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CATCH STATISTICS OF ATLANTIC HERRING AND STOCK OPTIONS FOR ASSESSMENT CONSIDERATIONS IN 1981

by

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I. INTRODUCTION

In this document four VPA's are presented which incorporate various combinations of catch at age matrices (millions of fish) from the herring fisheries between Chedabucto Bay and Cape Hatteras.

These analytical options were provided to the ad hoc herring working group since tagging studies conducted by both the US and Canada have indicated mixing does occur between regions, but the extent of this mixing is difficult to quantify. The first option treats the Jeffreys Ledge fishery as a independent unit (assumes the fishery and mixing do not change over time) while in the second the Jeffreys Ledge fishery and the Maine coastal fishery are considered together. In the third option all the fisheries between Chedabucto Bay and Cape Hatteras are considered as one stock. Option four examines the effect of removing the Georges Bank catch at age matrix incorporated in option three. Option four is useful for comparing the situations since 1977 (no Georges Bank fishery) with past recruitment and stock size estimates.

of what?

"as a whole" is less misleading + more correct

Analyses which consider the herring resources in NAFO Subarea 4WX as a separate stock have routinely been conducted by Canadian scientists (Sinclair and Iles 1980) and are not presented in this document.

We do not advocate one option over another except that it is unlikely that all juveniles found along the Maine coast recruit only to the Gulf of Maine. The pooled assessments are useful in that one of the major problems encountered with herring assessments in the Northwest Atlantic (mixing of stocks) is accounted for. A pooled analyses does not provide the managers with all the

= identifying catches by stocks

Implication here is accurate allocation of F to spawning stock components?

advice they need. However, to manage on a strict stock basis such information can probably never be achieved on an annual basis.

II. CATCH STATISTICS

The annual catches in tons, since 1950, for sea herring fisheries between Chedabucto Bay, Nova Scotia, and Cape Hatteras are given in Table 1 (Figure 1). The Maine and New Brunswick coastal fisheries have typically depended on young fish (Age 1, 2, and 3) while the offshore fisheries have depended on older fish. Catches increased rapidly in the mid-1960's as new fisheries for older herring developed and peaked at 660,000 tons in 1968. The catches steadily declined after 1968 and have remained at about 200,000 tons since 1977 coincident with the collapse of the Georges Bank fishery and management restrictions on other fisheries.

The management scenarios for the Georges Bank, Nova Scotia, and Gulf of Maine fisheries are given in (Tables 2-5). In all of these fisheries the TAC's and catches usually exceeded the recommendations of scientific committees. During the 1970's, stock declines were accompanied by generally poor recruitment.

Out see p. 8.

a. Maine Coastal Fishery:

The 1980 catch of 45,902 tons was the greatest observed since 1963 (66,889 tons) and was 14.1% above the 1979 catch (40,218 tons) (Table 1). The 1980 catch was dominated by the 1977 year class which accounted for 26,538 tons (Table 6). The 1978 year class (9,050 tons) and the 1976 year class (8,605 tons) comprised most of the remaining catch. The catch by fixed gear accounted for 78% of the 1980 landings (Table 7).

b. New Brunswick Coastal Fishery:

The 1980 catch of 14,967 tons was 64% below 1979 and is the lowest recorded since 1956 (Table 1). The low catch is atributed to poor recruitment of the 1978 year class (Age 2) to the weir fishery. The 1980 weir catch of 11,100 tons was the lowest observed since 1963 (Table 8).

c. Western Gulf of Maine (Jeffreys Ledge) Fishery:

The 1980 catch of 36,175 tons was the highest observed since 1972 (42,918 tons) and was 53.6% greater than the 1979 catch (23,547 tons) (Table 9). The 1976 year class was dominant in the 1980 catch (19,218 tons). This is the largest catch of age 4 fish in the history of this fishery.

The 1981 (1 January - 28 February) catch (3,552 tons) was dominated by the 1976 and 1977 year classes (Table 9).

d. Nova Scotia Fishery:

The 1980 Nova Scotia catch (fishery under management) increased from 55,182 tons in 1979 to 109,574 tons in 1980 (Table 8). The high catch was the result of extensive fishing in the 4Xa summer purse seine fishery. The reported landings in this fishery were adjusted upwards 40% by Canadian scientists to account for underreporting (Table 8). age comp?

III. WESTERN GULF OF MAINE (OPTION 1) AND GULF OF MAINE (OPTION 2) ASSESSMENTS.

The virtual population analyses are given in Tables 10-11 for options 1 and 2, respectively.

The fishing mortality on the various age groups for both options 1 and 2 in 1980 were estimated as follows:

(i) Large catches of the 1977 year class were taken from the eastern section of the Maine coast in 1980 but mainly in one area. The high catches are assumed to be a result of availability rather than abundance since this year class was poorly represented in both the southwestern Nova Scotia offshore fishery and the New Brunswick juvenile fisheries. Sinclair (pers. comm.)[1] indicated that catches (in number) of the 1977 year class at Ages 1-3 were only 42%, 48%, and 29% of the amount of the 1976 year class (Ages 1-3), respectively. Historically good year classes have been widely distributed and well represented in the catches of all regional juvenile and adult fisheries.

The 1977 year-class recruitment at age 3, therefore, was assumed equal to 50% of the size of the 1970 year-class. Under this assumption, the terminal F's in the VPA tables were 0.172 for Jeffreys Ledge and 1.52 for the Gulf of Maine analysis respectively. This great disparity in terminal F's is due to the concentration of this year class and subsequent large catches off the Maine coast.

(ii) The 1976 year class was well represented in both the juvenile and adult fisheries catch statistics. Additionally, it was widely distributed being taken in many of the smaller fishing areas off Nova Scotia (e.g. Liverpool trap fishery) where herring seldom occur unless they have been very abundant. This year class (Ages 1-4) has accounted for 28%, 64%, 29%, and 38% (in numbers) of the total herring catch (Ages 1-11) from Chedabucto Bay to Cape Hatteras (exluding Georges Bank) for the years 1977, 1978, 1979, and 1980, respectively. In the 1981 winter-spring fishery in the western Gulf of Maine this year class contributed 43% of the total catch in numbers.

[1] Dr. Mike Sinclair, Division of Fisheries and Oceans, Halifax, Canada

The 1976 year class recruitment at age 3 was assumed equal to 75% of the 1970 year class. Under this assumption the terminal F's in 1980 were 0.440 for the Jeffreys Ledge analysis and 0.760 for the Gulf of Maine, analysis.

(iii) For the 1975 and older year classes the starting F's selected for the Jeffreys Ledge option were applied to the Gulf of Maine option since these older age groups are not principally taken in Maine coastal fishery. For the 1975 year-class (Age 5) and the 1974 year-class (Age 6) the terminal F's were 0.550 and 0.650, respectively for each analysis. These estimates approximate the average mortality for ages 5 and 6 for the period 1971-1979. Catches of these year classes have been declining (only 13% in numbers of the Jeffreys Ledge catch in 19) and their abundance is known to be small (Table 10).

(iv) For the 1973 (Age 7) and older year-classes F's of 1.0 were applied for both analyses. This value of F generally corresponds to the average for the period 1971-1979. These older fish made up only 6.8% in number of the abundance on Jeffreys Ledge in 1980.

Estimates of stock biomass are determined by applying a vector of mean weights at age to the stock size in numbers at age. The weights used for both the Jeffreys Ledge and Gulf of Maine analysis for ages 3 to 11 were: 0.120, 0.180, 0.220, 0.240, 0.275, 0.300, 0.320, 0.340, and 0.360 kg.

IV. POOLED ASSESSMENTS WITH GEORGES BANK (OPTION 3) AND WITHOUT GEORGES BANK (OPTION 4).

The "pooled" analyses were conducted to avoid the problems of fish of one stock being taken in separate regions during its lifetime, as previously noted from tagging studies.

The two analyses were run utilizing catch at age data from fisheries between Chedabucto Bay, Nova Scotia, and Cape Hatteras, North Carolina (Tables 9-10). The first included catch data from all fisheries (Option 3) while for the

second the Georges Bank catch at age matrix was removed (Option 4). The second analysis is useful for comparing the situations since 1977 (no Georges Bank stock) with past recruitment and stock size estimates. Since herring of Georges Bank may be caught during summer in coastal Maine waters (primarily ages 1-3), population size estimates for young fish under option 4 may be inflated. In order to correct for this potential source of error, the option 4 catch matrix must be discounted for fish of Georges Bank origin (see Woods Hole Laboratory Reference Doc. 81-20).

They are there!

The terminal fishing mortality rates in 1980 on the various year classes for both situations are estimated as follows:

(i) For the 1979 year class (Age 1) an estimate of fishing mortality of 0.05 was (1965-1975 average) selected for the terminal F in the virtual population analysis since very little information is available on the size of this year class.

(ii) The size of the 1978 year class (Age 2) was set equal to the 1974 year class at age 2 which was the poorest observed in the history of the pooled data. This is based on the poor performance of this year class in the fisheries at ages 1 and 2. The terminal F in each analysis was 0.32.

(iii) The size of the 1977 year class at age 3 was assumed equal to 50% (as explained in p. 4) of the 1970 year class in 1973. The F for 1980 for each analysis was 0.14 (Option 3) and 0.24 (Option 4).

(iv) The size of the 1976 year class at age 3 was assumed equal to 75% (as explained on p.4) of the 1970 year class. The terminal F's required in 1980 (Age 4) were 0.21 and 0.43 for the pooled with Georges Bank (Option 3) and pooled without Georges Bank (Option 4), respectively.

(v) For the 1975 year class (Age 5) and the 1974 year class (Age 6) a terminal F of 0.6 was selected for both options. This value approximates the Age 5 average and Age 6 average F for the 1967-1977 period.

