Assessment of the 1982 4WX Herring fishery

by

T.D. Iles and J. Simon
Marine Fish Division
Fisheries and Oceans
P.O. Box 1006
Dartmouth, N.S.
B2Y 4A2

Abstract

The nominal catch of herring in Division 4WX in 1982 was 110,696 t of which 84,733 t was attributed to the "4WX stock", that is those components regulated by the 4WX TAC. This compares with 107,000 and 88,000 t respectively in 1981. The 1976 year class continued to support the fishery, but the 1979 year class appeared in both the prespawning and spawning fisheries to a degree significantly greater than expected on evidence available in 1981. In addition there were reports of the appearance of the 1980 year class outside the area fished during the summer and a small purse seine fishery developed on this year class in October.

Quantifying trends in abundance from the fishery itself was again difficult. Logbook coverage deteriorated still further from the low standards of 1981, and only the relatively good coverage of landings on Russian factory ships accepting over-the-side-sales" allowed reasonable catch distributions to be estimated.

The arval index based on the November larval survey was used to tune the cohort analysis. More representative estimates of spawning biomass were derived by using population abundance estimates for the beginning of the year (January) and comparing these with the larval abundance indices measured the previous November. Other important modifications were the inclusion of some of the newly recruited three year olds that contributed to the larvae counts in November, and the discounting of the proportion of four year olds not spawning.

Abundance indices based on purse seine and gillnet catch rates could not be used. The New Brunswick weir catch rates for two year old fish were considered but rejected because those weirs do not actually exploit the 4WX stock.

Cohort runs were made at varying levels of terminal F. Fine tuning suggested use of a terminal F of 0.375, rather than 0.320 as used in 1981. The 1983 $F_{0.1}$ catch projection ($F_{0.1} = 0.3$) was revised downwards compared to the previous projection from 75,000 to 72,000 t.

Further major stock decline was not diagnosed at catch levels implied by the projection levels given. However, unless the incoming year classes of 1979 and 1980 are larger than we can currently assume them to be, significant increase in the catch levels in 1985 and 1986 cannot be expected.

Résumé

Les prises nominales de hareng dans la Division 4WX se sont élevées à 110 696 t en 1982. De ce total, 84 733 t furent prélevées à même le stock de 4WX, soit cet ensemble de composantes réglementé par le TPA. En 1981, ces totaux étaient de 107 000 et 88 000 t respectivement. La classe d'âge de 1976 a continué de dominer les prises commerciales. Cependant le classe d'âge de 1979 s'est avérée beaucoup plus importante dans les captures effectuées avant et pendant le frai que ne l'avaient laissé croire les indications disponibles en 1981. Il appert en outre que la classe d'âge de 1980 est apparue en dehors des zones de pêche estivales et qu'elle fut exploitée de façon peu intensive à la seine coulissante en octobre.

L'analyse quantitative des indices commerciaux d'abondance fut à nouveau difficile. La qualité des données provenant des journaux de bord, bien que déjà pietre en 1981, a continué de se détériorer. Seules les données relativement bonnes provenant des débarquements sur les navires-usines soviétiques achetant directement des pêcheurs ont permis d'établir une répartition raisonnable des prises.

Un indice d'abondance larvaire basé sur les résultats des campagnes de novembre fut utilisé pour calibrer l'analyse des cohortes. Un meilleur estimé de la biomasse des reproducteurs fut obtenu en comparant la taille prédite de la population en janvier à l'indice d'abondance larvaire calculé à partir des résultats de la campagne du mois de novembre précédent. Une autre modification apportée aux calculs fut l'inclusion des harengs de trois ans ayant atteint la maturité sexuelle et l'exclusion de ceux de quatre ans n'y étant pas encore parvenu. Les indices d'abondance basés sur les prises des filets maillants et des seines coulissantes ne purent être utilisés. De même, les taux de capture des pêches à fascines du Nouveau Brunswick furent rejetés puisque celles-ci n'exploitent pas le stock de 4WX.

L'analyse des cohortes suggéra une augmentation du taux de mortalité par pêche (F) de 0,320 en 1981 à 0,375 en 1982. Le total des prises au niveau $F_{0.1}$ ($F_{0.1} = 0.3$) fut revisé à la baisse, passant de 75 000 t tel qu'estimé en 1982 à 72 000 t.

