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Assessment of the 1981 4WX Herring Fishery

by

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Abstract

The catches from the components prosecuting predominantly adult fish were moderately good in 1981 in relation to recent years. The 1981 juvenile fisheries in both Nova Scotia and New Brunswick, although slightly better than the disastrous 1980 season, were low in relation to historical levels. The 1981 catch against quota in 4WX (i.e. excluding the New Brunswick weirs and shutoffs) was 87,706 t, the total 4WX catch being 106,785 t. The catch of the adult fisheries was predominated by five-year olds (1976 year-class). The juvenile fisheries were supported by the two-year olds (1979 year-class), the 1978 year-class again being exceptionally weak in the weir catches. The adult fishery catch rates were again interpreted to be biased downwards due to market constraints and weather conditions (for 1981/82 4Wa winter purse seine fishery). The drift gillnet catch rate on pre-spawning and spawning fish was the highest recorded in the relatively short time series (1977 to 1981). The larval abundance index (of spawning stock size), which was used in the previous assessment to fine tune the VPA, declined sharply in 1981. The catch rates at Ages 1, 2 and 3 for the New Brunswick weirs were used as indices of year-class strength. The 1978 year-class is indicated to be the worst in the time series (since 1964), the 1979 of moderate size. Of the various abundance indices available, the gillnet and New Brunswick weir catch rates were chosen as the most suitable for fine tuning the VPA. With a fully recruited F of 0.32 the 1981 Age 4+ biomass, 349,000 t, indicates that the population biomass is beginning to decline subsequent to the maximization of biomass of the 1976 year-class. The year-classes since 1973, with the exception of 1976, are poor relative to the earlier period (1964 to 1972). An $F_{0.1}$ value of 0.3 was used for the projections. The 1982 and 1983 $F_{0.1}$ catches are projected to be 77,000 and 75,000 t respectively.

Résumé

Les prises des unités exploitant surtout le hareng adulte furent modérément bonnes en 1981 comparativement à celles des années antérieures. Cette même année, les prises de jeune hareng, tant en Nouvelle-Ecosse qu'au Nouveau-Brunswick, bien que légèrement supérieures à celles de la désastreuse saison de 1980, furent faibles par comparaison avec les niveaux historiques. Les prises de 1981 à même le contingent de 4WX (c.-à-d. à l'exclusion des pêches à fascines et des sennes-barrages du Nouveau-Brunswick) furent de 87 706 t, les prises totales dans cette zone étant de 106 785 t. Les prises de hareng adulte comprenaient surtout des poissons de 5 ans (classe d'âge de 1976); celles des jeunes, des poissons de 2 ans (classe d'âge de 1979), la classe d'âge de 1978 étant de nouveau très mal représentée dans les prises des pêches à fascines. On considère encore les taux de capture des pêcheries d'adultes comme étant biaisés vers le bas à cause des contraintes du marché et des conditions météorologiques (dans la pêcherie à la senne coulissante de l'hiver 1981/82 dans 4Wa). Le taux de capture de poissons sur le point ou en voie de pondre, par les filets maillants dérivants, était le plus élevé de la courte série (1977 à 1981). L'indice d'abondance des larves (indice de la taille du stock reproducteur) utilisé dans l'ajustement précis de l'analyse de population virtuelle (APV) lors de l'évaluation antérieure diminua brusquement en 1981. Les taux de capture des âges 1, 2 et 3 dans les pêches à fascines du Nouveau-Brunswick ont été utilisés comme indices d'abondance des classes d'âge. On constate que la classe d'âge de 1978 est la plus pauvre de la série (depuis 1964) tandis que celle de 1979 est d'importance modérée. Parmi les divers indices d'abondance disponibles, les taux de capture des filets maillants et des pêches à fascines du Nouveau-Brunswick ont été choisis comme convenant le mieux à l'ajustement précis de l'APV. Avec un F de plein recrutement de 0,32, la biomasse d'âge 4+, soit 349 000 t, indique un début de diminution de biomasse de la population à la suite de la maximisation de la biomasse de la classe d'âge de 1976. Les classes d'âge de 1973 et suivantes, sauf celle de 1976, ont été faibles comparativement à celles de la période antérieure (1964 à 1972). Nous avons utilisé pour les projections une valeur $F_{0,1}$ de 0,3. Les projections de prises à $F_{0,1}$ en 1982 et 1983 sont 77 000 et 75 000 t respectivement.

Catch Description

The seasonal timing of the various components of the overall 4WX herring fishery are shown in Figure 1, and their geographical location shown in Figure 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 1981 fishery are given in Table 1. The historical catch trends are shown in Table 2 and Figures 3, 4, and 5. The winter purse-seine catch in the Chedabucto Bay area increased after the poor 1980 season, but the 1982 fishery has been limited by both bad weather and market conditions. The latter factor was also important during the summer purse-seine fishery off southwest Nova Scotia in 1981. The gillnet catches, even though market limited, were high in relation to historical levels. In sum the catches from the adult fisheries were moderately good in relation to recent years. The juvenile fisheries in both Nova Scotia and New Brunswick were low in relation to historical levels. The Nova Scotia weirs, which are more dependent on 3 year olds than are the New Brunswick weirs, reported the lowest landings since 1963. As predicted the Liverpool trap fishery, which was supported almost solely by the expansion of the juvenile range due to the exceptional 1976 year-class, was inoperative (the 1976 year-class being fully recruited to the adult phase). The 'stock' total catch in 4WX (excluding catches which have traditionally been considered as coming largely from stocks not spawning in the southwest Nova Scotia area; ie. the New Brunswick weirs and shutoffs as well as the small catches along the "Eastern" and "Southern" shores of Nova Scotia by fixed gears) was 87,706 t. This is less than the 1980 catch but higher than the historical low reported during 1979.

Biological Sampling and Catch Recording

The 4WX herring catches by all gear components have again been well sampled (Table 3). The location of catch, however, by the summer purse-seine fishery could not be broken down in as fine a detail as in previous years due to the transfer of this function from MFD in St. Andrews to the Statistics Branch in Halifax. The catch was broken down by purse-seine area according to the percentage distribution of catch by months in the Logbooks (Table 4). The length frequency samples were matched with catch-by-area generally on a monthly basis. The areas used for the purse-seine and weir catches are shown in Figures 6 and 7 respectively. The age-length keys were done on a monthly and a gear component basis wherever adequate sampling data were available, (eg. separate age-length keys for the New Brunswick versus Nova Scotia weirs). The adequacy of sampling data to generate an age-length key was largely based on subjective judgement as to whether the following criterion was met: were there enough specimens aged to allow generation of an age-length key which would result in a reasonable partitioning of the length frequency data into the various age-groups in the fishery and the length ranges of those age-groups?

Age Composition

The overall age composition of the catch of the various components of the fishery are shown in Table 5 and Figure 8a. The catches for the 1970 and 1971 year-classes have been adjusted in accordance with the criteria adopted by Stobo et al., (1978). The adjustment has been deemed necessary due to an aging

problem for the 1970 year-class. The catch of the adult fisheries were dominated by the 5 year olds (1976 year-class). The 1977 year-class which has been reported to be large in the Gulf of Maine herring fisheries (V. Anthony, per. comm.) did not contribute as large a proportion as had been expected. The 1970 year-class, even after the adjustment upwards, is no longer of importance in the catch. The catch of the 1978 year-class at age two in the weirs, is the lowest in the documented period of the fishery and was also poorly represented in the catch at age 3. As mentioned above the Nova Scotia weirs, which depend to a large degree on age 3 fish, reported their lowest catch since 1963. The 1979 year-class alone supported the New Brunswick weir and shutoff fisheries. The overall percentage age composition for the "stock" and for the 4WX total are shown in Figure 8b. The dominance of the 1976 year-class and the very low percentage of age 3 and age 6+ fish is striking. The mean weights-at-age for the "stock" (weighted by catch) are given in Table 6.

Abundance Indices

Lacking independent estimates of abundance, a variety of indices derived from the different commercial fishery gear components have been reviewed annually for inferences on stock status. Purse-seine and gillnet catch rates are used to try and evaluate abundance of adult fish while the catch rates from the weirs are used to infer juvenile abundance. All these commercial indices however have a variety of constraints which limit their usefulness in estimating stock.

Market constraints and nightly boat quotas have made the purse-seine CPUE and effort statistics extremely difficult to interpret in relation to herring abundance fluctuations. The temporal trends in catch rates for the purse-seine, as well as the other gear components are shown in Table 7. The purse-seine catch rates in the 4Xa and 4Wa fisheries have increased by 47% and 21% respectively. However these catch rates have not increased as much as would be expected with the full recruitment of what is generally perceived to be an exceptional year-class (1976). In comparison, recruitment of the very large 1970 year-class resulted in an increase in catch rates in 4Xa from a 1971 low of 32.6 to a high of 57.4 in 1975 (76%) and from 109.7 to 142.7 in 4Wa (30%). The market influences prevalent in the late 1970's are at least partially responsible, but the more modest increase in catch rates associated with the 1976 year-class suggest that it may not be as large as originally perceived.

The gillnet catch rates however show a consistent increase between 1978 and 1981 as would be expected with a large year-class becoming increasingly available to the gillnet mesh size. The 1981 catch rate is the highest of the 5-year data series and could be interpreted as indicative of a large year-class, especially since both processors and fishermen reported that the gillnet catches were limited by market constraints. Unfortunately although the catch rate series support the perception that the 1976 year-class is large, the time series is not long enough to provide confidence in estimating its size relative to the other large year-classes, 1966 and 1970.

