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Southern Gulf of St. Lawrence Herring: Stock Status Report 1985

by

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ABSTRACT

Reported herring landings in 1984 in the southern Gulf of St. Lawrence (NAFO division 4T) were 25,320 tonnes, similar to those of 1983. The 1985 landings are approximately 30,000 tonnes. Partial recruitment for both the spring and fall seasonal fisheries were derived from experimental selectivity data while the F's on the oldest age groups were derived by assuming that the F on the plus age group would be approximately equal to the F's on the previous age group.

The spring spawning component appears to have a terminal F of 0.20 and the fall spawning component had an F of 0.25. Both components of this stock complex have strong year-classes upon which the landings are dependent.

The projected landings at an Fo.1 of 0.3 for 1987 are between 8,473 and 9,103 and between 14,199 and 16,022 tonnes for the spring and fall spawning components respectively.

RESUME

Les débarquements déclarés de harengs provenant du sud du golfe du Saint-Laurent (division 4T de l'OPANO) ont été de 25 320 t en 1984, niveau analogue à celui de 1983. En 1985, les débarquements se sont élevés à environ 30 000 t. On a déterminé le recrutement partiel correspondant aux pêches de printemps et d'automne à partir de données expérimentales de sélectivité. Dans le cas des groupes d'âges les plus élevés, on a obtenu F en présumant que sa valeur pour un groupe d'âge X+ donné serait à peu près égale à sa valeur pour le groupe d'âge antérieur.

Le F terminal semble être de 0,20 pour la reproduction de printemps et de 0,25 pour la reproduction d'automne. Dans les deux cas, le stock se caractérise par des classes d'âge abondantes dont dépendent les débarquements.

On prévoit qu'en 1987 les débarquements, pour un $F_{0,1}$ de 0,3, se situeront entre 8 473 t et 9 103 t pour les reproducteurs de printemps et entre 14 199 t et 16 022 t pour les reproducteurs d'automne.

INTRODUCTION

The southern Gulf (NAFO division 4T) herring (Clupea harengus harengus) complex has had a variable fishery history. A epizootic in the mid 1950's (Tibbo and Graham, 1963) is believed to have drastically reduced the stock biomass, however, soon afterwards two very large year-classes (autumn of 1958 and spring of 1959) led to the highest landings on record - 300,000 tonnes in 1970 (Winters et al. MS 1977). The landings declined thereafter to a recent historic low of 21,000 tonnes in 1981 (Tables 1A and B). This precipitous decline (Fig 1) is felt to have been due to high fishing mortalities and successive poor recruitment to both the spring and fall spawning components of the stock. *

The total annual nominal landings are presented by fishing season (Table 2) and spawning (management) group (Table 3).

The exploitation pattern on this stock complex has varied considerably over the past two decades. The advent of the mobile purse seine fleet to the Gulf in 1966 was the first big change from the traditional inshore set and drift gillnets and fixed traps. After the seiners became established they further changed from mainly a winter fishery along southwest Newfoundland and a summer fishery in the southern Gulf before 1972 to a predominantly spring purse seine fishery along the 'edge' of the Laurentian Channel and a fall fishery in the southern Gulf. The last year for the spring and summer seiner fishery was 1981 (Table 2). Currently this stock complex has a spring and fall southern Gulf gillnet fishery as well as a small fall seiner fishery.

There are at present two major passive fisheries; the spring gillnet fishery (Escuminac, western Prince Edward Island (P.E.I.) and southeastern New Brunswick) and the fall gillnet fishery (Caraquet and Gaspe, eastern P.E.I. and the Gulf coast of Nova Scotia). These fisheries exploit the spring and fall spawning components on their spawning grounds. The fall seiner fishery is not limited to spawning grounds and exploits both spawning groups. Because of its mobile nature, the seasonal distribution of landings has (in the past) tended to follow the migratory patterns of the herring. Today, with quota control the fishery occurs mostly in the fall in the Bay of Chaleur and Gaspe areas.

* Spring and fall are used with two different meanings with regards to this fishery. There are the spring and fall fishery (management) components where the seasons of fishing are referenced; there are also the spring and fall population components where the season of spawning is referenced. A spring population component can be harvested in a fall management component fishery.

Management was carried out with the aid of 'inshore - offshore' quotas from 1972 until 1982, then with 'spring - fall' season quotas and finally, since 1985 with regional allocations. The provisional landings for 1984 were 25,320 tonnes and for 1985, approximately 30,000 tonnes - including some 1,500 tonnes of herring confiscated by D.F.O. officials during the fall gillnet fishery of 1985.

A precautionary Total Allowable Catch (TAC) of 150,000 tonnes was first set in 1972 (Lett, et al, MS 1978). From 1975 to 1980 the TAC was approximately 55,000 tonnes (Table 1B). It dropped in 1981 to 16,000 tonnes and fluctuated between 15,000 and 20,000 tonnes until 1984. Landings have consistently exceeded these TAC's - and it must be noted, the reported or nominal landings do not include much of the herring used for bait, the unsaleable fish that are dumped at sea and those instances when under-reporting is known to have occurred.

CATCH AND WEIGHT-AT-AGE MATRICES

Separate catch-at-age matrices (Tables 4a and 5a) were available for the spring and fall spawning components of this complex, the present ones have been modified from Ahrens (MS 1985). The catch at age have been adjusted to ensure the total annual landings of each gear for both spawning groups (Table 3) equalled the total annual landings of each gear for both seasons (Table 2). The annual change in catch biomass and thus numbers ranged from -6% to +8% of the value used in Ahrens (MS 1985). Two sets of analyses were carried out to track the difference between these two catch matrices.

Lett et al. (MS 1978) used a catch matrix with the maximum age extending from age 10+ in 1967 to age 19+ in 1976. Most VPA runs since that time have utilized a truncated matrix to 11+ (Winters and Moores, MS 1980, Cleary, MS 1981 and MS 1982). Cleary (MS 1983) was the first to use an 'extended' matrix (to 21+) and it was used again by Ahrens and Nielsen (MS 1984). The catch at age of older fish was estimated by assuming that catches of successive cohorts would retain the same relative values as they progressed from age 10 to age 20 (diagonally down the matrix). As otolith determined ages are only reliable to aproximately 11 years it was felt this procedure may introduce invalid assumptions about age specific survival and the fishing mortality (F) in the older age classes. To avoid this extended matrix problem, Ahrens (MS 1985) showed there was little difference between the results obtained in using the 'extended' or the 'truncated' (to age 11+) matrix. McQuinn and White(unpub .) have discussed how best to estimate the F for the oldest age groups from such 'truncated' matrices. Their technique has been utilized throughout this document - their slightly altered APL program is listed in Appendix I.

Separate weight-at-age matrices (Tables 4b and 5b) were available for the spring and fall spawning components of this complex, the present ones have been taken from Ahrens (MS 1985). The observed weights at age for ages 2 to 11+ were input for each year between 1971 and 1976, and an average weight-at-age vector from the years 1981 to 1984 were used for the period 1977 to 1984. These average weights at age were used in the last assessments in an attempt to reduce the difference between the cross product of the weight-at-age matrix and the catch-at-age matrix with the reported landings.

FISHING EFFORT AND CPUE

Abundance indices are utilized to tune or calibrate Virtual Population Analysis (VPA) estimates of population biomass in order to select the most suitable terminal F for the final year of fishing. It is preferred that these indices are fishery independent, however, in many instances the only series available are commercial Catch-Per-Unit-Effort (CPUEs) indices. Such commercial series have been developed for the spring and fall management components of the gillnet fishery (Tables 6a and 7) and the seiner fishery (Table 8).

The average gillnet effort per fisherman (number of nets set per night) was estimated from questionnaires: O'Boyle and Cleary (1981) from 1973 to 1979; Cleary (MS 1983) from 1980 to 1982; Ahrens and Nielsen (MS 1983) for 1983; and Nielsen (MS 1986) for 1984 and 1985.

The most recent survey of herring gillnet fishermen was carried out after extensive interaction with fishermen and their representatives. Because of these consultations the general makeup and types of questions asked varied from the earlier surveys. In order to account for some of this variation as well as differences in the analysis, the data from the earlier series for the spring were re-calculated. The fall data were not re-calculated as only data from the Caraquet fishery were used. The major basis of this re-calculation was the weighting factors based on fishing areas - these areas are now weighted by landings rather than the number of responses; the area responses and weighting factors are listed in Table 6b.

The average number of nets used per trip (Table 6a) shows an increasing trend until 1984. This may, however, be partly the result of the type of questions asked (as suggested by the fishermen), the weighting factors used at different times (years) of the analysis, the lack of consistency of the questionnaires, and the recent understanding gained by fishermen's organizations of how questionnaire responses affect the estimated population abundance. Because of these problems the validity of the questionnaire technique **must** be critically assessed prior to the 1986 fishing season.

The average landing per successful trip, i.e. per purchase slip, (Table 6a) shows differing trends for the two seasonal fisheries. These data are biased because unsuccessful trips are not reported, by splitting a large catch among the crew so each obtains a purchase slip, by grouping several landings together by week, etc. This series is weighted by effort (number of purchase slips) resulting in a straight average of all available purchase slips.

The CPUE index (landings per net-successful trip) based on these data (Table 7) shows increases of about 25% for the spring fishery and a three fold increase for the fall fishery from 1983 to 1985. These increases depend very much upon the interpretation of the questionnaire as the only other data input, the landings per purchase slip (trip), show moderate declines for the spring fishery and less than a 1.5 fold increase for the fall fishery. It is possible that the responses to the 1985 questionnaire may have been influenced by the 'publicity' given the interview and the realization, either conscious or unconscious, that the fewer nets reported used, the greater the apparent stock recovery and thus the larger the resultant TAC.

Catch per unit effort from seiner log books from the 1969 to 1984 fall (Sept -Nov) fishery (Table 8, Fig 2) was taken from Ahrens (MS 1985). The 1985 point has been calculated from provisional Gulf observer data - based on 40 nights (= sets) of observed operation. This CPUE series shows a rather steady decline from 1969 to the low of 1980 with a continual increase since.

RESEARCH DATA

Spring spawning bed surveys: Spawning bed surveys were conducted in 1981, 1983 (Messieh et al., MS 1983) and 1984 (Messieh et al., MS 1985) with estimated spawning biomass levels of 150, 500 and 2236 tonnes respectively. The 1985 survey was terminated after only partial completion due to disturbances caused by the fishermen of the area.

Aerial surveys: Aerial surveys were conducted in 1980, 1981, (Murdoch, unpublished) and 1983 (Messieh, pers comm). These surveys show high interseasonal variability with the number of nets increasing toward the end of the season. No clear statement can be made due to the many unknowns with this type of survey (eg. number of sunken nets, number of times a net is emptied per day, nets that are fished during the night only, etc.)

Research vessel surveys: Bottom trawl surveys in the southern Gulf of St. Lawrence have been conducted on the E.E.Prince since 1970. The data series from 1970 to 1979 has been summarized by Koeller and LeGresley (1981) (Table 9). The schooling and migratory behaviour of herring limit the usefulness of any abundance index conducted by a bottom trawl. Data from 1980 to 1984 have not yet been analysed in detail but preliminary review

shows a continuing highly variable nature. The general trend from 1970 to 1979 is downwards, however, the variable nature of this series would make it impossible to use for VPA calibration.

Gillnet selectivity: Experimental gillnet fishing was conducted in 1984 (Ahrens, MS 1985) and from these data selectivity was calculated. Using these results an estimate of partial recruitment (PR) was calculated.

PARTIAL RECRUITMENT

PR was re-calculated from the previous assessment as new data were available from the questionnaire on the size composition of the gillnets used by the fishermen. PR was calculated separately for both the spring and fall management components and applied to the respective spawning components. Selectivity ogives for 12 different nets were used in the calculation of the PR. Selection ogives for four of these mesh sizes (2 1/4, 2 1/2, 2 5/8 and 2 3/4 in.) were derived from experimental fishing in 1984 and used in the previous assessment (Ahrens, MS 1985). The mean, variance, coefficients of skewness and kurtosis were determined for each of these curves. Selectivity ogives for other mesh sizes were interpolated from these experimental data. This was done by estimating the mean selection length using the following relationship obtained in the 1984 gillnet trials:

$$\text{Mean selection length} = 4.78 \times \text{mesh size}.$$

This selection factor is similar to the value of 4.79 obtained by Olsen (1959). The variance, coefficients of skewness and kurtosis were estimated by taking the average of these parameters of the four known curves. Using these parameters (Table 10a) and the Gram Charlier Series (Kendall & Stuart, 1969), the selectivity-at-length ogives were derived (Fig. 3) for each mesh size. Selectivity at age was obtained by multiplying the selectivity at length by the age-at-length key.