Il appert que la taille du stock devrait cesser de diminuer si les prises sont maintenues aux niveaux indiqués par les projections. Cependant, à moins que les classes d'âge de 1979 et 1980 ne s'avèrent plus abondantes qu'elles semblent l'être présentement, aucune hausse d'importance n'est à prévoir dans les niveaux de capture pour 1985 et 1986.

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 1982 fishery are given in Table 1. The historical catch trends are shown in Table 2 and in Figures 3, 4, and 5.

The Chedabucto Bay Winter Fishery beginning in November 1981 recorded lower catches than the previous season. Markets were relatively poor and this could account for the decline. Small fish were found in the area and, for the second year running, fishing was resumed in April after a stoppage in February.

The summer purse seine fishery served two distinct markets. Over-the-side sales to Russian boats accounted for 26,691 t and the Domestic market took 37,653. There were differences in the length and age distributions in these two markets (Figure 8, Table 5, 7). The June landings in the Domestic market were badly affected by a price dispute between fishermen and processors.

The gillnet fishery declined from about 12,000 to 6,799 t. In fact it is thought that a large proportion of this was caught by the purse seine fleet and transferred to gillnetters. The Nova Scotia weir catch was only 1,212 t in this area with 1,966 t for 1981. The recorded catch in this fishery in the past has been inversely related to the catch in New Brunswick weirs. 1982 was a relatively good year for the New Brunswick weir fishery; 22,183 t were recorded compared to 15,576 for 1981. The New Brunswick juvenile catch included also 2,557 t from "Shutoffs" and 1,223 for "Miscellaneous". Once again there was no Liverpool trap fishery. There was no winter purse-seine fishery for juveniles off the New Brunswick coast, but 103 t was recorded in that area from trawl gear. This was included in the 4X "stock" catch data; N.B. weir catches, "shutoff" catches and "miscellaneous" were excluded. The total catch for the 4WX "stock" excludes catches which have traditionally been considered as coming largely from stocks not spawning in the southwest Nova Scotia area (i.e. the New Brunswick weir and shutoffs as well as the small catches along the "Eastern" and "Southern" shores of Nova Scotia by fixed gears). This stock total for 1982 was 84,733 t compared to 87,706 in 1981.

Biological Sampling and Catch Recording

The 4WX herring catches were again well sampled (Table 3). Indeed the coverage of the over-the-side sale operation was intensive, with observers recording capture area (10 minute squares), length frequencies and weights for all transfers to the Russian processing

vessels. Logbook coverage of the purse seiners was very poor. Only 8.1% of the recorded catch was covered by logbooks. Landing information from Statistics Branch did not specify locations or areas of capture; area of capture for the Domestic market was determined by prorating daily catches assuming the same areas were fished for both markets (Table 4).

As in 1981 (Sinclair et al., 1982) 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, (e.g. separate age-length keys for the New Brunswick versus Nova Scotia weirs). The adequacy of sampling data to generate an age-length key was based largely 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 Figures 8a and 8b. The most important feature of the 1982 age distributions was the appearance of the 1979 year class in the summer purse seine fishery at a much higher level than anticipated.

The size of this year class was such as to generate a distinct bimodality to the overall age frequency for the two purse seine market components. Separation of these two modes has been carried out separately for both Domestic and Over-the-side sales (O.S.S.). Figure 9 shows representative results. Domestic markets would not accept the small fish as readily as did the USSR factory ships. This is reflected in the differences in the overall length frequency for the two components, shown in Table 7.

The extent to which this represents selection from the sea by the purse seiners, selection of the market once the catch is sampled in the seine, or dumping of small fish at sea is not known. These factors affect the degree to which the 1979 year class can be considered "recruited" to the fishery. In terms of landings, (i.e. recorded catches) this must be less that 100%.

The October purse seine fishery caught significant quantities of the 1980 year class with virtually no other younger or older individuals in the catch (Figure 9). The areas of capture for October were derived from logbooks and are outside the areas where most of the summer catch was recorded. However the logbook coverage was not good.

The New Brunswick weir catches were made up almost entirely of the 1980 year class as were the "shutoff" and "miscellaneous" gears (Figure 8a). Table 6 lists the mean weights-at-age for the various fishery components.

