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STATUS OF THE SOUTHERN NEW ENGLAND - MIDDLE ATLANTIC
RED HAKE STOCK - 1978

by

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78-59

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Laboratory Reference No. 78-59
December 22, 1978

[corrected copy]

INTRODUCTION

This report presents an update of the status of the red hake (Urophycis chuss) stock inhabiting the Southern New England-Middle Atlantic waters (ICNAF Subdiv. 5Zw and SA 6). The data utilized include USA and foreign commercial catches and estimated USA recreational catches for 1960-77, numbers-at-age catch data for 1968-77, and research vessel bottom trawl survey results for 1963-78. Estimates of stock size, fishing mortality, and recruitment for 1968-78 are presented, and projections are made giving catch options in 1979 and resultant stock sizes in 1980.

CATCH

Commercial catch by country for the period 1960-77, including estimates of USA recreational catch, are listed in Table 1. Recreational catches of red hake have been small and have been taken primarily in the New York-New Jersey area. Marine angler surveys provided estimates of the recreational catch in 1960, 1965, 1970, and 1974-77. The ratio between recreational and USA commercial catch was 0.076 in 1960, 0.026 in 1965, 0.089 in 1970, and 0.088 in 1974. Because of the fairly uniform relationship between recreational and USA commercial catch in the above years, these ratios were used to estimate recreational catch in the intervening years. Each of the above ratios was applied to the USA commercial catch in the preceding and succeeding two years (the mean of the 1970 and 1974 ratios was used for 1972). Estimated recreational catches ranged from 52 tons in 1975 to 892 tons in 1962 and averaged 456 tons per year during 1960-77.

USA commercial catches increased from 4,174 tons in 1960 to 32,622 tons in 1964, collapsed to 3,629 tons in 1966, and remained between 2,000 and 6,500 tons since, averaging 3,800 tons per year. The 1977 USA commercial catch was 2,514 tons.

Total catches increased from 4,491 tons in 1960 to 61,153 tons in 1966, followed by considerable fluctuation due primarily to the variability in the USSR catch which averaged about 80% of the total each year. In recent years, the total catch declined from 41,803 tons in 1973 to 5,680 tons in 1977. The 1977 catch is the lowest since 1960.

The ICNAF total allowable catch (TAC) was 40,000, 50,000, and 45,000 tons for 1973, 1974, and 1975, respectively (for ICNAF Div. 5Z west of 69°W and SA 6) and 16,000 tons for 1976. An optimum yield (OY) of 28,000 tons was set by the USA for 1977, with 7,600 tons designated as the capacity of the USA commercial and recreational fisheries and 20,400 tons allocated as the total allowable level of foreign fishing (TALFF). In 1978, the OY was reduced to 20,500 tons, with the same designated capacity for the USA commercial and recreational fisheries as in 1977 but with a reduction in the TALFF to 12,900 tons. The 1978 foreign catch, as of 2 December, was 1,329 tons, taken by Italy, Japan, Spain and the USSR. The USA commercial catch in 1978 was estimated to be 3,800 tons from projections comparing 1977 and available 1978 monthly catches. The recreational catch was considered to be about 750 tons, or the same level as in 1977. For the purposes of this assessment, the total 1978 catch was assumed to be 6,000 tons.

CATCH COMPOSITION

Numbers-at-age catch data were calculated for 1968-77 (Table 2) using USSR and USA commercial length frequency data, USSR commercial age/length keys and USA survey age/length keys. Pooled USSR keys were used for 1968-72 and USA keys were used for 1973-77 (Anderson and Almeida, 1978).

Age 2 and 3 fish dominated the catch in most years except 1968-69 and 1973, when ages 3 and 4 were predominant. In 1976, the catch at age 2 was greater than in any other year (47%), but ages 2 and 3 again made up the bulk of the 1977 catch (61%).

Calculated mean weights at age for the 1968-77 catches are given in Table 3. These values were generated by the application of a length-weight equation to the frequency data of the catches. These mean weights at age were applied to the numbers at age in Table 2 to obtain calculated catches (tons). Ratios between observed and calculated catches range from 0.887 to 1.042 and average 0.990. The 1977 mean weights (unadjusted) were utilized in the projections of 1979-80 catch and stock size.

ABUNDANCE INDICES

Due to the difficulty of defining USA directed red hake effort, since most are caught in a mixed fishery situation, there is no commercial catch-per-effort index for this stock. This same situation is true for the USSR fishery because of a general inability to distinguish directed red hake effort in the reported statistics.

The USA autumn bottom trawl survey catch-per-tow index (Table 4, Figure 2) exhibited a considerable amount of fluctuation during 1963-77, declining from 8.05 kg in 1963 to 2.67 in 1967, increasing to 6.62 in 1972, dropping to a low of 0.59 kg in 1974, increasing to 4.34 in 1975, and then decreasing to 3.15 kg in 1977. The spring survey catch-per-tow index (Table 4, Figure 2) increased from 1.65 kg in 1969 to 5.55 in 1972, decreased to 1.43 in 1975, increased sharply to 3.54 kg in 1976, dropped to a low of 1.04 in 1977, and then increased again sharply to 3.59 in 1978. The autumn and spring indices exhibited similar year-to-year fluctuations beginning in about 1971. However, the indices demonstrate only a general relationship with the changes in stock size determined from virtual population analysis (VPA) in terms of showing a stock build-up in the early 1970's followed by a decline. Of the two, the spring index shows a closer correspondence to the results of the VPA.

