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Herring assessment in Div. 4WX

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The herring fishery off southwest Nova Scotia has been in existence since the 1800's. The fishery first began as a gillnet fishery; the weir fishery developed around 1820, and the purse seine fishery about 1940. In 1964, a large fish meal industry developed in the Maritimes region and soon afterwards the size of the Bay of Fundy purse seine fishery increased greatly to meet the demand for herring for reduction.

Currently, three gear types (purse seines, weirs and gillnets) account for about 98% of the catch in the Bay of Fundy and surrounding area. Traditionally, each gear exploits a particular component of the herring population in a particular area and the geographical area of overlap between gears varies considerably (Fig. 1).

The gillnet fishery occurs only on the Nova Scotia side of the Bay and exploits primarily adult fish in pre-spawning and spawning aggregations. Historically catches remained relatively constant, in the order of 2,000-6,000 tons. In 1977, however, a substantial increase in effort occurred and a catch in excess of 18,000 tons was taken.

The weir fishery occurs on both sides of the Bay of Fundy although the majority of weirs are located on the New Brunswick side. Catches on the New Brunswick side have ranged up to 50,000 tons historically, but since the early 1960's have ranged between 16,000 and 39,000 tons. This

fishery exploits primarily 2 and 3-year old fish. The Nova Scotia weir fishery is considerably smaller, with catches in the order of 2,000 to 12,000 tons per year, and exploits primarily fish of ages 2-5.

The purse seine fishery has occurred throughout the year and on both sides of the Bay. A winter "brit" fishery in the 1960's exploited very small fish on the New Brunswick side for fish meal production and catches as high as 42,000 tons were made. This fishery was essentially ended in 1970 by Canadian legislation which prevented landings herring less than 11.5 cm long and utilization of herring between 11.5-18.0 cm for fish meal. Since that time, catches of "brit" herring have been substantially reduced. A summer-fall purse seine fishery exploiting both juveniles and adults occurs on the Nova Scotia side. Catches in this fishery have ranged between 35,000 and 130,000 tons.

Historical catch statistics for the various Bay of Fundy herring fisheries have been confounded by the habit of reporting by area of landing rather than area of catch and by the lack of catch locations for the considerable quantities exported to the United States. A report by Miller and Iles (1975) has attempted to designate catch by location and is probably more reliable than any other statistics on this fishery.

Stock interrelationships are not yet well defined for this southwest Nova Scotia stock and this lack of knowledge has hampered management objectives. Tagging experiments in the Bay of Fundy in 1973 and 1974 (Stobo et al., 1975) indicated that the herring fisheries in the Bay of Fundy exploit a stock complex, part of which migrates to the Chedabucto Bay area during winter while another portion moves westward as far as Cape Cod. As a result of these experiments the winter purse seine fishery occurring in the Chedabucto Bay area has been combined with southwest Nova Scotia for management purposes. This Chedabucto Bay area fishery began in 1969 and catches have ranged from 7,000-52,000 tons (see Stobo, 1974, 1975). Insufficient information has been collected, however, to determine the proportionate dependence of the New Brunswick weir and "brit" fishery on the southwest Nova Scotia and other stocks. Consequently, these two New Brunswick juvenile fisheries are not as yet included with any designated spawning stock for management purposes. Further, along the southern coast of Nova Scotia, between Cape Sable Island and Canso, there are a number of small, local gillnet fisheries presumably exploiting local stocks; the catches from these localized gillnet fisheries are not included in the present analyses.

Catch statistics

The 1977 catch (actually the 1976-77 fishing season catch) from the Div. 4WX stock was 117,980 tons. A detailed breakdown of the catch in Div. 4WX is given in Table 1. In the case of gears or areas which exploit more than the southwest Nova Scotia stock, the stock and total catch are presented separately. The fishing season is based on

November 1 to October 31 season rather than calendar year because the fishery off Chedabucto Bay usually commences in November and that off southwest Nova Scotia terminates in October. Due to a lack of sampling coverage and the provisional nature of the catch statistics, the small catches by Nova Scotia gill nets and weirs in November and December have been included in the 1977 fishing season.

Current catch composition

The level of sampling of the Div. 4WX commercial herring catch is very intensive throughout most of the fishery. As a result, monthly age-length keys and length-weight relationships by gear can be derived. In some months however, the catch by some gears are only a few hundred tons and in such cases samples for adjacent months are combined to obtain a representative age-length key. To the extent possible however, monthly length-weight relationships are retained.

The Bay of Fundy purse seine fishery has historically shown substantial differences in the monthly length frequency of the catch between different geographical areas in the Bay. In order to reduce the effects of these differences in the final length frequency distribution, the Bay was sub-divided into 20 areas. For the period 1973-76 the monthly purse seine catch was partitioned into these areas using log record information, then weighted against the length frequencies from each area. The same procedure was used in 1977, however a new statistical system was initiated in the Bay of Fundy in 1977 which allowed direct allocation of almost the total catch into the individual areas. In the Chedabucto Bay area the sampling coverage has been sufficiently intense since 1972 to weight the length frequencies against, in many cases, individual boat catches. Generally it has not been necessary to combine catches over more than one week periods in order to weight the length frequency samples.

The age composition for the 1977 Div. 4WX stock catch is given in Table 2. The fishery in 1977 in both the southwest Nova Scotia and Chedabucto Bay areas was dependent on the 1970-73 year classes. The younger year classes (1974-76) did not contribute substantially to the overall catch in either area. Although the catch of the 1975 year class in Nova Scotia weirs was 48×10^6, this catch is not large compared to other years (see Fig. 4).