The estimated annual catch-at-age in the weirs is potentially a useful preadult year-class strength index, especially since the number of active weirs has remained relatively constant since 1965. The New Brunswick weir 'catch

rate' time series is felt however to be influenced by immigration from Gulf of Maine stocks and, historically, by the Georges Bank juvenile abundance fluctuations (Sinclair et al, 1981). The Nova Scotia weir 'catch rate' data are also compromised since the catches by the weirs on the Nova Scotia side of the Bay of Fundy are strongly influenced by market demand. In spite of the above complications, and because of the lack of alternative abundance indices, considerable reliance is nevertheless given to the weir information. The Nova Scotia weirs 'catch rates' in 1980 and 1981 are the lowest in the 17-year time series while those for the New Brunswick weirs are the lowest since 1971 (Table 7). These 'catch rates' suggest that the 1977, 1978, and 1979 year-classes are poor since the weir catches rely largely on 2 and 3-year old fish, and ocassionally 1 year olds. The nature of the weir fisheries is such that even good year-classes do not necessarily contribute strongly to the catch at all three ages. This inconsistency is evident in the catch-at-age trends for the New Brunswick weirs as shown in Table 8a and indicates that any abundance index based on catch at a single age could be confounded. Considering cumulative catch of a year-class during the 3 years in which it contributed to the weir catch could however be more indicative of relative year-class size. The data are summarised for year-classes 1964-1978 in Table 8b and the 1966, 1970, and 1976 year-classes do appear large. The 1978 year-class appears as the poorest on record. This analysis also suggests however that the 1976 year-class is the largest observed and the 1977 year-class is also quite large, and is obviously in contrast with the catch rate data in Table 7.

In the 1980 assessment considerable weight was placed on the autumn Bay of Fundy larval abundance estimates (as a relative spawning size estimate) in the previous assessment. The larval abundance estimates from 1972 to the present are given in Table 9. The 1981 abundance estimate has decreased sharply, which was not expected since the exceptional 1976 year-class is fully mature and close to the age of maximal biomass. The results are preliminary but nevertheless suggest that there may be problems with this index.

Since the indices do not provide a consistent picture of adult or juvenile abundance, the gillnet and New Brunswick weir catch rate indices were chosen as the most suitable for "fine-tuning" the sequential population analysis.

Estimation of Population Size

The catch matrix for the 4WX stock is shown in Table 10. Annual fishing mortalities for age 10 fish were estimated by the standard iteration procedure using the ages 5 to 8 inclusive. Partial recruitment was estimated by averaging the F values estimated for the years 1975 to 1978. The mean F^S for ages 5 to 10 for this time period were averaged and divided into the mean F_S for Ages 1, 2, 3 and 4 respectively to generate the PR vector below: -

Age	1	2	3	4	5	6	7	8	9	10
PR	-	0.50	0.53	0.77	1	1	1	1	1	1

Fully recruited F for 1981 was selected in relation to the goodness of fit of the population estimates in relation to both the short gillnet CPUE series and the catch of age 2 fish by the New Brunswick weirs (year-classes 1964 to 1977 only). The results of three VPA runs using a range of fully recruited F^S (1981) are summarized below.

YEAR	GILLNET CPUE	4+ BIOMASS ESTIMATES ($\times 10^{-3}$t) Fully Recruited F		
		0.25	0.32	0.40
1977	4.2	293	289	285
1978	1.6	162	157	154
1979	2.1	108	98	91
1980	3.0	478	409	359
1981	4.4	427	349	286
	R	0.67	0.70	0.69

Year-Class	Catch-at-age N.B. Weirs ($\times 10^{-6}$)	Year-Class Size at Age 1 ($\times 10^{-9}$) (0.25)	(0.32)	(0.40)
1964	151	3.48	3.48	3.48
1965	195	2.71	2.71	2.71
1966	759	6.05	6.05	6.05
1967	376	1.25	1.25	1.25
1968	349	1.71	1.71	1.71
1969	184	2.17	2.16	2.16
1970	660	6.16	6.12	6.10
1971	149	0.98	0.98	0.97
1972	246	1.90	1.90	1.89
1973	463	1.41	1.41	1.40
1974	199	0.19	0.18	0.18
1975	124	0.71	0.65	0.61
1976	894	5.23	4.59	4.11
1977	448	0.97	0.90	0.76
	R	0.74	0.71	0.68

The lower 1981 F value gives the better relationship with the year-class strength time series. The residuals of the regression for these two variables however indicate that the CPUE time series has a temporal bias (Figure 9). This is consistent with the collapse of the Georges Bank stock and the inferred implications on the juvenile nursery grounds. Because of the suggested bias and the marginally better fit between 4+ biomass and gillnet CPUE at the intermediate 1981 F value the more conservative run was retained (F = 0.32). It should be noted again that the gillnet CPUE during 1980 and 1981 is reported to have been market limited. The results of this VPA run are shown in Tables 11, 12a,and 12b. The 1+ and 2+ biomass trends can be seen in Table 12b. The 4+ biomass trend and the year-class strengths, are shown in Figure 10. The 1980 year-class at age 1 is estimated as 1.56 billion (the geometric mean of the 1964 to 1979 estimates). Two points are to be noted. The population biomass is beginning to decline subsequent to the maximization of biomass of the 1976 year-class. Secondly the year-classes since 1973, with the exception of the 1976, are poor relative to the earlier time period. The relationship between stock and recruitment is shown in Figure 11.

Yield Per Recruit

Two runs were made, using respectively the July mean weights-at-age and the 1981 mean weights-at-age for the overall fishery.

Age	PR	July Weights (kg)	"1981 Fishery" Weights
1	0.0001	-	-
2	0.50	.041	.019
3	0.53	.112	.035
4	0.77	.172	.172
5	1	.218	.216
6	1	.254	.202
7	1	.286	.262
8	1	.323	.325
9	1	.354	.362
10	1	.389	.385
	$F_{0.1}$	0.279	0.249

The $F_{0.1}$ value used in the previous assessment was 0.293. Since the PR vector for this fishery changes in the short-term due to year-class strength differences a value of 0.3, close to the 0.28 and 0.29 estimates, was selected for the projections. The range of $F_{0.1}$ values used in various herring assessments are shown in Table 13.

Projection

The following input parameters were used to project the 1982 and 1983 catches at "$F_{0.1}$".

(i) mean weight-at-age for July (see above)
(ii) PR given above
(iii) catch-at-age for 1981 (Table 10)
(iv) population numbers-at-age, (see Table 12a, 1981)
(v) 1982 and 1983 recruitment-at-age 1, 1.56 billion (the G.M. of year-classes 1964 to 1979)
(vi) $F_{0.1}$ equal to 0.3

The detailed results of the projection are given in Table 14. The $F_{0.1}$ catches in 1982 and 1983 are respectively 77 and 75 thousand t.

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Table 1. Provisional catch during 1981 4WX herring fishery.

	1980 NOV	DEC	1981 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
4W Purse Seine (Chedabucto Bay)	193	2331	12215	1683	-	2159	7	-	-	-	-	-	-	-	18588
4Xa Purse Seine	-	-	-	-	-	11	124	6317	19195	18279	7744	2129	-	-	53799
Gillnet (stock)	-	-	-	-	-	-	68	155	251	5877	3596	-	-	-	9947
Gillnet (463)	-	-	-	-	-	-	136	1044	656	170	23	3	6	-	2038
N. S. Weir	-	-	-	-	-	-	50	437	1021	276	37	104	41	-	1966
4WXa TOTAL	193	2331	12215	1683	-	2170	385	7953	21123	24602	11400	2236	- 47	-	86338
4Xb Purse Seine	-	-	-	1088	280	-	-	-	-	-	-	-	-	-	1368
NB Weirs	-	-	-	-	-	-	70	325	5139	4678	2299	1434	1418	212	15575
Shutoffs	-	-	-	-	-	-	-	-	220	304	2309	452	219	-	3504
4XB TOTAL	-	-	-	1088	280	-	70	325	5359	4982	4608	1886	1637	212	20447

Table 2. Annual 4WX herring catch by different components of the fishery (tonnes)

YEAR	4W		$4X_a$					$4X_b$				4WX Foreign Total	Stock Total[c]
	Purse Seine[a]	Fixed Gear[b]	Summer Purse Seine	Gill[14] Net	Weir	Liverpool Trap	Fixed Gear Non-Stock[b]	Winter Purse Seine: Grand Manan	Winter Purse Seine: Saint John	Winter Purse Seine: Weir	Misc. & Shut-Offs		
1963	-		15093[5]	2955[5]	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[16]
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[10]	153449
1973	8348[4]		36618[5]	5205[5]	12492[5]	-		25155[5,8]	2167[5]	19088[5]	847[5]	32702[10]	122687
1974	27044[4]		76859[5]	4285[5]	6436[5]	-		-	10563[5]	19028[5]	1574[5]	24483[10]	149670
1975	27030[4]		79605[6]	4995[6]	7404[6]	-		-	1152[6]	30819[6]	?	23711[10]	143897
1976	37196[3]		58305[3]	8322[3]	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
1978	17274[1]		57973[13]	6059[13]	8057[13]	-		3832[13]	2687[13]	33570[13]	5272[13,11]	-	95882
1979	14073[13]		25265[7]	4363[7]	9307[7]	2174[15]		2973[7]	866[2]	32477[7]	5351[7,11]	-	59021
1980	8958[2]		74976[17,18]	19804[17,19]	2383[17]	2010[15]		656[15]	787[15]	11100[17]	2425[17,11]	-	109574
1981	18588[2]		53799[15]	11985[15,19]	1966[15]	-			1368[15]	15576[17]	3504[11,15]		87706
1982	8819[2]												
	A	B	C	D	E	F	G	H	I	J	K	L	M

a. winter catch, Nov.-Apr. is put into latest calender 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+H+I+L)

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

[2]"Best estimate", provisional

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

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

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

[6]"Catch-at-age" printouts

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

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

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

[10]ICNAF Stat. Bull.

[11]Shut-offs only

[13]Sinclair et al. CAFSAC Res. Doc. 79/19

[14]Gillnet catches in Stat. districts 28-44

[15]Statistics Branch

[16]Catch matrix starts in 1965

[17]St. Andrews provisional catch statistics, March 1981

[18]Adjusted upwards assuming 40% misreporting

[19]Includes area 463 catch

Table 3. Temporal distribution of catch to sample ratio for 4WX herring fishery (1977 to 1980).

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Purse Seine												
4X 1977	-	-	-	-	382	72	184	112	109	160	130	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 →		
4Wa 78/79	220	-	-	-	-	-	-	-	-	-	-	226
4Wa 79/80	220	-	-	-	-	-	-	-	-	-	-	118
4Wa 80/81	188	168	-	433	-	-	-	-	-	-		
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			
N.S. Weirs												
1977	-	-	-	-	366	127	1021	1144	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				
Liverpool Fishery												
1978	-	-	171	-	-	-	-	-	-	-	-	-
1979	-	-	50	-	-	-	-	-	-	-	-	-
1980	-	-	155	-	-	-	-	-	-	-	-	-
			-									
N.B. Weirs & Shut-offs												
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	165	94	75	29

Table 4. Distribution of catch by purse-seine fishery area as estimated from the log books.