Abundance Indices

The treatment of abundance indices differs little here from that of 1981 (Sinclair et al. 1982):

"A variety of indices derived from the different commercial fishery gear components have been reviewed annually to try and evaluate stock status. Purse-seine and gillnet catch rates are used to 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 for the other gear components are shown in Table 8."

"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 series support the perception that the 1976 year-class is large, the time series catch rate is not long enough to provide confidence in estimating its size relative to the other large year-classes, 1966 and 1970."

That much of the reported catch was caught by purse seine makes the index valueless.

"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 given to the weir information."

The significance of the New Brunswick weir catch rates is not direct, but represents the effect of year class parallelism for stocks in the same general area. As year class parallelism tends to be more marked at very high and at very low year class sizes this can be surprisingly effective. The New Brunswick weir catch-at-age 2 (Table 9) was considered for fine-tuning the cohort analysis but was finally discounted since the relationship is not direct.

Estimation of Population Size

The 1981 assessment (Sinclair et al., 1982) compared 4+ biomass in January year n, with the geometric mean of larval abundance measured in November of year n. At last years assessment meeting it was suggested that comparison with (residual) biomass 5+ as of January in the year n+1, would take into account removals by the fishery more objectively. This procedure has been followed and has generated acceptable data for fine tuning the SPA (see below). Table 10 lists the basic data for the larval indices.

Fine tuning was achieved by combination of both larval data and weir catch rates, to give the best combined results.

Initial fine-tuning suggested that the partial recruitment vector used in the 1981 analysis (Sinclair et al., 1982) overestimated the degree of recruitment at two years of age and underestimated recruitment at four years of age. Adjustments were made and the resulting recruitment ogive is shown in the table below and in Figure 10. These estimates conform more closely with the pattern of recruitment at age for herring generally.

AGE	1	2	3	4	5	6	7	8	9	10
PR 1981	.001	.5	.53	.77	1	1	1	1	1	1
PR 1982	.01	.22	.53	1	1	1	1	1	1	1

The table below lists the population estimates for a series of terminal F values; the estimates themselves are relatively insensitive to input F. The finally chosen estimate of F = 0.375 resulted from a comparison of R^2 for the correlations involving population estimates and larval abundance and New Brunswick weir catches at age 2+ for the equivalent year classes. The table indicates that F = 0.375 represents the best compromise. Natural mortality was taken to be M = 0.2.

Terminal F	R^2 for N.B. Weir Age 2	R^2 for Larval Index (1973-81)
.25	.595	.820
.30	.571	.855
.35	.546	.871
.375	.535	.875
.40	.524	.880
.45	.504	.879
.50	.486	.878
.60	.458	.869

The final input parameters used for the cohort analysis were:

(i)   catch-at-age matrix for 1982 (see Table 11)
(ii)   natural mortality of 0.2
(iii) terminal F of 0.375
(iv) partial recruitment pattern as given for 1982 (in text above)

The resulting population numbers and fishing mortality matrices are presented in Table 12.

Figure 11 shows the relationship between the New Brunswick weir catch rate for age 2 and the VPA optimum estimate for age 2 population size for the 4WX stock.

Figure 12 compares the VPA estimate of 5+ biomass in January of year n+1 with the larval abundance index for November in year n.

Yield-Per-Recruit Analysis

Table 13 shows the derivation of the Von Bertalanffy growth parameters based on mean weight for July over the period 1969-1978. The "predicted" weights in Table 13 were used to perform a Thompson-Bell yield-per-recruit analysis, the results of which are presented in Table 14.

Projections

The input variables for the projection of catches at $F_{0.1}$ for the period 1982-1989 inclusive are as follows:

(i)   "predicted" mean weight-at-age for July from Table 13
(ii)   partial recruitment pattern as for cohort analysis
(iii) catch-at-age for 1982 (Table 11)
(iv) population numbers-at-age (Table 12)

(v) recruitment-at-age 1 of 1.48 billion (the geometric mean of
      year classes 1964 to 1980)

(vi) $F_{0.1}$ equal to 0.3 (Sinclair et al., 1982)

      The 1982 catch was 84,733 t (Table 16) and the projected
$F_{0.1}$ catch biomass is 71,788 t and 78,474 t for 1983 and 1984
respectively (Table 15). This does not take into account a change in
the mean weight-at-age of 5% which, compared to earlier projections,
would inflate catch biomass by the same ratio.