In 1976 and 1977 an ageing problem has been noted in distinguishing between the 1970 and 1971 year classes, similar to that existing for the Subarea 5 herring stocks. Apparently the 1976 annulus is poorly defined in the 1970 year class resulting in large numbers of fish being aged as 1971 year class fish. The size of these two year classes are now well defined in cohort analyses with the 1970 year class being

about six times the size of the 1971. Therefore the relative contribution of each in the 1977 fishery was adjusted on the basis of their relative proportions in the 1975 catch, after adjusting for partial recruitment. These adjusted values were then used in subsequent analyses.

Assessment Parameters

a) Effort calculations

In order to get some method for examining the appropriateness of terminal F in cohort analyses, weighted effort figures for the period 1967-77 were derived for the Nova Scotia purse seine and weir fisheries (Table 3). The annual catch-per-unit-effort (CPUE) values for purse seines were obtained from log records, then standardized against the 11-year average CPUE. The number of weirs on the Nova Scotia side of the Bay of Fundy have remained constant during this period and an annual catch-per-unit-effort was derived by dividing the 11-year average into annual catch. A CPUE index was then calculated as:

$$\text{CPUE INDEX} = \frac{(\text{Purse seine catch} \times \text{CPUE/Ave} + \text{Weir catch/Ave})}{\text{Purse seine catch} + \text{Weir catch}}$$

and expanded to total effort exerted on the Div. 4WX stock:

$$\text{EFFORT UNITS} = \frac{\text{Total 4WX stock catch}}{\text{CPUE INDEX}}$$

b) Cohort analysis

Cohort analysis was first run using the same terminal F and partial recruitments as used for the 1977 catch projection. The F's placed on older year classes were the same as used in deriving the population matrix for the 1977 projection. The resultant fishing mortalities on age groups 5-8 were averaged and the analysis re-run. Age 5 fish are only 90% recruited and the fishing mortality on this age group was adjusted to account for this partial recruitment. Two iterations were conducted using this method.

The resultant weighted F's were then plotted against the derived effort (Fig. 2) and further adjustments were made in the terminal F and the F's on older age groups to improve the regression.

The partial recruitment factors were not adjusted because the F's on those year classes had very little affect on the weighted F. The best relationship obtained between effort and weighted F gave an r^2 of 0.632 but did not go through the origin. There are several possible reasons for the intercept being on the X-axis. The purse seine fishery in 4Wa has a much higher CPUE than in southwest Nova Scotia especially in recent years. Incorporation of these data into the calculation of total effort units would probably reduce the total effort in all years and swing the intercept closer to the origin. The catch-per-unit-effort in the purse seine fishery in southwest Nova Scotia declined in 1976 and again in 1977 resulting in an increase in calculated effort. Even though the catch-per-unit-effort in Nova Scotia weirs (see Table 3) showed similar declines, the management system in southwest Nova Scotia during 1976 and moreso 1977 limited nightly boat catches to market demand. The increase in effort in these two years is thus partly an artifact of this management system. Corrections for these limitations would probably move the intercept closer to the origin but would not have much other effect on the regression. The result of such corrections as discussed above would probably not affect the relationship and thus the weighted F's in recent years any appreciable amount.

The population size and fishing mortalities associated with the final cohort analyses are given in Table 4.

c) Recruitment estimates

There are no research surveys associated with pelagic fish thus no independent estimates of abundance or year class size can be made. Due to this lack of information, a conventional year class size of 750×10^6 fish at age 2 for Div. 4WX herring was adopted at the ICNAF scientific deliberations. This conventional year class size was in the lower end of the range of the observed year class sizes, but it was felt that a conservative estimate should be initially made until additional data allowed for adjustments.

The cohort analysis (Table 4) suggests that the 1974 and 1975 year classes are smaller than the conventional size, using current partial recruitment factors. The 1974 year class, in fact, is calculated to be the smallest year class observed since 1965.

The relationship of the catch of 2-year old fish to total catch and year class size calculated from cohort analysis was then examined for the southwest Nova Scotia purse seine and weir fishery. The relationship between the catch of 2-year olds as a ratio of total catch numbers in the southwest N.S. purse seine fishery to year class size at age 2 (Fig. 3) gave an $r^2 = 0.835$ and indicates that the 1974 and 1975 year classes are quite small. The relationships between the catch of 2 year olds in N.S. purse seines (Fig. 4) and N.S. weirs (Fig. 5) and year class size at age 2 were also examined. Although the relationships were not predictive, they both suggest that the 1974 and 1975 year classes are small.

d) Yield-per-recruit

The nature of the purse seine fishery in southwest Nova Scotia changed in 1976 and 1977 in that the season was extended from May-mid-August to May-October. This extension of the season changes the mean weight-at-age and thus possibly the yield-per-recruit. Weight-at-age of calculated removals by gear, month, and area were accumulated for the fishing season to derive mean annual weights at age as given below:

Annual mean weight-at-age (kg)

AGE	2	3	4	5	6	7	8	9	10	11+
WEIGHT	0.0296	0.0977	0.1658	0.2071	0.2615	0.2807	0.3002	0.3286	0.3490	0.3732

A new yield-per-recruit, using Beverton-Holt equations, was calculated (Fig. 6) with a resultant $F_{0.1}$ = 0.308 and an F_{max} = 0.517.

