STOCK ASSESSMENT OF WEAKFISH THROUGH 2000, INCLUDING ESTIMATES OF STOCK SIZE ON JANUARY 1, 2001

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INTRODUCTION

Weakfish range along the Atlantic coast from Florida up to the southern Gulf of Maine. The management unit is the entire Atlantic coast population. Currently, studies are underway in Florida to determine whether the species in that state is actually the sand seatrout, *Cynoscian arenarius.*

Life History

Using otoliths, the maximum age of any weakfish examined to date has been 17 years (Lowerre-Barbieri et al. 1995). Currently the species is considered to achieve an average maximum age of 12 years by the Technical Committee. Growth is relatively slow, with the world record fish weighing over 19 lbs. Recent studies in North Carolina and Delaware Bay found that 90 per cent of weakfish became sexually mature at age one. Spawning usually occurs in estuaries from late spring through late summer, although in southerly locations, weakfish are reported to spawn in the ocean. Weakfish are batch spawners. Consequently, age-specific fecundity is difficult to estimate (Lowerre-Barbieri et al. 1995).

Fishery Description

Weakfish are harvested both commercially and recreationally, with the former dominating landings historically. In estuaries, commercial gears include trap nets, gill nets, long haul seines, beach seines and hook-and-line. In the ocean, trawls and gill nets are dominant gears. Weakfish aggregate in the winter winter off the coasts of Virginia, North Carolina and more southern waters, and are harvested by gillnets and flynet trawlers in oceanic waters of North Carolina. In spring, weakfish move north and into estuaries. In coastal waters, gill nets are employed during the northern migration. Pound nets and gill nets are important gears in Chesapeake Bay. In Delaware Bay, gill nets are the major gear. In New Jersey, New York and Rhode Island, pound nets or other trap nets are again important, along with gill nets and otter trawls. In the fall, as weakfish migrate south, they are targeted with gill nets and otter trawls in New Jersey and Maryland coastal waters.

From spring through fall, weakfish are important recreational targets in the Mid-Atlantic and south through North Carolina. In periods of peak abundance, southern New England states have also seen high catches. Recreational catches are primarily estuarine.

Regulations

Amendment 3 to the FMP (Lockhart et al. 1996) was designed to restore the stock under the mandatory measures introduced by the Atlantic Coastal Fisheries Cooperative Management Act. The plan included a scheduled reduction in fishing mortality rates to a level of F = 0.5 by 2000, and included goals of restoration of historic age structure and geographical range.

Current regulations under Amendment 3 to the Fishery Management Plan include a 12 inch minimum size for commercial landings with an exemption for inland gear types such as haul seine and pound net. States have been required to implement either effort reductions or area closures for their commercial fisheries. Minimum mesh size requirements, in effect for gill net and trawl gears, are designed to retain less than 25% of weakfish less than 12 inches (L25). Bycatch reduction devices (BRDs) have been required for shrimp fisheries along the southern Atlantic coast to reduce mortality of young weakfish. BRDs must demonstrate at least a 40% reduction in weakfish mortality. Recreational regulations include a suite of combinations of minimum size and possession limits. The lowest minimum size, 12 inches, is paired with a 4 fish possession limit. If the minimum size is 16 inches or higher, no possession limit is required under the FMP. The most common regulation currently employed by states is a 14 inch minimum size and a 10 to 14 fish possession limit.

Currently, the Atlantic States Marine Fisheries Commission Weakfish Management Board is developing Amendment 4 to the Fishery Management Plan, with new proposals for recreational regulations, among other issues. The Amendment is scheduled for adoption in the fall of 2002.

Previous Stock Assessment

In 1999, the ASMFC Weakfish Stock Assessment Subcommittee presented the assessment through 1998 to the Stock Assessment Review Committee for a peer review at the Northeast Fisheries Science Center at Woods Hole, Massachusetts. The assessment as reviewed was included in the report of the 30th Northeast Regional Stock Assessment Workshop (NMFS, 2000). The Stock Status summary of that report stated that weakfish were "at a high level of abundance and subject to low fishing mortality rates." The assessment found biomass had increased rapidly from a low point in the early 1990s and that recruitment had been above average since 1993. Fishing mortality in 1998 was estimated at 0.21, although retrospective analysis indicated that F was probably underestimated and abundance was probably overestimated.

This report updates the assessment with the 1999 and 2000 data. Due to additional analyses, this report alters some of the specifics of the Advisory Report: 2002 Weakfish Stock Assessment (Anonymous, 2002) and supersedes that report. Readers should also consult the risk assessment based on the results in this report by Uphoff (2002).

DATA SOURCES

Commercial Catches

The 1999 catch-at-age estimates were provided in Vaughan (2000); methods are described therein. For the 2000 catch-at-age estimates, commercial landings by gear and month were obtained from states directly or from the National Marine Fisheries Service in the case of New Jersey and New York. Catch at age estimates were developed for each state, because of differing minimum size regulations in each state adopted since Amendment 3 came into effect. Previously, catch at age estimates had been developed by region. North Carolina, Virginian and Delaware produced their own catch-at-age estimates, which were summed as part of the coast-wide catch-at-age estimate. Virginia, Delaware and Rhode Island developed their own gear-specific length frequency distributions. Maryland data was developed into length frequencies for pound net catches in Maryland. In all cases, catch-at-age estimation was done separately for the first half of the year and the second half of the year. The catch at age for each half year was then combined.

North Carolina derived catch at age estimates for nearly all of its landings, excluding only miscellaneous gear catches remained to be included. This included channel net, skimmer, crab and shrimp trawl, crab and miscellaneous pot, hook and line and trolling gear. On advice of the NC DMF personnel, the length frequency distribution of the North Carolina sciaenid pound net was employed to represent these landings, with a mean weight of 0.612 lbs. North Carolina DMF supplied an appropriate age-length key. Because length samples were absent from the 2000 New York and New Jersey commercial landings, length frequencies from other states were substituted. For pound net and trawl landings, pooled length frequencies from the 2000 Virginia, Maryland and Rhode Island pound net samples (floating trap net in Rhode Island) were employed. Gill net length frequencies from the 2000 Virginia and Delaware samples were pooled for estimation of gill net catch-at-age from New Jersey and New York. When pooled, length frequencies were weighted by the landings of the state.