The proportion of each gillnet mesh size (Tables 10b and 10c) used in 8 different areas of NAFO Division 4T (Caraquet, Gaspe, Escuminac, southeast New Brunswick, Gulf Nova Scotia, eastern P.E.I., western P.E.I., and Magdalen Islands) was calculated for the spring and fall fishing seasons from the results of personal interviews conducted in the fall of 1985 (Nielsen, MS 1986). Gillnet landings for the corresponding areas and seasons (Table 10d) were broken down according to the proportion of gillnet mesh sizes and used as weighting factors to obtain a combined selectivity at age for each gillnet fishery.

Because immature fish are unavailable to gillnet fisheries being conducted on spawning grounds, maturity at age must be included to arrive at the partial recruitment for gillnets in each fishery. The following maturities at age were assumed for the

spring and fall fisheries and multiplied by the selectivity at age:

Age	2	3	4	5	6	
Spring fishery	0	0.5	0.8	1.0	1.0 .	(Ahrens, unpub)
Fall fishery	0	0.1	0.6	1.0	1.0 .	(Winters, unpub).

The maturity used for the fall fishery is that based on the April to May seiner 'edge' fishery in the 1970's - assumed to be the same fish as those caught in the fall fishery.

Selectivity at age for the purse seine fishery was assumed to be 1.0 for ages 3 and over. This vector was combined with the gillnet partial recruitment in order to obtain a global partial recruitment for each spawning group (Tables 11 and 12) - weighting was by respective landings. The same proportion of spring and fall spawners was used in the seiner landings as that used by Ahrens (MS 1985) (60% and 40% respectively). The resulting combined partial recruitments are as follows:

Age	3	4	5	6	7	8	9	10	11 +
Spring	0.77	1.00	0.82	0.58	0.51	0.40	0.40	0.40	0.40
Fall	0.11	0.53	1.00	0.73	0.54	0.31	0.22	0.18	0.19

Partial recruitments for spring and fall spawning component fisheries used in previous assessments and those derived for this assessment are presented in Tables 11 and 12.

Partial recruitment vectors were also calculated by the more traditional historical averaging technique and Separable VPA (SVPA) (Table 11 and 12). Historical averaging was carried out by standardizing to the average PR of ages 4 to 6 of the years 1981 to 1983 and setting all values over 1 to 1, then smoothing by eye. The fall PR did not converge with this method due to several year-classes in one year appearing exceedingly large and not appearing proportionately as large in the following year. These age-year anomalies also lead to the failure of SVPA for the fall fishery.

NATURAL MORTALITY

Due to the lack of any information to the contrary natural mortality (M) is assumed to be 0.2.

FISHING MORTALITY

Oldest age group: In the latest assessment (Ahrens, MS 1985) the F's on the oldest age group were "chosen to provide an appropriate balance between population abundance and catch at age n in year m and population abundance at age n+1 in year m+1". For this assessment we have utilized the technique described by

McQuinn and White (unpub .) assuming that the F on the oldest age (in this case the 11+ group) is the same as the F on the 2nd oldest, thus the catch matrix was then handled as though it ended at age 10 and subsequent calculations carried out on the 11+ group which were then added to the results (see Appendix I for an APL program listing).

One difficulty with this approach is the lack of convergence in the earliest years. This is due to the large percentage of the biomass which occurs in the 'plus' age group - such as occurred in the 1971 spring matrix where 50% of the catch biomass is in the 11+ and even as late as 1976 when 30% of the biomass is found in the 11+ group.

Last year: The annual gillnet catch (Table 3) of spring and fall spawners separately was divided by the seasonal gillnet catch rates (Table 7) to estimate the annual gillnet effort index for each spawning group (Table 13). The fully recruited F for the last year was selected by utilizing the appropriate spawning group partial recruitment derived above and a series of selected terminal F's. Regressions were run between each spawning group's catch numbers at age per unit effort and the corresponding estimated VPA population numbers at age (Tables 14 and 15). The selection criteria were based upon maximizing the coefficient of correlation (R2) and minimizing both the residuals of the last two years (1983 and 1984) and the intercept. This was repeated individually for ages 4, 5 and 6 for the years 1974 to 1984. The relationships were not strong and supplementary evidence was obtained from examination of other relationships:

1. Paloheimo total mortality (Z) (CPUE at age of a year-class in two adjacent years at ages 4/5 for the spring spawning component and 5/6 for the fall spawners) Tables 16a and 16b;

2. VPA Z's (VPA population numbers of a plus age group in one year by population numbers of the next plus age group in the following year - 4+/5+ for the spring spawning component and 5+/6+ for the fall spawners) Tables 16a and 16b;

3. a regression of VPA population biomass (all age groups above the age of full recruitment - 4+ and 5+ respectively for the spring and fall spawning groups) and the appropriate CPUE index (Table 7) Tables 14b and 15b; and

4. a time series of catch rates and age specific VPA population biomass estimates (all standardized to their respective means) (Figure 4).

ASSESSMENT RESULTS

Spring spawning component: From the tuning conducted on this component (Table 14) and supplemental information, the F in the terminal year (terminal F) was estimated to be 0.20. This value is a compromise between the various indicators. The CPUE at age by VPA numbers at age calibration (Table 14a) indicates a terminal F in the range of 0.25, while both the Z calculations (Table 16a) and the 4+ VPA population biomass versus the CPUE index (Table 14b) indicate an F of 0.15.

The output from the VPA runs at an F of 0.20 are listed in Appendix II. The 1979 year-class (age 5 in 1984) continued to be dominant for the third consecutive year, its abundance at age 2 in 1981 is estimated to be 251 million fish. The 1980 year-class at 111 million fish at age 2 appears to be above the geometric mean of approximately 100 million. The biomass appears to be about the same as in 1982 and up slightly from 1983. The exploitable biomass (Table 17) was calculated by multiplying the mean population biomass from the VPA by the historical PR (Table 18). This PR was calculated by standardizing a years F's at age (from the VPA) by the average of ages 4 to 6 and setting all values over 1 to 1. This shows a similar pattern for the 3 most recent years, it does however show a much more significant decline in 1981 than was apparent from the VPA biomass.

Fall spawning component: From the tuning conducted on this component (Table 15a and b) and supplemental information, the terminal F was estimated to be 0.25. The CPUE at age by VPA numbers at age calibration did not yield any useful interpretive data, the correlation coefficients were extremely low and had little discriminatory power. The 4+ VPA population biomass and the CPUE indicated a terminal F of approximately 0.25 and 5+ VPA population biomass and CPUE indicated an F in the range of 0.30. The Paloheimo Z estimates in this case did not yield useful results (Table 16b), the negative value for the 5/6 Paloheimo Z's for 1983/1984 indicates the effort may have been under-estimated in 1984, ie.the CPUE may have been overestimated from the questionnaire.

The output from the VPA runs at an F of 0.25 are listed in APPENDIX III. The 1980 year-class (age 4 in 1984) predominated in 1984 and its abundance at age 2 in 1982 is estimated to be 336 million fish. This is the strongest year-class in recent history and is projected to be a strong contributor to the landings through 1987. The geometric mean recruitment from 1973 to 1982 is approximately 140 million fish. The biomass has continued to drop over the last 3 years and now stands at a level slightly above that between 1974 and 1978. The exploitable biomass (Table 19) was calculated in the same manner as for the spring component above. The PR (Table 20) was calculated by standardizing a years F's-at-age (from the VPA) by the average of ages 5 to 7 and setting all values over 1 to 1.This shows the biomass to be

increasing significantly since the low in 1980. This is due to the 1980, 1981, and 1982 year-classes recruiting to the exploited population.

CATCH PROJECTIONS

For the purposes of catch projections for the two fishery components, the recruitment at age two in 1984 and subsequent years was set to the geometric mean of the period 1973 to 1982 inclusive. Partial recruitment in the period 1985 to 1987 was assumed to be as estimated for the 1984 fishery. In this instance the 1985 landings are known - provisionally at least - even though the 1985 catch at age is not known. The 1985 fall seiner landings (6600 tonnes) were broken down into the landings for the two spawning components in the same proportion as in 1984 (60:40 spring:fall). The fishing mortality estimated for the fall component in 1985 is very close to the 0.3 value taken by CAFSAC to be the optimum fishing mortality (Fo.1) level for herring. The spring component has an estimated F in 1985 of 0.37, somewhat higher than the target Fo.1 objective.

The projected Fo.1 level of fishing for the spring spawners is down considerably from the 10,300 tonnes in 1985. The 1986 to 1988 projected catches suggest a slightly increasing catch from 8,473 to 9109 tonnes respectively. Detailed projection output is listed in Appendix IV.

summary of projections - SPRING SPAWNERS Run date:19/ 1/86

year	: 1985	1986	1987	1988
population numbers	: 312127.17	313762.64	321452.71	326330.94
population biomass	: 50750.13	51482.20	52951.37	54597.80
catch	: **10300.01**	**8472.56**	**8814.79**	**9109.06**
f or quota	: 10300.00	0.30	0.30	0.30

age groups considered>2+

Using the catch matrix not corrected for cross product landings the following is a summary of the resulting projections for the spring spawners. In this case the recruitment is up slightly to 103 million fish at age 2 and the projected catches are about 7% greater than with the corrected catch matrix in 1986.

summary of projections - SPRING SPAWNERS Run date:22/ 1/86

year	: 1985	1986	1987	1988
population numbers	: 331747.93	332344.76	337311.43	340485.98
population biomass	: 55045.12	55136.79	56100.71	57444.21
catch	: **10300.01**	**9103.54**	**9306.80**	**9536.91**
f or quota	: 10300.00	0.30	0.30	0.30

age groups considered>2+

For the fall spawners it suggests a significant drop from the 1985 catch of 19,800 to 14,199 and 13,413 tonnes in 1986 and 1987 respectively. Detailed projection output is listed in Appendix V.

summary of projections - FALL SPAWNERS Run date:19/ 1/86

year	:	1985	1986	1987	1988
population numbers	:	608701.42	576248.55	564429.14	553810.10
population biomass	:	120771.06	115865.33	112869.72	109923.22
catch	:	19800.01	14199.40	13413.25	12792.30
f or quota	:	19800.00	0.30	0.30	0.30

age groups considered>2+

Using the catch matrix not corrected for cross product landings, the following is a summary of the resulting projections for the fall spawners. The geometric mean recruitment is up to 148 million fish and the projected catches are up by 13% in 1986 over the corrected catch matrix.

summary of projections - FALL SPAWNERS Run date:22/ 1/86

year	:	1985	1986	1987	1988
population numbers	:	667534.47	631279.20	611714.46	595433.36
population biomass	:	135095.36	128555.65	123821.17	119369.21
catch	:	19800.01	16022.14	14730.83	13790.97
f or quota	:	19800.00	0.30	0.30	0.30

age groups considered>2+

These projected catches rely upon a few recently recruited large year-classes and particularly upon a single young year-class for each spawning component. The population biomass of the spring component remains low compared to that 15 years ago - it is not expected to rise substantially in the next few years. The current apparent peak in the biomass of the autumn component is not expected to continue unless significant above average recruitment occurs.

REFERENCES

Ahrens,M. MS 1985. Annual assessment of herring in NAFO division 4T. CAFSAC Res. Doc. 85/45 pp38.

Ahrens,M. and G.Nielsen. MS 1984. An assessment of the 4T herring stock. CAFSAC Res.Doc. 84/64 pp35.

Cleary,L. MS 1981. An assessment of the Gulf of St. Lawrence herring stock complex. CAFSAC Res.Doc. 81/23 pp30.

Cleary,L. MS 1982. Assessment of the 4T herring stock. CAFSAC Res.Doc. 82/47 pp43.

Cleary,L. MS 1983. An assessment of the southern Gulf of St. Lawrence herring stock complex. CAFSAC Res.Doc. 83/69 pp40.

Kendall,M.G. and A.Stuart. 1969. The advanced theory of statistics. Vol 1. Distribution theory. Charles Griffin and Co., London, U.K.

Koeller,P.A. and M.LeGresley. 1981. Abundance and distribution of finfish and squid from E.E.Prince trawl surveys in the southern Gulf of St. Lawrence, 1970 - 79. Can. Tech. Rep. Fish. Aquat. Sci. No. 1028. 56pp.

Lett,P.F., R.N.O'Boyle and S.N.Messieh. MS 1978. Gulf of St. Lawrence herring stock complex - Spring 1978 status report. CAFSAC Res.Doc. 78/4 pp23.

Messieh,S.N. MS 1981. Fishing effort and catch-per-unit-effort of the inshore herring fisheries in the southern Gulf of St. Lawrence. CAFSAC Res.Doc. 81/12 pp17.

Messieh,S.N.,R.Pottle,P.MacPherson and C.Bourque. MS 1985. Herring spawning bed survey in Miramichi Bay, N.B. in spring 1984. CAFSAC Res.Doc. 85/40 pp18.

Messieh,S.N.,R.Pottle,P.MacPherson and T.Hurlbut. MS 1983. Herring spawning bed survey in Miramichi Bay, N.B. in spring 1983. CAFSAC Res.Doc. 83/70 pp21.

Nielsen,G.A. MS 1985. The 1985 4T herring gillnet questionnaire. CAFSAC Res.Doc. 86/3. pp25.