Partial Recruitment

Partial recruitment factors were not changed from those used in 1976 and 1977.

AGE	2	3	4	5	6	7	8	9	10
PR	0.30	0.41	0.76	0.90	1.00	1.00	1.00	1.00	1.00

Results of Assessment

Several options were considered in determining the catch level for 1979. The 1978 TAC was established in April 1977 with provisional catch statistics and using the conventional year class size for the 1974 and 1975 year classes. The final catch statistics indicate that the 1976-77 stock catch from 4Wa was 23,251 tons, 3,600 tons greater than that used in the 1977 assessment and the 1977 stock catch from 4X was 94,319 tons, considerably more than the 1977 TAC of 84,000 tons, which was also used in the 1977 projections to determine the 1978 catch.

The 1978 TAC was set at 98,000 tons with a sub-allocation of 20,000 tons for 4Wa and 78,000 tons for 4X. The catch in 4Wa was only 16,783 tons thus the 1978 catch of the whole stock could be limited to 95,200 tons if the under-run in 4Wa is not transferred to 4X.

In order to determine the difference between taking 92,500 tons in 1978 and managing catch closer to $F_{0.1}$ catch and population biomasses were projected to 1986 with a trial F = 0.319 ($F_{0.1}$ = 0.308) with 2 options for management and two recruitment levels (Fig. 7). The management options were:

1. 1978 catch = 92,500 tons; F = 0.319 thereafter; and

2. F = 0.319 for all years 1978-86.

The recruitment options were:

1. constant recruitment from 1976-86 of 750 x 10^6 fish at age 2; and

2. for the period 1975-77, constant recruitment of 750 x 10^6 and for the period 1978-86, recruitment was selected from a log normal distribution based on past recruitment levels excluding the 1970, 1974 and 1975 year classes. The projection shown in the average of 20 runs.

If the 1978 catch is 95,200 tons, under either recruitment option the 1979 catch is only slightly lower than if managed close to $F_{0.1}$. The population biomass is also depressed initially but there is little difference by 1981. Subsequently, there is no discernible difference if managed at the same F level. There is a considerable difference however using either management option in long term catch and population biomass under the different recruitment assumptions. With recruitment at the conventional level, the catch stabilizes just below 60,000 tons and the population at about 300,000 tons. With average recruitment, by 1986 catches between 90,000-100,000 tons would occur with a population biomass in excess of 460,000 tons.

On the basis that there is no long-term advantage to adjusting the 1978 TAC, projections for 1979 were made assuming a 1978 catch of 95,200 tons and projecting at $F_{0.1}$ = 0.308 for fully mature fish. The population structure in 1977 as generated by cohort analysis (Table 4) was used for the projections except that the 1975 year class was set at the conventional level of 750 x 10^6 fish. The sizes of the 1976 and 1977 year classes were also set at the conventional level. The relationship between 1979 catch and 1980 population biomasses is given in Fig. 8. At $F_{0.1}$ the 1979 catch and the 1980 population biomass would be 65,300 tons and 330,000 tons respectively.

Projections to 1986 using $F_{0.1}$ were also run using two recruitment options for the 1978 to 1984 year classes. The recruitment for year classes prior to 1978 were as in the 1979 projection. The

recruitment options were:

1. conventional year class size = 750×10^6 at age 2,

2. average year class size = 1.237×10^9 at age 2, where the average is based on the 1963-73 year classes excepting the 1970 year class.

The results (Table 5) are similar to those in Fig. 7. Setting recruitment at the conventional year class size results in catch and population biomass stabilizing at about 58,000 tons and 300,000 tons respectively by 1981. Setting recruitment at the second option results in a catch of almost 93,000 tons in 1986 with an associated populated biomass of almost 490,000 tons. Although both are still increasing the rate has dropped considerably.

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Table 1. Provisional catch (mt) during the 1977 Div. 4WX herring fishery. Catches in parentheses indicate catches associated with Div. 4WX stock. Total catch for 4WX stock refers to 1976-77 fishing season only.

	1977												1978			Total
	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	4WX Stock
4Wa Chedabucto Bay																
Total catch	1025	5783	10945	361	-	1704	3457	143	327	508	133	3	217	-	-	
Purse seine (stock)	(1025)	(5783)	(10945)	(361)	-	(1700)	(3437)	-	-	-	-	-	(274)	(66)	(16934)	23251
4Xa Southwest N.S.																
Purse seine	-	-	-	-	-	-	711	15526	18687	18494	13704	1416	-	-	-	68538
Gill Net (Total)	-	-	-	-	-	2	382	2321	3728	7031	5674	6	-	13	-	
Gill Net (Stock)	-	-	-	-	-	(1)	(347)	(2171)	(3353)	(6969)	(5668)	(6)	-	(7)	-	18523 *
Weir	-	-	-	-	-	-	366	1526	2042	1145	99	15	-	20	-	5213
Misc.	-	-	-	-	-	2	163	635	848	278	100	11	8	-	-	2045
4WX Foreign	23	23	-	-	102	101	1	160	-	-	-	-	-	-	-	410
4WX Stock Total	23	23	10945	361	102	1804	5025	20018	24930	26886	19571	1448	282	93		117,980
4Xb New Brunswick																Total
Weir	-	-	-	-	-	28	16	977	4224	6360	2815	2701	3325	752	-	20,697
Purse Seine	-	-	27	746	463	-	-	-	-	-	-	-	-	-	-	1,237
Misc.	-	-	-	-	-	-	-	10	77	1777	489	300	137	-	-	2,790
Total	-	-	27	746	463	28	16	987	4301	8137	2804	3001	3462	752	-	24,724

* Approximately 2,500 mt of this catch may have been taken by purse seine.

