Appendix A12: Estimating Fishing Mortality (F) on Ages 8+ Striped Bass Based on Landings and Survey Indices from 1982 to 2006

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Introduction

Our ability to assess the current status of Atlantic coast striped bass has been continually plagued by a pronounced discrepancy between fully recruited (ages 8+) F and stock size estimates from tagging and the ADAPT VPA. Recent fishing mortality (F) estimates on fully recruited stripers based on tagging and the catch equation have remained relatively low ($F < 0.22$) (Versak 2007), whereas the 2005 and 2006 F estimates on ages 8+ based on ADAPT have exceeded 0.35. All ADAPT model runs conducted thus far have exhibited a pronounced retrospective bias for the terminal (most recent year) age 8+ F and stock size estimates. The ADAPT model almost always overestimated F and underestimated stock size for fully recruited fish in the last three to five years by as much as 50%. Such a large systematic bias in recent F and stock size estimates greatly confounds our ability to determine whether or not striped bass are currently overfished. Due to shortcomings in the ADAPT model, the Statistical Catch-At-Age (SCAM) model has been recently proposed (Nelson 2007) to replace ADAPT in an effort to reduce the magnitude of retrospective bias in F and stock size for fully recruited striped bass. Recent (2007) model runs with SCAM indicate that the degree of retrospective was lower than that from ADAPT, but the SCAM model still overestimated F and underestimated stock size for ages 8+ stripers in recent years (2003-2006) of the time series by 20% to 30%.

Given the uncertainty and controversy surrounding current F estimates on larger striped bass based on tagging (Versak 2007), ADAPT and SCAM, index based approaches (Sinclair 1998; Cotter et al 2004; Crecco 2004) may be needed to corroborate the 2005 and 2006 F, and perhaps provide more stable and reliable terminal F and stock size estimates for fully recruited striped bass. The Striped Bass Stock Assessment Subcommittee (SBSAS) has recommended that annual trends (year effects) in fishing mortality (F) and stock biomass from 1990 to 2006 be examined independently from the VPA.

In this report, an index based approach using relative F (RelFt) and relative stock size (RelNt) estimates was used on fully recruited (ages 8+) striped bass from 1982 to 2006. Relative F and stock size estimates were derived as a ratio of landings to several selected tuning indices that were considered informative about changes in fully recruited (ages 8+) stock size. The objectives of this report were: 1) compare the trends in the RelFt estimates from 1982 to 2006 to corresponding trends in average annual F estimates derived from both SCAM and the catch equation method, and 2) compare the trend in relative stock size estimates (RelNt) to ages 8+ stock sizes from SCAM (Nelson 2007) and the catch equation method (Versak 2007).

Methods

Approach

In this analysis, relative fishing mortality estimates (RelFt) were derived on fully recruited (ages 8+) striped bass from 1982 to 2006. The theoretical underpinnings of this approach is based on a simple re-arrangement of the Baranov catch equation (Ricker 1975, page 13, equation 1.17) with respect to F:

$$F = \text{Catch} / \text{Mean Stock Size}, \quad (1)$$

where: mean stock size is typically expressed as the average stock size in years t and t+1. RelFt estimates were based on the ratio of coast-wide annual (commercial and sport plus discards) landings (numbers) of ages 8+ stripers in year t (Catcht) to the corresponding average relative abundance index (RelNt, RelNt+1) in year t and t+1:

$$\mathbf{RelFt = Catcht / [(RelNt + RelNt+1)/2]. \quad (2)}$$

Equation (2) is very similar to the equation introduced earlier by Sinclair (1998) except that he used relative exploitation:

$$\mathbf{Relu = Catch/ RelNt \quad (3)}$$

rather than relative F. Because the 2007 RelNt index is not yet available, the RelNt+1 value ayear later in 2006 was assumed to be the same as the 2006 RelNt index. Relative F estimates via equation (2) do not consider temporal and spatial shifts in the age structure, so this approach is designed only to address relative changes in F across time (1982-2006). Thus, the RelFt values are uninformative about year-class and age-specific changes in F over the time series. The strength of the relative F method, however, is in its simplicity and intuitive appeal, allowing scientists to evaluate the relative accuracy of tuning indices and how they might affect the trend in F estimates. Most importantly, since RelFt estimates are expressed as a ratio of annual harvest to mean relative abundance, the trends in relative F are not confounded by the assumption of constant natural mortality (M = 0.15) used explicitly to derive F estimates (F = Z – 0.15) in the MARK, ADAPT and SCAM models.

The time series of landings and discards (Catcht, n*1000) of ages 8+ stripers (Table 2)in the numerator of equations (1-3) was taken from the 2007 stock assessment (see page). The tuning indices, used to measure striped bass relative abundance in the denominator of equations (2 and 3), were based one or more of the seven tuning indices used in SCAM (Nelson 2007). These indices (Table 1) include the 1991-2006 Massachusetts commercial cpue (ages 8+), 1982-2006 Connecticut **r**ecreational cpue (ages 3+) based on catch-effort from the MRFSS and annual Volunteer Angler Surveys, 1989-2006 New Jersey trawl cpue (ages 8+), 1996-2006 Delaware River cpue (ages 8+), 1985-2006 Maryland spring cpue (ages 8+), 1982-2006 Northeast Fisheries Science Center (NEFSC) trawl cpue (ages 2+), 1982-2006 MRFSS (sport1) cpue (ages 2+) of the coast-wide private boat fishery based on intercept data. One additional tuning index introduced by Des Kahn was also used. This consisted of the 1982-2006 coast-wide MRFSS cpue index (ages 2+) for the private boat fishery (sport2) using the expanded total catch and effort estimates (trips) rather than intercept data. An extensive description of these eight tuning indices is found elsewhere in the assessment report.

Selection of Informative Tuning Indices

Except for the sport2 data set derived recently by Des Kahn, all of the other abundance indices (Table 1) were used to tune SCAM. Many of the tuning indices, however, were poorly correlated to the catch-at-age matrix used in SCAM and therefore were not considered as informative indices of ages 8+abundance. Only four of the eight indices (Maryland cpue, Connecticut cpue and sport1 cpue and sport2 cpue) were linearly correlated ($P < 0.05$) to the 1982-2002 ages 8+ abundance (N8) estimates from SCAM (Table 3, Figures 1-8). Of the four, only the fisheries independent Maryland cpue time series was truly linearly related to ages 8+ abundance on the basis of residual patterns (Figure 5). The other three fisheries dependent indices (Connecticut cpue, sport1 cpue and sport2 cpue) were positively related to ages 8+ abundance from SCAM, but were curvilinear with respect to abundance after 2000 (Figures 6-8), suggesting that these fishery dependent indices are less reliable measures of relative abundance at high stock size.