Purse-seine Area	JUNE Estimated Landings	JUNE % Breakdown by Area	JULY Estimated Landings	JULY % Breakdown by Area	AUGUST Estimated Landings	AUGUST % Breakdown by Area	SEPTEMBER Estimated Landings	SEPTEMBER % Breakdown by Area
3		-	1,658	8.6	455	2.5		-
12	61	.9	344	1.8		-		-
13		-	327	1.7		-		-
14		-	3,203	16.7	2,997	16.4	1,488	19.2
15	103	1.6	835	4.3	6,604	36.1	3,424	44.2
16	1,403	21.7	870	4.5	2,809	15.4	2,021	26.1
17	1,181	18.3	6,656	34.7	225	1.2	206	2.7
18	3,458	53.6	199	1.0		-		-
19	246	3.8	5,103	26.6	5,189	28.4	605	7.8
Landings from logs		2,851		6,575		4,379		640
Monthly Landings	6,452		19.195		18,279		7,744	

* No logs available from October, catch assigned to area 19.

Table 5. Catch-at-age ($x10^{-3}$) by gear for the 1981 4WX herring fishery,

	1	2	3	4	5	6	7	8	9	10	11+	Total No's	Tonnes
4Wa													
Purse Seine	0	145	1,691	17,298	75,783	15,780	1,017	894	540	441	536	114,125	18,588
4Xa													
Purse Seine	0	2,097	2,614	44,310	187,428	4,674	414	656	462	191	126	242,972	53,799
Gillnets			62	5,165	41,380	1,133	194	339	218	270	33	48,794	11,985
Weirs	0	26,008	913	1,966	2,125	141	6	25	146	117	89	31,536	1,966
4Xb													
Purse Seine	0	47,463	27,894	77	0	0	0	0	0	0	0	75,434	1,368
"Stock Total"	0	75,713	33,174	68,816	306,716	21,728	1,631	1,914	1,366	1,019 (361)*	784 (1,442)*	512,861	87,706
4Xb													
Weirs and Shutoffs	53,336	294,720	18,781	10,199	5,368	306	46	34	27	0	0	382,817	19,080

* adjustments made in the relative proportions of the 1970 and 1971 year-classes (see text for justifications)

Table 6. Weights-at-age of herring from various gear components of the 4WX herring fishery.

		1	2	3	4	5	6	7	8	9	10	11+
N.S. Weirs	No.	-	26,008	913	1,966	2,125	141	6	25	146	117	89
	Wt.	-	34.95	91.65	165.56	208.44	260.03	304.65	371.2	410.23	431.61	435.64
Gillnets	No.	-	-	62	5,165	41,380	1,133	194	339	218	270	33
	Wt.	-	-	220.77	218.04	244.89	277.65	293.19	350.43	397.16	420.05	430.39
4Xb Purse	No.	-	47,463	27,894	77*	-	-	-	-	-	-	-
Seine	Wt.	-	7.97	21.65	-	-	-	-	-	-	-	-
4Wa Purse	No.	-	145	1,691	17,298	75,783	15,780	1,017	894	540	441	536
Seine	Wt.	-	22.3	67.32	118.6	166.79	176.62	227.15	283.95	301.83	340.54	356.7
4Xa Purse	No.	-	2,097	2,614	44,310	187,428	4,674	414	656	462	191	126*
Seine	Wt.	-	64.45	129.15	188.39	229.57	266.29	332	367	401.43	411.11	-
Total	No.	-	75,713	33,174	68,739	306,716	21,728	1,631	1,914	1,366	1,019	658
	Wt. **	-	18.83	34.75	172.4	215.98	201.72	261.9	325.33	362.32	385.29	371.07
Mean July Purse Seine Wt (gms) 1969-1978		-	-	-	172	218	254	286	323	354	389	-

* Not included in totals.

** Mean weight-at-age weighted by numbers caught-at-age.

Table 7. CPUE trends for various components of the 4WX herring fishery.

	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	-	-		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[4]	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[2]	4.2	209 (25)	106 (195)
1978	39.5[2]	85.7[3]	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		59.9*[2]			

[1] Catch (t) per successful night

[2] Reanalysis of logs

[3] Sinclair & Iles, CAFSAC Res. Doc. 81/10

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

[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 8a. Catch-at-age from New Brunswick weirs and shutoffs (nos. $x10^{-3}$).

	AGES				AGES		
Year	1	2	3	Year	1	2	3
1965	992	852368	65449	1974	3259	246044	43483
66	3899	151087	432061	75	16880	462977	57228
67	127374	194566	57421	76	51791	199268	104624
68	2409	758766	51933	77	514970	124293	10334
69	71191	375586	101361	78	213778	894372	52125
70	3553	348916	9924	79	2135	447818	242047
71	92253	183690	37348	80	263106	5395	62087
72	8102	660547	6446	81	53336	294720	18781
73	31803	149051	125965				

Table 8b. Cumulative catch (nos. $x10^{-3}$) at age 1, 2, and 3 herring in the New Brunswick weirs and shutoffs (year-classes indicated).

Year-Class	Cumulative Catch	Year-Class	Cumulative Catch
1964	209500	1972	335075
1965	250398	1973	570860
1966	987501	1974	226482
1967	387919	1975	228209
1968	457455	1976	1651389
1969	193689	1977	723683
1970	878765	1978	26311
1971	200636		

Table 9. 4WX larval herring abundance indices

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	2.64	1.50

* interpolated

Table 10. 4WX herring catch matrix (ages 1 to 10) for the years 1965 to 1981.

Age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	270378	154323	722208	164703	108875	699720	87570	0	754	14151	0	0	0	0	311	2014	0
2	1084719	914093	613970	2389061	290329	576896	404224	649254	126421	596153	264491	48470	140494	346719	170523	9700	75713
3	34835	448940	153626	224956	531812	76532	183896	71984	595992	72381	180898	176226	28659	36177	226442	72957	33174
4	234383	73382	266454	83109	132319	286278	106630	148516	109530	616622	92487	130598	192958	11338	47200	502296	68816
5	49925	321857	110051	290285	162439	201215	113566	77207	34422	53199	383650	72334	106061	107627	4639	29948	306716
6	10592	45916	159203	73087	112631	120280	75593	75384	25562	15254	50599	219788	55066	60431	19695	4351	21728
7	1693	13970	57948	90617	62506	111937	93620	49065	19361	8120	9357	18960	150588	27286	15521	4291	1631
8	561	7722	4497	31977	22595	41257	50022	48700	17604	5313	3238	4967	12466	96741	9981	5508	1914
9	54	1690	409	15441	6345	21271	36618	26055	19836	10964	3481	3556	2873	9838	35386	2248	1366
10	37	215	296	5668	2693	7039	7536	13792	9661	5787	2842	1835	1253	2169	3834	8877	361

CATMAT+A

Table 11. 4WX herring fishing mortality matrix.

FISHING MORTALITY 18/ 3/82

I	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
1	0.089	0.065	0.141	0.156	0.073	0.441	0.016	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.001	0.003	0.000
2	0.372	0.485	0.391	0.925	0.450	0.662	0.495	0.157	0.191	0.544	0.294	0.446	0.341	0.107	0.266	0.037	0.160
3	0.040	0.259	0.138	0.242	0.538	0.203	0.457	0.151	0.211	0.159	0.313	0.326	0.520	0.137	0.095	0.174	0.170
4	0.219	0.110	0.241	0.103	0.219	0.631	0.480	0.840	0.359	0.352	0.313	0.392	0.719	0.400	0.266	0.313	0.246
5	0.174	0.525	0.239	0.448	0.298	0.600	0.556	0.782	0.470	0.297	0.387	0.432	0.642	1.243	0.283	0.269	0.320
6	0.136	0.240	0.539	0.247	0.313	0.376	0.475	0.916	0.654	0.393	0.511	0.401	0.693	0.922	0.810	0.468	0.320
7	0.046	0.266	0.537	0.684	0.345	0.586	0.566	0.654	0.639	0.446	0.447	0.365	0.530	0.925	0.738	0.407	0.320
8	0.149	0.305	0.128	0.650	0.357	0.403	0.571	0.660	0.520	0.358	0.320	0.455	0.436	0.791	1.132	0.641	0.320
9	0.057	0.877	0.023	0.834	0.253	0.675	0.765	0.672	0.626	0.727	0.422	0.700	0.521	0.741	0.774	0.869	0.320
10	0.126	0.334	0.360	0.507	0.328	0.491	0.542	0.753	0.571	0.373	0.416	0.413	0.575	0.984	0.741	0.446	0.320
1+	0.141	0.346	0.274	0.479	0.317	0.507	0.492	0.558	0.424	0.366	0.342	0.393	0.498	0.631	0.511	0.363	0.250

Table 12a. 4WX herring estimated population numbers-at-age for the time period 1965 to 1981.

POPULATION NUMBERS 18/ 3/82

	65	66	67	68	69	70	71	72	73	74	75	76
1	3480108	2710571	6051054	1252899	1707586	2150088	6098426	976408	1897818	1406192	180238	652056
2	3832654	2605394	2079973	4303318	877392	1299822	1132863	4913886	799416	1553121	1138512	147566
3	987080	2164062	1313983	1151903	1397526	458032	548734	565340	3438189	540668	737887	694377
4	1311139	776706	1367982	937341	740703	668050	306104	284400	397999	2278462	377451	441568
5	344167	862512	569746	880274	692483	487342	291027	155057	100523	227500	1311679	225918
6	91924	236811	417933	367450	460423	420945	219029	136623	58096	51448	138442	729563
7	41306	65714	152572	199637	235091	275746	236663	111575	44773	24722	28432	68023
8	4463	32290	41238	73032	82508	136334	125620	109981	47503	19351	12960	14888
9	1075	3148	19496	29709	31215	47262	74601	58087	46529	23126	11072	7701
10	344	832	1073	15593	10565	19849	19693	28413	24280	20360	9148	5943
1+	10094258	9458040	12015050	9211156	6235493	5963471	9052759	7339770	6855126	6144951	3945819	2987604
2+	6614150	6747469	5963996	7958257	4527907	3813383	2954333	6363362	4957308	4738759	3765581	2335547
3+	2781496	4142075	3884023	3654939	3650515	2513561	1821470	1449476	4157892	3185638	2627070	2187981
4+	1794416	1978013	2570040	2503035	2252988	2055529	1272736	884136	719704	2644969	1889183	1493604

	77	78	79	80	81
1	4578749	979423	362449	690462	0
2	533859	3748762	801884	296468	563483
3	77355	310889	2756584	503168	233970
4	410178	37666	221929	2052671	346245
5	244316	163571	20664	139251	1229195
6	120090	105230	38630	12747	87077
7	400089	49144	32430	14071	6536
8	38669	192722	15957	12700	7671
9	7736	20479	71527	4212	5474
10	3130	3761	7988	27000	1447
1+	6414170	5611648	4330042	3752750	2481099
2+	1835421	4632225	3967593	3062288	2481099
3+	1301563	883463	3165709	2765820	1917616
4+	1224208	572573	409124	2262653	1683645

Table 12b. 4WX herring estimated population biomass for the time period 1965 to 1981.

