052	.092	.135	.171	.197	.240	.257	.289	.334	.367	.399	.427	.451	.472	.490	.515	.509	.562	.581	.565	.604	.489	.560	.668
1973	.010	.020	.052	.092	.135	.171	.162	.213	.257	.281	.343	.341	.384	.402	.482	.454	.500	.492	.523	.525	.529	.641	.633	.568	.653	.620
1974	.010	.020	.064	.080	.135	.195	.150	.233	.270	.326	.331	.378	.399	.427	.449	.442	.503	.527	.540	.565	.525	.578	.585	.641	.633	.642
1975	.010	.020	.039	.098	.161	.221	.195	.383	.349	.317	.342	.394	.399	.420	.460	.469	.533	.527	.522	.550	.600	.547	.595	.607	.663	.662
1976	.010	.020	.052	.076	.135	.199	.195	.245	.345	.278	.296	.347	.395	.389	.405	.427	.511	.469	.542	.517	.518	.552	.645	.577	.628	.630
1977	.010	.020	.052	.092	.090	.173	.288	.245	.277	.297	.350	.413	.412	.408	.433	.454	.462	.534	.537	.610	.466	.595	.611	.544	.552	.605
1978	.010	.020	.052	.092	.135	.135	.209	.300	.277	.311	.383	.468	.402	.433	.423	.458	.551	.504	.526	.547	.523	.537	.633	.551	.606	.641
1979	.010	.020	.052	.092	.135	.200	.191	.251	.304	.295	.248	.402	.508	.472	.474	.564	.526	.543	.551	.617	.664	.597	.567	.605	.567	.647
1980	.010	.020	.052	.092	.135	.108	.175	.188	.283	.371	.421	.362	.424	.454	.506	.478	.499	.518	.554	.595	.647	.664	.629	.599	.681	.695
1981	.010	.020	.080	.092	.117	.150	.143	.195	.247	.318	.374	.466	.404	.532	.592	.543	.528	.499	.537	.550	.594	.617	.560	.633	.552	.650
1982	.010	.020	.052	.142	.203	.256	.242	.252	.277	.383	.395	.491	.563	.383	.544	.475	.540	.504	.564	.583	.592	.563	.621	.499	.535	.699
1983	.010	.020	.052	.107	.172	.198	.249	.329	.252	.368	.396	.425	.381	.471	.504	.595	.494	.579	.639	.580	.614	.647	.622	.630	.589	.682
1984	.010	.020	.110	.092	.206	.197	.195	.311	.252	.297	.333	.377	.403	.420	.497	.630	.569	.529	.519	.499	.610	.547	.568	.600	.517	.619
1985	.010	.020	.092	.146	.154	.177	.239	.245	.279	.345	.421	.362	.595	.443	.441	.591	.494	.545	.599	.552	.603	.635	.605	.699	.624	.692

Table 4. Spring NEFSC bottom trawl survey stratified mean catch per tow indices, average weights and average lengths of redfish in the Gulf of Maine/Georges Bank region.

	INSHORE 1				OFFSHORE 2				COMBINED 3	
	Stratified Mean Catch per Tow		Avg. Wt.	Avg. Length	Stratified Mean Catch per Tow		Avg. Wt.	Avg. Length	Stratified Mean Catch per Tow	
Year	Number	kg	kg	cm	Number	kg	kg	cm	Number	kg
1968	7.9	1.2	0.152	17.9	51.7	19.8	0.383	26.4	45.2	17.0
1969	59.0	8.3	0.141	20.3	44.2	21.7	0.491	30.6	46.4	19.7
1970	29.7	9.3	0.313	24.4	59.1	20.6	0.349	26.4	54.7	18.9
1971	49.9	13.3	0.267	24.9	176.0	81.7	0.464	29.8	157.2	71.6
1972	23.8	4.6	0.193	18.6	114.7	51.3	0.447	28.9	101.2	44.4
1973	14.4	4.6	0.319	22.0	49.6	28.9	0.583	31.4	44.4	25.3
1974	25.7	6.1	0.237	19.7	35.8	21.0	0.587	31.5	34.3	18.8
1975	50.9	18.9	0.371	25.5	37.4	17.4	0.465	28.5	38.9	17.6
1976	45.9	6.4	0.139	19.8	65.1	29.6	0.455	29.2	62.2	26.2
1977	79.1	24.0	0.303	25.3	15.6	9.4	0.603	32.1	25.1	11.6
1978	33.7	10.4	0.309	25.0	22.3	12.5	0.561	30.2	24.0	12.2
1979	27.5	8.5	0.309	25.4	67.5	36.4	0.539	30.0	61.6	32.3
1980	8.5	2.2	0.259	25.3	33.5	23.5	0.701	32.4	29.8	20.3
1981	3.0	1.0	0.333	22.5	38.9	21.7	0.558	30.5	33.6	18.6
1982	5.0	1.4	0.280	24.7	19.0	10.8	0.568	30.1	16.9	9.4
1983	4.8	0.9	0.188	21.6	10.7	7.0	0.654	31.0	9.9	6.1
1984	5.4	1.6	0.296	25.1	4.9	2.9	0.592	30.2	5.0	2.7
1985	1.2	0.4	0.333	24.8	13.6	7.7	0.566	30.1	11.7	6.6
1986	9.5	5.4	0.568	29.9	4.5	2.8	0.622	31.4	5.3	3.2
1987	5.5	1.4	0.255	23.9	27.8	14.9	0.536	30.5	24.5	12.9
1988	11.7	2.6	0.222	23.0	7.5	3.4	0.453	28.4	8.1	3.3
1989	17.6	2.7	0.153	17.6	6.5	3.0	0.462	27.8	7.6	2.9
1990	0.8	0.2	0.250	23.1	14.4	8.0	0.556	30.2	12.3	6.8
1991	5.5	0.8	0.145	19.4	10.2	4.9	0.480	28.0	9.5	4.3
1992	77.0	15.8	0.205	23.4	31.0	9.8	0.316	26.1	37.9	10.7
1993	12.4	2.3	0.182	22.6	39.5	20.2	0.510	29.7	35.5	17.5
1994	16.6	2.5	0.152	19.6	16.1	4.2	0.259	24.2	16.1	3.9
1995	11.8	2.1	0.176	20.7	6.4	1.9	0.293	23.6	7.2	1.9
1996	16.4	2.2	0.137	20.1	30.9	13.6	0.439	27.9	28.7	11.9
1997	1235.2	175.8	0.142	20.7	33.3	9.3	0.278	24.6	212.0	34.0
1998	13.6	2.0	0.145	20.4	38.4	8.9	0.231	23.6	34.7	7.8
1999	50.8	6.3	0.125	19.9	80.5	21.2	0.264	24.4	76.1	19.0
2000	12.0	2.9	0.238	23.8	209.4	65.3	0.312	25.9	180.1	56.0
2001	103.8	16.7	0.161	21.6	101.2	41.7	0.412	28.7	101.6	40.0
2002	11.6	1.8	0.155	18.4	262.5	71.6	0.273	25.4	225.2	61.2
2003	28.1	2.8	0.100	17.5	123.3	38.7	0.314	26.4	109.1	33.3
2004	72.8	38.2	0.525	27.2	166.2	58.7	0.353	27.1	152.3	55.7
2005	7.7	1	0.130	17.6	169.4	54.2	0.320	26.3	145.3	46.3

1. Strata Set: 26, 27, 39, 40
2. Strata Set: 24, 28-30, 36-38
3. Strata Set: 24, 26-30, 36-40

Table 5. Autumn NEFSC bottom trawl survey stratified mean catch per tow indices, average weights and average lengths of redfish in the Gulf of Maine/Georges Bank region.