O'Boyle,R.N. and L.Cleary. 1981. The herring (Clupea harengus harengus) gillnet fishery in the southern Gulf of St. Lawrence, 1970-1979. Can.Tech.Rep.Fish.Aquatic Sci. 1065. pp90.

Olsen,S. 1959. Mesh selection in herring gillnets. J.Fish.Res. Bd.Can. 23:423-454.

Tibbo,S.N. and T.R.Graham. 1963. Biological changes in herring stocks following an epizootic. J.Fish.Res.Bd.Can.20:435-439.

Winters,G.H., D.S.Miller and J.A.Moores. MS 1977. Analysis of stock size and yield of southern Gulf herring. CAFSAC Res.Doc. 77/2 pp30.

Winters,G.H. and J.A.Moores. MS 1980. An evaluation of the current status of southern Gulf herring. CAFSAC Res.Doc. 80/54 pp44.

Table 1A: Herring nominal landings (tonnes) in NAFO division 4T by month from 1971 to 1985 (after Ahrens, MS 1985).

Year	Ja-Ma	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
1971	42	10644	11895	4809	41521	23067	36282	5163	1053	370	134846
1972	-	400	6102	2583	11034	9092	14453	7777	2108	41	53590
1973	-	1876	12801	4221	2135	7737	9436	2079	69	3	40357
1974	-	1302	14474	1190	2958	3143	7282	3081	1714	9	35153
1975	-	4028	20229	1428	289	2398	4646	8986	2256	305	44565
1976	-	8461	14406	961	193	1082	1807	5244	6973	326	39453
1977	-	7625	8338	8850	244	2125	1148	7166	8726	602	44824
1978	240	2046	13363	883	526	2487	10095	13672	6981	2848	53141
1979	-	14072	6158	1113	680	1766	6381	5071	9904	2598	47743
1980	95	10458	9220	1032	910	2224	1952	9011	5001	540	40443
1981	13	1736	4566	729	1588	5119	3986	2171	1246	-	21154
1982	-	199	5667	876	442	5592	8047	3122	36	-	23981
1983	-	263	7282	1000	851	10291	2735	2160	1291	-	25873
1984*	-	87	5603	428	506	5217	7881	5389	210	-	25320
1985*	-	75	5075	750	110	6800	15600	1550	110	-	30070

*provisional

The 1985 nominal landings reported here include some 1500 tonnes of herring confiscated by D.F.O. during the fall fishery.

Table 1B. Nominal landings of the southern Gulf herring complex including NAFO division 4T and sub-division 3Pn with associated TACs (after Lett et al. MS 1978 and Ahrens MS 1985).

YEAR	LANDINGS		TAC
	NAFO 4T	NAFO 3Pn	
1958	24705		
1959	22350		
1960	21711		
1961	18823	19	
1962	34442	38	
1963	39900	27	
1964	39333	47	
1965	44254	58	
1966	36905	127	
1967	62736	259	
1968	112130	35996	
1969	154415	95459	
1970	175497	94224	
1971	134846	69912	
1972	53590	18993	150000
1973	40357	395	35000
1974	35153	74	45000
1975	44565	24	45000
1976	39453	15	55000
1977	44824		60000
1978	53141		55000
1979	47743		55000
1980	40443		55000
1981	21154		16000
1982	23981		15000
1983	25873		20000
1984*	25320		19000
1985*	30070		32500

* provisional

Table 2: Nominal landings of herring (tonnes) by gear and by fishing season in NAFO Division 4T, 1971-1985

	GILLNETS (and other inshore)		SEINES (and other offshore)		
YEAR	SPRING	FALL	SPRING	FALL	TOTAL
1971	14074	10327	13316	97129	134846
1972	8137	9585	948	34910	53580
1973	11713	7920	7185	13539	40357
1974	8285	4199	8681	13988	35153
1975	7119	4741	18566	14139	44565
1976	6611	3419	17217	12206	39453
1977	4926	3285	19887	16726	44824
1978	8484	4853	8048	31756	53141
1979	7444	5780	13899	20620	47743
1980	6443	6784	13330	13886	40443
1981	6545	10926	20	4552	22043
1982	6742	14130	0	3109	23981
1983	8545	13858	0	3470	25873
1984*	6118	16273	0	3050	25441
1985*	5900	17600	0	6600	30100

*provisional The 1985 total does not equal the total in Tables 1A and 1B. This total includes some 2000 tonnes of fish confiscated by D.F.O.

Table 3: Nominal landings of herring (tonnes) by gear and by spawning group in NAFO Division 4T, 1974 to 1984.

	GILLNETS (and other inshore)		SEINES (and other offshore)		
YEAR	SPRING	FALL	SPRING	FALL	TOTAL**
1974	7903	4581	6561	16108	35153
1975	8319	3590	16544	16161	44614
1976	7094	2935	14833	14590	39452
1977	5555	2656	18029	18584	44824
1978	8891	4446	15205	24599	53141
1979	8480	4744	9680	24839	47743
1980	8979	4248	10678	16538	40443
1981	5818	11653	2640	1931	22043
1982	7595	14808	300	2809	25512
1983	8311	14079	1588	1882	25860
1984*	4322	15647	1815	1235	23019

* provisional

** Values in this table are based on the cross products of the catch matrices and the weight matrices. Consequently, totals may vary slightly from reported landed weights in the VPA.

Table 4a: Catch-at-age matrix for the southern Gulf herring (NAFO division 4T) spring spawning component.

CATCH NUMBERS AT AGE x 1000 Run date:12/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979
2 :	3200	100	1600	5260	1521	15931	3351	14434	21741
3 :	65700	2100	1700	8736	27837	8498	58673	14121	13689
4 :	6800	27500	2500	3285	18829	27893	6874	65301	5856
5 :	13600	5800	31700	1647	3260	6746	10264	4692	33954
6 :	9300	5000	6100	21560	16243	2237	3563	6956	2130
7 :	8800	3300	3900	3699	20158	465	604	1277	3072
8 :	14300	3900	6000	4128	2683	8805	498	1182	707
9 :	15000	4500	2300	6245	3395	1034	6513	191	203
10 :	5000	4900	2300	947	5457	1488	510	3584	718
11+:	67507	4006	4905	2529	6157	19853	13472	1992	3488

:	1980	1981	1982	1983	1984
2 :	21382	6141	924	424	207
3 :	42580	17775	33383	10821	3712
4 :	5689	8250	6201	31206	10572
5 :	3096	1304	1476	3934	11149
6 :	15768	868	337	1104	1109
7 :	3269	4444	217	70	173
8 :	2033	755	339	50	54
9 :	740	756	114	17	57
10 :	320	108	2	2	105
11+:	2910	1198	110	10	73

Table 4b: Weight-at-age matrix for the southern Gulf herring (NAFO division 4T) spring spawning component.

WEIGHT AT AGE grams Run date:12/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2 :	75	75	87	95	90	104	133	133	133	133	133	133	133	133
3 :	103	140	141	160	154	177	172	172	172	172	172	172	172	172
4 :	185	207	184	202	185	210	213	213	213	213	213	213	213	213
5 :	221	233	219	238	229	247	247	247	247	247	247	247	247	247
6 :	243	274	267	275	266	275	287	287	287	287	287	287	287	287
7 :	268	311	282	291	298	271	291	291	291	291	291	291	291	291
8 :	292	318	310	319	304	304	310	310	310	310	310	310	310	310
9 :	290	339	327	320	316	310	348	348	348	348	348	348	348	348
10 :	301	323	332	328	329	333	324	324	324	324	324	324	324	324
11+:	319	344	374	348	357	353	359	359	359	359	359	359	359	359

Table 5a: Catch-at-age matrix for the southern Gulf herring (NAFO division 4T) fall spawning component.

CATCH NUMBERS AT AGE x 1000 Run date:12/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979
2 :	4900	5700	1700	5403	96	93	205	1514	2906
3 :	33100	5200	3300	5715	2090	277	3037	19348	6217
4 :	92800	15600	4500	17524	4169	1758	7676	27378	35031
5 :	35300	51100	7900	6097	25621	5034	3604	14092	27629
6 :	59800	20800	19800	4235	6860	28944	3622	3973	11109
7 :	87600	28500	9000	10666	3262	4154	22200	3465	2323
8 :	114300	26200	11800	2827	4854	1849	2219	13853	3128
9 :	57800	23400	7400	5444	2159	3510	1412	1606	5242
10 :	30900	11500	9500	4295	3568	737	2761	890	702
11+:	221407	73506	14905	19110	20635	16451	16704	16259	10386

:	1980	1981	1982	1983	1984
2 :	1369	109	184	35	10
3 :	32429	10075	9273	4782	1275
4 :	9995	33204	21526	23879	24896
5 :	23278	5971	26147	10971	16332
6 :	8343	2606	5663	13643	10959
7 :	4130	978	2344	2409	5608
8 :	637	977	1004	1867	1150
9 :	848	216	641	623	327
10 :	320	108	132	114	91
11+:	2966	872	162	309	94

Table 5b: Weight-at-age matrix for the southern Gulf herring (NAFO division 4T) fall spawning component.

WEIGHT AT AGE grams Run date:12/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2 :	40	40	40	47	40	35	119	119	119	119	119	119	119	119
3 :	93	53	100	126	115	111	177	177	177	177	177	177	177	177
4 :	142	168	170	190	169	184	245	245	245	245	245	245	245	245
5 :	189	194	206	235	215	217	283	283	283	283	283	283	283	283
6 :	129	238	242	255	248	253	313	313	313	313	313	313	313	313
7 :	234	253	269	283	272	276	338	338	338	338	338	338	338	338
8 :	248	262	292	314	288	283	359	359	359	359	359	359	359	359
9 :	264	277	295	327	314	300	380	380	380	380	380	380	380	380
10 :	272	287	313	331	325	323	364	364	364	364	364	364	364	364
11+:	297	312	342	354	362	349	395	395	395	395	395	395	395	395

Table 6a: Average landing (tonnes) per successful trip and number of nets used per successful trip for herring gillnet fisheries in NAFO division 4T, 1973-1985 (modified after Messieh MS 1981, Cleary MS 1983 and Ahrens MS 1985).

YEAR	SPRING FISHERY (Jan - June)		FALL FISHERY (July - Dec.)	
	tonnes/trip	nets/trip	tonnes/trip	nets/trip
1973	2.09	21.00	2.66	7.1
1974	1.23	20.57	2.99	7.6
1975	1.29	30.10	3.63	7.2
1976	1.34	28.90	3.13	8.9
1977	1.89	27.87	3.56	9.3
1978	2.22	29.40	3.21	11.4
1979	1.49	34.40	1.78	11.9
1980	1.09	31.46	1.45	11.0
1981	0.92	35.95	2.15	11.0
1982	1.73	35.39	2.33	11.0
1983+	1.79	(30)	3.45	(11)
1984*	1.65	22.29	3.32	5.3
1985*	1.74	22.84	4.83	5.2

* provisional
\+ 1983 is interploated and not based on an actual survey

Table 6b: The weightings by landings of the historic effort series in Table 6a (above) as re-calculated for the spring.

YEAR	.....SPRING.....				SUMMARY	
	----Chaleur------		----Escuminac---		SPRING	FALL
	# nets	landings	# nets	landings		
1973*	5.25	2274	29.33	4314	21.0	7.10
1974*	5.25	1200	27.34	2743	20.6	7.55
1975*	6.00	304	32.81	2688	30.1	7.17
1976*	6.33	688	33.50	3381	29.9	8.86
1977*	8.40	316	31.69	1639	27.9	9.33
1978*	8.60	738	33.02	4225	29.4	11.38
1979*	9.50	660	38.74	3780	34.4	11.92
1980**	12	907	39	2342	31.5	11
1981**	13	599	41	2661	35.9	11
1982**	11	891	41	3827	35.3	11
1983					(30)	(11)
1984***	7.2	563	25.4	2616	22.2	5.3
1985***	7.5	632	25.1	4262	22.8	5.2

* landings and # nets from O'Boyle and Cleary (1981).

** landings taken from purchase slip and supplementary 'B' summaries and # nets taken from Cleary (MS 1983).

*** landings from Statistics Branch, Gulf Region and # nets from November 1985 questionnaire.

Table 7: CPUE index - landings (tonnes) per net-trip for gillnet herring fisheries in NAFO Division 4T, 1973 - 1985. These values are calculated by dividing column 1 (tonnes per trip) by column 2 (nets per trip) for each seasonal fishery component in Table 6.

YEAR	SPRING FISHERY (Jan - June)	FALL FISHERY (July - Dec)
1973	0.100	0.375
1974	0.060	0.393
1975	0.043	0.504
1976	0.046	0.352
1977	0.068	0.383
1978	0.076	0.282
1979	0.043	0.150
1980	0.035	0.132
1981	0.026	0.196
1982	0.049	0.212
1983+	(0.060)	(0.314)
1984*	0.074	0.626
1985*	0.076	0.929

* provisional
+ 1983 data is interpolated and not based on an actual survey.