For the 2000 catch at age matrix, commercial catch at age was estimated by the following procedures for the states of Maryland, New Jersey, New York and Connecticut. Other states supplied their own estimates of catch at age. Length frequencies were developed by state so that minimum sizes in New Jersey (13 inches for most landings) and New York (16 inches) were applied to the length frequency distributions. These minimum sizes concentrated the catch at age estimates for those states in the larger, older ages. This procedure had not been followed for previous years. These minimum sizes only came into effect in the mid-1990s with Amendment 3 to the ASMFC Weakfish Management Plan and the ensuing regulatory changes by individual states.
To allocate landings among lengths, lengths were converted to weight using a length-weight equation, developed from length-weight data supplied by the states. This procedure was followed for north regional landings, so the north early equation was Weight (lbs) = 0.000203 * Length $(cm)^{3.1969}$, and the north late equation was Weight (lbs) = 0.000237 * $Length(cm)^{3.1359}$. The frequencies at length then became the frequencies for each mean weight. Frequencies were then converted to proportions at length. The total

landings for a gear-state-season were multiplied by these proportions to give the landings at each length. Landings at each length were then divided by the mean weight at that length to convert from pounds into numbers of fish at length. The catch at length was then converted into the catch at age by means of an age-length key.

Otolith age-length data was contributed by North Carolina, Virginia, Maryland and Delaware (Table 1). A north regional and south regional division was employed, with the northern region including Virginia and states to the north. Four age-length keys were developed, a north early key (January-June), a north late key (July-December), a south early key and a south late key. Because the North Carolina Division of Marine Fisheries developed its own catch-at-age estimate (K. West, personal communication), the south keys were only applied commercially to Florida catches, as well as to the SEAMAP survey lengths for 2000.

Commercial hook and line landings were estimated with MRFSS recreational length frequencies and recreational keys (see below). No data is available on commercial discards and no estimates were attempted.

Recreational Catches

Recreational landings and discard data were obtained from the Marine Recreational Fisheries Statistics Survey (MRFSS) of the National Marine Fisheries Service (NMFS) by region and wave (Table 2). Length frequency distributions by wave and region were also obtained from MRFSS. There was no length data available for the New England states. These distributions were developed into four regional and seasonal length frequency distributions: north early, north late, south early, and south late. When proportional length frequency distributions from each wave were pooled for a given regional-seasonal distribution, each wave's values were weighted by the Type A landings for that wave. The pooled distributions for each of the four were in terms of proportions at length. Because the length distributions were obtained from only a portion of the recreational landings (Type A), the proportions at length were then multiplied by the Type A harvest per wave to convert to numbers at length.

The length data for commercial use were in centimeters, but recreational data length frequencies are in inches. Age-length data were developed into two sets of age-length keys, one set in centimeters for commercial data and one set in inches for the recreational data. Four keys were developed in each set: a north-early key, a north-late key, a south-early key and a south-late key. For the recreational landings, these were then applied to the four length frequency distributions: north-early, north-late, south-early and south-late to develop catch at age estimates. These estimates of number at age were then converted to proportion at age. Total losses for a regional-seasonal combination was estimated by adding the Type A + B1 estimate of number harvested to the estimated discards. Discards were estimated by multiplying the released catch (B2) by the assumed hook-and-release mortality rate of 0.20. Because data on discard length frequencies was available only from Connecticut, the discards were assumed to have the same length distribution as the harvest. The total losses (harvest plus discards) were then multiplied by the estimated proportions at age to develop the recreational catch at age estimate.

Fishery-Independent Surveys

Four fishery independent age-structured adult trawl surveys were employed as tuning indices in the ADAPT Virtual Population Analysis (VPA). These trawl surveys comprised the New Jersey coastal survey, the Delaware survey in Delaware Bay, the NMFS fall inshore survey and the fall SEAMAP coastal survey (North Carolina waters only). The SARC recommended that the VPA be tuned by survey indices only from the core areas (New Jersey through North Carolina). For full description of these surveys, see Weakfish in the 30th Northeast Regional Stock Assessment Workshop (NMFS 2000). Index values have changed since then, however.

One change from the 1998 assessment was the inclusion of the fall SEAMAP survey. Since North Carolina is in the core area, the indices were revised to include only data from the North Carolina portion of the survey. A second change was that we restricted the NMFS survey data to strata in which weakfish had been regularly caught (Wenner and Gregory 2000). A third major change for all the age-structured tuning indices was that the survey length-frequencies were now aged with age-length data collected on the cruise itself in the same year as the length-frequency data, as opposed to use of pooled regional age-length data. In some years, no age-length data were collected on a given survey, and in those cases we used the pooled regional data to convert lengths to ages. A fourth change was the alignment for the Delaware survey, which had been lagged, so it now tunes the year in which the data was collected. The other surveys are conducted in the fall, so they are lagged to tune the January 1 abundance of the following year. In contrast, the Delaware survey runs from monthly from March through December. The length-frequency distributions from the NMFS survey were re-aged for 1996 through 2000 with age-length data collected on the survey. For previous years, the same proportions-at-age used in the SARC-approved run were multiplied by the new catch-per-tow value. The new mean catch-per-tow values were obtained from strata from northern New Jersey south to Cape Hatteras in depths less than 27 meters (Wenner and Gregory 2000). Since these are the strata from which consistent weakfish catches, the mean catch-per-tow is higher than the older values.

The New Jersey survey was re-aged in recent years, employing either age-length data collected specifically on the cruise or age-length data from the nearby Delaware survey to convert lengths to catch-at-age indices. For 1994-1997, age-length samples collected on the survey were employed to develop the indices. Previously, the pooled regional keys were used to age length frequencies from the survey catches. The 1999 and 2000 indices were developed using age-length samples from the nearby Delaware survey. The 1998 values and those prior to 1994 are still based on the pooled key (the 1998 values were unintentionally left unchanged).

Length frequency distributions and mean catch-per-tow data from the fall SEAMAP survey were developed from the NC station catches exclusively (Charles

Wenner, SC DNR, personal communication). Age-length samples collected on the survey were used to age the catches for 1991-1993, 1995-1996 and 1999. Regional pooled keys were employed for remaining years, in which no age-length data were collected on the survey (1990, 1994, 1997-1998 and 2000).

Weight-at-age

Mean weights at age for 1982-1999 were developed by estimating a Von Bertalanffy growth model for each year from age-length data with L_{inf} set at 31.6 inches (D. Vaughan, NMFS, personal communication). The 2000 weights at age were assumed equal to those in 1999 (Table 3). Estimates of mean weight at age were highest in 1990-1993, declined during 1994-1998, and then increased somewhat for ages 3+ in 1999. Mean weight of fish caught in the recreational harvest has been increasing (Figure 1).

