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Assessment of the 1983 4WX herring fishery

by

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ABSTRACT

The total nominal (reported) catch for 4WX herring fisheries declined by 16,600 t in 1983. Much of this decrease resulted from the poor (non-stock) New Brunswick weir juvenile fishery. The Nova Scotia trap and Grand Manan purse seine stock fisheries were active after a 2-yr lapse. The 1979 year-class made the largest contribution to the 1983 stock fisheries (32% by numbers), although the previously dominant 1976 year-class was still much in evidence (12%). The 1981 year-class contributed 24% by numbers and was mainly exploited by purse seiners supplying sardine markets in response to the reduced New Brunswick weir catches.

The final catch figures obtained from the Statistics Branch are thought to be underestimates of total removals due to continued misreporting. Two catch matrices were prepared and used in the analysis. The first was the "nominal" catches as provided by the Statistics Branch and the second was the "adjusted nominal" catches which attempted to account for the degree of misreporting over the last 4 yr. Logbook coverage was the most complete in recent years accounting for 68% of total purse seine catches.

Abundance indices from the fishery indicated a general decline since 1981 but, as in recent assessments, were not used to tune SPA. Currently, the larval abundance index from November research surveys represents the only satisfactory measure of trends in spawning stock size. The geometric mean larval abundances in year N were regressed with both mature biomass and age 5^+ biomass estimates on January 1 of year N + 1.

Cohort runs were made at varying levels of F. Fine tuning suggested use of a terminal F of 0.3 as opposed to 0.375 used in 1983. The catch projection resulted in an estimated fishing mortality of 0.284 on fully recruited ages in 1984 using a TAC of 80,000 and catches of 91,000 t corresponding to $F_{0.1} = 0.3$ in 1985.

It was noted, that while the current catch projections suggest an optimistic outlook for the 4WX herring stock, past projections have not been very precise in predicting the age compositions. In addition, the catches of juvenile herring by the directed purse seine fishery represent a significant loss of yield to the fishery in future years and, if uncontrolled, would compromise the average recruitment pattern used to project the 1985 catches.

RESUME

Les prises nominales totales de hareng qui ont été signalées dans la Division 4WX ont subi une baisse de 16 600 t en 1983, en raison surtout des captures peu élevées de jeunes poissons (ne faisant pas partie des stocks) dans les pêches à fascines du Nouveau-Brunswick. La pêche concentrée sur le stock à la trappe en Nouvelle-Ecosse et la pêche à la senne coulissante à Grand Manan ont repris après une interruption de deux ans. La classe d'âge de 1979 a constitué la plus grande partie des captures en 1983 (32 % des prises en nombre); la classe d'âge de 1976, qui était auparavant la plus abondante, était encore assez nombreuse (12 %). La classe d'âge de 1981 représentait, pour sa part, 24 % des prises en nombre; elle était principalement exploitée par les senneurs à hareng qui approvisionnaient le marché de la sardine pour compenser la diminution des captures des pêches à fascines du Nouveau-Brunswick.

On estime que les dernières données fournies par la Direction de la statistique sont fondées sur des rapports inexacts et sous-évaluent le total des prises. Deux matrices de prises ont été utilisées pour l'analyse. L'une était fondée sur les prises "nominales" établies par la Direction de la statistique, et l'autre sur les prises "nominales rectifiées", qui tenaient compte des rapports inexacts présentés pendant les quatre dernières années. Les données provenant des journaux de bord étaient, au cours des dernières années, les plus complètes: elles rendent compte de 68 % du total des prises des sennes coulissantes.

Les indices d'abondance calculés à partir des pêches montrent une baisse généralisée depuis 1981, mais, tout comme dans les dernières évaluations, ils n'ont pas été utilisés pour calibrer l'ASP. A l'heure actuelle, l'indice d'abondance larvaire basé sur les résultats des campagnes de novembre constitue la seule évaluation satisfaisante des tendances que connaît la taille du stock de frai. Les indices d'abondance larvaire pour l'année N, fondés sur la moyenne géométrique, ont été mis en corrélation avec les évaluations de la biomasse des poissons adultes et de la biomasse des poissons âgés de 5 ans et plus, au 1er janvier de l'année N + 1.

Les analyses des cohortes ont été effectuées avec differents taux de mortalité par pêche de la dernière année. Le calibrage d'analyse a suggéré l'emploi d'un taux de mortalité par pêche de la dernière année de 0,3; en 1983, le taux utilisé était de 0,375. La projection des prises a permis d'évaluer le taux de mortalité par pêche à 0,284 pour les classes d'âge disponibles pour la pêche en 1984; la projection a été faite à partir d'un TPA de 80 000 et de captures de 91 000 t, ce qui correspond à $F_{0,1}$ = 0,3 pour 1985.

On a constaté que bien que les projections actuelles de prises à même le stock de hareng de la division 4WX soient optimistes, les projections antérieures n'étaient pas assez précises pour prévoir la composition des prises par classe d'âge. En outre, la pêche de jeunes harengs à la senne coulissante peut signifier, pour les années à venir, une baisse importante des prises; si cette pêche n'est pas contrôlée, elle pourrait altérer le modèle de recrutement moyen utilisé pour faire les projections de prises pour 1985.

CATCH DESCRIPTION

The seasonal timing of the various components of the overall 4WX herring fishery are shown in Fig. 1, and their geographical location shown in Fig. 2. Both juveniles and adults are being, or have been, fished at all seasons and at each phase of the adults' annual migration. Reported landings by gear type for the 1983 fishery are given in Table 1. The historical catch trends are shown in Table 2 and in Fig. 3, 4, and 5.

The Chedabucto Bay Winter Fishery

The Chedabucto Bay winter fishery has declined persistently since 1981, although provisional figures for the 1984 fishery (not included in this assessment) are only slightly lower than those for 1983. An acoustic survey in the area carried out in February detected large concentrations of fish and data from this survey are being evaluated. (See Appendix A, Cruise Report E. E. Prince P-300, 21 January 1984 - 21 February 1984)

The Summer Purse Seine Fishery

The summer purse seine fishery served at least three distinct markets: over-the-side sales to Soviet factory ships and domestic markets for both juvenile and adult fish. Catches of juvenile fish in the New Brunswick weirs were low, and local processing plants purchased an unusually large amount of sardine-sized herring from the seiners. The exact amount cannot be accurately estimated because Statistics Branch landing information specifies neither catch location nor the market the fish are destined for.

The Gillnet Fishery

The gillnet fishery recorded a higher catch in 1984 than in 1983. It is impossible to estimate how reliably this reflects the amount caught or landed by gillnet boats, although the 1982 practice of transfer of fish from purse seiner to gillnetter was apparently less common in 1983. The available gillnet catch effort records are not considered to be useful for assessment purposes.

The Nova Scotia Weir Fishery and the Liverpool Bay Trap Fishery

This Nova Scotia weir fishery declined still further in 1983 to a recorded catch of less than 1000 t. The Liverpool Trap fishery was active for the first time since 1980; a total of 943 t was recorded for all Nova Scotia trap fisheries.

The New Brunswick Weir and Shut-Off Fisheries

The weir and shutoff fisheries reported their worst year ever, only 10,594 t being recorded. Because demand exceeded supply this is not thought to be a significant underestimate of catches. The season was very late and concern was expressed amongst both Canadian and U.S. sardine industry interests.

The indications are that the low catch is reflecting the cumulative effect of the virtually uncontrolled U.S. fisheries on both adult and juvenile stocks in the Gulf of Maine (and Georges Bank) since the extension of their management mandate.

Because of the implication that the 1981 year-class for these "trans-boundary" stocks is reacting to intensive stock reduction (as demonstrated by information from U.S. larval surveys) the New Brunswick weir catches cannot be used as an indication of recruitment for the more strictly controlled Canadian fisheries in 4WX. Any "year-class parallelism" that is environmentally induced would tend to be obscured.

The New Brunswick Winter Purse Seine Fishery

Almost 2000 t were recorded as being caught in this fishery over the period January to March.

Total "Stock" Catch

The total "stock" catch for 1983, based on Statistics Branch information, (excluding catches from New Brunswick weirs and shutoffs) was 82,682 t, slightly lower than the stock total estimated for 1982 (see Table 2). The same fishery components were included in the stock total in 1983 as in 1982 and earlier years. The question of the stock status of the New Brunswick winter purse seine fishery will be reviewed for the assessment of the 1984 fishery.

BIOLOGICAL SAMPLING AND CATCH RECORDING

Catch Statistics

The Statistics Branch catch reporting is thought to be incomplete, and information on area of capture, except for the New Brunswick Weir Fishery which is monitored locally by the St. Andrews Statistical Co-ordinator, is not easily available.

Estimates of discrepancies in total catch for the purse seine fisheries are listed below.

Fishery	Statistics Branch	Independent Estimate
1982 4X "fall" fishery	500	500 (TAC=250 t)
1983 4X "brit" (winter)	2,200	3,200
1982-83 4W (winter)	8,225	9,500
1983 4X (summer)		
Direct Sales (over-the-side)	14,110	15,500
Domestic	47,900	62,000
Total	72,935	90,700

For the 1983 domestic market purse seine fisheries there is an estimated degree of under-reporting of about 30% (Peacock, unpublished data). This estimate does not include fish released at sea and therefore not landed (Mace, unpublished data).

It was not possible to estimate the degree of under-reporting for the gillnet fishery.

Logbook Information

In the absence of adequate data from Statistics Branch, location or area of catch information can be determined only by the analysis of logbook information and this only for the purse seine fleet.

A total of 48,920 t was accounted for by logbook records and this was allocated to individual 10-min squares. This amounted to 68% of the total catch by purse seiners and was much improved in comparison to 8% coverage in 1982.

Length-Frequency and Catch Data

The existence of the three different markets each with its own size preference resulted in "size-selection" in the purse seine fishery to a degree that was dependent on the detailed and local distribution of fish of a common size. It became obvious that the "grid" areas used as a basis for the consolidation of catch and sampling data in recent years could not take this into account. However, it was established that the overlap between adult and juvenile catch areas was significantly reduced if the basic area, the 10-min squares, was used as the reporting unit, rather than the "Grid Area" as used in previous assessments. Catches and length frequencies were therefore matched by individual 10-min square and month, as far as was possible. Catches for squares and months with no corresponding length-frequency samples were allocated, on a monthly basis, to samples without catches.

The complete schedule recording this aspect of the analysis is available (Power, unpublished data) but is not reproduced here. In the absence of data on area or location of capture the gillnet data was dealt with as a unit on a monthly basis. The New Brunswick weir fishery was also analyzed on a monthly basis, for pooled catches.

AGE COMPOSITION OF THE CATCH

The monthly length-frequency and catch data were combined with monthly length-weight relationships to generate the length frequency of the catch by 10-minute square (where applicable) and by month. The numbers at age in the catch were calculated by the application of a monthly age-length key.

This was done for each fishery component as shown in Table 3 to generate the age composition of the catch (Table 4). It should be noted that this analysis did not take into account the "3 market" problem in the major fishery, the summer purse seine fishery. This has been dealt with to the degree possible, by the analysis by 10-min squares. The variation in monthly length-weight relationships is shown in Table 5.

Pooled Estimate of Catch At Age

As an overall check on the "ball-park" accuracy of the calculations, the catch at age was calculated independently for the 4Xa purse seine fishery using:

(a) Total Catch
(b) Total Length Frequency
(c) Total Length-Weight Relationship
(d) Total Age-length Key

There is reasonable overall agreement in the total number removed (see Table 4), although the "pooled" estimate gives somewhat higher numbers for older fish.

ABUNDANCE INDICES

The abundance indices for the various components of the 4WX herring fishery are listed in Table 6. An analysis of the summer purse seine fishery is underway and preliminary results are discussed by Mace (1984 unpublished data). At present, none of the available fishery abundance indices are sufficiently reliable and/or relevant to allow their use as independent checks on population estimates.

Larval Abundance Indices

The 1983 November larval survey cruise was successfully concluded and herring larvae were identified and counted. Results are included in the historical series listed in Table 7. In 1983, both the arithmetic mean and the geometric mean increased relative to 1982, suggesting an appreciable increase in spawning biomass.

As in 1982 (Iles and Simon, 1983), the geometric mean series was used to fine-tune the cohort analysis.

CATCH MATRICES (TABLES 8a, 8b)

Two catch matrices were prepared, the first being the "nominal" catch (i.e. the catch provided by Statistics Branch) and the second the "adjusted nominal" catch, which attempts to account for misreporting by purse seine fisheries over the last 4 yr. Estimates of the degree of underreporting were as follows:

Year	Adjustment	Source
1980	40% underreporting	Sinclair and Iles, 1981.
1981	30% underreporting	CAFSAC and Peacock estimates.
1982	20% underreporting	CAFSAC and Peacock estimates.
1983	30% underreporting	Peacock, unpublished data.

