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Status of Atlantic Coast Bluefish - 1987

by

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
INTRODUCTION	1
MANAGEMENT	2
THE FISHERIES.	3
Recreational.	4
Index of bluefish directed effort	4
Catch per effort	4
Commercial	5
AGE AND GROWTH	5
INDICES OF RECRUITMENT.	6
MORTALITY ESTIMATION	7
Natural mortality	7
Fishing and total mortality	7
Virtual population analysis	9
STOCK SIZE AND BIOMASS ESTIMATES.	10
YIELD PER RECRUIT.	12
DISCUSSION	12
LITERATURE CITED	13
TABLES	15-39
FIGURES.	40-50
APPENDIX TABLES.	51-54

EXECUTIVE SUMMARY

The bluefish has become among the most important species in the U.S. Atlantic coast recreational fishery in recent years. Total catch (commercial and recreational) increased from about 24200 MT in 1960 to a peak of 76200 MT in 1980. The 1985 total catch was about 51000 MT; 1986 total catch was 65700 MT. The recreational fishery accounts for about 90% of the total, and peaked in 1980 at 69600 MT. Recreational catch in 1985 was estimated at about 45000 MT; the 1986 recreational catch was about 59400 MT. Commercial catch peaked in 1983 at 7300 MT. Commercial catch in 1985 was 6000 MT, in 1986 about 6300 MT.

The NEFC fall inshore trawl survey catch/tow, 1974 - 1986, and Marine Recreational Fishery Statistics Survey (MRFSS) Middle Atlantic shore-based angling YOY CPUE, 1979 - 1986, are used as indices of recruitment for bluefish. Strong year classes appeared to recruit to the stock in 1977, 1981, and 1984. The 1986 recruitment indices were average.

Coastwide recreational CPUE (all ages) peaked in 1981. Results of VPA indicate a decline in stock size over the 1979 - 1986 period of about 68%, as the strong 1977 and 1981 year classes passed through and out of the stock/fishery. Instantaneous fishing mortality was estimated at 0.40 for 1986. Yield per recruit analysis provided estimates of $F_{0.1} = 0.31$ and $F_{max} = 0.81$. The dominant 1984 year class (age 2 fish) is supporting the current high yield in the Atlantic coast bluefish fishery.

Introduction

The bluefish (Pomatomus saltatrix) was the species most sought by recreational fisherman along the Atlantic coast during 1979 - 1983, and was surpassed in total catch numbers by only summer flounder in 1984, winter flounder in 1985, and black sea bass and scup in 1986 (U.S. Department of Commerce 1985). Because of the current importance of bluefish to anglers, the Atlantic States Marine Fisheries Commission (ASMFC) is developing a coastwide bluefish fishery management plan in cooperation with the New England, Mid-Atlantic, and South Atlantic Fishery Management Councils, the National Marine Fisheries Service (NMFS), and the Atlantic coastal states.

Wilk (1977) compiled the first and still only comprehensive synopsis of biological data for Atlantic Coast bluefish. Lund (1961) suggested that, based on meristic studies, as many as six races of Atlantic coast bluefish might exist. Wilk (1977) and Kendall and Walford (1979) indicated that two genetically distinct stocks may exist. These distinctions have not been fully resolved, however, and since genetic bluefish stocks are likely to be mixed in the areas where the fishery is prosecuted, an operational unit stock of Atlantic coast bluefish has been assumed.

Hayden and Anderson (1978), Anderson and Almeida (1979), Anderson (1980), and Boreman (1983) prepared previous documents assessing the status of bluefish. The present document addresses the current status of Atlantic coast bluefish, incorporating commercial landing statistics, NMFS Northeast Fisheries Center (NEFC) trawl survey data, and NMFS Marine Recreational Fishery Statistics Survey (MRFSS) catch and effort data (1979 - 1986). Topics reviewed include current management, catch statistics, recruitment indices, mortality estimation, and stock abundance.

Management

All Atlantic coastal states require a permit or license for the commercial harvest of bluefish. All states with permit requirements, except Maine and New Hampshire, also impose gear restrictions on the commercial fishery. Connecticut, New York, New Jersey, Maryland, and Florida also have minimum commercial size limits of 8 - 10 in. (20.3 - 25.4 cm). Maryland has an 8 in. (20.3 cm), and Florida a 10 in. (25.4 cm), minimum size limit in the recreational fishery. These regulations restrict the capture of young of the year (YOY) bluefish (see Age and Growth).

Federal regulation of bluefish is based on provisions of the Magnuson Fisheries Conservation and Management Act of 1976 (MFCMA), which, since March 1, 1977, have restricted the foreign catch of bluefish on the Atlantic coast. The foreign catch of bluefish peaked in 1973 at 0.214 MT, and has been less than 0.100 MT since 1977 (Table 1).

A coastwide fishery management plan for bluefish is currently being developed by the ASMFC in cooperation with the New England, Mid-Atlantic, and South Atlantic Fishery Management Councils, NMFS, and the Atlantic coastal states.

The Fisheries

Recreational

Estimates of total recreational bluefish catch and effort (all fishing effort used as an index of bluefish directed effort) from the Salt Water Angling Surveys (Clark 1962, Deuel and Clark 1968, Deuel 1973) and the Marine Recreational Fishery Statistics Survey (MRFSS) (US Dept. Commerce; 1984, 1985a & b, 1986) indicate that coastwide bluefish effort and catch have expanded greatly over the past 25 years, and are currently near historical peaks (Figure 1).

Detailed recreational catch data for bluefish are available from the MRFSS data base for 1979 - 1986. MRFSS catch is reported as 1) type A, catch available for identification and measurement of length and weight, 2) type B1, catch not available for identification, and either cleaned or discarded, and 3) type B2, catch released alive. Because no data are available on the mortality rate of released bluefish, in this assessment type B2 catch is included in the estimation of total bluefish catch to avoid an underestimation of fishing mortality.

Since catch weight is provided by the MRFSS only for catch type A, the calculation of total weight of all three catch types was made by applying mean weight per fish of type A catch to total (A + B1 + B2) catch number on a subregion (North - ME to CT; Middle - NY to VA; South - NC to FL, East coast), mode (man-made, beach/bank, party/charter, private/rental), area (inland, territorial sea, EEZ) basis, and aggregated as needed.

Recreational bluefish catch peaked in 1980 at an estimated 69600 MT; the 1985 estimate was about 45000 MT, the 1986 estimate was 59400 MT (Table 1, Figure 2). The recreational fishery accounts for about 90% of the total

catch. A breakdown of total catch numbers and weight is provided in tables 2 & 3. Most of the catch is taken in the Middle Atlantic subregion (NY to VA) by boat-based fishermen (party/charter & private/rental). The largest fish are usually caught in the North Atlantic subregion (ME to CT), and the smallest in the South Atlantic subregion (NC to FL)(Table 4, Figure 3).

Index of bluefish directed effort

The MRFSS does not provide expanded estimates of species directed effort. However, several levels of aggregation in numbers of total fishing trips are provided which may be used as indices of directed effort. Since bluefish are taken in nearly every subregion/mode/area cell sampled by the MRFSS on an annual basis, and are among the top 3 species captured by anglers along the Atlantic coast, the total number of fishing trips in subregion/mode/area cells with recorded bluefish catch (bluefish catch cells) is used here as an index of bluefish directed effort in analyses of MRFSS data (Table 5).

Catch per unit effort

Catch per unit effort (CPUE) was calculated for boat (party/charter + private/rental) and shore (man-made + beach/bank) based fishing modes within each subregion. CPUE (by weight) was generally highest in the North Atlantic subregion and lowest in the South Atlantic. Boat-based CPUE was higher than shore-based (except 1981 South Atlantic), probably reflecting both an increased availability of older, larger fish to boat fisherman and a greater ability of boat fisherman to locate and follow bluefish schools (ability to search inshore/offshore as well as along shore)(Table 6).

Coastwide, bluefish CPUE exhibited a declining trend following a peak in

1981. Coastwide effort varied from a peak in 1980, to a nadir in 1981, and back to near peak levels during 1983-1986 (Figure 4). Subregional trends are shown in figures 5 - 7.

Commercial

Commercial landings of bluefish reached their highest level since 1901 (Wilk 1977) at an estimated 7300 MT in 1983; landings in 1986 were about 6300 MT (Table 1, Figure 1). The commercial fishery has consistently accounted for about 10% of total annual bluefish catch during 1979 - 1986. Detailed commercial catch and effort data for bluefish are not currently available, and therefore commercial catch is not included in the current assessment analyses. The inability to include commercial catch data in the forthcoming virtual population analysis will result in a conservative estimate of stock size, but assuming that commercial data would not alter the proportions in the catch-at-age matrix, will not affect the estimation of fishing mortality.

Age and growth

A contemporary (1982 - 1986) bluefish age/length key, incorporating mean length at age data ($n = 4861$) from NH, CT, MD, and NC, was developed for use in the current assessment (ASMFC unpublished data). Updated von Bertalanffy growth parameters were also calculated from this key ($L_{inf} = 907$ mm, $k = 0.25$, $t_0 = -1.12$ yr). The oldest fish aged in assembling the key were 11 to 12 yr old.

Coastwide age/length sample data for bluefish are not available from either the commercial or recreational fishery. However, length frequencies are available from MRFSS intercept data for the 1979 - 1986 recreational

fishery. In this assessment, MRFSS expanded catch at age was determined by applying the ASMFC 1987 age/length key to MRFSS expanded catch at length (Tables 7 & 8, Figure 8).

Indices of recruitment

Several indices of abundance were compared by correlation analysis in order to determine adequate indices of recruitment to the stock. These data included pound net catch per haul from NY, NJ, MA, MD, VA, and NC fisheries, the NMFS fall inshore trawl survey, and MRFSS subregional YOY catch per trip. The NMFS fall inshore survey, Cape May to Cape Hatteras (stratified geometric mean catch number per tow), and MRFSS Middle Atlantic shore-based fishery CPUE (YOY catch number per trip) correlated best (Table 9, Figure 9). These measures indicate variable recruitment with no evidence of a declining trend in recruitment at this time. Strong year classes (YC's) appeared to recruit in 1977, 1981, and 1984. These YC's are reflected in the fishery as a whole in the following ways: 1) the 1977 YC reflected in the high proportion at age 2 in the 1979 catch (Table 7), 2) the 1981 YC by the high proportion of YOY in 1981, and high CPUE of all ages in 1981 and 1982 (Table 6), and 3) the 1984 YC by the high proportion of YOY in 1984 catch, of age 1 in 1985 catch, of age 2 in 1986 catch, and increased CPUE in 1985 and 1986.

The 1980 YOY, and 1982 YOY and 1983 age 1 proportion at age (Table 7) indicate that recruitment may have been good in 1980 and 1982 as well, but the above indices do not reflect the total fishery in this instance, possibly reflecting changes in the temporal and spatial distribution of YOY bluefish in these years, and/or stronger influence of later spawning groups on recruitment in those years (Kendall and Walford 1979; Boreman 1983).

The median of the NMFS inshore index, Cape May to Cape Hatteras, was 11.6 (strat. geom. mean no. per tow) for the period 1974 - 1986. The 1986 estimate was slightly above the median value, at 12.9 fish/tow.

Mortality estimation

Natural mortality

Previous natural mortality (M) estimates for bluefish were generally quite variable, ranging from 0.2 to 1.0 (Boreman 1983). In this work, M was estimated by applying the methods of Pauly (1980) and Hoenig (1983) to growth parameters derived from the ASMFC 1987 key (Table 10). The Pauly method uses von Bertalanffy growth parameters and habitat water temperatures to estimate M for fish species. Input temperatures for the Pauly method were taken from Wilk (1977) and NEFC Fall Inshore Trawl Survey data. For a temperature range of 12 - 18 °C, the Pauly method provided estimates of M from 0.346 - 0.417.

The Hoenig method provides an estimate of M based on the maximum age of the animal. For a maximum age of 11 - 12 years, the method indicated values of M for bluefish of 0.350 - 0.401. The above methods indicate that an estimate of $M = 0.35 - 0.40$ is reasonable for bluefish (Table 10).