FISHING MORTALITY

Fishing mortality (F) for fully recruited ages (3 and older) in 1977 was estimated from a linear relationship ($r = 0.820$, $p = 0.05$) between relative exploitation (international catch divided by USA spring survey catch per tow)

and fishing mortality from VPA (Table 5, Figure 3). An F of 0.40 for 1977 was obtained using the above relationship. Anderson and Almeida (1978) describe the method used in estimating this value as a starting F for the virtual population analysis (Table 6).

Fishing mortality increased sharply from 0.25 in 1968 to 0.98 in 1969, dropped to 0.22 in 1970, increased to average 0.90 during 1973-76, and dropped to an estimated 0.40 in 1977 (Table 6).

RECRUITMENT

The sizes of the 1967-74 year classes at age 1 were estimated from VPA (Table 6), and varied from 616 to 124 million fish (mean = 314 million). The 1969 year class was the largest on record (616 million fish), but the year-class size decreased steadily to 124 million fish for the 1973 year class. A linear relationship ($r = 0.972$, $p = 0.01$) was found to exist between the spring survey catch per tow (numbers) at age 1 and the year-class size at age 1 from the VPA for the 1967-74 year classes (Table 7, Figure 4). From this relationship, the 1975, 1976, and 1977 year-class sizes at age 1 were estimated to be 178, 174, and 245 million fish, respectively (Table 6).

For the purposes of catch and stock size projections for 1979-80, the 1978 year-class size at age 1 was assumed to be equal to the median year-class size (225 million fish). Other values based on past probabilities of year-class size could be used in the projections if desired.

STOCK SIZE

Stock size estimates for 1968-77 were determined from VPA (Table 6). Mean weights at age (Table 3) were applied to stock numbers at age to obtain stock biomass values. The annual biomass values were adjusted using the appropriate observed/calculated catch ratios (Table 2). The 1978 stock size at age was determined from the relationship:

$$N_{78} = N_{77} e^{-Z_{77}}$$

Total stock biomass (age 1+) ranged from 111,600 tons to 145,800 tons during 1968-71, averaging 135,600 tons, dropped steadily to 42,300 tons in 1976, and increased to an estimated 61,200 tons at the beginning of 1978 (Table 6, Figure 1).

Spawning stock biomass (age 2+) ranged from 89,100 tons to 125,200 tons during 1968-71, averaging 107,000 tons, steadily decreased to a low of 26,500 tons in 1976, and increased to 44,000 tons in 1978 (Table 6, Figure 5).

PARTIAL RECRUITMENT

Red hake have generally been fully-recruited to the fishery at about age 3 as evidenced by age-specific fishing mortalities estimated from VPA (Table 6). Partial recruitment, defined here as the ratio between the fishing mortality at a given age (in a given calendar year) not fully recruited to the fishery and the mean F at the fully recruited ages in that year was estimated to 11% at age 1, 22% at age 2 and 100% at ages 3 and older in 1977. These values were derived from the fishing mortality rates estimated for 1977 (Table 6), and were used in the projections of catch and stock size for 1979-80.

CATCH AND STOCK SIZE PROJECTIONS

A total stock (age 1+) biomass of 61,200 tons was calculated to be available at the beginning of 1978, and the spawning stock (age 2+) biomass was calculated to be 44,000 tons (Table 6). These estimates represent increases of 36% and 33% respectively, from 1977.

Equilibrium yield calculations under conditions of a constant level of recruitment at age 1 and partial recruitment coefficients of 11, 22, and 100% at ages 1, 2, and 3+, respectively, indicate in $F_{0.1}$ of about 0.65.

A total catch of 6,000 tons requiring an F of 0.25 for ages 3 and older was assumed for 1978, leaving an age 2+ biomass of 59,800 tons at the beginning of 1979 (35% increase from 1978). An estimated 1978 year class of median strength (225 million fish) was also assumed. Catch projections for 1979 and the resulting age 2+ spawning stock biomass in 1980 were calculated with F ranging from 0.05 to 1.00 (Table 8). Fishing at $F_{0.1}$ (0.65) in 1979 would result in a catch of 17,400 tons and allow the spawning stock biomass to increase by 1% from 1979 to 1980.

A catch of 18,200 tons ($F = 0.685$) could be taken in 1979 and still maintain the same spawning stock biomass in 1980 as in 1979.

STOCK-RECRUITMENT

Spawning stock biomass is plotted versus recruitment in Figure 5. The data presented do not suggest any direct relationship. The spawning biomass which produced the strong 1969 year class was quite similar in size to those which produced the weak 1971 and 1972 year classes (Figure 5). The 1971-76 year classes, all about the same size, originated from spawning stocks ranging from about 26,000 to 125,000 tons, the full range observed during the available data series (1968-present). This suggests that the size of the spawning stock bears no relationship to the year classes produced.

In spite of the apparent lack of a stock-recruitment relationship and the relatively short data series (10 years), the recent low levels of spawning stock (26,000-44,000 tons), are the lowest observed and have not produced strong year classes, although the 1977 year class is estimated to be better than any since the 1970 year class. Therefore, based on the data available, it may be advisable to prevent any major decline in the stock size below current levels from the standpoint of improving recruitment prospects.