Table 8: Landings (tonnes) per set (CPUE) in the fall purse seine herring fishery in NAFO Division 4T, 1969 - 1985.

YEAR	FALL FISHERY
1969	110.2
1970	90.9
1971	56.7
1972	45.1
1973	41.5
1974	37.9
1975	34.5
1976	40.6
1977	44.4
1978	44.3
1979	24.5
1980	18.7
1981	26.6
1982	N/A
1983	35.5
1984	42.4
1985*	77.2

* Gulf region observer program

Table 9: Population abundance indices for the southern Gulf (NAFO 4T) component of the 4T herring complex. These data are from the southern Gulf fall (September) groundfish cruise on the E.E.Prince.

YEAR	POPULATION NUMBERS	POPULATION BIOMASS
1970*	93 million	21,000 tonnes
1971	200	51,000
1972	79	15,000
1973	98	11,000
1974	10	2,000
1975	83	28,000
1976	31	8,000
1977	33	8,000
1978	159	34,000
1979	38	4,000

* cruise not complete

Table 10a: Parameters of the selectivity curves used in the calculation of partial recruitment of the gillnet fishery.

Net size	Mean	Variance	Skew	Kurtosis
1 5/8"	19.73	4.783	.1456	2.94
2 "	24.28	4.783	.1456	2.94
2 1/8"	25.80	4.783	.1456	2.94
2 1/4" *	27.888	6.857	.16024	2.909
2 5/16"	28.08	4.783	.1456	2.94
2 3/8"	28.84	4.783	.1456	2.94
2 1/2" *	30.044	3.219	.10945	2.963
2 5/8" *	31.476	3.722	.0976	2.897
2 3/4" *	33.669	5.334	.21530	2.991
2 7/8"	34.91	4.783	.1456	2.94
3 "	36.42	4.783	.1456	2.94
3 1/4"	39.46	4.783	.1456	2.94

* experimentally derived curves from Ahrens (MS 1985).

Table 10b: Percentage of each mesh size used in the 4T Spring season gillnet fishery.

AREA	NET SIZE inches									
	1.625	2.00	2.125	2.250	2.31	2.375	2.50	2.625	2.75	2.875	3.00	3.25
Magdalen Is.	4.2		25.4		29.9		33.7		6.7			
Quebec	7.8		5.8	48.9	6.0		9.5	11.0	6.3	1.0	0.6	2.9
Caraquet	3.3			14.7	40.6		26.5	13.7	1.2			
Escuminac			0.6	72.1	17.5		9.8					
South East N.B.				89.3	6.9		3.7					
Nova Scotia	2.6			5.1	21.7		48.0	22.6				
East P.E.I.				15.2	46.2		21.7	7.1	4.9	3.9	1.0	
West P.E.I.	0.3			55.2	4.2	23.4	10.1	1.1	4.0	1.0	0.5	

Table 10c: Percentage of each mesh size used in the 4T Fall season gillnet fishery.

AREA	NET SIZE inches									
	2.00	2.125	2.250	2.31	2.375	2.50	2.625	2.75	2.875	3.00 3.25
Quebec	10.4	6.0	0.5		5.1	18.8	18.5	27.3	5.1	8.1
Caraquet						1.0	79.7	16.6	2.5	0.3
Escuminac								100.0		
Nova Scotia					2.5	3.7	93.8			
East P.E.I.							98.6	1.4		
West P.E.I.			3.3	0.9	3.7	2.7	40.1	30.1	19.2	

Table 10d: Southern Gulf of St. Lawrence herring landings in tonnes by seasonal fishery for the 8 fishing areas used in the 1985 questionnaire (Nielsen, MS 1986).

AREA	SPRING 1984	FALL 1984
Magdalen Islands	10.0	nil
Quebec	518.0	1073.0
Caraquet, N.B.	623.4	7098.1
Escuminac, N.B.	2135.8	22.5
southeastern N.B.	290.7	431.0
Nova Scotia	184.1	2435.0
east P.E.I.	90.5	4267.8
west P.E.I.	281.7	652.5

Table 11: Partial recruitment for the spring spawning component used in the past and in the current assessment of the 4T herring complex.

	-----past assessments-----			----current assessment-----		
Age	Cleary 1983	Ahrens & Nielsen 1984	Ahrens 1985	Selectivity	Historical Averaging	SVPA
2		0.025			0.14	0.076
3	0.64	0.80	0.47	0.77	0.71	0.73
4	0.87	0.87	1.00	1.00	0.89	1.00
5	1.00	1.00	1.00	0.82	0.88	0.93
6	0.95	0.95	0.50	0.58	1.00	0.95
7	0.72	0.72	0.34	0.51	1.00	0.59
8	0.50	0.50	0.20	0.40	1.00	0.33
9	0.36	0.36	0.15	0.40	1.00	0.18
10	0.21	0.21	0.15	0.40	0.52	0.21
11+	0.16	0.16	0.15	0.38	0.52	

Table 12: Partial recruitment for the fall spawning component used in the past and in the current assessment of the 4T herring complex.

	-----past assessments-----			----current assessment-----		
Age	Cleary 1983	Ahrens & Nielsen 1984	Ahrens 1985	Selectivity	Historical Averaging	SVPA
2					0.007	0.23
3	0.23	0.23	0.03	0.11	0.21	0.86
4	0.72	0.72	0.50	0.53	0.64	1.00
5	0.96	0.96	1.00	1.00	1.00	0.90
6	1.00	1.00	0.85	0.73	1.00	0.58
7	0.90	0.90	0.63	0.54	1.00	0.54
8	0.79	0.79	0.53	0.31	1.00	0.34
9	0.66	0.66	0.50	0.22	1.00	0.25
10	0.55	0.60	0.50	0.18	1.00	0.20
11+	0.42	0.60	0.50	0.19	1.00	

Table 13: Effort index - annual gillnet effort indices for the southern Gulf herring complex. These values are comparable within columns but not between columns due to the different types of gillnet fishing in the two fisheries. These values are calculated by dividing Table 7 (tonnes/net-trip) into Table 3 (gillnet landings in tonnes).

YEAR	SPRING FISHERY (Jan - June)	FALL FISHERY (July - Dec)
1974	132	12.2
1975	193	7.1
1976	154	8.3
1977	75	6.4
1978	117	15.8
1979	197	30.4
1980	256	32.2
1981	224	59.5
1982	155	69.8
1983	138	44.8
1984*	58	25.0

* provisional

Table 14: Calibration results from the spring spawning component of the southern Gulf herring complex. A terminal F of 0.2 was selected as being most appropriate.

14a:
These runs use all data.
Not all runs are shown.
CPUE at age vs VPA # at age.

AGE 4

Trial F	R	res 83	res 84
.10	.53	45	138
.15	.72	16	86
.20	.84	2	60
.25	.90	-6	44
.30	.93	-12	33
.35	.94	-16	26

AGE 5

Trial F	R	res 83	res 84
.10	.69	58	13
.15	.80	29	6
.20	.85	14	3
.25	.86	5	-7
.30	.84	-.6	-.7
.35	.82	-5	-2

AGE 6

Trial F	R	res 83	res 84
.10	.77	15	3.5
.15	.80	9	3
.20	.80	6	3
.25	.81	4	3
.30	.81	3	3
.35	.81	2	3

14b:
These runs use all data.
Not all runs are shown.
VPA biomass at age vs CPUE.

AGE 4

Trial F	R	res 83	res 84
.10	.56	11933	10498
.15	.52	-7631	-2414
.20	.47	-17404	-8866
.25	.43	-23260	-12733
.30	.41	-27158	-15308
.35	.39	-29938	-17144

Table 15: Calibration results from the fall spawning component of the southern Gulf herring complex. A terminal F of 0.25 was selected as being most appropriate.

15a:
These runs use all data.
Not all runs are shown.
CPUE at age vs VPA # at age.

AGE 4

Trial F	R	res 83	res 84
.15	.004		
.20	.021		
.25	.048		
.30	.079		
.35	.111		
.40	.140		

AGE 5

Trial F	R	res 83	res 84
.15	.066		
.20	.177		
.25	.297		
.30	.406		
.35	.495		
.40	.566	8.2	34.9
.45	.621	4.8	31.0

AGE 6

Trial F	R	res 83	res 84
.15	.109		
.20	.232		
.25	.359		
.30	.471		
.35	.564		
.40	.637	24.9	36.7
.45	.694	21.0	29.7
.50	.739	18.0	27.3

15b:
These runs use all data.
Not all runs are shown.
VPA biomass at age vs CPUE.

AGE 4

Trial F	R	res 83	res 84
.15	.43	49305	51107
.20	.55	18583	28880
.25	.58	162	15558
.30	.55	-12108	6687
.35	.49	-20864	360
.40	.43	-27425	-4376

AGE 5

Trial F	R	res 83	res 84
.15			
.20	.60	-20130	18623
.25	.52	-29919	8287
.30	.45	-36438	1401
.35	.40	-41089	-3514
.40	.35	-44571	-7196
.45	.32		

Table 16a: Total mortality (Z) for the spring spawning component was calculated by two different techniques. The Paloheimo Z's are calculated from two adjacent years years with ln(CPUE at age 4) - ln(CPUE at age 5); the VPA Z's are calculated from two adjacent years by ln(VPA population numbers at age 4+) - (VPA population numbers at age 5+).

YEAR	Paloheimo Z's	VPA 4+/5+ Z's
74/75	0.723	0.28
75/76	0.588	0.65
76/77	0.689	0.73
77/78	0.880	0.71
78/79	0.858	0.80
79/80	0.875	0.86
80/81	0.866	1.15
81/82	1.363	0.99
82/83	0.481	0.45
83/84	0.354	0.52

Table 16b: Total mortality (Z) for the fall spawning component was calculated by two different techniques. The Paloheimo Z's are calculated from two adjacent years years with ln(CPUE at age 5) - ln(CPUE at age 6); the VPA Z's are calculated from two adjacent years by ln(VPA population numbers at age 5+) - (VPA population numbers at age 6+).

YEAR	Paloheimo Z's	VPA 5+/6+ Z's
74/75	0.36	0.39
75/76	0.53	0.44
76/77	0.43	0.53
77/78	0.73	0.62
78/79	1.35	0.80
79/80	1.15	1.09
80/81	0.88	0.84
81/82	0.34	0.34
82/83	0.17	0.41
83/84	-0.08	0.35

Table 17: The exploitable or fishable biomass for the spring spawning component of the 4T herring complex.

VPA exploitable biomass:tonnes - SPRING SPAWNERS Run Date:18/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979
2 :	997	37	542	2512	151	3131	965	3512	5111
3 :	27119	1454	934	7041	4767	2852	21924	3964	3058
4 :	5238	28206	1792	2929	3896	10133	3183	22484	2208
5 :	8513	5725	25402	1972	831	3151	5521	2121	10580
6 :	9409	6465	3894	19564	2646	1170	1700	3282	1082
7 :	4764	5080	4296	2209	6703	239	381	681	1473
8 :	5484	2893	7264	2801	915	5091	335	412	389
9 :	5014	2598	1538	4800	1159	349	3101	121	125
10 :	884	2543	915	383	658	445	111	953	200
11+:	16108	6599	7124	4413	2428	11207	4516	1298	2200
2+:	83529	61601	53699	48623	24154	37767	41739	38827	26425

:	1980	1981	1982	1983	1984
2 :	3052	1390	436	172	172
3 :	6212	5241	20414	5681	3990
4 :	1314	2220	4701	20340	11260
5 :	826	553	1169	2972	16792
6 :	3830	427	345	777	1989
7 :	728	809	224	62	315
8 :	556	153	216	48	104
9 :	153	60	33	18	125
10 :	65	32	1	0	54
11+:	1114	727	139	11	164
2+:	17850	11613	27678	30080	34964

Table 18: Historic partial recruitment for the spring spawning component calculated from the VPA fishing mortality - Appendix III. The F table was standardized to the mean of ages 4,5, and 6 with all values over 1 set to 1.

VPA partial recruitment - SPRING SPAWNERS Run Date:18/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2 :	0.240	0.019	0.090	0.202	0.036	0.104	0.186	0.697	0.451	0.322
3 :	1.000	0.241	0.321	0.850	0.341	0.482	0.635	1.000	1.000	1.000
4 :	0.765	0.778	0.294	1.000	0.735	1.000	0.733	1.000	1.000	0.980
5 :	1.000	1.000	1.000	0.328	0.410	1.000	0.953	0.747	1.000	0.733
6 :	0.761	1.000	1.000	1.000	1.000	0.891	1.000	1.000	0.583	1.000
7 :	1.000	0.451	0.996	1.000	0.578	0.312	0.479	0.829	1.000	1.000
8 :	1.000	1.000	0.927	1.000	0.915	0.861	0.580	1.000	0.872	1.000
9 :	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.283	0.648	1.000
10 :	1.000	1.000	0.656	0.411	0.224	1.000	1.000	0.730	0.824	0.738
11+:	1.000	1.000	0.656	0.411	0.224	1.000	1.000	0.730	0.824	0.738

:	1981	1982	1983	1984
2 :	0.047	0.033	0.040	0.013
3 :	0.754	0.721	0.432	0.963
4 :	1.000	0.961	0.908	1.000
5 :	0.932	1.000	0.842	1.000
6 :	0.703	0.928	1.000	0.725
7 :	1.000	0.602	0.240	0.638
8 :	1.000	1.000	0.164	0.500
9 :	1.000	1.000	0.119	0.500
10 :	1.000	0.305	0.030	0.500
11+:	1.000	0.305	0.030	0.475

Table 19: The exploitable or fishable biomass for the fall spawning component of the 4T herring complex.