Fishing and total mortality

Sorting MRFSS catch at age into subregion/mode cells allows a detailed examination of the age composition of the catch at a given location. Using the estimated catch proportion at age (numbers), it is evident that in the North and Middle Atlantic region shore fisheries, most of the catch are YOY fish (Tables 11 - 18). In the South Atlantic shore fishery, YOY and age 1 proportions are usually nearly equal. In the North and Middle Atlantic boat

fisheries most of the catch are age 1 and 2 fish. In the South Atlantic boat fishery, YOY and age 1 proportions again are nearly equal. However, in all regions in the boat-based component, nearly as many age 6, 7, and 8+ fish are caught as age 3, 4, and 5 fish, even though the number of older fish in the stock is probably much less than the number at younger ages. Thus, MRFSS catch data sorted at the subregional mode level indicates that the boat fishery exerts increased fishing mortality on older fish. Trends in weight per fish and CPUE suggest this tendency occurs in all years, and may be strongest in the North Atlantic subregion (Tables 4 & 6).

The perceived increase in F at age is reflected by the slow decline in MRFSS catch proportions at increasing age within cohorts (Table 7). This trend may result in artificially low values of Z when cohort catch curve analysis is performed on catch data from the recreational fishery. With this caution, estimates of total mortality were calculated by regression of MRFSS 1979 - 1985 cohort catch curves across years using total cell fishing trips to standardize effort between years. Estimates of Z were about 0.6 (Table 19).

Estimates of Z were also calculated using two fishery independent data sources. The first was CT Bureau of Fisheries trawl survey catch at age (number per tow, aged by CT Bureau of Fisheries) for 1984 - 1986. Regression of catch curves provided estimates of Z from 0.67 to 0.86 (Table 20).

The second independent data source was NMFS fall inshore trawl survey catch at age, 1974 - 1985 (age 2+ number per tow, aged by ASMFC 1987 key). This data was pooled into 3 year periods and also subjected to catch curve regression analysis. Estimates of Z ranged from 0.42 to 0.66 (Table 21).

Virtual population analysis

Based on the range of Z values estimated from catch curve analyses, MRFSS catch at age was analyzed by virtual population analysis (VPA) to verify fishing mortality rates and to estimate stock size and biomass. Catch proportion at age indicated that bluefish are fully recruited to the fishery at age 1 (Table 7). VPA was performed using the lower value in the assumed likely range of natural mortality ($M = 0.35$) to minimize stock size estimation errors (Sims 1984). Selection of terminal F in 1986 was made by an iterative process of regressing the results of VPA (mean annual F) against a relative exploitation index (REI, derived by dividing annual MRFSS age 1+ catch by NEFC age 1+ trawl survey indices) until a suitable fit was obtained. The REI is a fishery independent estimate of fishing effort which is not subject to the biases due to variable fishing efficiency that are common in fishery dependent measures of effort (e.g., fishing trips) (Anderson *et. al.* 1976). After the method of Anderson and Overholtz (1978), the distribution of NEFC inshore trawl survey abundance indices over time were first fit to a function, with the resulting predicted values of the abundance indices then used to calculate the REI. Linear, exponential, and ARIMA models of the NEFC survey time-series were tested, with the linear model ($r = 0.796$, $p < .02$) providing predicted values that 1) best matched the trend in stock numbers predicted by the VPA ($r = 0.980$, $p < .001$), and 2) when used as input to the calculation of the REI, resulted in the best fit of this effort index to the trend in fishing mortality predicted by the VPA (Table 22).

Three criteria were used to select the best fitting value of terminal F : 1) maximization of the correlation coefficient, 2) minimization of the 1986

residual for predicted F, and 3) minimization of the summed residuals of predicted F, 1983 - 1986. The best fitting relationship was a linear function relating annual mean F and the REI with terminal F (F in 1986) equal to 0.40 ($r = .980$, $p < .001$) for ages 1 and older (Table 23, Figure 10). Assuming an estimate of natural mortality (M) of 0.35, current total mortality (Z) is estimated to be about 0.75, which is in good agreement with estimates of Z calculated by regression of catch curves from fishery independent data sources (Tables 19 - 21). The VPA indicates a rising trend in F from 1979 (0.13) to 1983 (0.30), a one-third drop in F in 1984, and a return to rising F in 1985 and 1986. Fishing mortality is currently estimated to be at its highest level of the 1979 - 1986 MRFSS time-series (Figure 11).

In most years, the VPA indicated that F is highest on ages 1 and 2 and ages 6 through 8+, as expected from trends in catch proportion at age (Table 24). The steep increase in F from 1985 to 1986 is due to the combination of a 25% increase in catch numbers of age 1+ fish (19.6 million fish in 1985 to 24.6 million fish in 1986), a 23% increase in coastwide bluefish catch cell boat trips (19.0 million trips in 1985 to 23.3 million trips in 1986), and declining stock size.

Stock size and biomass estimates

Stock size estimates (age 1 and older) for 1979 - 1986 were determined from VPA. The VPA indicates a 68% decrease in stock size of age 1+ fish over the period, as the strong 1977 and 1981 year classes passed through and out of the stock/fishery. Mean weights at age from the recreational fishery (Table 25) were applied to stock numbers to obtain stock biomass estimates. The analysis indicates that the bluefish stock biomass (ages 1+) has declined by

about 67% from 1979 - 1986 (Table 24).

Spawning stock biomass was estimated by applying a simple maturity ogive (Boreman 1983) to stock biomass at age. Percent mature at age values employed were 50% mature at age 1 and 100% mature at age 2 and older. VPA determined that bluefish spawning stock biomass also declined 67% during 1979 - 1986 (Table 24).

To check the sensitivity of the analysis to possible error in the estimation of terminal F, additional runs of the bluefish VPA were made using values of terminal F that were 10% and 20% higher and lower than 0.40. VPA runs at terminal F's of 0.32 and 0.36 indicated declines in stock size of 64% and 66%, respectively. Runs at higher terminal F values (terminal F = 0.44 and 0.48) indicated declines in stock size of 70% and 71%, respectively. Thus, the estimate of the relative decline in stock size is robust with respect to the value of terminal F selected.

In absolute terms, setting $F_{86} = 0.32$ resulted in a 7% increase in the 1979 stock size estimate relative to the final run, and a 20% increase in the 1986 estimate. Setting $F_{86} = 0.36$ overestimated 1979 by 3% and 1986 by 9% relative to the estimates from the final run. Setting $F_{86} = 0.44$ underestimated 1979 and 1986 stock size by 3% and 8% relative to the final run. A terminal F of 0.48 underestimated 1979 and 1986 estimates by 4% and 14%. These analyses demonstrate that an overestimation of terminal F leads to smaller percentage errors in the estimation of bluefish stock size than does an underestimation of terminal F.

Yield per recruit

The Thompson and Bell (1934) yield model was used to estimate values of $F_{0.1}$ and F_{max} for Atlantic coast bluefish. Input parameters were $M = 0.35$, 50% maturity at age 1 and 100% at age 2 and older, and full recruitment to the fishery at age 1. Spawning was assumed to begin in April (Wilk 1977). The means of weights at age from the recreational fishery during 1979 - 1985 were used as values for mean weight at age in the catch and stock. The analysis indicated that $F_{0.1} = 0.31$ and $F_{max} = 0.81$.

Discussion

Recruitment indices suggest that at least three strong year classes (1977, 1981, and 1984) recruited to the Atlantic coast bluefish stock over the past decade. These year classes supported total (commercial and recreational) yields in the 65 - 75 thousand MT range during 1979 - 1983, which declined to 45 - 50 thousand MT in 1984 and 1985, and then increased to >59 thousand MT in 1986. The VPA using recreational catch at age, encompassing 90% of total yield, determined that the fishery is currently experiencing a rising trend in fishing mortality ($F_{86} = 0.40$) and a declining trend in stock size. These results, and the reference points calculated by yield per recruit analysis ($F_{0.1} = 0.31$, $F_{max} = 0.81$), indicate that 1) the high yield in the fishery is currently being supported by the dominant 1984 year class (age 2 fish), and 2) the fishery is currently operating above the $F_{0.1}$ reference point, with the stock nearing a state of full exploitation.

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Table 1. Estimated Bluefish Catch: Atlantic Coast (000 KG).

YEAR	COMMERCIAL	RECREATIONAL	FOREIGN	TOTAL
1960	1251	22950 (11475)	0	24201 (12726)
1961	1401	N/A	0	N/A
1962	2256	N/A	0	N/A
1963	2123	N/A	0	N/A
1964	1743	N/A	0	N/A
1965	1847	41054 (20522)	0	42901 (22369)
1966	2172	N/A	0	N/A
1967	1671	N/A	0	N/A
1968	2159	N/A	0	N/A
1969	2445	N/A	0	N/A
1970	2952	54047 (27018)	0	56999 (29969)
1971	2624	N/A	23	N/A
1972	3115	N/A	18	N/A
1973	4566	N/A	214	N/A
1974	4538	N/A	99	N/A
1975	4502	N/A	103	N/A
1976	4547	N/A	1	N/A
1977	4859	N/A	4	N/A
1978	4937	N/A	35	N/A
1979	5629	63759*	28	69416
1980	6540	69612*	23	76175
1981	7158	58216*	71	65445
1982	6897	56573*	77	63547
1983	7297	62859*	33	70189
1984	5454	39327*	68	44849
1985	6014	44977*	18	51009
1986	6328	59365*	28	65721

(----): Adjusted Angling Survey Est.; Boreman 1983

*: MRFSS, Type (A + B1 + B2) Catch

Table 2. Estimated total number (000's) of bluefish caught by recreational fisherman, MRFSS 1979 - 1986.

North: ME to CT
 Middle: NY to VA
 South: NC to FL

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

REGION/MODE	YEAR							
	1979	1980	1981	1982	1983	1984	1985	1986
NORTH								
SHORE	1883	3359	2176	3898	7010	2656	2120	2211
BOAT	3444	4064	6907	6398	6756	3686	5812	8435
TOTAL	5327	7423	9083	10296	13766	6342	7932	10646
MIDDLE								
SHORE	3409	7628	5902	3095	5085	6228	3926	6187
BOAT	20897	19486	11855	11882	13758	11077	9718	12192
TOTAL	24306	27114	17757	14977	18843	17305	13644	18379
SOUTH								
SHORE	3565	2816	3302	3258	3134	3309	2608	1895
BOAT	2548	4445	1859	4413	6894	2862	2842	1206
TOTAL	6113	7261	5161	7671	10028	6171	5450	3101
ALL REGIONS								
SHORE	8857	13803	11380	10251	15229	12193	8654	10293
BOAT	26889	27995	20621	22693	27408	17625	18372	21833
TOTAL	35746	41798	32001	32944	42637	29818	27026	32126

Table 3. Estimated total weight (000's KG) of bluefish caught by recreational fisherman, MRFSS 1979 - 1986.

North: ME to CT
 Middle: NY to VA
 South: NC to FL

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

REGION/MODE	<u>YEAR</u>							
	1979	1980	1981	1982	1983	1984	1985	1986
NORTH								
SHORE	936	1010	825	762	3302	497	1377	2844
BOAT	10201	11580	24111	26030	18993	9048	13373	26276
TOTAL	11137	12590	24936	26792	22295	9545	14750	29120
MIDDLE								
SHORE	1225	3747	2004	964	3071	1002	2048	3786
BOAT	45483	46422	26295	24061	22016	21743	19668	23389
TOTAL	46708	50169	28299	25025	25087	22745	21716	27175
SOUTH								
SHORE	2121	2172	4240	1232	2334	2103	1395	1605
BOAT	3793	4681	741	3524	13143	4934	7116	1465
TOTAL	5914	6853	4981	4756	15477	7037	8511	3071
ALL REGIONS								
SHORE	4282	6929	7069	2958	8707	3602	4820	8235
BOAT	59477	62683	51146	53615	54152	35725	40157	51129
TOTAL	63759	69612	58216	56573	62859	39327	44977	59365

Table 4. Estimated mean weight per fish (KG), MRFSS 1979 - 1986.

Mean wgt fish = $\text{wgt}(A + B1 + B2) / \text{num}(A + B1 + B2)$.

North: ME to CT
 Middle: NY to VA
 South: NC to FL

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

REGION/MODE	YEAR							
	1979	1980	1981	1982	1983	1984	1985	1986
NORTH								
SHORE	0.497	0.301	0.379	0.195	0.471	0.187	0.650	1.286
BOAT	2.962	2.849	3.491	4.068	2.811	2.455	2.301	3.115
ALL	2.091	1.696	2.745	2.602	1.620	1.505	1.860	2.735
MIDDLE								
SHORE	0.359	0.491	0.340	0.311	0.604	0.161	0.522	0.612
BOAT	2.177	2.339	2.218	2.025	1.600	1.963	2.024	1.918
ALL	1.922	1.850	1.594	1.673	1.331	1.314	1.592	1.479
SOUTH								
SHORE	0.595	0.771	1.284	0.378	0.745	0.636	0.535	0.847
BOAT	1.489	1.053	0.399	0.799	1.906	1.724	2.504	1.215
ALL	0.967	0.944	0.965	0.620	1.543	1.140	1.562	0.990
ALL REGIONS								
SHORE	0.483	0.502	0.621	0.289	0.572	0.295	0.557	0.800
BOAT	2.212	2.239	2.480	2.363	1.976	2.207	2.186	2.342
ALL	1.784	1.665	1.819	1.717	1.474	1.319	1.664	1.848

Table 5. Estimated total number (000's) of fishing trips in subregion/mode/area cells with recorded bluefish catch: summarized by subregion/mode, MRFSS 1979 - 1986.