	INSHORE 1				OFFSHORE 2				COMBINED 3	
	Stratified Mean Catch per Tow		Avg. Wt.	Avg. Length	Stratified Mean Catch per Tow		Avg. Wt.	Avg. Length	Stratified Mean Catch per Tow	
Year	Number	kg	kg	cm	Number	kg	kg	cm	Number	kg
1963	86.3	7.6	0.088	17.4	87.5	27.0	0.309	26.4	87.3	24.1
1964	81.3	13.5	0.166	20.2	122.3	61.8	0.505	30.8	116.3	54.6
1965	189.5	22.3	0.118	17.7	33.9	11.5	0.339	25.3	57.0	13.1
1966	172.8	17.0	0.098	16.2	77.8	31.2	0.401	27.4	91.9	29.1
1967	62.9	5.3	0.084	17.7	107.1	27.6	0.258	23.6	100.5	24.3
1968	41.1	4.7	0.114	18.3	161.3	46.6	0.289	25.1	143.4	40.4
1969	105.9	16.0	0.151	20.7	65.2	24.8	0.380	27.4	71.2	23.5
1970	18.2	2.8	0.154	20.3	107.2	38.2	0.356	26.3	94.0	32.9
1971	20.7	4.7	0.227	21.8	52.8	26.7	0.506	29.7	48.0	23.4
1972	36.4	6.6	0.181	20.8	58.9	27.8	0.472	29.2	55.6	24.6
1973	26.2	2.1	0.080	15.6	41.4	19.7	0.476	29.7	39.2	17.0
1974	44.4	4.7	0.106	18.0	49.0	27.6	0.563	30.1	48.3	24.2
1975	45.7	6.0	0.131	19.6	79.9	45.9	0.574	30.6	74.8	39.9
1976	11.6	2.5	0.216	22.6	31.9	17.5	0.549	30.2	28.9	15.3
1977	54.6	12.3	0.225	23.4	37.9	18.1	0.478	28.5	40.4	17.3
1978	20.4	5.5	0.270	24.6	49.5	23.4	0.473	29.0	45.2	20.7
1979	6.2	2.1	0.339	26.5	32.8	18.4	0.561	30.5	28.9	16.0
1980	20.6	6.2	0.301	24.6	20.6	13.8	0.670	31.8	20.6	12.6
1981	6.8	1.9	0.279	24.9	22.7	14.0	0.617	31.8	20.4	12.2
1982	28.2	4.6	0.163	21.2	5.6	3.2	0.571	31.5	9.0	3.4
1983	30.2	8.7	0.288	24.8	6.5	3.3	0.508	29.1	10.0	4.1
1984	7.7	3.2	0.416	27.9	7.8	4.1	0.526	29.0	7.8	3.9
1985	7.2	2.1	0.292	24.8	14.0	6.3	0.450	28.0	13.0	5.7
1986	67.6	15.3	0.226	23.3	18.8	6.7	0.356	26.1	26.1	8.0
1987	26.5	4.8	0.181	21.9	11.5	5.6	0.487	29.2	13.7	5.5
1988	18.5	5.1	0.276	21.9	11.4	6.5	0.570	29.1	12.4	6.3
1989	14.0	2.9	0.207	22.6	21.3	7.5	0.352	25.9	20.3	6.8
1990	57.6	14.5	0.252	23.8	31.7	11.7	0.369	26.7	35.5	12.2
1991	7.2	1.1	0.153	20.4	21.1	9.6	0.455	28.5	19.1	8.4
1992	7.8	1.2	0.147	20.0	24.9	9.3	0.374	27.3	22.4	8.1
1993	53.7	7.4	0.137	20.0	32.5	11.9	0.366	26.3	35.6	11.2
1994	31.5	5.4	0.171	21.7	19.0	6.0	0.317	25.0	20.9	5.9
1995	109.7	11.1	0.102	18.5	19.9	3.5	0.177	21.3	33.2	4.7
1996	53.8	9.1	0.169	21.5	189.9	34.4	0.181	21.9	169.6	30.6
1997	105.6	15.7	0.149	20.3	57.9	19.5	0.337	26.0	65.0	18.9
1998	48.7	10.7	0.219	20.4	128.9	35.4	0.275	23.6	117.0	31.7
1999	164.2	35.1	0.214	23.2	68.2	20.7	0.304	25.6	82.5	22.9
2000	133.3	21.8	0.164	21.6	99.4	26.9	0.271	24.8	104.4	26.2
2001	144.4	28.9	0.200	22.8	80.2	28.0	0.349	27.3	89.8	28.2
2002	217.7	31.6	0.145	20.7	179.5	43.7	0.243	24.4	185.2	41.9
2003	664.0	153.1	0.231	25.0	178.8	50.2	0.281	25.6	250.9	65.5
2004	61.2	7.0	0.114	15.3	138.8	41.8	0.301	25.6	127.3	36.6

1. Strata Set: 26, 27, 39, 40
2. Strata Set: 24, 28-30, 36-38
3. Strata Set: 24, 26-30, 36-40

Table 6. Commercial landings (mt), NEFSC autumn survey biomass index (kg/tow, and index of exploitation for Gulf of Maine redfish.

Year	Commercial landings (mt)	Biomass Index	Exploitation Ratio	Exp Biomass Index	Exploitation Ratio
1963	10046	24.1	0.0417	23.841	0.0421
1964	8313	54.6	0.0152	54.487	0.0153
1965	8057	13.1	0.0615	12.708	0.0634
1966	8569	29.1	0.0294	28.553	0.0300
1967	10864	24.3	0.0447	23.826	0.0456
1968	6777	40.4	0.0168	40.05	0.0169
1969	12455	23.5	0.0530	23.361	0.0533
1970	16741	32.9	0.0509	32.807	0.0510
1971	20034	23.4	0.0856	22.098	0.0907
1972	19095	24.6	0.0776	23.077	0.0827
1973	17360	17.0	0.1021	16.209	0.1071
1974	10471	24.2	0.0433	22.833	0.0459
1975	10572	39.9	0.0265	37.828	0.0279
1976	10696	15.3	0.0699	14.42	0.0742
1977	13223	17.3	0.0764	15.494	0.0853
1978	14083	20.7	0.0680	19.231	0.0732
1979	14755	16.0	0.0922	15.341	0.0962
1980	10183	12.6	0.0808	12.195	0.0835
1981	7915	12.2	0.0649	11.953	0.0662
1982	6903	3.4	0.2030	2.062	0.3348
1983	5328	4.1	0.1300	2.294	0.2323
1984	4793	3.9	0.1229	2.542	0.1886
1985	4282	5.7	0.0751	3.121	0.1372
1986	2929	8.0	0.0366	2.951	0.0993
1987	1894	5.5	0.0344	2.6	0.0728
1988	1177	6.3	0.0187	2.896	0.0406
1989	637	6.8	0.0094	2.676	0.0238
1990	601	12.2	0.0049	4.535	0.0133
1991	525	8.4	0.0063	3.521	0.0149
1992	849	8.1	0.0105	3.071	0.0276
1993	800	11.2	0.0071	3.742	0.0214
1994	440	5.9	0.0074	1.432	0.0307
1995	440	4.7	0.0095	0.566	0.0777
1996	322	30.6	0.0011	3.387	0.0095
1997	251	18.9	0.0013	4.393	0.0057
1998	320	31.7	0.0010	4.37	0.0073
1999	353	22.9	0.0015	3.753	0.0094
2000	319	26.2	0.0012	3.938	0.0081
2001	360	28.2	0.0013	5.554	0.0065
2002	368	41.9	0.0009	5.848	0.0063
2003	416	65.5	0.0006	11.688	0.0036
2004	398	36.6	0.0011	6.954	0.0057