VPA exploitable biomass:tonnes - FALL SPAWNERS Run Date:18/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979
2 :	293	371	138	769	11	8	61	348	383
3 :	4623	449	668	2179	685	80	1342	6622	1220
4 :	19809	4290	1551	10069	2011	847	4706	13026	9581
5 :	10032	16274	3313	4342	15739	2867	2558	7751	7946
6 :	11612	7506	9770	3277	4055	18281	2844	2131	3905
7 :	22722	11846	3517	6591	2148	2345	12096	2278	882
8 :	26547	8751	6222	1831	3564	1192	1494	4627	917
9 :	10772	9676	4054	3273	775	1903	742	623	818
10 :	6821	2733	1793	1334	1144	219	1094	294	184
11+:	86436	37237	10300	20389	21231	14984	16443	10495	4313
2+:	199667	99133	41325	54054	51363	42728	43382	48194	30149

:	1980	1981	1982	1983	1984
2 :	185	68	100	26	6
3 :	6522	9315	7481	5362	1193
4 :	2783	36672	24084	24915	32245
5 :	7552	8840	27091	19705	18488
6 :	2634	4267	8096	19070	18133
7 :	1485	1158	3618	5167	10021
8 :	262	571	675	3012	2183
9 :	189	198	212	307	657
10 :	79	44	58	79	37
11+:	1326	837	290	772	197
2+:	23018	61970	71704	78414	83160

Table 20: Historic partial recruitment for the fall spawning component calculated from the VPA fishing mortality - Appendix III. The F table was standardized to the mean of ages 5,6 and 7 with all values over 1 set to 1.

VPA partial recruitment - FALL SPAWNERS Run Date:18/ 1/86

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	0.103	0.034	0.062	0.476	0.003	0.002	0.003	0.028	0.011	0.007
3	0.655	0.158	0.030	0.414	0.240	0.011	0.076	0.305	0.084	0.168
4	0.739	0.622	0.231	0.311	0.400	0.247	0.385	0.798	0.527	0.191
5	0.770	0.919	0.689	0.675	0.613	0.657	0.713	0.902	1.000	0.775
6	0.865	1.000	0.902	0.932	1.000	1.000	0.723	1.000	0.947	1.000
7	1.000	0.997	1.000	1.000	1.000	1.000	1.000	0.961	0.945	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.682
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	0.834	0.312	0.522	0.643	0.614	0.933	1.000	1.000	0.812
11+	1.000	0.834	0.312	0.522	0.643	0.614	0.933	1.000	1.000	0.812

	1981	1982	1983	1984
2	0.003	0.003	0.004	0.013
3	0.315	0.294	0.123	0.145
4	1.000	0.806	1.000	0.700
5	0.750	1.000	0.814	1.000
6	0.753	0.899	1.000	0.965
7	1.000	0.852	0.763	0.714
8	1.000	1.000	1.000	0.410
9	1.000	1.000	1.000	0.291
10	1.000	0.490	0.997	0.238
11+	1.000	0.490	0.997	0.251

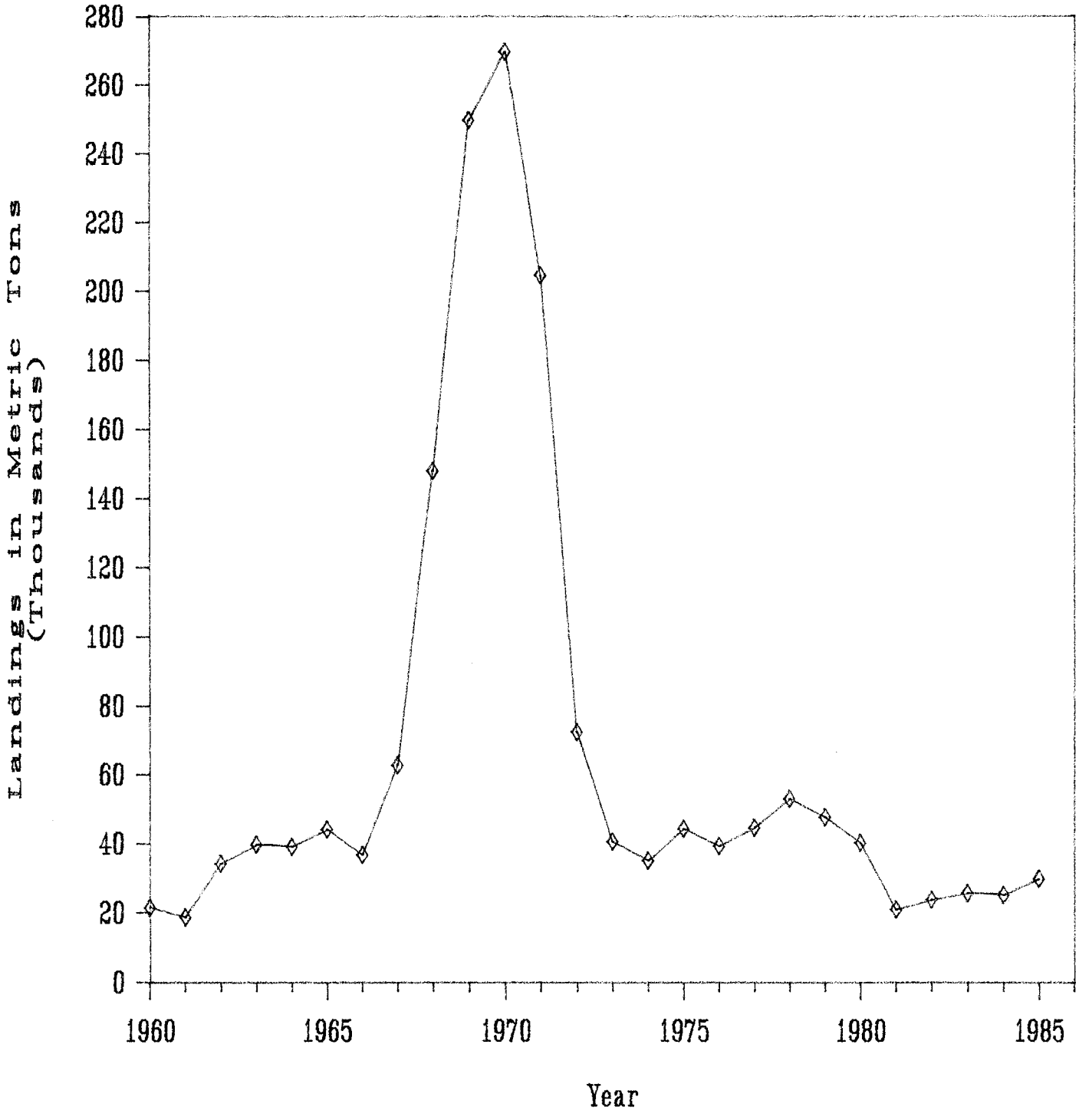

Figure 1. Nominal landings of southern Gulf herring reported from NAFO division 4T and Subdivision 3Pn.

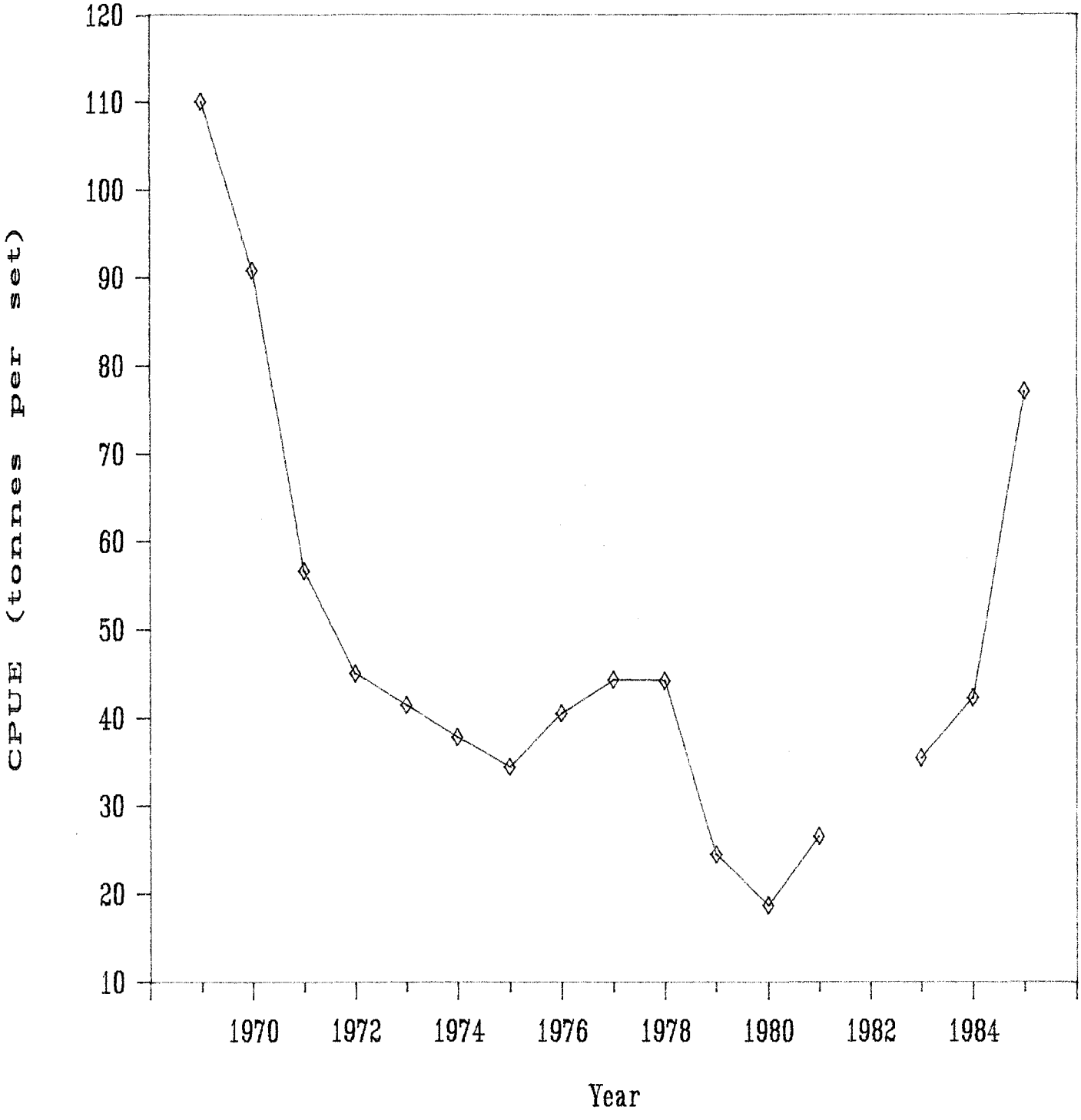

Figure 2. CPUE for the fall (Sept. to Dec.) seiner fishery on the southern Gulf herring complex (NAFO division 4T and Subdivision 3Pn).