Table 2. Herring catch at age (X 10^{-3}) in 1977 from the Div. 4WX Stock.

	AGE											
	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Southwest N.S.												
Purse Seine	37	4610	5916	118428	62004	56472	54460	4282	559	186	763	307717
Weir	1110	48005	8653	9281	4127	1866	1554	141				74737
Gillnet			14	9428	11728	13498	29086	2086	842	145	258	67085
Miscellaneous	17	2970	479	3554	2011	1994	1794	146	30	11	32	13038
Chedabucto Area												
Purse seine		42	4311	51568	25819	14036	30034	5789	1424	894	2362	136279
Foreign bycatch		7	95	564	372	616	245	22	18	17	33	1989
TOTAL	1164	55634	19468	192823	106061	88482 (55066)*	117173 (150588)*	12466	2873	1253	3448	600845

* Adjustments in proportional catch of 1970 and 1971 year classes based on 1975 removals.

Table 3. Derivation of standardized effort and catch-per-unit effort using Nova Scotia purse seine and weir catch and effort.

	NOVA SCOTIA PURSE SEINE			NOVA SCOTIA WEIR				
YEAR	CATCH	CPUE[1]	CPUE/ AVE.	CATCH	CATCH/ AVE.	CPUE[2] INDEX	TOTAL CATCH	EFFORT[3] UNITS
1967	117,382	55.5	1.253	12,475	1.374	1.2646	135,250	106,951
68	133,267	52.8	1.192	12,571	1.385	1.2086	151,714	125,528
69	84,525	41.7	0.941	10,744	1.184	0.9684	139,047	134,653
1970	70,849	39.0	0.880	11,706	1.290	0.9381	176,941	188,617
71	35,071	32.6	0.736	8,081	0.890	0.7648	124,814	163,189
72	61,158	45.0	1.016	6,766	0.745	0.9890	148,868	150,523
73	36,618	49.1	1.108	12,492	1.376	1.1762	121,091	102,953
74	76,859	45.2	1.020	6,436	0.709	0.9960	143,942	144,525
1975	79,605	50.9	1.149	7,404	0.816	1.1207	149,332	133,253
76	58,396	41.8	0.943	5,959	0.656	0.9164	114,486	124,927
77	68,538	33.8	0.763	5,213	0.574	0.7496	111,562	148,820
AVE.		44.3		9,077				

[1] Catch/effort from log records.

[2] CPUE INDEX = $\frac{\text{(Purse Seine Catch x CPUE/Ave. + Weir Catch/Ave Catch)}}{\text{Purse Seine Catch + Weir Catch}}$

[3] EFFORT UNITS = $\frac{\text{Total 4WX Stock Catch}}{\text{CPUE Index}}$

Table 4. Results of Cohort Analyses.

DIV.4WX HERRING POPULATION NUMBERS

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	2573883	1520603	1256924	2361178	622708	789346	863222	5168989	799690	1261696	1683197	194992	541745
3	961249	1916581	1205487	985697	1252997	446006	549520	576299	3644541	627897	925947	1164915	141620
4	1301419	763071	1324796	925051	734694	677987	312528	292773	406700	2474822	472818	614285	807496
5	343998	855456	571734	868943	698456	493877	296884	159810	105319	233871	1468646	303543	384765
6	91885	236624	420997	368733	463037	426419	222392	140313	60982	55082	143341	854384	183070
7	40626	65645	152581	200631	235996	278799	240340	113680	46669	26798	31295	71574	500638
8	4460	31730	41105	72489	82269	136659	127000	112063	48678	20691	14593	17156	41444
9	1033	3144	18991	29585	30415	46911	74556	58717	47684	23925	12133	9018	9551
10	327	797	1045	15179	10251	19160	19161	27908	24498	21092	9668	6784	4166
T	5318880	5393652	4993660	5827485	4130822	3315166	2705605	6650553	5184760	4745874	4761637	3236650	2614495

DIV.4WX HERRING CATCH-AT-AGE

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	210796	43630	47948	751706	70536	106916	144167	649254	29656	118301	235590	19922	55634
3	26450	270068	68430	79933	384467	58166	173662	71984	562616	45600	158941	161637	19468
4	232147	58591	238394	65107	118960	285361	106170	148516	109530	616206	92356	130597	192823
5	49752	308775	109814	274518	160723	201097	113561	77207	34422	53199	384646	72334	106061
6	10592	45479	159203	72827	110852	120223	75593	75384	25562	15254	50599	219788	55066
7	1693	13970	57948	90617	62506	111911	93620	49065	19361	8120	9357	18960	150588
8	561	7722	4497	31977	22595	41257	50022	48700	17604	5313	3238	4967	12466
9	54	1690	409	15441	6345	21271	36618	26055	19836	10964	3481	3556	2873
10	37	215	296	5668	2693	7039	7536	13792	9661	5787	2842	1835	1253
11	1	1	148	1175	722	2674	5695	11679	11120	7359	4599	3071	3448
T	532083	750141	687087	1388969	940399	955915	806644	1171636	839368	886103	945649	636667	599680

