3.13 Acadian Redfish

Catch and Survey Indices

Redfish, *Sebastes fasciatus* Storer, are assessed as a unit stock in the Gulf of Maine and Georges Bank region (NAFO Subarea 5). The fishery on this stock developed rapidly during the 1930s (Mayo 1980). Landings rose rapidly from less than 100 mt in the early 1930s to over 20,000 mt in 1939, peaking at 56,000 mt in 1942, then declined throughout the 1940s and 1950s (Figure 3.13.1). Redfish have been harvested primarily by domestic vessels, although distant water fleets took considerable quantities for a brief period during the early 1970s. 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. Landings declined throughout the 1980s and have averaged less than 500 mt per year during the 1990s

Relative biomass indices (stratified mean weight per tow) have been 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). Trends in total abundance and biomass are similar in both spring and autumn surveys (Figure 3.13.1). Relative biomass of redfish has declined sharply in both survey series, from peak levels in the late 1960s and early 1970s to generally less than 2 kg per tow during the mid-1980s through mid-1990s. Both series suggest a slight increase in biomass between the mid-1980s and 1990s followed by a sharp increase in autumn 1996 and spring 1997.

Stock Assessment

The most recent stock assessment was completed in 2001 (Mayo *et al.* 2002b), and the results were reviewed at the 33rd Northeast Regional Stock Assessment Workshop in June, 2001 (NEFSC 2001c). The assessment was based on several analyses including trends in catch/survey biomass exploitation ratios; a yield and biomass per recruit analysis; an age-structured dynamics model which incorporates information on the age composition of the landings, size and age composition of the population, and trends in relative abundance derived from commercial CPUE and research vessel survey biomass indices; and an age-aggregated biomass dynamics model. Surplus production estimates were derived from the age-structured dynamics model, and information on current biomass and fishing mortality relative to MSY-based reference points were also provided by the biomass dynamics model.

Exploitation ratios (catch/survey biomass) suggested that fishing mortality has been very low since the mid-1980s compared to previous periods. Estimates of fishing mortality derived from the age-structured dynamics model and the age-aggregated biomass model were similar, both indicating that current fishing mortality is low relative to past decades and less than 5% of F_{msy}. Stock biomass has increased since the mid-1990s, and current biomass was estimated to be about 33% of B_{msy} due, in large part, to strong recruitment from the early 1990s. The spawning stock and recruitment estimates derived from the age-structured dynamics model are provided in Figures 3.13.2 and 3.13.3.

Yield and SSB per Recruit Analysis

The yield and spawning stock biomass analysis conducted during the course of the 2001 assessment was revised slightly during the present analysis to provide an estimate of F50% MSP as recommended by the Stock Assessment Review Committee of the 33rd SAW. Partial recruitment, catch and stock mean weights, and maturation at age were the same as those employed in the 2001 assessment. Estimates of $F_{0.1}$ and $F_{50\%}$ are presented in Table 3.1.1. The spawning stock biomass per recruit estimate corresponding to $F_{50\%}$, when combined with information on historical recruitment, provides an estimate of SSB_{msy} as described in the following section.

MSY-based Reference Point Estimation

Empirical Nonparametric Approach

Estimates of recruitment obtained from the age-structured biomass dynamics model reviewed at the 33rd SAW were used to imply the probable recruitment that could be produced by a rebuilt stock. Recruitment estimates derived by the model from the1952-1999 yearclasses 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 3.13.2). 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 of the 33rd SAW, 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 Point Advice

Reference points derived from the nonparametric approach are: MSY = 8,235 mt and SSB_{msy} = 236,700 mt (Table 4.2). In lieu of an analytically-derived estimate of F_{msy}, the F proxy advised by the 33rd SAW ($F_{50\%}$ = 0.04) is recommended. The estimate of MSY represents total landings..