As previously noted, high and persistent retrospective bias was clearly evident from SCAM (see Nelson 2007, Figures 12 and 13) particularly on recent (2003-2006) age 8+ F and abundance estimates. The degree of retrospective bias in SCAM appeared to decline for ages 8+ abundance prior to 2003. For this reason the assumption was made here that the 1982-2002 ages 8+ abundance estimates (N8) from SCAM were our best estimates of ages 8+ abundance, and therefore could be used as an objective basis to eliminate tuning indices that were not linearly correlated to ages 8+ abundance. It is clear that this regression approach to define informative indices using SCAM results is somewhat tainted by the fact that seven of the eight candidate indices were used to some extent to derive ages 8+ abundance from SCAM. Nevertheless, the magnitude and trend in ages 8+ abundance from SCAM are fairly robust to the choice of tuning indices (Gary Nelson MADMF pers comm.).

The choice of the 1982-2002 time series of ages 8+ abundance (N8) from SCAM (Table 2) as a time frame with which to ground truth the tuning indices is arbitrary. Moreover, retrospective bias in ages 8+ F and stock size was discernible as far back as the year 1999 (Nelson 2007). As a result, to further examine the sensitivity of the choice of tuning indices to the 1982-2002 time frame, the correlation analyses (Table 3) between tuning indices and ages 8+ abundance (N8) from SCAM were extended to include abundance estimates (N8) for the periods 1982-1999, 1982-2000 and 1982-2001.

Results of the correlation analyses that included tuning indices from the three additional time frames (1982-1999, 1982-2000 and 1982-2001) were similar to those from the previous analysis on the 1982-2002 time frame (Table 3). The same four indices, namely the Connecticut recreational cpue, both sport cpue indices (sport1 and sport2), and the Maryland spring cpue remained highly ($P < 0.0001$) correlated to ages 8+ abundance (N8) from SCAM for the periods 1982-1999, 1982-2000, 1982-2001 and 1982-2002. The results for the Massachusetts commercial index were sensitive to the chosen time frame of ages 8+ abundance (Table 3). The time series of Massachusetts commercial cpue indices was a poor indicator ($P <0.78$) of ages 8+ abundance for the periods 1982-2002 and 1982-2001, but were significantly correlated ($P <0.02$) to abundance from SCAM for the periods 1982-2000 and 1982-1999. This rapid shift in the correlation coefficient among time frames occurred because the relationship between the Massachusetts indices and ages 8+ abundance was strongly parabolic (Figure 1).

Based on the correlation results (Table 3), three tuning indices were chosen separately to express relative N (RelNt). They included the Connecticut cpue, the Maryland spring cpue and the sport2 cpue. The sport1 index based directly on intercept catch and directed fishing effort

was, in most cases, less strongly correlated to ages 8+ abundance than the sport2 index across the four time periods (Table 3). There were also clear periods of nonlinearity between sport1 and sport2 cpue and ages 8+ abundance after 2002 (Figures 6 and 7). The time series trends of sport1 and sport2 cpue are somewhat redundant since they were both derived from basically the same MRFSS catch and effort data. Thus only one of the MRFSS indices should be selected as an informative index of ages 8+ fish. For this reason, the time series of sport2 tuning indices was selected over the sport1 data set based on the overall strength of the correlation with ages 8+ abundance from SCAM (Table 3).

Ages 8+ Relative Abundance (RelNt) and Relative F (RelFt)

In this analysis, relative stock size (RelNt) of fully recruited stripers (ages 8+) was estimated from 1982 to 2006 based on the CT cpue, the MD cpue and the MRFSS cpue (sport2). The final RelFt and RelNt estimates were derived from 1982 to 2006 as the blended average relative F and N values from the three tuning indices. The relative abundance indices from the Connecticut, Maryland and sport2 data sets differed in magnitude across the time series (Table 1). For this reason, the Connecticut and sport2 indices were scaled to units of the Maryland indices in order to facilitate blending the indices. Since the time series of Maryland cpue indices began in 1985, the blended estimates of relative F and N from 1982-1984 were based solely on the scaled Connecticut and Sport2 cpue.

Results and Discussion

Relative Fishing Mortality (RelF) and Stock Size (RelN)

Relative fishing mortality estimates (RelFt) based on the ratio of landings to the Connecticut cpue index (Table 4) were derived from 1982-2006 (Table 4). These RelFt estimates declined steadily from 1982 to 1989, rose to a peak level in 2004 then relative F declined to pre-2002 levels in 2005 and 2006. When the Connecticut cpue data were used to index relative abundance (Table 4), RelNt estimates rose steadily from low levels in 1983 to peak levels in 2006.

Using the Maryland spring cpue index, relative fishing mortality and stock size estimates (Table 5) were derived from 1982-2006. Relative fishing mortality (RelF) estimates generally rose after 1989 but varied without trend thereafter (Table 5). When the Maryland spring cpue data were used to index relative ages 8+ abundance (Table 5), ages 8+ relative abundance rose steadily from low levels prior to 1995 to peak levels in 2006.

When sport 2 indices were used to express relative F and stock size (Table 6) from 1982 to 2006, the trends were very similar to those based on the Connecticut cpue (Table 4). Relative fishing mortality (RelF) estimates based on the sport2 indices rose to peak levels in 2004 then relative F declined slightly thereafter. When Sport2 cpue data were used to index relative abundance (Table 6), relative stock size generally rose from low levels prior to 1994 to peak levels in 2006.

Blended Ages 8+ Relative F and Abundance

Ages 8+ relative F and stock size estimates were derived as a blended average across the three indices (Table 7, Figure 9 and 10). Blended relative F estimates from 1982 to 2004 generally followed the same trend as absolute F estimates based on SCAM (Figure 9), although

the trend in the blended relative F estimates diverged substantially from SCAM F estimates in 2005 and 2006 (Table 7, Figure 9). The ages 8+ F estimates from SCAM continued to rise steadily from 2003 to a peak level of 0.31 in 2006, whereas the blended relative F estimates peaked in 2004 then dropped by 15 to 20% in 2005 and 2006.

Both the blended ages 8+ abundance and SCAM-based absolute abundance estimates rose steadily from about 1988 to 2004 (Table 7, Figure 10). After 2004, however, the trends in abundance changed dramatically between the two methods (Figure 10). The blended relative abundance estimates continued to rise beyond 2004 to peak levels in 2006, whereas the absolute abundance estimates from SCAM peaked in 2004 then fell by 15 to 20% in 2005 and 2006 (Figure 10). The results from this analysis suggest that the degree of retrospective bias in F and stock abundance from SCAM is largely confined to the most recent two (2005-2006) years of the time series.

The blended relative F and corresponding abundance estimates were also compared to tag-based F and abundance of ages 7+ fish based on the catch equation method (Versak 2007) from 1988 to 2006 (Table 7, Figures 9 and 10). Like the trend in the blended relative F values, the tag-based F estimates did not exhibit a steady rise in F beyond 2004 (Figure 9) as was clearly reflected by the SCAM F estimates (Figure 9). Moreover, ages 7+ abundance from tagging also rose fairly steadily from 1998 to peak levels in 2006 in a similar pattern as that exhibited by the blended relative stock estimates (Figure 10). The trends in relative F and stock size after 2002 are more consistent with trends in F and stock size from the catch equation method than those from SCAM.