      Table 16 compares the age distribution for 1982, projected
from last year's analysis and the actual age distribution in the
fishery in 1982. It demonstrates a very close correspondence for ages
4 and above and a more than doubling of the contribution by the 1979
year class to the catch. The projected 1983 catch biomass from this
year's assessment assumed an approximate doubling of the contribution
of this year class in 1983; there is a good correspondence.

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Table 1 . Provisional catch for the 1982 4WX herring fishery.

	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTAL
4Wa Purse seine[1]															
(Chedabucto Bay)	2256	3669	2901	459	–	2990	–	–	–	–	–	–	–	·	12,275
4Xa Purse seine															
Domestic[2]	–	–	–	–	–	–	–	82	4113	8255	17333	7870	–	–	37,653
Over-the-side sales[2]	–	–	–	–	–	–	–	1450	10827	10319	4095	–	–	–	26,691
TOTAL (Purse Seine)	–	–	–	–	–	–	–	1532	14940	18574	21428	7870	–	–	64,344
Gillnets (stock)[3]	–	–	–	–	–	–	17	58	290	2083	2672	160	–	–	5,280
Gillnet (463)[3]	–	–	–	–	–	–	–	45	339	708	416	11	–	–	1,519
N.S. Weirs[3]	–	–	–	–	–	–	16	267	478	228	172	51	–	–	1,212
4WXa TOTAL	2256	3669	2901	459	–	2990	33	1902	16047	21593	24688	8092	–	–	84,630
4Xb															
Purse seine[3]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Midwater Trawl[3]	–	–	–	–	55	48	–	–		–	–	–	–	–	103
N.B. Weirs[3]	–	–	–	17	–	–	132	30	2871	7311	7682	3204	849	87	22,183
Shutoffs[3]	–	–	–	–	–	–	26	· –	135	580	671	1034	101	10	2,557
Miscellaneous[3]	–	–	–	–	–	–	133	166	504	190	188	39	2	1	1,223
4Xb TOTAL	–	–	–	17	55	48	291	196	3510	8081	8541	4277	952	98	26,066

[1]Best estimate from logs, hails and delivery notes
[2]Best estimate from hails and delivery notes
[3]From Statistics

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

[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 1982 catch-at-age-matrix (columns A+C+D+E+F+G+H+K).

| | 4W | | 4XA | | | | 4XB | | | | 4WX | |
| | Purse seine[a] | Fixed gear[b] | Summer purse seine | Gill net[13] | Weir | Liverpool trap | Winter purse seine Grand Manan | Saint John | Weir[b] | Misc. & shut-offs[b] | Foreign total | Stock total[c] |
Year												
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]	621[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	3348[4]		36618[5]	5205[5]	12492[5]	-	25155[5,8]	2167[5]	19088[5]	847[5]	32702[10]	122687
1974	27044[3]		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[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
1978	17274[1]		57973[12]	6059[12]	8057[12]	-	3832[12]	2687[12]	33570[12]	5272[12,11]	-	95882
1979	14073[12]		25265[7]	4363[7]	9307[7]	2174[14]	2973[7]	866[2]	32477[7]	5351[7,11]	-	59021
1980	8958[2]		74975[16,17]	19804[16,18]	2383[16]	2010[14]	556[14]	787[14]	11100[16]	2425[17,11]	-	109574
1981	18588[2]		53799[14]	11985[14,18]	1966[14]	-	-	1368[14]	15576[16]	3504[11,14]	-	87706
1982	12275[2]		64344[14]	5799[14,18]	1212[14]	-	-	103[19]	22183[14]	3780[11,14]	-	84733
1983	8800[2]											
	A	B	C	D	E	F	G	H	I	J	K	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.
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[11]Shut-offs only.
[12]Sinclair et al. CAFSAC Res. Doc. 79/19.
[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]Adjusted upwards assuming 40% misreporting.
[18]Includes area 463 catch.
[19]Midwater gear only.