Projections

Stochastic age-based projections (Brodziak and Rago MS 2002) were performed over a 10-year time horizon beginning in 2001 to evaluate relative trajectories of stock biomass and catch under various fishing mortality scenarios. Recruitment was generated by resampling observed recruitment using a cumulative distribution function which allows predicted recruitment values to occur within the range of those from the 1952 through 1999 yearclasses as estimated by the age structured dynamics model. Stock and catch mean weights at age, the maturity at age schedule, are the same as those employed in the yield and SSB per recruit analyses presented above, and the partial recruitment at age vector was derived from the age structured dynamics model. The 2001 survivors at ages 1 through 26+ age estimated by the age structured dynamics model were employed as the initial population vector. The projection was performed at two fishing mortality rates: $F_{50\%}$ (0.04) and F calculated to rebuild spawning biomass to SSB_{msy} by 2009. Fully recruited fishing mortality in 2001 was derived from iterative calculations based on the estimated total 2001 commercial landings (328 mt). Fishing mortality in 2002 was fixed at the 2001 value.

The medium-term projections (Figures 3.13.4 and 3.13.4 and 3.13.6) suggest that fishing at $F_{50\%}$ (0.04) between 2003 and 2009 will result in less than a 1% probability of rebuilding spawning biomass to SSB_{msy} (236, 700 mt) by 2009 (Figure 3.13.4). Even if F is reduced to 0, there is still less than a 1% probability of rebuilding spawning biomass to SSB_{msy} by 2009 (Figures 3.13.5).

Table 3.13.1. Yield and biomass per recruit of Acadian redfish.

The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
PC Ver.2.0 [Method of Thompson and Bell (1934)] 1-Jan-1999
----Run Date: 27- 6-2001; Time: 15:33:57.67
REDFISH UPDATED AVE WTS & FPAT, MAT VECTOR (MAYO ET AL. 1990)

Proportion of F before spawning: .4000
Proportion of M before spawning: .4000
Natural Mortality is Constant at: .050
Initial age is: 1; Last age is: 26
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> d:\assess\redf\Yrred.dat

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0138	1.0000	.0100	.010	.002
2	.0312	1.0000	.0200	.020	.012
3	.0697	1.0000	.0500	.059	.033
4	.1507	1.0000	.1500	.099	.064
5	.2999	1.0000	.3600	.145	.103
6	.5084	1.0000	.6400	.178	.148
7	.7291	1.0000	.8500	.201	.196
8	.9289	1.0000	.9500	.250	.246
9	1.0000	1.0000	.9800	.272	.295
10	1.0000	1.0000	.9900	.310	.343
11	1.0000	1.0000	1.0000	.348	.388
12	1.0000	1.0000	1.0000	.391	.430
13	1.0000	1.0000	1.0000	.423	.469
14	1.0000	1.0000	1.0000	.429	.505
15	1.0000	1.0000	1.0000	.463	.537
16	1.0000	1.0000	1.0000	.495	.566
17	1.0000	1.0000	1.0000	.503	.592
18	1.0000	1.0000	1.0000	.508	.615
19	1.0000	1.0000	1.0000	.548	.636
20	1.0000	1.0000	1.0000	.558	.654
21	1.0000	1.0000	1.0000	.565	.669
22	1.0000	1.0000	1.0000	.581	.683
23	1.0000	1.0000	1.0000	.595	.696
24	1.0000	1.0000	1.0000	.583	.706
25	1.0000	1.0000	1.0000	.581	.716
26+	1.0000	1.0000	1.0000	.637	.750

Summary of Yield per Recruit Analysis for:
REDFISH UPDATED AVE WTS & FPAT, MAT VECTOR (MAYO ET AL. 1990)

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Slope of the Yield/Recruit Curve at F=0.00: -->    7.5310
  F level at slope=1/10 of the above slope (F0.1): ----->    .059
    Yield/Recruit corresponding to F0.1: ----->     .1632
  F level to produce Maximum Yield/Recruit (Fmax): ----->    .127
    Yield/Recruit corresponding to Fmax: ----->     .1806
  F level at 50 % of Max Spawning Potential (F50): ----->    .040
    SSB/Recruit corresponding to F50: -------->    4.1073
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Listing of Yield per Recruit Results for:
REDFISH UPDATED AVE WTS & FPAT, MAT VECTOR (MAYO ET AL. 1990)