North: ME to CT
 Middle: NY to VA
 South: NC to FL

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

REGION/MODE	YEAR							
	1979	1980	1981	1982	1983	1984	1985	1986
NORTH								
SHORE	1163	830	1101	1545	2228	1400	1519	2189
BOAT	2798	3162	2814	3076	4205	2491	3571	4638
TOTAL	3961	3992	3915	4621	6433	3891	5090	6827
MIDDLE								
SHORE	3486	6165	3067	4350	5011	3766	4027	6227
BOAT	12270	15138	8451	8856	13056	13015	10080	12829
TOTAL	15756	21303	11518	13206	18067	16781	14107	19056
SOUTH								
SHORE	6410	6964	4267	6064	6052	7051	8368	4846
BOAT	4081	4505	1742	5678	4805	7055	5328	5819
TOTAL	10491	11469	6009	11742	10857	14106	13696	10665
ALL REGIONS								
SHORE	11059	13959	8435	11959	13291	12217	13914	13262
BOAT	19149	22795	13007	17610	22066	22561	18979	23287
TOTAL	30208	36754	21442	29569	35357	34778	32893	36549

Table 6. Estimated catch per unit effort: (KG / trip).

Trip = Fishing trip in subregion/mode/area cell with recorded bluefish catch.

North: ME to CT
 Middle: NY to VA
 South: NC to FL

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

REGION/MODE	<u>YEAR</u>							
	1979	1980	1981	1982	1983	1984	1985	1986
NORTH								
SHORE	0.805	1.217	0.749	0.493	1.482	0.355	0.907	1.299
BOAT	3.646	3.662	8.568	8.462	4.517	3.632	3.745	5.665
TOTAL	2.812	3.154	6.369	5.798	3.466	2.453	2.898	4.265
MIDDLE								
SHORE	0.493	0.608	0.653	0.222	0.613	0.266	0.509	0.608
BOAT	3.707	3.069	3.111	2.717	1.686	1.671	1.951	1.823
TOTAL	2.964	2.355	2.457	1.895	1.389	1.355	1.539	1.426
SOUTH								
SHORE	0.331	0.312	0.994	0.203	0.385	0.298	0.166	0.331
BOAT	0.929	1.039	0.425	0.621	2.735	0.699	1.336	0.252
TOTAL	0.564	0.598	0.829	0.405	1.426	0.499	0.621	0.288
ALL REGIONS								
SHORE	0.387	0.496	0.838	0.247	0.655	0.295	0.346	0.621
BOAT	3.106	2.750	3.932	3.045	2.454	1.583	2.116	2.196
TOTAL	2.111	1.894	2.715	1.913	1.778	1.131	1.367	1.624

Table 7. Estimated age composition of Atlantic coast bluefish (number):
from MRFSS 1979 - 1986, aged by ASMFC 1987 key.

PROPORTION AT AGE									
YEAR	0	1	2	3	4	5	6	7	8+
1979	.2208	.2674	.1792	.1305	.0789	.0445	.0399	.0227	.0160
1980	.3174	.2330	.1573	.1048	.0790	.0374	.0323	.0217	.0171
1981	.3523	.2287	.1170	.0901	.0719	.0441	.0453	.0297	.0209
1982	.3597	.2245	.1217	.0809	.0630	.0568	.0366	.0244	.0324
1983	.2632	.3622	.1082	.0433	.0579	.0646	.0508	.0261	.0237
1984	.4280	.2518	.0924	.0542	.0454	.0399	.0398	.0258	.0227
1985	.2747	.3250	.1638	.0532	.0472	.0415	.0403	.0271	.0272
1986	.2329	.2171	.2285	.1151	.0683	.0459	.0460	.0249	.0210

NUMBER (000'S) AT AGE									
YEAR	0	1	2	3	4	5	6	7	8+
1979	7893	9558	6406	4665	2820	1591	1426	811	572
1980	13267	9739	6575	4380	3302	1563	1350	907	715
1981	11274	7319	3744	2883	2301	1411	1450	950	669
1982	11850	7396	4009	2665	2075	1871	1206	804	1068
1983	11222	15443	4613	1846	2469	2754	2166	1113	1010
1984	12762	7508	2755	1616	1354	1190	1187	769	677
1985	7424	8783	4427	1438	1276	1122	1089	732	735
1986	7485	6971	7357	3695	2185	1475	1478	803	675

Table 8. Estimated age composition of Atlantic coast bluefish (weight):
from MRFSS 1979 - 1986, aged by ASMFC 1987 key.

PROPORTION AT AGE									
YEAR	0	1	2	3	4	5	6	7	8+
1979	.0585	.1668	.2049	.1684	.1325	.0938	.0822	.0508	.0422
1980	.1090	.1532	.1826	.1678	.1501	.0744	.0615	.0388	.0626
1981	.0707	.1391	.1399	.1581	.1471	.0924	.0934	.0622	.0971
1982	.0587	.1009	.1129	.1509	.1488	.1408	.1035	.0720	.1115
1983	.1342	.2243	.1273	.0676	.0923	.1145	.1030	.0596	.0774
1984	.0809	.1563	.1290	.1095	.1301	.1208	.1219	.0797	.0719
1985	.1150	.2161	.1687	.0647	.0772	.0884	.1010	.0700	.0989
1986	.0500	.1399	.2668	.1613	.1147	.0847	.0923	.0499	.0404

WEIGHT (000'S KG) AT AGE									
YEAR	0	1	2	3	4	5	6	7	8+
1979	3730	10635	13064	10737	8448	5981	5241	3239	2691
1980	7588	10665	12711	11681	10449	5179	4281	2701	4358
1981	4116	8098	8144	9204	8564	5379	5437	3621	5653
1982	3321	5708	6387	8537	8418	7965	5855	4073	6308
1983	8436	14099	8002	4249	5802	7197	6474	3746	4865
1984	3182	6147	5073	4306	5116	4751	4794	3134	2828
1985	5172	9710	7588	2910	3472	3976	4543	3148	4448
1986	2968	8305	15839	9576	6809	5028	5479	2962	2398

Table 9. Atlantic coast bluefish: Indices of recruitment.

YEAR	NMFS FALL INSHORE SURVEY CAPE MAY TO CAPE HATT. STRAT. MEAN NO./TOW		MRFSS MID-ATL. YOY SHORE CPUE
	ARITH.	GEOM.	NO./TRIP
----	-----	-----	-----
1974	15.2	9.4	N/A
1975	22.8	6.9	N/A
1976	68.9	20.9	N/A
1977	90.1	31.6	N/A
1978	12.6	6.4	N/A
1979	64.0	8.9	0.517
1980	57.6	14.6	0.742
1981	178.3	50.8	1.041
1982	49.5	10.7	0.509
1983	30.8	11.4	0.346
1984	95.7	40.6	0.909
1985	22.8	11.7	0.578
1986	73.5	12.9	0.666

Correlation, 1979-1986

NMFS ARITH. w/ MID YOY CPUE: $r = 0.85^{**}$

NMFS GEOM. w/ MID YOY CPUE: $r = 0.89^{**}$

** : $p < 0.01$

Table 10. Estimation of instantaneous natural mortality of bluefish, using methods of Pauly (1980) and Hoenig (1983).

Pauly (1980):

$$\log M = -0.0066 - 0.279(\log \text{LinfTL}) + 0.654(\log K) + 0.463(\log T)$$

Von Bertalanffy parameters: ASMFC 1987 Combined key

LinfTL: 102.4 cm
 LinfFL: 90.7 cm
 K : 0.25
 t0 : -1.12 yr
 T : C

Wilk 1977: bluefish migrate into an area when temperature reaches 12 - 15 C

NMFS Fall Inshore Survey, 1974 - 1985: mean bottom temperature of strata with bluefish: 18.3 C

Temperature, C	calculated M
12	0.346
15	0.383
18	0.417

Hoenig (1983):

A) For all taxonomic groups: $\ln M = 1.44 - 0.982(\ln t_{\max})$

B) For fish stocks: $\ln M = 1.46 - 1.010(\ln t_{\max})$

ASMFC 1987 Combined key: Bluefish $t_{\max} = 11 - 12$ yr

A) 11 yr, calculated M = 0.401

12 yr, calculated M = 0.368

B) 11 yr, calculated M = 0.382

12 yr, calculated M = 0.350

From Pauly (1980) and Hoenig (1983):

Range of M from 0.35 - 0.40 assumed likely for bluefish

Table 11. 1979 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

 NORTH

MODE	0	1	2	3	4	5	6	7	8+
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
SHORE	.724	.139	.104	.027	.005	.000	<.001	.000	.000
BOAT	.079	.103	.228	.096	.091	.087	.153	.122	.041
ALL	.354	.125	.175	.067	.054	.050	.088	.070	.024

MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
SHORE	.719	.170	.050	.031	.017	.011	.002	<.001	<.001
BOAT	.078	.223	.243	.196	.115	.061	.047	.021	.016
ALL	.168	.215	.216	.173	.101	.054	.041	.018	.013

SOUTH

MODE	0	1	2	3	4	5	6	7	8+
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
SHORE	.369	.560	.040	.012	.015	.003	<.001	<.001	<.001
BOAT	.302	.568	.039	.001	.000	.000	.007	.018	.065
ALL	.341	.563	.039	.008	.009	.002	.003	.008	.027

Table 12. 1980 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

 NORTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.987	.009	.003	.001	.000	<.001	<.001	<.001	<.001
BOAT	.149	.100	.229	.171	.143	.092	.063	.035	.018
ALL	.536	.058	.127	.092	.077	.050	.034	.019	.010

 MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.712	.269	.006	.001	.001	.001	.004	.003	.002
BOAT	.130	.217	.185	.168	.126	.054	.041	.027	.052
ALL	.283	.231	.138	.124	.093	.040	.031	.021	.038

 SOUTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.698	.256	.016	<.001	.003	.001	.009	.006	.002
BOAT	.069	.503	.329	.014	.003	.002	.034	.030	.015
ALL	.156	.469	.287	.013	.003	.002	.031	.027	.013

Table 13. 1981 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

 NORTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.871	.010	.027	.012	.020	.013	.024	.015	.009
BOAT	.026	.077	.161	.315	.233	.080	.067	.032	.009
ALL	.375	.049	.106	.190	.145	.053	.049	.025	.009

MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.907	.063	.005	.004	.001	.001	.002	.003	.014
BOAT	.082	.246	.198	.122	.102	.074	.070	.044	.062
ALL	.351	.186	.135	.083	.069	.050	.048	.031	.046

SOUTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.273	.564	.046	.006	.002	.009	.033	.035	.031
BOAT	.393	.574	.032	.000	.000	.000	.000	.000	.000
ALL	.301	.567	.043	.004	.002	.007	.025	.027	.024

Table 14. 1982 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

 NORTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.956	.024	.011	.006	.002	.001	<.001	<.001	.001
BOAT	.086	.044	.128	.236	.167	.095	.085	.067	.093
ALL	.442	.036	.080	.142	.099	.057	.052	.040	.055

MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.815	.158	.012	.002	.002	.003	.005	.003	.001
BOAT	.190	.211	.205	.090	.080	.099	.049	.029	.045
ALL	.319	.200	.165	.072	.064	.079	.040	.024	.036

SOUTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.530	.430	.038	.001	.000	<.001	.001	.001	.001
BOAT	.199	.679	.112	.004	.001	.001	.001	.001	.004
ALL	.357	.560	.077	.002	<.001	<.001	.001	.001	.002

Table 15. 1983 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

NORTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.201	.381	.077	.038	.085	.111	.077	.030	<.001
BOAT	<.001	.157	.237	.139	.189	.126	.072	.042	.038
ALL	.115	.285	.146	.081	.130	.118	.075	.035	.016

MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.598	.287	.043	.003	.001	<.001	.001	.005	.056
BOAT	.198	.243	.161	.054	.042	.022	.019	.013	.025
ALL	.307	.417	.129	.040	.031	.017	.015	.011	.033

SOUTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.453	.467	.049	.002	<.001	.002	.009	.009	.009
BOAT	.321	.295	.009	.002	.027	.125	.122	.058	.042
ALL	.361	.348	.021	.002	.019	.087	.087	.042	.032

Table 16. 1984 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
 Shore: man-made + beach/bank

 NORTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.964	.023	.007	<.001	.001	.002	.002	.001	<.001
BOAT	.060	.136	.321	.199	.085	.058	.055	.040	.046
ALL	.438	.089	.190	.116	.050	.035	.033	.023	.027

 MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.887	.100	.011	.002	<.001	<.001	.000	.000	.000
BOAT	.192	.320	.121	.078	.088	.075	.058	.033	.035
ALL	.450	.238	.080	.050	.055	.047	.037	.021	.022

 SOUTH

MODE	0	1	2	3	4	5	6	7	8+
SHORE	.465	.461	.029	.002	<.001	.002	.008	.013	.021
BOAT	.222	.425	.032	.009	.031	.055	.117	.079	.030
ALL	.357	.445	.030	.005	.014	.026	.056	.042	.025

Table 17. 1985 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
Shore: man-made + beach/bank

NORTH

MODE	0	1	2	3	4	5	6	7	8+
----	----	----	----	----	----	----	----	----	----
SHORE	.824	.085	.032	.020	.018	.010	.006	.004	.001
BOAT	.072	.136	.334	.159	.124	.075	.042	.020	.037
ALL	.275	.122	.253	.121	.096	.057	.033	.016	.027

MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
----	----	----	----	----	----	----	----	----	----
SHORE	.720	.139	.101	.020	.009	.003	.003	.002	.003
BOAT	.133	.441	.168	.028	.027	.033	.036	.024	.110
ALL	.309	.352	.147	.025	.022	.024	.026	.017	.078

SOUTH

MODE	0	1	2	3	4	5	6	7	8+
----	----	----	----	----	----	----	----	----	----
SHORE	.454	.494	.033	.002	.001	.002	.006	.006	.002
BOAT	.253	.271	.023	.009	.048	.092	.138	.107	.059
ALL	.358	.387	.028	.005	.023	.046	.069	.054	.029

Table 18. 1986 MRFSS, Atlantic coast bluefish: estimated catch proportion at age (number).

Boat: party/charter + private/rental
Shore: man-made + beach/bank

NORTH

MODE	0	1	2	3	4	5	6	7	8+
----	----	----	----	----	----	----	----	----	----
SHORE	.356	.033	.319	.132	.074	.062	.015	.008	.001
BOAT	.002	.082	.316	.206	.129	.085	.102	.051	.026
ALL	.075	.072	.317	.191	.118	.080	.084	.042	.021

MIDDLE

MODE	0	1	2	3	4	5	6	7	8+
----	----	----	----	----	----	----	----	----	----
SHORE	.687	.171	.101	.033	.007	<.001	<.001	<.001	.001
BOAT	.119	.336	.255	.105	.055	.039	.035	.022	.035
ALL	.318	.278	.201	.080	.038	.025	.023	.014	.023

SOUTH

MODE	0	1	2	3	4	5	6	7	8+
----	----	----	----	----	----	----	----	----	----
SHORE	.382	.445	.018	.029	.060	.030	.020	.010	.005
BOAT	.297	.429	.041	.019	.055	.044	.060	.039	.016
ALL	.345	.438	.028	.025	.058	.036	.037	.023	.010

Table 19. Total mortality estimation: Atlantic coast bluefish.
MRFSS 1979-1985, FROM CATCH NUMBER PER TRIP AT AGE

<u>COHORT</u>	<u>AGES</u>	<u>ESTIMATED Z</u>
1972	7 - 8	0.66
1973	6 - 8	0.48
1974	5 - 8	0.25
1975	4 - 8	0.39
1976	3 - 8	0.45
1977	2 - 8	0.44
1978	1 - 7	0.44
1979	1 - 6	0.45
1980	1 - 5	0.59
1981	1 - 4	0.66
1982	1 - 3	1.15
1983	1 - 2	0.47

Table 20. Total mortality estimation: Atlantic coast bluefish.
CT TRAWL SURVEY, 1984 - 1986 (CATCH NUMBER PER TOW)

YEAR	AGES	ESTIMATED Z
-----	-----	-----
1984	1 - 8	0.72
1985	1 - 8	0.67
1986	1 - 8	0.86

Table 21. Total mortality estimation: Atlantic coast bluefish.
NMFS FALL INSHORE TRAWL SURVEY, 1974 - 1985 (CATCH NUMBER PER TOW)

PERIOD*	AGES	ESTIMATED Z
-----	-----	-----
1974-76	2 - 8	0.63
1977-79	3 - 8	0.42
1980-82	2 - 8	0.66
1983-85	2 - 8	0.59

*Data pooled into 3 year periods and subjected to catch curve analysis

Table 22. Derivation of Relative Exploitation Index (REI) for tuning (calibration of terminal F) Atlantic Coast bluefish Virtual Population Analysis, 1979 - 1986.

Year	MRFSS Catch (000'S) Age 1+	NEFC Fall Inshore Survey Cape Cod - Cape Hatteras [strat. mean no. (*E3) per tow] Age 1+		REI*	VPA annual mean F
		<u>Actual</u>	<u>Calculated</u>		
1979	27849	3715	3319	8.217	.127
1980	28531	3701	3104	9.992	.153
1981	20727	2449	2819	7.353	.129
1982	21094	1763	2534	8.324	.159
1983	31407	1654	2249	13.963	.300
1984	17506	2066	1964	8.913	.186
1985	19602	2322	1678	11.682	.223
1986	24639	1459	1393	17.688	.400

* REI = MRFSS catch / NEFC strat. mean no. per tow

Table 23. Summary of Atlantic coast bluefish VPA tuning results. Tuning measures include the correlation coefficient (r), the absolute value of the 1986 residual (R86), and the sum of residuals for 1983-1986 (R8386); * = Best fit.

Fishing mortality (F, age 1+) on Relative Effort Index

First trial

	<u>Terminal F Value</u>					
	<u>0.10</u>	<u>0.20</u>	<u>0.30</u>	<u>0.40</u>	<u>0.50</u>	<u>0.60</u>
r	.813	.948	.976	.980*	.974	.967
R86	.0101	.0108	.0049	.0044*	.0214	.0390

Second trial

	<u>Terminal F Value</u>		
	<u>0.39</u>	<u>0.40</u>	<u>0.41</u>
r	.979348	.980133*	.978718
R86	.0051	.0044*	.0078
R8386	.0426	.0307*	.0482

Table 24. Estimates of fishing mortality (F), stock size (000's), and stock biomass (000's KG) determined by VPA for Atlantic coast bluefish.

AGE	YEAR							
	1979	1980	1981	1982	1983	1984	1985	1986
	FISHING MORTALITY							
1	0.130	0.183	0.156	0.211	0.468	0.232	0.246	0.400
2	0.118	0.146	0.116	0.140	0.233	0.166	0.247	0.400
3	0.152	0.130	0.103	0.133	0.104	0.140	0.143	0.400
4	0.128	0.181	0.109	0.117	0.206	0.121	0.184	0.400
5	0.086	0.113	0.128	0.143	0.265	0.170	0.163	0.400
6	0.146	0.115	0.171	0.181	0.289	0.206	0.275	0.400
7	0.127	0.153	0.129	0.159	0.300	0.186	0.223	0.400
8+	0.146	0.115	0.171	0.181	0.289	0.206	0.275	0.400
MEAN F REC AGE	0.127 1+	0.153 1+	0.129 1+	0.159 1+	0.300 1+	0.186 1+	0.223 1+	0.400 1+
AGE	1979	1980	1981	1982	1983	1984	1985	1986
	STOCK SIZE							
1	92501.3	68762.1	59901.1	45810.6	48261.9	42673.0	47434.6	24772.2
2	67805.0	57235.6	40364.9	36128.0	26143.2	21293.5	23841.8	26143.9
3	38921.7	42450.5	34865.2	25329.1	22125.6	14596.0	12715.2	13130.6
4	27806.6	23550.3	26271.5	22168.6	15632.1	14054.5	8941.9	7764.6
5	22738.8	17249.8	13851.9	16598.0	13896.1	8966.3	8776.4	5241.6
6	12373.8	14699.8	10854.8	8587.4	10140.6	7510.0	5329.7	5252.2
7	8025.2	7533.8	9235.5	6444.6	5049.7	5352.0	4306.9	2853.5
8+	4963.4	7785.5	5008.2	7604.8	4719.2	4283.3	3597.1	2398.7
TOT NOS	275135.8	239267.4	200353.0	168671.0	145968.4	118728.7	114943.6	87557.2
WGHTUNAD	600904.9	560610.7	552063.0	468078.2	295756.9	283632.7	245230.1	200326.3
SPWN NOS	228885.1	204886.3	170402.5	145765.7	121837.4	97392.2	91226.3	75171.1
WGHTUNAD	549566.6	522791.6	518817.9	450441.1	273797.7	266136.8	218903.9	185586.9
AGE	1979	1980	1981	1982	1983	1984	1985	1986
	STOCK BIOMASS AT AGE							
1	102676.4	75638.3	66490.2	35274.1	43918.3	34991.8	52652.4	29478.9
2	138322.2	110464.8	87995.6	57443.5	45489.1	39180.0	40769.4	56209.3
3	89519.9	113342.9	111219.8	81053.1	50888.9	38971.4	25684.6	34008.2
4	83419.9	74418.9	97730.2	90004.7	36735.5	53126.0	24322.0	24225.6
5	85952.8	57096.7	52775.6	70707.4	36268.8	35775.6	31068.5	17873.7
6	45535.5	46598.4	40705.6	41734.8	30320.3	30340.6	22224.6	19485.8
7	32100.6	35559.3	52826.9	46916.4	29389.5	33343.1	26745.6	10529.6
8+	23377.6	47491.3	42319.2	44944.1	22746.3	17904.3	21762.7	8515.3

Table 25. Estimated weight at age of Atlantic coast bluefish:
MRFSS, 1979 - 1986.

YEAR	AGE								
	0	1	2	3	4	5	6	7	8+
1979	0.473	1.113	2.039	2.302	2.996	3.759	3.675	3.994	4.705
1980	0.572	1.095	1.933	2.667	3.164	3.313	3.171	4.720	6.095
1981	0.365	1.106	2.175	3.193	3.722	3.812	3.750	5.723	8.450
1982	0.280	0.772	1.593	3.203	4.057	4.257	4.855	7.282	5.906
1983	0.752	0.913	1.735	2.302	2.350	2.613	2.989	5.817	4.817
1984	0.249	0.819	1.841	2.665	3.778	3.992	4.039	6.234	4.177
1985	0.697	1.106	1.714	2.024	2.721	3.544	4.172	6.206	6.052
1986	0.397	1.191	2.153	2.592	3.116	3.409	3.707	3.689	3.553