LITERATURE CITED

Anderson, E. D. and F. P. Almeida. 1978. Assessment of the Southern New England - Middle Atlantic red hake stock. NMFS, NEFC, Woods Hole Lab. Ref. 78-06.

Table 1. Red hake catch (MT) from the Southern New England - Middle Atlantic stock.¹

Year	Bulgaria	Cuba	GDR	Japan	Poland	Romania	Spain	USSR	USA commercial	USA recreational	Total
1960	-	-	-	-	-	-	-	-	4,174	317 ²	4,491
1961	-	-	-	-	-	-	-	-	8,047	612	8,659
1962	-	-	-	-	-	-	-	-	11,737	892	12,629
1963	-	-	-	-	-	-	-	770	29,608	770	31,148
1964	-	-	-	-	-	-	-	8,427	32,622	848 ²	41,897
1965	-	-	-	-	-	-	-	17,611	24,759	634 ²	43,004
1966	-	-	-	-	-	-	-	57,430	3,629	94	61,153
1967	-	-	-	-	39	-	-	29,539	5,788	150	35,516
1968	-	-	-	-	-	-	-	8,698	6,464	575	15,737
1969	114	-	-	-	-	-	-	44,913	5,491	489	51,007
1970	197	-	-	-	-	-	-	5,534	4,591	410 ²	10,732
1971	1,218	-	9	8	-	-	-	23,234	3,225	287	27,981
1972	471	-	40	549	5	43	-	33,368	1,995	177	36,648
1973	216	-	-	2	25	-	-	37,640	3,603	317	41,803
1974	401	-	-	-	-	51	-	20,917	2,182	191 ²	23,742
1975	14	-	-	-	-	-	4	11,195	2,065	52 ²	13,330
1976	-	-	-	-	-	35	-	7,122	3,904	645 ²	11,706
1977	-	37	-	-	-	8	1	2,370	2,514	750 ²	5,680

¹Non-USA catches before 1968 are estimated.

²From angler surveys; remaining years estimated (see text).

Table 2. Red hake catch-at-age (millions of fish) from the Southern New England-Middle Atlantic stock (+ denotes less than 0.1 million).

Year	Age										Total	Observed weight	Calculated weight	Obs calc.
	1	2	3	4	5	6	7	8	9	10+				
1968	2.7	14.3	24.4	20.5	5.8	2.5	1.2	0.5	0.2	0.2	74.1	15,737	17,748	.887
1969	1.6	25.6	98.4	64.3	20.4	6.2	2.1	1.0	+	+	219.6	51,007	51,441	.992
1970	5.3	12.1	19.8	10.7	3.4	1.4	0.7	0.3	0.1	+	53.8	10,732	10,903	.984
1971	3.2	74.4	50.3	21.2	5.9	2.3	1.1	0.7	0.3	0.1	159.5	27,981	27,537	1.016
1972	5.6	72.4	84.4	39.0	10.8	4.4	1.6	0.9	0.1	+	219.2	36,648	36,363	1.008
1973	6.3	27.6	60.6	36.5	27.1	4.8	2.2	1.7	0.3	+	167.1	41,803	40,111	1.042
1974	4.7	30.9	39.8	19.1	13.2	1.9	0.9	0.8	0.2	-	111.5	23,742	23,852	.995
1975	5.8	20.0	19.7	10.9	3.5	2.1	1.1	0.2	0.7	+	63.9	13,330	13,340	.999
1976	3.0	30.2	17.1	8.2	2.6	1.4	0.7	0.1	0.6	+	64.0	11,706	11,860	.987
1977	6.3	8.0	9.4	3.1	1.1	0.3	0.2	0.1	-	-	28.5	5,680	5,721	.993

Table 3. Mean weights (kg) at age of red hake catches from the Southern New England-Middle Atlantic stock.

Year	Age									
	1	2	3	4	5	6	7	8	9	10+
1968	.05	.11	.18	.27	.32	.40	.53	.57	.88	1.08
1969	.05	.12	.20	.28	.33	.37	.49	.55	.64	.85
1970	.05	.10	.21	.29	.32	.38	.47	.51	.65	.89
1971	.05	.11	.18	.27	.37	.43	.49	.56	.70	1.02
1972	.04	.09	.16	.25	.31	.39	.48	.52	.69	1.05
1973	.06	.13	.21	.28	.35	.44	.42	.33	.39	1.28
1974	.10	.14	.21	.27	.31	.41	.42	.30	.26	-
1975	.08	.13	.23	.30	.30	.36	.33	.47	.27	1.01
1976	.09	.13	.22	.28	.28	.33	.30	.41	.27	1.26
1977	.07	.16	.26	.30	.36	.42	.37	.30	-	-

Table 4. Stratified mean catch per tow (kg) of red hake from the Southern New England-Middle Atlantic stock from the USA bottom trawl surveys in the spring and autumn (strata 1-12).