(vi) For the 1973 to 1970 year classes (Ages 7 to 10) the terminal F used was 0.7 in both options. This approximates the 1967-1977 average for each age group.

(vii) For the 1969 year class and older year classes a terminal F of 1.0 was used in both options. The F's on the older age groups have usually approximated or exceeded 1.0 and these older fish contributed less that 1% (in numbers) of the total catch each year.

The stock biomass for both pooled VPA's were determined using the following vector of mean weights at age.

Age	1	2	3	4	5	6	7	8	9	10	11
kg	.009	.031	.085	.181	.246	.267	.287	.317	.342	.365	.370

These were derived from 1979 mean weight at age, weighted by catch in numbers at age, for the western Gulf of Maine fishery, Maine coastal fishery, New Brunswick fishery, and southwest Nova Scotia fishery combined. The 1980 data was not available for all fisheries at the time this analysis was performed.

V. PROJECTION OF CATCH AND SPAWNING STOCK BIOMASS

For each of the four analyses, the stock sizes (number at age) in the beginning of 1981 (Tables 10-13) were calculated using the catch equation ($N_{i+1} = N_{ie}^{-Z_i}$). By applying the appropriate mean weights at age data the estimates of the spawning biomass (Age 4+) for each "stock" were also derived. Except for the Gulf of Maine analysis (Table 11) estimates of the spawning stock biomass (Age 4+) at the beginning of 1981 was greater than the 1980 levels. The increase for each option is proportional to the abundance of the 1976 and 1977 year classes. These year classes contribute 90% or more of the biomass in each analysis.

At the request of the scientific staff of the NERFMC the long-term projections for the Gulf of Maine "stock" (Option2) and the pooled stock without Georges Bank (Option 4) were determined under two assumptions of recruitment and three levels of fishing mortality (at 100% recruitment).

For the Gulf of Maine "stock" (Option 2) recruitment of 210 million fish at age 3 (1965-1978 average) for each year and fishing mortality between 0.2 - 0.4 will increase this spawning stock biomass until 1987 and then maintain the stock between 70-150 x 10^3 MT (Figure 2). For the higher level of recruitment, 330 million fish at age 3, (1971-1978 average) and the same range of fishing mortality the stock increases to 120-170 x 10^3 MT (Figure 3). Cut see p2

For the "pooled" stock (Option 4), recruitment of 755 million fish at age 3 (average over years 1965-1978) and fishing mortality between 0.2 and 0.4 would cause this spawning stock to decline to 240 - 390 x10^3 tons (Figure 4). Whereas for the higher level of recruitment, 1495 million fish at age 3 (average over years 1971-1978) and the same range of fishing mortalities the spawning stock would only decline to 515 - 810 x 10^3 tons (Figure 5).

CONCLUSION

The increased catches observed in 1980 were due in part to the availability and abundance of the 1977 and 1976 year classes. These year classes should contribute heavily to the 1981 fisheries, directed on age 3 and older fish, as indicated in the 1981 winter/spring fishery in the Western Gulf of Maine. These year class comprised over 80% of the landing in this fishery from January through February.

The advantage of the pooled VPA's (Options 3 and 4) over (Options 1 and 2) are that they account for fishing mortality of fish from the same cohort migrating

between regions by year and season. It also provides estimates of year class abundance for the total region. This is important since localized abundance of a specific year class when viewed in the context of component VPA's (e.g. Options 1 and 2 or the Canadian 4WX analysis) may potentially result in over-estimates of a year class in a particular region in a given year. This could result in the setting of TAC's higher than intended.

For each option the 1977 and 1976 year classes will comprise 90% or more of the abundance of herring of age 4 and older (tons) at the beginning of 1981. The expected poor recruitment of the 1978 year class (Age 3 in 1981) combined with the low abundance of the 1975 and older year classes will direct fishing pressure in 1981 into the 1977 and 1976 year classes. This will result in spawning stock size (Age 4 and older) declines in the beginning of 1982 when the 1978 year class recruits to the spawning stock.

Based on the stock projection results applied to both Option 2 and Option4 data, stock stabilization was obtained in eight years under various assumptions of constant recruitment and fishing mortality. However, recruitment of herring is very variable with instances of very good recruitment (e.g. 1970 year class) followed by very poor recruitment (e.g. 1971 year class). Likewise levels of constant fishing mortality have never been observed in any herring fishery in the Northwest Atlantic. Additionally, an inherent assumption in this model is that a well balanced age structure exists in the population. Currently the resource is dominated by two year classes. The stock projection results, however, provide managers with a tool for viewing stock rebuilding or stabilization of stocks.

REFERENCES

Sinclair, M., and T.D. Iles. 1980. 1979 4WX herring assessment. CAFSAC Res. Doc. 80/47.

Table 1. Herring catches in major fishing areas between southwest Nova Scotia and Cape Hatteras.

	METRIC TONS					
YEAR	Maine Coastal Fishery	Western Gulf of Maine Fishery	Georges[1] Banks	New[2] Brunswick	Nova Scotia[2]	Total
1950	90,557	3,661		62,981[3]		157,199
1	34,411	1,305		51,316[3]		87,032
2	79,139	1,598		62,399[3]		143,136
3	58,337	2,032		44,961[3]		105,330
4	64,067	1,303		46,716[3]		112,086
5	43,506	1,561			33,313[3]	78,380
6	66,494	2,058		21,533	22,712	112,797
7	68,623	3,007		33,733	27,114	132,477
8	80,759	3,182		18,854	46,444	149,239
9	53,037	1,472		47,762	28,771	131,042
1960	59,348	1,126		49,563	32,216	142,253
1	24,131	3,178	67,655	18,614	41,272	154,850
2	69,376	2,485	152,242	34,403	35,367	293,873
3	66,895	3,217	97,968	36,237	23,393	227,710
4	26,295	8,815	131,438	45,023	41,405	252,976
5	32,088	2,635	42,882	49,101	70,639	197,345
6	26,178	4,360	142,704	61,450	124,681	359,373
7	28,490	7,807	218,743	50,920	135,853	441,813
8	30,205	31,900	373,598	75,368	154,139	665,210
9	23,852	32,406	310,758	39,741	137,250	544,007
1970	15,581	40,187	247,294	30,589	175,633	509,284
1	12,407	38,575	267,347	17,528	124,233	460,090
2	19,513	42,918	174,190	32,720	153,428	422,769
3	16,400	15,926	202,335	22,102	120,093	376,856
4	19,143	18,098	149,525	30,733	139,170	356,669
5	15,182	21,076	146,096	31,971	142,745	357,068
6	30,195	20,124	43,502	30,046	114,006	237,874
7	32,357	17,891	2,157	34,723	115,935	203,063
8	29,857	18,558	2,059	45,361	89,353	185,188
9	40,218	23,546	1,270	41,021	55,182	161,237
1980	45,902	36,175	1,700	14,969	108,131	206,877
Total	1,302,543	412,181	2,775,463	1,215,751	2,259,165	7,964,390

[1]incorporates USA 5Z catches

[2]1965-80 revised Canadian catches as per Dr. Mike Sinclair, Division of Fisheries and Oceans, Halifax, Canada.

[3]cannot be separated into New Brunswick and Nova Scotia fishery components

Table 2. MANAGEMENT SCENARIO - GEORGES BANK HERRING

Year	Year Class	Recruitment age 3 (000 tons)	TAC (000 tons) Recommended by scientists (STRACES)	TAC (000 tons) Accepted by ICNAF	Catch age 3 and older (000 tons)	Stock size end of year age 4 and older (000 tons)
1965-1967	1962-1964	239	-	-	134	1078
1968	1965	222	-	-	373	752
1969	1966	236	-	-	306	592
1970	1967	149	-	-	247	440
1971	1968	104	-	-	263	240
1972	1969	96	50-135	150	174	137
1973	1970	496	83-135	150	199	325
1974	1971	33	150	150	146	203
1975	1972	22	90-150	150	146	65
1976	1973	16	60	60	43	34
1977	1974	12	50	33	2	40

Optimum stock level[1] - 500 MT

Optimum catch level[1] - 100-150,000 MT

Minimum stock level constraint[1] - 225,000 MT

Maximum TAC in ICNAF unless at optimum stock size[1] - 150,000 MT - 1973 through 1975
60,000 MT - 1976 and 1977

[1]ICNAF REDBOOK 1976 APP. II

Table 3. MANAGEMENT SCENARIO - Western Gulf of Maine Fishery - ICNAF Division 5Y (thousand metric tons).

Year	Recruitment Age 3		TAC: Recommended by Scientists (STACRES)	TAC: Accepted by ICNAF (1972-1977)	Catch Age 3 and Older	Stock Size at End of Year Age 4 and Older
1967-1969	28		-		24	144
1970	18.3		-		40	101
1971	14.0		-		39	66
1972	8.8	Jan 72 -	15-18	30	41	31
1973	64.4	Jan 73 -	21-30	25	16	88
1974	9.4	Jan 74 -	18-25	25	18	83
1975	9.3	Jan 74 -	15-25	17	22	63
		Apr 75 -	9			
1976	14.0	Jun 75 -	9	7	20	57
		Jan 76 -	4-7			
1977	8.8	Apr 76 -	7	7	20	41
		Jun 76 -	7			

[1] ICNAF Redbook 1976 App. II.

Optimum catch level[1]	25-25	Optimum stock[1] size	80-100
Maximum TAC unless[1] stock size at optimum level	25	Minimum stock[1] size constraint	60

Table 4. Summary of catch allocations (tons) set for the Northwest Atlantic herring fisheries under US jurisdiction by the NERFMC.