Table 3.   Temporal distribution of catch to sample ratio for 4WX herring fishery (1977 to 1982)

	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——►			
4X 1982 (OSS)												
(Dom.)	-	-	-	-	-	76	85	78	93	-	-	-
4Wa 78/79	220	-	-	-	-	-	-	-	-	-	-	226
4Wa 79/80	220	-	-	-	-	-	-	-	-	-	-	118
4Wa 80/81	188	168	-	433	-	-	-	-	-	-	-	-
4Wa 81/82	107	33	-	214	-	-	-	-	-	-	-	-
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———►		-	-
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				
1982	-	-	-	-	16	45	25	18	57	51	-	-
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
1982	-	◄————— 25 —————►				15	49	85	135	132	86	24
Liverpool Fishery												
1978	-	-	171	-	-	-	-	-	-	-	-	-
1979	-	-	50	-	-	-	-	-	-	-	-	-
1980	-	-	155	-	-	-	-	-	-	-	-	-

Table 4. Distribution of Purse Seine Landings as Partitioned by Over-the-Side-Sales (O.S.S.) Observer Reports.

Purse Seine	JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER*	
	Percentage Breakdown	Domestic	O.S.S.	Percentage Breakdown	Domestic	O.S.S.	Percentage Breakdown	Domestic	O.S.S.	Percentage Breakdown	Domestic	O.S.S.	Percentage Breakdown	Domestic
12													40.8	3211
13							0.4	33	41					
14				1.5	62	162	0.8	66	83	0.6	104	25		
15							16.8	1387	1734	23.1	4021	946		
16				3.4	140	368	0.9	74	93	72.8	12619	2981		
17	8.1	7	117	30.0	1234	3248	31.8	2625	3281	1.3	225	53		
18	91.9	75	1333	42.8	1760	4634	13.2	1090	1362	0.3	35	12	59.2	4659
19				22.3	917	2415	36.1	2980	3725	1.9	329	78		
TOTAL		82	1450		4113	10827		8255	10319		17333	4095		7870

*No O.S.S. Program; therefore purse seine log records used.

- 12 -

Table 5. Catch-at-age ($\times 10^{-3}$) by gear for the 1982 4WX herring fishery.

	1	2	3	4	5	6	7	8	9	10	11+	Total No's.	Tonnes
4Wa													
Purse Seine	-	21	4,872	3,749	18,403	35,239	1,523	453	365	354	435	65,414	12,275
4Xₐ													
Purse Seine (OSS)	6	1,443	63,556	7,197	20,812	36,146	3,075	312	110	208	51	132,918	26,691
Purse Seine (Domestic)	-	53,691	46,736	5,131	27,380	67,490	5,236	538	321	307	204	207,034	37,653
Gillnets	-	-	2,673	1,280	5,829	14,884	1,034	229	174	17	24	26,144	6,799
Nova Scotia Weirs	1,432	13,915	3,274	391	593	783	42	3	7	-	5	20,445	1,212
4Xb													
Otter Trawl	2,151	3,521	1,269	8	8	-	-	-	-	-	-	6,957	103
"Stock Total"	3,589	72,591	122,380	17,756	73,025	154,542	10,910	1,535	977	886	719	458,910	84,733
4Xb													
Weirs, Shutoffs & Misc.	30,210	395,416	73,197	3,199	1,795	1,596	196	42	68	-	-	505,716	25,963

Table 6. Weights-at-age of herring from various gear components of the 1982 4WX herring fishery (g).

		1	2	3	4	5	6	7	8	9	10	11+
N.S. Weirs	No.	1,432	13,915	3,274	391	593	783	42	3	7	-	5
	Wt.	6.00	34.27	99.03	165.3	211.46	247.46	275.88	374.29	346.6		461.76
Gillnets	No.	-	-	2,673	1,280	5,829	14,884	1,034	229	174	17	24
	Wt.			162.83	203.74	258.93	277.25	296.25	323.59	365.37	358.67	448.48
4Xb Otter Trawl	No.	2,151	3,521	1,269	8	8	-	-	-	-	-	-
	Wt.	10.24	13.89	23.29	123.57	102.87						
4Wa Purse Seine	No.	-	21	4,872	3,749	18,403	35,239	1,523	453	365	354	435
	Wt.		35.23	89.73	136.06	178.3	203.94	231.61	275.93	316.26	340.21	330.04
4Xa Purse Seine												
(OSS)	No.	6	1,443	63,556	7,197	20,812	36,146	3,075	312	110	208	51
	Wt.	-	65.72	140.56	187.7	247.46	274.91	307.86	367.74	405.52	405.28	373.54
(Domestic)	No.	-	53,691	46,736	5,131	27,380	67,490	5,236	538	321	307	204
	Wt.		58.45	142.46	183.65	244.87	269.24	290.11	326.51	399.47	403.11	384.35
TOTAL	No.	3,589	72,591	122,380	17,756	73,025	154,542	10,910	1,535	977	886	719
	Wt.	8.54	51.79	137.42	176.26	229.67	256.34	287.47	319.62	362.61	377.64	353.4
Mean July Purse Seine Wt. (gm) (1969-1978)					172	218	254	286	323	354	389	