DIV. 4WX HERRING FISHING MORTALITY

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	.095	.032	.043	.434	.134	.162	.204	.149	.042	.109	.168	.120	.120
3	.031	.169	.065	.094	.414	.156	.430	.149	.187	.084	.210	.166	.164
4	.220	.089	.222	.081	.197	.626	.471	.822	.353	.322	.243	.268	.304
5	.174	.509	.239	.429	.293	.598	.549	.763	.448	.290	.342	.306	.360
6	.136	.239	.541	.246	.307	.373	.471	.901	.622	.365	.494	.334	.400
7	.047	.268	.544	.691	.346	.586	.563	.648	.613	.408	.401	.346	.400
8	.150	.313	.129	.669	.362	.406	.571	.654	.510	.334	.281	.386	.400
9	.060	.902	.024	.860	.262	.695	.783	.674	.616	.706	.381	.572	.400
10	.133	.351	.372	.525	.340	.514	.562	.773	.564	.358	.389	.352	.400
WF	.119	.179	.176	.322	.295	.403	.408	.234	.201	.235	.250	.247	.294

Table 5. Projections of catch and population biomass to 1980 for 4WX herring at $F_{0.1}$.

A. Recruitment set at conventional level 750 x 10^6 fish at age 2.

YEAR	POP NUMBERS	POP BIOMASS	CATCH NUMBERS	CATCH BIOMASS	MATURE F
1977	2822750	455036	596232	119270.88	.4000
1978	2523085	372109	501101	95200.39	.4011
1979	2362484	329614	355215	65289.97	.3080
1980	2357055	315528	347687	60829.02	.3080
1981	2312324	295546	336294	55904.78	.3080
1982	2328470	299072	340042	56724.95	.3080
1983	2334527	299721	341504	56881.63	.3080
1984	2332010	298112	340896	56493.07	.3080
1985	2349542	304150	345130	57951.19	.3080
1986	2350581	304492	345381	58033.93	.3080

B. Recruitment set at an average level 1.237 x 10^9 fish at age 2.

YEAR	POP NUMBERS	POP BIOMASS	CATCH NUMBERS	CATCH BIOMASS	MATURE F
1977	2822750	455036	596232	119270.88	.4000
1978	2523085	372109	501101	95200.39	.4011
1979	2362484	329614	355215	65289.97	.3080
1980	2843779	329952	386682	61984.66	.3080
1981	3162373	345460	414437	60884.42	.3080
1982	3440695	392454	467969	69958.72	.3080
1983	3616606	428281	506874	77869.90	.3080
1984	3719486	454229	531719	84136.26	.3080
1985	3800435	478066	551267	89892.57	.3080
1986	3839632	489865	560733	92741.91	.3080

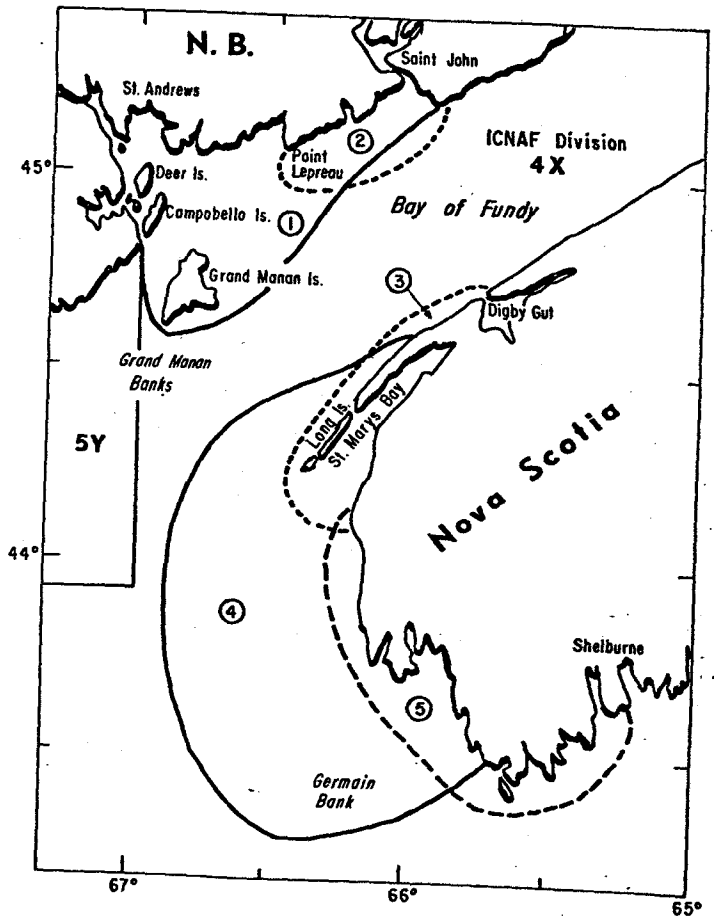


Fig. 1. Canadian herring fisheries in the Bay of Fundy area (modified from Miller and Iles, 1975). Area designations are as follows:

Fishery	Area-Gear	Season
1	NB - Weir	Summer
2	NB - PS	Fall-Winter
3	NS - Weir	Spring-Summer
4	NS - PS	Summer-Fall
5	NS - Gill Net	Summer-Fall