Natural Mortality

As recommended by the Stock Assessment Review Committee during the 26th Northeast Regional Stock Assessment Workshop, M = 0.25 (NEFSC 1998).

RESULTS

Catch-at-Age Matrix

The most abundant age in the catch in 2000 was age 5, the 1995-year class of the 7,684,379 weakfish in the 2000 catch-at-age (Table 4). Age 6+ fish constituted 6.1% of the total number. The oldest age in the 2000 samples was 9 years. Commercial catch was 61% by number, and recreational catch, including estimated discard mortality, was 39% of the total. While the commercial landings in weight has always been larger than the recreational landings, data for 2000 show the two sectors are almost equal in landings by weight (Figure 2). The estimated total number of weakfish harvested or lost as recreational discards was lower for 2000 than any other year in the time series since 1982 (Table 5, Figure 3).

Estimates of Fishing Mortality and Stock Size

Virtual population analysis, tuned with auxiliary indices, was used to estimate fishing mortality and stock size (ADAPT VPA in FACT, Northeast Fishery Science Center; Gavaris 1988; Conser and Powers 1990). Use of this model was requested by the 30th Stock Assessment Review Committee at the Northeast Fishery Science Center. ADAPT assumes the catch-at-age matrix was estimated without error; it develops estimates of the stock size at age in the terminal year from tuning indices. A catchability coefficient was estimated for each index by regressing the index against the estimates of stock size for each year the index is available. The resulting catchability coefficients for the various surveys are calibrated to estimate terminal year stock size at age. This iterated method does not assume separability of age effects and years effects. The fishery selection pattern emerges from the analysis. Past weakfish assessments have employed conventional VPA (Vaughan et al. 1991), separable VPA with auxiliary data (CAGEAN; Gibson 1993) and extended Survivors VPA (NEFSC 1998).

Estimates of stock size and instantaneous fishing mortality (F) were developed for ages 1-5 and a 6+ group. In the latest year, 2000, the 6+ group totaled only 6% of the total number in the matrix (Table 4). The VPA estimated terminal stock sizes in 2001 for ages 1 through 6. Age 6 abundance was estimated so that F on age 5 could be estimated. Without an estimate of age 6 abundance, F could only be estimated for ages 1-4. In estimation of the 6+ group, age 6+ indices were calibrated against 6+ VPA populations, as opposed to using only indices for age 6 itself. Ages above 6 in the plus group of the catch-at-age matrix amounted to 2.9% of the total for 2000 (Table 4). The total age 6+ comprised 6.1% of the total catch at age number for 2000 of weakfish. A plus group should not contain more than 10% of the catch at age number (M. Teircero, NMFS, personal communication). Fishing mortality of the oldest true age, other than in the terminal year, was estimated from the survival ratio of the 4 and 5 year old stock sizes.

Uncertainty and bias in estimates of terminal stock sizes and F rates were evaluated with two approaches: the bootstrap and a retrospective analysis. While bootstrap estimates of confidence intervals were relatively tight, a strong pattern of retrospective bias was apparent.

Fishing Mortality and Selectivity

The estimates presented by the ADAPT output were shown to be seriously biased by the retrospective analysis (Table 6). This bias causes F to be underestimated in recent years and stock size to be over-estimated in recent years. Therefore, initial output values for recent years are not reliable estimates. As such, each parameter will be presented as uncorrected, then effects of the retrospective bias will be discussed.

Uncorrected estimates of directed F on the fully recruited ages 4 and 5 fluctuated between 0.68 and 2.52 from 1982 through 1994, then dropped sharply in 1995 to 0.22 (Table 7). From 1995 through 1998, directed F fluctuated as high as 0.32. For 1999, the estimate of F declined to 0.14. The 2000 estimate was F = 0.12. The bootstrapped 80% confidence interval on F_{2000} runs from 0.10 to 0.16. The retrospective analysis, however, showed that when 1996 is the terminal year, F_{1996} = 0.17 (Table 6). After 4 additional years of data are added, F_{1996} = 0.32. This is an 88% increase. If the same bias affects the 2000 estimate, then the corrected estimate of F_{2000} would rise to 0.23. This is still a low estimate of F, well below the proposed F_{TARGET} = 0.31. The backcalculated partial recruitment averaged over the last three years (geometric mean) was 0.09 for age 1, 0.25 for age 2, 0.61 for age 3, 0.98 for age 4 and 1 for age 5.

Stock and Recruitment

During 1982-2000, uncorrected estimates of spawning stock biomass (SSB) varied five fold, and uncorrected estimates of recruitment varied slightly more than five-fold (Table 6, Figure 4; note that in Fig. 2, SSB estimates are lagged one year to match the correct year class of one-year old recruits).

The uncorrected estimate of spawning stock biomass (SSB) in the ADAPT output increased to 20,805 Metric Tons (MT) by 1986 and then declined to a low of 8,307 MT in 1989 (Table 7, Figure 4). The estimates of SSB remain low until 1993. The uncorrected estimates then begin to climb to a high of 51,598 MT in 2000. The bootstrapped 80% CI for the 2000 estimate extends from 41,813 MT to 56,683 MT. The retrospective analysis revealed, however, that the estimate of SSB for 1996, when that is the terminal year, declined by 33% after 4 additional years of data are added (Table 6). Similarly, the 1995 estimate, when 1996 is the terminal year, declines by 32% when 4 additional years of data are added. This means these values were overestimated by about 50%. If the same bias affects the 2000 estimate, the corrected value for 2000 would be about 35,000 MT. This is well above the proposed SSB overfishing threshold of 14,428 MT.

Recruitment of age 1 weakfish ranged from a low of 18,875,000 in 1989 to an uncorrected high of 111,184,000 in 2000 (Table 6, Figure 4). The bootstrap 80% confidence interval for the 2001 recruitment estimate of 58,993 thousand was 39,507 to 86,332 thousand. Retrospective analysis indicated that when 1996 was the terminal year, recruitment in 1995 was overestimated by more than 100%. If the same bias affects the 2000 estimate of 111,184,000, the corrected estimate would be 52,256,000. In general, recruitment was moderate from 1982 through 1984, increased in 1985-1987, then dropped significantly from 1988 through 1991 to levels below 30,000,000 age 1 weakfish. Since 1992, recruitment has been above 30,000,000, with peak years over 60,000,000. Large year classes were produced in 1984, 1985, 1993, 1995, 1998 and 1999.