These estimates were assumed to apply equally to the domestic 4Xa, 4Xb, and 4Wa purse seine landings but were not used to adjust foreign over-the-side sales where misreporting is less problematic. A 40% adjustment for 4Xa domestic landings had already been included in the 1980 catch-at-age estimates used in the last three assessments. For consistency, this was removed from the "nominal" catch matrix, and added back in along with 40% increases for 4Xb and 4Wa domestic landings for the "adjusted nominal" matrix.

ESTIMATION OF POPULATION SIZE

Fine-Tuning

Terminal fishing mortality was estimated by regressing SPA-estimated adult biomass on the larval abundance indices. Two measures of adult biomass were used:

(i) Mature biomass - 30% age 4 on 1 January (age 3 during spawning season), 80% age 5(4), 100% ages 6^+ (5^+).

(ii) 5^+ biomass - as in Iles and Simon (1983).

Larval abundance indices derived from November surveys in year N were matched with January 1st biomass estimates of year N + 1. To calculate the adult biomass corresponding to the 1983 larval index, it was assumed that the partial recruitment presented in the last assessment was applicable for ages 3^+ (i.e. 0.53 for age 3, 1 for ages 4^+). Weights used were mean July values from 1969-78, as in Iles and Simon (1983):

Age	1	2	3	4	5	6	7	8	9	10
Mean July weight (kg)	.010	.041	.112	.172	.218	.254	.286	.323	.354	.389

Natural mortality was taken to be M = 0.2.

Both linear least-squares and resistant line regressions were performed for a series of terminal F-values of 0.25-0.50, with 0.05 increments. Results from least-squares regressions are presented in Table 9a. Based on the criteria of high correlation and proximity of recent years (1982 and 1983) to the resistant regression line, terminal F values of 0.3 and 0.4 were selected for the"nominal" and "adjusted nominal" options, respectively. More weight was placed on mature rather than 5^+ biomass estimates as these logically should give better indications of spawning stock size. The results of these runs are presented in Fig. 6 and 7.

Inspection of the results suggested that the regressions could be further improved. Two modifications to the initial assumptions are shown in Tables 9b, 9c. First, ages 6^+, rather than 4^+, were used to calculate F for the oldest age (based on examination of fishing mortality patterns which suggested that the first fully-recruited age may often be closer to 6

than 4). Second, the 1981 point was dropped from the analysis (on the basis of resistant line regressions which consistently indicated that it was an outlier). Exclusion of the 1981 point had the greatest effect, producing intercepts closer to zero, although still high, especially for the mature biomass option.

It was noted that the 1974 and 1975 points are influential in determining the relationship between larval abundance and adult biomass. These are years in which misreporting is suspected to have been high. Slopes of least squares regression lines for mature biomass were not significantly different for the two options. Large positive intercepts for both relationships examined are consistent with the view that failure to adjust for underreporting in the early 1970's results in underestimates of adult biomass in those years.

Population Estimates

Estimates of population size and fishing mortalites were generated using the selected terminal F values of 0.3 for the "nominal" catch matrix and 0.4 for the "adjusted nominal" matrix, mean July weights at age from the above text table and a natural mortality rate of M = 0.2. For the "nominal" option, recruitment at age 1 was set at 1.48 billion, the geometric mean of year classes 1964 to 1979 as calculated in Iles and Simon (1983). For the "adjusted nominal" option, a corresponding 1964-79 geometric mean recruitment of 1.60 billion was recomputed from new SPA runs using F = 0.40. Total fishing mortalities for ages 1 and 2 in the last year were fixed to generate the appropriate mean recruitment levels. This resulted in the following values:

	Age 1	Age 2
Nominal	.0025	.1244
Adjusted nominal	.0033	.1559

A partial recruitment vector was used for the remaining ages. It was assumed to be identical to that of the last assessment (Iles and Simon, 1983):

Age	3	4	5	6	7	8	9	10
PR	0.53	1	1	1	1	1	1	1

Estimated population numbers, mean population biomass and fishing mortalities using these input parameters are given in Tables 10, 11 and 12. Both options suggest a moderate increase in population size between 1982 and 1983. Estimates of 2^+ population biomass for 1982 and 1983 from Table 11 are respectively, 306821 and 328109 t for the "nominal" option and 317590 and 321560 t for the "adjusted nominal" options.

Partial Recruitment

Selectivity estimates, calculated using fishing mortalities for ages 6-10 to obtain F at age 10 and then dividing each element in Table 12 by the appropriate value of F at age 10, were extremely variable (Table 13). Partial recruitment factors used in past assessments have also been inconsistent (Table 14 and Fig. 8). However, attempts to derive a representative partial recruitment vector (e.g. Fig. 9) suggested that the 1982 vector was, in fact, somewhat representative of "average conditions."

It was, therefore, used in the catch projections below.

CATCH PROJECTIONS

Catch projections were generated for both catch matrix options from the following input:

(i) 1983 population numbers (Tables 10a, 10b).

(ii) Catch at age for 1983 (Tables 8a, 8b).

(iii) Partial Recruitment vector from 1982:

Age	1	2	3	4	5	6	7	8	9	10
PR	.01	.22	.53	1	1	1	1	1	1	1

(iv) Natural mortality = 0.2.

(v) Mean weight at age for July purse seine from 1969-1978.

(vi) Recruitment at age 1 of 1.48 billion for "nominal" matrix. and 1.60 billion for "adjusted nominal" matrix.

(vii) Quota in 1984 = 80,000; F = 0.30 thereafter.

The projected $F_{0.1}$ catch biomass for 1985 is 90,866 t for the nominal matrix and 89,599 t or the adjusted nominal (Table 15).

RECOMMENDATIONS

Catch projections suggest an optimistic outlook for the 4WX herring fisheries. However, there are three main areas of concern:

(i) Past projections have not always been accurate (Fig. 10);

(ii) The directed fishery for sardines by purse seiners in 1983 may be problematic since these catches represent a significant loss of yield to the fishery in future years. Juvenile herring supplied by N.B. weirs in 1982 were taken from the "stock total" by seiners in 1983 (Table 16);

(iii) Lack of information on incoming year classes makes it difficult to predict their probable size and contributions to the fishery; and

(iv) The average recruitment pattern used to project 1985 catches will not be appropriate if the directed purse seine fishery for sardines is repeated in 1984 and beyond.

REFERENCES

Hodder, V.M. 1984. ICNAF Statistical Bulletin for the year 1972. Int. Comm. Northwest Atl. Fish. Stat. Bull. Vol. 22: 239 p.

1975. ICNAF Statistical Bulletin for the year 1973. Int. Comm. Northwest Atl. Fish. Stat. Bull. Vol. 23: 277 p.

1976. ICNAF Statistical Bulletin for the year 1974. Int. Comm. Northwest Atl. Fish. Stat. Bull. Vol. 24: 255 p.

1977. ICNAF Statistical Bulletin for the year 1975. Int. Comm. Northwest Atl. Fish. Stat. Bull. Vol. 25: 234 p.

Iles, T.D., and J. Simon. 1983. Assessment of the 1982 4WX herring fishery. CAFSAC Res. Doc. 83/89: 37 p.

Miller, D.S. 1973. The Canadian fisheries exploiting the southwestern Nova Scotia Div. 4X-4W herring stock. Int. Comm. Northwest Atl. Fish. Res. Doc. 73/95: 10 p.

Miller, D.S., and T.D. Iles. 1975. Catch statistics for the Bay of Fundy herring fisheries 1963-1974. Fisheries & Marine Services Technical Report No. 595: 75 p.

Miller, D.S., and W.T. Stobo. 1977. Herring assessment in ICNAF Div. 4WX. CAFSAC Res. Doc. 77/11: 6 p.

Sinclair, M., and T.D. Iles. 1981. Assessment of the 1980 4WX herring fishey. CAFSAC Res. Doc. 81/10: 40 p.

Sinclair, M., K. Metuzals, and W.T. Stobo. 1979. The 1978 4WX herring assessment. CAFSAC Res. Doc. 79/19: 44 p.

Sinclair, M., J. Simon, W. Stobo, and T.D. Iles. 1982. Assessment of the 1981 4WX herring fishery. CAFSAC Res. Doc. 82/36: 34 p.

Stobo, W.T. 1975. The 1974-75 Canadian Cape Breton (Div. 4VWa) herring fishery. Int. Comm. Northwest Atl. Fish. Res. Doc. 75/39: 12 p.

Stobo, W.T., D.F. Gray and K. Metuzals. 1978. Herring assessment in 4WX. CAFSAC Res. Doc. 78/25: 17 p.

Table 1. Provisional catch for the 1983 4WX herring fishery from Statistics Branch data (t).

4WX Catches	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Total
4Wa Purse Seine	-	-	1968	3311	2590	260	97	-	-	-	-	-	-	8226
Gillnet (area 463)	-	-	-	-	-	-	1	4	155	322	363	411	-	1256
Gillnet (stock)	-	-	-	-	-	-	119	112	479	174	2355	4264	3	7506
4X Purse Seine	1702	-	-	-	-	-	-	-	3642	15630	22517	18481	1407	63379
4X Traps (463)	-	-	-	-	-	-	1	-	555	37	145	202	3	943
N.S. Weirs	-	-	-	-	-	-	2	-	286	141	188	209	92	918
4WX TOTAL	1702	-	1968	3311	2590	260	219	116	5117	16304	25568	23567	1505	82227

4Xb Catches	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Total
Purse Seine		-	-	171	558	1210	-	-	-	-	-	-	32	1971
Midwater Trawl	-	-	-	5	76	105	-	-	-	-	-	-	-	186
N.B. Weirs		-	-	-	-	-	-	65	29	299	2103	5251	2847	10594
Shutoffs		-	-	-	-	-	-	-	-	-	149	400	129	678
Miscellaneous	-	-	-	-	-	-	2	2	35	20	50	2	-	111
4Xb TOTAL	-	-	-	176	634	1315	2	67	64	319	2302	5653	3008	13540

Table 2. Annual 4WX herrring catch by different components of the fishery (t).

[a]Winter catch, Nov.-Apr., is put into latest calendar year.
[b]Fixed gear catch not considered part of major 4WX migratory stock.
[c]Estimate of annual catch incorporated into 1980 catch-at-age-matrix (columns A+C+D+E+F+G+H+K).

	4W		4XA				4XB				4WX		
							Winter purse seine						
Year	Purse seine[a]	Fixed gear[b]	Summer purse seine	Gillnet[13]	Weir	Liverpool trap	Grand Manan	Saint John	Weir[b]	Misc. & shutoffs[b]	Foreign total	Stock total[c]	TAC
1963	-		15093[5]	2955[5]	5345[5]	-	-	6871[5]	28203[5]	1163[5]			
1964	-		24894[5]	4053[5]	12458[5]	-	-	15991[5]	27337[5]	2095[5]			
1965	-		54527[5]	4091[5]	12021[5]	-	-	15755[5]	31684[5]	1662[5]		86394[15]	
1966	-		112457[5]	4413[5]	7711[5]	-	-	25645[5]	35601[5]	204[5]		150226	
1967	-	431	117382[5]	5398[5]	12475[5]	-	-	20888[5]	29932[5]	100[5]	598[9]	156741	
1968	-	375	133267[5]	5884[5]	12571[5]	-	-	42223[5]	32114[5]	1031[5]	2417[9]	196362	
1969	25112[4]	343	84525[5]	3474[5]	10744[5]	-	-	13202[5]	25646[5]	893[5]	13405[9]	150462	
1970	27107[4]	151	70849[5]	5019[5]	11706[5]	-	-	14749[5]	15073[5]	767[5]	60952[9]	190382	
1971	52535[4]	169	35071[5]	4607[5]	8081[5]	-	-	4868[5]	12139[5]	521[5]	23939[9]	129101	
1972	25656[4]	330	61158[5]	3789[5]	6766[5]	-	32153[5,8]	21[5]	31995[5]	704[5]	23906[10a]	153449	
1973	8348[4]		36618[5]	5205[5]	12492[5]	-	25155[5,8]	2167[5]	19088[5]	847[5]	32702[10b]	122687	
1974	27044[4]		76859[5]	4285[5]	6436[5]	-	-	10563[5]	19028[5]	1574[5]	24483[10c]	149670	
1975	27030[4]		79605[6]	4995[6]	7404[6]	-	-	1152[6]	30819[6]	?	23711[10d]	143897	
1976	37196[3]		58305[3]	8322[2]	5959[3]	-	94[6]	652[6]	29206[6]	?	4133[3]	114661	
1977	23251[1]	1138	68538[1]	18523[1]	5213[1]	-	-	1236[1]	20697[1]	2790[1]	410[1]	117171	109
1978	17274[1]		57973[12]	6059[12]	8057[12]	-	3832[12]	2687[12]	33570[12]	5272[12,11]	-	95882	110.0
1979	14073[12]		25265[7]	4363[7]	9307[7]	2174[14]	2973[7]	866[2]	32477[7]	5351[7,11]	-	59021	99[21]
1980	8958[2]		44986[16,17]	19804[16,18]	2383[16]	2010[14]	656[14]	787[14]	11100[16]	2425[11]	-	79584	65[20]
1981	18588[2]		53799[14]	11985[14,18]	1966[14]	-		1368[14]	15576[16]	3504[11,14]		87706	100.0
1982	12275[2]		64344[14]	6799[14,18]	1212[14]	-	-	103[19]	22183[14]	3780[11,14]	-	84733	80.2
1983	8226[14]		63379[14]	8762[14,18]	918[14]	943[14,18]	1971[14]	186[19]	10594[14]	789[11,14]		84385	82.0
1984	7389[2]												80.0
	A	B	C	D	E	F	G	H	I	J	K	L	