POPULATION BIOMASS 18/ 3/82

	65	66	67	68	69	70	71	72	73	74	75	76	77	78
1	34801	27106	60511	12529	17076	21501	60984	9764	18978	14062	1802	6521	45787	9794
2	157139	106821	85279	176436	35973	53293	46447	201469	32776	63678	46679	6050	21888	153699
3	110553	242375	147166	129013	156523	51300	61458	63318	385077	60555	82643	77770	8664	34820
4	225516	133593	235293	161223	127401	114905	52650	48917	68456	391895	64922	75950	70551	6478
5	75028	188028	124205	191900	150961	106241	63444	33802	21914	49595	285946	49250	53261	35659
6	23349	60150	106155	93332	116947	106920	55633	34702	14756	13068	35164	185309	30503	26729
7	11813	18794	43636	57096	67236	78863	67686	31910	12805	7071	8131	19455	114426	14055
8	1441	10430	13320	23589	26650	44036	40575	35524	15343	6250	4186	4809	12490	62249
9	381	1114	6902	10517	11050	16731	26409	20563	16471	8187	3920	2726	2739	7250
10	134	323	417	6066	4110	7721	7660	11053	9445	7920	3558	2312	1217	1463
1+	640155	788735	822883	861701	713928	601510	482947	491023	596022	622281	536952	430151	361525	352196
2+	605354	761629	762372	849172	696852	580009	421963	481259	577044	608219	535149	423631	315738	342401
3+	448215	654808	677093	672736	660879	526716	375515	279789	544268	544541	488470	417580	293850	188702
4+	337662	412433	529927	543723	504356	475417	314057	216471	159191	483986	405827	339810	285186	153883

	79	80	81
1	3624	6905	0
2	32877	12155	23103
3	308737	56355	26205
4	38172	353059	59554
5	4505	30357	267965
6	9812	3238	22118
7	9275	4024	1869
8	5154	4102	2478
9	25320	1491	1938
10	3107	10503	563
1+	440584	482189	405791
2+	436960	475284	405791
3+	404083	463129	382689
4+	95345	406774	356484

Table 13. $F_{0.1}$ values used in 4WX and Gulf of St. Lawrence herring assessments.

	$F_{0.1}$	
4WX Herring	(range 0.246 to 0.308)	
1977	0.300	
1978	0.308	
1979	0.282	
1980	0.293 0.246	two PR options
1981	0.249 0.293	1980 fishery conditions average conditions
1982	0.249 0.279	1981 fishery conditions average conditions
4T Herring	(range 0.30 to 0.89)	
1977	0.52	
1978	?	
1979	0.38	
1980	0.30	
1981	0.87 0.89	spring spawners fall spawners
1982	0.35	
W. Newfoundland	(range 0.345 to 0.640)	
1977	0.45	
1978	0.45	
1979	0.35	
1980	0.55 0.64	spring spawners fall spawners
1981	0.345 0.381	spring spawners fall spawners

Table 14. Catch projections for 4WX herring for the years 1982 to 1985 (see assumptions in text).

CATCH BIOMASS 19/ 3/82

	81	82	83	84	85
1	0	0	0	0	0
2	3104	6632	6632	6632	6632
3	3715	5882	13476	13476	13476
4	11836	5219	8862	20303	20303
5	66864	11403	5407	9182	21038
6	5519	43821	8059	3821	6489
7	466	3495	29927	5504	2610
8	618	296	2394	20500	3770
9	484	381	197	1592	13627
10	140	299	254	131	1061
1+	92748	77429	75209	81142	89005

FISHING MORTALITY 19/ 3/82

	81	82	83	84	85
1	0.000	0.000	0.000	0.000	0.000
2	0.160	0.150	0.150	0.150	0.150
3	0.170	0.159	0.159	0.159	0.159
4	0.246	0.231	0.231	0.231	0.231
5	0.320	0.300	0.300	0.300	0.300
6	0.320	0.300	0.300	0.300	0.300
7	0.320	0.300	0.300	0.300	0.300
8	0.320	0.300	0.300	0.300	0.300
9	0.320	0.300	0.300	0.300	0.300
10	0.320	0.300	0.300	0.300	0.300

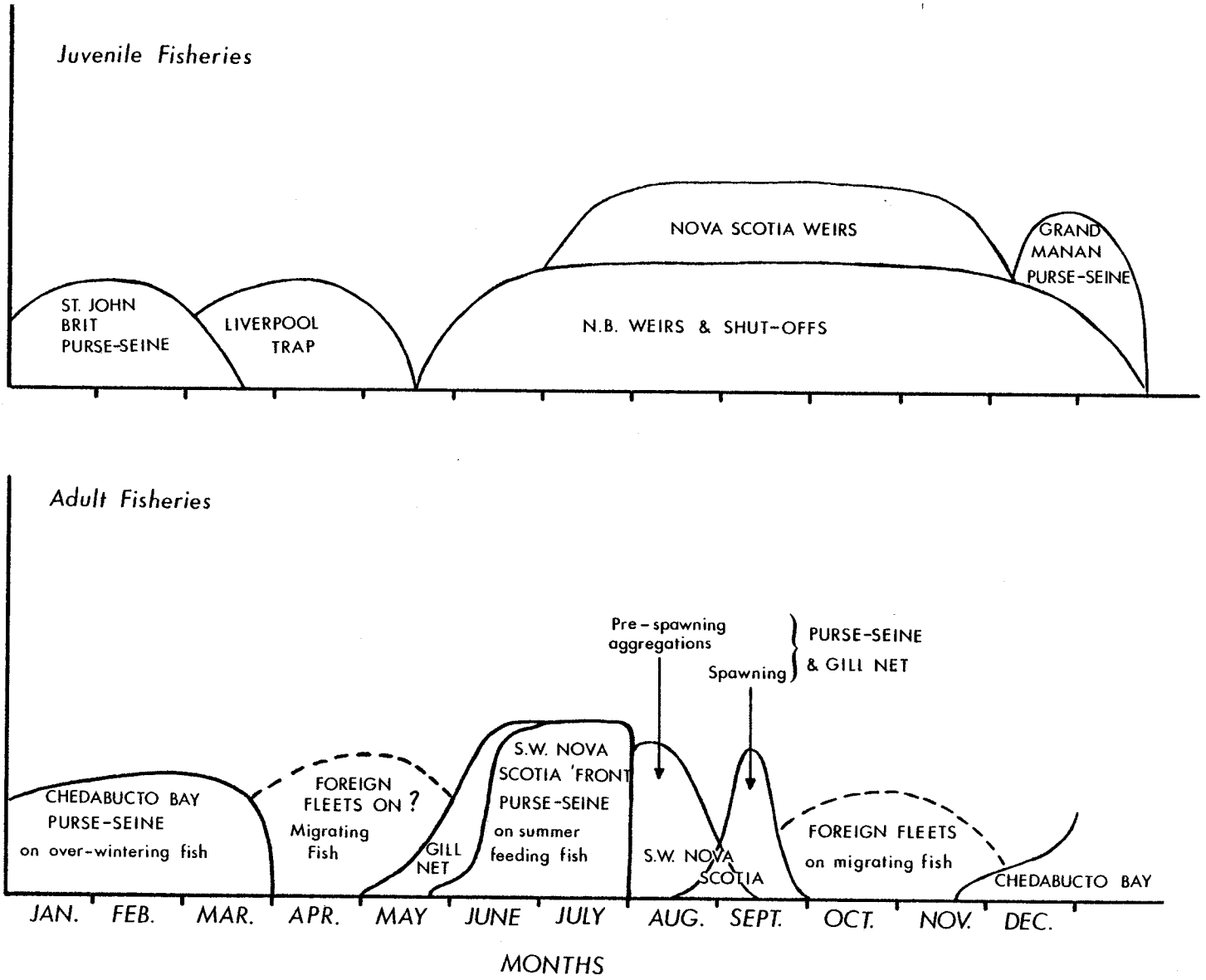

Figure 1. Schematic representation of approximate seasonal distribution of the various components of the juvenile and adult 4WX herring fishery.