Year	Spring	Autumn
1963	-	8.05
1964	-	4.35
1965	-	5.62
1966	-	2.90
1967	-	2.67
1968	1.93	4.42
1969	1.65	4.80
1970	2.39	3.90
1971	5.38	3.37
1972	5.55	6.62
1973	2.13 ¹	3.05
1974	1.58 ¹	0.59
1975	1.43 ¹	4.34
1976	3.54 ¹	3.38
1977	1.04 ¹	3.15
1978	3.59 ¹	-

¹Adjusted from No. 41 trawl catches to equivalent No. 36 catches using a 3.00:1 ratio.

Table 5. Estimation of F in 1977 for the Southern New England-
Middle Atlantic red hake stock.

Year	Spring survey catch per tow (kg)	International catch (tons)	Relative exploitation index ¹	Fishing mortality ²
1968	1.93	15,737	8,154	.245
1969	1.65	51,007	30,913	.975
1970	2.39	10,732	4,490	.218
1971	5.38	27,981	5,201	.349
1972	5.55	36,648	6,603	.603
1973	2.13	41,803	19,626	.966
1974	1.58	23,742	15,027	.968
1975	1.43	13,330	9,322	.788
1976	3.54	11,706	3,307	(.334) ^{3,4}
1977	1.04	5,680	5,462	(.398) ³

¹International catch divided by spring survey catch per tow.

²Weighted mean F for ages 3+ obtained from virtual population analysis assuming F = 0.400 in 1977.

³Calculated from regression of fishing effort on fishing mortality for 1968-75: $Y = 0.236 + 0.000030X$, $r=0.820$

⁴Value calculated from VPA was 0.863.

Table 6. Fishing mortality rates and stock sizes for the Southern New England-Middle Atlantic red hake stock from virtual population analysis (M = 0.40).

Year	Age										100% recruitment			
	1	2	3	4	5	6	7	8	9	10+	Wtd. F ₃	Age		
	Fishing Mortality													
1968	.010	.055 ⁵	.170	.379	.348	.300	.354	(.245) ¹	(.245) ¹	(.245) ¹	.245	3+		
1969	.004	.148	.833	1.226	1.107	1.045	.570	.737	-	-	.975	3+		
1970	.010	.045	.203	.242	.218	.240	.381	.181	-	-	.218	3+		
1971	.010	.247	.331	.441	.255	.282	.380	1.128	(.349) ¹	(.349) ¹	.349	3+		
1972	.030	.387	.633	.598	.545	.389	.410	.812	(.603) ¹	-	.603	3+		
1973	.047	.256	.868	.835	1.712	.651	.436	1.499	(.966) ¹	-	.966	3+		
1974	.047	.426	.951	1.039	1.190	.674	.300	.353	(.968) ¹	-	.968	3+		
1975	.053 ²	.361	.695	1.042	.702	.797	1.642	.124	(.788) ¹	-	.788	3+		
1976	.021 ²	.535 ²	.790 ⁵	.962 ⁵	1.056 ⁵	.925 ⁵	.925 ⁵	(.863) ¹	(.863) ¹	-	.863	3+		
1977	.044 ²	.086 ²	(.400) ⁵	-	-	.400	3+							
	Stock size (millions)										Age 1+		Age 2+	
											Total	Wt(10 ³ tons) ⁴	Total	Wt(10 ³ tons) ⁴
1968	338.2	323.9	187.8	77.8	23.7	11.6	4.8	1.8	1.1	1.1	972.8	111.6	634.6	96.7
1969	500.0	224.7	205.5	106.2	35.7	11.2	5.8	2.3	-	-	1091.4	141.7	591.4	116.9
1970	616.0	334.2	129.9	59.9	20.9	7.9	2.6	2.2	0.7	-	1174.3	119.4	558.3	89.1
1971	407.1	408.6	214.2	71.1	31.5	11.3	4.2	1.2	1.2	0.4	1150.8	145.8	743.7	125.2
1972	226.1	270.5	213.9	103.1	30.6	16.4	5.7	1.9	0.3	-	868.5	114.1	642.4	105.0
1973	166.6	147.0	123.2	76.2	38.0	11.9	7.4	2.5	0.6	-	573.4	103.2	406.8	92.8
1974	123.8	106.5	76.3	34.7	22.2	4.6	4.2	3.2	0.4	-	375.9	64.0	252.1	51.6
1975	136.7	79.2	46.6	19.8	8.2	4.5	1.6	2.1	1.5	-	300.2	43.8	163.5	32.9
1976	(178.0) ⁵	86.9	37.0	15.6	4.7	2.7	1.4	0.2	1.2	-	327.7	42.3	149.7	26.5
1977	(174.0) ⁵	116.8	34.1	11.3	4.0	1.1	0.7	0.4	-	-	342.4	45.1	168.4	33.0
1978	(245.0) ⁵	111.6	71.8	15.3	5.1	1.8	0.5	0.3	0.2	-	451.6	61.2	206.6	44.0

¹Mean F in that year.

²Determined from assumed stock size and known catch.

³Weighted by stock size of age.

⁴Determined by applying mean weights at age to stock size at age and adjusting totals with ratios of observed to calculated catch.

⁵Estimated.

Table 7. Catch per tow (numbers) of age 1 red hake from the USA spring bottom trawl surveys and year-class size (millions of fish) at age 1 from VPA for the Southern New England-Middle Atlantic stock.