Period	TAC (Age 3 and older)	Catch (Age 3 and older)
[1]July-Nov 78	4,000	6,073
Dec 78-Jun 79	4,000	7,480
[2]July-Nov 79	8,850	13,972
July-Nov 80	8,850	35,049
Oct 79-Jun 80	1,620	1,100
Dec 80-Jun 81	1,620	?
[3]July-Nov 79	9,000	16,945
July-Nov 80	9,000	22,609
April-Jun 80	1,530	2,838
[4]Dec 79-Mar 80	12,000	11,120
Dec 80-Mar 81	12,000	5,000 (Projected)

[1]TAC for western Gulf of Maine

[2]TAC for 5Y North of Cape Elizabeth

[3]TAC for 5Y South of Cape Elizabeth

[4]TAC for 5Y South of Cape Elizabeth and 5Z east of 71°50'

Table 5. MANAGEMENT SCENARIO - Southwest Nova Scotia Fishery - ICNAF Area 4WX (thousands of metric tons) (Area 4W(a) is Chedabucto Bay; Nova Scotia south of Chedabucto Bay is 4WX(b)).

Year	Recruitment Age 2 (4WX)		TOTAL ALLOWABLE CATCH (TAC) Recommended by Scientists[4] 4XW(b)	4W(a)[1]	4WX	Accepted by ICNAF (1972-1977), Canada (1978-) 4XW(b)	4W(a)	4WX	Catch Age 2 and Older	Stock Size at end of Year - Age 2 and Older
1965-1968	58		--	--	--	--	--	--	121	716
1969	19		--	--	--	--	--	--	137	574
1970	24		--	--	--	--	--	--	176	428
1971	27		--	--	--	--	--	--	124	509
1972	156	Jan (72)	65	--	--	65	--	--	153	607
1973	22	Jan (73)	90	--	--	90	--	--	120	645
1974	35	Jan (74)	90	20	--	90	20	--	139	637
1975	41	Jun (74)	90	30[2]	--	90	30[2]	--	143	507
1976	3	Jun (75) op 1[3]	81	25[2]	--	89	25[2]	--	114	389
		op 2			115					
		Jan (76) op 1[3]		25[2]		89	25[2]			
		op 2			115					
1977	6	Jun (76) op 1[3]	84	22.5[2]		84	22.5[2]		118	265
		op 2			109					
1978	82	Apr (77)	78	20					89	
		Apr (78)	89	20		--	--	109		
1979	82	Apr (77)			99	--	--	99	55	
		Apr (79)			60					
1980		Apr (80)			55			55	101	
1981		Apr (81)			101			101		

[1] TAC's were recommended for 4VW(a); the 4W(a) area was proportioned out
[2] TAC's were recommended and set for the fishing season 1 July/30 June
[3] TAC was recommended for the fishing season 1 Nov/31 Oct.
[4] STRACES 1972-1976; CAFSAC 1977-
[5] ICNAF Redbook 1976 APP. II.

Minimum stock size constraint 250,000 tons (age 4 and older).[5]

Table 6. Maine coastal fishery herring catches (metric tons).

YEAR	1	2	3	4	5	6	7	8	8+	TOTAL
1947	1,369	38,500	31,617							65,486
1948	4,342	27,441	44,654							76,437
1949	11,993	29,916	32,121							74,029
1950	281	30,644	59,631							90,557
1951	18,018	8,048	8,345							34,411
1952	5,358	44,619	29,162							79,139
1953	20,033	18,271	20,033							58,337
1954	6,067	19,970	38,030							64,067
1955	8,714	19,238	15,553							43,506
1956	5,293	33,307	27,894							66,494
1957	3,218	43,802	21,603							68,623
1958	4,498	36,592	39,669							80,759
1959	2,238	15,805	34,994							53,037
1960	950	37,864	20,534							59,348
1961	2,703	14,575	6,853							24,131
1962	624	64,520	4,232							69,376
1963	736	17,928	48,231							66,895
1964	1,210	16,645	4,023	4,155	262					26,295
1965	449	24,676	5,872	353	738					32,088
1966	174	6,330	18,452	276	648	199	75	25		26,178
1967	225	6,636	14,575	5,819	113	698	--	--	424	28,490
1968	80	21,037	7,933	744	376	---	33			30,205
1969	72	6,702	15,909	883	72	95	72	24	24	23,852
1970	294	6,258	4,422	2,673	531	726	294	265	118	15,581
1971	1,909	2,838	1,731	3,388	1,793	409	127	126	86	12,407
1972	3	17,366	833	498	242	318	264			19,513
1973	164	8,100	7,456	193	164	80	121	56	66	16,400
1974	486	9,074	5,489	3,780	230	75	9			19,143
1975	797	8,451	2,539	925	1,249	96	8		120	15,182
1976	478	13,228	18,740	1,203	1,122	1,390	11	6	16	30,195
1977	1,226	18,102	7,560	2,483	614	481	1,836	19	39	32,357
1978	653	12,853	7,402	1,731	2,912	364	710	3,020	212	29,857
1979	27	25,942	11,531	1,715	192	330	197	184	180	40,218
1980	1,012	9,050	26,538	8,605	440	24	101		133	45,902

Table 7. 1980 Maine coastal herring fishery age composition in metric tons and number ($x10^{-3}$).

	YEAR CLASS AND AGE										
	79	78	77	76	75	74	73	72	71	70	
Gear Type/Area	1	2	3	4	5	6	7	8	9	10	
Fixed Gear											
Western	40.1	1,463.6	1,363.9	198.0	11.8	-	-	-	-	-	3,077.3
Central	851.9	3,695.8	5,797.1	1,206.6	194.6	-	28.1	-	-	28.5	11,802.6
Eastern	119.9	3,156.6	12,291.6	5,155.1	152.6	-	62.0	-	17.9	72.0	21,027.7
Σ	1,011.9	8,316.0	19,452.6	6,559.7	359.0	-	90.1	-	17.9	100.5	35,907.6
Mobile Gear											
Western	-	212.9	828.9	229.4	40.6	-	4.3	-	-	8.2	1,324.3
Central	-	520.6	6,193.3	1,710.5	40.7	20.8	6.8	-	5.7	-	8,498.4
Eastern	-	-	63.0	105.6	-	3.3	-	-	-	-	171.9
Σ	-	733.5	7,085.2	2,045.5	81.3	24.1	11.1	-	5.7	8.2	9,994.7
ΣΣ	1,011.9	9,049.5	26,537.8	8,605.2	440.3	24.1	101.2	-	23.6	108.7	45,902.3

	CATCH IN NUMBERS $x10^{-3}$										
Fixed Gear											
Western	2,946.2	35,525.5	13,851.7	1,399.2	46.6	-	-	-	-	-	53,769.2
Central	51,909.0	89,132.4	60,017.5	6,350.2	661.3	-	142.3	-	75.3	-	208,288.0
Eastern	10,238.3	83,118.4	113,412.7	30,440.5	627.0	-	183.0	-	50.8	216.5	238,287.3
Σ	65,093.5	207,776.3	187,281.9	38,189.9	1,335.0	-	325.3	-	126.1	216.5	500,344.5
Mobile Gear											
Western	-	3,851.1	8,190.2	1,338.0	146.1	-	11.2	-	-	17.9	13,554.5
Central	-	10,834.3	56,915.0	8,561.8	154.1	50.6	17.2	-	25.8	-	76,558.8
Eastern	-	-	598.5	687.6	-	12.6	-	-	-	-	1,298.7
Σ	-	14,685.4	65,703.7	10,587.4	300.2	63.2	28.4	-	25.8	17.9	91,412.0
ΣΣ	65,093.5	222,461.7	252,985.6	48,777.3	1,635.2	63.2	353.7	-	151.9	234.4	591,756.5

TABLE 8. CATCH OF HERRING AT AGE MT IN THE WESTERN GULF OF MAINE 1967-1981

YEARS	AGES 2	3	4	5	6	7	8	9	10	11	12	TOTAL AGES 2+
1967	1.7	47.2	510.9	1567.1	3083.0	2166.9	162.9	105.6	74.1	87.0		7807.0
1968	44.6	2494.7	2853.5	5881.0	6377.7	6972.8	5008.3	919.5	620.8	728.5		31900.0
1969	146.3	5467.9	1680.7	2101.1	5230.2	7097.5	6144.6	3421.7	553.5	763.6		32406.0
1970	260.3	1265.0	4153.4	3532.4	5635.5	6483.3	6187.9	7838.2	2249.8	2641.2		40187.0
1971	49.3	3202.0	3845.7	6676.0	7876.0	6468.4	4290.1	3149.7	1479.0	1736.8		38575.0
1972	959.1	2426.3	7085.7	9710.3	10560.7	8062.9	2980.8	423.5	463.0	245.7		42918.0
1973	144.1	2484.1	1012.2	2531.3	3427.4	3207.5	2171.2	676.7	137.4	134.1		15926.0
1974	234.9	1682.2	10824.9	1530.6	1253.2	958.3	847.6	414.9	243.3	84.4	23.7	18098.0
1975	20.4	2222.7	3345.7	12078.0	1180.0	1027.3	509.5	377.8	170.2	148.8		21076.0
1976	3.8	2696.2	2374.3	2383.8	11084.5	995.6	195.6	285.1	58.5	41.7	8.8	20184.0
1977	60.3	640.8	3939.5	1814.8	1964.4	8714.1	520.6	68.8	99.7	53.4	14.6	17891.0
1978	203.9	2087.3	1880.1	5194.3	1010.8	1576.3	5980.4	287.3	136.4	56.8	36.9	18658.8
1979	181.5	4065.9	6863.5	3668.8	4077.9	818.6	1038.3	2106.6	91.0	0.1	0.7	23507.7
1980	38.5	4611.8	10218.6	5307.8	1990.0	2778.8	281.0	172.8	1728.1	31.6	15.3	36174.7
1981		13.3	1318.8	1542.4	258.5	76.3	65.5	0.0	17.8	95.4		3388.0

CATCH OF AGE 1 FISH IN 1978 = 68.8 MT
1981 CATCH FOR PERIOD 1 JAN.-28 FEB.