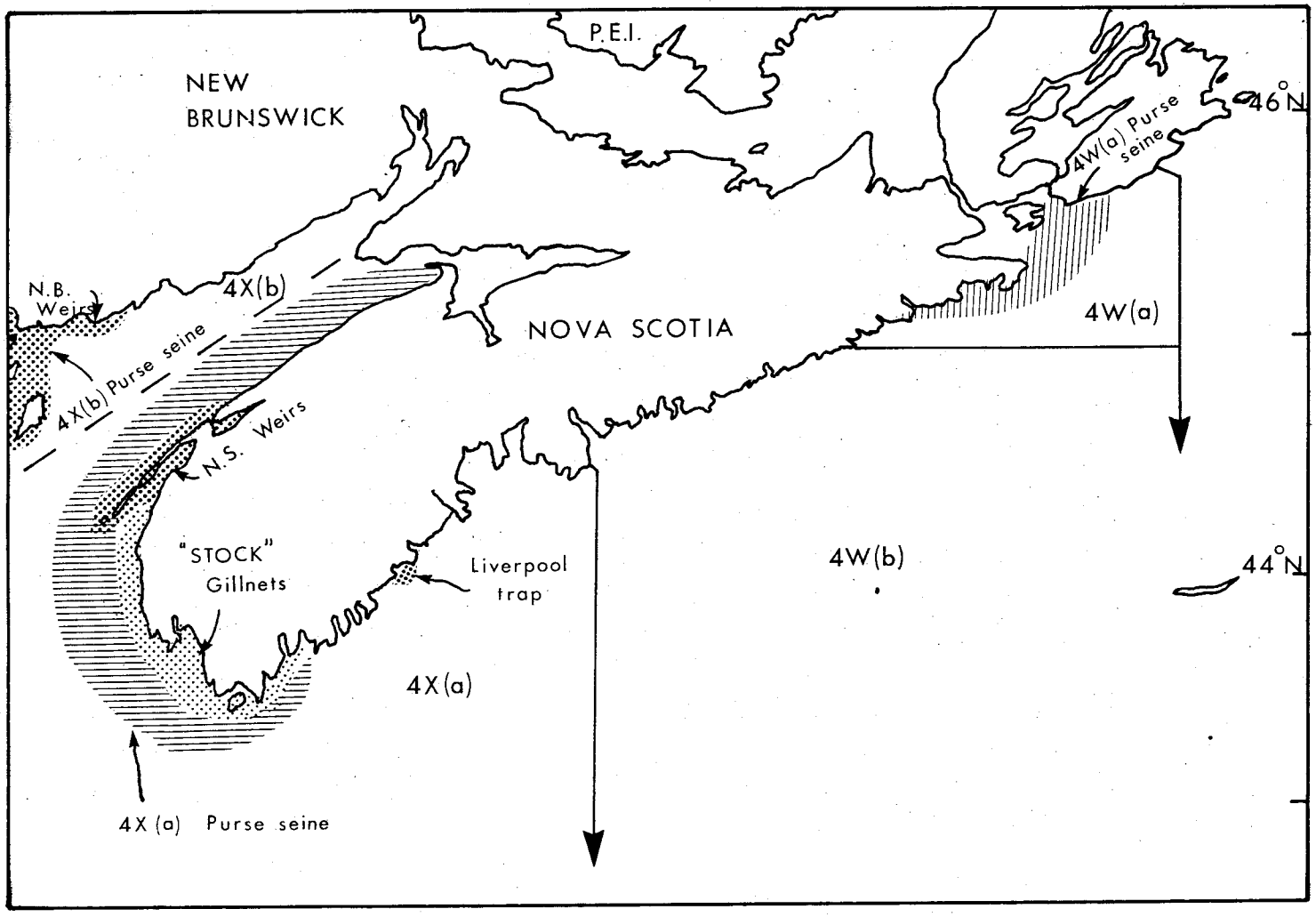

Figure 2. Geographical location of various components of the 4WX herring fishery.

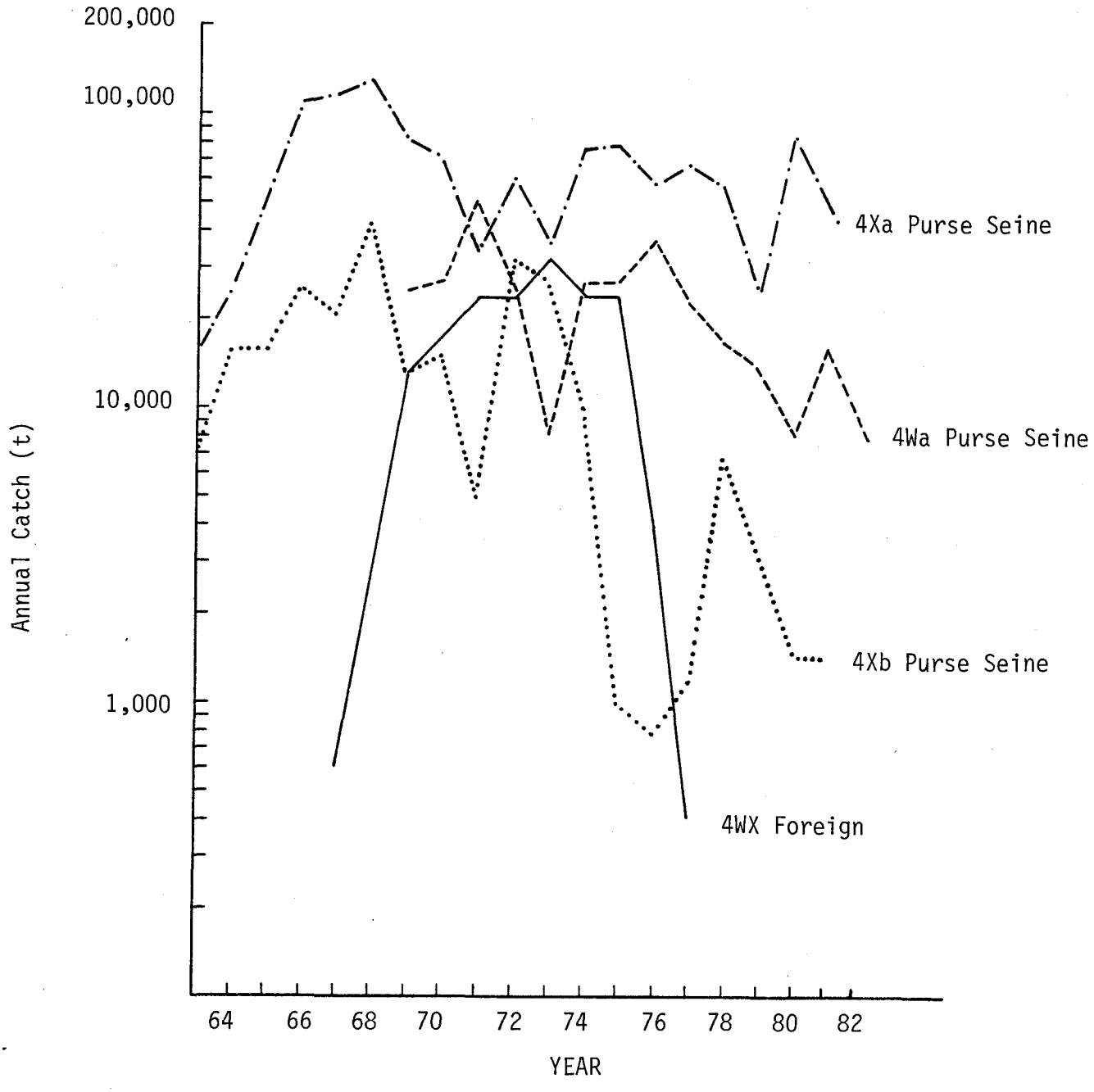

Figure 3. 4WX mobile gear herring catch (1963-1982).

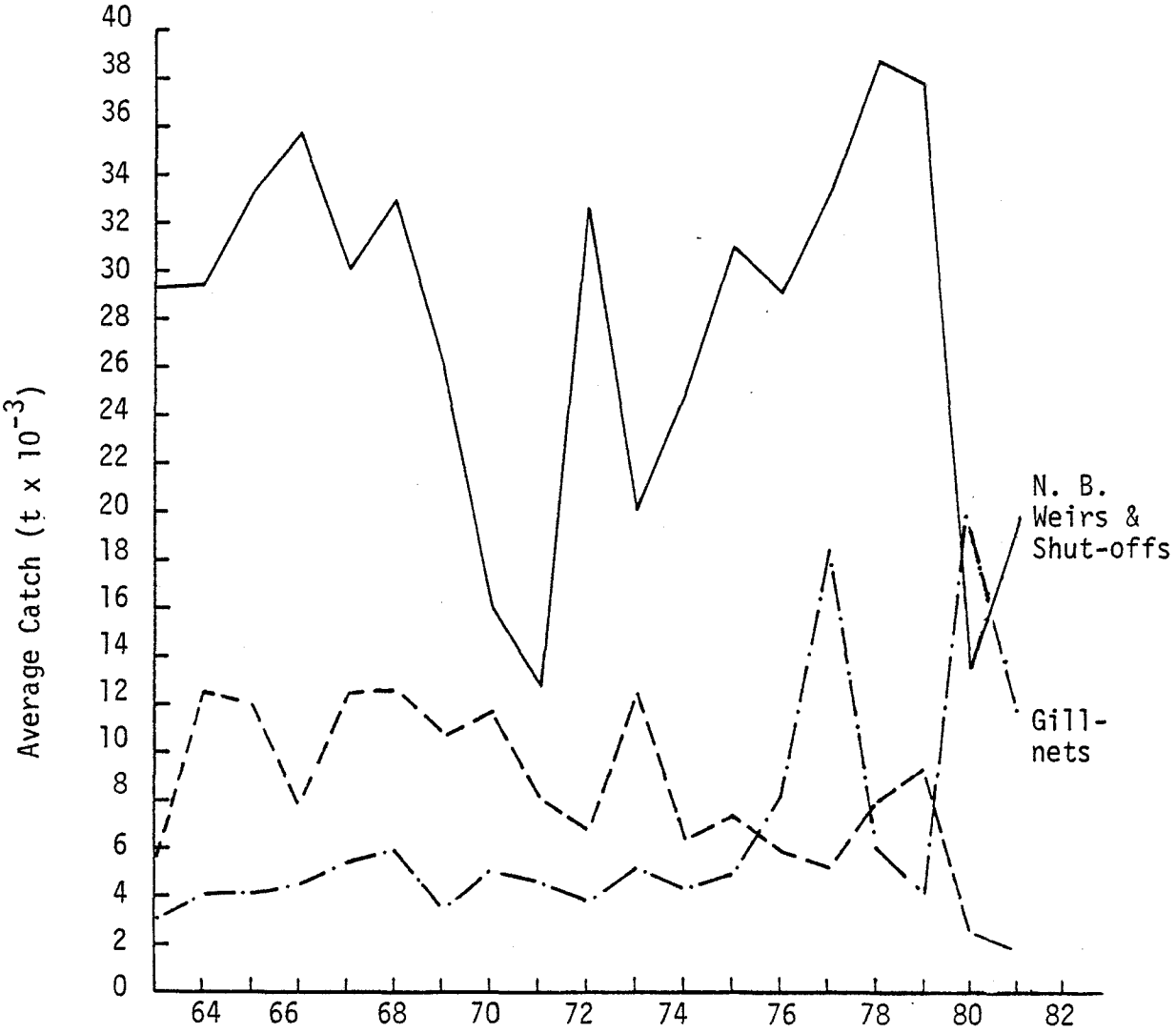

Figure 4. 4X fixed gear herring catch (1963 to 1981)