ATLANTIC COAST 1960 - 1986

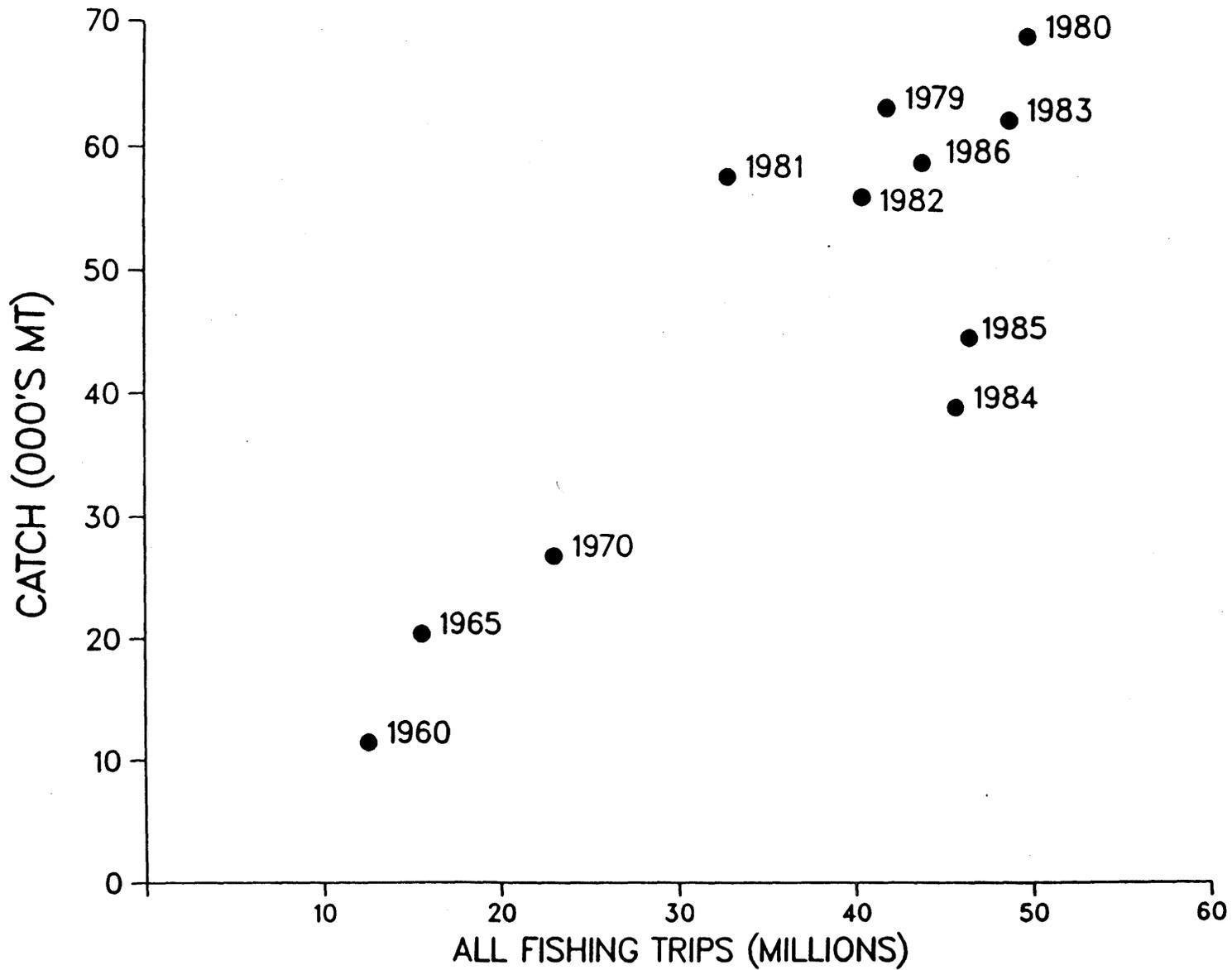


Figure 1. Recreational catch of bluefish and coastwide fishing trips: 1960, 1965, 1970, 1979 - 1986.

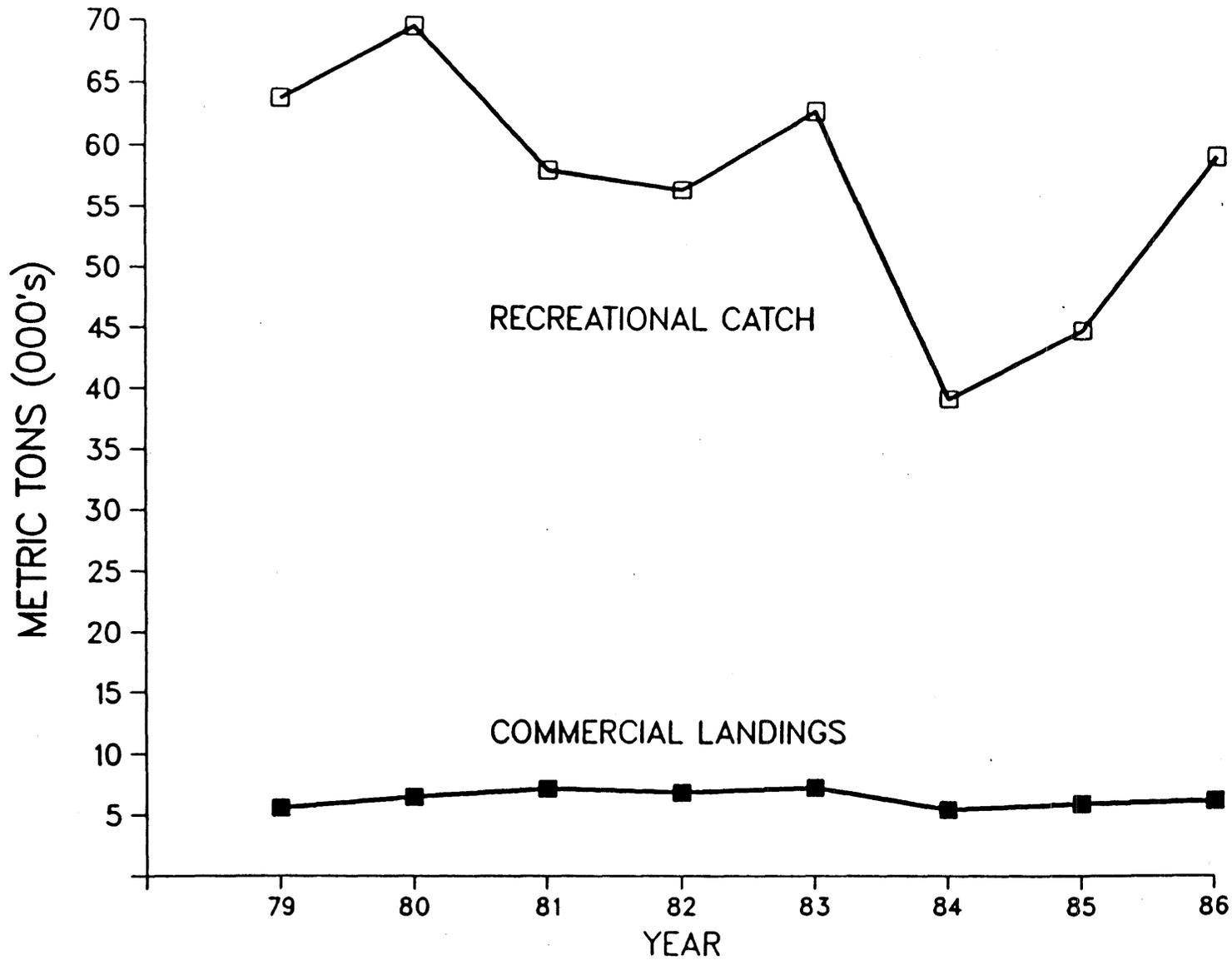


Figure 2. Estimated bluefish catch: Atlantic Coast (000's KG)

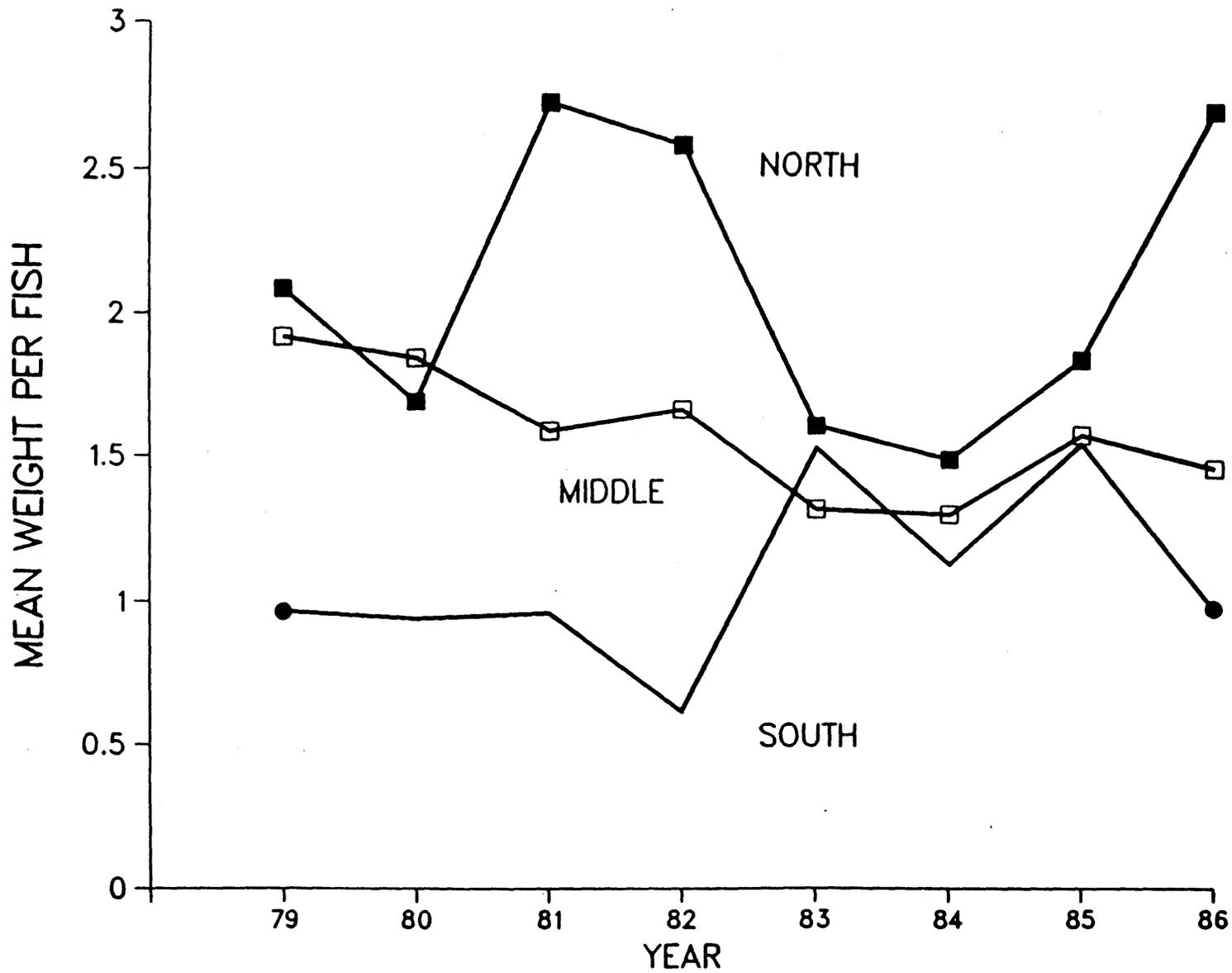


Figure 3. Atlantic coast bluefish, estimated mean weight per fish: MRFSS 1979 - 1986.

ATLANTIC COAST

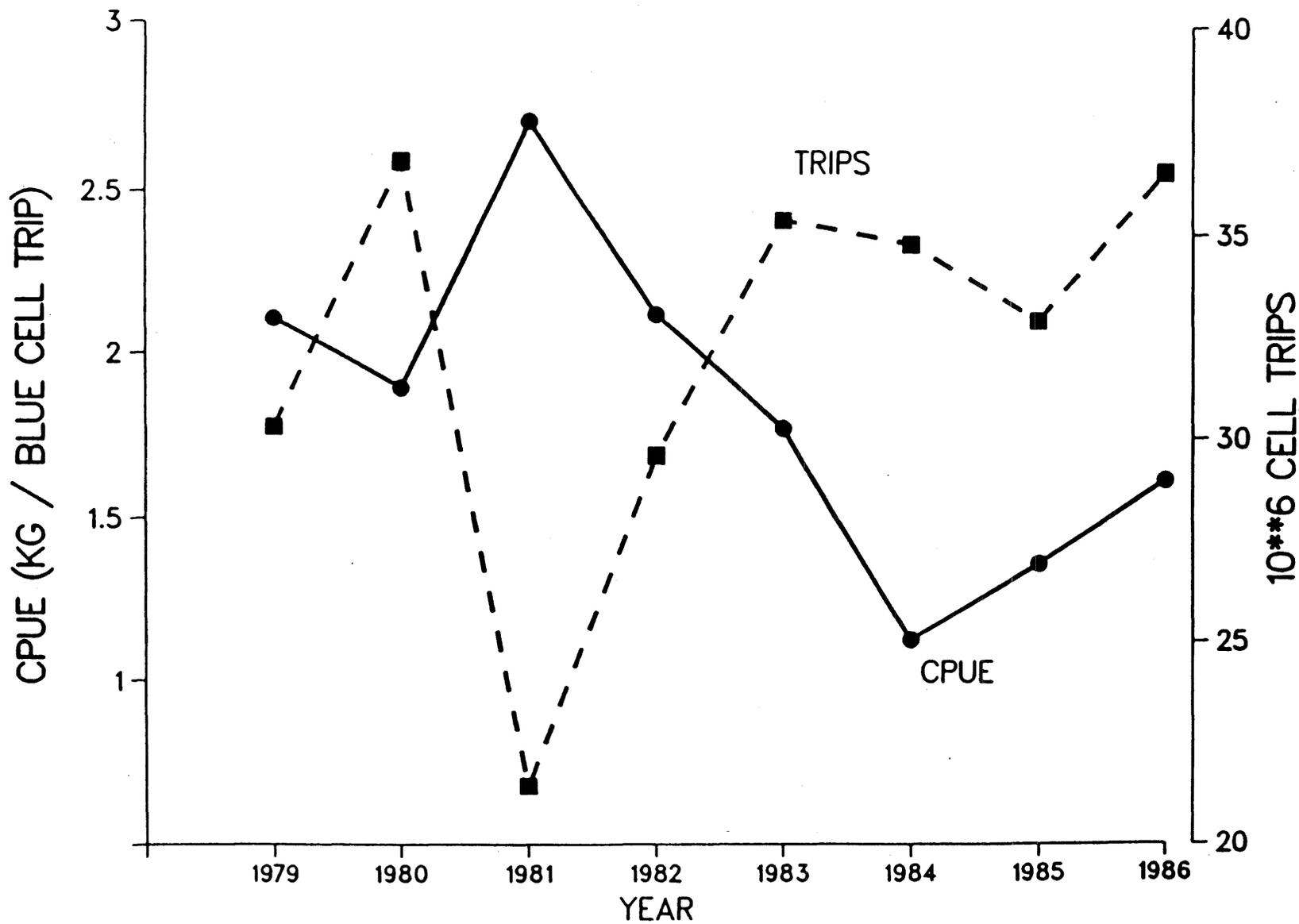


Figure 4. Bluefish recreational CPUE and fishing trips in subregion/mode/area cells with recorded bluefish catch: Atlantic Coast, 1979 - 1986.