Year-class	Spring survey Age 1	VPA Age 1
1967	1.60	338.2
1968 ¹	0.54	500.0
1969	4.04	616.0
1970	1.71	407.1
1971	0.82	226.1
1972	0.45	166.6
1973	0.57	123.8
1974	0.42	136.7
1975	0.56	(178.0) ²
1976	0.53	(174.0) ²
1977	1.06	(245.5) ²

¹Not used because the survey value appears excessively low in comparison to the year-class size.

²Calculated from linear regression of spring survey catch-per-tow on VPA year-class size for 1967-74: $Y = 102.429 + 135.015X$, $r=0.972$.

Table 8. Projected catch (age 1+) in 1979 from the Southern New England-Middle Atlantic red hake stock with fishing mortality ranging from 0.05 to 1.00. Resulting stock sizes (age 2+) in 1980 and percentage changes (by weight) from 1979 are also given. All catch and stock size values are in thousands of tons.

Fishing mortality	1979 catch	1980 stock	% change in stock size from 1979
.05	1.7	76.8	+28.4
.10	3.3	75.2	+25.8
.15	4.8	73.6	+23.1
.20	6.3	72.0	+20.4
.25	7.8	70.6	+18.1
.30	9.1	69.1	+15.6
.35	10.4	67.8	+13.4
.40	11.7	66.4	+11.0
.45	13.0	65.2	+ 9.0
.50	14.1	64.0	+ 7.0
.55	15.3	62.8	+ 5.0
.60	16.4	61.6	+ 3.0
* .65	17.4	60.6	+ 1.3
.70	18.5	59.5	- 0.5
.75	19.4	58.5	- 2.2
.80	20.4	57.5	- 3.8
.85	21.3	56.5	- 5.5
.90	22.2	55.6	- 7.0
.95	23.1	54.7	- 8.5
1.00	23.9	53.8	-10.0

*F_{0.1}

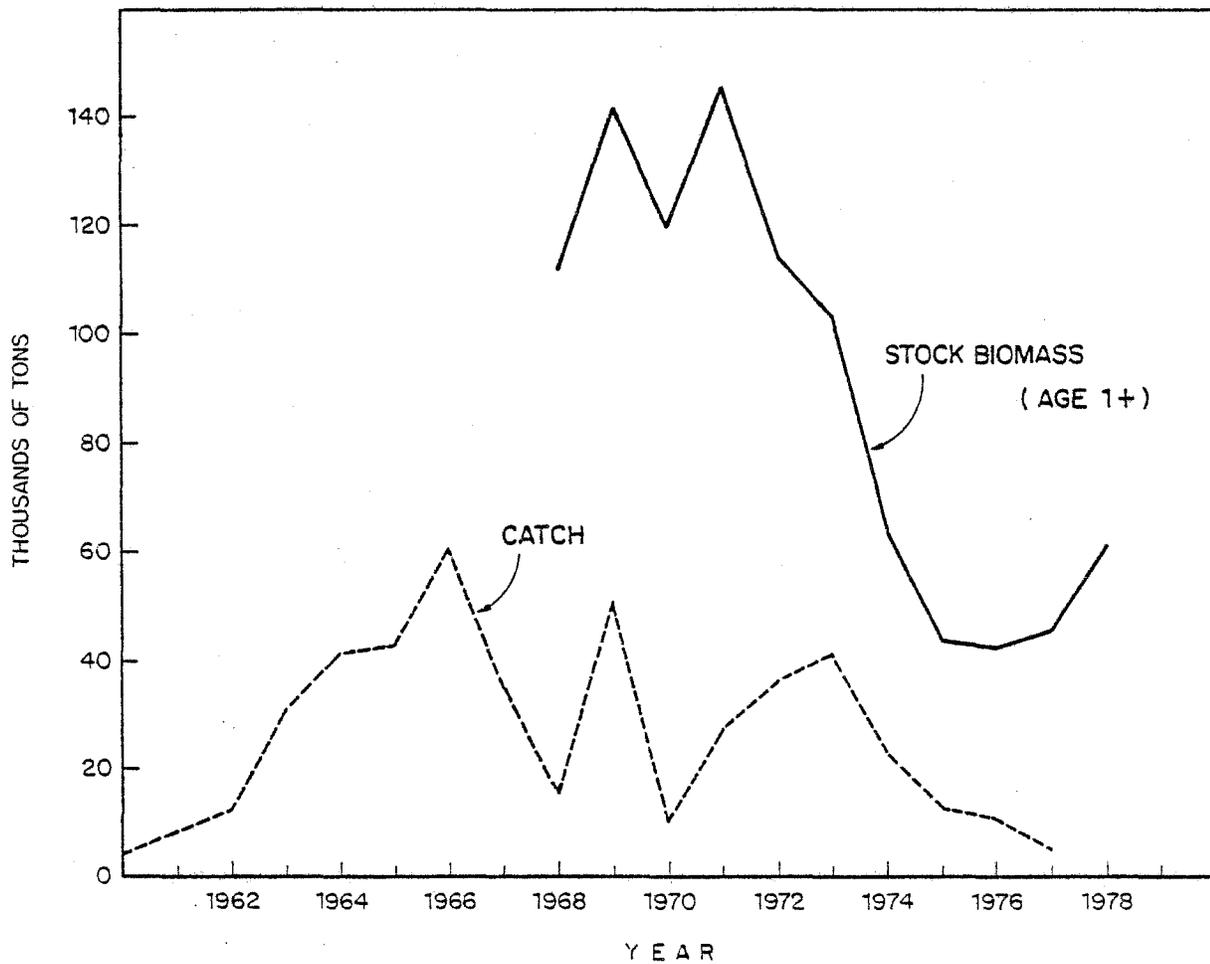


Figure 1. International catch (1960-77) and stock biomass (age 1+) from virtual population analysis (1968-78) from the Southern New England-Middle Atlantic red hake stock.