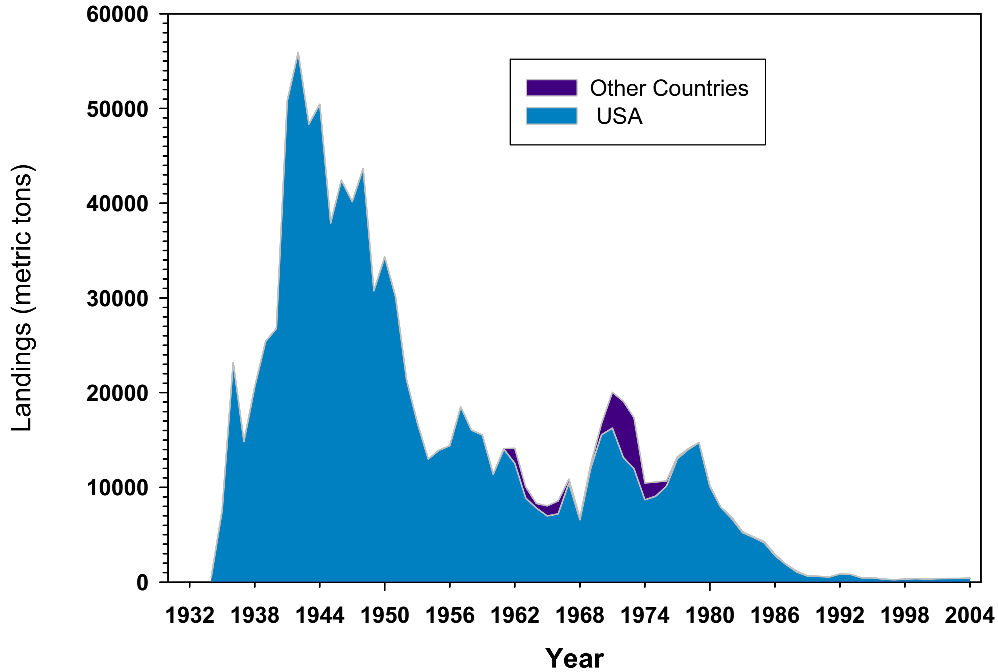

Figure 1. Acadian Redfish Landings Trends

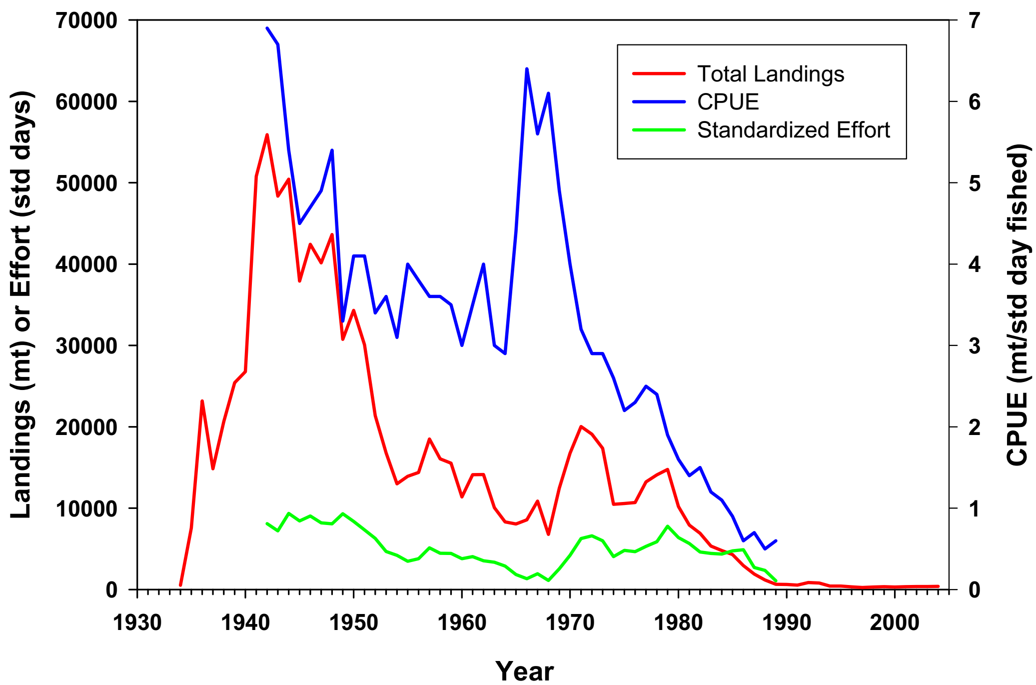

Figure 2. Acadian Redfish Total Landings, Effort and CPUE

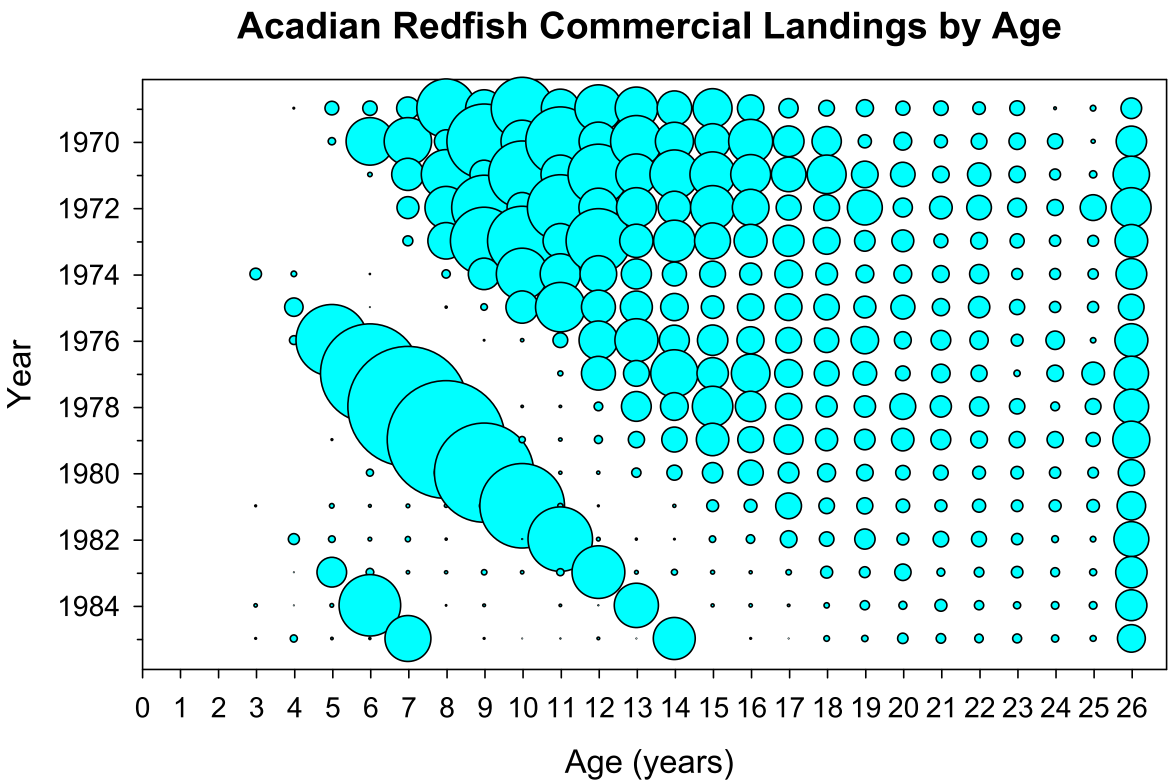

Figure 3. Age structure of the Acadian redfish landings, 1969-1985.

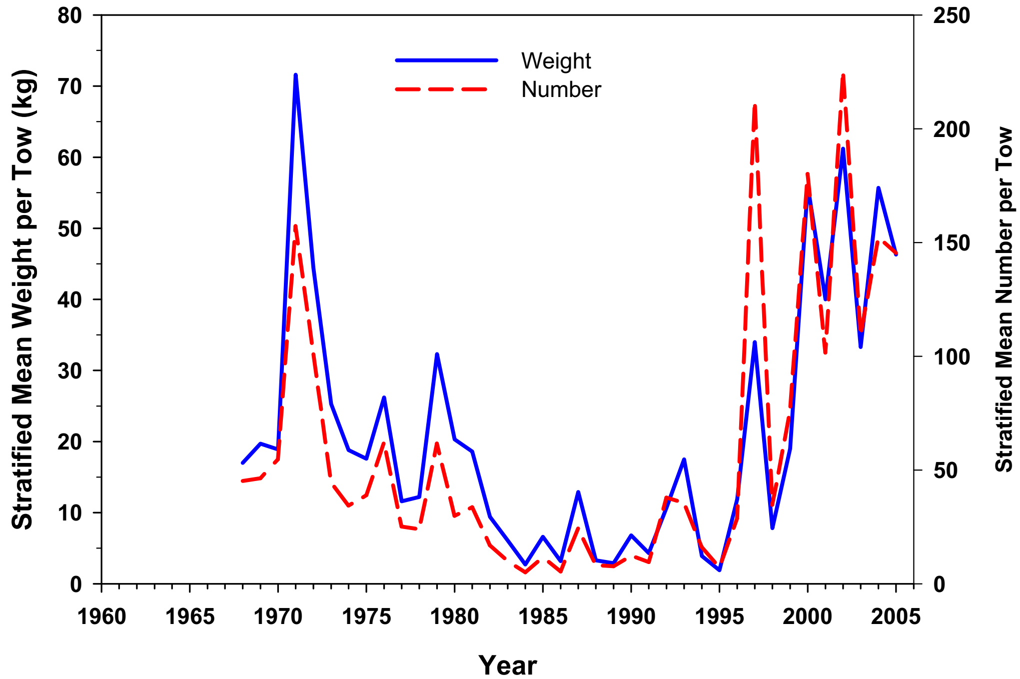

Figure 4. Acadian Redfish Stratified Mean Catch per Tow
NEFSC Spring Bottom Trawl Survey

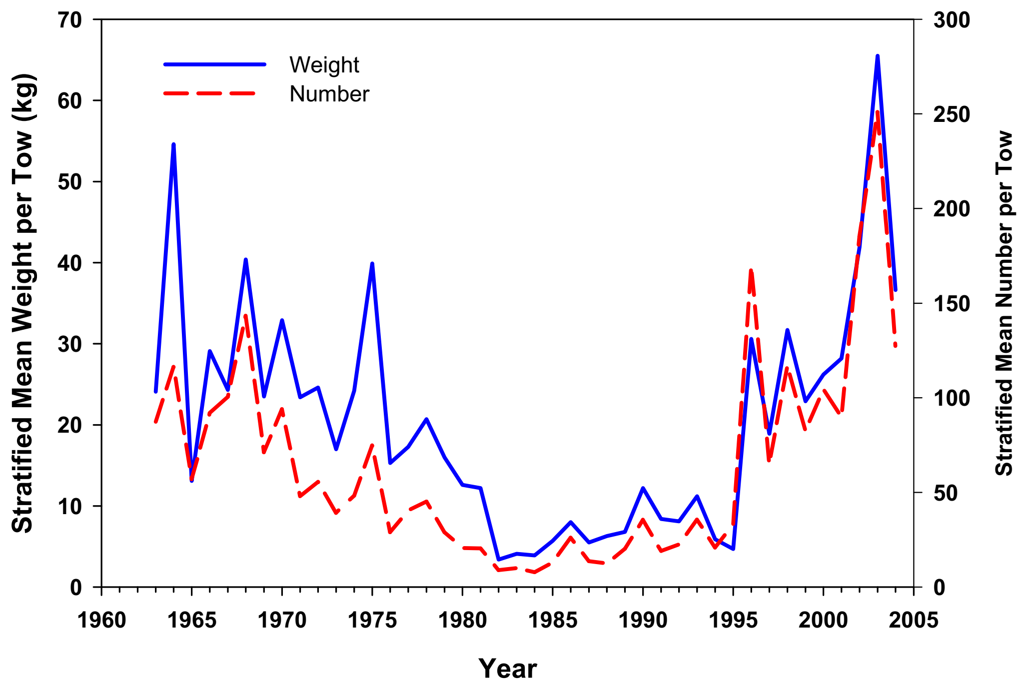

Figure 5. Acadian Redfish Stratified Mean Catch per Tow
NEFSC Autumn Bottom Trawl Survey