NORTH ATLANTIC REGION

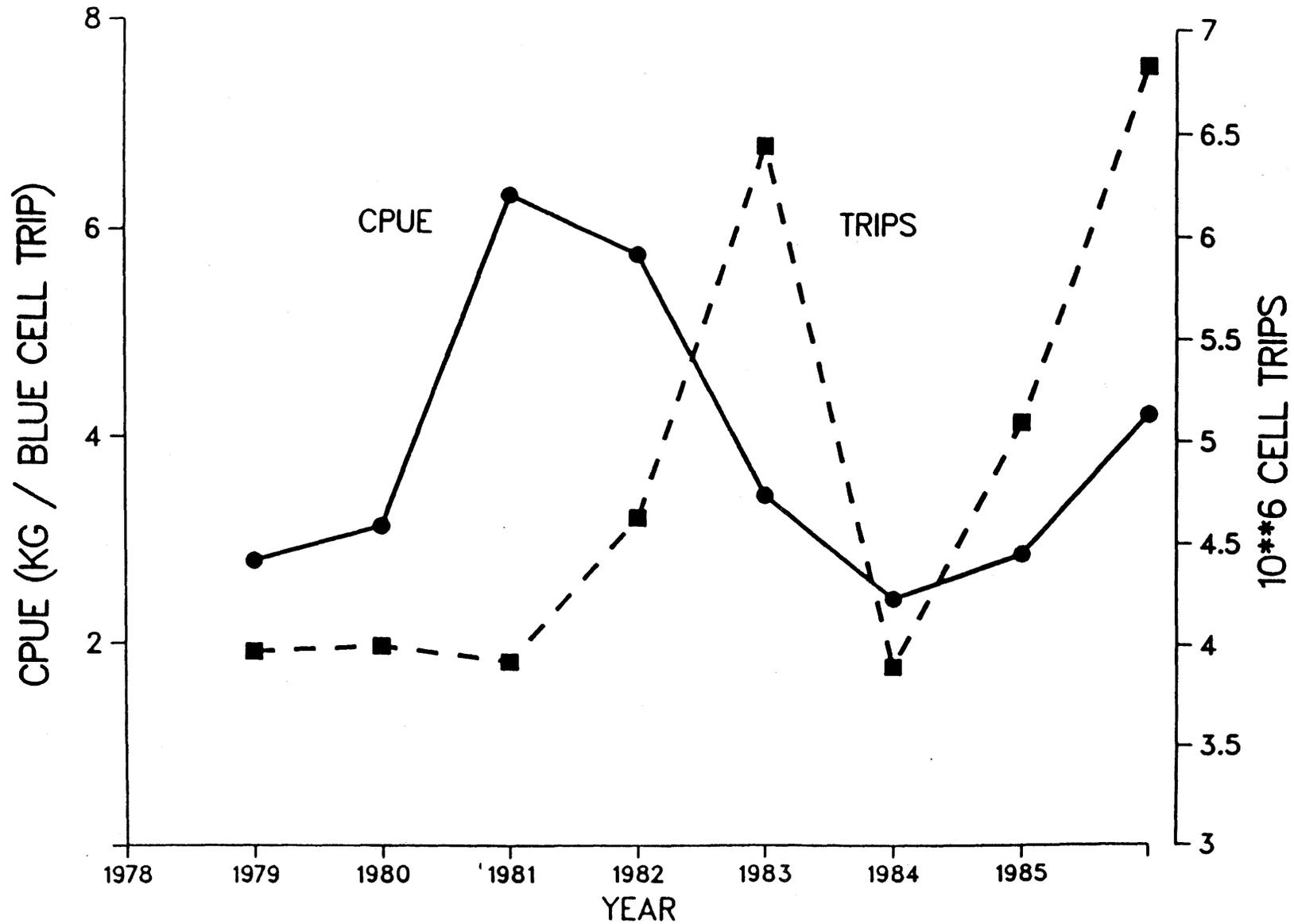


Figure 5. Bluefish recreational CPUE and fishing trips in subregion/mode/area cells with recorded bluefish catch: North Atlantic subregion, 1979 - 1986.

MIDDLE ATLANTIC REGION

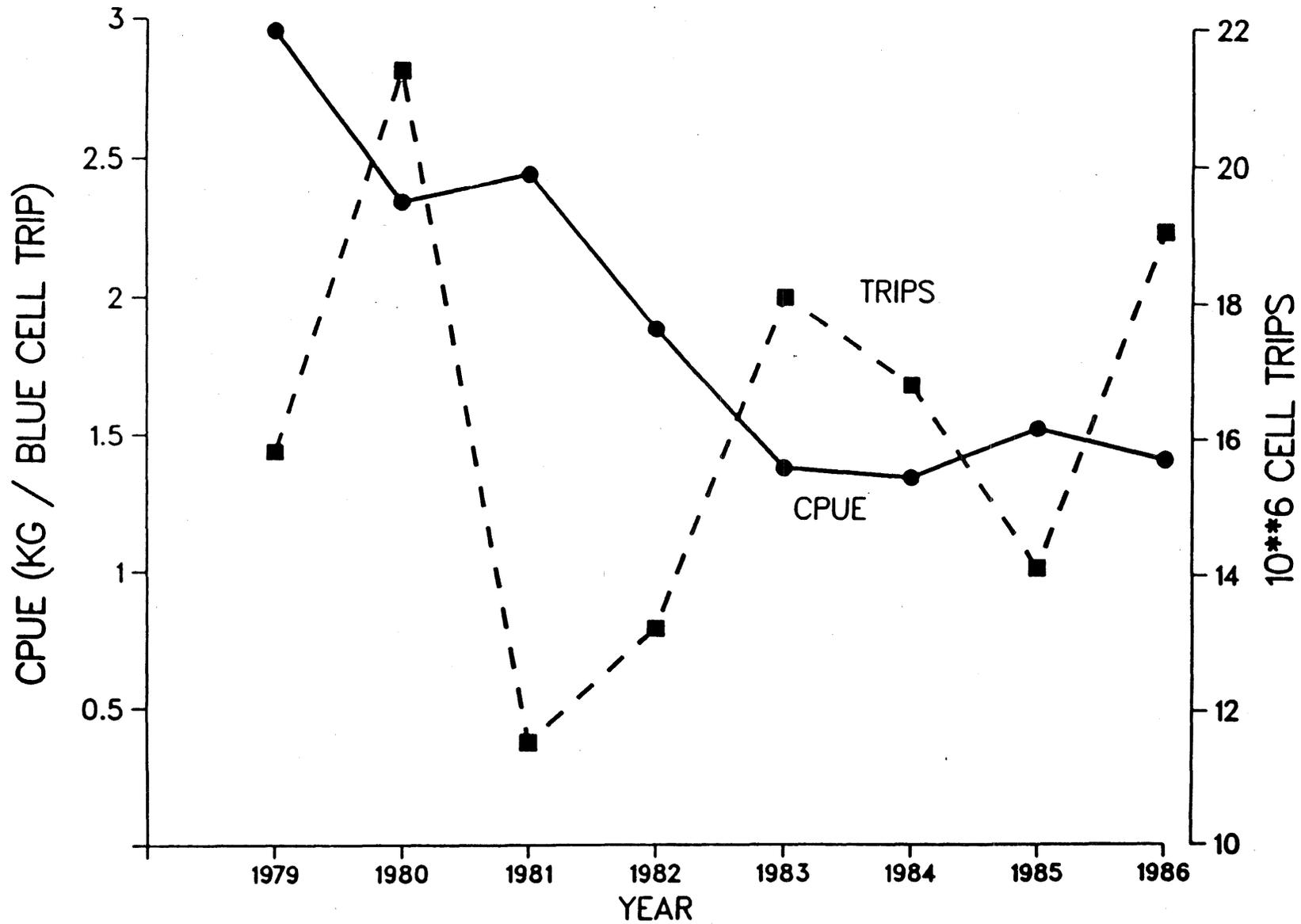


Figure 6. Bluefish recreational CPUE and fishing trips in subregion/mode/area cells with recorded bluefish catch: Middle Atlantic subregion, 1979 - 1986.

SOUTH ATLANTIC REGION

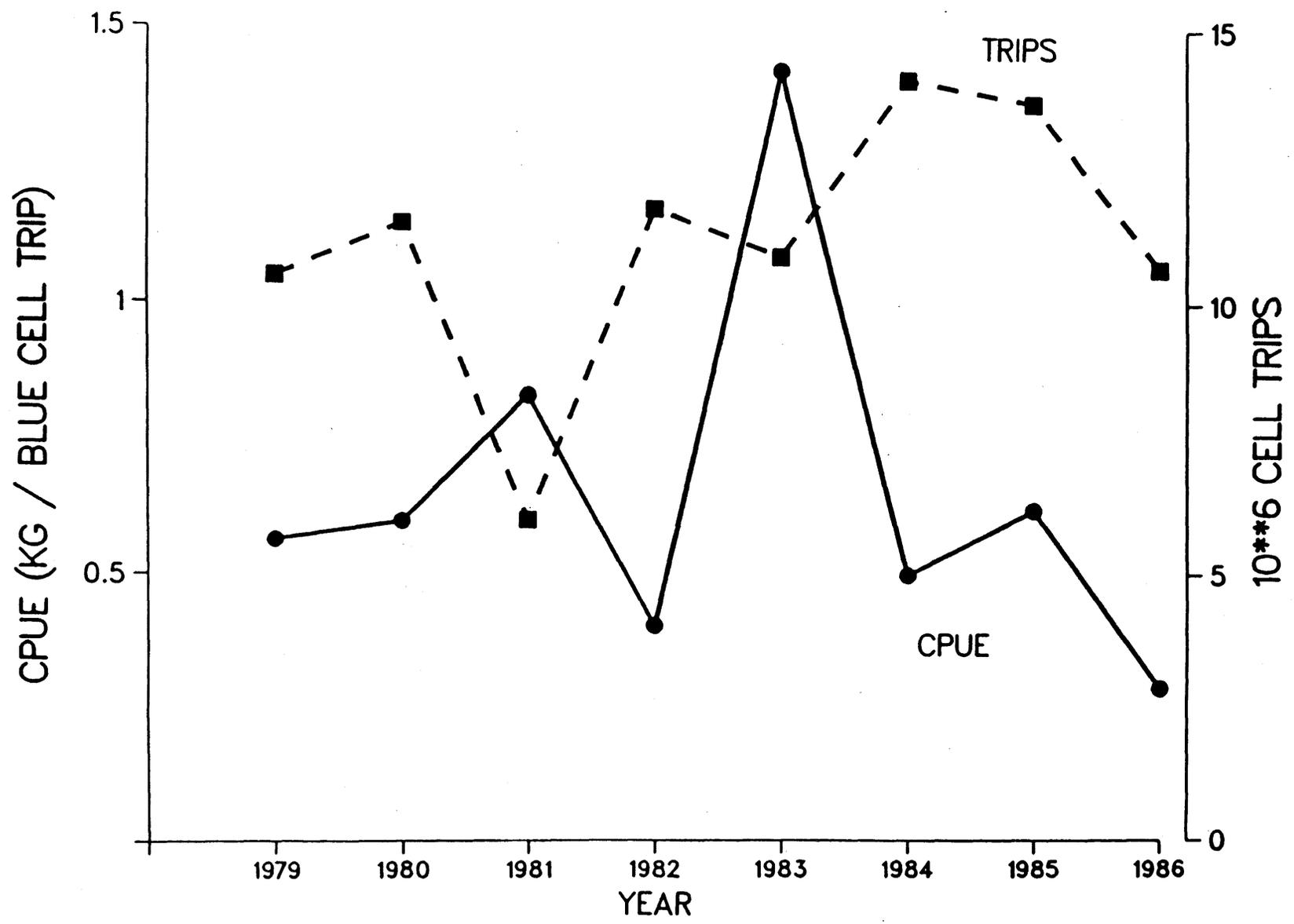


Figure 7. Bluefish recreational CPUE and fishing trips in subregion/mode/area cells with recorded bluefish catch: South Atlantic subregion, 1979 - 1986.