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Appendix A12 Tables

Table 1. Time Series of Tuning Indices Used to Index Ages 8+ Stripers. Indices Include the MA Commercial (Ages 8+) CPUE, Connecticut (Ages 3+) Rec CPUE, New Jersey (Ages 8+) Trawl index, Delaware River Spawning (Ages 8+) Index, Maryland Spawning (Ages 8+) Index, Sport1 Ocean (Ages 2+) CPUE, Sport2 Coast-Wide (Ages 2+) CPUE and NMFS Trawl (Ages 2+) Index.

YEAR	MACOMM	CT3	NJTRWL	DESSN	MDSSN	Sport1	Sport2	NEFSC
1982		0.56					0.030	
1983		0.35					0.031	
1984		0.80					0.024	
1985		0.83			1.38		0.034	
1986		1.41			0.95		0.043	
1987		0.81			0.63		0.034	
1988		0.81			0.37	0.362	0.080	
1989		1.06	0.017		0.95	0.266	0.082	
1990		1.36	0.183		1.53	0.241	0.125	
1991	0.455	1.21	0.167		2.26	0.414	0.182	0.235
1992	0.628	1.46	0.007		2.43	0.749	0.257	0.237
1993	0.652	2.49	0.016		3.80	0.611	0.279	0.481
1994	0.614	3.27	0.028		1.56	0.908	0.562	1.394
1995	0.756	4.41	0.060		8.18	1.175	0.697	0.952
1996	0.842	6.57	0.026	3.01	6.32	1.333	0.794	0.602
1997	0.717	5.36	0.051	4.20	5.55	1.370	1.031	1.182
1998	0.665	6.96	0.263	7.67	12.38	1.715	1.050	0.729
1999	0.712	4.10	0.065	4.07	3.88	1.615	0.948	0.448
2000	0.751	6.12	0.192	4.65	10.39	1.511	0.969	1.274
2001	0.499	6.32	0.069	6.90	10.25	1.262	0.750	0.623
2002	0.535	4.19	0.224	5.16	10.90	1.053	0.885	0.981
2003	0.548	4.26	0.497	11.13	21.51	0.929	0.898	0.774
2004	0.634	6.61	0.417	11.10	23.60	1.009	0.985	0.335
2005	0.603	6.57	0.216	5.00	18.90	1.168	1.040	0.293
2006	0.719	10.76	0.471	7.80	29.20	1.387	1.282	0.628

Table 2. time series of ages 8+ fishing mortality (FSCAM) and stock size (N8T*1000) of stripers based on the SCAM model, ages 8+ landings (Catch*1000) in number and ages 7+ fishing mortality (FCAT) and stock size (NCAT) from the catch equation, 1982-2006.

YEAR	CATCH	FSCAM	N8	N8T	Fcat	Ncat
1982	79.5	0.45	463	463		
1983	34.5	0.42	333	333		
1984	21.0	0.32	245	245		
1985	39.2	0.21	232	232		
1986	53.6	0.15	337	337		
1987	32.3	0.08	412	412		
1988	60.8	0.15	495	495	0.06	1770
1989	49.3	0.11	628	628	0.04	2830
1990	118.2	0.12	1375	1375	0.08	1996
1991	205.1	0.11	1918	1918	0.18	1526
1992	200.3	0.09	2329	2329	0.10	1715
1993	294.0	0.11	2621	2621	0.12	2177
1994	340.5	0.13	3052	3052	0.08	3728
1995	514.8	0.18	3496	3496	0.15	3308
1996	523.5	0.20	3865	3865	0.16	4869
1997	912.6	0.24	4498	4498	0.27	4397
1998	800.1	0.20	4372	4372	0.24	3739
1999	747.2	0.17	4421	4421	0.23	3921
2000	737.1	0.22	4982	4982	0.14	7454
2001	1012.1	0.20	6934	6934	0.14	9339
2002	941.6	0.19	7133	7133	0.15	11371
2003	1404.2	0.24		7669	0.16	12168
2004	1873.7	0.26		8028	0.16	14727
2005	1708.9	0.29		6927	0.19	11865
2006	1781.3	0.31		5915	0.15	12852

Table 3. Pearson Correlation (r) Analyses between relative abundance (cpue) of each of the eight candidate tuning indices and ages 8+ abundance from SCAM. This analysis was conducted on ages 8+ abundance over four time periods (1982-2002, 1982-2001, 1982-2000, 1982-1999). An asterisk (*) indicates a statistically significant ($P < 0.05$) correlation between the tuning index and ages 8+ abundance.

Index	Time Periods (Years)			
	82-02	82-01	82-00	82-99
MaCOMM	-0.12	0.08	0.70*	0.69*
NJtrwl	0.32	0.13	0.22	0.08
DESSN	0.42	0.54	0.26	0.44
MDSSN	0.87*	0.84*	0.81*	0.77*
Sport1	0.76*	0.85*	0.95*	0.95*
Sport2	0.90*	0.91*	0.97*	0.96*
NEFSC	0.36	0.32	0.56	0.44
CT cpue	0.87*	0.92*	0.92*	0.91*

Table 4. Time series of relative fishing mortality (RefF1) and relative stock size (CTsc) on ages 8+ stripers based on landings and the Connecticut CPUE index from 1982-2006.

YEAR	CATCH	ctsc	ctscl	RelF1
1982	79.50	1.27	0.79	77.31
1983	34.50	0.79	1.81	26.55
1984	21.00	1.81	1.88	11.40
1985	39.20	1.88	3.19	15.49
1986	53.60	3.19	1.83	21.37
1987	32.30	1.83	1.83	17.64
1988	60.80	1.83	2.40	28.77
1989	49.30	2.40	3.07	18.03
1990	118.20	3.07	2.73	40.70
1991	205.10	2.73	3.30	67.98
1992	200.30	3.30	5.63	44.88
1993	294.00	5.63	7.39	45.17
1994	340.50	7.39	9.97	39.24
1995	514.80	9.97	14.85	41.49
1996	523.50	14.85	12.11	38.83
1997	912.59	12.11	15.73	65.55
1998	800.10	15.73	9.27	64.02
1999	747.20	9.27	13.83	64.70
2000	737.10	13.83	14.28	52.44
2001	1012.10	14.28	9.47	85.22
2002	941.55	9.47	9.63	98.61
2003	1404.19	9.63	14.94	114.32
2004	1873.69	14.94	14.85	125.81
2005	1708.88	14.85	24.32	87.26
2006	1781.32	24.32	24.30	73.28

Table 5. Time series of relative fishing mortality (RelF2) and relative stock size (MDSNN) on ages 8+ stripers based on landings and the Maryland CPUE index from 1985-2006.