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	20.5042	9.1737	15.7030	8.7760	100.00
F50%	.04	.34434	.14293	13.6199	4.4727	8.8513	4.1073	46.80
	.05	.38712	.15522	12.7649	3.9263	8.0041	3.5674	40.65
F0.1	.06	.41925	.16317	12.1227	3.5252	7.3690	3.1719	36.14
	.10	.51797	.17890	10.1507	2.3604	5.4286	2.0284	23.11
Fmax	.13	.55860	.18057	9.3395	1.9207	4.6377	1.6001	18.23
	.15	.58466	.17981	8.8194	1.6549	4.1345	1.3428	15.30
	.20	.62564	.17533	8.0023	1.2684	3.3532	.9718	11.07
	.25	.65370	.16973	7.4432	1.0297	2.8287	.7459	8.50
	.30	.67435	.16423	7.0323	.8698	2.4512	.5967	6.80
	.35	.69033	.15916	6.7145	.7561	2.1657	.4923	5.61
	.40	.70318	.15459	6.4593	.6714	1.9418	.4158	4.74
	.45	.71381	.15049	6.2483	.6060	1.7611	.3578	4.08
	.50	.72281	.14681	6.0696	.5540	1.6119	.3124	3.56
	.55	.73058	.14349	5.9156	.5117	1.4864	.2762	3.15
	.60	.73739	.14047	5.7808	.4765	1.3793	.2467	2.81
	.65	.74343	.13772	5.6612	.4467	1.2868	.2222	2.53
	.70	.74885	.13520	5.5540	.4212	1.2058	.2016	2.30
	.75	.75376	.13288	5.4570	.3991	1.1345	.1841	2.10
	.80	.75823	.13072	5.3685	.3797	1.0710	.1690	1.93
	.85	.76234	.12871	5.2872	.3625	1.0141	.1559	1.78
	.90	.76614	.12683	5.2122	.3471	.9628	.1444	1.65
	.95	.76967	.12506	5.1425	.3333	.9163	.1343	1.53
	1.00	.77296	.12340	5.0775	.3208	.8740	.1253	1.43