Lower SSB produced lower average recruitment (Figure 5). If estimated SSB was above 20,000 metric tons, estimated recruitment was generally above 40,000,000 age 1 weakfish. Lower estimates of SSB produced both high and low values of recruitment, ranging down to about 20,000,000 age 1 recruits.

STOCK STATUS SUMMARY

Weakfish are at a high level of abundance and fishing mortality appears to be low. A strong retrospective bias in the ADAPT VPA output, however, produced high levels of uncertainty in recent estimates of stock size and fishing mortality. Recent history of the coast-wide stock shows that SSB estimates were low from 1982 through 1985, about 10,000 MT. High recruitment to age one in 1985-1987 produced a brief increase in biomass, but fishing mortality was high. By 1989, biomass had again declined and remained low through 1993. Since then, biomass has been building to higher levels. Although the most recent estimate is over 50,000 MT, a pattern of retrospective bias suggests this could be overstated by 50%, so an estimate corrected for this level of bias would be approximately 35,000 MT, still a large increase over the lower levels. While the exact level of bias in the most recent estimates is unknown, the current level of SSB is well above the proposed threshold level of $SSB_{THRESHOLD}$ = 14,400 MT.

Estimates of fishing mortality range from a high of $F_{1984} = 2.52$ to a low of $F_{2000} = 0.12$. Since 1995, estimates of F have been below the Amendment 3 target of 0.50. The 2000 estimate of 0.12 could be underestimated by almost 100%, based on retrospective analysis of the 1996 estimate. Despite this bias, the corrected value would still be well below the proposed $F_{TARGET} = F_{30\%} = 0.31$ and far below the proposed $F_{THRESHOLD} = F_{20\%} = 0.50$.

One goal of Amendment 3 was to support an increase in the size and age structure. The ADAPT VPA results indicate this has happened. In 1982, the estimate of the proportion of age 6+ fish was 1.0% of the total. By 1990, this had shrunk to only 0.3% of the total number of weakfish. This proportion has been increasing in recent years to the level of 6.8% of the total in 2001.

DISCUSSION

During the course of developing the catch-at-age estimate for 2000, certain deficiencies in the available data came into focus. In some states, no biological data was available to estimate the catch-at-age from commercial landings. Collectively, these states accounted for a significant share of the landings, well over 1.3 million pounds. An additional deficiency affecting these and other states was the shortage of length samples from trawl gear in the northern region. No more than 45 fish in trawl landings of the entire northern region had been measured. These gaps required major assumptions in estimation of the catch at age matrix. The assessment team was forced to assume that landings in the northern region of the range had the same length frequency distribution as those in the southern part of the range, after accounting for the state-specific minimum size regulations. This assumption may not be a sound one, as length frequencies obtained from Rhode Island indicated those landings to be comprised of much larger, older fish than data from more southerly states. Consequently, the estimation of catch at age may be inaccurate to a greater or lesser extent due to gaps in the available data.

A second major deficiency in the data collection process is the total lack of data from commercial discards. All commercial fisheries induce some discard mortality. This can be a significant source of mortality in some situations. Lack of estimates tends to underestimate estimates of fishing mortality and stock size (M. Terceiro, NMFS, personal communication).

A third data deficiency is that virtually no data is available to characterize the estimated recreational discards. Volunteer angler programs are a potential source of such data. Currently, only Connecticut has supplied such data. Lacking this data, recreational discard losses are assigned to the same ages as recreational harvests. In fact, they almost certainly tend to come from sub-legal fish of younger ages, on average.
These and other shortcomings of the catch-at-age matrix may be part of the source of the severe retrospective bias in the ADAPT VPA output. The Weakfish Technical Committee intends to explore other modeling approaches. Work to date has progressed on a separable virtual population analysis, Integrated Catch at Age (ICA). Unlike ADAPT

VPA, separable VPA does not assume that the catch-at-age data is measured without error. Production models are under investigation, continuing work done by Gibson (1999). Relative exploitation analysis is a third approach under development. These alternative modeling methods will allow a fuller evaluation of the results of ADAPT VPA.

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Table 1. Age-length sample sizes contributed by states to the assessment. Early and late refer to the first six months of 2000 and the last six months, respectively. Numbers are the numbers of fish aged and measured. This data was used to develop pooled regional age-length keys for converting catches at length into catches at age. Virginia and north was the northern region, while North Carolina and south was the southern region. For each region, both an early and late key was developed.

STATE	NUMBER AGED EARLY	NUMBER AGED LATE	SOURCE
DE	481	965	TRAWL SURVEY, GILL NET
MD	112	57	POUND NET, TRAWL
VA	165	389	SEINE, GILL AND POUND
NC	424	192	VARIOUS SURVEY AND COMMERCIAL GEARS
FL	25	0	TRAWL

Table 2. Precision of recreational weakfish landing estimates in numbers (Type A + B1)
by wave from the Marine Recreational Fisheries Statistics Survey, NMFS.

	WAVE						
	1	**2**	**3**	**4**	**5**	**6**	**Total**
North Atlantic			2,588	5,037			7,625
			(76.6)	(77.9)			
Mid-Atlantic		30,210	560,342	661,496	480,291	81,921	1,814,260
		(49.4)	(11.6)	(17.3)	(14)	(29.3)	
South Atlantic	12,984	48,657	32,061	40,642	40,746	22,089	197,179
	(41.3)	(27.7)	(34.5)	(44.5)	(28.2)	(29.5)	

Table 3. Catch mean weights at age. Values were obtained from year-specific Von Bertalanffy growth models set to estimate weight in the middle of each year. Values for 2000 were assumed equal to those of 1999.