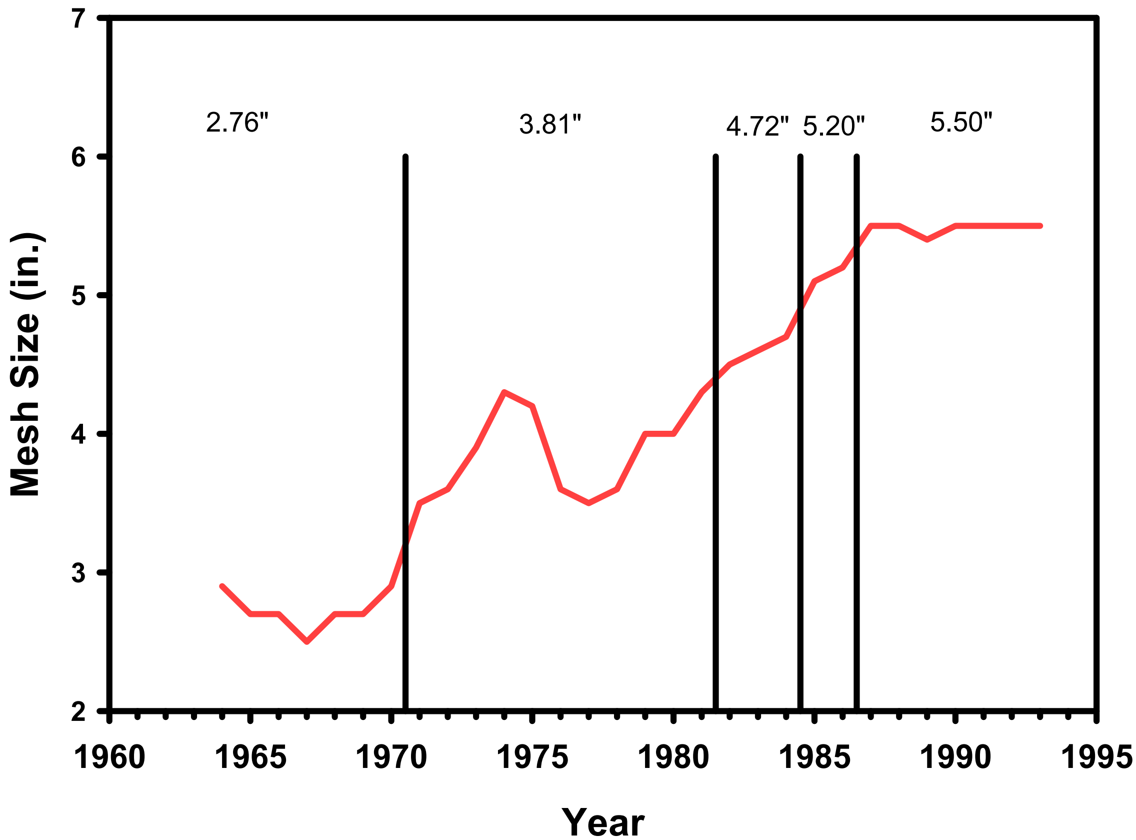

Figure 6. Average Mesh Size in the Acadian Redfish Fishery

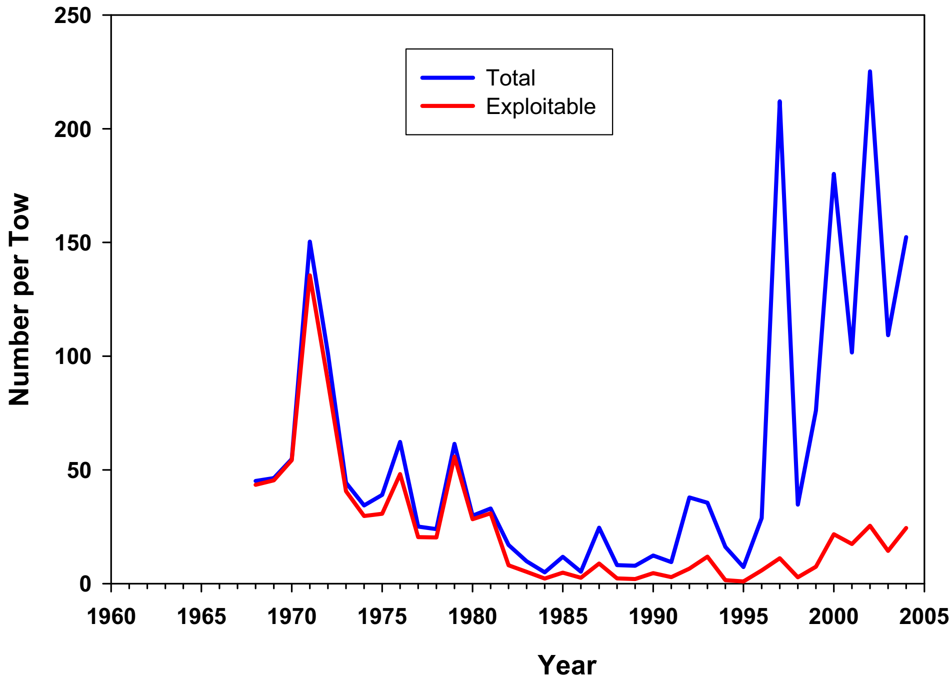

Figure 7a. Acadian Redfish Number per Tow in NEFSC Spring Survey (1968-2004)

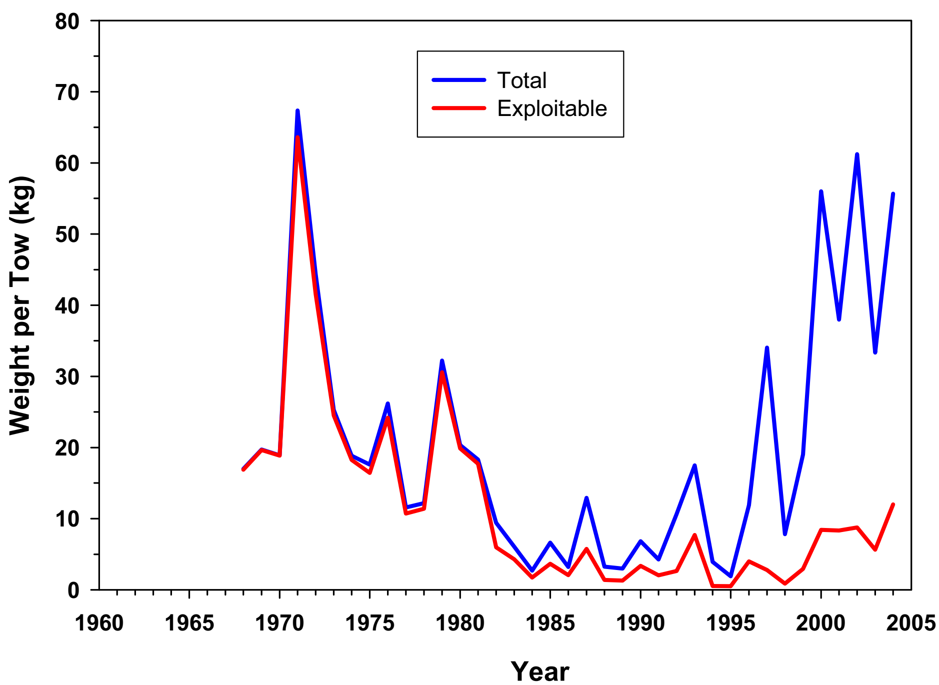

Figure 7b. Acadian Redfish Weight (kg) per Tow in NEFSC Spring Survey (1968-2004)

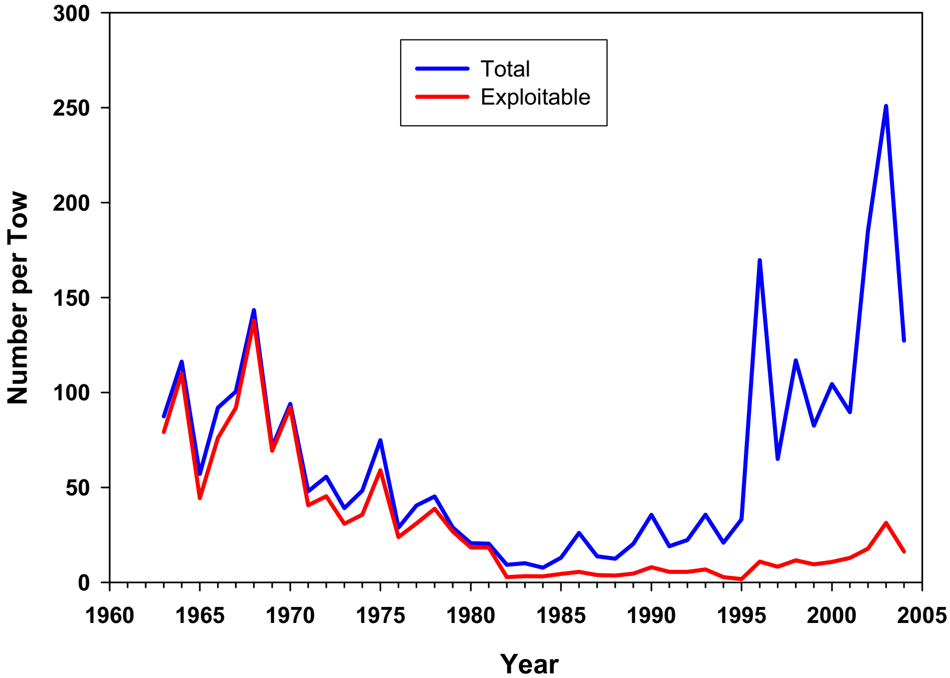

Figure 8a. Acadian Redfish Number per Tow in NMFS Autumn Survey (1963-2004)

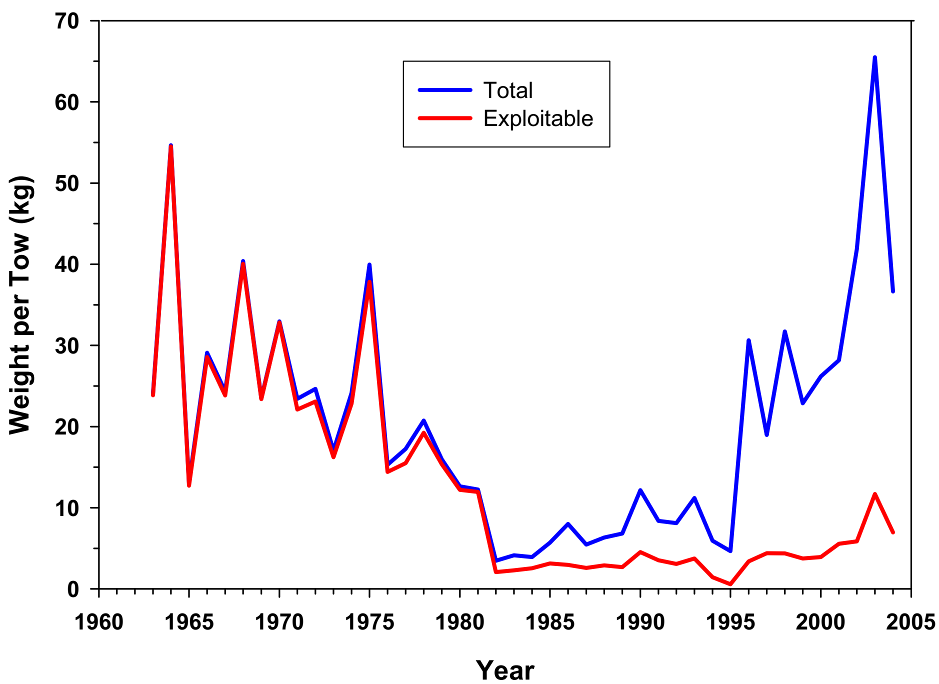

Figure 8b. Acadian Redfish Weight (kg) per Tow in NMFS Autumn Survey (1963-2004)