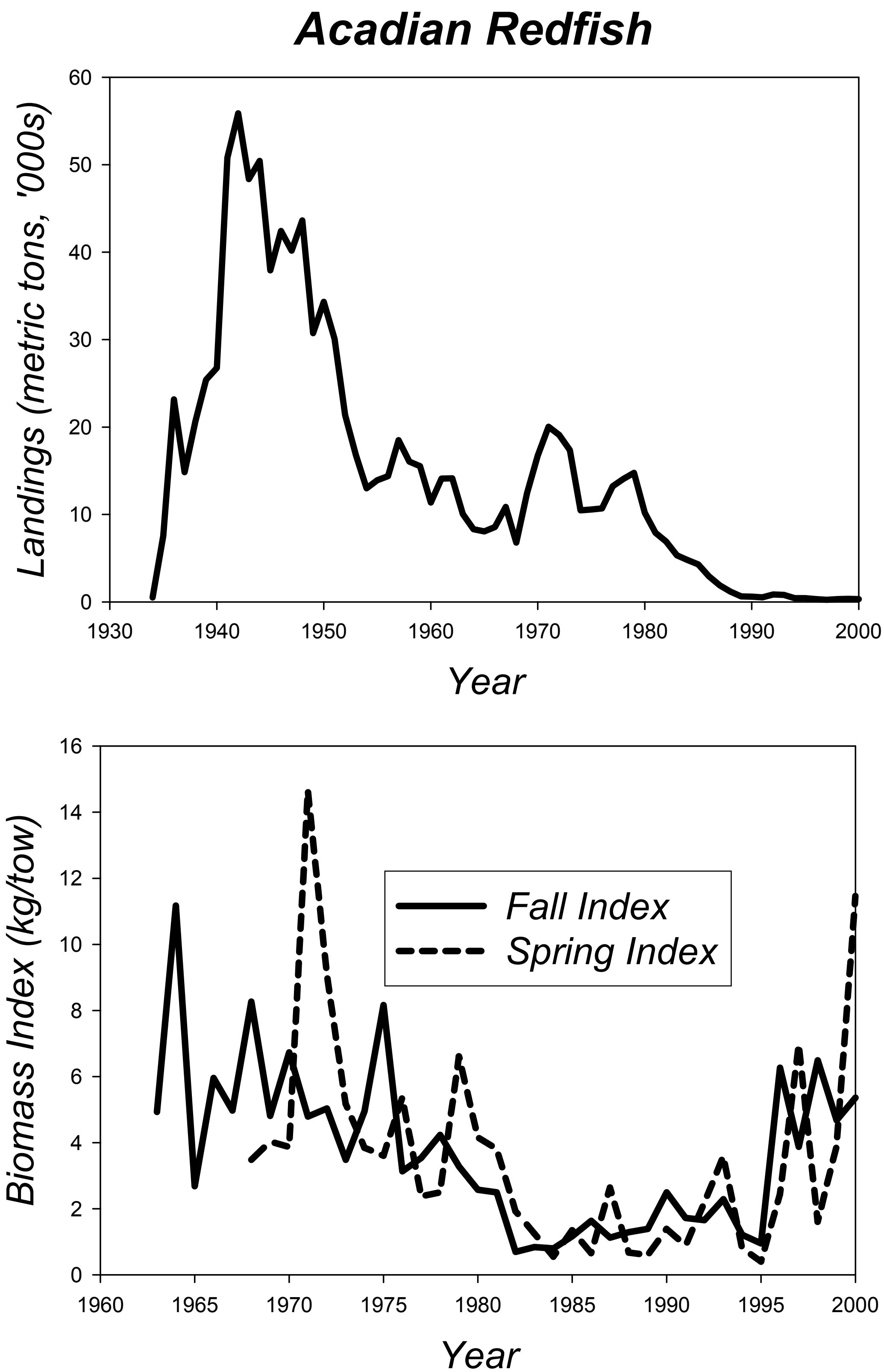
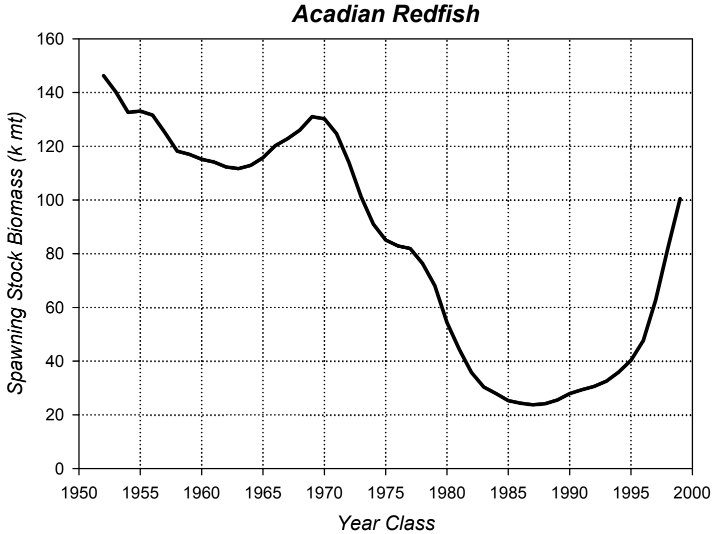
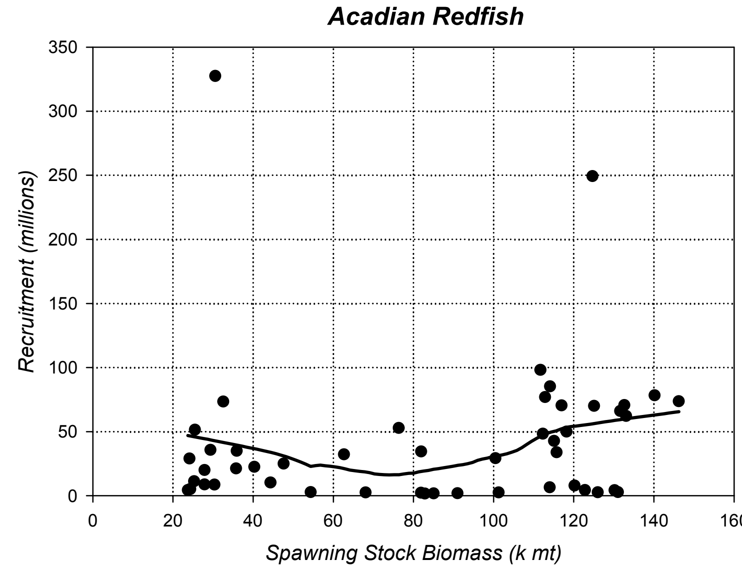