YEAR	CATCH	MDSSN	mdSsnl	RelF2
1982	79.50			
1983	34.50			
1984	21.00		1.38	
1985	39.20	1.38	0.95	33.66
1986	53.60	0.95	0.63	68.11
1987	32.30	0.63	0.37	64.93
1988	60.80	0.37	0.95	92.26
1989	49.30	0.95	1.53	39.69
1990	118.20	1.53	2.26	62.29
1991	205.10	2.26	2.43	87.50
1992	200.30	2.43	3.80	64.35
1993	294.00	3.80	1.56	109.68
1994	340.50	1.56	8.18	69.90
1995	514.80	8.18	6.32	71.01
1996	523.50	6.32	5.55	88.24
1997	912.59	5.55	12.38	101.82
1998	800.10	12.38	3.88	98.41
1999	747.20	3.88	10.39	104.69
2000	737.10	10.39	10.25	71.40
2001	1012.10	10.25	10.90	95.69
2002	941.55	10.90	21.51	58.11
2003	1404.19	21.51	23.60	62.26
2004	1873.69	23.60	18.90	88.17
2005	1708.88	18.90	29.20	71.06
2006	1781.32	29.20	29.20	61.00

Table 6. Time series of relative fishing mortality (RelF3) and relative stock size (SPORT2sc) on ages 8+ stripers based on landings and the sport2 CPUE index from 1982-2006.

YEAR	CATCH	SPORT2SC	sport2scl	RelF3
1982	79.50	0.46	0.48	168.60
1983	34.50	0.48	0.37	81.15
1984	21.00	0.37	0.53	46.84
1985	39.20	0.53	0.66	65.86
1986	53.60	0.66	0.53	90.05
1987	32.30	0.53	1.24	36.65
1988	60.80	1.24	1.27	48.55
1989	49.30	1.27	1.93	30.81
1990	118.20	1.93	2.81	49.81
1991	205.10	2.81	3.97	60.44
1992	200.30	3.97	4.31	48.34
1993	294.00	4.31	8.69	45.22
1994	340.50	8.69	10.78	34.99
1995	514.80	10.78	12.28	44.67
1996	523.50	12.28	15.94	37.11
1997	912.59	15.94	16.23	56.73
1998	800.10	16.23	14.66	51.81
1999	747.20	14.66	14.98	50.42
2000	737.10	14.98	11.60	55.47
2001	1012.10	11.60	13.68	80.08
2002	941.55	13.68	13.88	68.31
2003	1404.19	13.88	15.23	96.47
2004	1873.69	15.23	16.08	119.70
2005	1708.88	16.08	19.82	95.21
2006	1781.32	19.82	19.82	89.88

Table 7. Overall average fishing mortality and stock abundance (n*1000) ages 8+ stripers based on SCAM (FSCAM, N8T) and the catch equation (FCAT, NCAT) compared to average RELF (AVRELF) and stock size (AVRELN) by the three blended tuning indices, 1982-2006.

YEAR	AVRELF	FSCAM	Fcat	AVRELN	N8T	Ncat
1982	122.96	0.45		0.86	463	
1983	53.85	0.42		0.64	333	
1984	29.12	0.32		1.09	245	
1985	38.34	0.21		1.26	232	
1986	59.84	0.15		1.60	337	
1987	39.74	0.08		0.99	412	
1988	56.53	0.15	0.06	1.15	495	1770
1989	29.51	0.11	0.04	1.54	628	2830
1990	50.93	0.12	0.08	2.18	1375	1996
1991	71.97	0.11	0.18	2.60	1918	1526
1992	52.52	0.09	0.10	3.23	2329	1715
1993	66.69	0.11	0.12	4.58	2621	2177
1994	48.04	0.13	0.08	5.88	3052	3728
1995	52.39	0.18	0.15	9.64	3496	3308
1996	54.73	0.20	0.16	11.15	3865	4869
1997	74.70	0.24	0.27	11.20	4498	4397
1998	71.41	0.20	0.24	14.78	4372	3739
1999	73.27	0.17	0.23	9.27	4421	3921
2000	59.77	0.22	0.14	13.07	4982	7454
2001	87.00	0.20	0.14	12.04	6934	9339
2002	75.01	0.19	0.15	11.35	7133	11371
2003	91.02	0.24	0.16	15.01	7669	12168
2004	111.23	0.26	0.16	17.92	8028	14727
2005	84.51	0.29	0.19	16.61	6927	11865
2006	74.72	0.31	0.15	24.45	5915	12852

Appendix A12 Figures

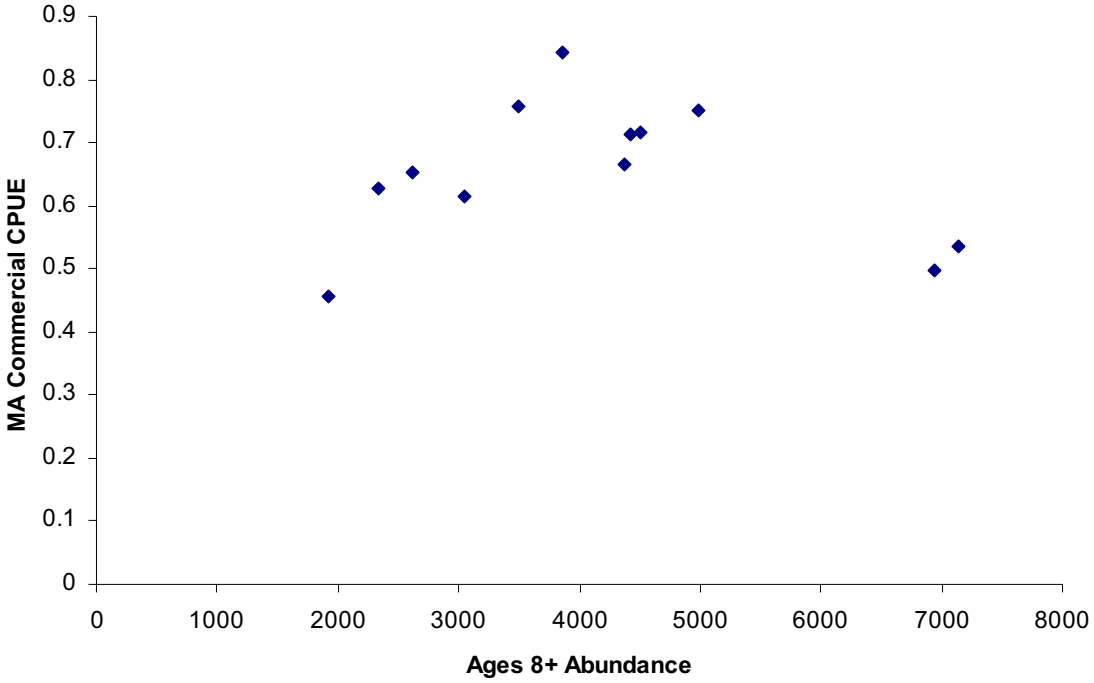

Figure 1. MA Commercial CPUE (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