	AGE					
YEAR	**1**	**2**	**3**	**4**	**5**	**6+**
1982	0.142	0.279	0.521	0.821	1.411	3.033
1983	0.121	0.254	0.485	1.504	2.371	2.862
1984	0.159	0.294	0.567	1.186	1.667	2.536
1985	0.142	0.448	1.14	2.689	2.576	3.055
1986	0.189	0.485	1.283	2.713	2.955	3.173
1987	0.125	0.294	0.567	1.186	1.667	2.536
1988	0.129	0.256	0.539	1.118	1.881	3.026
1989	0.126	0.267	0.572	1.097	1.796	3.348
1990	0.1	0.231	0.621	1.127	1.674	2.207
1991	0.105	0.363	0.748	1.205	1.687	2.157
1992	0.085	0.313	0.666	1.097	1.559	2.017
1993	0.076	0.204	0.394	0.635	0.911	1.208
1994	0.118	0.257	0.446	0.675	0.932	1.206
1995	0.108	0.205	0.333	0.486	0.662	0.853
1996	0.104	0.21	0.351	0.522	0.717	0.93
1997	0.186	0.3	0.438	0.596	0.77	0.956
1998	0.12	0.23	0.374	0.547	0.742	0.953
1999	0.105	0.241	0.428	0.657	0.915	1.191
2000	0.105	0.241	0.428	0.657	0.915	1.191

Table 4. Weakfish catch at age for 2000. Recreational numbers at age include estimated discard mortality.										
COMMERCIAL	**AGE**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**TOTAL**
FL	2,265	4,112	4,000	2,993	381	36	8			13
NC	254,749	342,893	558,792	563,382	137,323	26,472	6,190	579	439	1,890
VA	603,652	354,119	336,662	290,605	182,058	8,664	10,566	2,307	1,580	1,790
MD	1,641	13,715	20,941	18,300	24,943	3,521	2,258	882	166	86
DE	714	5,558	29,285	35,286	33,032	19,314	24,952	2,622	430	151
NJ	7,310	56,878	149,932	158,237	215,189	26,421	17,824	3,792	2,283	637
NY	-	376	8,846	19,461	70,722	9,743	7,155	1,396	1,305	119
RI + CT			795	2,900	11,387	8,125	3,012	3,708	817	30
TOTAL COMM	870,332	777,651	1,109,253	1,091,163	675,036	102,294	71,965	15,285	7,020	4,719
RECREATIONAL CAA										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**TOTAL**
SOUTH EARLY	14,221	23,078	36,546	49,881	14,078	1,561	1,496	3,573		144
SOUTH LATE	7,888	24,539	65,609	57,999	11,267	851				168
NORTH EARLY	810	16,194	101,781	121,253	360,206	79,834	57,340	33,680	4,692	775
NORTH LATE	41,135	204,405	349,434	433,320	761,786	51,777	30,571	3,573		1,876
TOTAL REC	64,054	268,216	553,371	662,452	1,147,337	134,024	89,407	40,827	4,692	2,964
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**TOTAL**
GRAND TOTAL	**934,385**	**1,045,867**	**1,662,624**	**1,753,615**	**1,822,373**	**236,318**	**161,372**	**56,112**	**11,712**	**7,684**

Table 5. Weakfish catch-at-age matrix, 1982-2000.

	AGE						
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
1982	7,893.4	11,793.7	5,418.6	2,774.0	720.2	639.2	29,239.1
1983	6,430.8	12,099.9	5,702.4	2,775.4	567.1	423.9	27,999.5
1984	7,533.2	13,891.9	6,437.3	3,039.7	483.2	254.2	31,639.5
1985	12,790.2	10,690.1	3,133.5	1,165.4	211.6	54.8	28,045.6
1986	17,032.4	15,000.4	4,815.3	1,816.0	262.3	51.8	38,978.2
1987	14,976.3	13,533.3	4,253.8	1,478.3	143.7	10.6	34,396.0
1988	6,952.0	15,442.8	10,455.5	6,057.7	1,042.3	69.2	40,019.5
1989	2,245.8	4,796.0	4,306.5	2,917.6	625.1	84.4	14,975.4
1990	8,895.0	4,536.5	2,012.2	1,200.2	590.4	88.9	17,323.2
1991	9,103.7	5,460.1	2,685.9	1,354.6	459.0	56.4	19,119.7
1992	4,305.9	5,682.0	2,175.8	1,251.7	527.0	64.8	14,007.2
1993	3,769.4	5,770.2	2,125.9	1,133.1	399.9	48.0	13,246.5
1994	3,165.8	2,876.2	3,000.8	1,362.4	199.4	38.3	10,642.9
1995	3,470.6	3,095.2	3,379.0	1,574.2	196.1	53.6	11,768.7
1996	1,482.4	2,052.7	4,073.4	2,955.9	1,333.7	97.9	11,996.0
1997	970.2	1,553.4	2,562.6	5,036.5	1,469.2	397.1	11,989.0
1998	835.3	1,709.1	3,535.1	1,903.7	2,827.1	870.5	11,680.8
1999	804.9	1,148.4	2,076.0	3,057.8	702.4	1,123.0	8,912.5
2000	934.4	1,045.9	1,662.6	1,753.6	1,822.4	465.5	7,684.4

Table 6. Retrospective pattern summary for weakfish ADAPT VPA through 2000.

Fully Directed F estimate per year

Data through	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
1996	1.49	1.73	2.52	1.43	1.88	0.68	1.95	1.16	0.78	0.83	0.98	1.05	0.52	0.13	0.17				
1997	1.49	1.73	2.52	1.43	1.88	0.68	1.95	1.16	0.79	0.83	0.98	1.07	0.54	0.14	0.18	0.19			
1998	1.49	1.73	2.52	1.43	1.88	0.68	1.95	1.16	0.79	0.84	1.02	1.18	0.67	0.19	0.25	0.2	0.14		
1999	1.49	1.73	2.52	1.43	1.88	0.68	1.95	1.16	0.79	0.84	1.01	1.16	0.63	0.17	0.23	0.18	0.15	0.13	
2000	1.49	1.73	2.52	1.43	1.88	0.68	1.95	1.17	0.79	0.85	1.04	1.24	0.75	0.22	0.32	0.27	0.25	0.14	0.12

Spawning Stock Biomass estimate per year (Metric Tons)

Data through	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
1996	12,254	10,825	8,722	11,813	20,810	19,273	12,432	8,355	9,113	10,950	11,046	12,164	25,130	29,901	40,379				
1997	12,254	10,825	8,722	11,813	20,810	19,272	12,429	8,349	9,100	10,905	10,876	11,851	24,664	29,006	38,206	60,996			
1998	12,254	10,825	8,722	11,812	20,806	19,266	12,415	8,320	9,031	10,665	9,965	9,775	21,840	25,964	33,993	53,391	49,425		
1999	12,254	10,825	8,722	11,813	20,807	19,267	12,419	8,327	9,047	10,721	10,179	10,262	23,562	26,995	34,476	51,294	46,748	57,875	
2000	12,254	10,825	8,722	11,813	20,805	19,263	12,409	8,307	9,001	10,562	9,574	8,884	18,693	20,396	27,134	42,038	38,116	48,980	51,598