Table 7. Monthly length frequencies for the 1982 4Xa purse seine fishery.

Length (cm)	June Dom.[1]	June O.S.S.[2]	July Dom.	July O.S.S.	August Dom.	August O.S.S.	September Dom.	September O.S.S.	Total Dom.	Total O.S.S.
11	-	-	-	-	-	1	-	-	-	1
12	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	1	1	1	-	2	1
16	-	-	3	7	-	15	2	-	5	22
17	-	-	2	12	4	36	29	-	35	48
18	-	1	5	31	4	109	45	-	54	141
19	-	2	7	37	8	171	81	-	96	210
20	-	18	42	54	2	195	83	-	127	267
21	3	125	80	163	6	268	39	-	128	556
22	8	289	126	575	10	365	36	-	180	1229
23	46	449	122	1672	25	877	23	7	216	3005
24	89	361	100	2888	72	1707	78	67	339	5023
25	94	97	91	3388	200	2847	203	420	588	6752
26	68	132	58	2460	323	3299	373	816	822	6707
27	36	304	27	876	260	1972	306	741	629	3893
28	46	520	8	461	126	776	101	273	281	2030
29	96	358	50	962	258	1214	136	376	540	2910
30	144	114	166	1816	685	2825	411	986	1406	5741
31	132	13	204	1632	802	3525	588	1364	1726	6534
32	39	2	95	589	384	1674	412	852	930	3117
33	4	1	13	126	83	451	116	286	216	864
34	-	2	5	22	9	83	21	52	35	159
35	1	-	2	9	12	35	6	13	21	57
36	-	-	1	2	7	25	5	9	13	36
37	-	-	-	5	3	10	1	6	4	21
38	-	-	-	1	-	6	-	1	-	8

[1] Domestic

[2] Over-the-side Sales

Table 8. 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	40.6 [2]	68.7*[2]	3.44	48 (25)	114 (195)
1983		51.0*[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 9. Catch-at-age from New Brunswick weirs and shutoffs (nos. $\times 10^{-3}$).

| Year | A G E S | | |
	1	2	3
1965	992	852368	65449
1966	3899	151087	432061
1967	127374	194566	57421
1968	2409	758766	51933
1969	71191	375586	101361
1970	3553	348916	9924
1971	92253	183690	37348
1972	8102	660547	6446
1973	31803	149051	125965
1974	3259	246044	43483
1975	16880	462977	57228
1976	51791	199268	104624
1977	514970	124293	10334
1978	213778	894372	52125
1979	2135	447818	242047
1980	263106	5395	62087
1981	53336	294720	18781
1982	30210	395416	73197

Table 10. 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
1982	9.10	3.73

* interpolated

Table 11. Catch matrix for the 4WX "stock" herring used in the cohort analysis.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	270378	154323	722208	164703	108875	699720	87570	0	754	14151	0	0	0	0	311	2014	0	3589
2	1084719	914093	613970	2389061	290329	576896	404224	649254	126421	596153	264491	48470	140494	346719	170523	9700	75713	72591
3	34835	448940	153626	224956	531812	76532	183896	71984	595992	72381	180898	176226	28659	36177	226442	72957	33174	122380
4	234383	23382	266454	83109	132319	286278	106630	148516	109530	616622	92487	130598	192958	11338	47200	502296	68816	17756
5	49925	321857	110051	290285	162439	201215	113566	77207	34422	53199	383650	72334	166061	107627	4639	29948	306716	73025
6	10592	45916	159203	73087	112631	120280	75593	75384	25562	15254	50599	219788	55066	60431	19695	4351	21720	154542
7	1693	13970	57948	90617	62506	111937	93620	49065	19361	8120	9357	18960	150588	27286	15521	4291	1631	10910
8	561	7722	4497	31977	22595	41257	50022	48700	17604	5313	3238	4967	12466	96741	9981	5508	1914	1535
9	54	1690	409	15441	6345	21271	36618	26055	19836	10964	3481	3556	2073	9838	35386	2248	1366	977
10	37	215	296	5668	2693	7039	7536	13792	9661	5787	2842	1835	1253	2169	3834	8877	361	886