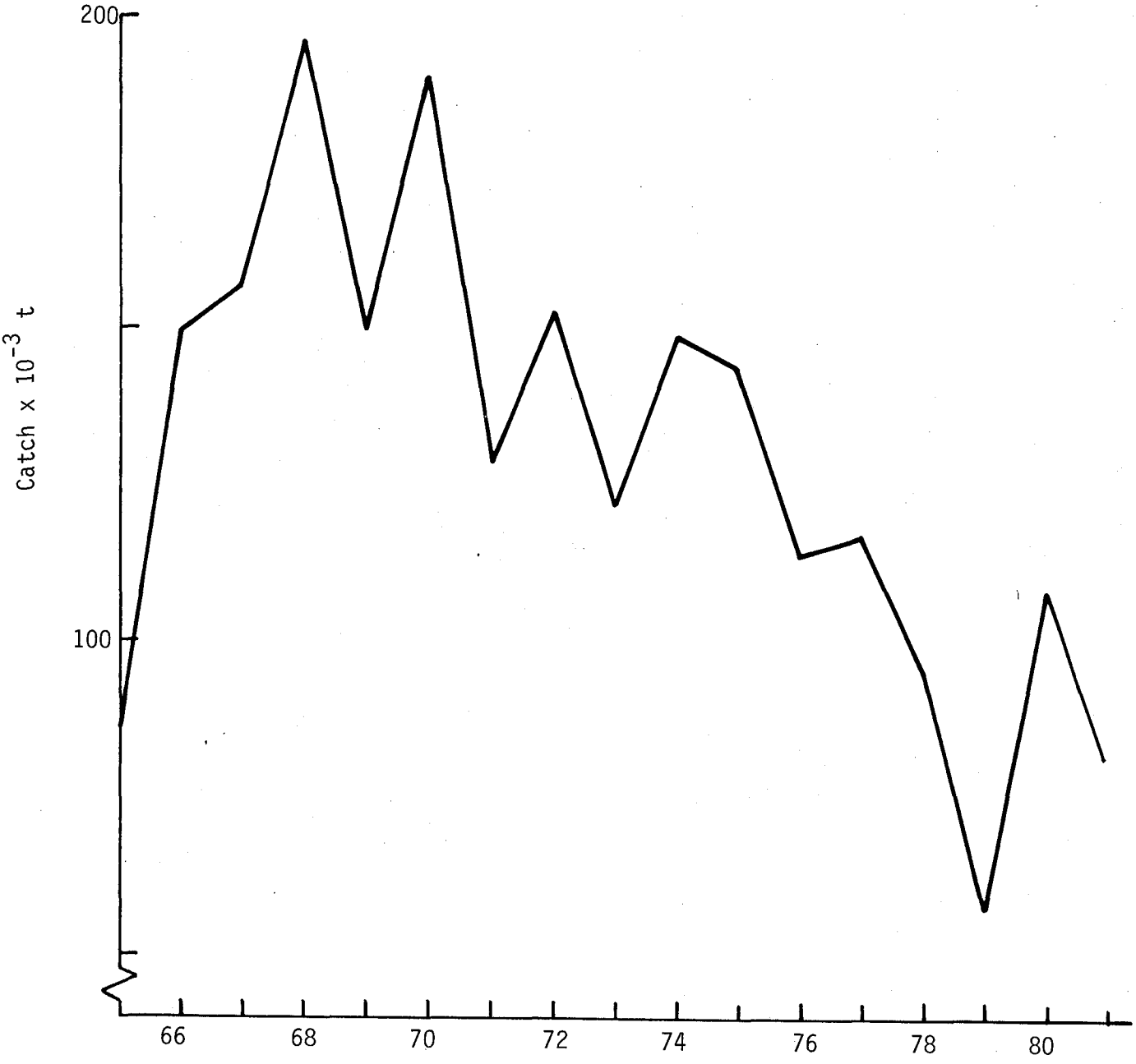

Figure 5. 4WX "Stock" annual catch (1965-1981).

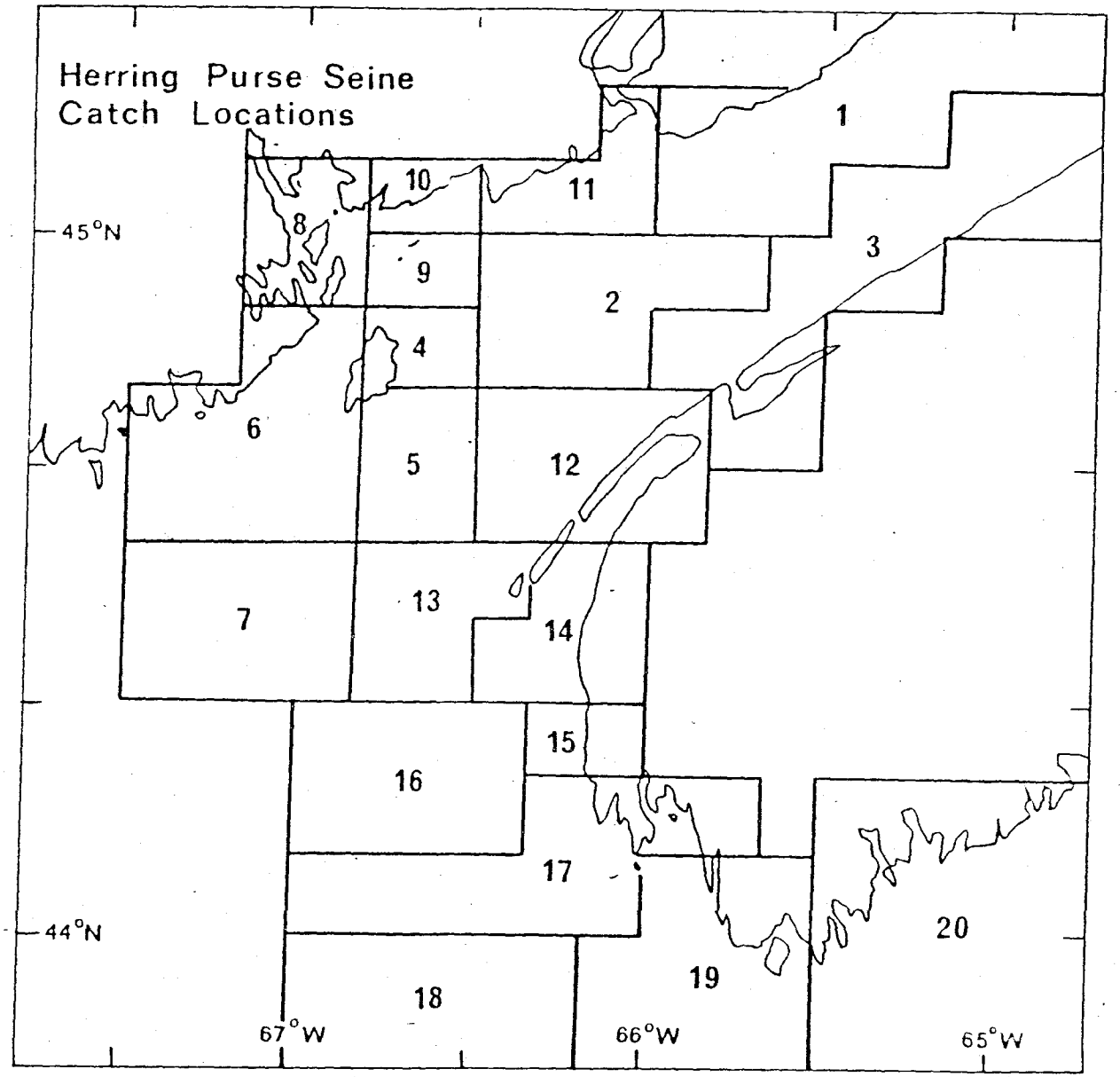

Figure 6. Herring purse-seine catch locations that are used for the matching of catch and samples for the generation of numbers-at-age.