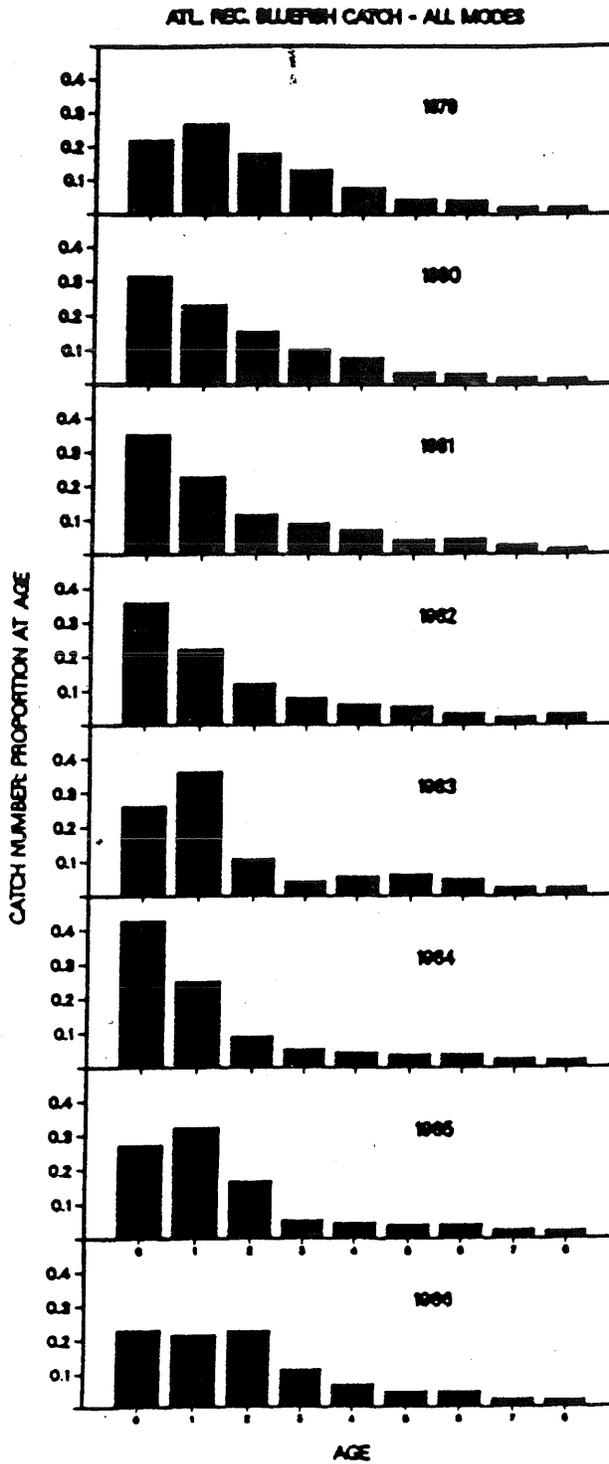


Figure 8. Estimated age frequency of Atlantic Coast bluefish: MRFSS, 1979 - 1986.

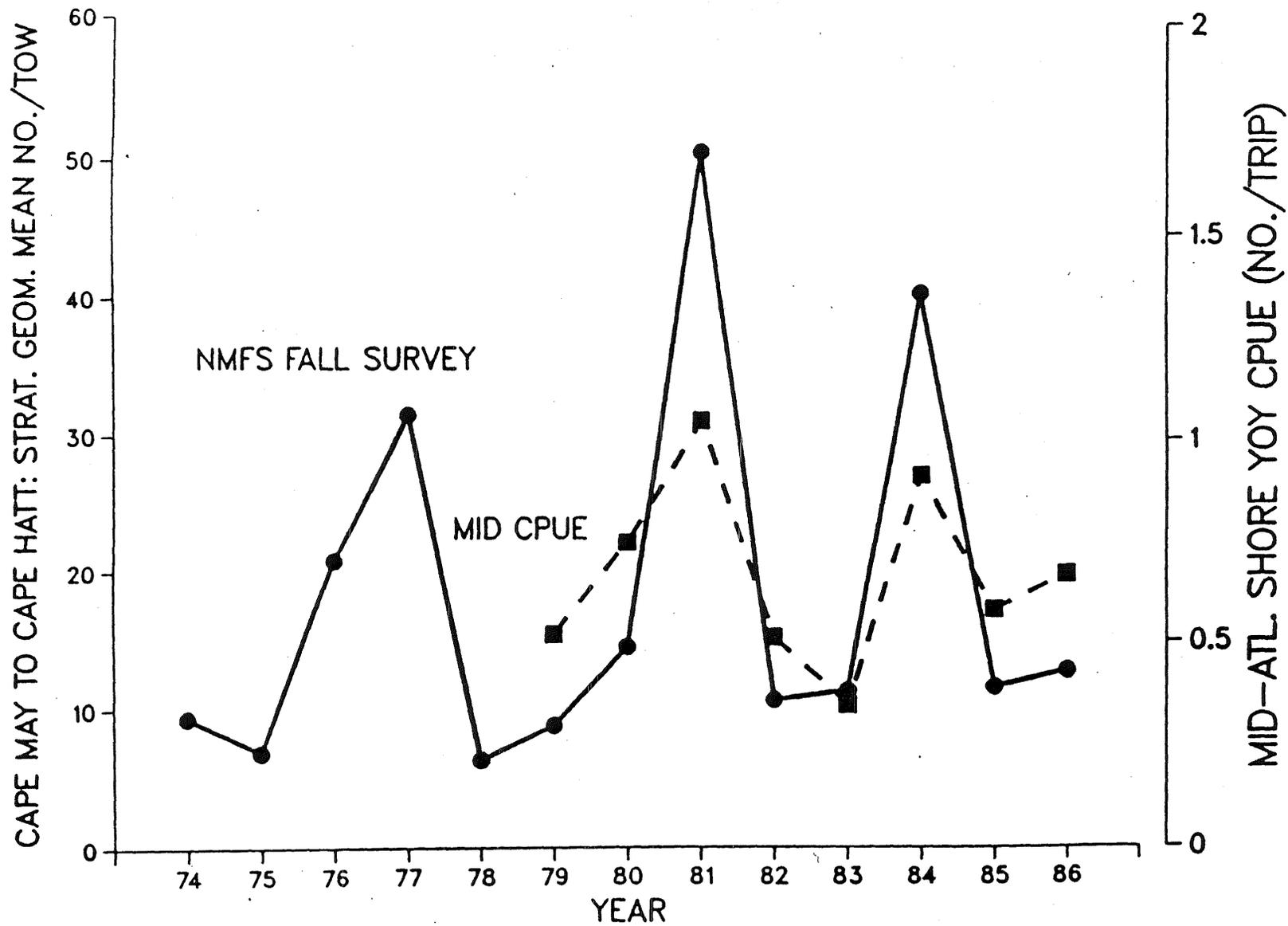


Figure 9. Atlantic Coast bluefish indices of recruitment: NMFS NEFC fall inshore trawl survey (strat. geom. mean number/tow); MRFSS Middle Atlantic shore YOY CPUE (catch number/trip).

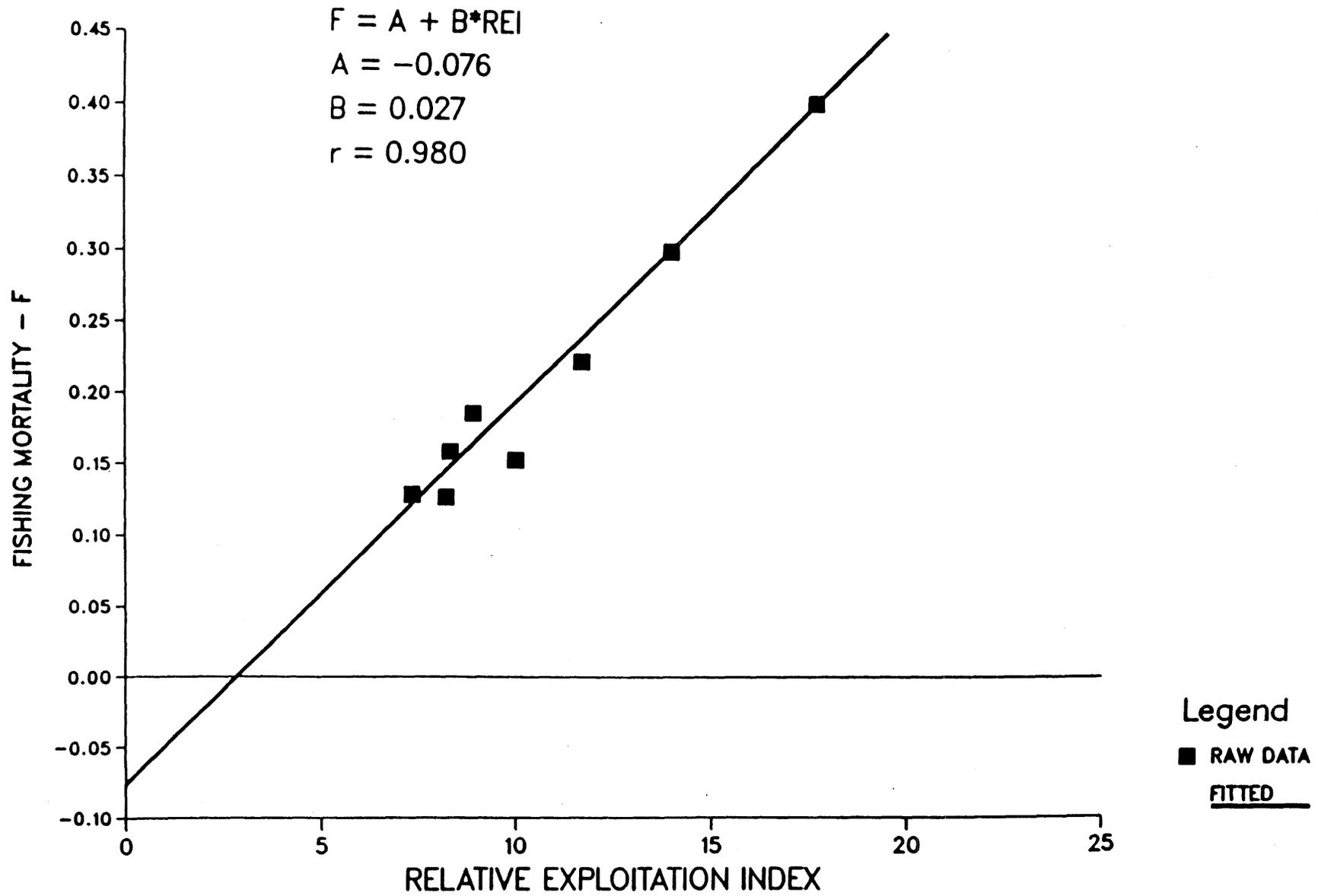


Figure 10. Regression of mean annual F from VPA on relative exploitation index (REI), 1979 - 1986.