Table 9. Annual 4WX herring catch by different components of the fishery (tonnes)

YEAR	4W		4X$_a$					4X$_b$				4WX Foreign Total	Stock Total (Traditional)[c]	Stock Total (Option 2)[d]
	Purse Seine[a]	Fixed Gear[b]	Summer Purse Seine	Gill Net[14]	Weir	Liverpool Trap	Fixed Gear Non-Stock[b]	Winter Purse Seine: Grand Manan	Winter Purse Seine: Saint John	Winter Purse Seine: Weir	Misc. & Shut-Offs			
1963	-		15093[5]	2955[5]	6345[5]	-		-	6071[5]	28203[5]	1163[5]			
1964	-		24894[5]	4053[5]	12450[5]	-		-	15991[5]	27337[5]	2095[5]			
1965	-		54527[5]	4091[5]	12021[5]	-		-	15755[5]	31684[5]	1662[5]		70639[16]	95899
1966	-		112457[5]	4413[5]	7711[5]	-		-	25645[5]	35601[5]	204[5]		124681	160906
1967	-	431	117382[5]	5398[5]	12475[5]	-		-	20888[5]	29932[5]	100[5]	598	135053	165721
1968	-	375	133267[5]	5884[5]	12571[5]	-		-	42223[5]	32114[5]	1031[5]	2417	154139	205996
1969	25112[4]	343	84526[5]	3474[5]	10744[5]	-		-	13202[5]	25646[5]	893[5]	13405	137250	158156
1970	27107[4]	151	70849[5]	5019[5]	11706[5]	-		-	14749[5]	15073[5]	767[5]	60952	175633	194903
1971	52535[4]	169	35071[5]	4607[5]	8081[5]	-		-	4868[5]	12139[5]	521[5]	23939	124233	132743
1972	25656[4]	330	61158[5]	3789[5]	6766[5]	-		32153[5,8]	21[5]	31995[5]	704[5]	23906	153428	163048
1973	7921[4]		36618[5]	5205[5]	12492[5]	-		25155[5,8]	2167[5]	19088[5]	847[5]	32702	120093	127986
1974	27107[4]		76859[5]	4285[5]	6436[5]	-		-	10131[5]	19028[5]	1574[5]	24483	139170	155009
1975	27030[4]		79605[6]	4995[6]	7404[6]	-		-	1152[6]	30819[6]	?	23711	142745	152143
1976	37196[3]		58396[3]	8322[3]	5959[3]	-		94[6]	746[6]	29206[6]	?	4133	114006	126335
1977	23251[1]	1138	68538[1]	18523[1]	5213[1]	-		-	1236[1]	30697[1]	2790[1]	410	115935	120007
1978	17274[1]		57973[13]	6059[13]	8057[13]	-		3832[13]	2687[13]	33570[13]	5272[13,11]	-	89353	107543[12]
1979	14073[13]		25265[7]	4363[7]	9307[7]	2174[15]		2973[7]	220[2]	32477[7]	5351[7,11]	-	55182	69723[12]
1980	8900	58	74976[17]	19804	2383	2010		656	707	11100	2425	-	109574	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N

a. winter catch, Nov.-Apr. is put into latest calendar year

b. fixed gear catch not considered part of major 4WX migratory stock

c. estimate of annual catch incorporated into catch-at-age matrix in previous assessments (columns A+C+D+E+F+L (and during 1972-73H)

d. Column M + (H+I(0.3(J+K))) represents option 2 catch, see text for rationale

[1] Stobo et al. CAFSAC Res. Doc. 78/25

[2] "Best estimate", provisional

[3] Miller & Stobo, CAFSAC Res. Doc. 77/11

[4] Stobo, ICNAF Res. Doc. Dec. 75/39

[5] Miller & Iles, FRB Tech. Rep. 594

[6] "Catch at age" printouts

[7] St. Andrews provisional catch statistics, March 1980

[8] Grand Manan catch incorporated into previous assessments catch-at-age matrix

[9] Miller, ICNAF Res. Doc. 73/95

[10] ICNAF Stat. Bull.

[11] Shut-off only

[12] 30% of shut-offs (Column K) is included in option 2 (1978)

[13] Sinclair et al. CAFSAC Res.

[14] Gill net catches in Stat. districts 32-44

[15] Statistics Branch

[16] Catch matrix starts in 1965

[17] Adjusted upward 40% to account for under reporting.

TABLE 10. HERRING VPA FOR THE WESTERN GULF OF MAINE (JEFFERYS LEDGE) FISHERY INCLUDING USA-5ZW.

YEAR	AGE 0	1	2	3	4	5	6	7	8	9	10	11	MEAN F	AGE
	FISHING MORTALITY													
1967	.000	.000	.000	.003	.020	.051	.091	.092	.027	.077	.273	1.000	.059	4+
1968	.000	.000	.002	.089	.125	.226	.273	.269	.292	.213	.813	1.000	.232	4+
1969	.000	.000	.008	.153	.087	.138	.285	.335	.353	.570	.718	1.000	.251	4+
1970	.000	.000	.026	.069	.127	.172	.377	.780	.856	1.182	1.147	1.000	.440	4+
1971	.000	.000	.008	.250	.254	.368	.661	1.039	1.455	1.391	1.258	1.000	.598	4+
1972	.000	.000	.031	.263	.841	.911	1.169	1.147	1.306	1.080	1.666	1.000	1.018	4+
1973	.000	.000	.010	.042	.147	.554	.836	1.271	1.494	.976	.603	1.000	.638	4+
1974	.000	.000	.104	.150	.224	.266	.540	.421	.680	.801	.691	1.000	.245	4+
1975	.000	.000	.005	.276	.337	.346	.610	.969	.663	.995	1.274	1.000	.375	4+
1976	.000	.000	.002	.158	.398	.328	.386	.520	.453	.692	.382	1.000	.385	4+
1977	.000	.000	.015	.153	.349	.660	.535	.587	.765	.533	.656	1.000	.490	4+
1978	.000	.000	.006	.211	.319	.602	.686	.842	.886	1.045	3.163	1.000	.623	4+
1979	.000	.000	.012	.091	.477	.657	.666	.996	1.309	.584	.917	1.000	.583	4+
1980	.000	.000	.050	.172	.440	.550	.650	1.000	1.000	1.000	1.000	1.000	.489	4+

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	AGE 4+ NUMBERS	AGE 4+ TONS (000)
	STOCK SIZE (MILLIONS)													
1967	.0	.0	276.3	205.5	203.8	176.6	180.2	110.3	23.3	6.4	1.8	.3	702.7	158.9
1968	.0	.0	321.9	235.1	167.9	163.6	137.4	134.7	82.4	18.6	4.9	1.1	710.6	169.0
1969	.0	.0	196.6	262.3	176.1	121.2	106.9	85.6	84.3	60.4	12.3	1.8	638.6	153.8
1970	.0	.0	158.3	159.7	184.3	132.1	86.5	65.9	60.1	48.5	23.3	4.9	595.6	141.4
1971	.0	.0	97.5	126.4	122.0	132.9	91.0	48.6	24.7	17.4	12.2	6.1	454.0	105.7
1972	.0	.0	781.9	79.2	80.6	77.6	75.3	38.5	14.1	4.7	3.6	2.8	297.1	68.2
1973	.0	.0	140.0	620.9	49.9	28.5	25.5	19.2	10.0	3.1	1.3	.5	138.0	31.3
1974	.0	.0	103.0	113.5	487.4	35.3	13.4	9.1	4.4	1.8	1.0	.6	652.9	103.6
1975	.0	.0	216.1	76.0	79.9	319.0	22.1	6.4	4.9	1.8	.7	.4	435.2	94.0
1976	.0	.0	94.8	176.3	47.3	46.7	184.8	9.8	2.0	2.1	.6	.2	293.3	67.3
1977	.0	.0	184.3	77.5	123.2	26.0	27.6	102.9	4.8	1.0	.9	.3	286.7	65.0
1978	.0	.0	681.8	148.7	54.5	71.2	11.0	13.2	46.8	1.8	.5	.4	199.4	46.7
1979	.0	.0	389.0	473.4	98.6	32.4	31.9	4.5	4.7	15.8	.5	.0	188.5	40.4
1980	.0	.0	15.8	314.7	354.0	50.1	13.7	13.4	1.4	1.0	7.2	.2	441.1	85.0
1981					218.9	186.7	21.4	6.9	4.0	0.4	0.3	2.2	437.8	89.1
	CATCH AT AGE (MILLIONS)												TOTAL AGE 3+ NUMBERS	TOTAL AGE 3+ TONS (000)
1967	.0	.0	.0	.6	3.6	8.0	14.2	8.8	.6	.4	.4	.2	36.8	8.0
1968	.0	.0	.6	18.1	18.0	30.1	29.9	28.9	19.0	3.2	2.6	.6	150.3	32.0
1969	.0	.0	1.6	33.8	13.4	14.2	24.1	22.2	22.8	20.0	6.7	1.0	157.3	32.3
1970	.0	.0	3.6	9.7	20.0	19.0	24.8	32.7	26.5	31.1	14.7	2.9	181.4	41.8
1971	.0	.0	.7	25.4	24.9	37.3	40.4	28.9	17.6	12.1	8.1	3.5	198.2	39.9
1972	.0	.0	21.4	16.7	42.1	42.6	48.0	24.2	9.5	2.9	2.7	1.6	190.4	44.3
1973	.0	.0	1.3	23.3	6.8	11.1	13.3	12.8	7.2	1.8	.5	.3	76.4	20.0
1974	.0	.0	9.2	14.4	89.0	7.5	5.1	2.8	2.0	.9	.4	.3	122.6	20.7
1975	.0	.0	.0	16.7	20.9	86.0	9.3	3.6	2.2	1.1	.4	.2	139.4	25.4
1976	.0	.0	.2	23.4	14.1	11.9	54.0	3.6	.7	.8	.2	.1	108.8	20.3
1977	.0	.0	2.4	10.0	33.1	11.6	10.4	41.8	2.4	.4	.4	.2	110.2	18.1
1978	.0	.0	3.3	26.7	13.6	29.6	5.0	6.9	25.3	1.1	.4	.2	107.7	20.4
1979	.0	.0	4.3	37.3	34.1	14.3	14.2	2.6	3.1	6.4	.3	.0	112.4	24.6
1980	.0	.0	.7	45.2	115.1	19.4	6.0	7.8	.8	.6	4.2	.1	199.8	36.8

TABLE 11. GULF OF MAINE VPA ANALYSIS.