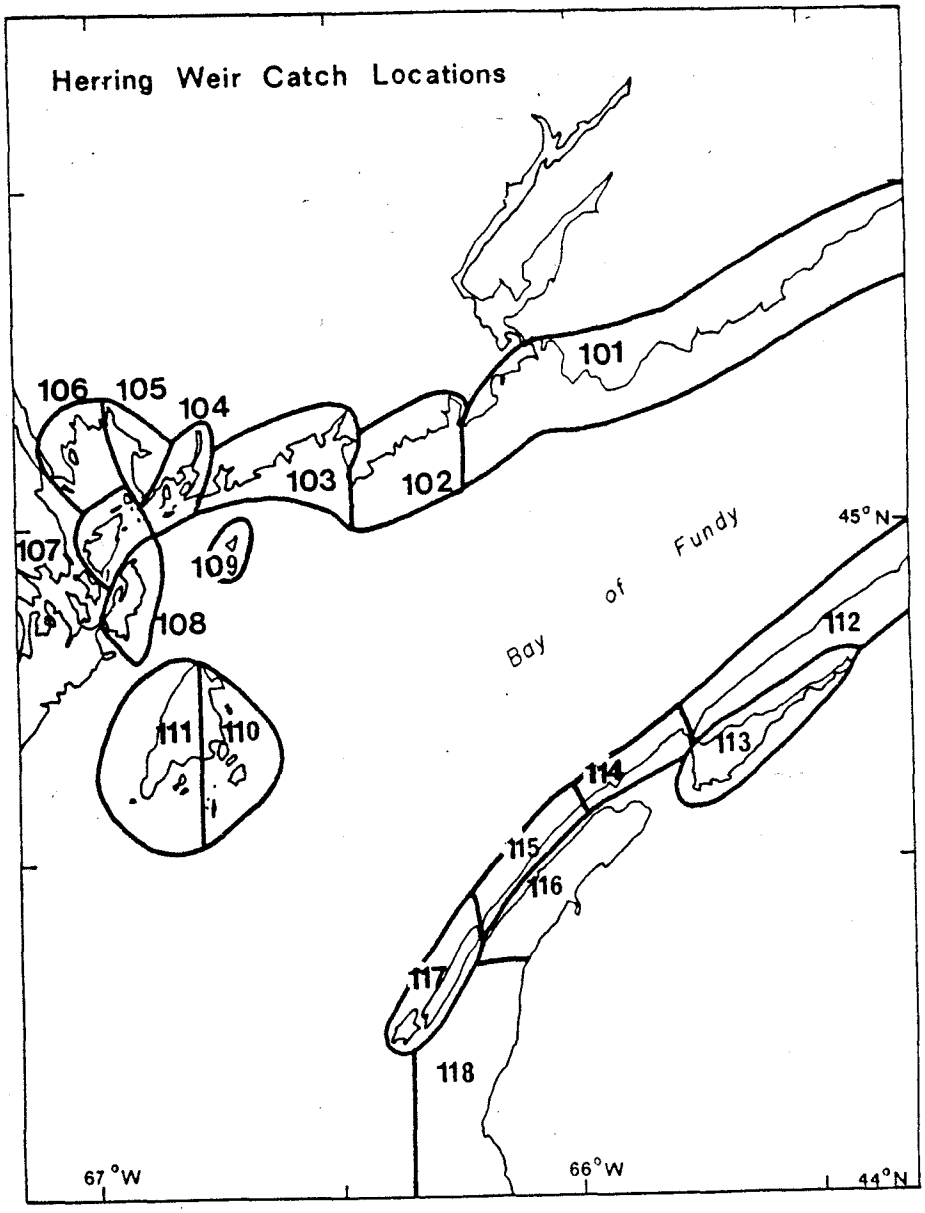

Figure 7. Herring weir locations that are used for the matching of catch and samples for the generation of numbers-at-age.

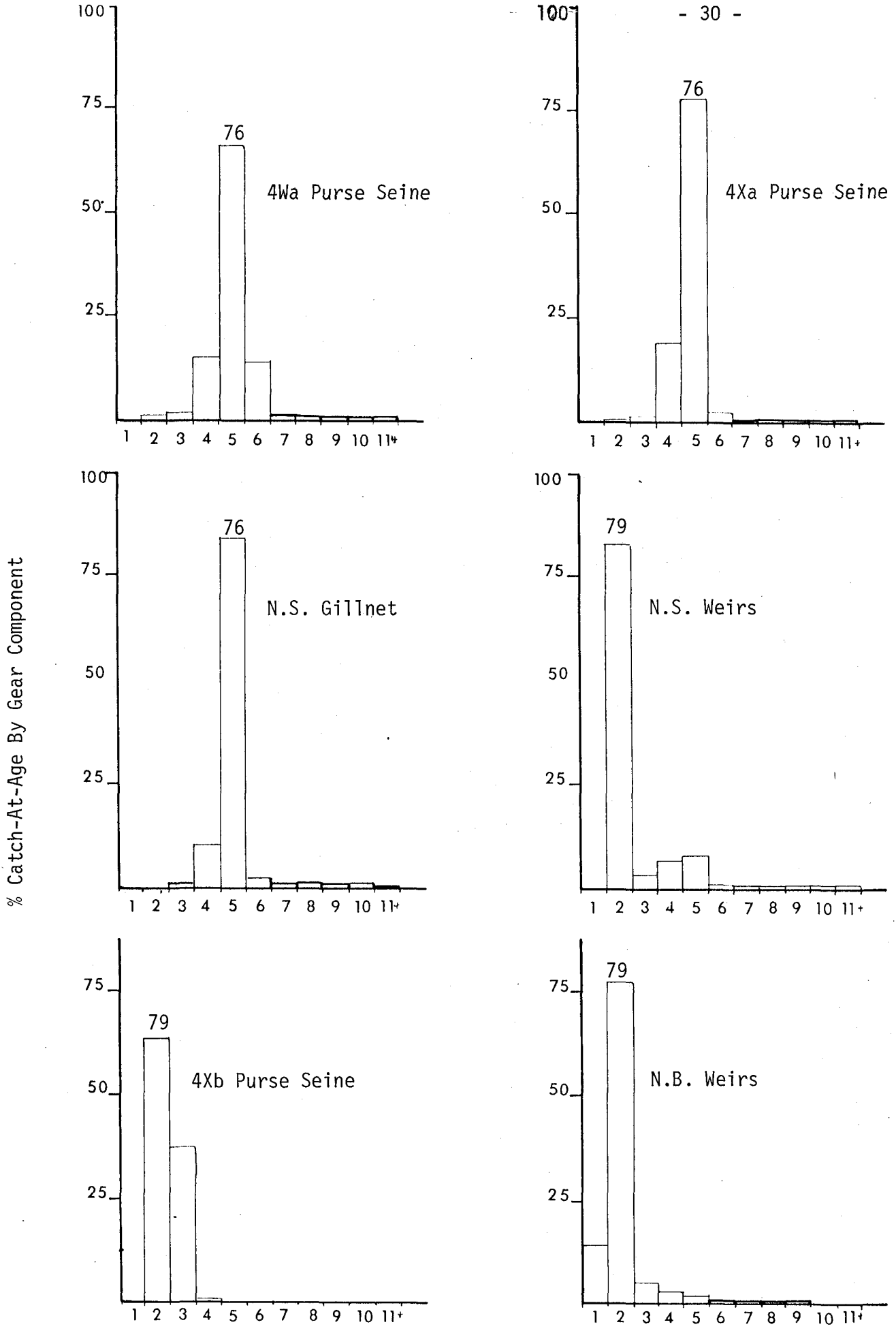

Figure 8a. Age composition (%) of various components of the 4WX herring fishery during 1980.

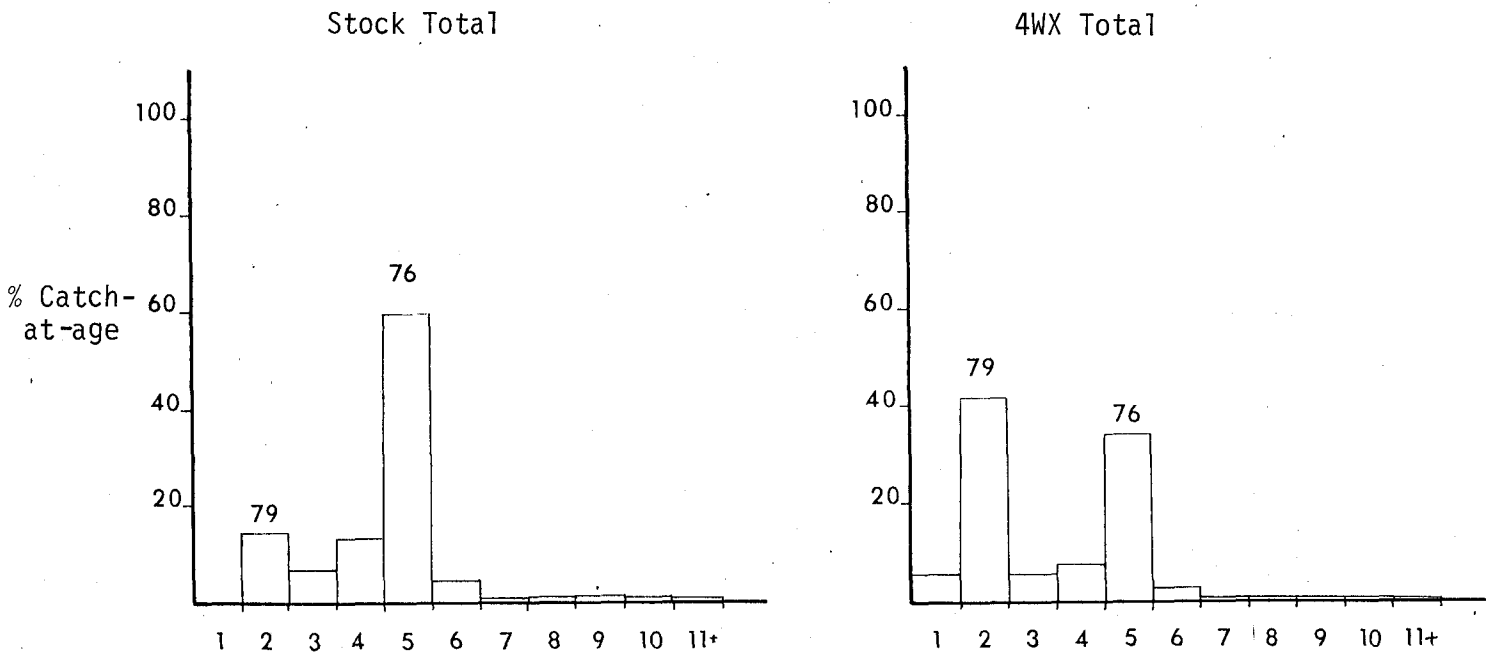

Figure 8b. Age composition (%) of the overall 4WX herring fishery during 1981.