Figure 3.13.1. Landings and research vessel survey abundance indices for Acadian redfish.

(a)



(c)



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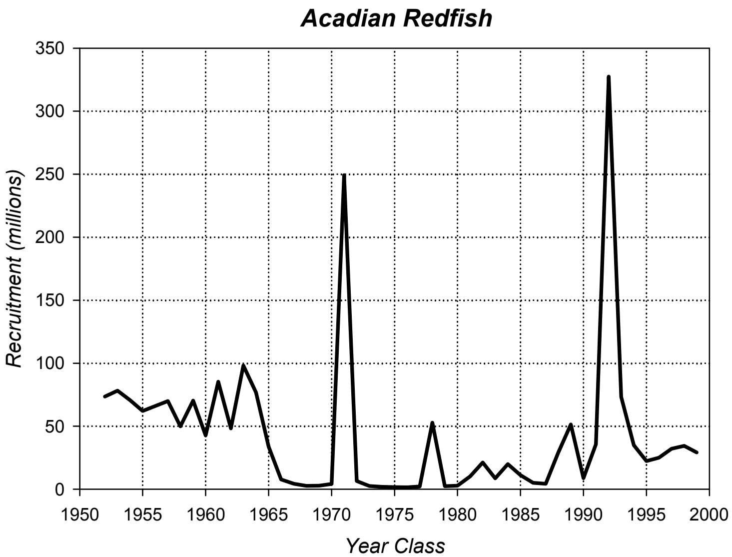

		F0.1	F50% MSP
F reference point		0.059	0.04
ssb per recruit at F		3.1719	4.1073
	Recruitment (millions)	SS Biomass at F0.1	SS Biomass at F50%
n	48	48	48
mean	42.84	135.87	175.94
min	1.56	4.95	6.41
max	327.49	1038.76	1345.10
10th %'tile	2.52	7.98	10.33
25th %'tile	4.91	15.58	20.17
50th %'tile	29.12	92.36	119.59
75th %'tile	63.12	200.20	259.24
90th %'tile	77.26	245.07	317.34
Std Dev	59.48	188.68	244.32
CV	1.39	1.39	1.39
For Top Quartile of SSB			
Mean	57.63	182.80	236.71
Median	64.11	203.34	263.31

Figure 3.13.2. Spawning stock (a), recruitment (age 1 millions, b), and scatterplot (c) for Acadian redfish. Data are the calculated spawning stock biomasses for various recruitment scenarios multiplied by the expected SSB per recruit for F0.1 and 50% MSP, assuming recent patterns of growth, maturity and partial recruitment at age (Table 3.13.1). Smoother in the stock-recruitment plot is lowess with tension = 0.5.