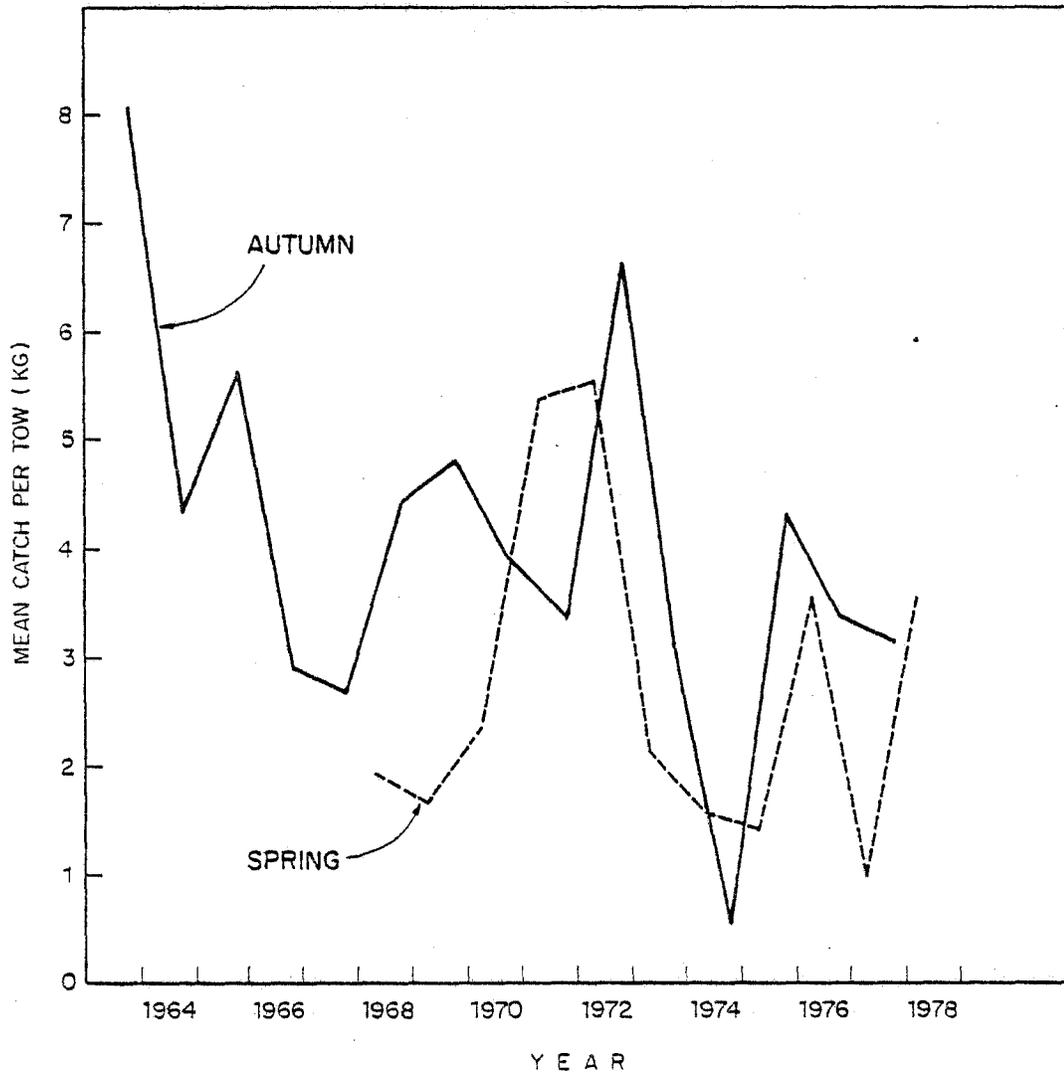


Figure 2. Stratified mean catch-per-tow (kg) of red hake from the Southern New England-Middle Atlantic stock from USA autumn (1963-77) and spring (1968-78) bottom trawl surveys.