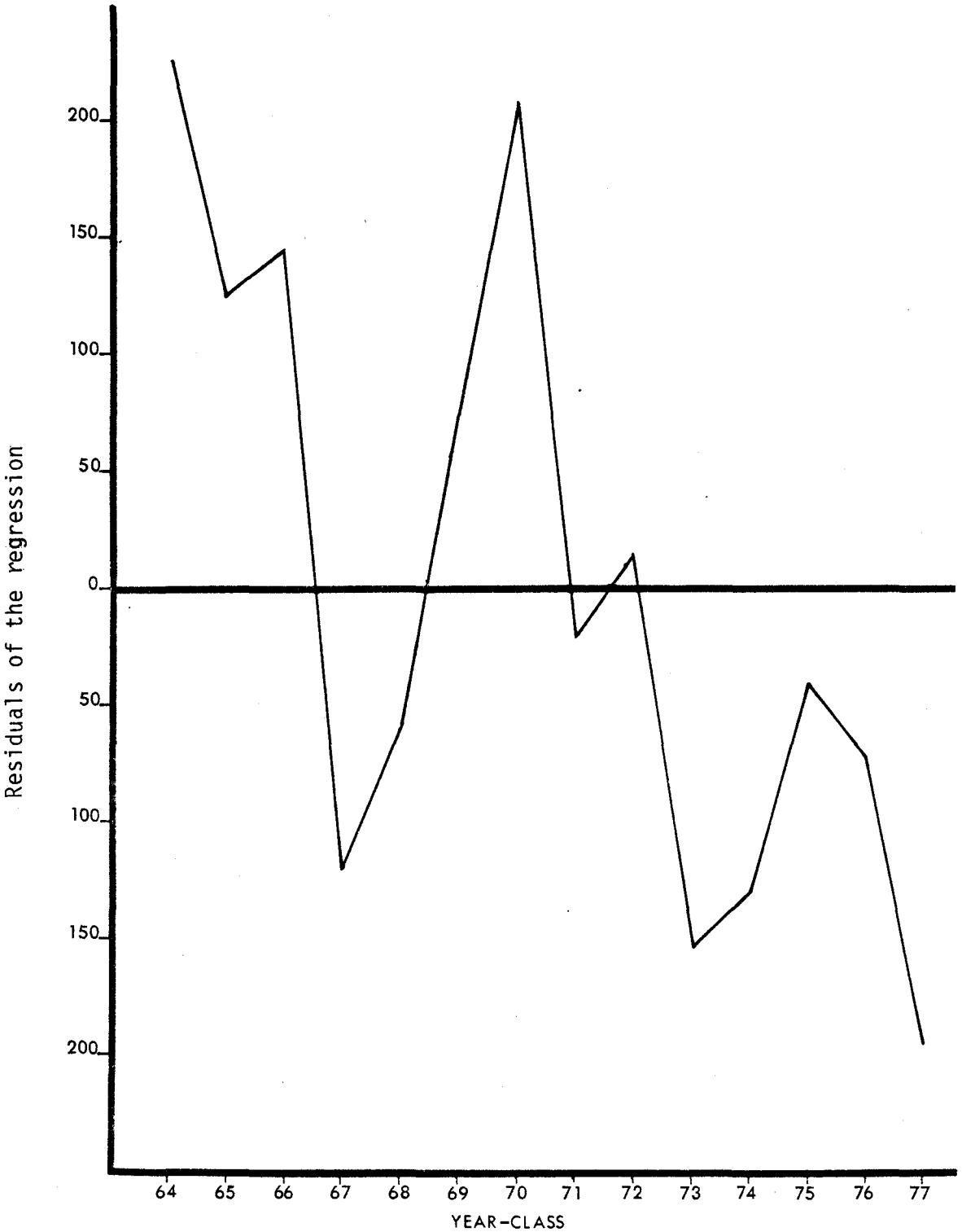

Figure 9. Residuals of the regression of VPA year-class strength on numbers caught at age 2 by N. B. weirs.

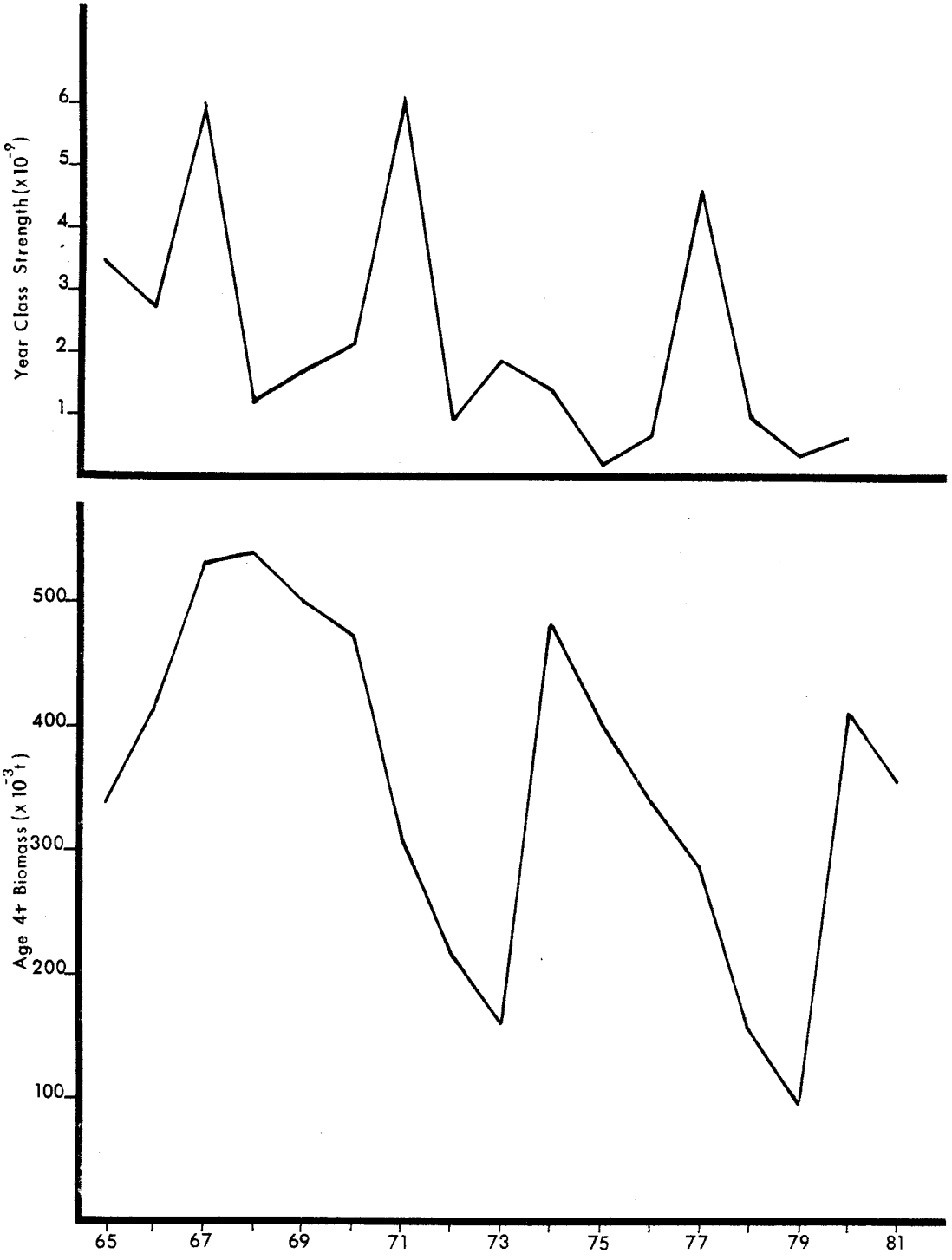

Figure 10. 4WX herring year-class strength and 4+ biomass trends.

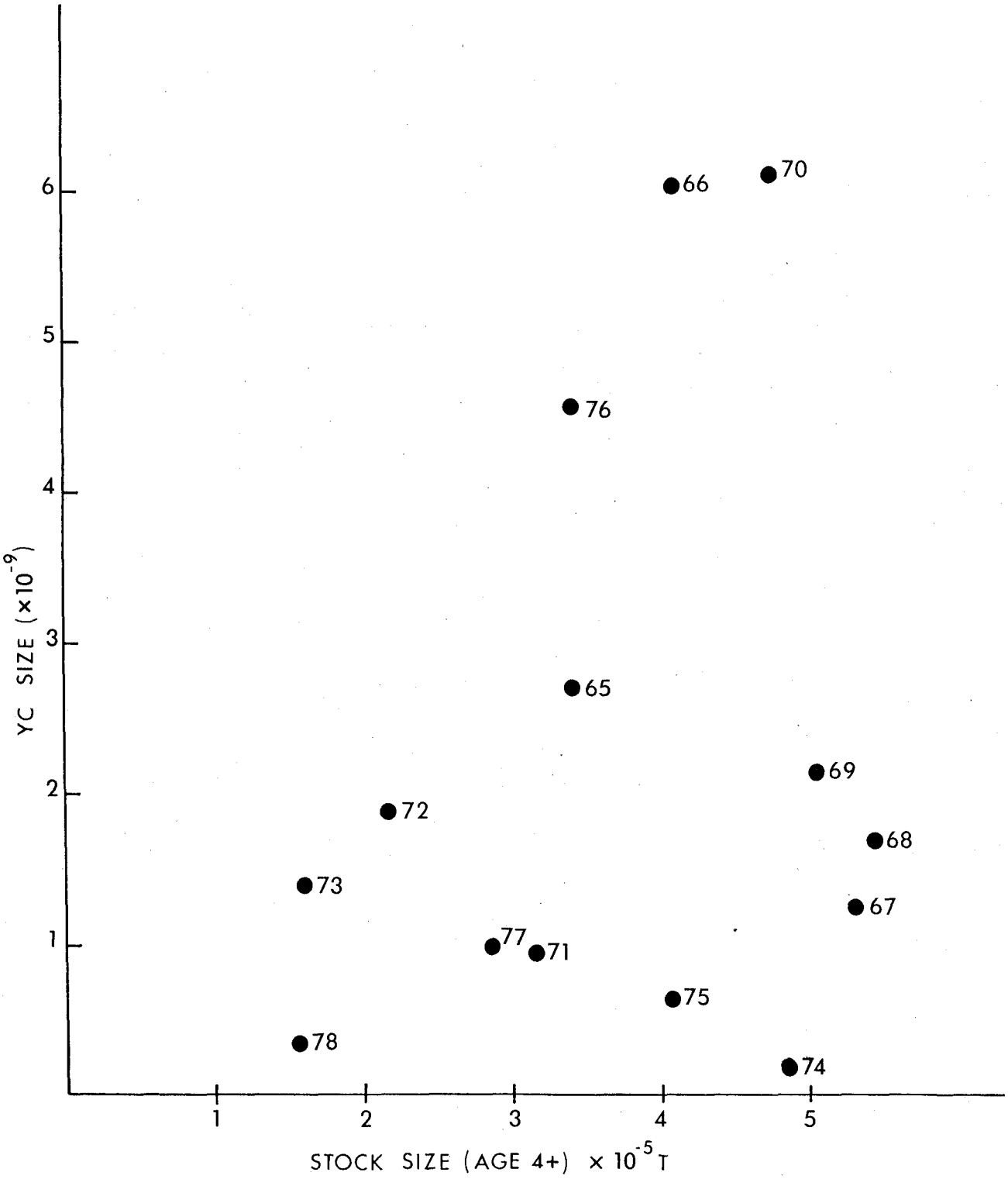

Figure 11. Year-class size in relation to stock biomass.