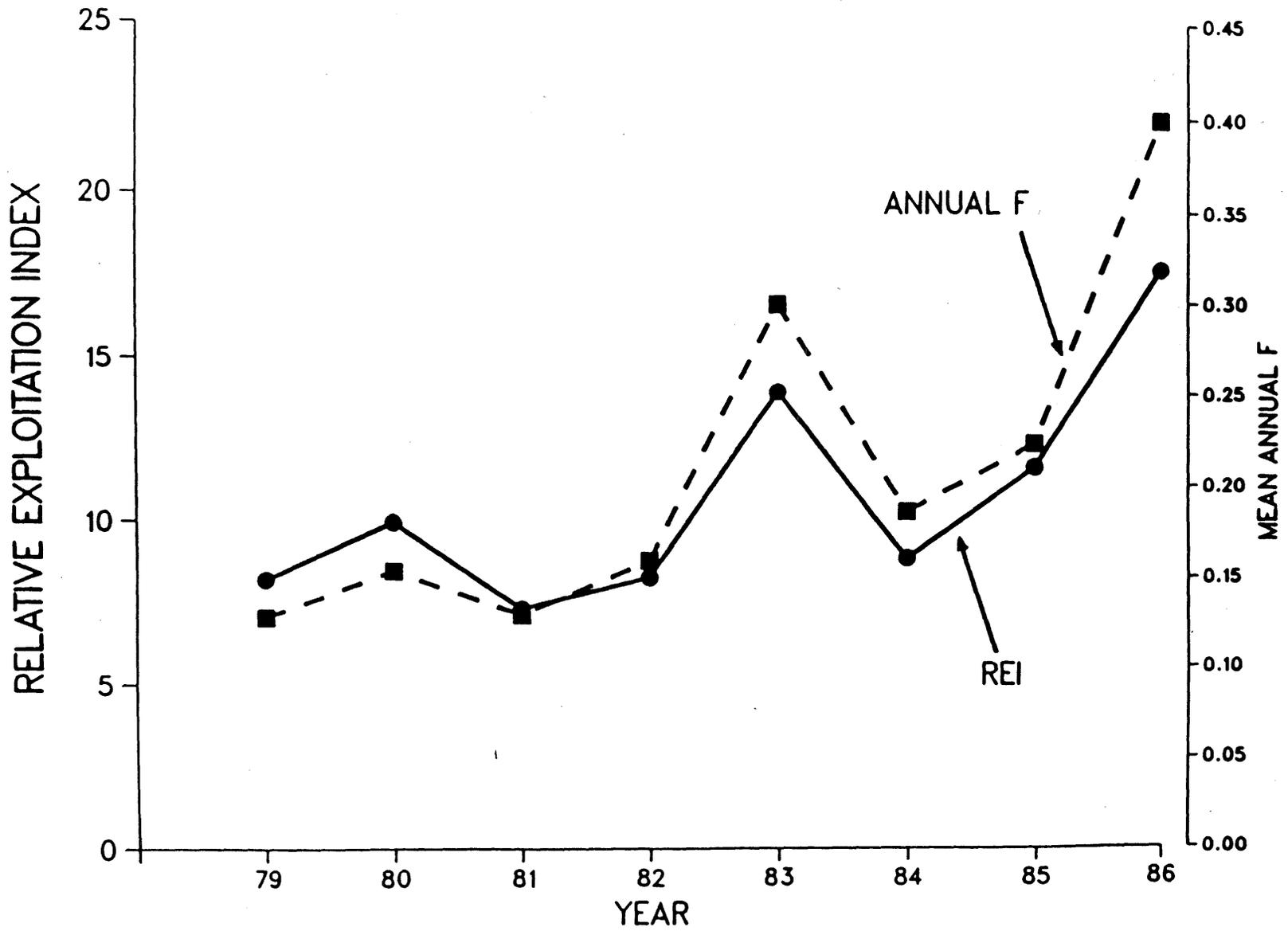


Figure 11. Mean annual F_t (age 1 and older) from VPA and relative exploitation index (REI) derived from MRFSS catch and NEFC trawl survey abundance index, 1979 - 1986.

Appendix Table 1. Stratified mean catch (number) per tow of bluefish: NMFS NEFC Fall Inshore Trawl Survey, Cape Cod to Cape May, 1974 - 1986.

STRATA SET 1: CAPE COD TO CAPE MAY

STRATUM	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	*	2.0	0	0	0	243.0	*	5.0	0	0	3.0	0	1.0
2	1.0	0	1.5	0	0	19.5	0	8.0	4.0	67.5	0.5	7.0	13.0
3	*	2.0	0	19.0	674.0	4.0	0	0	*	0	*	16.0	11.0
4	4.0	1.0	4.5	7.5	49.0	0.5	1.0	25.0	23.5	0.5	1.5	23.5	3.5
5	3.5	3.5	20.5	3.5	1.0	4.0	2.5	114.5	1.0	0.5	0	10.5	0.5
6	*	3.0	*	0	*	0	0	*	*	0	*	1.0	1.0
7	0	12.7	0	1.5	2.7	67.5	0.5	208.0	4.5	0	0.5	18.5	3.0
8	7.3	0.5	3.0	0	3.0	3.5	1.0	2.5	4.5	2.0	0	5.5	1.0
9	*	5.5	28.0	51.0	0	12.0	0	31.0	1.0	0	162.0	0	59.0
10	0.5	1.0	15.5	18.5	2.5	20.0	29.0	43.5	0	8.3	14.5	0.5	4.5
11	1.3	0.3	13.5	3.0	1.5	8.3	0.5	7.0	3.0	5.5	2.0	2.5	2.0
12	*	*	27.0	3.0	23.0	4.0	242.0	15.0	*	65.0	50.0	0	8.0
13	19.5	3.7	10.5	1.5	4.5	1.0	131.0	2.5	0	2.5	3.0	1.0	3.5
14	0.5	1.0	0	0.5	6.5	4.0	5.0	0	1.0	3.5	0.5	1.0	0.5
15	*	*	*	9.0	1.0	1.0	*	*	0	40.0	*	1.0	5.0
16	3.5	8.0	6.7	3.5	1.5	54.5	1.0	72.0	1.5	0.5	5.0	1.0	3.0
17	0.3	0.7	1.0	0.5	6.5	0.5	0.5	5.5	0.5	0	0.5	15.0	1.0
18	*	11.0	17.0	9.0	157.0	7.0	0	92.0	*	0	120.0	76.0	0
19	0.5	4.3	1.5	209.0	61.0	182.0	10.0	13.0	150.0	40.0	18.0	42.5	0.5
20	0	0.5	1.5	0.5	0	1.0	11.0	11.5	1.0	0	2.0	0.5	0
21	*	1.5	103.0	*	2.0	5.0	7.0	0	26.0	37.0	147.0	10.0	0
22	2.0	0.5	1.5	1.0	3.0	0	9.0	2.0	13.5	11.5	30.5	12.5	0.5
23	0	3.0	1.0	0.5	2.0	0.5	3.5	34.5	5.0	0.5	22.5	20.0	0
45	*	0.5	*	0	6.0	6.0	0.5	2.0	5.5	0	2.0	1.0	0
46	*	*	*	0.5	5.0	0	0.5	0	0	0.5	2.0	5.5	0.5
ARITH. MEAN	1.5	1.9	5.4	18.7	16.8	23.3	12.3	18.4	15.5	8.5	14.7	11.5	2.2
GEOM. MEAN	2.5	3.0	5.4	3.8	6.0	6.5	3.9	10.3	3.9	4.6	6.9	5.5	2.9

* = strata not sampled

Appendix Table 2. Stratified mean catch (number) per tow of bluefish: NMFS NEFC Inshore Trawl Survey, Cape May to Cape Hatteras, 1974 - 1986.

STRATA SET 2: CAPE MAY TO CAPE HATTERAS

STRATUM	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
24	*	8.5	64.0	0	7.0	0	4.0	0	6.0	86.0	1.0	27.0	31.0
25	3.3	6.5	62.0	2.5	10.5	0	72.5	85.5	3.5	64.0	2.0	24.0	102.5
26	0.5	7.0	2.0	1.0	19.5	0	9.5	1.5	22.0	0	2.5	0	6.0
27	*	1.5	4.0	39.0	29.0	18.0	42.0	377.0	*	*	103.0	0	*
28	12.7	1.0	89.0	91.0	46.0	24.5	26.5	354.0	213.0	29.0	150.0	48.5	0.5
29	0	0.5	9.0	271.5	33.0	0.5	0.5	539.5	300.0	98.0	134.0	31.5	0
30	*	2.0	4.0	0	0	*	27.0	67.0	*	*	203.0	50.0	598.0
31	11.7	1.3	352.5	375.5	1.0	1.5	342.0	539.0	53.5	55.5	202.0	78.0	435.5
32	51.0	0	214.0	223.0	1.0	0.5	0	2.5	2.5	3.5	48.0	71.0	76.5
33	0	0	80.0	90.0	14.0	1.0	5.0	97.0	*	10.0	24.0	1.0	0
34	2.7	3.5	0.5	44.0	0.5	8.0	53.5	152.5	126.0	23.5	84.5	8.0	0.5
35	6.5	115.5	13.0	82.0	0	6.5	4.5	55.5	8.5	10.5	15.0	7.0	45.0
36	28.0	0	34.0	62.0	4.0	0	1.0	4.0	0	14.0	587.0	1.0	*
37	11.0	3.0	3.0	62.0	8.5	130.5	6.5	17.5	13.0	0	87.5	2.0	1.0
38	41.5	171.0	55.5	127.0	17.5	532.0	3.5	0	3.0	0.5	56.5	1.0	27.0
39	*	42.5	0	101.0	10.0	6.0	189.0	859.0	*	8.0	1.0	28.0	285.0
40	9.5	35.0	19.5	7.5	42.5	9.5	196.5	22.5	16.5	5.5	59.5	16.0	2.0
41	3.0	31.5	39.0	14.0	9.5	5.0	0	8.0	12.5	0	34.5	16.5	1.0
42	*	10.0	30.0	115.0	0	159.0	8.0	1619.0	0	33.0	71.0	21.0	0
43	*	21.0	139.0	25.5	1.5	82.5	24.0	261.5	0.5	201.5	23.5	17.0	5.0
44	39.5	1.7	4.0	6.5	0	68.0	57.6	53.0	0.5	0	83.5	14.0	46.0
ARITH. MEAN	15.2	22.8	68.9	90.1	12.6	64.0	57.6	178.3	49.5	30.8	95.7	22.8	73.5
GEOM. MEAN	9.4	6.9	20.9	31.6	6.4	8.9	14.6	50.8	10.7	11.4	40.6	11.7	12.9

* = strata not sampled

Appendix Table 3. Stratified mean catch (number * E+3) per tow of bluefish:
 NMFS NEFC Inshore Trawl Survey, Cape May to Cape Hatteras, 1974 - 1986.

Year	Length (cm)													
	1- 6	7- 12	13- 18	19- 24	25- 30	31- 36	37- 42	43- 48	49- 54	55- 60	61- 66	67- 72	73- 78	79- 81
1974	619	9	1918	6405	487	217	132	0	0	0	0	20	16	0
1975	34	160	3265	8821	252	166	158	378	355	227	49	162	165	0
1976	1097	221	22114	17569	2059	320	560	41	71	127	99	0	28	21
1977	1439	339	23135	32311	487	140	74	23	106	36	53	113	63	12
1978	50	1400	1709	2409	3439	2337	77	17	86	119	186	85	0	0
1979	0	936	11219	48593	1510	398	827	599	939	275	133	122	0	126
1980	259	9290	2556	25655	6374	1882	207	0	75	77	32	72	123	16
1981	0	2934	41819	52613	3676	236	703	89	81	137	269	71	119	40
1982	980	678	2858	26298	2073	1019	203	35	56	14	5	0	0	25
1983	51	410	4119	14034	921	952	387	33	26	0	5	37	14	16
1984	0	3151	27983	23719	3600	729	228	83	78	92	82	19	72	0
1985	0	625	7941	6039	998	1411	262	40	261	62	46	5	41	0
1986	107	744	30667	6831	1151	692	186	52	102	82	43	49	21	22
TOTAL	4636	20897	181303	218684	27027	10499	4004	1390	2236	1248	1002	755	662	278

Appendix Table 4. Stratified mean catch (number) per tow (E-3) of bluefish at age: NMFS NEFC Fall Inshore Trawl Survey, Cape Cod to Cape Hatteras, 1974-1986.

YEAR	AGE								
	0	1	2	3	4	5	6	7	8+
1974	9357	443	0	0	4	17	12	7	0
1975	12482	398	644	313	74	135	103	61	0
1976	42668	1274	93	159	85	1	18	14	17
1977	57627	304	106	70	64	9	36	23	8
1978	8355	3076	90	167	178	64	0	0	0
1979	61973	1550	1311	495	134	96	0	18	111
1980	42928	3302	63	101	39	61	72	46	17
1981	100332	1643	148	197	244	61	72	49	35
1982	32496	1616	85	24	9	0	0	4	25
1983	19355	1517	52	8	16	32	6	6	17
1984	57765	1650	139	119	72	19	42	25	0
1985	15420	1863	244	122	45	10	24	14	0
1986	39281	1102	126	107	44	41	12	10	17

*AGED BY APPLICATION OF ASMFC 1987 BLUEFISH AGE/LENGTH KEY TO ALL YEARS