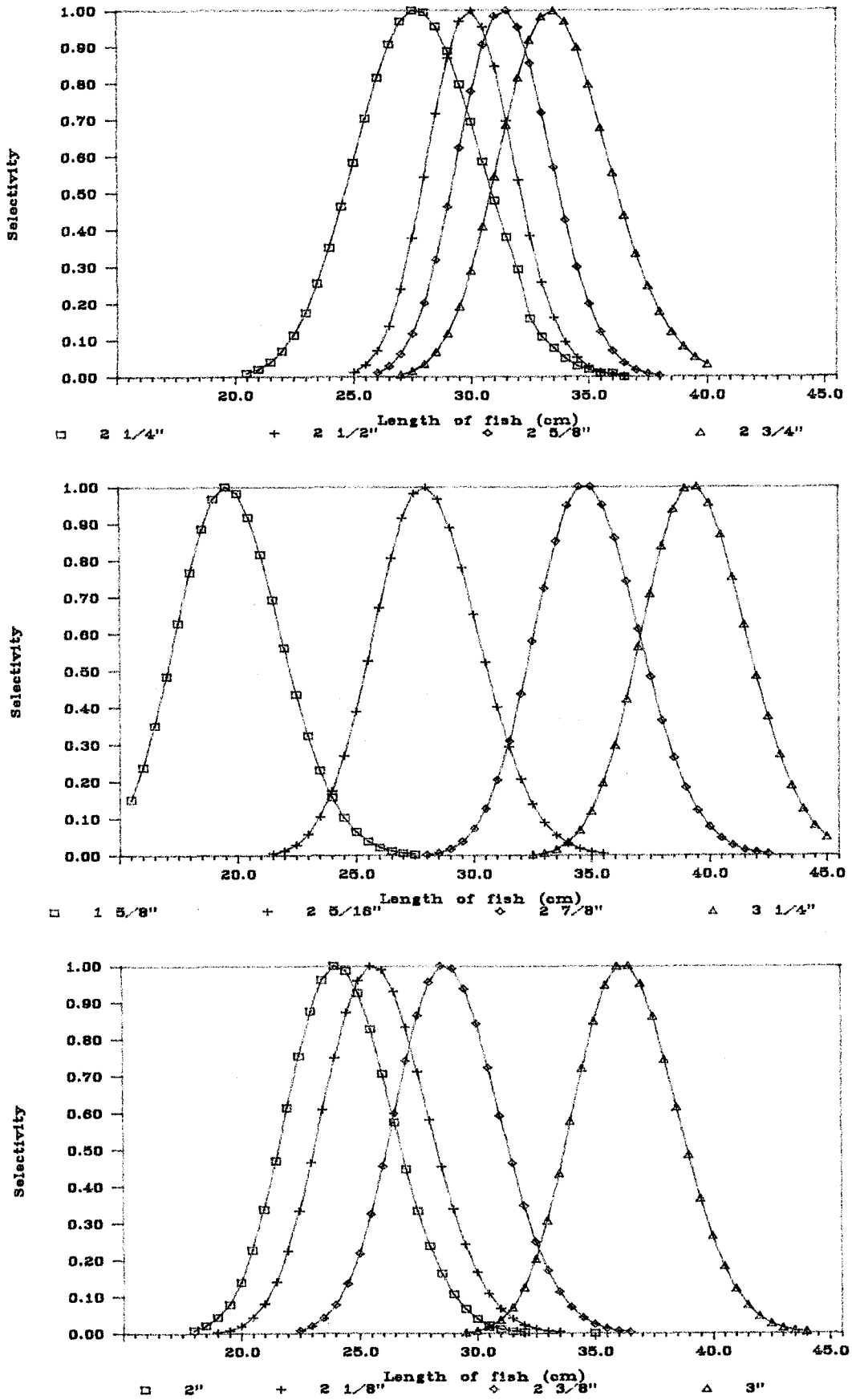

Figure 3. Selectivities of herring gill nets of various mesh sizes. The selectivity of the $2\frac{1}{4}$", $2\frac{1}{2}$", 2 5/8" and 2 3/4" mesh were determined empirically and the others were interpolated from them.

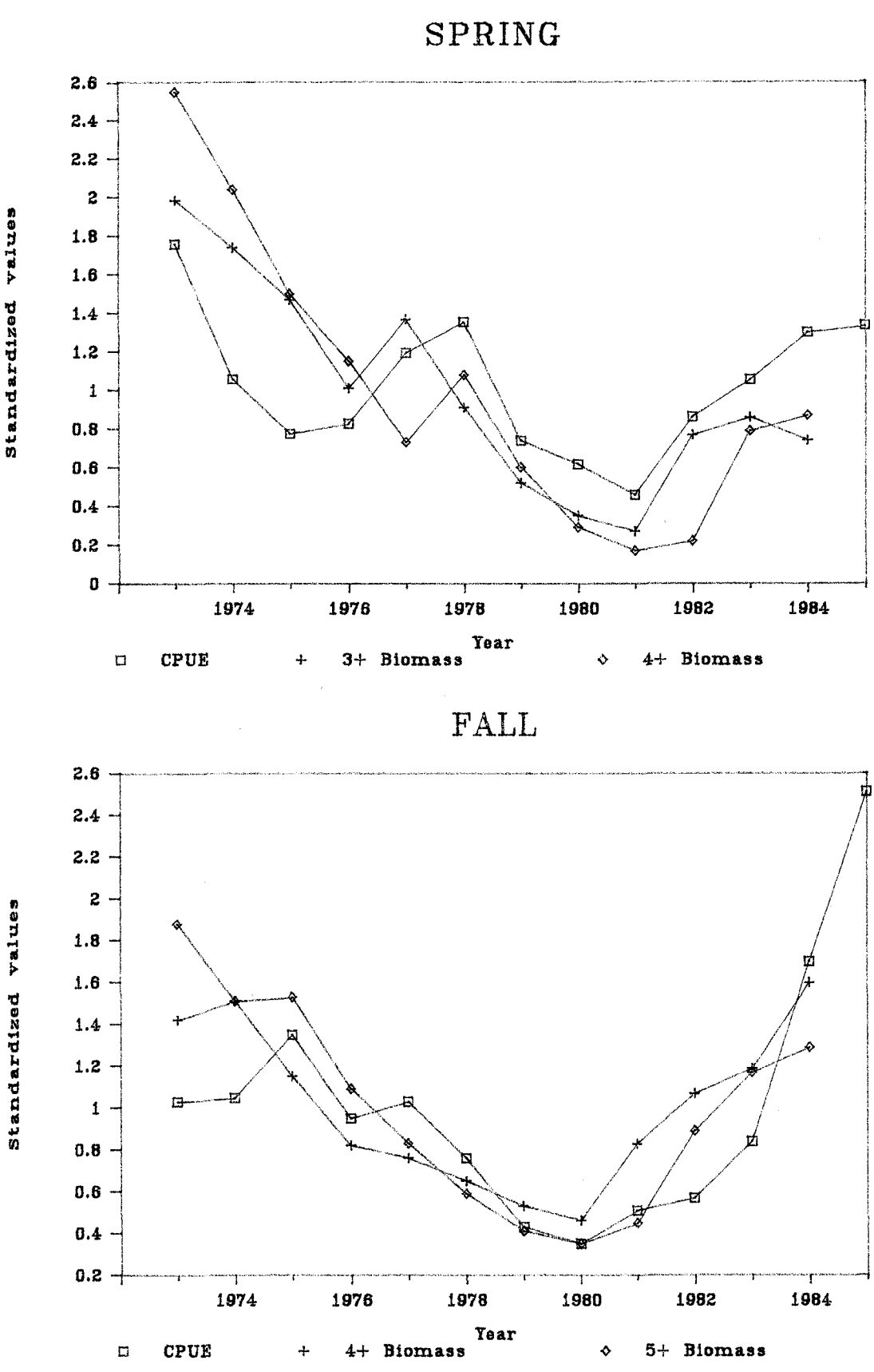

Figure 4. Spring and fall CPUE and age specific VPA biomass of the southern Gulf herring complex.

APL proram listing adapted from McQuinn and White (unpublished) for calculating the F oldest for the southern Gulf herring complex.

```
      ∇CALC△FOLD[□]
[  0] CALC△FOLD
[  1] A←1 ⋄ Y←J
[  2] FEND←FEND_M1←PEND←PEND_M1←NEND_M1←Y⍴0
[  3] CEND_M1←CATCH[A;]+CATCH[A-1;]
[  4] FEND[Y]←FEND_M1[Y]←FI[A]
[  5] DO: PEND[Y]←(CATCH[A;Y]×FEND[Y]+M)÷FEND[Y]×1-*-FEND[Y]+M
[  6] PEND_M1[Y-1]←(PEND[Y]××M)+CEND_M1[Y-1]××M÷2
[  7] FEND_M1[Y-1]←(⊗PEND_M1[Y-1]÷PEND[Y])-M
[  8] F_Z←FEND_M1[Y-1]×1-*-FEND_M1[Y-1]+M
[  9] PEND_M1[Y-1]←(CATCH[A-1;Y-1]×FEND_M1[Y-1]+M)÷F_Z
[ 10] PEND[Y-1]←(CATCH[A;Y-1]×FEND_M1[Y-1]+M)÷F_Z
[ 11] FEND[Y-1]←FEND_M1[Y-1]
[ 12] →(2≤Y←Y-1)/DO
[ 13] FC←FEND_M1
[ 14] TIT←'F OLDEST AGE GROUP CALCULATED BY $CALC△FOLD$'
[ 15] PRT              ⋄  3 OUT FC        ⋄  ⎕PUT ' '        ⋄  CRT
[ 16] ⎕EX 'FEND_M1'   ⋄  ⎕EX 'PEND_M1'   ⋄  ⎕EX 'CEND_M1'   ⋄  ⎕EX 'NEND_M1'
[ 17] ⎕EX 'F_Z'
[ 18] ∇
```

```
      ∇COHO_TRUNC[□]
[  0] COHO_TRUNC
[  1] CALC△FOLD
[  2] I←I-1
[  3] CATCH←(I,J)↑CATEMP←CATCH
[  4] FI←I↑FITEMP←FI
[  5] F←(I,J)↑F
[  6] POP←(I,J)↑POP
[  7] CALC△POP△F
[  8] CATCH←CATEMP
[  9] FI←FITEMP
[ 10] I←I+1
[ 11] POP←POP,[1]PEND
[ 12] F←F,[1]FEND
[ 13] MORT←MORT,[1]J⍴M
[ 14]  ⍝  EE4:PRINT△RESULTS
[ 15] ⎕EX 'PEND'   ⋄   ⎕EX 'FEND'
[ 16] ⎕EX 'CATEMP' ⋄   ⎕EX 'FITEMP'
[ 17] ∇
```

APPENDIX II

Virtual population analysis results for the spring spawning component of the southern Gulf of St. Lawrence herring complex using the partial recruitment (selectivity - Table 11), a terminal F of 0.20 and other parameters as documented in the text.

Table 1.

VPA population numbers - SPRING SPAWNERS Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977
2 :	62919	28995	77415	147267	52488	328179	44953
3 :	327106	48619	23648	61935	115813	41597	254275
4 :	44565	208364	37905	17823	42804	69632	26368
5 :	50210	30334	145711	28772	11620	18008	31771
6 :	61295	28803	19587	90615	22066	6564	8639
7 :	24720	41769	19058	10517	54681	3369	3350
8 :	29369	12276	31212	12074	5264	26529	2337
9 :	28294	11106	6522	20125	6151	1882	13753
10 :	5748	9593	5021	3259	10827	1964	605
11+:	98866	23370	34697	35396	36813	46631	22224
2+:	733093	443228	400778	427784	358527	544355	408276
3+:	670173	414234	323362	280517	306039	216177	363324
4+:	343067	365615	299714	218582	190226	174580	109049
5+:	298502	157251	261809	200759	147422	104948	82681

:	1978	1979	1980	1981	1982	1983	1984
2 :	50032	106133	90588	251082	111310	35425	114297
3 :	33772	27902	67222	54820	200012	90297	28620
4 :	155093	14874	10459	16509	28799	133550	64137
5 :	15369	67892	6879	3415	6052	17968	81105
6 :	16725	8338	24862	2831	1616	3620	11151
7 :	3849	7399	4899	6088	1532	1018	1965
8 :	2197	1995	3278	1053	963	1058	770
9 :	1463	729	994	844	179	482	821
10 :	5367	1025	413	145	7	43	380
11+:	6596	10196	6357	2931	1464	1124	1097
2+:	290462	246484	215952	339717	351935	284584	304343
3+:	240431	140350	125364	88635	240625	249159	190046
4+:	206658	112448	58141	33815	40612	158862	161426
5+:	51565	97574	47683	17306	11813	25312	97288

Table 2.