[1]Stobo et al. (1978).
[2]"Best estimate", provisional.
[3]Miller & Stobo (1977).
[4]Stobo (1975).
[5]Miller & Iles (1975)
[6]Catch at age" printouts.
[7]St. Andrews provisional statistics, March 1980.
[8]Grand Manan catch incorporated into previous assessments catch-at-age matrix.
[9]Miller (1973).
[10a]Holder (1974).
[10b]Holder (1975).
[10c]Holder (1976).
[10d]Holder (1977).
[11]Shutoffs only.
[12]Sinclair et al. (1979).
[13]Gillnet catches in Stat. districts 28-44.
[14]Statistics Branch.
[15]Catch matrix starts in 1965.
[16]St. Andrews provisional statistics, March, 1981.
[17]Previous 40% upward adjustment removed.
[18]Includes area 463 catch.
[19]Midwater gear only.
[20]F0.1 yield estimated at 60.0.
[21]TAC rasied to 65.0 from 60.0 in mid-season.

Table 3. Ratio of monthly catches (t) to number of biological detail samples for the 4WX herring fishery.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Purse Seine												
4X 1977	-	-	-	-	382	72	184	112	109	160	103	107
4X 1978	-	-	-	-	139	598	498	157	294	164	-	-
4X 1979	217	123	-	-	4	222	140	182	396	389	40	-
4X 1980		394		-	209		316	455	682	94		235
4X 1981	-	91		-	-	179	231	215	206			
4X 1982	-	-	-	-	-	76	85	78	93	-	-	-
4X 1983	44	159	63	-	-	173	93	111	210	101		-
4Wa 78/79	220	-	-	-	-	-	-	-	-	-	-	226
4Wa 79/80	220	-	-	-	-	-	-	-	-	-	-	118
4Wa 80/81	188	168	-	433	-	-	-	-	-	-	-	-
4Wa 81/82	107	33	-	214	-	-	-	-	-	-	-	-
4Wa 82/83	123	26	260	97	-	-	-	-	-	-	-	219
Gillnet												
1977	-	-	-	-	348	271	1118	462	945	-	-	-
1978	-	-	-	-	21	116	114	305	219	-	-	-
1979	-	-	-	-		481		188	378		-	-
1980	-	-				519	778	492	663		-	-
1981					280		151	178	173			
1982	-	-	-	-			154			81	-	-
1983	-	-	-	79			226	91		156	-	-
N.S. Weirs												
1977	-	-	-	-	366	127	1021	1114	50	15	-	-
1978	-	-	-	-	176	200	212	95	22	51	239	28
1979	-	-	-	-	64	126	127	73	-	111	15	-
1980	-	-	-	-	120		212	99	-	-	-	-
1981	-	-	-	-		137		92				
1982	-	-	-	-	16	45	25	18	57	51	-	-
1983	-	-	-		288		20	13	151		-	-
N.B. Weirs & Shutoffs												
1977	-	-	-	-	-	42	136	93	110	169	123	107
1978	-	-	-	-	17	43	148	114	236	270	-	132
1979	286	52	-	-	14	51	97	228	155	132	142	37
1980	-	-	-	-	37	40	103	124	288	326	283	-
1981	-	-	-	-	86		143	128	164	94	75	29
1982	-			25		15	49	85	135	132	86	24
1983	-	-	-	-	47		13	30	161	58	-	-
Liverpool Fishery												
1978	-	-	171	-	-	-	-	-	-	-	-	-
1979	-	-	50	-	-	-	-	-	-	-	-	-
1980	-	-	155	-	-	-	-	-	-	-	-	-
1983	-	-	-	1	69		6		39			

Table 4: Catch at age (numbers $x10^{-3}$) by gear for the 1983 4WX herring fishery.

	1	2	3	4	5	6	7	8	9	10	11+	Total No's.	Tonnes
4Wa													
Purse Seine	-	-	7,659	17,091	4,508	9,001	10,197	933	191	135	209	49,924	8,226
4Xa													
Traps	-	21	492	2,495	151	881	586	29	-	-	-	4,655	943
Purse Seine	-	34,979	74,323	132,652	9,612	27,626	41,458	5,015	530	253	567	327,015	61,677
Gillnets	-	-	882	14,104	2,391	3,812	11,136	1,351	626	38	110	34,449	8,762
Nova Scotia Weirs	-	9,694	2,691	1,109	222	265	88	6	4	8	9	14,096	918
4Xb													
N.B. Purse	3,367	73,580	13,449	928	62	22	3	-	-	-	-	91,411	1,971
Otter Trawl	-	10,104	1,521	-	-	-	-	-	-	-	-	11,625	186
"Stock Total"	3,367	128,378	101,017	168,379	16,946	41,607	63,468	7,334	1,351	434	895	533,175	82,683
4Xb (Non-stock)													
Weirs, Shutoffs & Misc.	2,532	135,283	21,684	7,526	444	398	189	-	-	-	-	168,056	11,383
P. Seine combined*	518	47,619	79,472	130,712	11,316	28,816	39,399	5,786	904	470	1,167	346,178	61,677

*All 4Xa, 4Xb purse seine length-frequency samples combined.

Table 5A. Length-weight relationship for herring taken by N.S. purse seines in 1983.

Month	a	b	Observations	Correlation Coefficient
June	.00543	3.1439	293	.9797
July	.00240	3.3840	2210	.9897
August	.00164	3.4979	1467	.9923
September	.00232	3.3919	980	.9890
October	.00401	3.1933	519	.9869

Table 5B. Length-weight relationships for herring taken by N.B. weirs in 1983.

Month	a	b	Observations	Correlation Coefficient
June/July	.00376	3.2195	369	.9891
August	.00261	3.3627	1204	.9844
September	.00183	3.4616	600	.9928
October	.00514	3.1115	760	.9884

Table 6. CPUE trends for various components of the 4WX herring fishery.

Year	Purse Seine			Fixed Gear	
	4Xa[1]	4Wa[1]	Gillnets[5]	N.S. Weirs[6,7]	N.B. Weirs[6,7]
1965	-	-		481 (25)	162 (195)
1966	-[4]	-		308 (25)	183 (195)
1967	55.5[4]	-		499 (25)	153 (195)
1968	52.8[4]	-		503 (25)	165 (195)
1969	41.7[4]	-		430 (25)	132 (195)
1970	39.0[4]	-		468 (25)	77 (195)
1971	32.6[4]	109.7[2]		323 (25)	62 (195)
1972	45.0[4]	62.6[2]		271 (25)	164 (195)
1973	49.1[2]	69.7[2]		500 (25)	98 (195)
1974	53.4[2]	143.1[2]		257 (25)	98 (195)
1975	57.4[2]	142.7[2]		296 (25)	158 (195)
1976	44.6[2]	125.4[2]		238 (25)	150 (195)
1977	37.4[2]	97.9[3]	4.2	209 (25)	106 (195)
1978	39.5[2]	85.7[2]	1.6	269 (25)	172 (195)
1979	31.7[2]	70.1[2]	2.1	372 (25)	167 (195)
1980	28.5*[2]	63.4*[2]	3.0	95 (25)	57 (195)
1981	42.0[2]	76.8*[2]	4.4	79 (25)	80 (195)
1982	40.6[2]	68.7*[2]	3.44	48 (25)	114 (195)
1983	34.8	51.0*[2]	2.29	37 (25)	54 (195)

[1]Catch (t) per successful night
[2]Reanalysis of logs
[3]Sinclair & Iles (1981)
[4]Stobo et al. (1978)
[5]t/purchase slip (areas 32-37)
[6]t/year
[7]No. of weirs used in brackets
*Misreporting and/or avoidance of large sets

Table 7. 4WX larval herring abundance indices; from number of larvae per m^2 (to bottom) of all stations sampled (n = 116-150) for each year.

Year	Arithmetic Mean	Geometric Mean
1972	7.24	2.64
1973	5.27	2.30
1974	37.49	7.60
1975	24.56*	6.02*
1976	11.62	4.44
1977	4.57	1.83
1978	3.51	1.24
1979	6.32	2.18
1980	19.48	4.61
1981	2.59	1.50
1982	9.10	3.73
1983	11.33	4.29

*Interpolated.

Table 8a. "NOMINAL" catch matrix (based upon Statistics Branch figures) used in the cohort analysis.

4WX HERRING CATCH AT AGE FROM NOMINAL LANDINGS (NOS x 10⁻3) 30/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	754	14151	0	0	0	0	311	1623	0	3589	3367
2	126421	596153	264491	48470	140494	346719	170523	9566	75713	72591	128378
3	595992	72381	180898	176226	28659	36177	226442	60559	33174	122380	101017
4	109530	616622	92487	130598	192958	11338	47200	359484	68816	17756	168379
5	34422	53199	383650	72334	106061	107627	4639	21958	306716	73025	16946
6	25562	15254	50599	219788	55066	60431	19695	3583	21728	154542	41607
7	19361	8120	9357	18960	150588	27286	15521	3507	1631	10910	63468
8	17604	5313	3238	4967	12466	96741	9981	4951	1914	1535	7334
9	19836	10964	3481	3556	2873	9838	35386	2009	1366	977	1351
10	9661	5787	2842	1835	1253	2169	3834	8179	361	886	434

Table 8b. "ADJUSTED NOMINAL" catch matrix (including estimate of misreporting) used in the cohort analysis.

4WX HERRING CATCH AT AGE FROM ADJUSTED NOMINAL LANDINGS (NOS x 10 ⁻3) 30/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	754	14151	0	0	0	0	311	2684	0	3589	4810
2	126421	596153	264491	48470	140494	346719	170523	13917	97015	86019	171442
3	595992	72381	180898	176226	28659	36177	226442	90128	46974	135282	134561
4	109530	616622	92487	130598	192958	11338	47200	529273	95252	19976	219825
5	34422	53199	383650	72334	106061	107627	4639	30804	419521	84471	22073
6	25562	15254	50599	219788	55066	60431	19695	4753	30494	180224	54580
7	19361	8120	9357	18960	150588	27286	15521	5263	2244	12600	81504
8	17604	5313	3238	4967	12466	96741	9981	7334	2578	1783	9387
9	19836	10964	3481	3556	2873	9838	35386	3010	1795	1149	1608
10	9661	5787	2842	1835	1253	2169	3834	12558	457	1051	575

Table 9. a) Intercepts and r for terminal F values of 0.25 - 0.50 using "nominal" and "adjusted nominal" catch matrices under the assumptions of:

- ages 4^+ used in determination of F's for oldest age;
- all larval abundance indices included.

	Nominal		Adjusted Nominal	
Terminal F	Mature biomass	5+ biomass	Mature biomass	5+ biomass
	r / intercept	r / intercept	r / intercept	r / intercept
0.25	.823 / 97435	.821 / 47302	.705 / 130718	.730 / 73518
0.30	.849* / 86112	.847 / 37249	.787 / 116095	.785 / 60535
0.35	.843 / 78043	.852 / 30084	.823 / 105674	.813 / 51282
0.40	.826 / 72006	.849 / 24724	.830* / 97878	.824 / 44361
0.45	.806 / 67325	.842 / 20568	.821 / 91832	.826 / 38994
0.50	.786 / 63592	.833 / 17255	.807 / 87012	.824 / 34715

*Chosen as best estimate.

b) Intercepts and r for terminal F values of 0.3 and 0.4 for the "nominal" and "adjusted nominal" catch matrices respectively and under the assumptions of:

- ages 6^+ in determination of F's for oldest age;
- all larval abundance indices included.

	F = 0.30 Nominal		F = 0.40 Adjusted Nominal	
	Mature biomass	5+ biomass	Mature biomass	5+ biomass
	r / intercept	r / intercept	r / intercept	r / intercept
	.844 / 82973	.841 / 34686	.822 / 94134	.817 / 41390

c) Intercepts and r for terminal F values of 0.3 and 0.4 for the "nominal" and "adjusted nominal" catch matrices respectively and under the assumptions of:

- ages 6^+ used in determination of F's for oldest age;
- 1981 point excluded.