YEAR	AGE 0	1	2	3	4	5	6	7	8	9	10	11	MEAN F	AGE
							FISHING MORTALITY							
1965	.000	.048	.939	.191	.009	.027	.000	.000	.000	.000	.000	.000	.016	4+
1966	.000	.023	.547	.558	.010	.048	.011	.015	.021	.000	.000	.000	.024	4+
1967	.000	.012	.439	.470	.180	.152	.111	.092	.027	.344	.273	1.000	.141	4+
1968	.000	.013	.860	.555	.152	.232	.265	.268	.291	.213	.813	1.000	.236	4+
1969	.000	.013	.590	.789	.144	.135	.279	.327	.352	.574	.710	1.000	.258	4+
1970	.000	.009	.735	.286	.208	.232	.407	.791	.879	1.193	1.147	1.000	.470	4+
1971	.000	.070	.468	.368	.411	.417	.665	1.009	1.430	1.409	1.858	1.000	.636	4+
1972	.000	.000	.342	.325	.835	.886	1.153	1.158	1.155	.990	1.666	1.000	.998	4+
1973	.000	.027	.537	.142	.156	.546	.786	1.237	1.515	1.192	.756	1.000	.624	4+
1974	.000	.045	.857	.467	.241	.282	.518	.363	.604	.801	.691	1.000	.257	4+
1975	.000	.057	.379	.477	.326	.320	.576	.812	.553	1.157	1.274	1.000	.348	4+
1976	.000	.029	.974	.577	.455	.380	.362	.511	.451	.847	.382	1.000	.390	4+
1977	.000	.061	.982	.756	.396	.660	.518	.565	.676	.504	.691	1.000	.497	4+
1978	.000	.034	.401	.506	.451	.717	.690	.910	1.025	1.242	2.365	1.000	.741	4+
1979	.000	.003	.965	.373	.536	.681	.686	1.195	1.228	.595	.938	1.000	.625	4+
1980	.000	.050	.300	1.620	.780	.550	.650	1.000	1.000	1.000	1.000	1.000	.743	4+
							STOCK SIZE (MILLIONS)						AGE 4+ NUMBERS	AGE 4+ TONS (000)
1965	.0	969.2	1664.3	366.4	292.6	171.4	.0	.0	.0	.0	.0	.0	464.0	90.4
1966	.0	1031.5	756.7	532.8	247.1	237.6	136.5	28.9	10.5	.0	.0	.0	660.6	140.6
1967	.0	2045.9	825.9	358.4	249.6	200.4	185.5	110.7	23.3	8.4	1.8	.3	779.9	174.4
1968	.0	661.6	1656.2	435.8	183.5	170.7	141.0	135.9	82.7	18.6	4.9	1.1	738.3	174.6
1969	.0	483.5	534.8	574.1	204.8	129.0	110.9	88.5	85.2	50.6	12.3	1.8	683.0	162.8
1970	.0	225.9	391.0	242.8	217.8	145.3	92.3	68.6	52.3	49.0	23.3	4.9	663.5	153.3
1971	.0	1788.2	183.3	153.5	149.4	144.8	94.3	50.3	25.5	17.8	12.2	6.1	500.2	114.8
1972	.0	501.7	1365.7	94.0	86.9	81.1	78.1	39.7	15.0	5.0	3.6	2.8	312.3	71.5
1973	.0	436.4	410.9	794.5	55.6	30.9	27.4	20.2	10.2	3.9	1.5	.5	150.2	33.9
1974	.0	766.4	347.9	196.6	564.3	39.0	14.6	10.2	4.8	1.8	1.0	.6	636.3	119.0
1975	.0	699.8	600.0	120.8	100.9	363.2	24.1	7.1	5.8	2.1	.7	.4	504.3	108.6
1976	.0	943.7	541.2	336.2	61.4	59.7	216.0	11.1	2.6	2.7	.6	.2	394.2	81.0
1977	.0	1409.6	750.4	167.2	154.6	31.9	33.4	123.2	5.4	1.4	1.0	.3	351.1	79.2
1978	.0	1665.4	1085.4	230.2	64.3	85.1	13.5	16.3	57.4	2.3	.7	.4	239.9	56.3
1979	.0	1157.2	1317.9	594.9	113.6	33.5	34.0	5.5	5.4	16.8	.5	.1	209.5	44.7
1980	.0	1471.3	945.3	411.0	335.3	54.4	13.9	14.0	1.4	1.3	7.6	.2	428.1	83.0
1981					73.6	128.4	25.7	5.9	4.2	0.4	0.4	2.3	240.9	51.6
							CATCH AT AGE (MILLIONS)						TOTAL NUMBERS	AGE 3+ TONS (000)
1965	.0	40.9	932.9	57.8	2.4	4.2	.0	.0	.0	.0	.0	.0	64.4	11.3
1966	.0	21.0	291.7	208.5	2.2	10.1	1.3	.4	.2	.0	.0	.0	222.7	20.9
1967	.0	21.5	268.1	128.7	37.3	25.7	17.7	8.8	.6	2.2	.4	.2	215.6	30.0
1968	.0	7.8	877.9	169.8	23.6	32.1	29.9	29.1	19.0	3.2	2.5	.6	309.8	41.1
1969	.0	6.7	218.1	282.8	24.9	14.8	24.6	28.5	23.0	20.2	5.7	1.0	419.6	60.4
1970	.0	1.9	186.7	54.9	37.2	27.4	28.2	34.4	28.1	31.6	14.7	2.9	259.4	60.3
1971	.0	109.0	62.6	43.1	45.9	45.1	41.9	29.4	18.0	18.4	8.1	3.6	247.5	47.6
1972	.0	.2	360.4	23.8	46.2	43.8	49.4	25.1	9.5	2.9	2.7	1.6	204.0	46.5
1973	.0	10.6	158.2	95.7	7.3	11.9	13.7	13.3	7.4	2.5	.7	.3	152.7	28.1
1974	.0	30.5	184.1	67.0	109.8	8.7	5.4	2.8	2.0	.9	.4	.3	197.6	30.2
1975	.0	35.2	172.7	41.0	25.6	90.5	8.6	3.6	2.3	1.4	.4	.2	176.8	31.3
1976	.0	24.8	310.3	134.9	80.5	17.2	69.8	4.1	.9	1.4	.2	.1	238.9	38.0
1977	.0	76.2	432.1	81.4	46.2	14.1	12.3	48.6	2.4	.5	.4	.2	205.3	31.1
1978	.0	60.5	327.3	83.6	21.3	40.0	6.2	9.0	33.9	1.5	.6	.2	196.2	38.8
1979	.0	3.3	761.2	169.0	43.1	15.2	15.5	3.6	3.5	6.9	.3	.0	267.8	38.8
1980	.0	65.1	223.2	208.2	163.8	21.0	6.1	8.2	.8	.8	4.4	.1	603.3	78.0