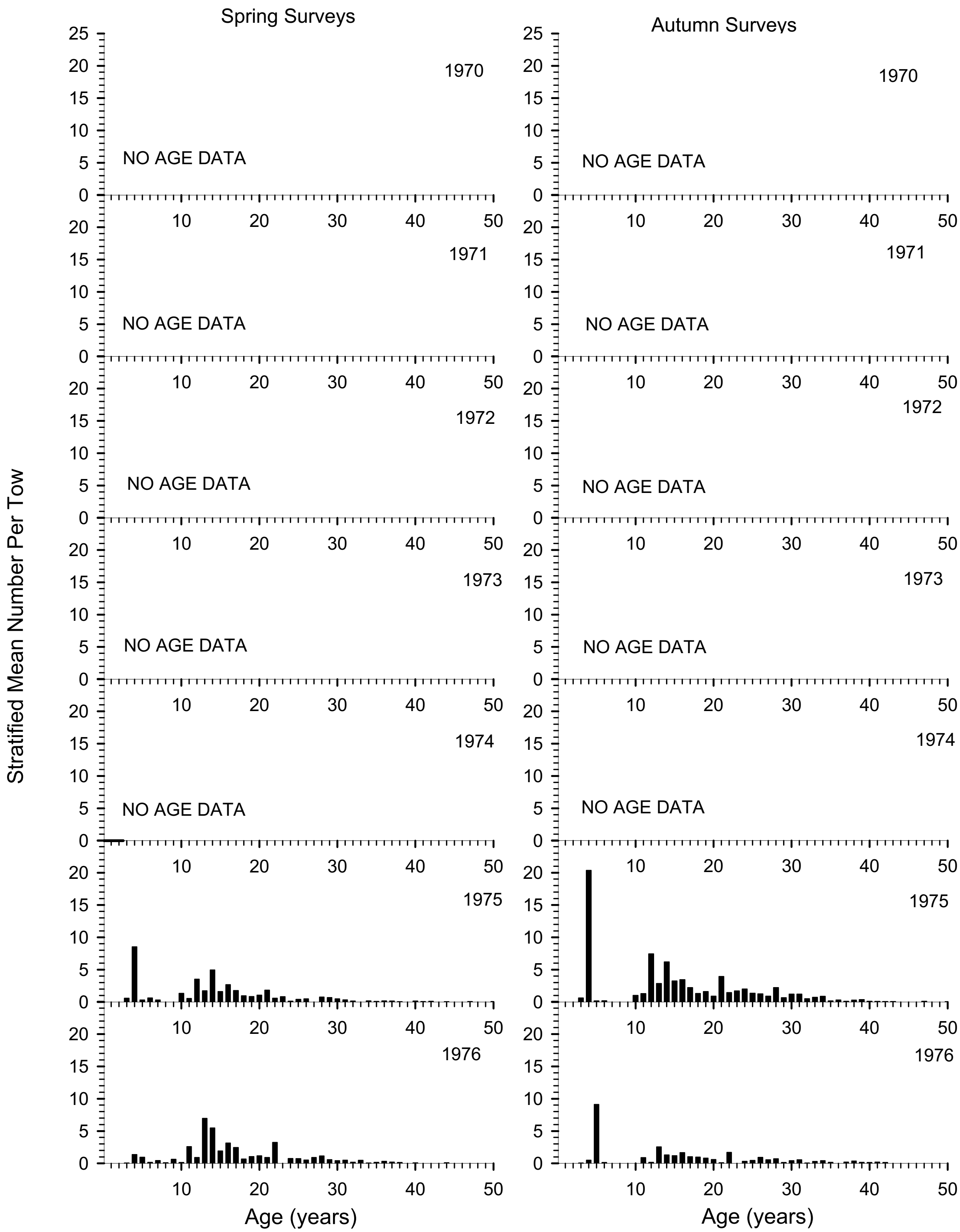

Figure 9. Age composition of redfish in NEFSC spring and autumn surveys.

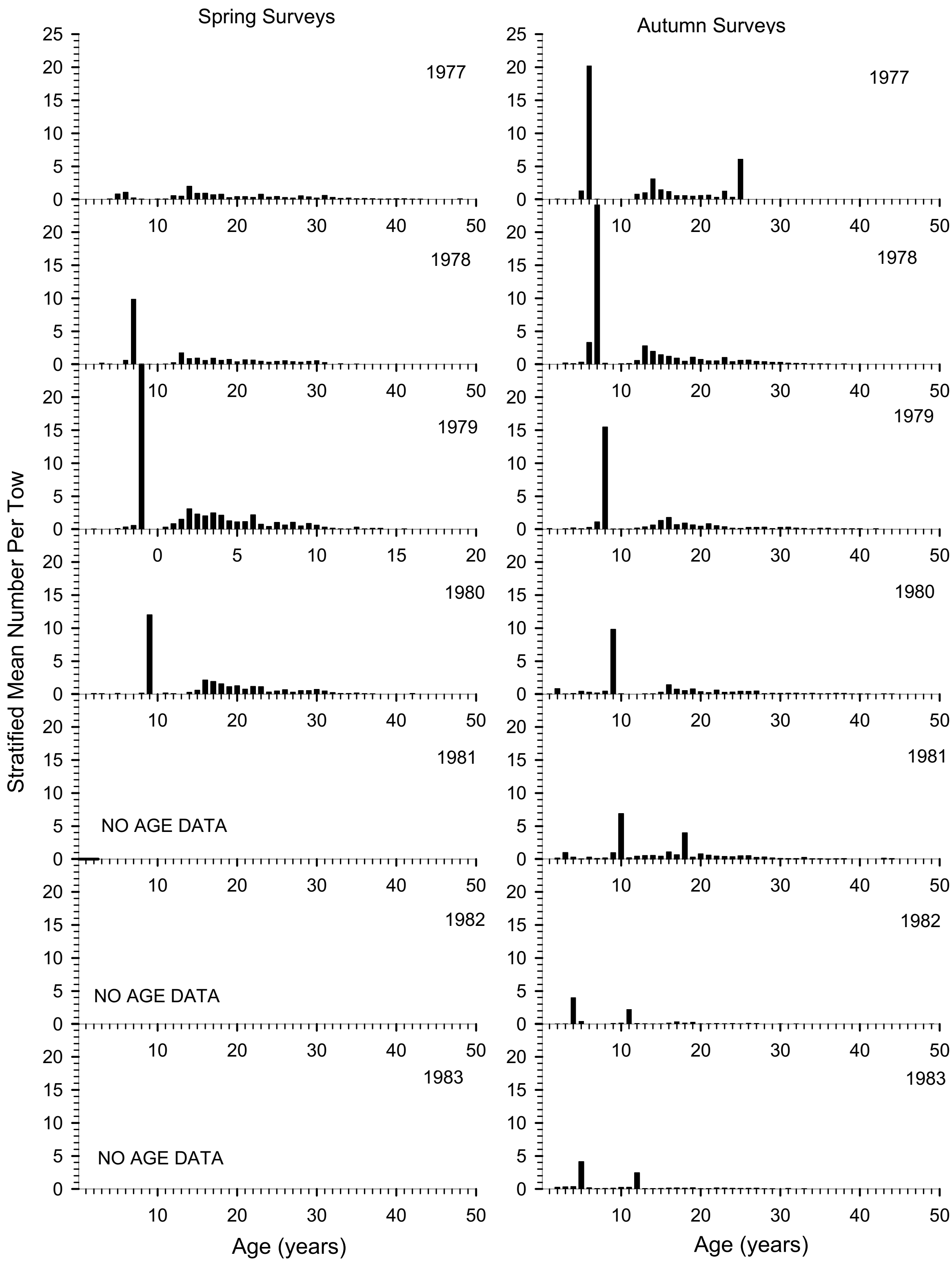

Figure 9 (Continued).