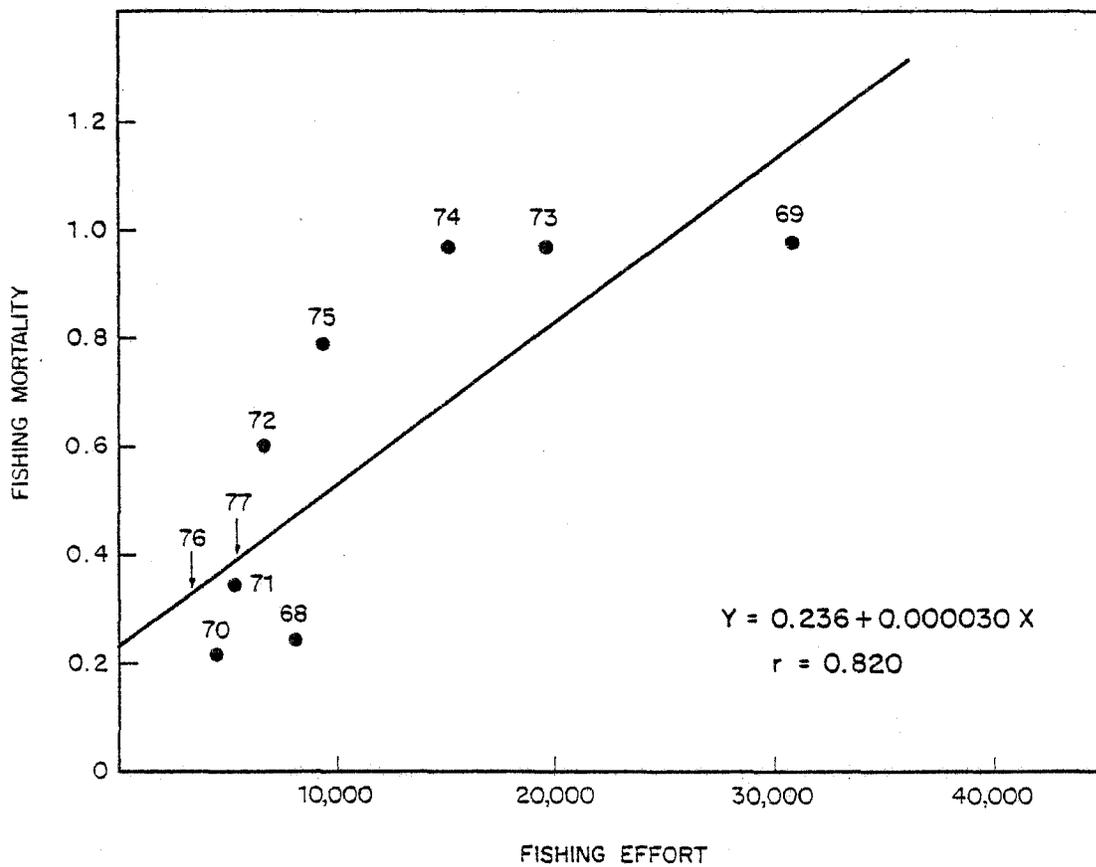


Figure 3. Relationship between fishing mortality from virtual population analysis and fishing effort derived from spring survey catch-per-tow and international catch.

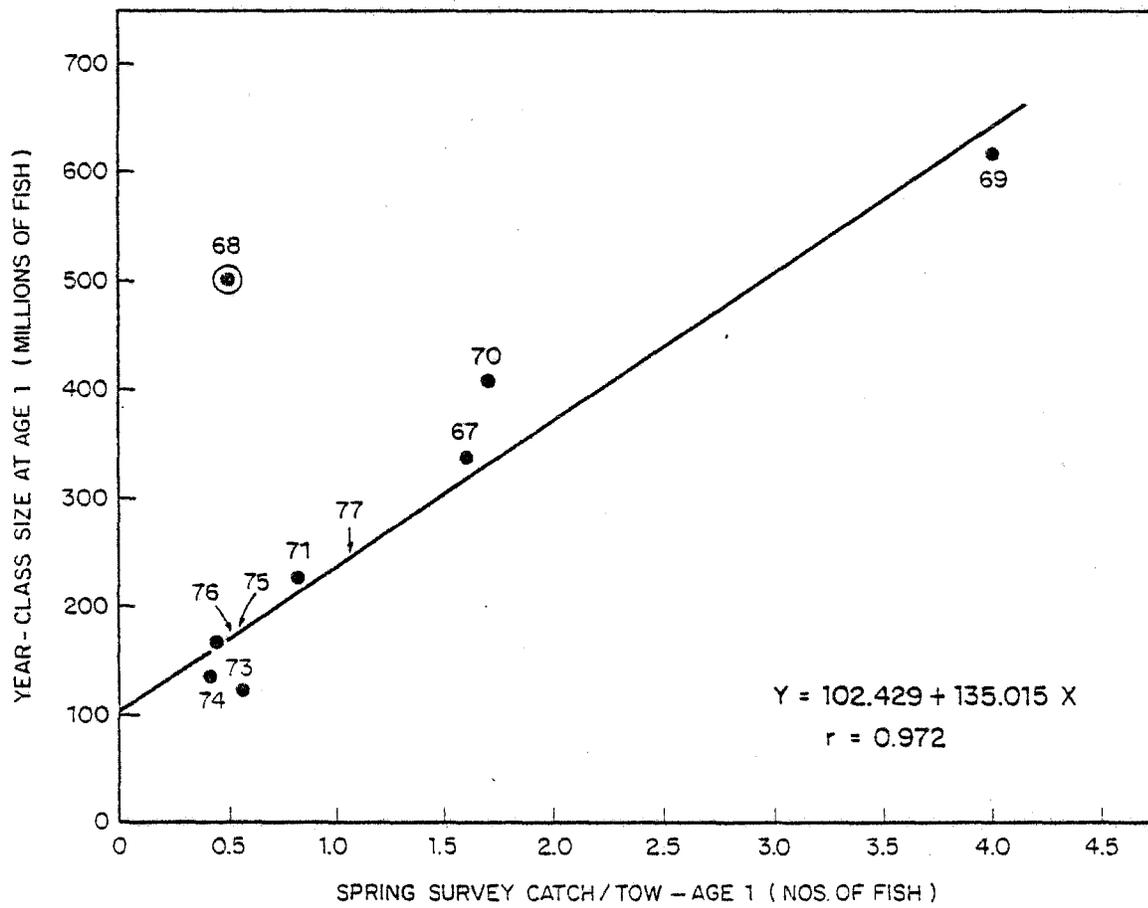


Figure 4. Relationship between year-class size at age 1 from VPA and USA spring survey catch-per-tow at age 1 for the Southern New England-Middle Atlantic red hake stock.