TABLE 12. HERRING VPA FOR THE STOCKS FROM SW NOVA SCOTIA TO CAPE HATTERAS

YEAR	AGE 1	2	3	4	5	6	7	8	9	10	11	MEAN F	AGE
				FISHING MORTALITY									
1965	.061	.480	.060	.105	.083	.102	.045	.034	.000	.000	.000	.088	4+
1966	.032	.385	.280	.074	.234	.206	.267	.276	.134	.368	.000	.178	4+
1967	.085	.273	.125	.181	.171	.276	.472	.636	1.715	1.502	1.000	.276	4+
1968	.049	.603	.199	.122	.416	.386	.552	.761	.278	1.236	1.000	.375	4+
1969	.060	.367	.363	.217	.437	.438	.612	.670	.711	1.252	1.000	.426	4+
1970	.230	.513	.193	.493	.533	.469	.635	.664	.674	1.071	1.000	.544	4+
1971	.024	.363	.666	.569	.630	.595	.683	.701	.695	.632	1.000	.621	4+
1972	.004	.101	.134	.765	1.145	1.293	1.208	1.044	.979	.732	1.000	1.042	4+
1973	.017	.380	.308	.635	.673	.705	.813	.724	.896	.682	1.000	.675	4+
1974	.018	.662	.264	.410	.446	.439	.495	.365	.686	.540	1.000	.418	4+
1975	.050	.529	.386	.302	.612	.761	.656	.522	.514	.538	1.000	.578	4+
1976	.046	1.065	.510	.443	.463	.567	.460	.484	.758	.306	1.000	.513	4+
1977	.061	.728	.701	.625	.666	.579	.594	.460	.348	.416	1.000	.611	4+
1978	.040	.283	.404	.476	1.038	.946	.630	.996	.742	.525	1.000	.885	4+
1979	.006	.286	.136	.435	.541	.774	.814	.554	1.130	.677	1.000	.602	4+
1980	.050	.320	.140	.210	.600	.600	.700	.700	.700	.700	1.000	.237	4+
				STOCK SIZE (MILLIONS)								AGE 4+ NUMBERS	AGE 4+ TONS (000)
1965	6905.0	9169.3	3299.7	3918.4	2674.3	511.5	174.2	29.1	.0	.0	.0	7307.4	1562.9
1966	6246.6	5372.2	4932.0	2545.5	2888.4	2055.4	378.1	136.4	23.0	.8	.0	8027.6	1880.0
1967	11753.8	4952.6	3179.1	3051.4	1935.2	1872.2	1370.6	237.0	84.8	16.5	.5	8568.0	2031.9
1968	4053.4	8838.5	3085.8	2297.1	2083.9	1335.6	1163.1	700.2	102.7	12.5	3.0	7698.1	1881.6
1969	4201.6	3160.9	3618.3	2070.5	1664.1	1126.7	743.0	548.3	267.8	63.7	3.0	6487.0	1587.9
1970	3773.9	3272.7	1793.6	2061.3	1364.6	880.2	595.6	329.8	229.6	107.7	14.9	5583.6	1342.6
1971	13645.9	2455.3	1604.5	1211.4	1030.8	655.8	451.0	258.4	140.3	95.8	30.2	3873.7	953.4
1972	2119.4	10913.3	1398.5	674.7	561.4	449.5	296.0	186.6	105.0	57.3	41.7	2372.2	596.6
1973	2875.6	1731.1	7384.9	1001.3	259.7	146.2	101.0	72.4	53.8	32.3	22.6	1689.3	374.6
1974	2982.0	2315.4	1029.4	4441.4	434.5	108.5	59.2	36.7	28.7	18.0	13.4	5140.3	989.7
1975	1185.1	2398.3	977.6	647.3	2414.1	227.7	57.3	29.5	20.8	11.9	8.6	3417.2	812.3
1976	1885.0	923.3	1157.3	543.9	361.5	1072.2	87.1	24.3	14.3	10.2	5.7	2119.3	517.1
1977	11065.0	1474.3	260.5	569.2	286.1	186.4	497.7	45.0	12.3	5.5	6.1	1608.3	308.8
1978	7544.1	8524.6	583.1	105.8	249.5	120.3	85.5	225.0	23.3	7.1	3.0	819.4	220.2
1979	1171.4	5935.7	5583.1	318.8	53.9	72.3	38.2	37.3	68.0	9.1	3.4	601.1	140.9
1980	7348.6	953.0	3650.1	3991.8	169.0	25.7	27.3	13.9	17.5	18.0	3.8	4267.0	797.1
				CATCH AT AGE (MILLIONS)								TOTAL AGE 3+ NUMBERS	TOTAL AGE 3+ TONS(000)
1965	312.3	2870.7	173.0	354.8	148.7	45.1	6.9	.9	.0	.0	.0	729.4	153.9
1966	179.2	1357.1	1097.3	165.3	547.5	346.8	80.7	29.9	2.6	.2	.0	2270.4	319.8
1967	871.1	1077.8	339.3	460.0	276.2	411.2	470.8	102.2	64.7	11.9	.3	2136.6	410.3
1968	174.9	4051.3	506.4	240.4	646.0	390.5	451.3	342.5	22.7	8.2	1.8	2609.6	500.8
1969	185.8	884.7	1003.6	387.4	537.8	364.6	311.5	245.5	124.9	42.0	1.7	2990.8	610.6
1970	705.2	1200.1	285.6	733.1	515.3	300.8	256.4	145.1	103.2	65.3	8.7	2413.5	473.6
1971	200.8	681.4	715.1	481.0	441.2	269.3	204.5	119.4	64.5	41.1	17.6	2333.6	437.4
1972	8.3	1721.7	169.4	328.1	353.5	301.9	191.9	111.4	60.3	37.3	24.3	1558.0	340.1
1973	43.1	431.8	1785.7	431.1	116.6	67.8	51.6	34.2	29.3	14.6	13.1	2544.1	360.4
1974	47.9	1027.5	217.4	1362.3	142.7	35.2	21.1	10.2	13.1	6.9	7.8	1816.6	322.9
1975	52.1	996.3	285.8	187.6	1011.3	111.3	26.3	11.0	7.6	4.6	5.0	1640.4	321.6
1976	76.0	658.0	422.4	177.6	122.3	424.8	29.4	8.5	7.0	2.4	3.3	1197.7	214.8
1977	591.1	699.1	120.4	242.2	127.5	74.9	204.0	15.1	3.3	1.7	3.6	792.7	178.1
1978	266.9	1551.5	176.7	38.8	148.6	67.7	36.6	130.7	11.2	2.6	1.7	618.4	148.4
1979	8.1	1345.5	642.7	102.6	20.6	35.8	19.6	14.5	42.5	4.1	2.0	804.5	121.5
1980	325.1	237.8	433.2	687.7	69.8	10.6	12.6	6.4	8.1	8.3	2.2	1230.0	104.0

TABLE 13. HERRING VPA FOR THE AREA FROM SW NOVA SCOTIA TO CAPE HATTERAS EXCLUDING GEORGES BANK

YEAR	AGE 1	2	3	4	5	6	7	8	9	10	11	MEAN F	AGE
				FISHING MORTALITY									
1965	.074	.582	.117	.199	.136	.102	.052	.080	.000	.000	.000	.178	4+
1966	.049	.610	.432	.127	.407	.158	.191	.330	.209	.368	.000	.268	4+
1967	.107	.465	.830	.290	.819	.368	.329	.097	.174	.188	1.000	.288	4+
1968	.081	.987	.346	.133	.431	.242	.456	.447	.588	1.236	1.000	.308	4+
1969	.076	.726	.636	.204	.283	.314	.338	.322	.443	.681	1.000	.279	4+
1970	.340	.828	.236	.509	.606	.392	.618	.469	.717	.795	1.000	.518	4+
1971	.036	.606	.468	.467	.498	.527	.661	.664	.717	.478	1.000	.547	4+
1972	.005	.293	.176	.824	.798	.942	.756	.771	.669	.661	1.000	.813	4+
1973	.017	.364	.228	.357	.458	.638	.683	.626	.765	.623	1.000	.479	4+
1974	.018	.669	.258	.342	.891	.366	.363	.316	.695	.503	1.000	.345	4+
1975	.050	.531	.384	.289	.390	.520	.459	.372	.390	.432	1.000	.379	4+
1976	.048	1.066	.603	.429	.487	.428	.399	.375	.638	.273	1.000	.421	4+
1977	.088	.790	.701	.625	.666	.579	.594	.460	.348	.416	1.000	.611	4+
1978	.056	.349	.468	.476	1.038	.946	.630	.996	.742	.525	1.000	.885	4+
1979	.008	.432	.838	.549	.641	.774	.814	.654	1.130	.677	1.000	.674	4+
1980	.050	.328	.248	.430	.800	.600	.700	.700	.700	.700	1.000	.450	4+
				STOCK SIZE (MILLIONS)								AGE 4+ NUMBERS	AGE 4+ TONS(000)
1965	4823.7	7893.7	1580.9	1767.4	528.9	123.7	39.7	9.7	.0	.0	.0	2469.3	497.5
1966	4133.4	3667.7	3403.0	1151.9	1186.0	378.0	91.5	30.8	7.3	.8	.0	2846.3	640.0
1967	9468.7	3222.9	1787.7	1809.1	830.8	646.1	265.9	61.9	18.1	4.4	.5	3636.6	808.2
1968	2473.7	6967.4	1673.4	1163.3	1108.2	546.6	366.3	156.7	46.0	12.5	3.0	3402.6	805.3
1969	2838.2	1867.7	2126.9	969.0	833.7	589.7	351.3	190.1	82.1	20.9	3.0	3039.7	735.8
1970	2683.9	2156.3	740.1	921.8	647.2	514.4	352.6	205.4	112.8	43.1	9.6	2806.8	687.6
1971	8126.3	1664.0	773.9	478.8	453.7	319.7	284.5	156.7	105.2	45.1	16.0	1858.6	473.0
1972	1900.5	7212.2	698.8	396.7	248.2	225.8	154.6	120.3	66.6	42.0	22.9	1276.1	321.9
1973	2850.2	1551.1	4403.5	480.1	148.5	91.5	72.1	59.5	46.5	27.5	19.6	938.4	218.8
1974	2970.5	2296.7	882.3	2889.6	274.9	74.3	39.6	89.8	26.1	17.3	13.4	3344.9	847.9
1975	1186.1	2389.2	962.6	657.9	1668.9	168.3	42.2	22.5	17.8	10.7	8.6	2496.9	588.9
1976	1786.7	923.3	1150.1	536.8	342.0	925.3	81.9	21.8	12.7	9.9	5.7	1936.1	468.8
1977	7711.1	1394.0	260.5	560.2	286.1	186.4	497.7	45.0	12.3	5.5	6.1	1608.3	388.8
1978	5422.9	5780.2	518.0	105.8	249.6	120.3	85.5	225.0	23.3	7.1	3.0	819.4	220.2
1979	1171.4	4199.1	3339.1	265.7	53.9	72.3	38.2	37.3	68.0	9.1	3.4	647.9	131.3
1980	7348.8	953.0	2231.1	2165.6	186.7	25.7	27.3	13.9	17.5	18.0	3.8	2387.4	454.1
1981				1436.9	1148.1	66.5	11.6	11.1	5.7	7.1	7.3	2684.3	671.7
				CATCH AT AGE (MILLIONS)								TOTAL AGE 3+ NUMBERS	TOTAL AGE 3+ TONS(000)
1965	312.3	2870.0	158.0	289.9	61.1	10.8	1.8	.7	.0	.0	.0	622.3	113.2
1966	179.8	1356.9	1089.4	124.7	362.1	48.4	14.4	7.9	1.7	.2	.0	1849.0	181.8
1967	871.1	1076.6	333.7	414.9	148.3	181.8	67.9	6.8	2.6	.7	.3	1164.8	192.9
1968	174.9	4026.7	448.6	131.7	354.1	107.0	182.5	51.6	18.7	8.8	1.8	1842.1	208.1
1969	185.8	884.0	918.0	162.3	187.1	145.0	91.5	47.7	26.0	8.4	1.7	1586.5	812.5
1970	765.2	1112.5	141.3	336.0	234.7	152.2	148.7	70.3	52.9	21.7	6.8	1163.4	829.1
1971	288.8	660.4	864.3	160.5	168.6	119.6	128.1	69.8	49.4	16.6	9.3	976.8	174.8
1972	8.3	1670.1	102.8	284.6	126.3	126.8	75.2	50.4	29.3	16.5	13.4	768.8	170.4
1973	43.1	431.7	817.6	131.8	47.3	39.5	32.7	26.3	22.4	10.8	11.4	1138.8	163.3
1974	47.9	1026.3	188.9	767.8	63.1	26.8	11.0	7.3	12.0	6.3	7.8	1068.7	176.9
1975	62.1	900.2	880.0	187.0	491.6	62.4	14.8	6.4	5.3	3.4	5.0	995.7	180.2
1976	78.6	568.0	416.7	171.1	104.4	289.7	24.8	6.2	5.6	2.1	3.3	1028.8	171.9
1977	691.1	609.1	126.4	248.2	127.6	74.9	204.0	16.1	3.3	1.7	3.8	798.7	178.3
1978	266.9	1561.6	176.7	36.6	148.8	67.7	36.6	130.7	11.2	2.6	1.7	612.4	148.4
1979	6.1	1346.5	642.7	102.6	20.8	35.8	19.8	14.5	42.5	4.1	2.0	884.5	181.5
1980	325.1	837.8	433.2	687.7	61.9	18.8	18.8	6.4	8.1	8.3	2.2	1881.5	194.0