VPA mean population biomass:tonnes - SPRING SPAWNERS

Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978
2 :	4160	1967	6037	12437	4215	30124	5200	5040
3 :	27119	6026	2904	8285	13979	5913	34506	3964
4 :	6844	36261	6096	2929	5298	10133	4340	22484
5 :	8513	5725	25402	6014	2027	3151	5792	2840
6 :	12371	6465	3894	19564	2646	1314	1700	3282
7 :	4764	11269	4315	2209	11599	765	795	821
8 :	5484	2893	7832	2801	1000	5912	578	412
9 :	5014	2598	1538	4800	1159	349	3101	428
10 :	884	2543	1394	931	2931	445	111	1306
11+:	16108	6599	10852	10734	10816	11207	4516	1779
2+:	91260	82346	70263	70704	55670	69312	60640	42357
3+:	87100	80379	64227	58267	51455	39188	55441	37316
4+:	59981	74354	61322	49982	37476	33275	20935	33353
5+:	53137	38092	55227	47053	32178	23142	16595	10869

:	1979	1980	1981	1982	1983	1984
2 :	11332	9471	29869	13358	4243	13765
3 :	3058	6212	6953	28303	13153	4146
4 :	2208	1340	2220	4890	22398	11260
5 :	10580	1126	594	1169	3530	16792
6 :	1856	3830	607	371	777	2744
7 :	1473	728	809	373	258	493
8 :	446	556	153	216	290	208
9 :	193	153	60	33	149	249
10 :	242	88	32	2	13	107
11+:	2669	1510	727	457	364	344
2+:	34057	25016	42024	49172	45175	50108
3+:	22725	15544	12155	35813	40932	36343
4+:	19667	9332	5202	7511	27779	32198
5+:	17459	7992	2982	2621	5381	20938

Table 3.
VPA catch biomass:tonnes - SPRING SPAWNERS Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978
2 :	240	8	139	500	137	1657	446	1920
3 :	6767	294	240	1398	4287	1504	10092	2429
4 :	1258	5693	460	664	3483	5858	1464	13909
5 :	3006	1351	6942	392	746	1666	2535	1159
6 :	2260	1370	1629	5929	4321	615	1023	1996
7 :	2358	1026	1100	1076	6007	126	176	372
8 :	4176	1240	1860	1317	816	2677	154	367
9 :	4350	1526	752	1998	1073	321	2267	67
10 :	1505	1583	764	311	1795	496	165	1161
11+:	21535	1378	1834	880	2198	7008	4837	715
2+:	47454	15468	15720	14464	24863	21927	23158	24094
3+:	47214	15461	15581	13964	24726	20270	22712	22174
4+:	40447	15167	15341	12567	20439	18766	12621	19746
5+:	39189	9474	14881	11903	16956	12909	11156	5836

:	1979	1980	1981	1982	1983	1984
2 :	2892	2844	817	123	56	28
3 :	2354	7324	3057	5742	1861	638
4 :	1247	1212	1757	1321	6647	2252
5 :	8387	765	322	364	972	2754
6 :	611	4525	249	97	317	318
7 :	894	951	1293	63	20	50
8 :	219	630	234	105	16	17
9 :	71	258	263	40	6	20
10 :	233	104	35	1	1	34
11+:	1252	1045	430	39	4	26
2+:	18160	19657	8458	7895	9899	6137
3+:	15268	16813	7641	7772	9843	6109
4+:	12914	9489	4584	2030	7981	5471
5+:	11667	8278	2827	709	1335	3219

Table 4.
VPA mean weight:kg - SPRING SPAWNERS Run date:13/ 1/86

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0.23	0.25	0.25	0.25	0.24	0.24	0.22	0.21	0.21	0.20	0.20	0.18	0.21	0.23

Table 5.
VPA mean age:years - SPRING SPAWNERS Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
:	6.97	5.95	6.13	5.86	5.60	5.73	4.82	4.18	4.27	3.93

:	1981	1982	1983	1984
:	4.05	3.31	3.90	4.42

Table 6.

VPA distribution of growth over ages:% - SPRING SPAWNERS

Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2 :	8.6	5.3	31.9	44.4	18.6	73.5	16.2	15.8	46.3	47.8
3 :	62.3	11.2	10.1	18.3	45.1	9.1	69.4	11.7	11.9	30.6
4 :	5.2	58.3	11.7	4.4	8.3	9.3	4.0	52.4	6.7	5.1
5 :	6.1	4.7	23.3	6.6	2.4	2.7	5.0	5.1	24.7	3.3
6 :	10.1	3.8	3.3	19.2	1.6	0.6	1.0	4.1	2.8	8.5
7 :	2.7	6.4	2.1	0.9	5.3	0.2	0.3	0.3	0.6	-0.1
8 :	2.7	1.5	0.5	1.2	0.2	1.2	0.4	0.3	0.6	0.7
9 :	1.7	1.0	0.2	0.8	-0.1	0.0	1.2	0.2	0.1	0.2
10 :	1.5	5.9	3.9	1.6	10.7	0.9	0.3	7.6	1.8	0.8
11+:	-0.8	2.0	13.1	2.6	7.8	2.6	2.3	2.3	4.5	3.2

:	1981	1982	1983	1984
2 :	76.7	30.3	12.1	35.1
3 :	16.7	59.2	34.4	10.6
4 :	4.3	8.0	46.1	24.0
5 :	0.9	1.5	5.8	24.8
6 :	0.6	0.3	0.8	4.1
7 :	-0.2	0.1	0.1	0.1
8 :	0.1	0.2	0.3	0.1
9 :	0.0	0.0	0.1	0.3
10 :	0.2	0.0	0.0	0.2
11+:	0.8	0.4	0.4	0.6

Table 7.

VPA production - SPRING SPAWNERS Run date: 13/ 1/86

source	1971	1972	1973	1974	1975	1976	1977
recruitment biomass	3454	1592	4235	9448	3916	21061	3635
growth	30248	23241	13861	16992	12412	28078	18253
total production	33702	24832	18096	26439	16329	49139	21888
loss through fishing	47454	15468	15720	14464	24863	21927	23158
surplus production	15450	8363	4043	12298	5195	35277	9760
net production	-32004	-7105	-11677	-2166	-19668	13350	-13398

source	1978	1979	1980	1981	1982	1983	1984
recruitment biomass	5851	12413	10595	29365	13018	4143	13367
growth	8186	6285	5098	10008	11343	9048	10068
total production	14037	18698	15692	39373	24361	13191	23435
loss through fishing	24094	18160	19657	8458	7895	9899	6137
surplus production	5566	11886	10689	30968	14527	4156	13414
net production	-18528	-6274	-8968	22510	6632	-5743	7277

Table 8.

VPA production/biomass ratio - SPRING SPAWNERS Run date:13/ 1/86

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0.37	0.30	0.26	0.37	0.29	0.71	0.36	0.33	0.55	0.63	0.94	0.50	0.29	0.47

Table 9.

VPA fishing mortality - SPRING SPAWNERS Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979
2 :	0.058	0.004	0.023	0.040	0.033	0.055	0.086	0.384	0.257
3 :	0.251	0.049	0.083	0.169	0.309	0.256	0.294	0.620	0.781
4 :	0.185	0.158	0.076	0.228	0.666	0.585	0.340	0.626	0.571
5 :	0.356	0.237	0.275	0.065	0.371	0.535	0.442	0.412	0.805
6 :	0.184	0.213	0.422	0.305	1.679	0.473	0.609	0.616	0.332
7 :	0.500	0.091	0.256	0.492	0.523	0.166	0.222	0.457	0.614
8 :	0.772	0.432	0.239	0.475	0.828	0.457	0.269	0.903	0.496
9 :	0.882	0.594	0.494	0.420	0.942	0.934	0.741	0.156	0.369
10 :	1.337	0.209	0.169	0.082	0.203	0.625	1.071	0.402	0.469
11+:	1.337	0.209	0.169	0.082	0.203	0.625	1.071	0.402	0.469
4+:	0.691	0.188	0.245	0.257	0.622	0.563	0.589	0.593	0.684

:	1980	1981	1982	1983	1984
2 :	0.302	0.027	0.009	0.013	0.002
3 :	1.204	0.444	0.204	0.142	0.154
4 :	0.919	0.804	0.272	0.299	0.200
5 :	0.688	0.548	0.314	0.277	0.164
6 :	1.207	0.414	0.262	0.411	0.116
7 :	1.338	1.644	0.170	0.079	0.102
8 :	1.157	1.572	0.492	0.054	0.080
9 :	1.728	4.623	1.226	0.039	0.080
10 :	0.692	0.592	0.086	0.010	0.080
11+:	0.692	0.592	0.086	0.010	0.076
4+:	1.051	0.996	0.277	0.293	0.173

APPENDIX III

Virtual population analysis results for the fall spawning component of the southern Gulf of St. Lawrence herring complex using the partial recruitment (selectivity - Table 12), a terminal F of 0.25 and other parameters as documented in the text.

Table 1.

VPA population numbers - FALL SPAWNERS Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977
2 :	81032	305472	62000	40868	88990	137264	178598
3 :	102740	61910	244942	49223	28571	72772	112298
4 :	262211	54166	45982	197555	35130	21500	59330
5 :	96637	130711	30232	33575	145888	24989	16012
6 :	149939	47179	60780	17604	21972	96261	15905
7 :	161246	68651	19806	31847	10580	11782	52622
8 :	190437	52753	30419	8072	16423	5711	5888
9 :	83397	52493	19484	14227	4051	9054	3003
10 :	39023	15980	21805	9256	6723	1363	4237
11+:	452885	200273	114642	132254	112043	86280	58664
2+:	1619546	989587	650091	534482	470371	466977	506555
3+:	1538514	684115	588091	493614	381381	329713	327958
4+:	1435775	622206	343149	444391	352810	256941	215659
5+:	1173564	568039	297167	246836	317680	235440	156330

:	1978	1979	1980	1981	1982	1983	1984
2 :	116174	320839	233522	199825	336147	63366	4461
3 :	146038	93745	260051	189953	163505	275047	51848
4 :	89194	102059	71127	183569	146405	125476	220862
5 :	41630	48253	51861	49190	120249	100388	81125
6 :	9848	21333	14507	21397	34871	74793	72263
7 :	9744	4469	7414	4328	15161	23426	48890
8 :	22996	4842	1557	2333	2659	10292	17000
9 :	2813	6293	1134	698	1026	1269	6737
10 :	1181	849	409	161	376	259	476
11+:	38799	18384	6315	2832	1741	2330	2242
2+:	478417	621066	647897	654287	822138	676646	505904
3+:	362243	300228	414375	454461	485992	613280	501443
4+:	216205	206483	154324	264508	322487	338234	449595
5+:	127011	104423	83197	80939	176082	212758	228733

Table 2.

VPA mean population biomass:tonnes - FALL SPAWNERS

Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978
2 :	2842	10964	2215	1615	3224	4353	19251	12442
3 :	7057	2838	22040	5264	2860	7306	17754	21725
4 :	26823	6895	6707	32380	5031	3426	12240	16327
5 :	13037	17717	4810	6431	25662	4363	3589	8591
6 :	13423	7506	10833	3518	4055	18281	3936	2131
7 :	22722	11883	3517	6591	2148	2345	12096	2369
8 :	26547	8751	6222	1831	3564	1192	1494	4627
9 :	10772	9676	4054	3273	775	1903	742	623
10 :	6821	3279	5747	2557	1779	357	1173	294
11+:	86436	44672	33013	39076	33024	24415	17629	10495
2+:	216479	124182	99157	102536	82123	67942	89903	79625
3+:	213637	113218	96942	100921	78898	63590	70652	67183
4+:	206580	110380	74902	95657	76039	56283	52899	45458
5+:	179758	103484	68195	63277	71007	52857	40659	29131

:	1979	1980	1981	1982	1983	1984
2 :	34436	25108	21546	36245	6832	481
3 :	14499	38868	29601	25426	43713	8208
4 :	18167	14574	36672	29878	24915	46035
5 :	7946	9738	11779	27091	24213	18488
6 :	4122	2634	5665	9005	19070	18795
7 :	933	1485	1158	4249	6774	14042
8 :	917	384	571	675	3012	5329
9 :	818	189	198	212	307	2260
10 :	184	97	44	118	79	154
11+:	4313	1632	837	592	774	785
2+:	86336	94711	108070	133490	129689	114575
3+:	51899	69603	86524	97246	122856	114095
4+:	37400	30735	56924	71819	79144	105886
5+:	19234	16161	20251	41941	54229	59852

Table 3.
VPA catch biomass:tonnes - FALL SPAWNERS Run date:13/ 1/86

	1971	1972	1973	1974	1975	1976	1977	1978
2 :	196	228	68	254	4	3	24	180
3 :	3078	276	330	720	240	31	538	3425
4 :	13178	2621	765	3330	705	324	1881	6708
5 :	6672	9913	1627	1433	5508	1092	1020	3988
6 :	7714	4950	4792	1080	1701	7323	1134	1243
7 :	20498	7211	2421	3018	887	1147	7503	1171
8 :	28346	6864	3446	888	1398	523	797	4973
9 :	15259	6482	2183	1780	678	1053	537	610
10 :	8405	3301	2974	1422	1160	238	1005	324
11+:	65758	22934	5098	6765	7470	5741	6598	6422
2+:	169104	64779	23703	20689	19751	17475	21036	29045
3+:	168908	64551	23635	20435	19747	17472	21012	28865
4+:	165830	64276	23305	19715	19507	17441	20474	25440
5+:	152653	61655	22540	16385	18802	17117	18594	18733

	1979	1980	1981	1982	1983	1984
2 :	346	163	13	22	4	1
3 :	1100	5740	1783	1641	846	226
4 :	8583	2449	8135	5274	5850	6100
5 :	7819	6588	1690	7400	3105	4622
6 :	3477	2611	816	1772	4270	3430
7 :	785	1396	330	792	814	1896
8 :	1123	229	351	360	670	413
9 :	1992	322	82	244	237	124
10 :	255	116	39	48	42	33
11+:	4103	1172	345	64	122	37
2+:	29583	20786	13584	17617	15961	16882
3+:	29237	20623	13571	17595	15957	16881
4+:	28137	14883	11788	15954	15111	16655
5+:	19554	12434	3653	10680	9260	10555

Table 4.
VPA mean weight:kg - FALL SPAWNERS Run date:13/ 1/86

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0.23	0.25	0.26	0.25	0.27	0.28	0.33	0.28	0.28	0.25	0.25	0.26	0.27	0.28

Table 5.
VPA mean age:years - FALL SPAWNERS Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
:	7.87	7.70	7.49	6.81	7.31	7.49	7.52	5.88	5.53	4.55

:	1981	1982	1983	1984
:	4.28	4.66	4.92	5.01

Table 6.