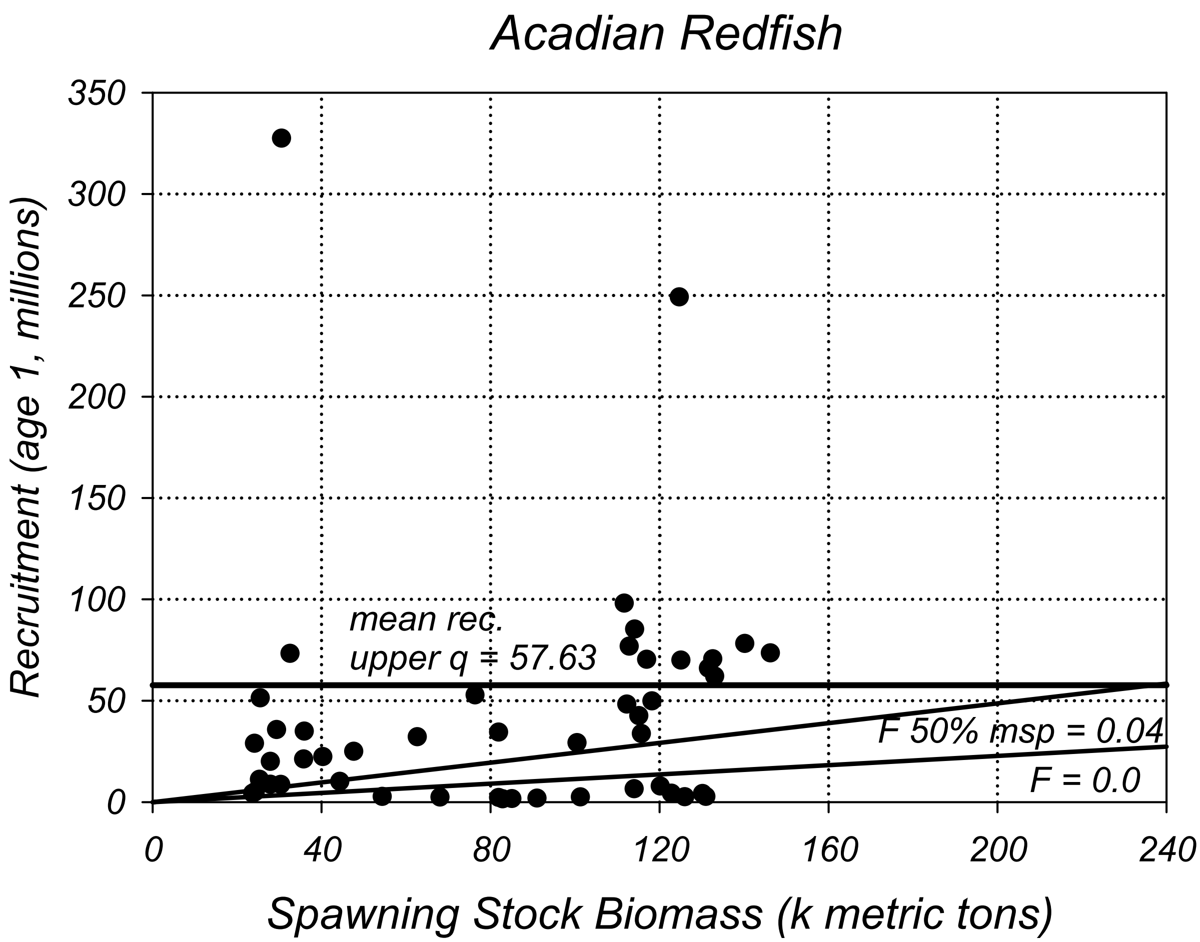

Figure 3.13.3. Stock and recruitment data for Acadian redfish, 1952-1999. For the empirical non-parametric approach the mean recruitment is plotted along with the replacement lines for F=0.0 and F 50% msp = 0.04.