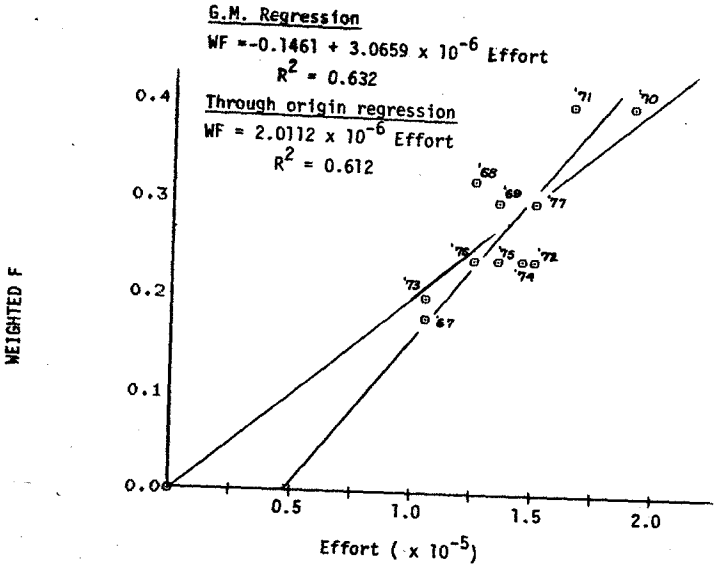


Fig. 2. Relationship between weighted F and effort in standardized units.

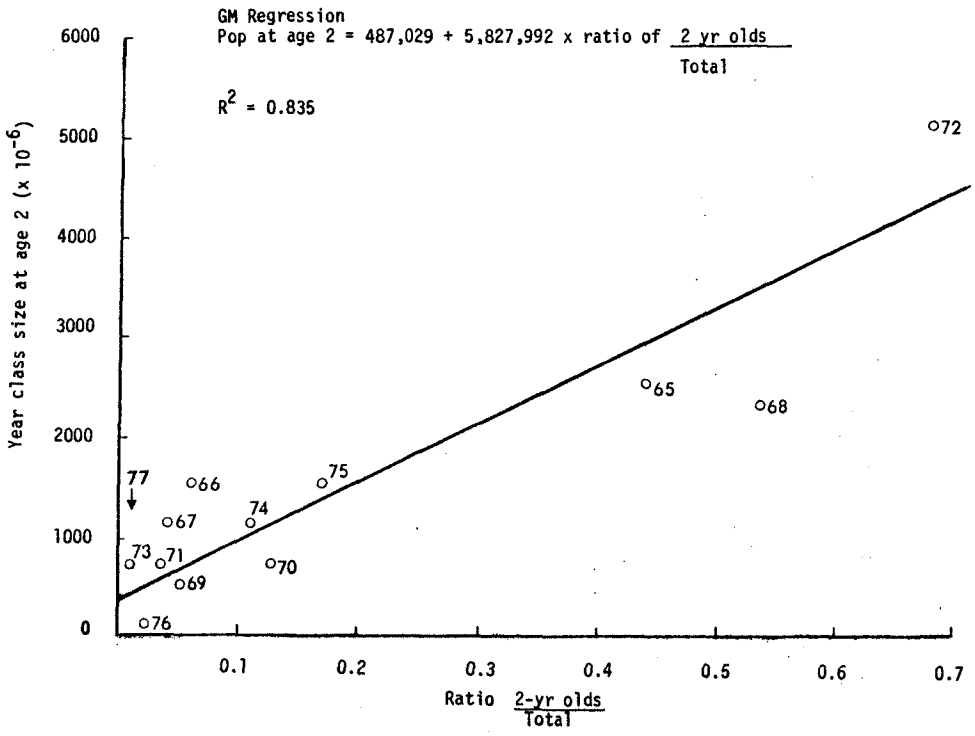
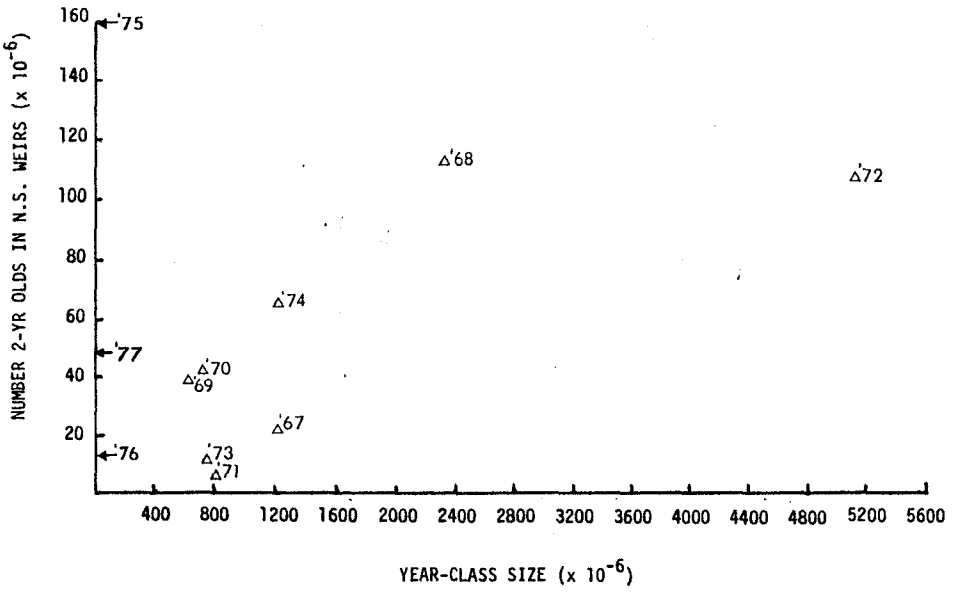


Fig. 3. Ratio of the 2-yr olds to total numbers in southwest Nova Scotia purse seine fishery as an indication of year class size at age 2. Fishing year indicated.