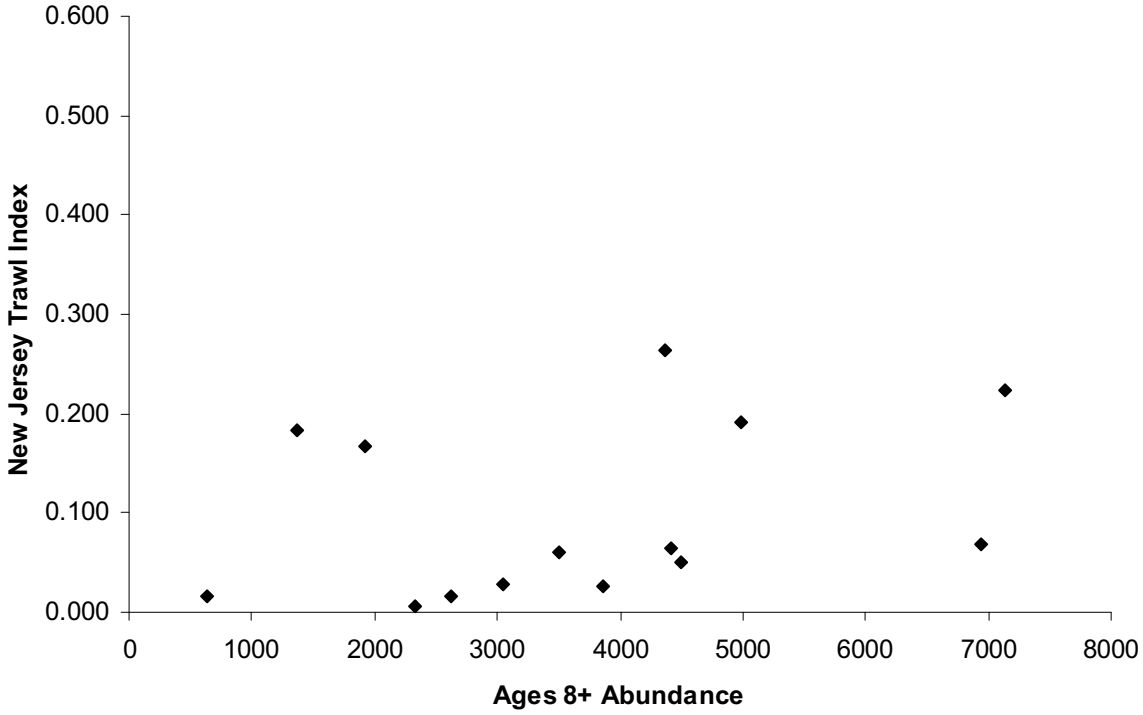

Figure 2. New Jersey Trawl Index (Ages 8+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

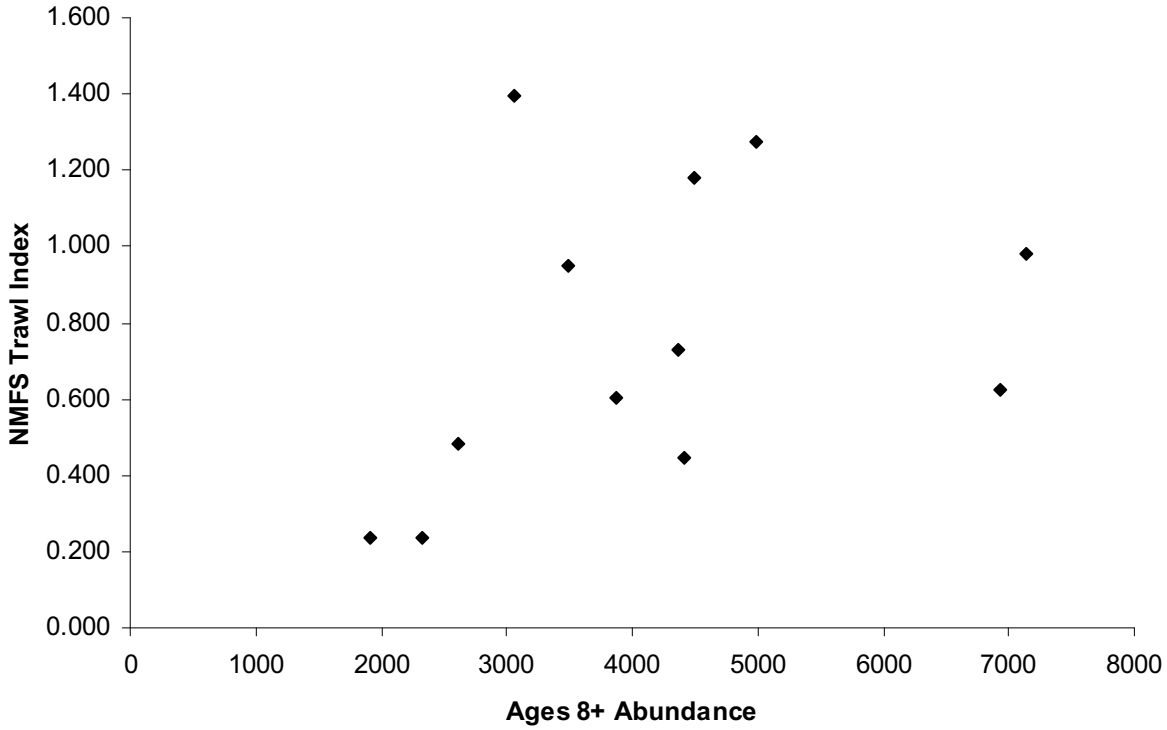

Figure 3. Delaware Spawning Stock Index (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