	F = 0.30 Nominal		F = 0.40 Adjusted Nominal	
	Mature biomass	5+ biomass	Mature biomass	5+ biomass
	r / intercept	r / intercept	r / intercept	r / intercept
	.919 / 59399	.947 / -2126	.903 / 69885	.929 / 2723

TABLE 10a. Population numbers at age estimated from "NOMINAL" catch matrix.

POPULATION NUMBERS 10/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	1915657	1413584	198893	629633	3676520	1127288	263457	1605344	1226071	1480024	1481783
2	805207	1567725	1144541	162839	515500	3010080	922945	215419	1312876	1003822	1208494
3	3501218	544857	744123	697749	89464	294932	2150721	601348	167715	1006384	756177
4	413093	2327279	380598	445553	411813	47315	208735	1555968	437546	107296	713224
5	102206	239105	1347472	227922	246618	162568	28479	128190	948645	295965	71780
6	58347	52533	147626	756076	121156	105946	35715	19119	85084	499156	176240
7	45561	24641	29208	75082	420150	49368	32061	11420	12412	50001	268839
8	49205	19784	12827	15447	44317	207732	15730	12205	6177	8686	31066
9	48502	24357	11390	7572	8152	25004	82542	3847	5513	3325	5723
10	30335	21761	10021	6176	2982	4075	11569	35561	1332	3278	1838
1+	6969330	6235627	4026700	3024050	5536673	5034309	3751955	4188423	4203371	4457937	4715164
2+	5053673	4822042	3827807	2394417	1860153	3907021	3488498	2583078	2977299	2977914	3233380
3+	4248466	3254317	2683266	2231577	1344653	896941	2565553	2367659	1664423	1974091	2024887
4+	747249	2709460	1939143	1533828	1255188	602009	414832	1766311	1496708	967707	1268710

TABLE 10b. Population numbers at age estimated from "ADJUSTED NOMINAL" catch matrix.

POPULATION NUMBERS 10/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	1930304	1424388	203902	684503	4380098	1271601	300120	1688606	1271423	1480024	1482495
2	810106	1579717	1153386	166941	560423	3586121	1041098	245436	1380085	1040953	1208493
3	3544353	548868	753941	704991	92822	331712	2622343	698084	188353	1042135	774427
4	418401	2362595	383882	453592	417742	50065	238848	1942100	489991	111707	730820
5	102823	243451	1376386	230611	253200	167423	30730	152844	1111151	314983	73383
6	58544	53038	151184	779749	123357	111334	39689	20962	97266	530135	181454
7	45842	24803	29621	77995	439532	51171	36473	14674	12862	52042	270964
8	49490	20013	12959	15785	46701	223601	17206	15817	7252	8500	31208
9	48908	24590	11578	7680	8430	26956	95534	5056	6314	3605	5346
10	30638	22094	10212	6330	3071	4302	13168	46198	1416	3545	1912
1+	7039409	6303557	4087054	3128177	6325376	5824284	4435210	4829777	4566113	4587630	4760502
2+	5109105	4879169	3883151	2443674	1945278	4552684	4135090	3141171	3294690	3107606	3278007
3+	4298998	3299452	2729765	2276733	1384855	966563	3093991	2895735	1914605	2066653	2069514
4+	754646	2750583	1975824	1571742	1292033	634851	471648	2197651	1726251	1024518	1295087

TABLE 11a. Mean population biomass from "NOMINAL" catch matrix.

MEAN POPULATION BIOMASS (t.) 10/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	17359	12743	1803	5707	33322	10217	2386	14542	11112	13397	13414
2	27330	45315	37015	5023	16195	104811	30779	7813	47267	35841	42315
3	321933	51277	65199	60735	7411	27928	205781	57693	15150	95358	71157
4	54732	308392	51216	57850	46123	6382	28415	211107	62291	15196	96537
5	16270	41355	223113	36832	36296	18247	5121	22927	152603	50348	12314
6	9932	10093	27254	145227	20310	15701	5412	3943	16763	94538	35227
7	8838	5175	6178	16689	86250	8412	5880	2440	2985	11379	60506
8	11414	4910	3220	3687	10899	43812	2726	2720	1487	2294	7896
9	11811	5714	3016	1744	2081	6171	19751	840	1522	888	1594
10	8758	6526	2968	1811	794	975	3308	10931	398	980	563
1+	488377	491502	420980	335304	259682	242656	309558	334955	311578	320218	341523
2+	471018	478758	419177	329597	226360	232439	307172	320413	300465	306821	328109
3+	443689	433443	382163	324574	210165	127628	276393	312600	253198	270980	285795
4+	121755	382167	316964	263840	202754	99700	70612	254907	238049	175623	214638

TABLE 11b. Mean population biomass from "ADJUSTED NOMINAL" catch matrix.

MEAN POPULATION BIOMASS (t.) 10/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	17492	12841	1848	6204	39699	11525	2719	15292	11523	13397	13413
2	27512	45772	37346	5177	17881	126245	35186	8841	49332	36946	41421
3	326328	51685	66204	61476	7757	31667	253705	65846	16431	98257	71089
4	55568	313952	51732	59119	47088	6814	33137	255963	68123	15688	94525
5	16394	42220	228892	37371	37640	19345	5567	26807	171160	52781	12030
6	9979	10211	28088	150743	20838	17039	6386	4212	18367	98085	34658
7	8913	5218	6287	17451	91376	8913	7071	3012	3012	11652	58275
8	11499	4978	3259	3787	11605	48644	3204	3343	1685	2197	7580
9	11945	5792	3077	1780	2172	6813	24038	1012	1698	945	1423
10	8867	6645	3036	1866	826	1059	3879	13798	407	1040	559
1+	494497	499313	429768	344975	276882	278063	374892	398126	341739	330987	334973
2+	477005	486472	427920	338771	237183	266538	372173	382834	330216	317590	321560
3+	449493	440700	390575	333594	219302	140293	336987	373993	280884	280644	280139
4+	123165	389015	324371	272117	211545	108626	83282	308147	264453	182387	209050

TABLE 12a. Fishing mortalities at age estimated from "NOMINAL" catch matrix.

FISHING MORTALITY 10/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.000	0.011	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.003	0.003
2	0.191	0.545	0.295	0.399	0.358	0.136	0.228	0.050	0.066	0.083	0.124
3	0.208	0.159	0.313	0.327	0.437	0.146	0.124	0.118	0.247	0.144	0.159
4	0.347	0.346	0.313	0.391	0.729	0.308	0.288	0.295	0.191	0.202	0.300
5	0.466	0.282	0.378	0.432	0.645	1.316	0.198	0.210	0.442	0.318	0.300
6	0.662	0.387	0.476	0.388	0.698	0.995	0.940	0.232	0.332	0.419	0.300
7	0.634	0.453	0.437	0.327	0.504	0.944	0.766	0.415	0.157	0.276	0.300
8	0.503	0.352	0.327	0.439	0.372	0.723	1.208	0.595	0.419	0.217	0.300
9	0.601	0.688	0.412	0.732	0.493	0.571	0.642	0.861	0.320	0.393	0.300
10	0.429	0.345	0.372	0.394	0.614	0.865	0.451	0.291	0.353	0.352	0.300
4+	0.435	0.346	0.373	0.395	0.620	0.911	0.485	0.292	0.359	0.355	0.300

TABLE 12b. Fishing mortalities at age estimated from "ADJUSTED NOMINAL" catch matrix.

FISHING MORTALITY 10/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.000	0.011	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.003	0.004
2	0.189	0.540	0.292	0.387	0.324	0.113	0.200	0.065	0.081	0.096	0.170
3	0.206	0.158	0.308	0.323	0.417	0.128	0.100	0.154	0.322	0.155	0.212
4	0.342	0.340	0.310	0.383	0.714	0.288	0.246	0.358	0.242	0.220	0.400
5	0.462	0.276	0.368	0.426	0.622	1.239	0.183	0.252	0.540	0.352	0.400
6	0.659	0.383	0.462	0.373	0.680	0.916	0.795	0.288	0.425	0.471	0.400
7	0.629	0.449	0.429	0.313	0.476	0.890	0.635	0.505	0.214	0.311	0.400
8	0.499	0.347	0.323	0.427	0.350	0.650	1.025	0.718	0.499	0.264	0.400
9	0.595	0.679	0.404	0.717	0.473	0.516	0.527	1.073	0.377	0.434	0.400
10	0.424	0.339	0.364	0.382	0.590	0.796	0.384	0.354	0.436	0.393	0.400
4+	0.430	0.340	0.365	0.383	0.597	0.838	0.407	0.355	0.446	0.397	0.400

Table 13a. Selection matrix for "NOMINAL" catches.

SELECTION MATRIX 30/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.001	0.024	0.000	0.000	0.000	0.000	0.002	0.003	0.000	0.007	0.008
2	0.300	1.191	0.608	0.994	0.643	0.156	0.267	0.123	0.209	0.207	0.415
3	0.332	0.346	0.646	0.816	0.784	0.167	0.144	0.288	0.782	0.359	0.530
4	0.570	0.768	0.643	0.979	1.308	0.353	0.336	0.721	0.605	0.503	1.000
5	0.733	0.653	0.796	1.074	1.163	1.509	0.232	0.513	1.401	0.793	1.000
6	1.030	0.845	1.070	0.998	1.247	1.156	1.098	0.567	1.051	1.043	1.000
7	1.003	0.968	0.902	0.931	0.952	1.074	0.921	1.013	0.497	0.687	1.000
8	0.857	0.775	0.654	1.097	0.811	0.915	1.377	1.542	1.328	0.541	1.000
9	1.123	1.746	0.859	1.732	0.889	0.919	0.920	1.973	1.113	0.978	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
F	0.635	0.458	0.485	0.401	0.558	0.872	0.856	0.409	0.316	0.402	0.300

Table 13b. Selection matrix for "ADJUSTED NOMINAL" catches.

SELECTION MATRIX 30/ 8/84

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.001	0.024	0.000	0.000	0.000	0.000	0.002	0.003	0.000	0.005	0.008
2	0.300	1.192	0.613	0.991	0.606	0.140	0.278	0.126	0.200	0.212	0.390
3	0.331	0.347	0.648	0.828	0.779	0.160	0.140	0.300	0.797	0.342	0.530
4	0.568	0.766	0.649	0.985	1.333	0.358	0.343	0.698	0.598	0.486	1.000
5	0.732	0.652	0.795	1.089	1.167	1.540	0.254	0.491	1.334	0.777	1.000
6	1.030	0.845	1.069	0.998	1.266	1.152	1.106	0.562	1.051	1.041	1.000
7	1.001	0.970	0.903	0.930	0.949	1.100	0.908	0.983	0.529	0.688	1.000
8	0.858	0.773	0.657	1.099	0.808	0.911	1.407	1.478	1.233	0.583	1.000
9	1.123	1.748	0.859	1.742	0.887	0.917	0.919	2.013	1.024	0.959	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
F	0.632	0.453	0.477	0.390	0.536	0.805	0.719	0.513	0.405	0.453	0.400

Table 14. Historical partial recruitments used in previous 4X herring assessments.

Number	References	Age					
		1	2	3	4	5	6-10
1a	Sinclair and Iles (1981) "average" conditions	0	0.8	0.6	0.9	1	1
1b	Sinclair and Iles 1981) "representative" of 1978 to 1979	0.006	0.4	0.23	0.9	1	1
2	Sinclair et al. (1982) average for 1975 to 1978	0.001	0.5	0.53	0.77	1	1
3	Iles and Simon (1983) "conform more closely with the pattern of recruitment at age for herring generally"	0.01	0.22	0.53	1	1	1

Table 15. 4WX herring catch projections generated assuming an 80,000 ton TAC in 1984 and F = 0.3 in subsequent years.