Table 12. 4WX herring estimated population numbers-at-age and fishing mortality for the time period 1965 to 1982.

POPULATION NUMBERS   1/ 2/84

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	3507897	2732980	6132016	1264242	1726884	2168656	6144713	985483	1917119	1416960	187803	610287	4080262	1058907	181577	1215922	1233641	1109809
2	3862516	2627375	2097938	4366989	886044	1315339	1142413	4951629	806845	1568922	1147304	153760	499661	3340636	866960	148381	993690	1010019
3	993427	2180866	1324007	1162103	1413677	462731	554911	569571	3466582	546198	745103	700012	82030	281964	2421357	555511	112707	745057
4	1323321	781830	1379325	944999	747901	676217	309603	287927	401192	2298921	381696	446356	413665	41229	198118	1777546	388800	62260
5	346668	871365	573709	888198	698499	492602	294605	156999	101352	229361	1324255	228821	247275	164085	23496	119497	1000835	256055
6	92591	238653	422185	370135	464534	424902	221242	138443	58680	51834	139649	737067	121892	106484	36956	15040	70738	541887
7	41382	66223	153846	201603	236909	278416	239047	112738	45137	24914	28635	68551	404587	49971	32501	12437	8377	38255
8	4503	32349	41578	73525	83065	137407	126663	111004	47906	19437	13050	14978	38969	194990	16223	12566	6300	5382
9	1074	3179	19498	29972	31263	47563	75168	58441	46817	23294	11106	7755	7769	20625	72110	4251	5304	3426
10	344	831	1074	15593	10568	19855	19695	28409	24272	20382	9151	5943	3132	3761	7985	27020	1447	3107
	10175724	9535652	12145176	9317360	6299345	6023689	9128059	7400644	6915901	6200222	3987752	2973529	5899242	5262652	3857283	3888170	3821838	3775256

FISHING MORTALITY   1/ 2/84

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.089	0.064	0.139	0.155	0.072	0.441	0.016	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.004
2	0.372	0.485	0.391	0.928	0.450	0.663	0.496	0.157	0.190	0.545	0.294	0.428	0.372	0.122	0.245	0.075	0.088	0.082
3	0.040	0.258	0.137	0.241	0.537	0.202	0.456	0.150	0.211	0.158	0.312	0.326	0.488	0.153	0.109	0.157	0.393	0.199
4	0.218	0.110	0.240	0.102	0.218	0.631	0.479	0.844	0.359	0.352	0.312	0.391	0.725	0.362	0.306	0.374	0.218	0.375
5	0.173	0.525	0.238	0.448	0.297	0.600	0.555	0.784	0.471	0.296	0.386	0.430	0.643	1.291	0.246	0.324	0.414	0.375
6	0.135	0.239	0.539	0.246	0.312	0.375	0.474	0.921	0.657	0.393	0.512	0.400	0.692	0.987	0.889	0.385	0.415	0.375
7	0.046	0.265	0.538	0.687	0.345	0.588	0.567	0.656	0.643	0.447	0.448	0.365	0.530	0.925	0.750	0.480	0.242	0.375
8	0.148	0.306	0.127	0.655	0.358	0.403	0.574	0.663	0.521	0.360	0.320	0.456	0.436	0.795	1.139	0.662	0.409	0.375
9	0.057	0.885	0.023	0.842	0.254	0.682	0.773	0.679	0.632	0.734	0.425	0.707	0.525	0.749	0.782	0.878	0.335	0.375
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	0.375
	0.211	0.277	0.217	0.572	0.305	0.509	0.176	0.211	0.175	0.306	0.325	0.303	0.171	0.190	0.177	0.216	0.174	0.153

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Table 13. Derivation of von Bertalanffy parameters from mean weight
for July over the period 1969 to 1978.