Fig. 4. Relationship between year class size at age 2 and catch of 2-yr olds in Nova Scotia weirs. The fishing season, not year class, is indicated in the figure.



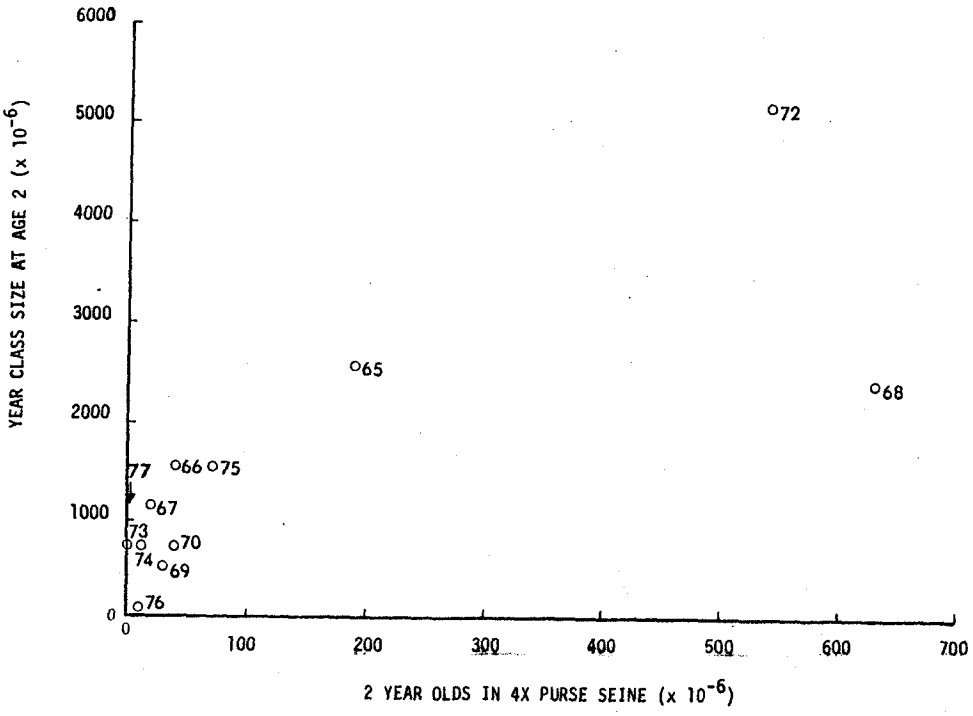


Fig. 5. Number of 2-yr olds taken in southwest Nova Scotia purse seine fishery as an indication of the year class size at age 2. Fishing year indicated.

Fig. 6. Yield-per-recruit from Div. 4WX herring using 1977 weight at age.

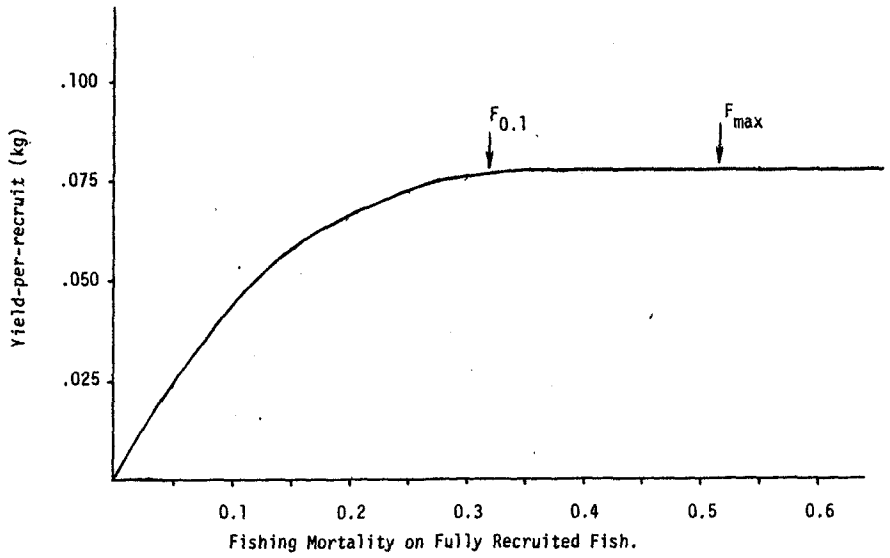
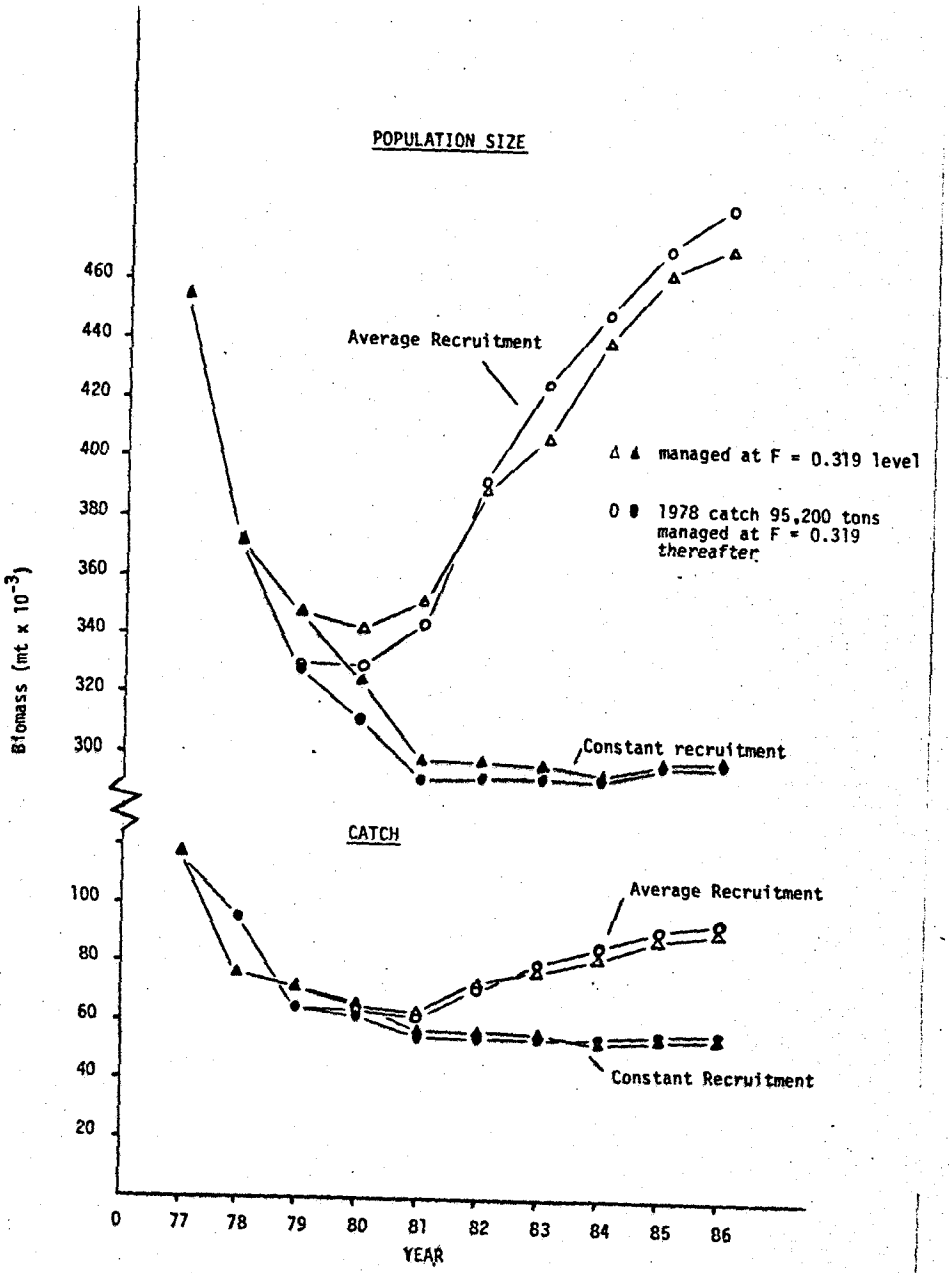