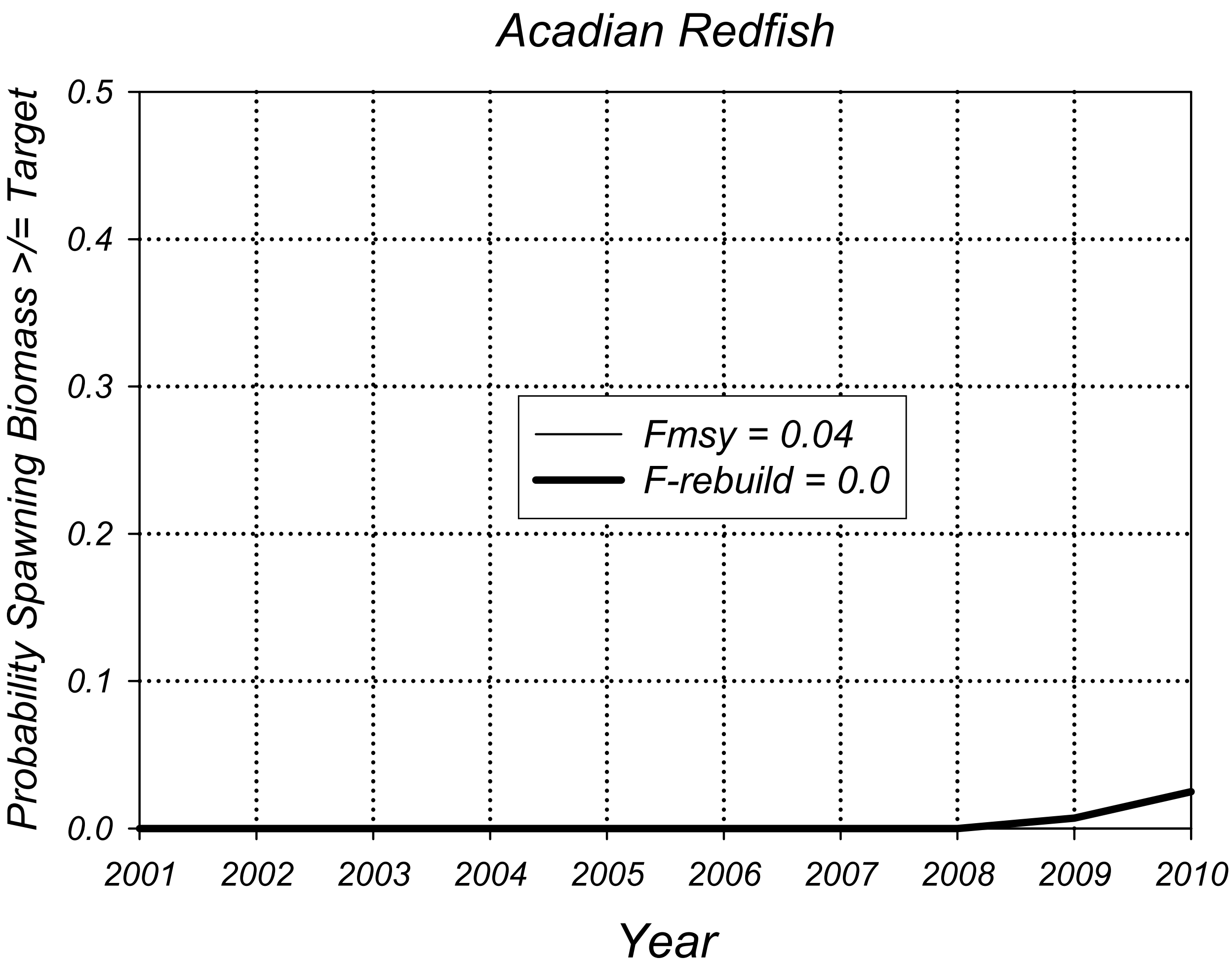

Figure 3.13.4. Probability that Acadian redfish spawning biomass will exceed Bmsy (236,700 mt) annually under two fishing mortality scenarios: Fmsy and F required to rebuild the stock to Bmsy by 2009.