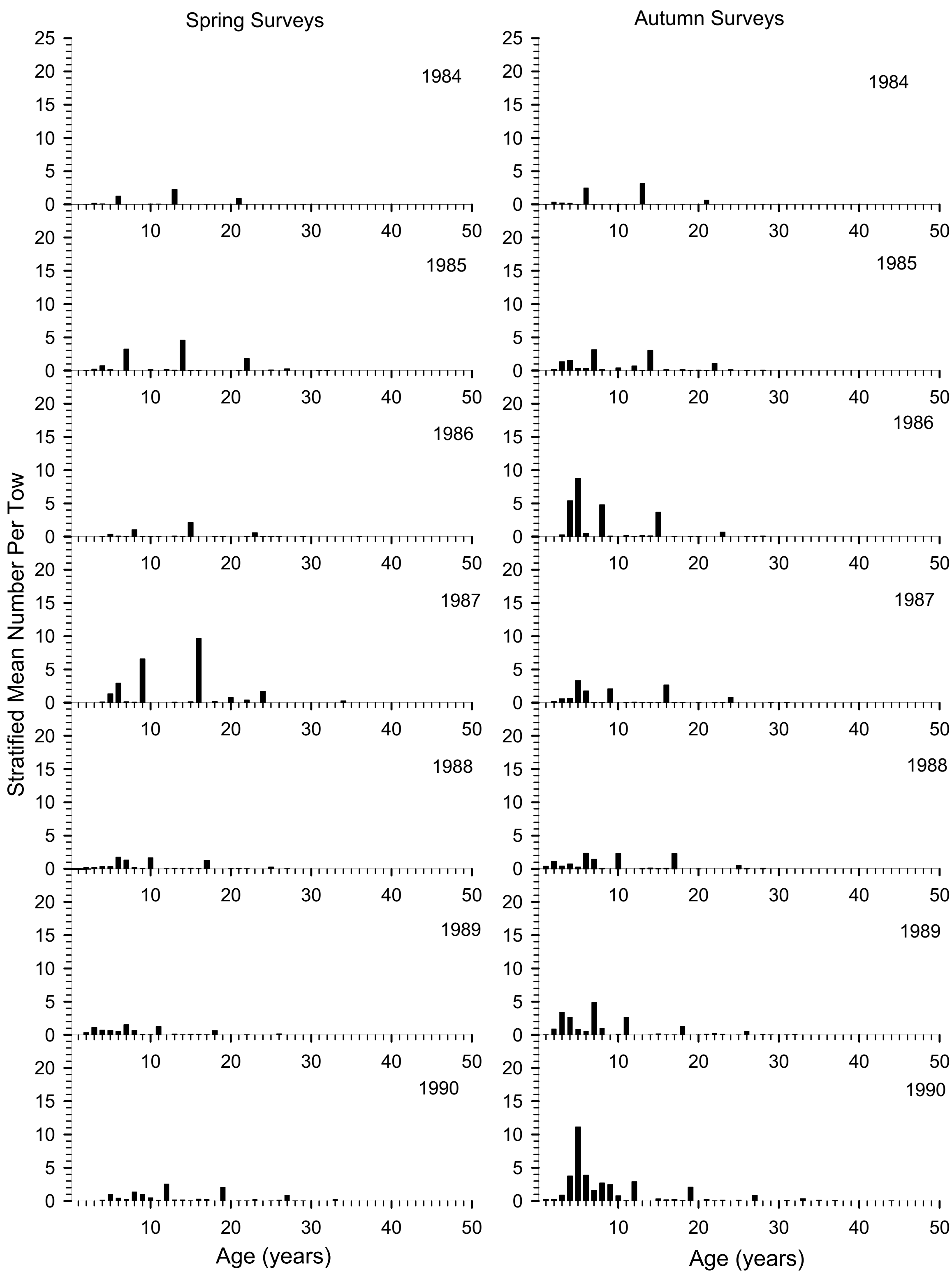

Figure 9 (Continued).

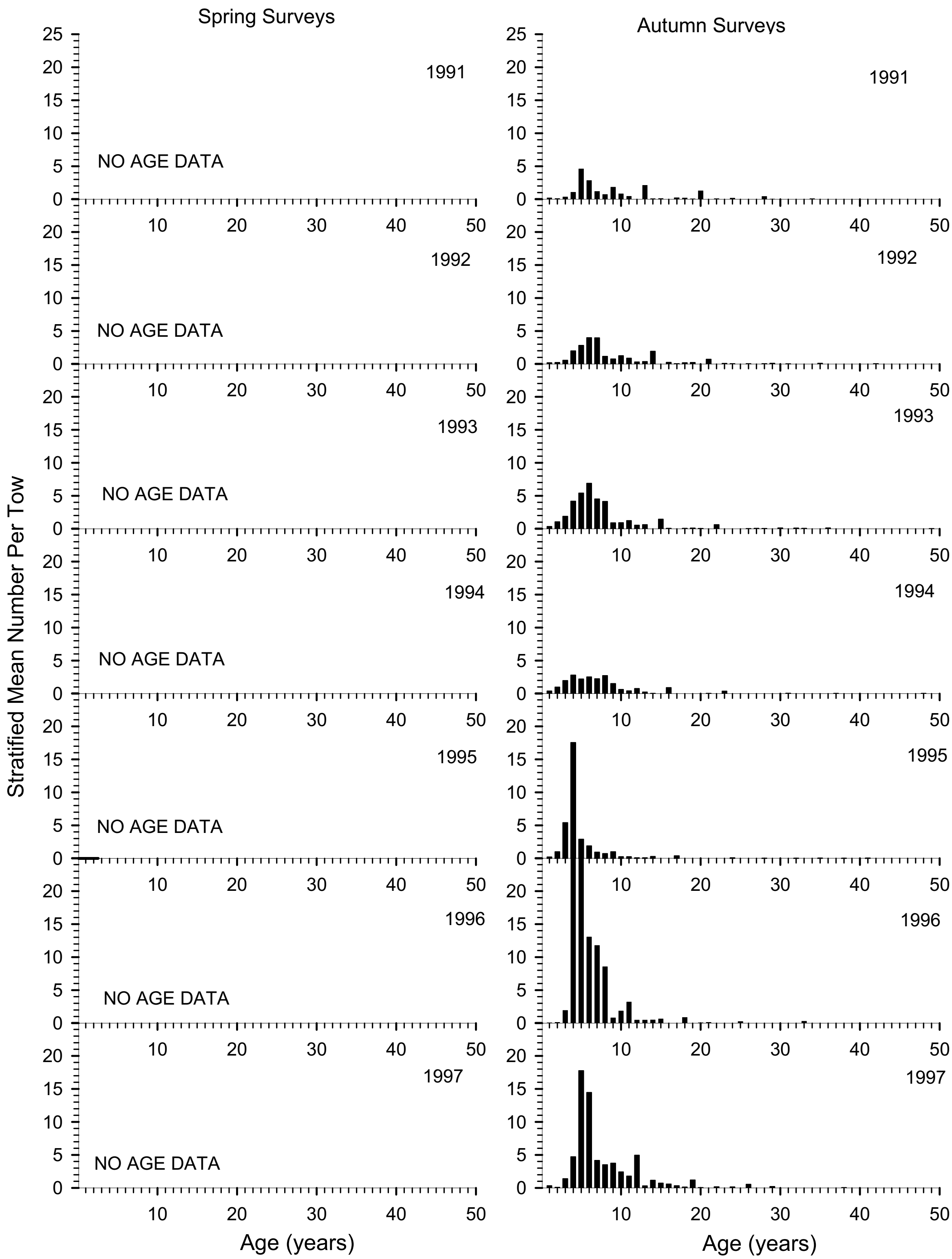

Figure 9 (Continued).

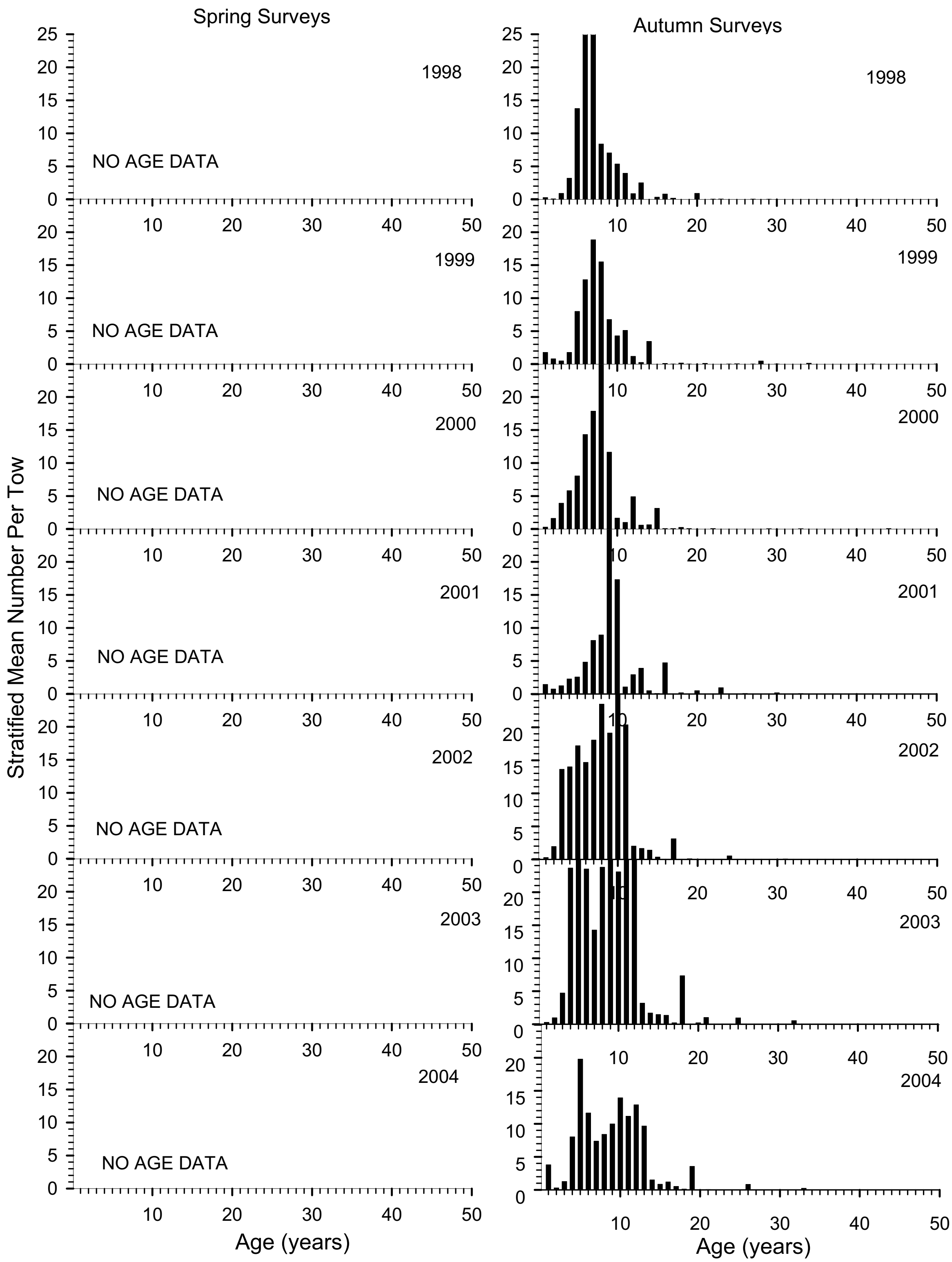

Figure 9 (Continued).