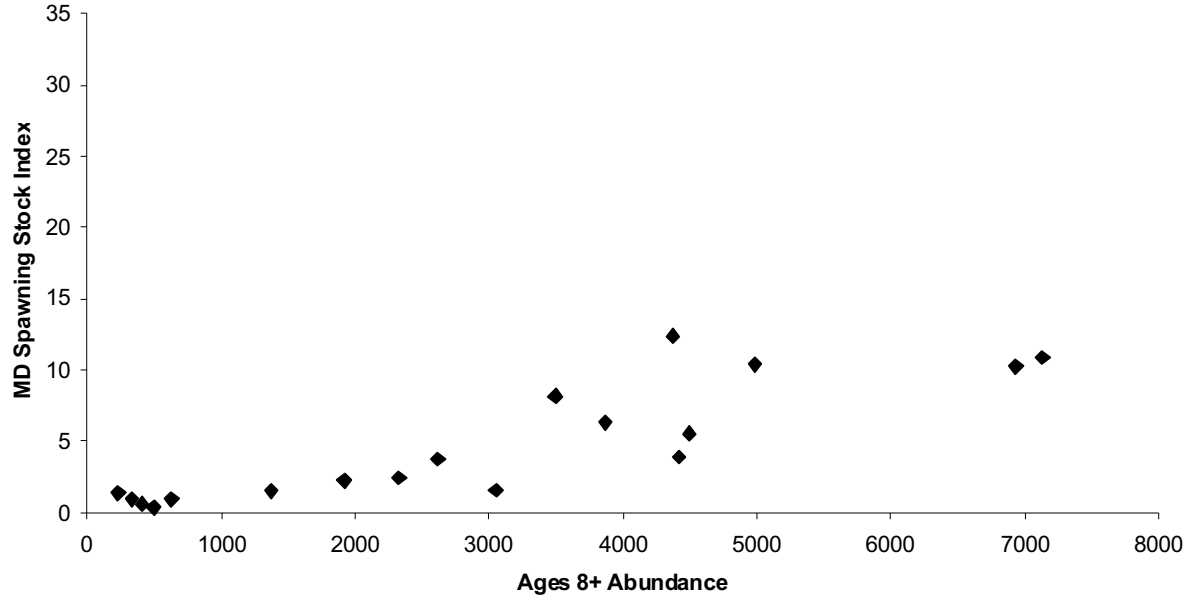

Figure 4. NMFS Trawl Index (Ages 2+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

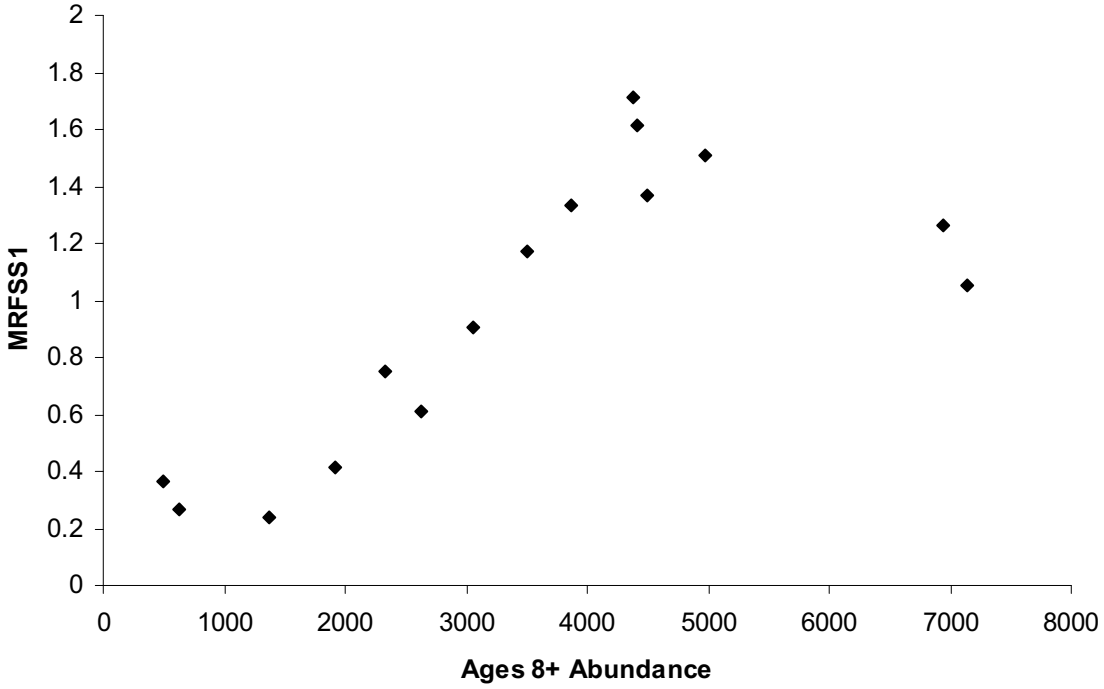

Figure 5. Maryland Spawning Stock Index (Ages 8+) plotted against age 8+ abundance based on SCAM model1982-2002

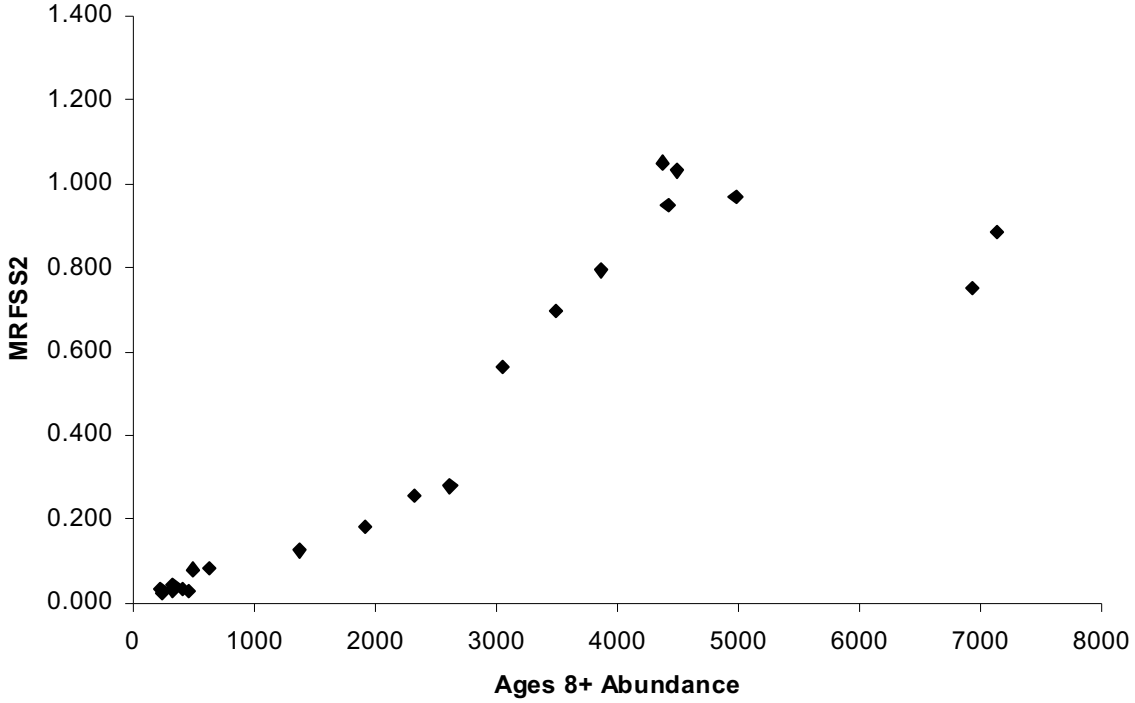

Figure 6.Sport1 CPUE Index based (ages 2+) on private boat intercepts plotted against ages 8+ abundance based on SCAM model, 1982-2002