Fig. 7. Catch and biomass projections under varying *management options* and recruitment levels.



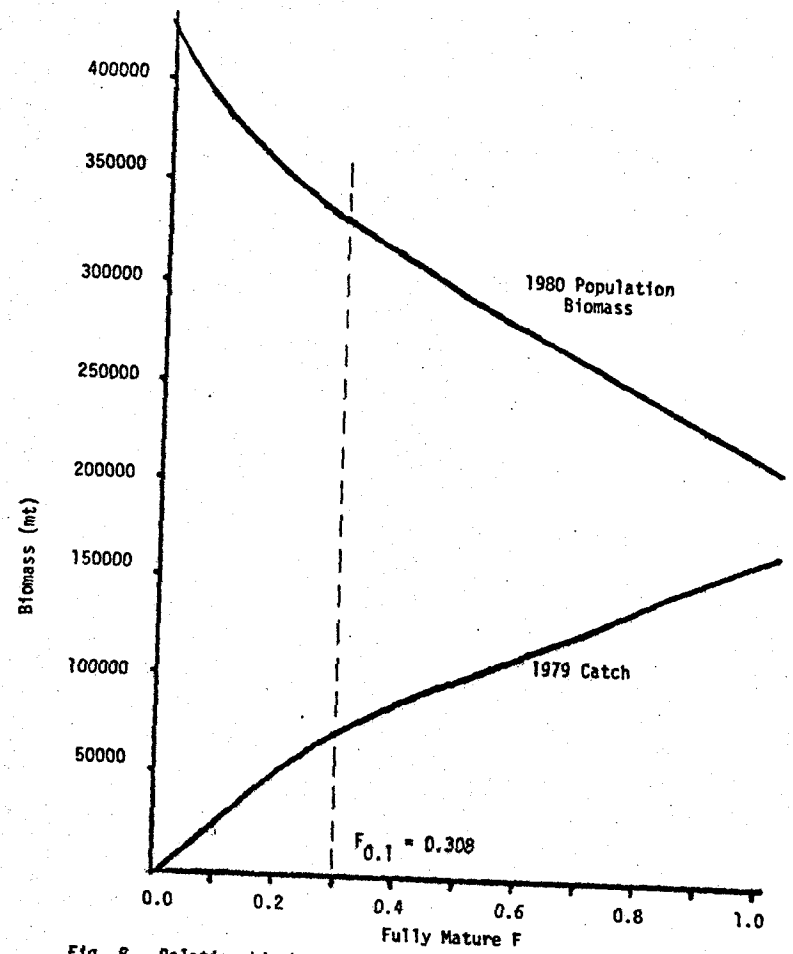


Fig. 8. Relationship between 1979 catch and 1980 population biomass for 4WX herring.