"NOMINAL"

CATCH BIOMASS t. 10/ 8/84

	1983	1984	1985	1986	1987	1988	1989
1	34	36	38	38	38	38	38
2	5263	2729	2871	2871	2871	2871	2871
3	11314	12463	13956	13888	13886	13886	13886
4	20961	20467	24975	26383	26255	26252	26252
5	3694	21249	16746	19199	20282	20184	20181
6	10568	2492	15983	11834	13568	14333	14264
7	18152	6889	1811	10915	8082	9266	9789
8	2369	11868	5022	1241	7477	5536	6347
9	478	1503	8396	3339	825	4970	3680
10	169	304	1066	5596	2225	550	3313
1+	81002	80000	90866	95305	95510	97886	100620
2+	80969	79964	90827	95267	95471	97848	100582
3+	75705	77235	87956	92396	92601	94977	97711
4+	64391	64772	74000	78508	78715	81091	83825

FISHING MORTALITY 10/ 8/84

	1983	1984	1985	1986	1987	1988	1989
1	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2	0.124	0.063	0.066	0.066	0.066	0.066	0.066
3	0.159	0.151	0.159	0.159	0.159	0.159	0.159
4	0.300	0.284	0.300	0.300	0.300	0.300	0.300
5	0.300	0.284	0.300	0.300	0.300	0.300	0.300
6	0.300	0.284	0.300	0.300	0.300	0.300	0.300
7	0.300	0.284	0.300	0.300	0.300	0.300	0.300
8	0.300	0.284	0.300	0.300	0.300	0.300	0.300
9	0.300	0.284	0.300	0.300	0.300	0.300	0.300
10	0.300	0.284	0.300	0.300	0.300	0.300	0.300
1+	0.139	0.119	0.130	0.133	0.134	0.135	0.136

"ADJUSTED NOMINAL"

CATCH BIOMASS t. 10/ 8/84

	1983	1984	1985	1986	1987	1988	1989
1	48	41	41	41	41	41	41
2	7029	3083	3104	3104	3104	3104	3104
3	15071	13632	15028	15012	15012	15012	15012
4	37810	20695	25980	28410	28381	28380	28380
5	4812	20510	16047	19972	21840	21817	21817
6	13863	2400	14620	11340	14114	15434	15418
7	23310	6681	1653	9985	7745	9639	10541
8	3032	11267	4616	1132	6839	5305	6603
9	569	1422	7555	3068	753	4546	3526
10	224	268	956	5035	2045	502	3030
1+	105768	80000	89599	97099	99873	103760	107472
2+	105720	79959	89557	97058	99832	103739	107431
3+	98691	76876	86454	93954	96728	100635	104327
4+	83620	63243	71426	78942	81716	85624	89315

FISHING MORTALITY 10/ 8/84

	1983	1984	1985	1986	1987	1988	1989
1	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2	0.156	0.066	0.066	0.066	0.066	0.066	0.066
3	0.212	0.158	0.159	0.159	0.159	0.159	0.159
4	0.400	0.298	0.300	0.300	0.300	0.300	0.300
5	0.400	0.298	0.300	0.300	0.300	0.300	0.300
6	0.400	0.298	0.300	0.300	0.300	0.300	0.300
7	0.400	0.298	0.300	0.300	0.300	0.300	0.300
8	0.400	0.298	0.300	0.300	0.300	0.300	0.300
9	0.400	0.298	0.300	0.300	0.300	0.300	0.300
10	0.400	0.298	0.300	0.300	0.300	0.300	0.300
1+	0.179	0.119	0.126	0.130	0.132	0.134	0.136

Table 16. Numbers of age 1 and 2 fish caught by New Brunswick weirs (non-stock fish) and stock fisheries (mostly purse seiners) in 1982 and 1983.

	Age 1	Age 2	Total 1+2	% of total caught by stock fisheries
1982				
Stock total	3,589	72,591	76,180	15.18
N.B. weirs & misc.	30,210	395,416	425,626	
			501,806	
1983				
Stock total	3,367	128,378	131,745	48.87
N.B. weirs & misc.	2,532	135,283	137,815	
			269,560	

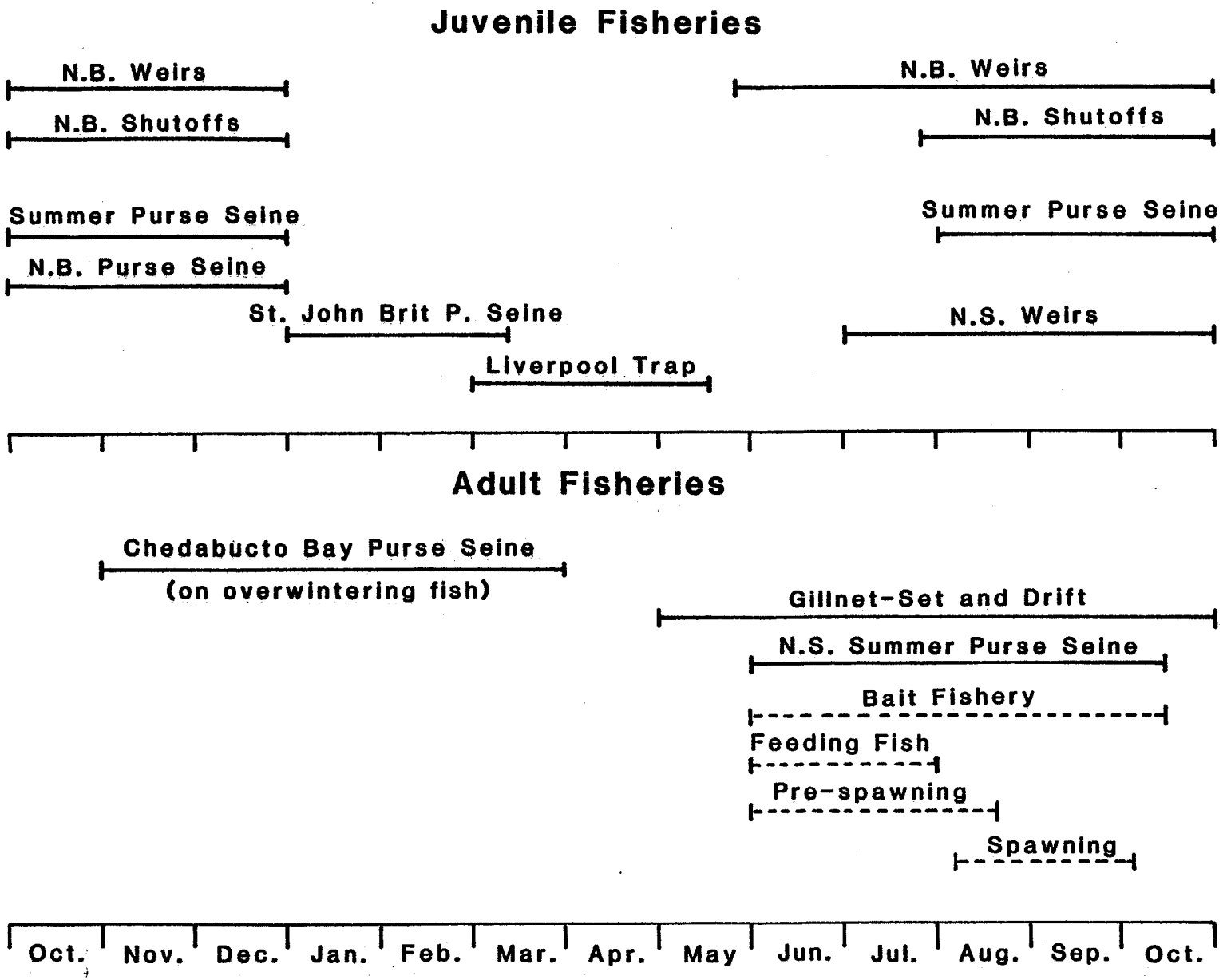

Fig. 1. Schematic representation of approximate seasonal distribution of the various components of the juvenile and adult 4WX herring fisheries.

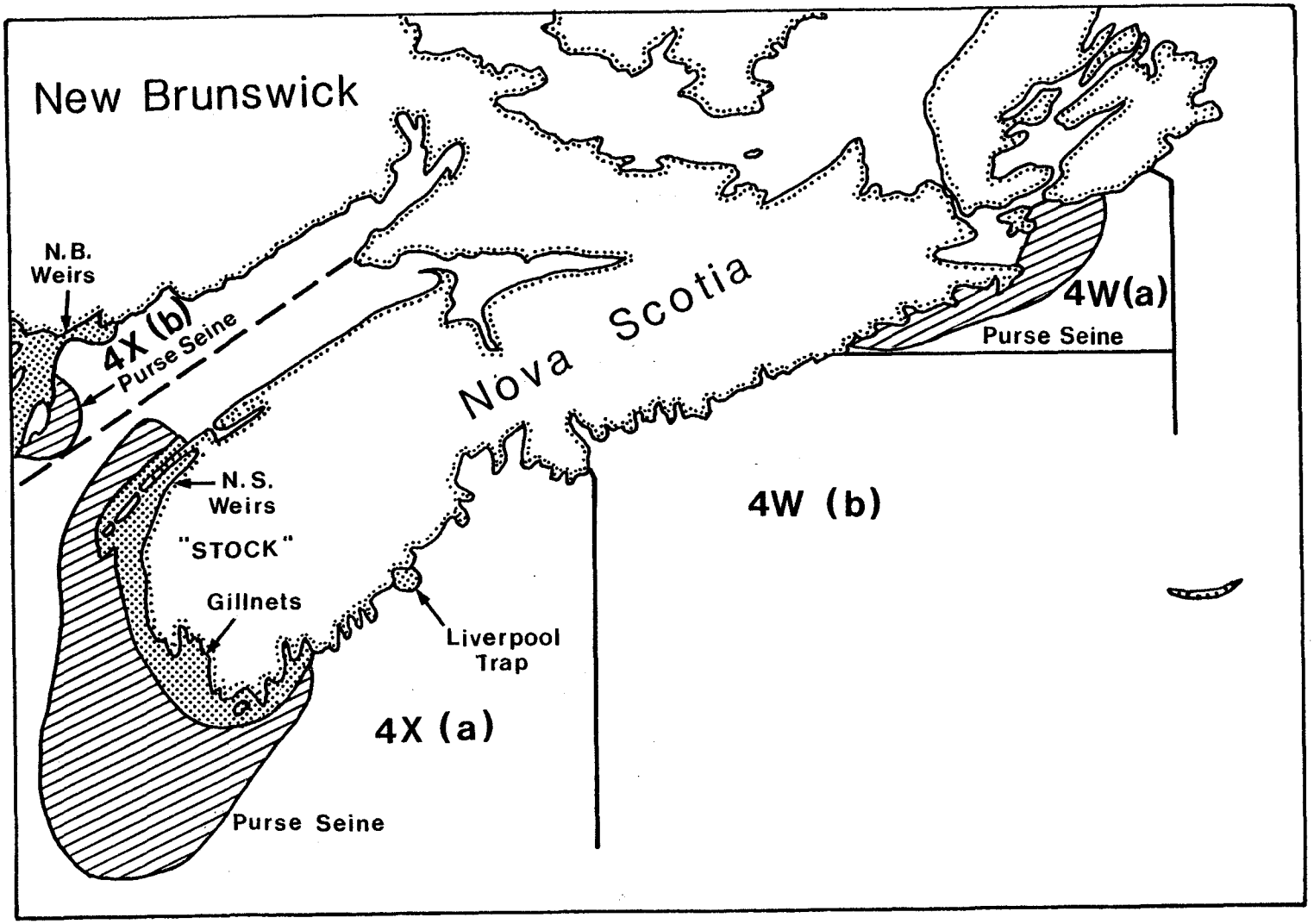

Fig. 2. Geographical location of various components of the 4WX herring fishery.

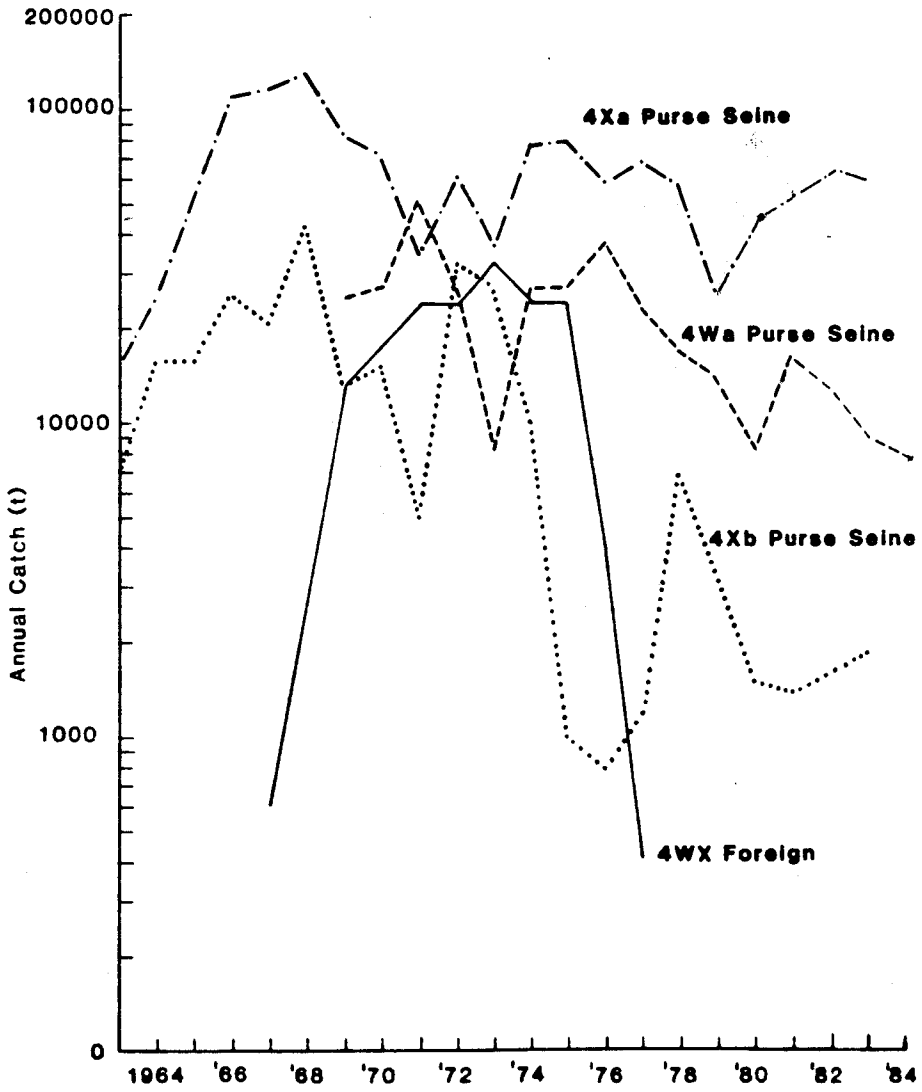

Fig. 3. 4WX mobile gear herring catch (1963 to 1984 "NOMINAL" catches).