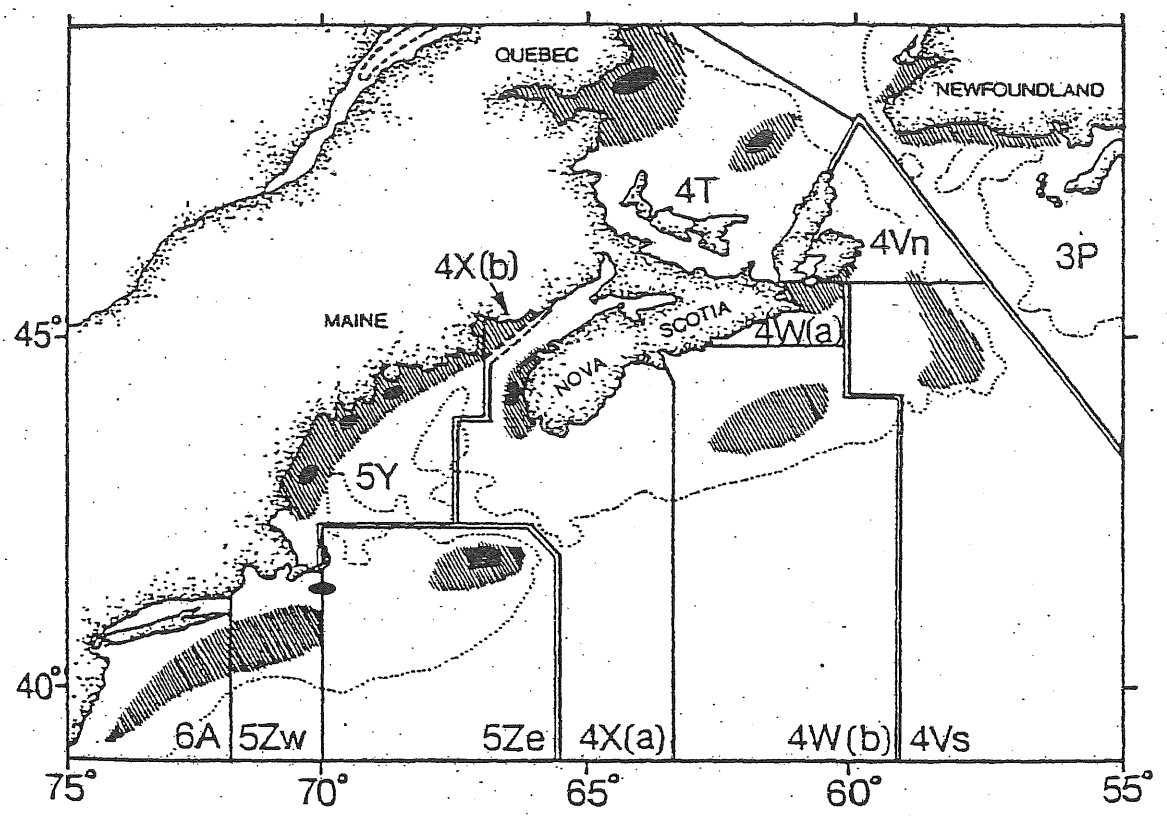

Figure 1. Major fishing areas (dashed line) and spawning grounds (dark circles) for Atlantic herring in the Northwest Atlantic. Chedabucto Bay is in NAFO Subarea 4Wa.

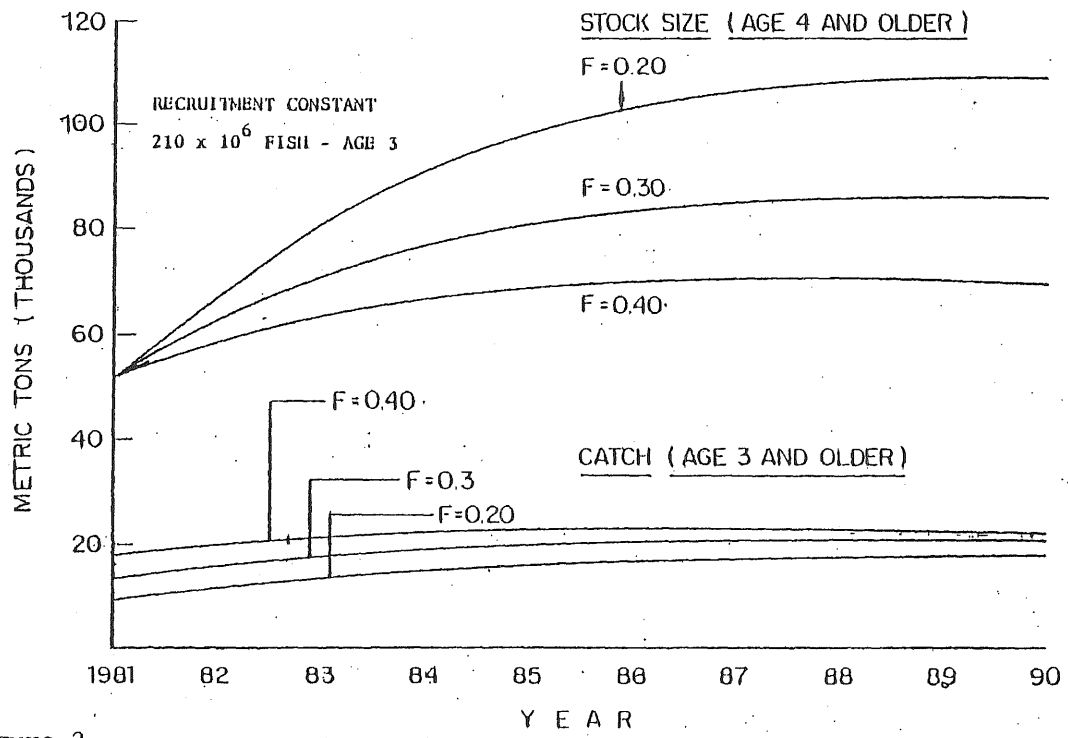

Figure 2. Long-term catch (Age 3+) and stock size (Age 4+) projections with constant recruitment and three levels of fishing mortality for the USA Gulf of Maine herring fisheries.