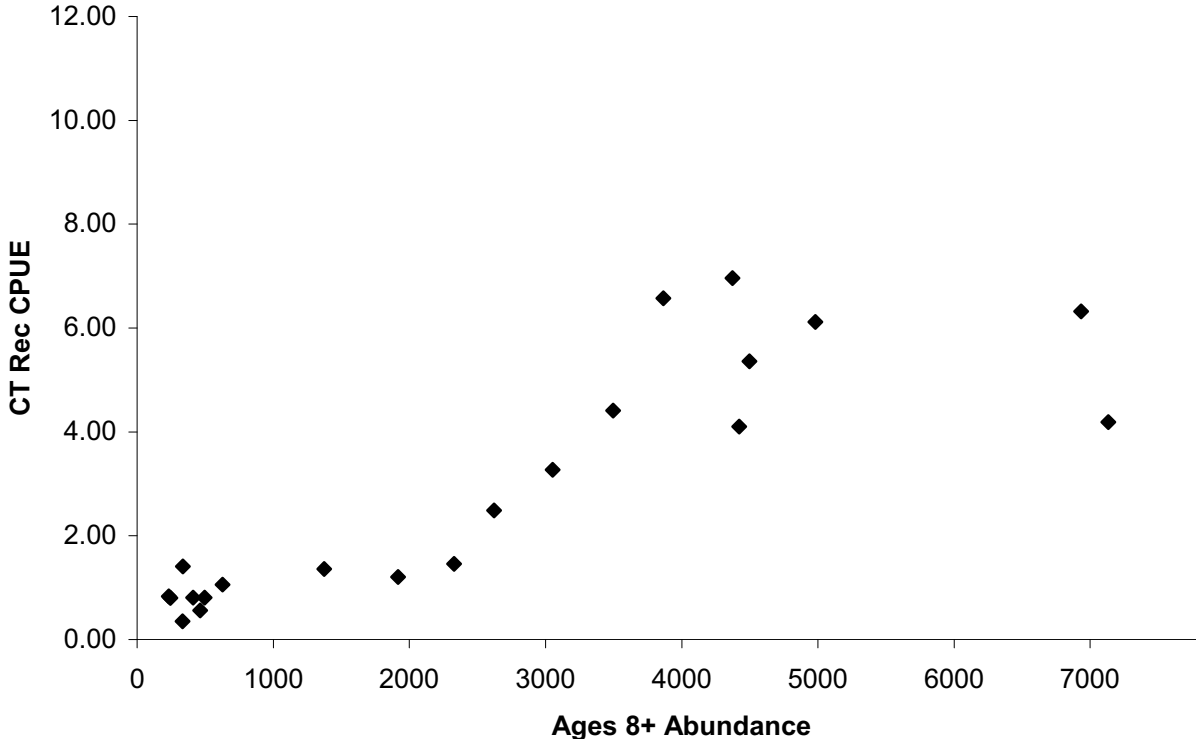

Figure 7. Sport2 CPUE Index based (ages 2+) on private boat data from north and mid-Atlantic combined plotted against ages 8+ abundance based on SCAM model, 1982-2002

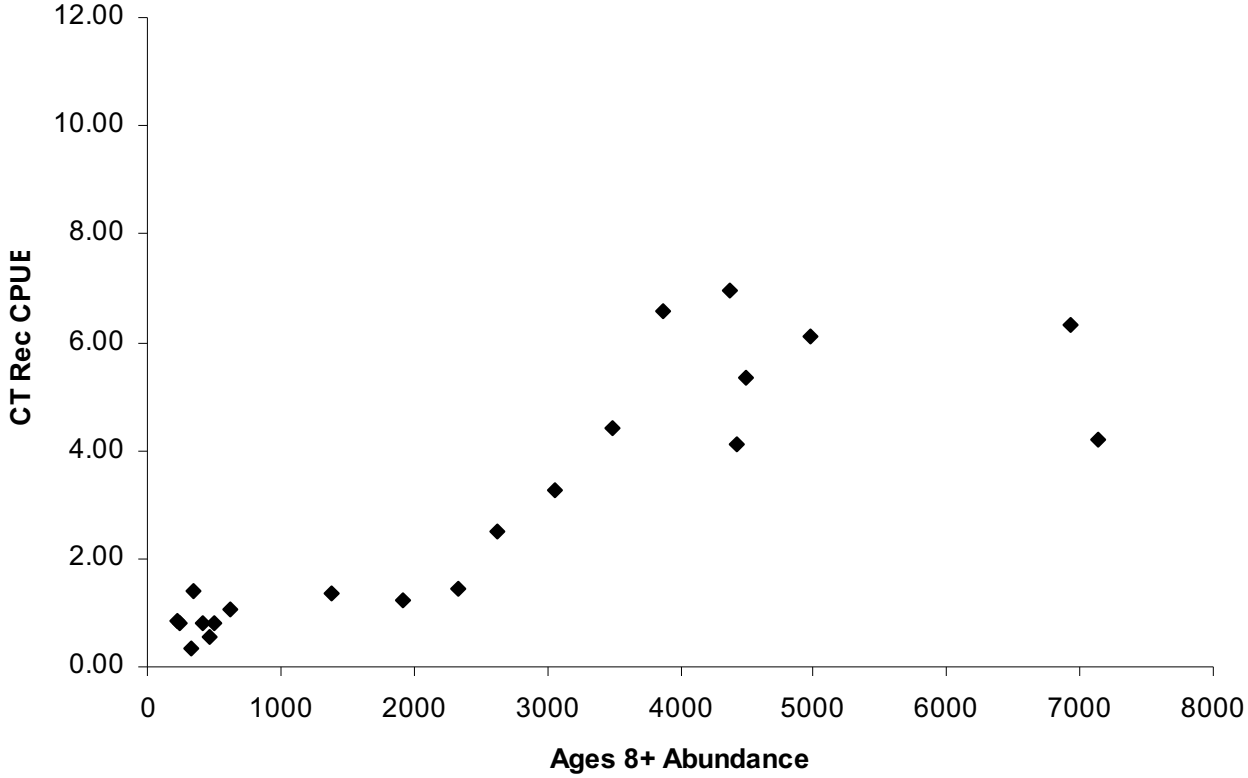

Figure 8. Connecticut Recreational CPUE (ages 3+) based on volunteer angler survey plotted against ages 8+ abundance based on SCAM model, 1982-2002