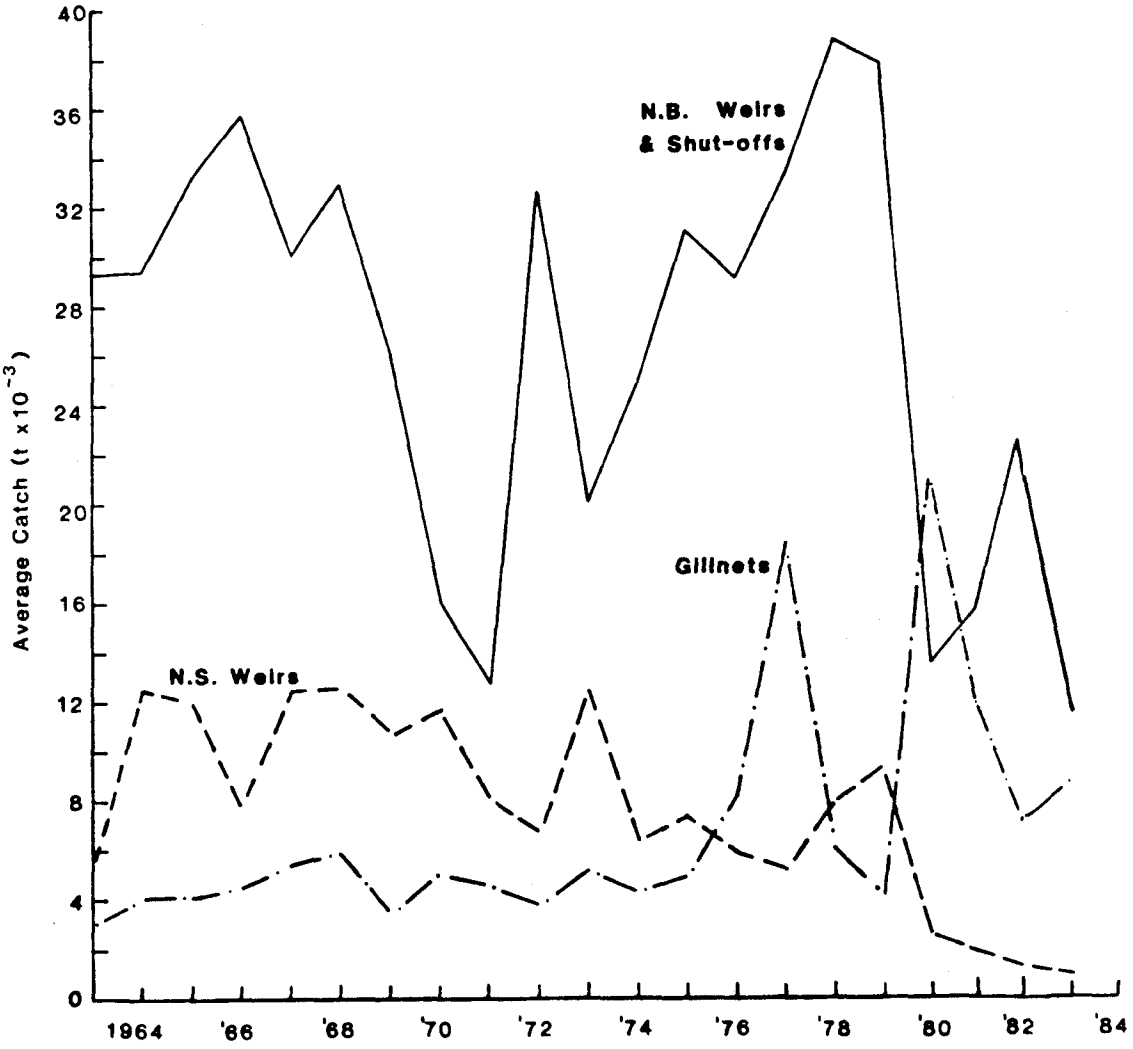

Fig. 4. 4X fixed gear herring catch (1963 to 1983).

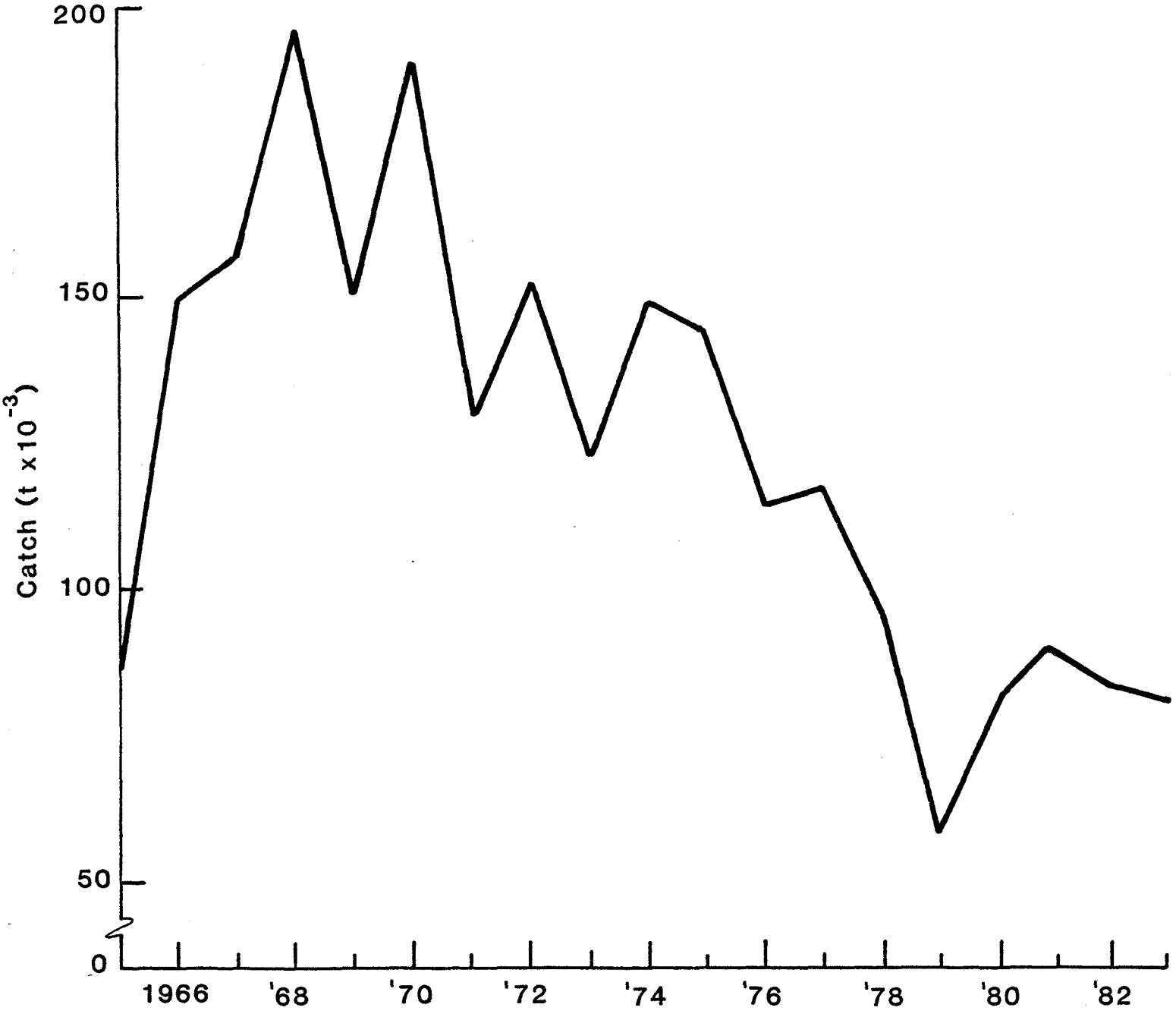

Fig. 5. 4WX herring "stock" annual catch (1965-1983 'nominal' catches).

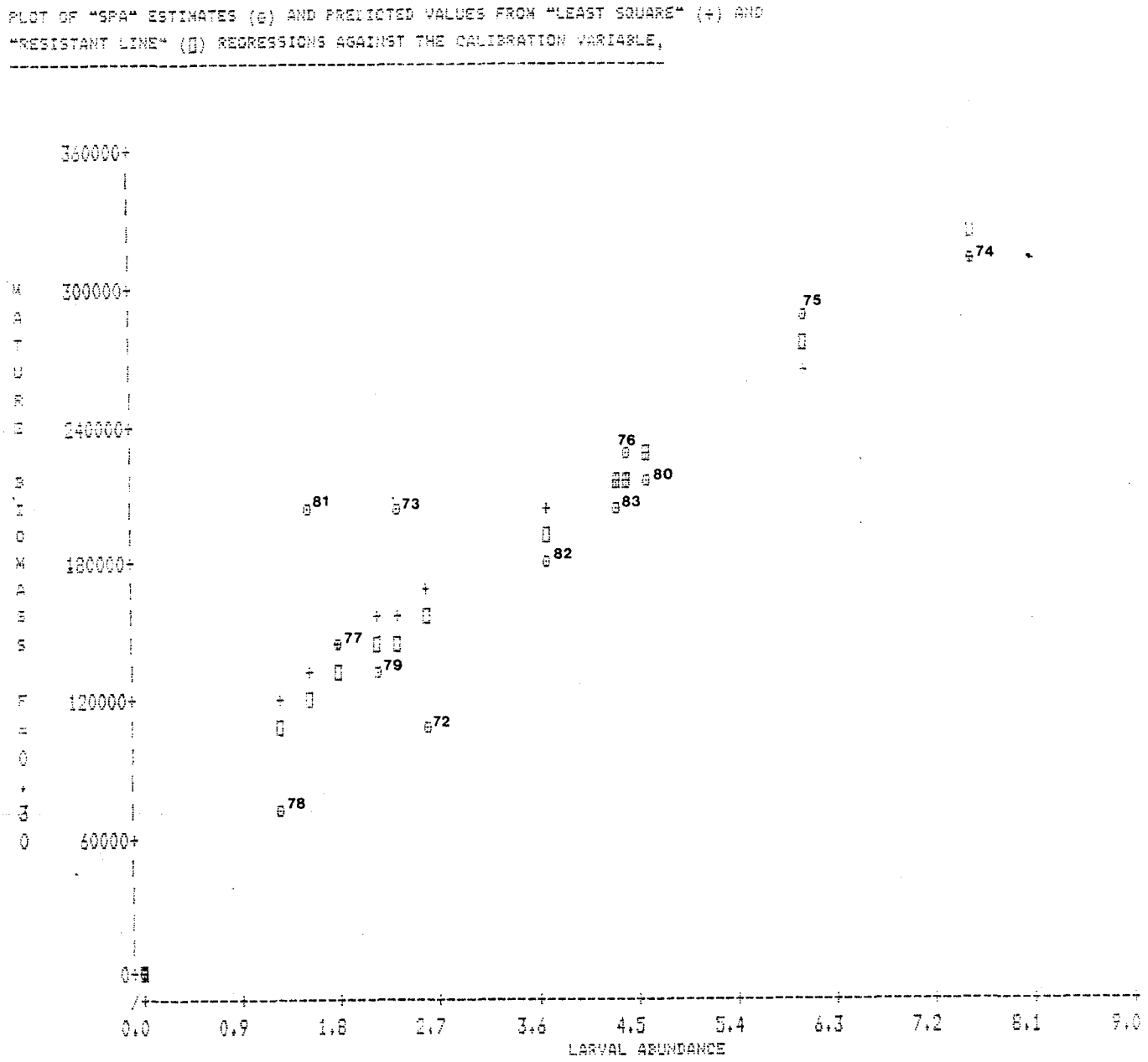

Fig. 6a. 4WX herring "NOMINAL" SPA estimated mature biomass vs. larval abundance.