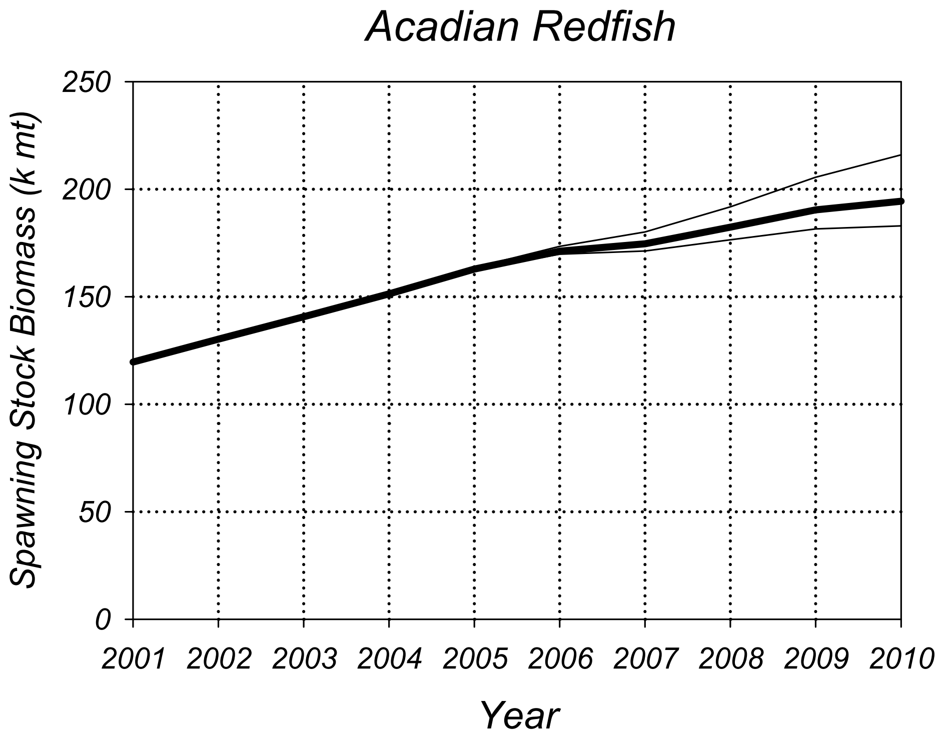

Figure 3.13.5. Median and 80% confidence interval of predicted spawning biomass for Acadian redfish F-rebuild fishing mortality rates.

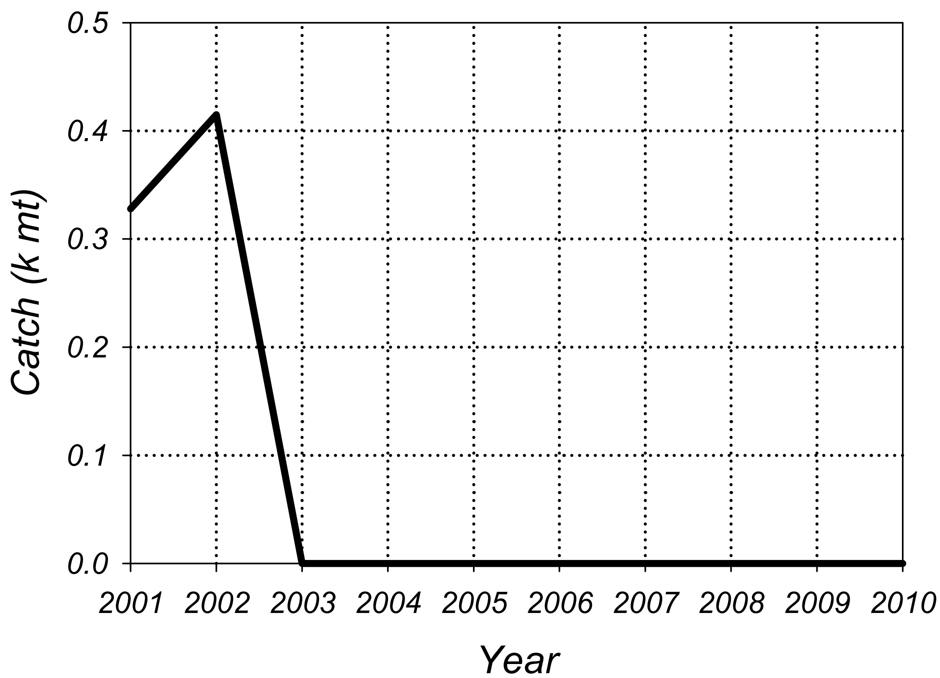

Figure 3.13.6. Median and 80% confidence interval of predicted catch for Acadian redfish under F-rebuild fishing mortality rates.