Recruitment estimate per year (Thousands)

Data through	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1996	42,308	38,597	40,311	61,567	68,851	52,851	24,442	19,037	26,315	30,686	49,448	60,177	67,870	69,996	81,395	98,761				
1997	42,308	38,597	40,311	61,566	68,848	52,846	24,431	19,018	26,274	30,471	48,101	58,961	69,013	64,290	68,946	76,671	49,373			
1998	42,308	38,597	40,310	61,562	68,833	52,823	24,377	18,918	26,057	29,317	40,870	46,454	81,810	54,758	60,012	59,989	43,670	62,278		
1999	42,308	38,597	40,310	61,563	68,837	52,828	24,390	18,942	26,108	29,588	42,565	49,384	89,649	44,338	53,300	51,338	38,769	58,990	96,531	
2000	42,308	38,597	40,309	61,560	68,826	52,812	24,354	18,875	25,964	28,824	37,776	41,104	67,498	32,696	66,530	44,945	38,694	64,042	111,184	58,993

Table 7. Weakfish ADAPT VPA summary through 2000, with estimated stock size through January 1, 2001. F on ages 4 and 5 is the full F, averaged over ages 4-5. Weights are metric tons. Landings are observed weight of catch as provided by NMFS.

YEAR	1	2	3	4	5	6+	4-5 F	Landings, 1000s	Stock Size, Numbers (1000s)	Spawning Stock Biomass
1982	0.24	0.65	0.8	1.43	1.54	1.54	1.49	12,597	87,508	12,254
1983	0.21	0.75	0.84	1.65	1.81	1.81	1.73	13,251	81,193	10,825
1984	0.24	1.04	1.44	2.27	2.78	2.78	2.52	12,154	78,970	8,722
1985	0.27	0.67	0.75	1.38	1.48	1.48	1.43	10,183	95,187	11,812
1986	0.33	0.62	0.81	1.78	1.98	1.98	1.88	14,215	118,206	20,805
1987	0.39	0.51	0.38	0.68	0.69	0.69	0.68	10,809	110,455	19,263
1988	0.39	0.99	1.06	1.83	2.06	2.06	1.95	12,186	79,971	12,409
1989	0.14	0.55	0.92	1.14	1.19	1.19	1.17	7,414	45,834	8,307
1990	0.49	0.52	0.5	0.78	0.8	0.8	0.79	4,894	48,354	9,001
1991	0.44	0.69	0.73	0.84	0.86	0.86	0.85	4,911	50,816	10,562
1992	0.14	0.59	0.72	1.01	1.06	1.06	1.04	4,017	60,258	9,574
1993	0.11	0.29	0.49	1.21	1.27	1.27	1.24	3,610	75,469	8,884
1994	0.05	0.12	0.26	0.74	0.76	0.76	0.75	3,623	114,512	18,693
1995	0.13	0.07	0.21	0.22	0.22	0.22	0.22	4,063	112,601	20,396
1996	0.03	0.11	0.14	0.31	0.32	0.32	0.32	4,476	143,369	27,134
1997	0.02	0.04	0.21	0.27	0.27	0.27	0.27	4,987	144,529	42,038
1998	0.02	0.06	0.11	0.25	0.25	0.25	0.25	5,658	139,793	38,116
1999	0.01	0.05	0.1	0.14	0.14	0.14	0.14	4,559	160,618	48,980
2000	0.01	0.02	0.09	0.12	0.12	0.12	0.12	4,260	222,381	51,598
2001									225,404	