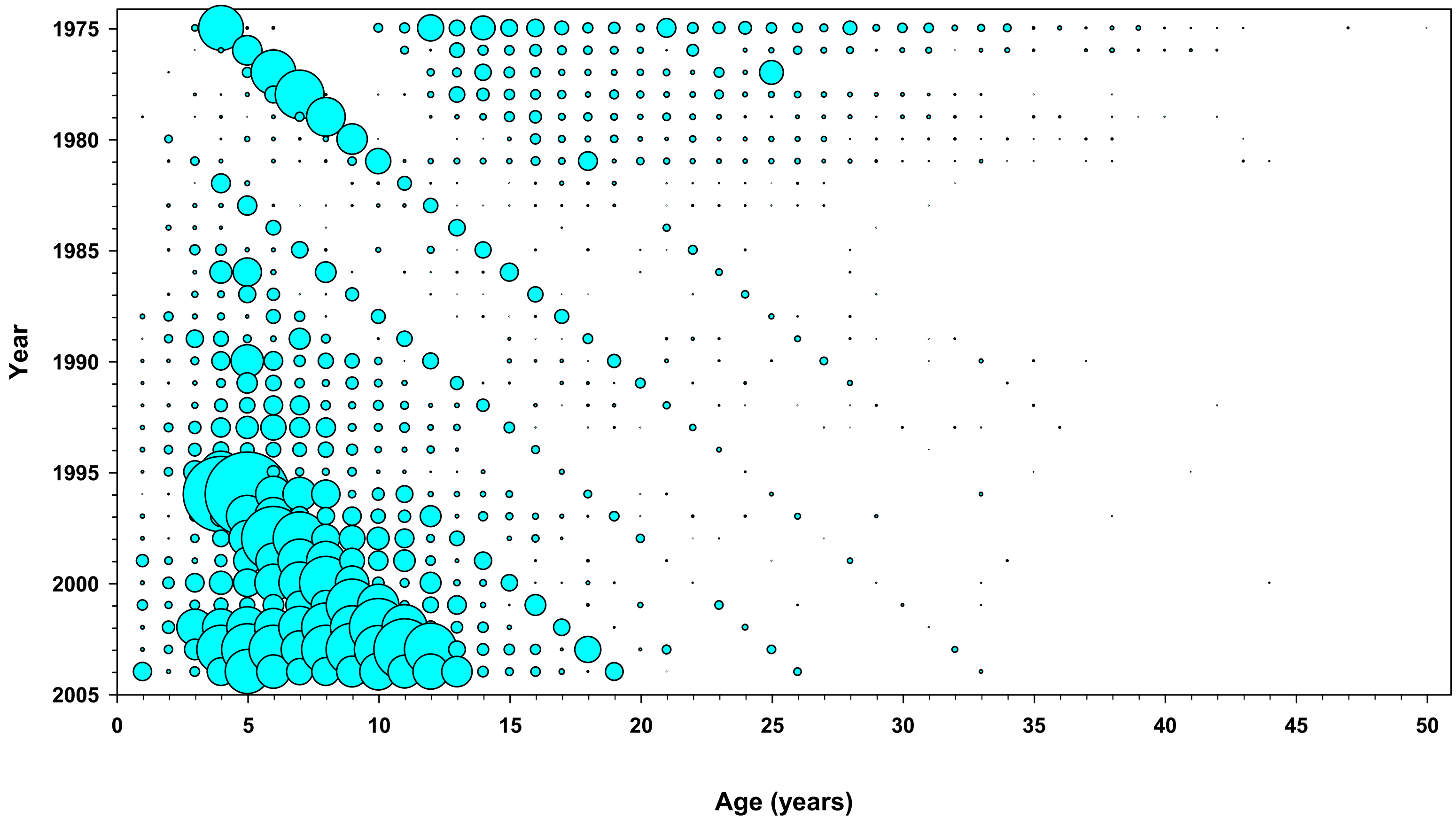

Figure 10. Acadian Redfish Autumn Survey Indices by Age

N Aged	142	CV	0.99
N Agreed	127		
Disagreed	15	%Agreement	89.4%

Figure 11. Results of redfish age-reader precision exercise against randomly selected samples from the NEFSC 2004 autumn bottom trawl survey. Error bars indicate 95% confidence intervals.

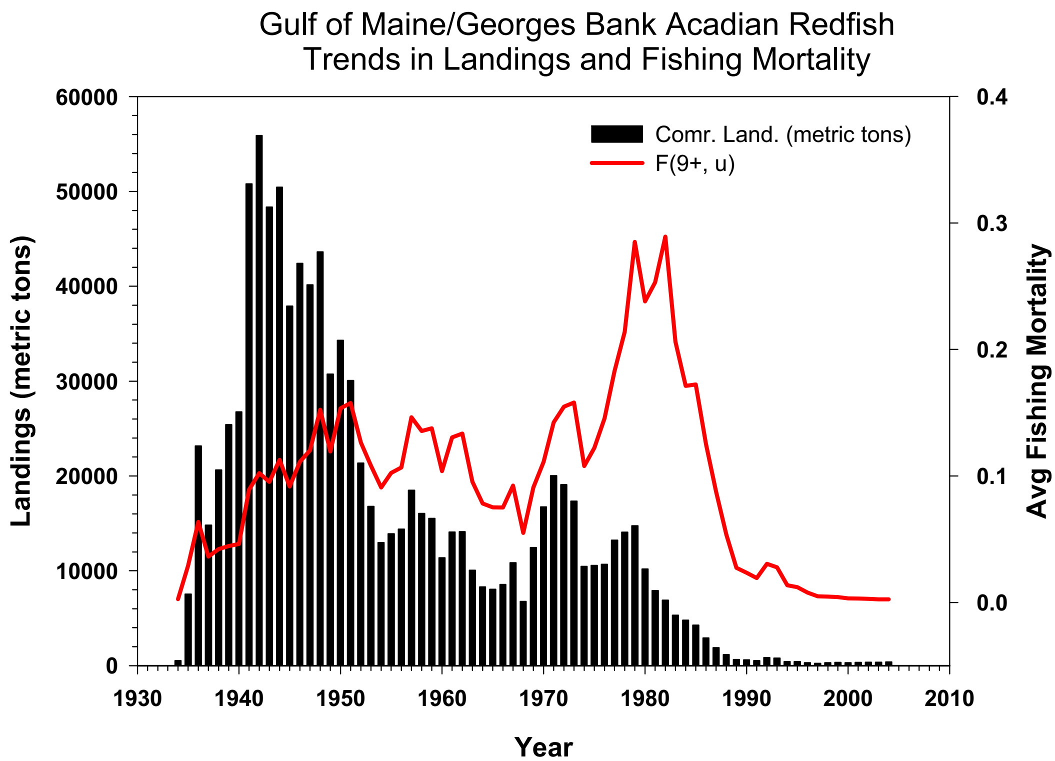

Figure 12. Trends in landings and fishing mortality for Gulf of Maine/ Georges Bank Acadian redfish.

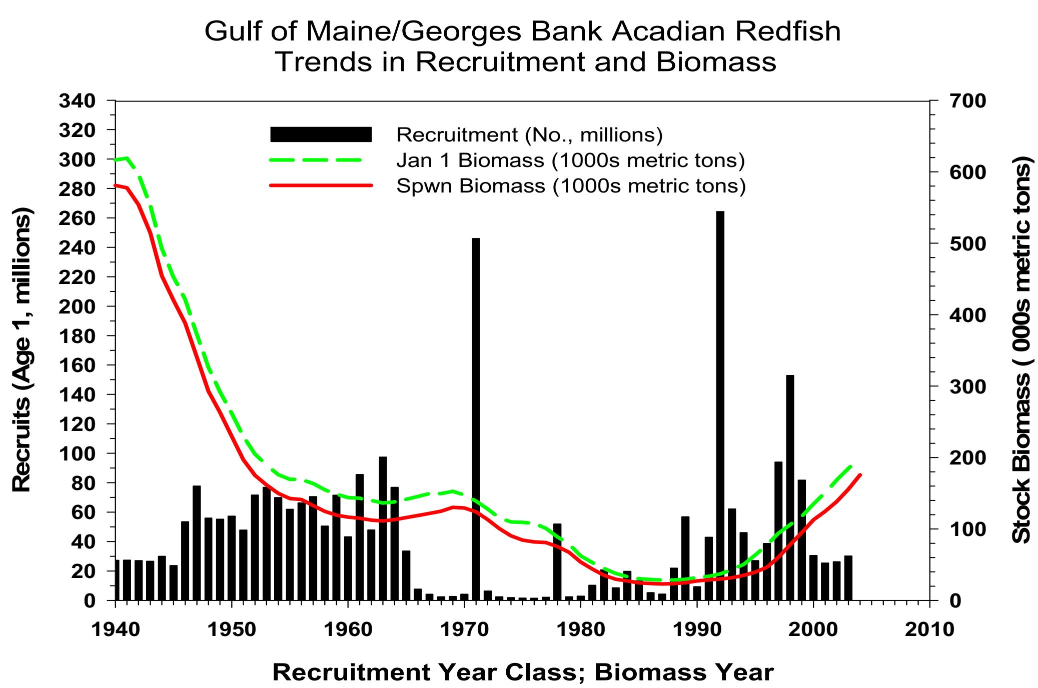

Figure 13. Trends in recruitment (age 1) and biomass for Gulf of Maine/ Georges Bank Acadian redfish.

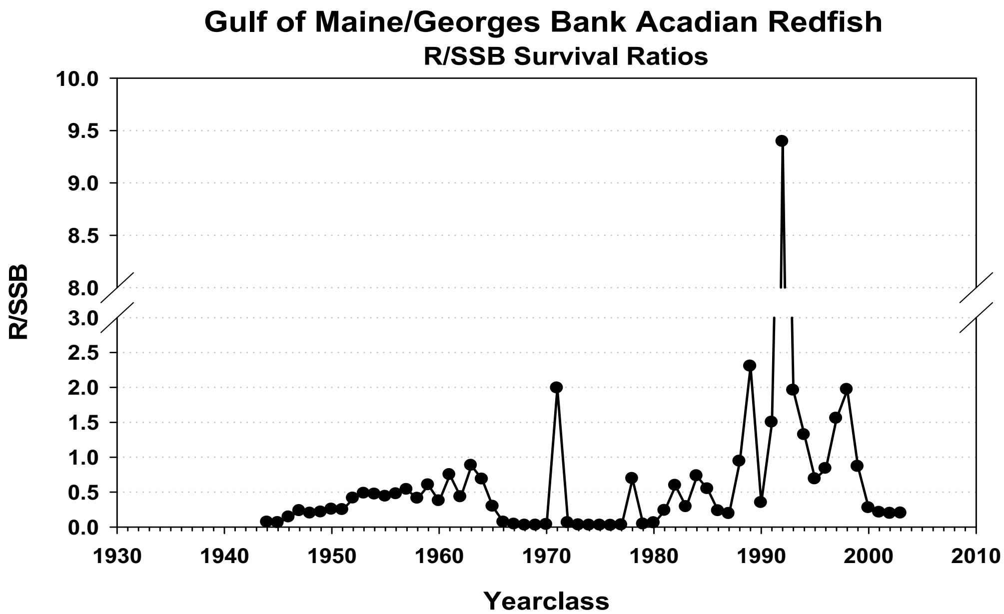

Figure 14. Trends in survival ratios (R/SSB) for Gulf of Maine/ Georges Bank Acadian redfish.