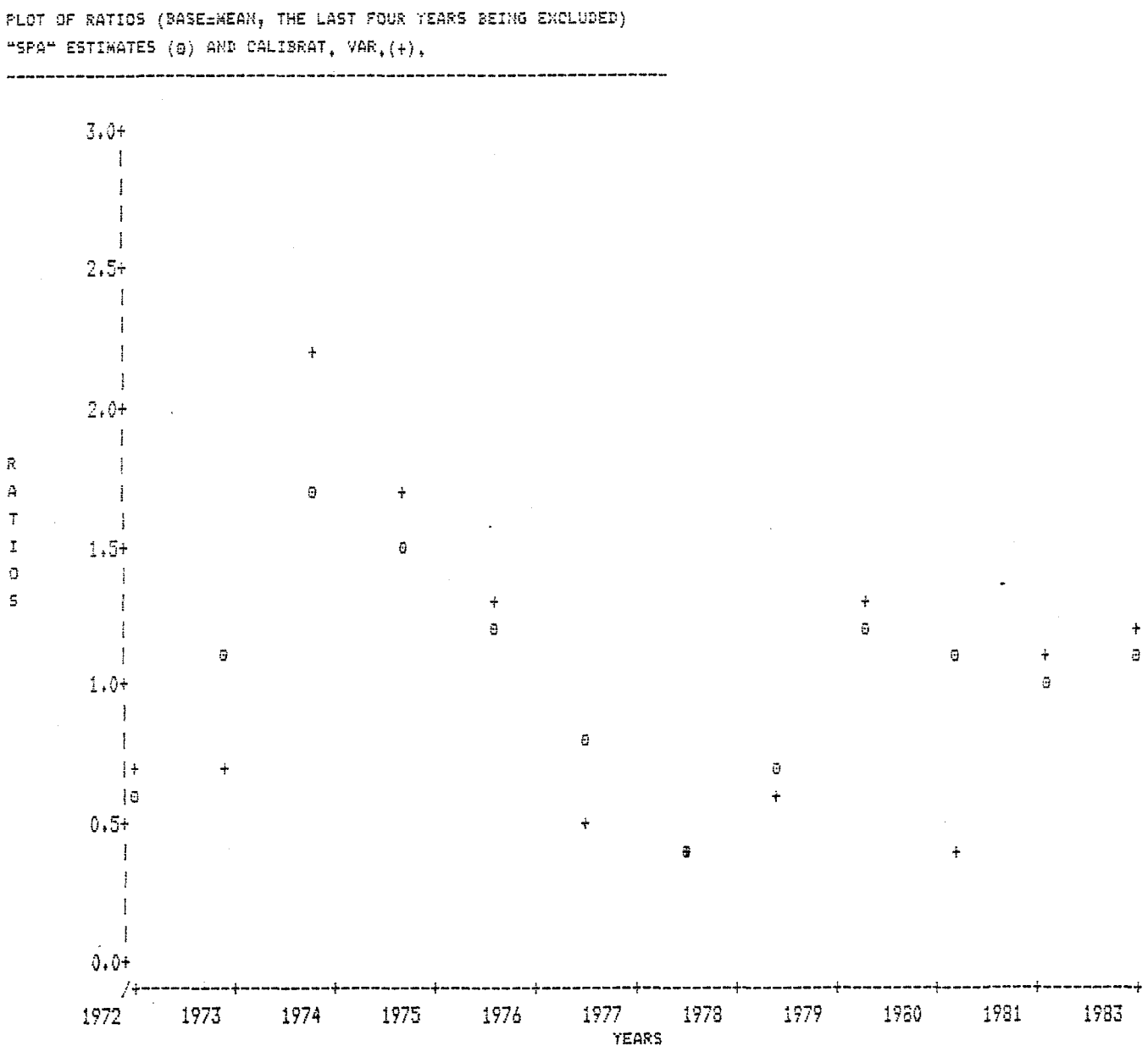

Fig. 6b. Ratios of 4WX herring "NOMINAL" SPA estimated mature biomass and larval abundance for 1972 to 1983.

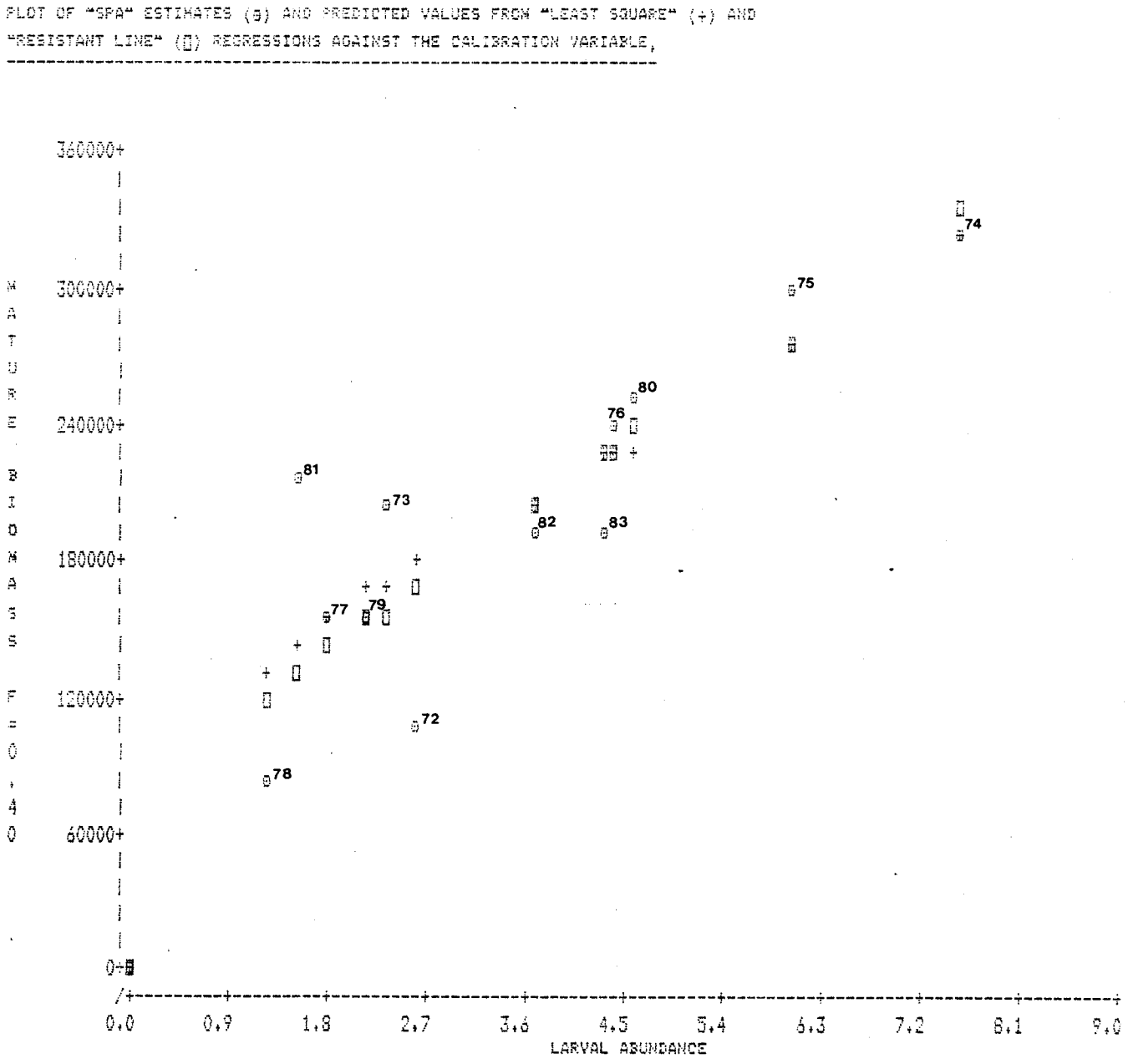

Fig. 7a. 4WX herring "ADJUSTED NOMINAL" SPA estimated mature biomass vs. larval abundance.

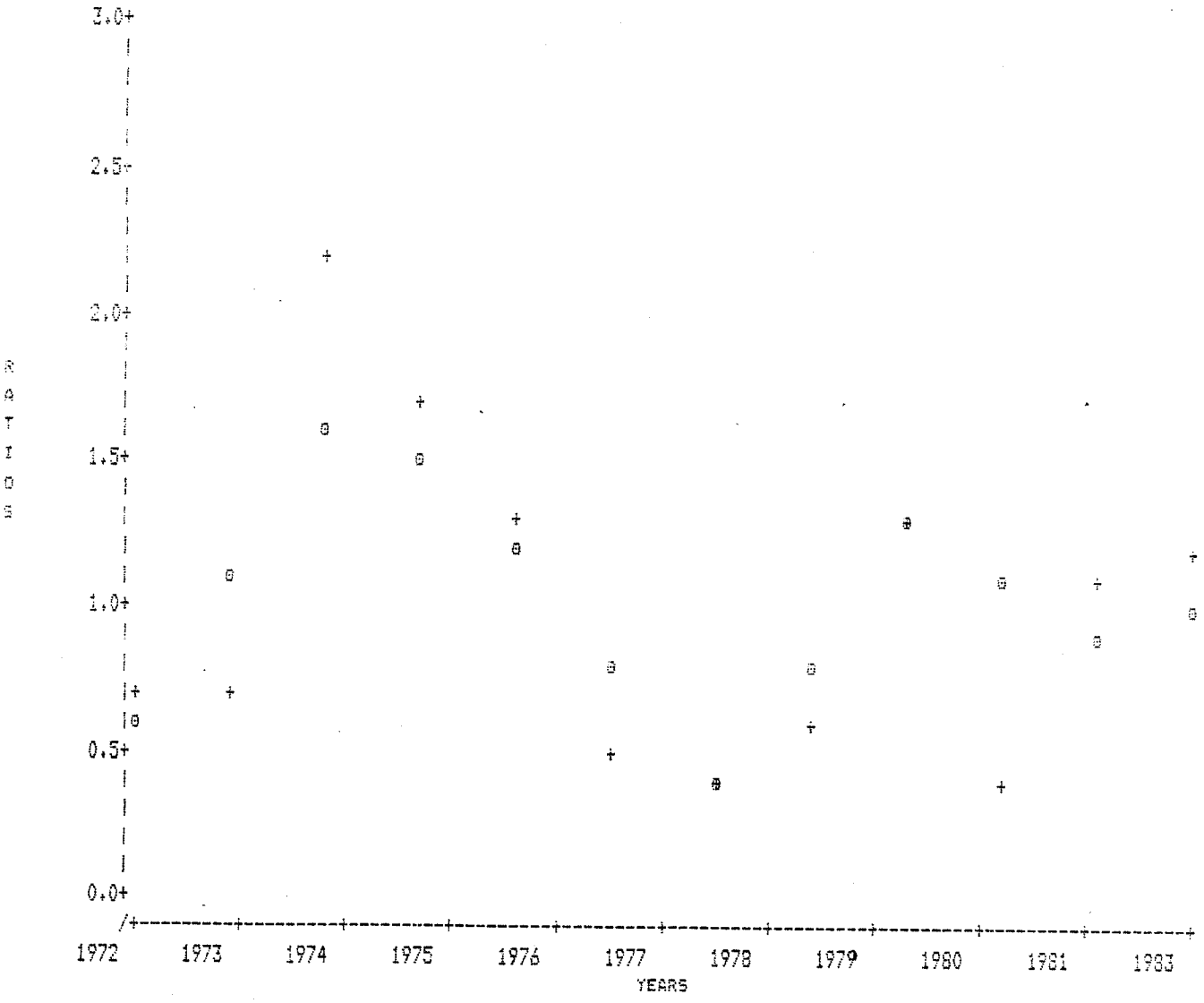

Fig. 7b. Ratios of 4WX herring "ADJUSTED NOMINAL" SPA estimated mature biomass and larval abundance for 1972 to 1983.