Figure 1. Mean Weight of Recreational Weakfish Harvest

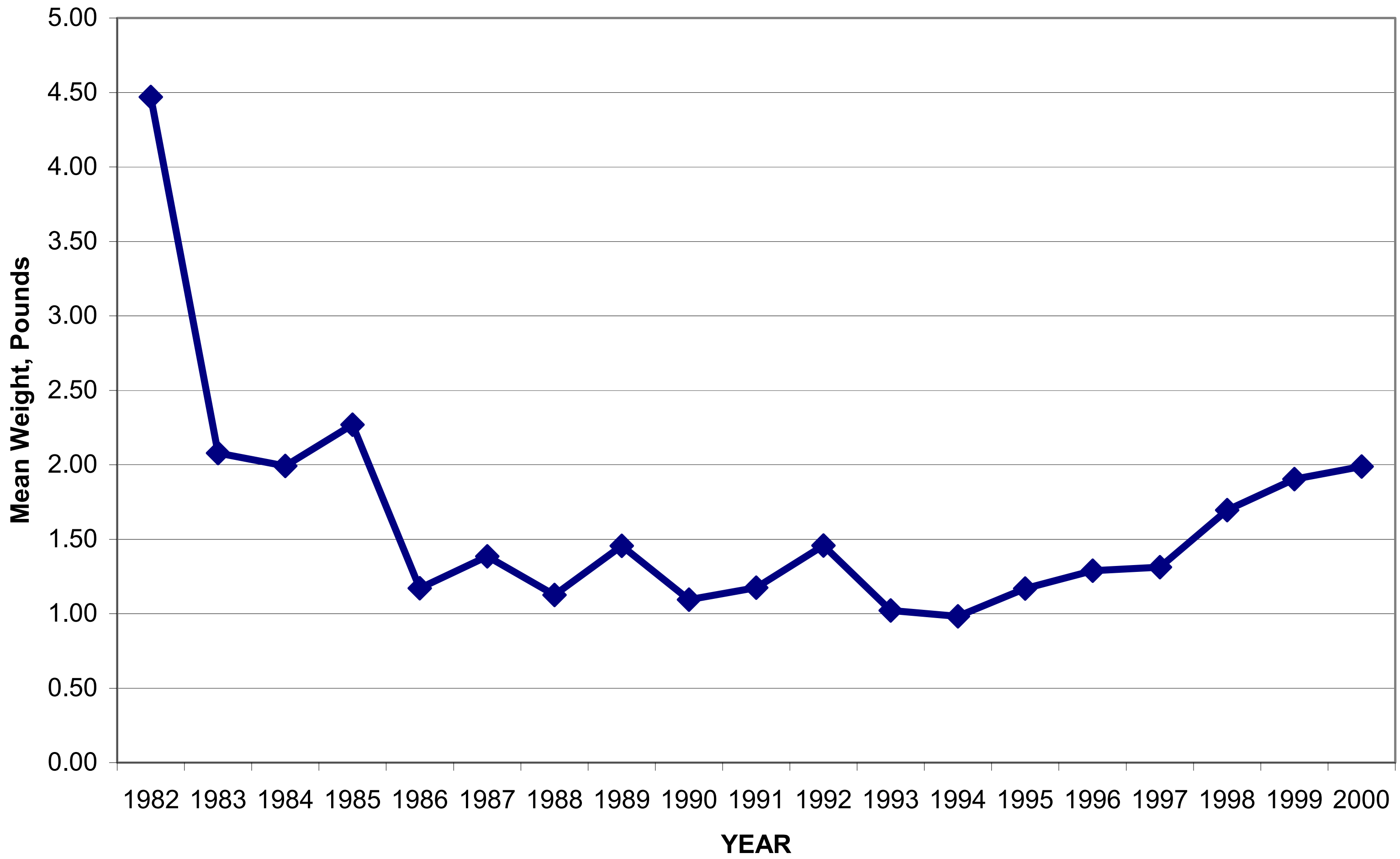

Figure 2. Weakfish Landings by Fishery

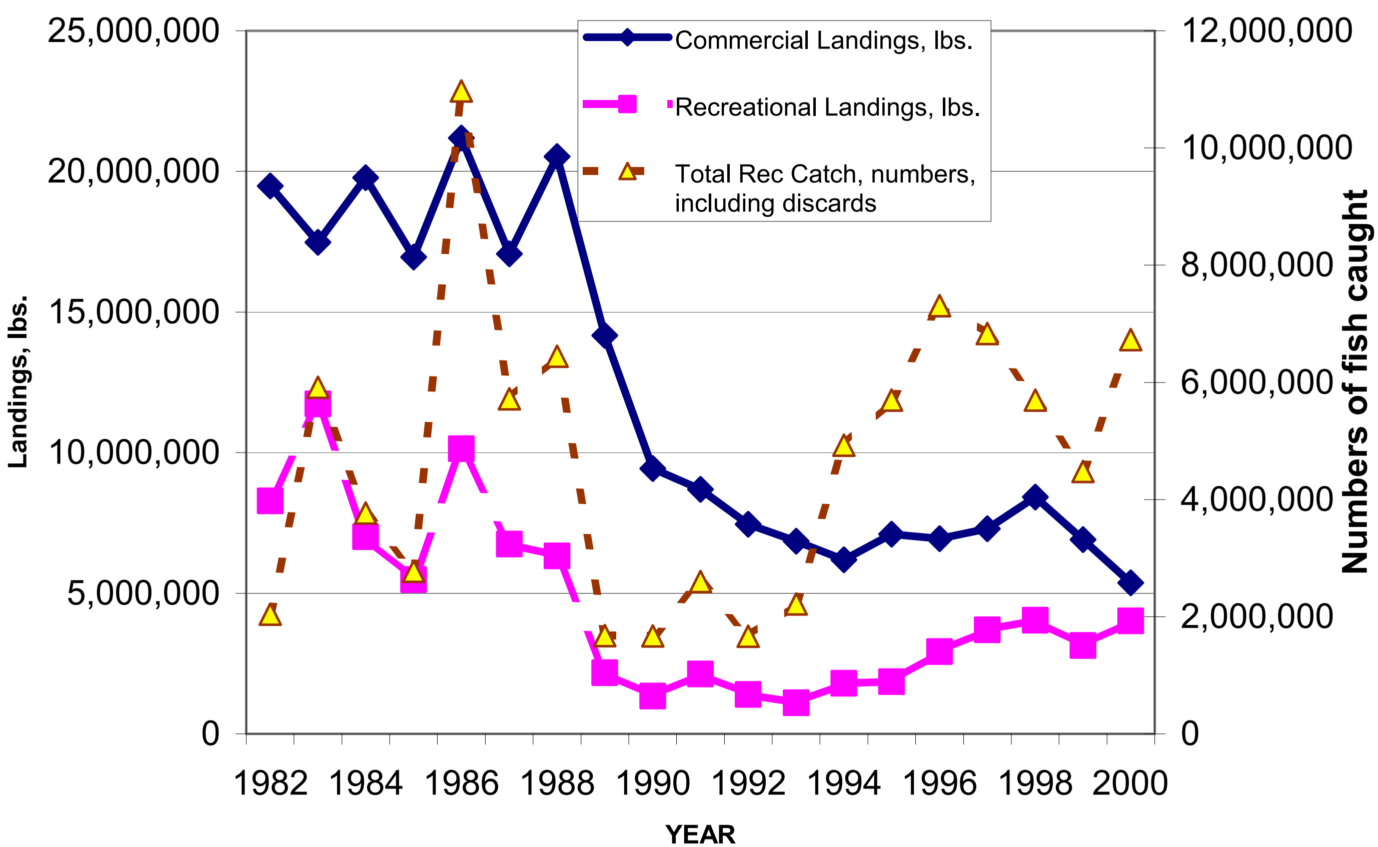

Figure 3. Total Numbers in the Catch-at-Age Matrix, Including Recreational Discards