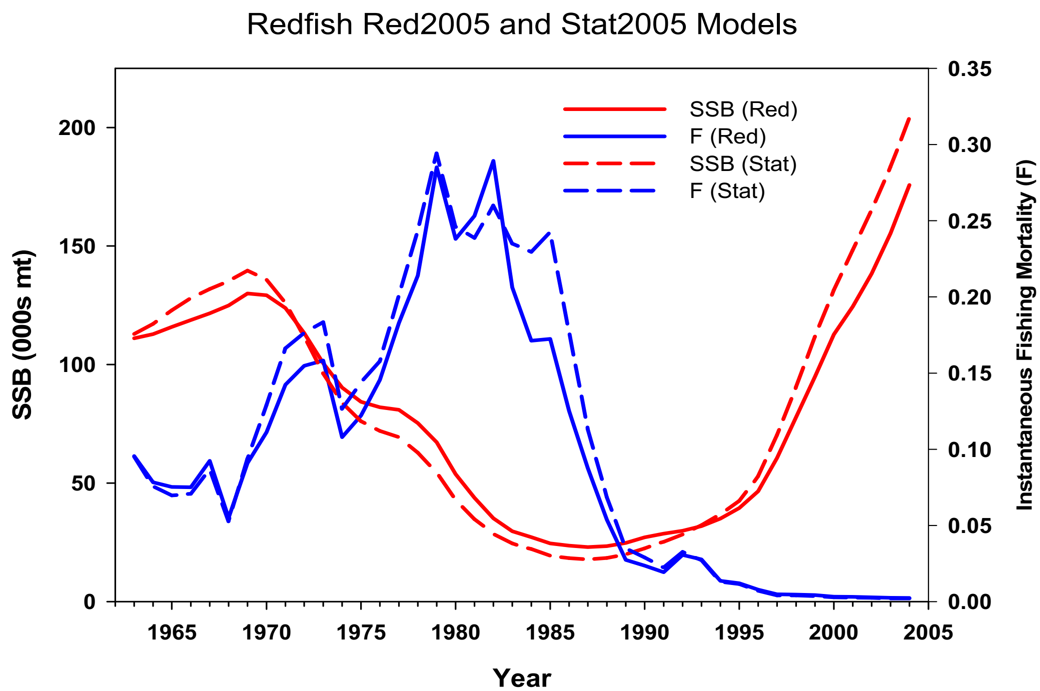

Figure 15. Comparison of trends in Spawning Stock Biomass (SSB) and Instantaneous Fishing Mortality (F) derived from the base model (RED) and STATCAM (Stat).

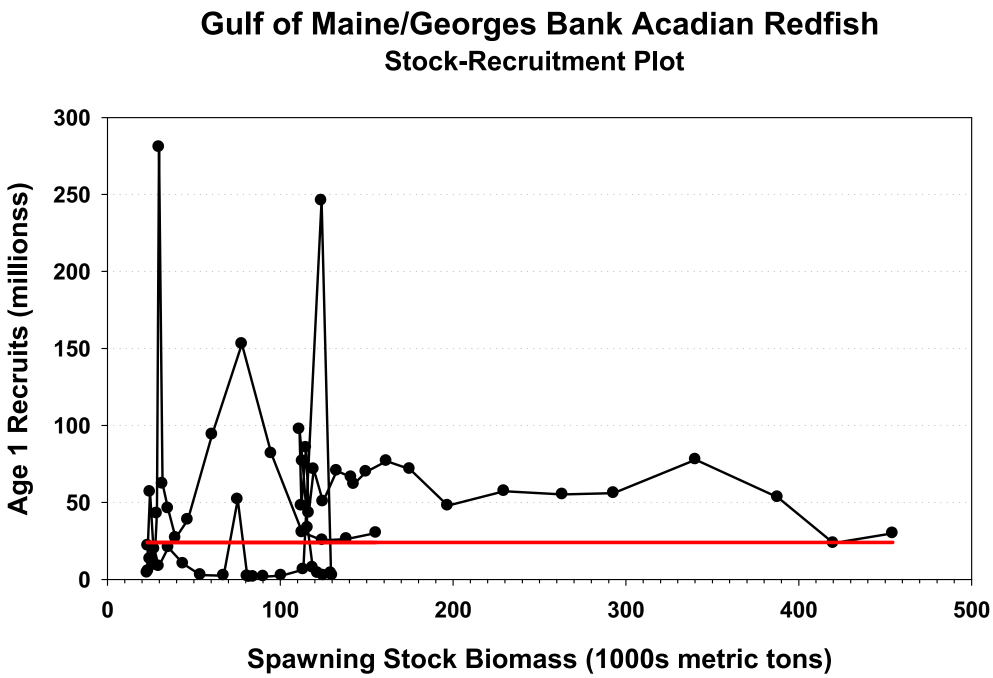

Figure 16. Spawning stock-recruitment scatterplot for Gulf of Maine/Georges Bank Acadian redfish. The solid horizontal line represents the geometric mean vrecruitment.

Procedures for Issuing Manuscripts in the *Northeast Fisheries Science Center Reference Document* (CRD) Series

Clearance

All manuscripts submitted for issuance as CRDs must have cleared the NEFSC's manuscript/abstract/webpage review process. If any author is not a federal employee, he/she will be required to sign an "NEFSC Release-of-Copyright Form." If your manuscript includes material from another work which has been copyrighted, then you will need to work with the NEFSC's Editorial Office to arrange for permission to use that material by securing release signatures on the "NEFSC Use-of-Copyrighted-Work Permission Form."

For more information, NEFSC authors should see the NEFSC's online publication policy manual, "Manuscript/abstract/webpage preparation, review, and dissemination: NEFSC author's guide to policy, process, and procedure," located in the Publications/Manuscript Review section of the NEFSC intranet page.

Organization

Manuscripts must have an abstract and table of contents, and (if applicable) lists of figures and tables. As much as possible, use traditional scientific manuscript organization for sections: "Introduction," "Study Area" and/or "Experimental Apparatus," "Methods," "Results," "Discussion," "Conclusions," "Acknowledgments," and "Literature/References Cited."

Style

The CRD series is obligated to conform with the style contained in the current edition of the United States Government Printing Office Style Manual. That style manual is silent on many aspects of scientific manuscripts. The CRD series relies more on the CSE Style Manual. Manuscripts should be prepared to conform with these style manuals.

The CRD series uses the American Fisheries Society's guides to names of fishes, mollusks, and decapod crustaceans, the Society for Marine Mammalogy's guide to names of marine mammals, the Biosciences Information Service's guide to serial title abbreviations, and the ISO's (International Standardization Organization) guide to statistical terms.

For in-text citation, use the name-date system. A special effort should be made to ensure that all necessary bibliographic information is included in the list of cited works. Personal communications must include date, full name, and full mailing address of the contact.

Preparation

Once your document has cleared the review process, the Editorial Office will contact you with publication needs – for example, revised text (if necessary) and separate digital figures and tables if they are embedded in the document. Materials may be submitted to the Editorial Office as files on zip disks or CDs, email attachments, or intranet downloads. Text files should be in Microsoft Word, tables may be in Word or Excel, and graphics files may be in a variety of formats (JPG, GIF, Excel, PowerPoint, etc.).

Production and Distribution

The Editorial Office will perform a copy-edit of the document and may request further revisions. The Editorial Office will develop the inside and outside front covers, the inside and outside back covers, and the title and bibliographic control pages of the document.

Once both the PDF (print) and Web versions of the CRD are ready, the Editorial Office will contact you to review both versions and submit corrections or changes before the document is posted online.

A number of organizations and individuals in the Northeast Region will be notified by e-mail of the availability of the document online.

Research Communications Branch
Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
166 Water St.
Woods Hole, MA 02543-1026

MEDIA
MAIL

Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "conducting ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources and to generate social and economic opportunities and benefits from their use." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Currently, there are three such media:

NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term field or lab studies of important species or habitats; synthesis reports for important species or habitats; annual reports of overall assessment or monitoring programs; manuals describing program-wide surveying or experimental techniques; literature surveys of important species or habitat topics; proceedings and collected papers of scientific meetings; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

Northeast Fisheries Science Center Reference Document -- This series is issued irregularly. The series typically includes: data reports on field and lab studies; progress reports on experiments, monitoring, and assessments; background papers for, collected abstracts of, and/or summary reports of scientific meetings; and simple bibliographies. Issues receive internal scientific review and most issues receive copy editing.

Resource Survey Report (formerly *Fishermen's Report*) -- This information report is a regularly-issued, quick-turnaround report on the distribution and relative abundance of selected living marine resources as derived from each of the NEFSC's periodic research vessel surveys of the Northeast's continental shelf. This report undergoes internal review, but receives no technical or copy editing.

TO OBTAIN A COPY of a *NOAA Technical Memorandum NMFS-NE* or a *Northeast Fisheries Science Center Reference Document*, either contact the NEFSC Editorial Office (166 Water St., Woods Hole, MA 02543-1026; 508-495-2350) or consult the NEFSC webpage on "Reports and Publications" (http://www.nefsc.noaa.gov/nefsc/publications/). To access *Resource Survey Report*, consult the Ecosystem Surveys Branch webpage (http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage/).