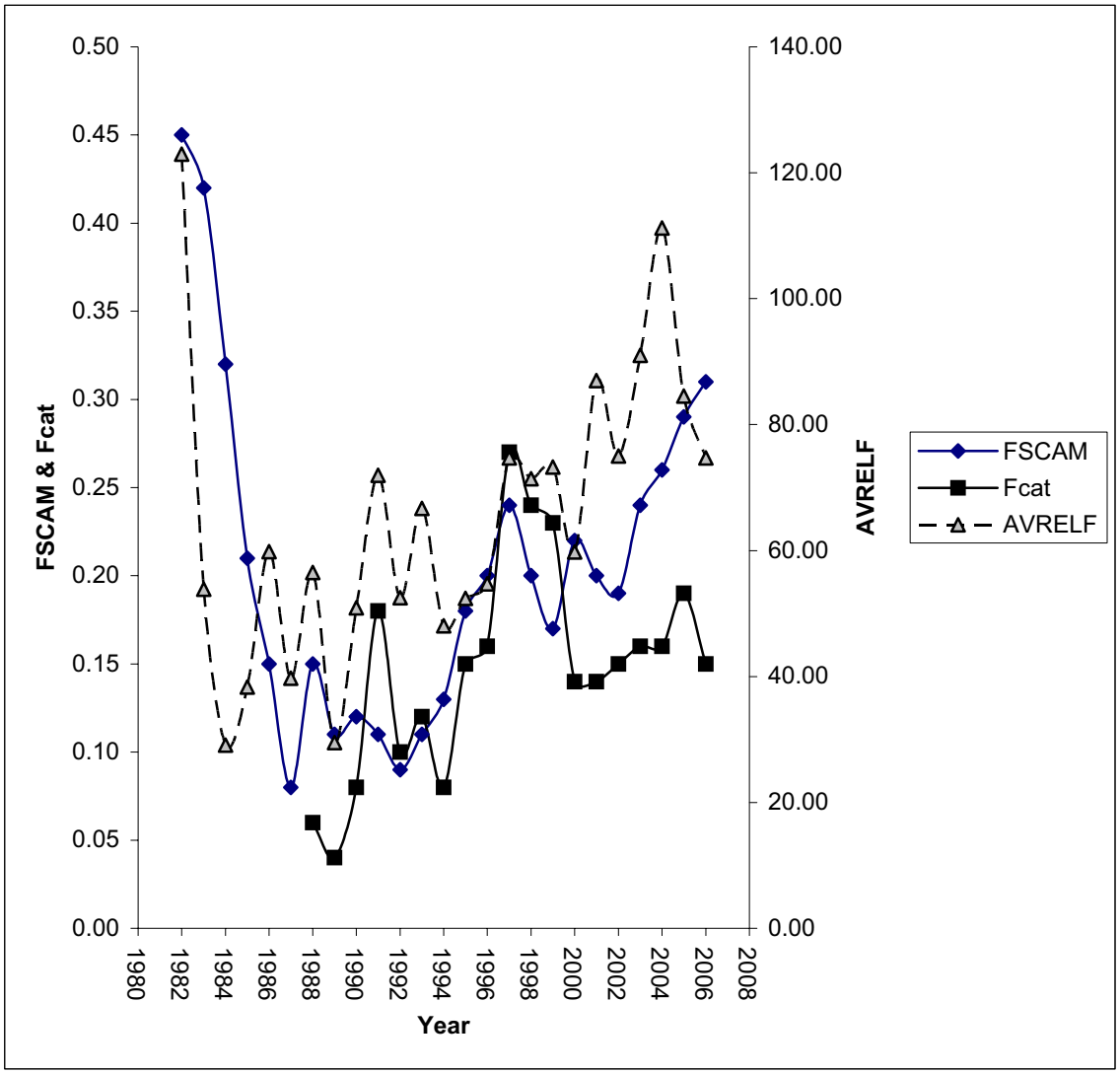

Figure 9. Comparison among the blended relative F (AVRELF), F from SCAM (FSCAM) and the F from the catch equation (Fcat) from 1982 to 2006

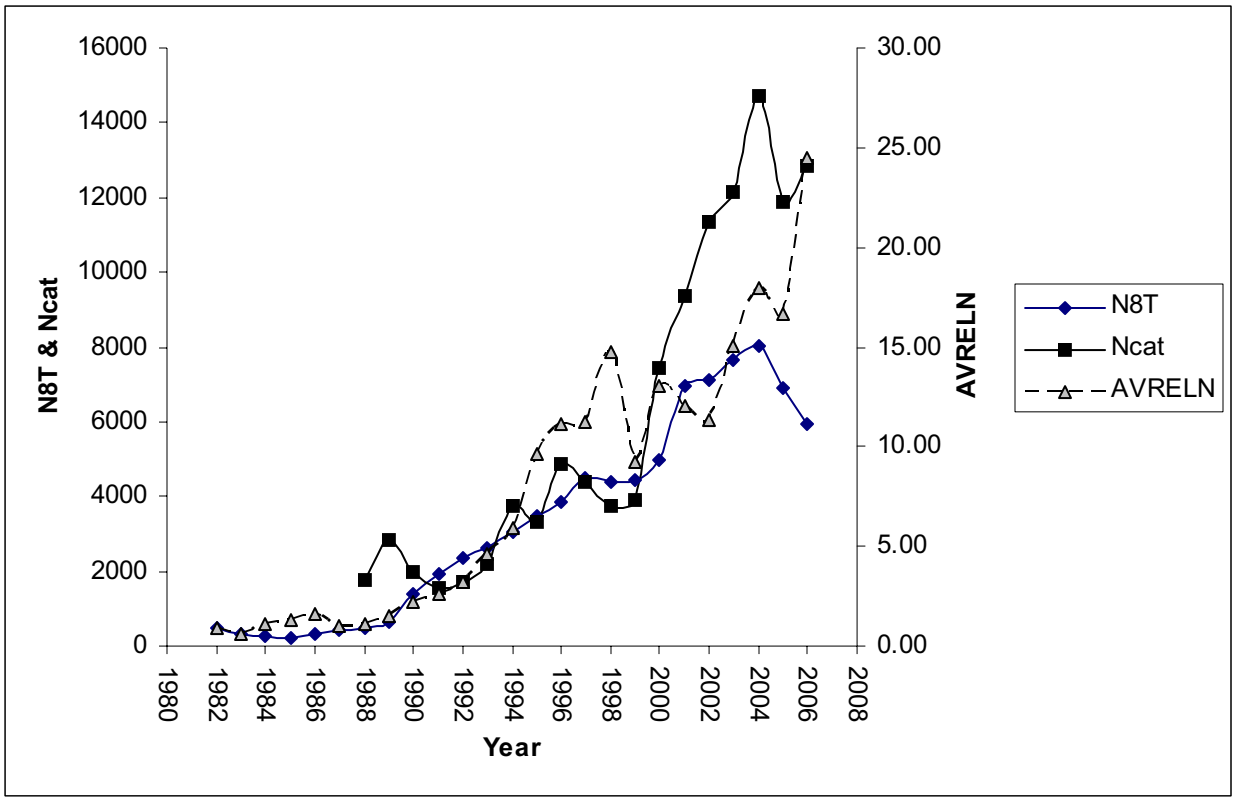

Figure 10. Comparison among the blended relative stock size (AVRELN), stock size from SCAM (N8T) and stock size from the catch equation (Ncat) from 1982-2006.