VPA distribution of growth over ages:% - FALL SPAWNERS
Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2 :	2.1	22.5	6.9	7.0	19.2	30.4	44.5	25.2	53.8	34.1
3 :	10.7	7.3	47.0	13.7	12.5	30.4	27.6	40.0	20.5	47.9
4 :	21.7	8.8	12.7	48.4	9.3	7.3	11.0	21.0	18.2	12.0
5 :	7.8	15.2	2.9	5.3	24.6	6.3	2.0	5.6	4.0	4.3
6 :	23.2	4.5	6.1	2.1	2.0	18.5	1.9	1.0	1.4	0.8
7 :	6.3	16.8	1.3	2.8	0.8	1.8	5.1	0.8	0.2	0.3
8 :	7.0	3.0	2.3	0.7	0.6	0.8	0.6	1.1	0.2	0.1
9 :	1.8	3.3	1.3	0.9	0.0	0.8	0.3	0.1	-0.1	0.0
10 :	10.9	6.2	8.0	5.0	5.5	0.9	1.5	0.7	0.3	0.2
11+:	8.5	12.4	11.5	14.1	25.6	2.9	5.5	4.6	1.5	0.5

:	1981	1982	1983	1984
2 :	28.3	40.7	9.1	0.8
3 :	35.1	25.8	52.3	13.2
4 :	29.4	20.3	20.3	60.6
5 :	4.9	9.7	10.1	10.9
6 :	1.7	2.3	5.8	7.7
7 :	0.3	0.8	1.6	4.4
8 :	0.1	0.1	0.6	1.3
9 :	0.0	0.0	0.0	0.5
10 :	0.1	0.1	0.1	0.1
11+:	0.2	0.1	0.2	0.4

Table 7.

VPA production:tonnes - FALL SPAWNERS Run date:13/ 1/86

source	1971	1972	1973	1974	1975	1976	1977
recruitment biomass	2816	10615	1568	921	2674	3296	2780
growth	38696	32424	35077	24943	14683	21138	50052
total production	41512	43039	36645	25864	17357	24434	52831
loss through fishing	169104	64779	23703	20689	19751	17475	21036
surplus production	-1784	18203	16814	5356	933	10845	34851
net production	-170889	-46576	-6889	-15333	-18818	-6630	13815

source	1978	1979	1980	1981	1982	1983	1984
recruitment biomass	11336	31306	22786	19498	32799	6183	435
growth	19584	25426	29250	30273	35363	29936	24684
total production	30919	56731	52036	49771	68162	36119	25119
loss through fishing	29045	29583	20786	13584	17617	15961	16882
surplus production	14994	39464	33094	28157	41464	10181	2204
net production	-14051	9881	12308	14573	23847	-5780	-14678

Table 8.

VPA production/biomass ratio - FALL SPAWNERS Run date:13/ 1/86

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0.19	0.35	0.37	0.25	0.21	0.36	0.59	0.39	0.66	0.55	0.46	0.51	0.28	0.22

Table 9.

VPA fishing mortality - FALL SPAWNERS Run date:13/ 1/86

:	1971	1972	1973	1974	1975	1976	1977	1978	1979
2 :	0.069	0.021	0.031	0.158	0.001	0.001	0.001	0.015	0.010
3 :	0.440	0.097	0.015	0.137	0.084	0.004	0.030	0.158	0.076
4 :	0.496	0.383	0.114	0.103	0.141	0.095	0.154	0.414	0.477
5 :	0.517	0.566	0.341	0.224	0.216	0.252	0.286	0.469	1.002
6 :	0.581	0.668	0.446	0.309	0.423	0.404	0.290	0.590	0.857
7 :	0.917	0.614	0.698	0.462	0.417	0.494	0.628	0.499	0.855
8 :	1.089	0.796	0.560	0.489	0.396	0.443	0.539	1.096	1.252
9 :	1.452	0.679	0.544	0.550	0.889	0.559	0.733	0.998	2.533
10 :	0.761	0.513	0.154	0.173	0.226	0.235	0.374	0.612	0.951
11+:	0.761	0.513	0.154	0.173	0.226	0.235	0.374	0.612	0.951
5+:	0.842	0.592	0.336	0.259	0.259	0.336	0.455	0.651	1.060

:	1980	1981	1982	1983	1984
2 :	0.006	0.001	0.001	0.001	0.003
3 :	0.148	0.060	0.065	0.019	0.028
4 :	0.169	0.223	0.177	0.236	0.133
5 :	0.685	0.144	0.275	0.129	0.250
6 :	1.009	0.145	0.198	0.225	0.183
7 :	0.956	0.287	0.187	0.121	0.135
8 :	0.602	0.622	0.540	0.224	0.078
9 :	1.754	0.419	1.175	0.781	0.055
10 :	0.718	0.412	0.108	0.158	0.045
11+:	0.718	0.412	0.108	0.158	0.048
5+:	0.782	0.178	0.259	0.171	0.183

APPENDIX IV

Projection analysis results for the spring spawning component of the southern Gulf of St. Lawrence herring complex using the partial recruitment (selectivity - Table 12), 1984 catch numbers (Table 4a), 1984 population numbers (Appendix II - Table 1), and the 1984 weights at age (Table 4b) with a recruitment of 100 million fish. The 1985 landings were set to 5124 tonnes.

Table 1.

PROJECTION population numbers - SPRING SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	100000	100000	100000	100000	100000
3 :	28620	81686	81570	81628	81628
4 :	64137	20088	50270	53009	53047
5 :	81105	42993	11352	30490	32152
6 :	11151	56359	25972	7267	19519
7 :	1965	8130	37215	17868	5000
8 :	770	1453	5509	26147	12554
9 :	821	582	1025	4001	18986
10 :	380	620	411	745	2905
11+:	1097	217	438	298	541
2+:	290046	312127	313763	321453	326331
3+:	190046	212127	213763	221453	226331
4+:	161426	130441	132193	139825	144703
5+:	97288	110353	81922	86816	91657

Table 2.

PROJECTION population biomass:tonnes - SPRING SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	12041.09	12032.83	12036.94	12036.94	12036.94
3 :	4145.68	11130.50	11397.91	11405.98	11405.98
4 :	11259.60	3260.28	8426.20	8885.27	8891.56
5 :	16791.84	8341.29	2262.07	6075.84	6406.87
6 :	2744.05	13238.44	6218.74	1740.06	4673.75
7 :	493.46	1959.87	9124.57	4380.98	1225.84
8 :	208.18	380.24	1461.63	6936.49	3330.42
9 :	249.09	171.00	305.36	1191.46	5654.36
10 :	94.20	169.69	113.89	206.45	805.51
11+:	344.24	65.99	134.89	91.90	166.58
2+:	48371.43	50750.13	51482.20	52951.37	54597.80
3+:	36330.33	38717.30	39445.25	40914.43	42560.85
4+:	32184.65	27586.80	28047.34	29508.45	31154.88
5+:	20925.05	24326.52	19621.15	20623.18	22263.32

Table 3.

PROJECTION catch biomass:tonnes - SPRING SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	28	45	36	36	36
3 :	638	3177	2633	2635	2635
4 :	2252	1209	2528	2666	2667
5 :	2754	2536	556	1495	1576
6 :	318	2847	1082	303	813
7 :	50	371	1396	670	188
8 :	17	56	175	832	400
9 :	20	25	37	143	679
10 :	34	25	14	25	97
11+:	26	9	15	10	19
2+:	6137	10300	8473	8815	9109
3+:	6109	10255	8436	8779	9073
4+:	5471	7078	5804	6144	6438
5+:	3219	5869	3276	3478	3771

Table 4.

PROJECTION fishing mortality - SPRING SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	0.002	0.004	0.003	0.003	0.003
3 :	0.154	0.285	0.231	0.231	0.231
4 :	0.200	0.371	0.300	0.300	0.300
5 :	0.164	0.304	0.246	0.246	0.246
6 :	0.116	0.215	0.174	0.174	0.174
7 :	0.102	0.189	0.153	0.153	0.153
8 :	0.080	0.148	0.120	0.120	0.120
9 :	0.080	0.148	0.120	0.120	0.120
10 :	0.360	0.148	0.120	0.120	0.120
11+:	0.076	0.141	0.114	0.114	0.114
2+:	0.112	0.187	0.153	0.156	0.157

Table 5.

PROJECTION production - SPRING SPAWNERS Run date:19/ 1/86

source :	1984	1985	1986	1987	1988
recruitment biomass :	11695	11695	11695	11695	11695
growth :	9009	8999	8786	9371	9438
total production :	20704	20694	20481	21066	21134
loss through fishing :	6137	10300	8473	8815	9109
surplus production :	11030	10544	10185	10476	10214
net production :	4893	244	1712	1661	1105

APPENDIX V

Projection analysis results for the fall spawning component of the southern Gulf of St. Lawrence herring complex using the partial recruitment (selectivity - Table 12), 1984 catch numbers (Table 5a), 1984 population numbers (Appendix III - Table 1), and the 1984 weights at age (Table 5b) with a recruitment of 140 million fish. The 1985 landings were set to 21,200 tonnes.

Table 1.

PROJECTION population numbers - FALL SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	140000	140000	140000	140000	140000
3 :	51848	114613	114265	114279	114279
4 :	220862	41298	90673	90516	90526
5 :	81125	158387	28661	63324	63214
6 :	72263	51727	94935	17384	38408
7 :	48890	49295	33728	62439	11433
8 :	17000	34973	34104	23484	43475
9 :	6737	12880	25995	25442	17520
10 :	476	5221	9846	19924	19500
11+:	2242	307	4041	7638	15455
2+:	641443	608701	576249	564429	553810
3+:	501443	468701	436249	424429	413810
4+:	449595	354088	321983	310150	299531
5+:	228733	312790	231310	219634	209005

Table 2.

PROJECTION population biomass:tonnes - FALL SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	15099.15	15076.99	15077.85	15077.85	15077.85
3 :	8208.08	18085.16	18041.59	18043.72	18043.72
4 :	46034.69	8475.97	18664.56	18632.20	18634.41
5 :	18487.62	35082.37	6382.92	14102.41	14077.96
6 :	18795.27	13173.63	24274.86	4445.05	9820.89
7 :	14041.84	13937.15	9564.70	17706.53	3242.30
8 :	5329.29	10864.21	10612.80	7308.05	13528.93
9 :	2259.67	4292.25	8673.46	8489.08	5845.65
10 :	140.25	1676.42	3165.06	6404.43	6268.29
11+:	784.54	106.91	1407.54	2660.38	5383.22
2+:	129180.40	120771.06	115865.33	112869.72	109923.22
3+:	114081.26	105694.07	100787.48	97791.86	94845.37
4+:	105873.17	87608.90	82745.89	79748.14	76801.65
5+:	59838.48	79132.93	64081.33	61115.94	58167.24

Table 3.

PROJECTION catch biomass - FALL SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	1	47	45	45	45
3 :	226	620	595	595	595
4 :	6100	1401	2968	2963	2963
5 :	4622	10940	1915	4231	4223
6 :	3430	2999	5316	973	2151
7 :	1896	2347	1549	2868	525
8 :	413	1050	987	680	1258
9 :	124	294	572	560	386
10 :	33	94	171	346	338
11+:	37	6	80	152	307
2+:	16882	19800	14199	13413	12792
3+:	16881	19753	14154	13368	12747
4+:	16655	19133	13559	12773	12152
5+:	10555	17732	10591	9810	9189

Table 4.

PROJECTION fishing mortality - FALL SPAWNERS
Run date:19/ 1/86

:	1984	1985	1986	1987	1988
2 :	0.000	0.003	0.003	0.003	0.003
3 :	0.028	0.034	0.033	0.033	0.033
4 :	0.133	0.165	0.159	0.159	0.159
5 :	0.250	0.312	0.300	0.300	0.300
6 :	0.183	0.228	0.219	0.219	0.219
7 :	0.135	0.168	0.162	0.162	0.162
8 :	0.078	0.097	0.093	0.093	0.093
9 :	0.055	0.069	0.066	0.066	0.066
10 :	0.237	0.056	0.054	0.054	0.054
11+:	0.047	0.059	0.057	0.057	0.057
2+:	0.113	0.140	0.103	0.101	0.099

Table 5.

PROJECTION production - FALL SPAWNERS
Run date:19/ 1/86

source :	1984	1985	1986	1987	1988
recruitment biomass :	13660	13660	13660	13660	13660
growth :	25419	21938	21560	21242	21269
total production :	39079	35598	35221	34902	34929
loss through fishing :	16882	19800	14199	13413	12792
surplus production :	13243	11444	12048	12328	12944
net production :	-3639	-8356	-2152	-1085	152