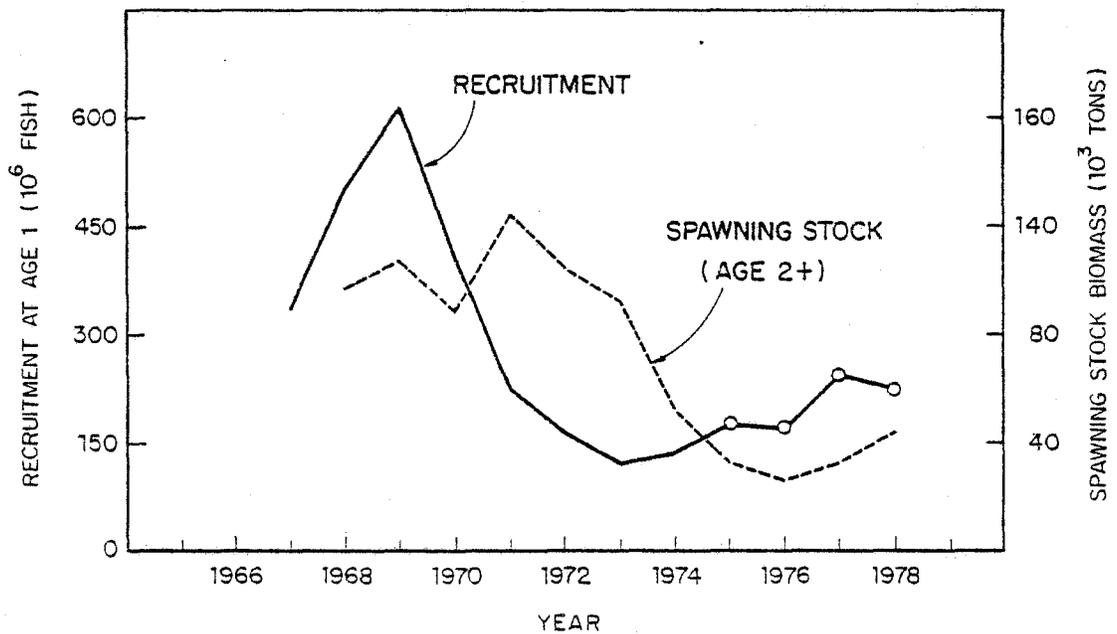
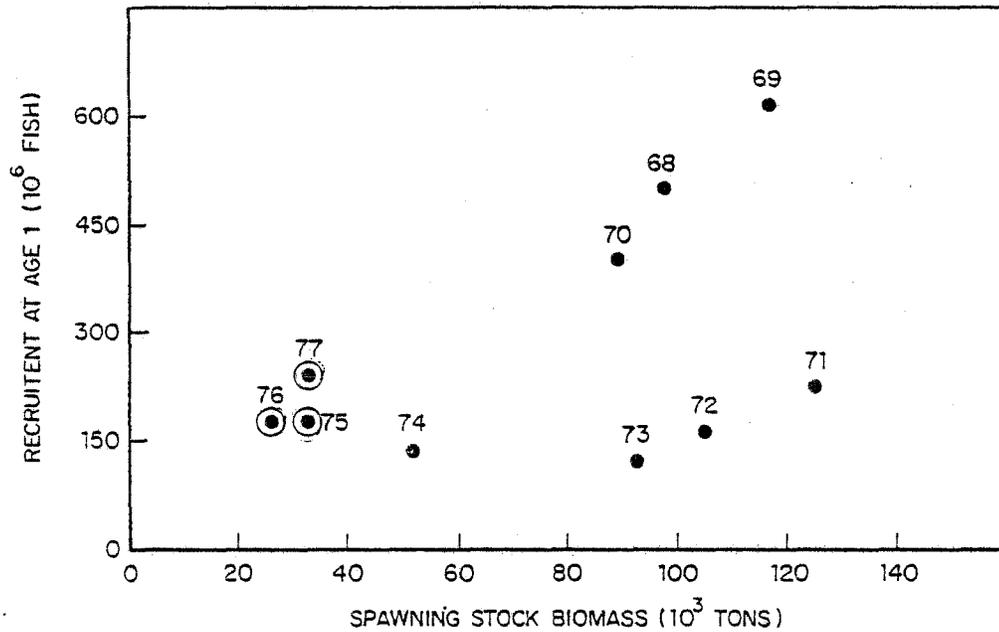


Figure 5. Relationship between spawning stock biomass (age 2+) and recruitment (expressed as abundance at age 1) for the Southern New England-Middle Atlantic red hake stock during 1968-76. Open circles indicate estimated year-class sizes.