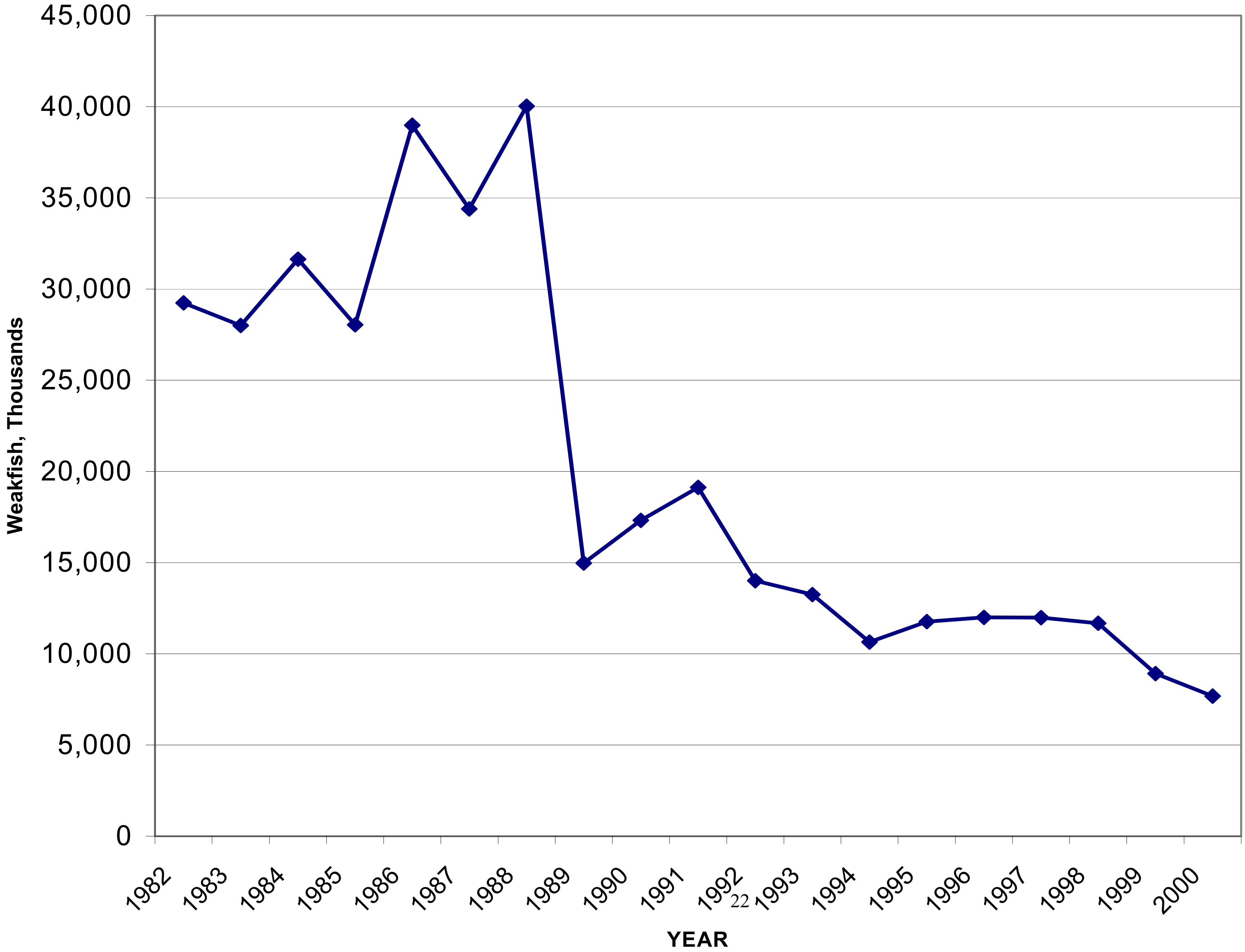

Figure 4. Recruitment and SSB

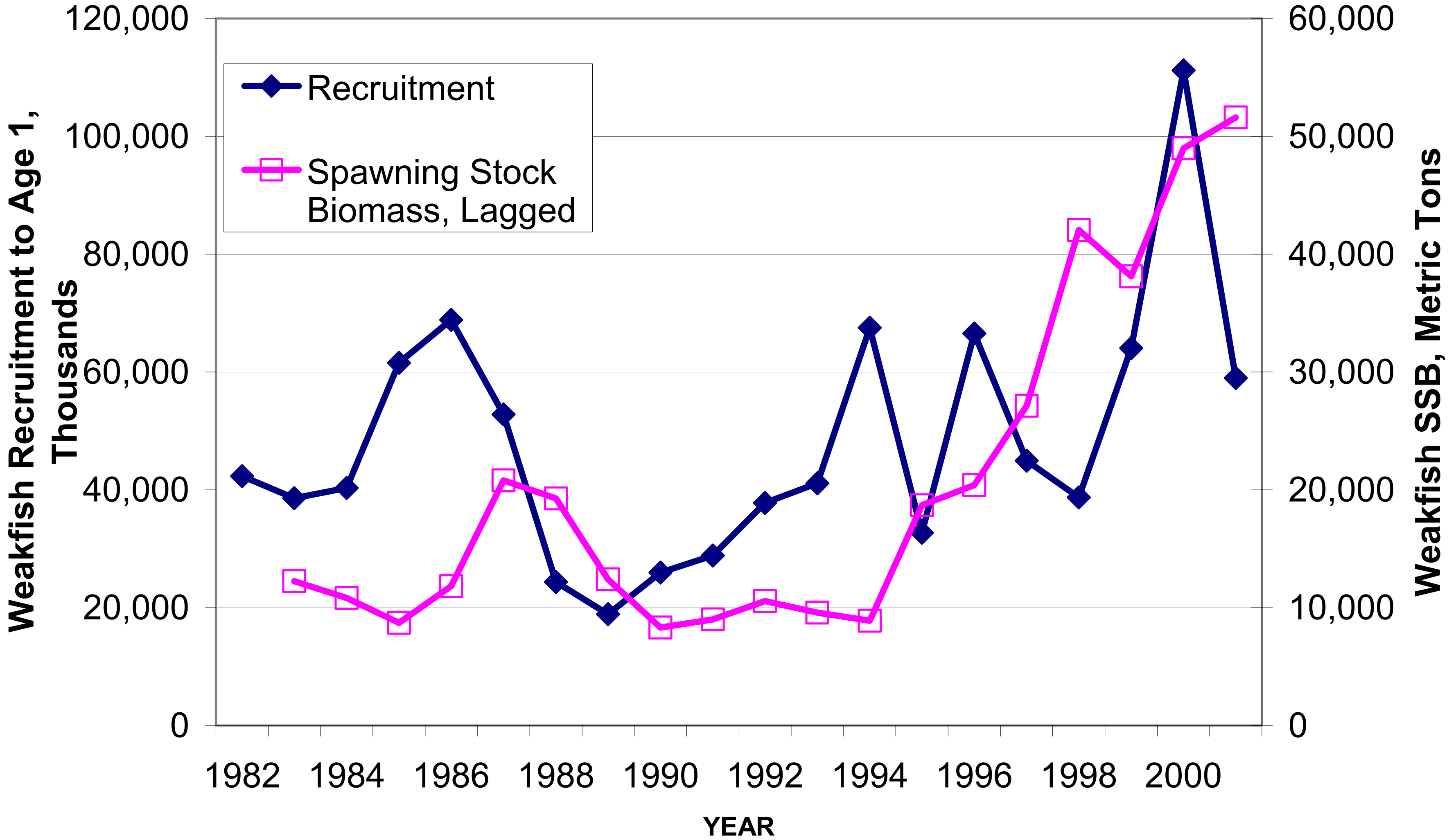

Figure 5. Stock-Recruitment Relationship