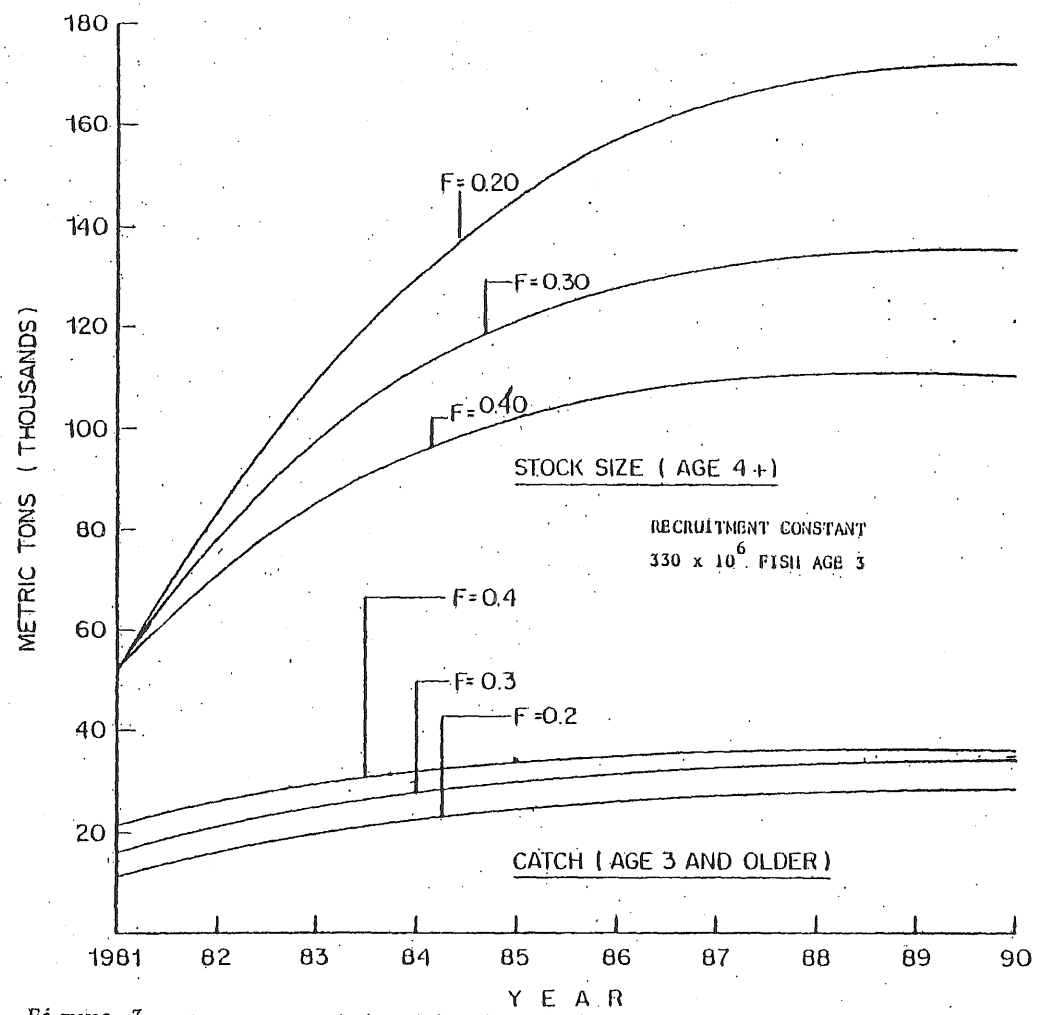

Figure 3. Long-term catch (Age 3+) and stock size (Age 4+) projections with constant recruitment and three levels of fishing mortality for the USA Gulf of Maine herring fisheries.

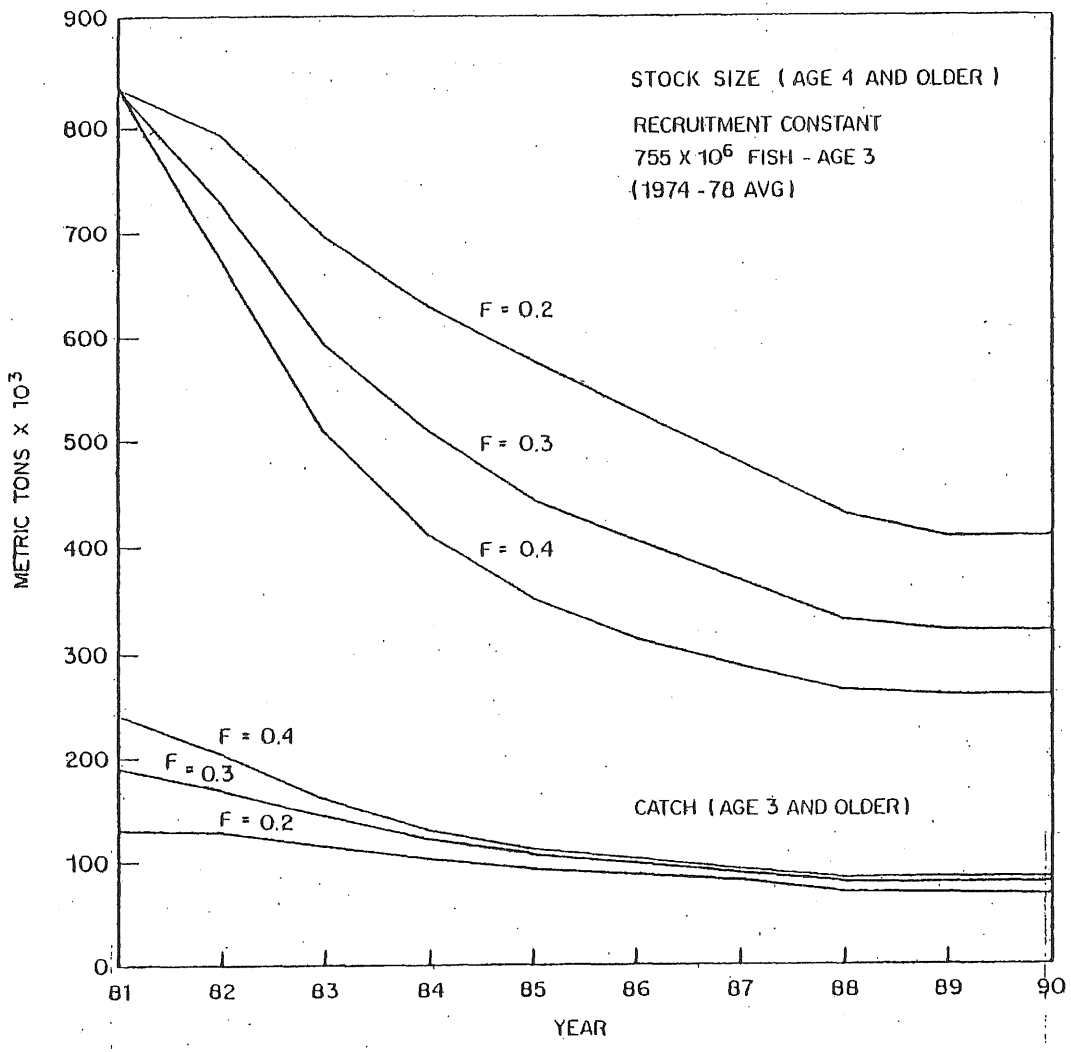

Figure 4. Long-term catch (Age 3+) and stock size (Age 4+) projections with constant recruitment and three levels of fishing mortality for herring in the region between Chedabucto Bay and Cape Hatteras excluding Georges Bank.

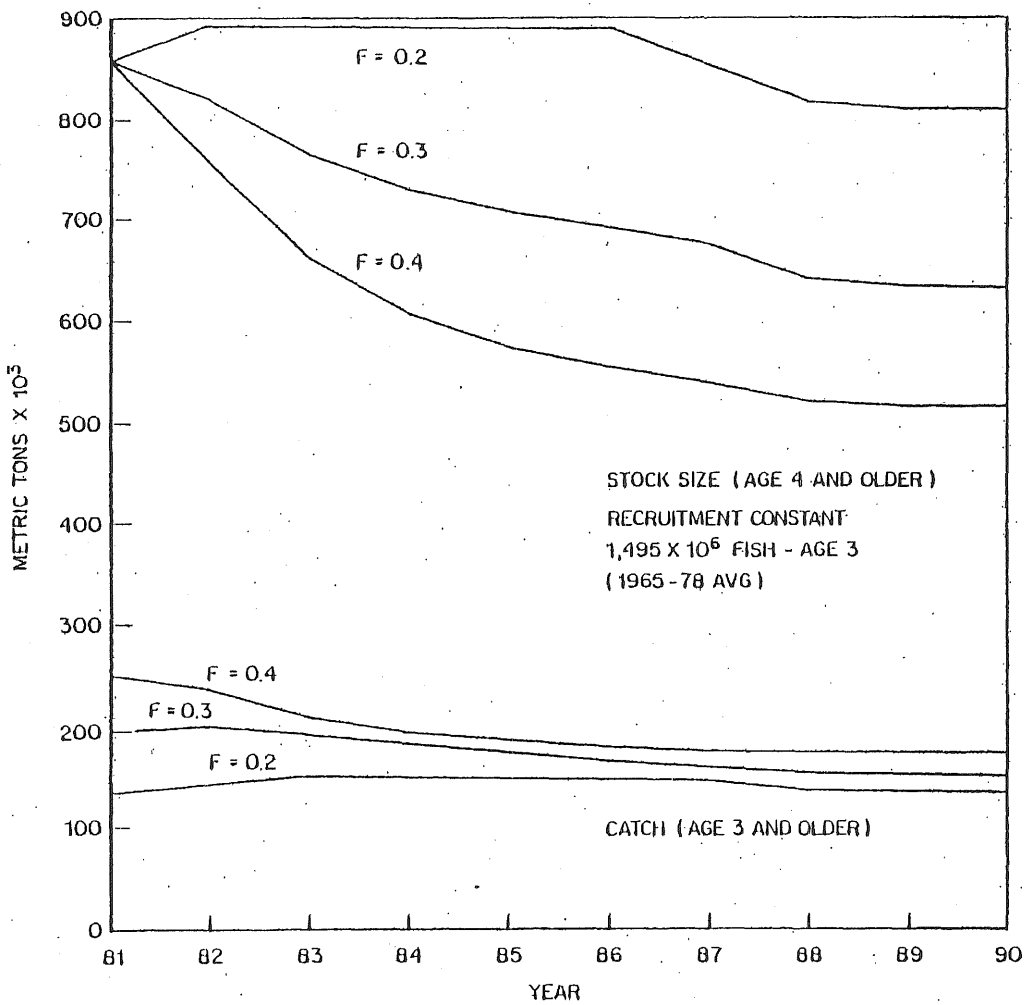

Figure 5. Long-term catch (Age 3+) and stock size (Age 4+) projections with constant recruitment and three levels of fishing mortality for herring in the region between Chedabucto Bay and Cape Hatteras excluding Georges Bank.