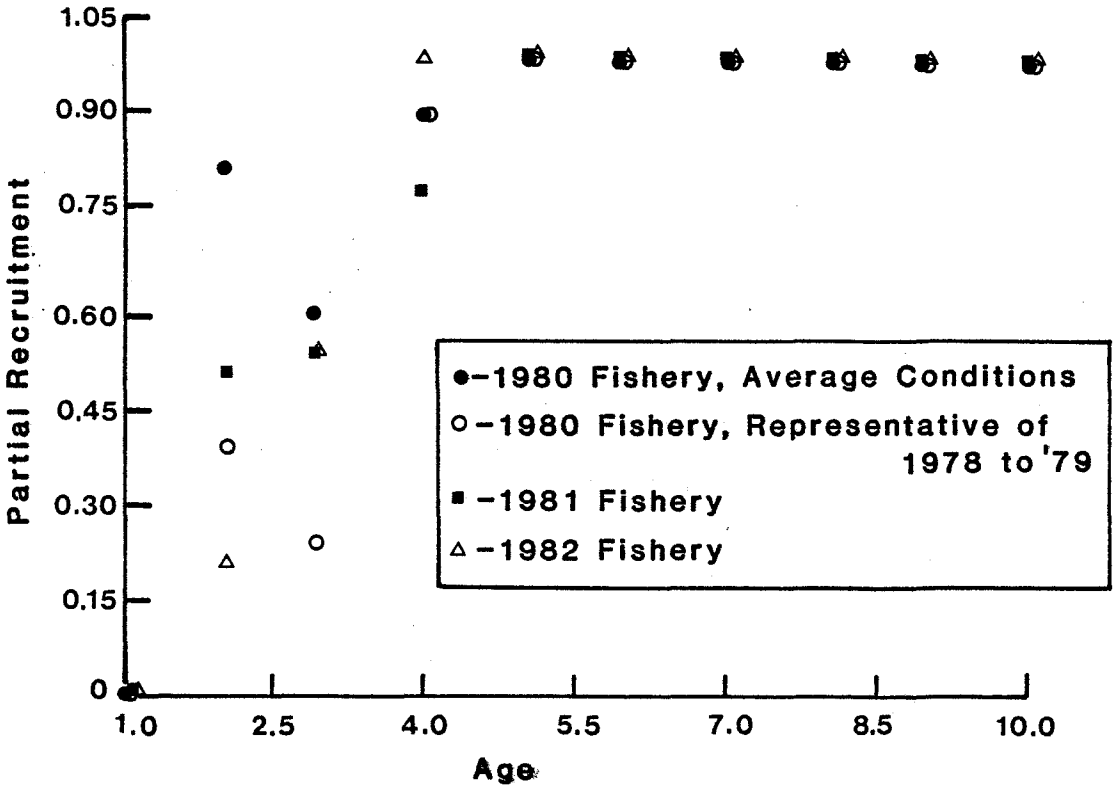

Fig. 8. Partial recruitment vectors used in recent 4WX herring assessments.

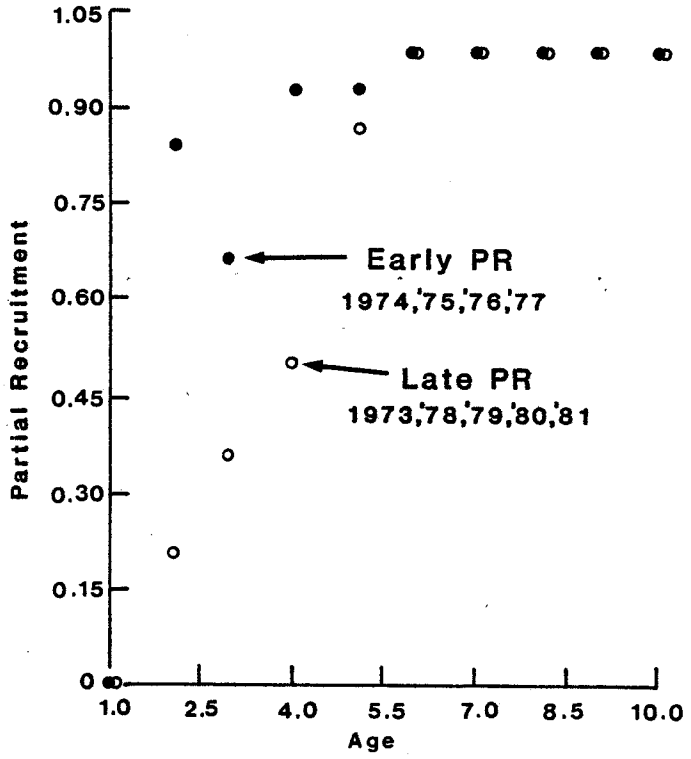

Fig. 9. 4WX herring average partial recruitment vector calculated from Table 13 for "early" and "late" years.

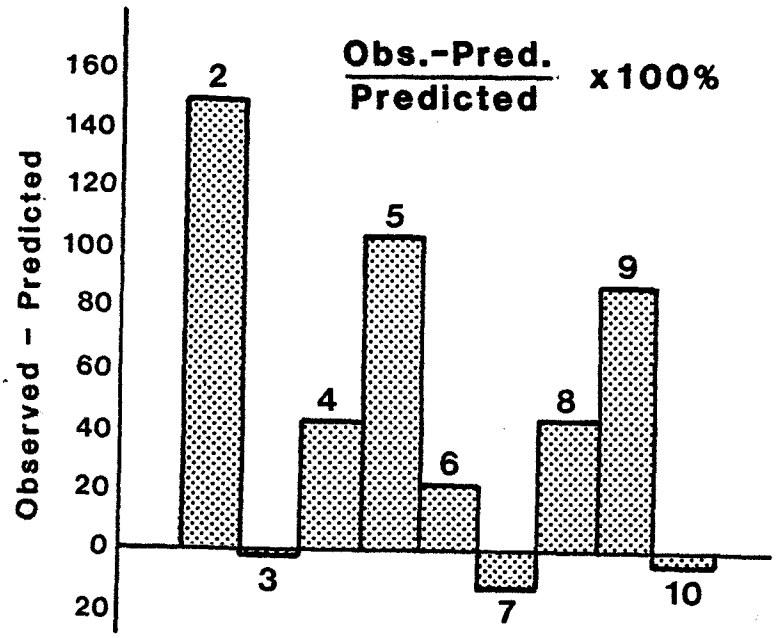

Fig. 10. Comparison of 4WX herring projected catch at age from 1982 fishery assessment vs. actual catch in 1983.

Appendix A. Cruise Report for E.E. Prince P-300, January 21, 1984 - February 21, 1984.

Cruise Report

VESSEL and CRUISE NUMBER: E.E. PRINCE P-300

DEPARTURE PORT: Halifax, N.S. DATE: 21 January 1984

ARRIVAL PORT: Halifax, N. S. DATE: 21 February 1984

PERSONNEL: U. Buerkle, i/c 22 Jan.-10 Feb. 84
C. Dickson, i/c 10 Feb.-21 Feb. 84
J. Trynor
R. Arsenault
J. Leslie
D. Haughn

PURPOSE:

To collect acoustic scattering data in the Chedabucto Bay winter herring fishery as an index of herring distribution and abundance. To photograph tilt-angle distributions of herring with BRUTIV.

METHODS:

The area to be surveyed was determined from the locations of purse seine catches in NAFO Division 4WA for the previous ten (10) years. The cruise track (Fig. 1) was searched with the acoustic system operating continuously at a vessel speed of eight (8) knots. Acoustic targets were sampled by a mid-water trawl (Engel 400). BRUTIV was towed to photograph the herring at various depths in order to determine the tilt angle.

Detailed log records were kept and the echo sounder paper was marked every 15 minutes (5 minutes when in fish) or whenever a change in course occurred. Herring samples were measured and a biological sample (50 fish) was returned to St. Andrews for detailed sampling.

RESULTS:

A very large school of herring was found in Chedabucto Bay.

It was about 6.5 x 2.5 miles in extent with herring from bottom to about 30 fathoms up. It was mapped repeatedly during different nights with the acoustic system. Seven (7) mid-water trawl tows were made, all being successful. Two tows at the extreme western end of the school produced juvenile fish (Table 1). The remaining five tows produced a majority of adult fish (Table 2).

At times during the day, the school (or part of) disappeared. Apparently, the herring went to bottom and were invisible to acoustics. (A 15 minute bottom trawl tow made in the area over a piece of ground where the echo sounder showed nothing, caught 700 to 800 lbs of herring).

BRUTIV was deployed eleven (11) times on this school. The test films developed on-the-spot showed good concentrations of fish being photographed.

Two other concentrations of fish were logged with the acoustic system - one in the Green Island-Cape Hogan area where two (2) mid-water tows were successful, a mixture of juvenile and adult fish were caught (Table 3); the other school in the Carousse Bank area - no tows were made in this area. Since the fish were laying against the side of the bank and on bottom, it was impossible to sample these fish with a mid-water trawl.

Due to unseasonably fine weather, 2830 km of cruise track were completed (some duplication in areas of fish). Approximately seven (7) days were necessitated in the setting up and testing the acoustic data logger and BRUTIV. Eight days were lost to inclement weather.

Future surveys, exceeding five weeks, should be done in two parts with a one-week break at midpoint.

Responsible officer: C. K. Pickerson

Date: 15 March 1984

Approved for release: G. J. Scott
for W. T. Stobo, A/Chief
Marine Fish Division

Table 1. Size composition of juvenile herring sampled in Chedabucto Bay (2 tows).

Size class	No. of fish	Size class	No. of fish
14.5	5	18.0	10
15.0	16	18.5	4
15.5	23	19.0	1
16.0	47	19.5	2
16.5	36	20.0	0
17.0	19	20.5	2
17.5	10		
		Total	175

Table 2. Size composition of herring sampled in Chedabucto Bay (5 tows).

Size Class	No. of fish	Size class	No. of fish	Size class	No. of fish
15.0	1	25.0	14	33.0	22
17.5	1	25.5	14	33.5	27
18.0	1	26.0	13	34.0	15
18.5	1	26.5	30	34.5	6
19.0	0	27.0	29	35.0	6
19.5	1	27.5	32	35.5	4
20.0	0	28.0	47	36.0	2
20.5	3	28.5	45	36.5	0
21.0	4	29.0	48	37.0	0
21.5	5	29.5	56	37.5	2
22.0	4	30.0	36	38.0	1
22.5	11	30.5	31	38.5	0
23.0	15	31.0	21	39.0	3
23.5	16	31.5	27	39.5	1
24.0	8	32.0	22		
24.5	5	32.5	17	Total	646

Table 3. Size composition of herring sampled in the Green Island-Cape Hogan area (2 tows).

Size class	No. of fish	Size class	No. of fish
11.0	1	26.0	13
13.5	3	26.5	7
16.0	2	27.0	19
16.5	1	27.5	10
17.0	1	28.0	20
19.0	0	28.5	19
19.5	2	29.0	18
20.0	3	29.5	12
20.5	4	30.0	8
21.0	7	30.5	6
21.5	3	31.0	5
22.0	7	31.5	4
22.5	8	32.0	5
23.0	23	32.5	3
23.5	12	33.0	2
24.0	18	33.5	1
24.5	9	34.0	1
25.0	14	34.5	1
25.5	9		
		Total	281

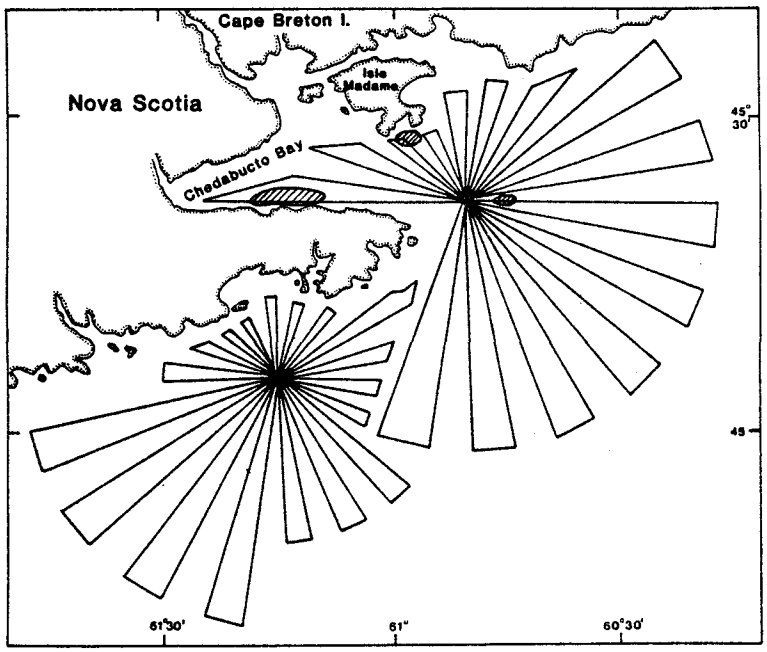

Fig. 1. Map showing survey track in the Chedabucto Bay area. Shaded areas show where major concentrations of herring were located.