VON BERTALANFFY PARAMETERS   1/ 2/84

$L\infty$ -------- 658.1683721
K -------- 0.1088905376 $L=L\infty(1-EXP(KT\circ-KT))$
$T\circ$ -------- 0.9554388522

AGE	OBSERVED WEIGHT	PREDICTED WEIGHT	ERROR	REL ERROR
1	6.000	3.186	-2.314	-0.469
2	60.000	70.761	10.761	0.179
3	134.000	131.365	-2.635	-0.020
4	191.000	185.716	-5.284	-0.028
5	254.000	234.460	-19.540	-0.077
6	270.000	273.174	3.174	0.030
7	293.000	317.379	24.379	0.083
8	358.000	352.539	-5.461	-0.015
9	391.000	384.071	-6.929	-0.018
10	413.000	412.350	-0.650	-0.002

SOURCE	SS	DF	MS
REGRESSION	731672	3	243890.7
RESIDUAL	1279.8	7	182.33
TOTAL	732952	10	73295.2

$R*2$ -------- 99.2527098

Table 14. Thompson-Bell yield per recruit analysis based on 'predicted' von Bertalanffy weights.

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	*CATCH (NUMBER)*	*YIELD (KG)*	*AVG. WEIGHT (KG)*	*YIELD PER UNIT EFFORT*
	0.1000	0.197	44.781	227.866	1.000
	0.2000	0.314	66.215	211.166	0.739
	0.3000	0.388	76.322	196.785	0.568
F0.1---	0.3071	0.392	76.786	195.847	0.558
	0.4000	0.438	80.879	184.602	0.452
	0.5000	0.474	82.687	174.345	0.369
	0.6000	0.502	83.123	165.696	0.309
FMAX---	0.6021	0.502	83.123	165.530	0.308
	0.7000	0.523	82.871	158.356	0.264
	0.8000	0.541	82.276	152.067	0.230
	0.9000	0.556	81.515	146.623	0.202
	1.0000	0.569	80.681	141.859	0.180
	1.1000	0.580	79.823	137.647	0.162
	1.2000	0.590	78.968	133.890	0.147
	1.3000	0.599	78.128	130.509	0.134
	1.4000	0.607	77.312	127.444	0.123
	1.5000	0.614	76.523	124.647	0.114
	1.6000	0.621	75.761	122.080	0.106
	1.7000	0.627	75.028	119.711	0.099
	1.8000	0.632	74.323	117.516	0.092
	1.9000	0.638	73.644	115.473	0.087
	2.0000	0.643	72.991	113.565	0.081

Table 15. Catch projections for 4WX herring for the year 1983 to 1989.

CATCH BIOMASS   1/ 2/84

	1982	1983	1984	1985	1986	1987	1988	1989
1	151	161	161	161	161	161	161	161
2	6461	4670	6232	6232	6232	6232	6232	6232
3	16277	13558	12356	16490	16490	16490	16490	16490
4	3054	20296	21585	19671	26252	26252	26252	26252
5	15919	1803	15602	16594	15122	20181	20181	20181
6	39254	8640	1274	11026	11727	10687	14262	14262
7	3120	20588	5901	870	7530	3009	7298	9740
8	496	1641	14103	4042	596	5158	5486	4999
9	346	253	1091	9375	2687	376	3429	3647
10	345	177	169	727	6248	1791	264	2285
1+	85422	71788	78474	85137	93044	95355	100053	104247
2+	85271	71627	78313	85026	92883	95174	99992	104086
3+	78810	66957	72081	78794	86651	88962	93660	97854
4+	62534	53398	59725	62305	70161	72472	77171	81365

Table 16. Age distributions projected and actual for 1982.

Age	Projected catch (t)[a]	Actual catch (t)[b]	Projected catch (no's. x 10^{-5})[c]	Observed catch (no's. x 10^{-5})[d]	Projected 4[+] (no's. x 10^{-5})[e]
1	-	-	-	-	-
2	6632	7258	177.02	72.59	-
3	5882	6437	57.47	122.38	-
4	5219	5711	33.20	17.76	29.15
5	11403	12479	57.24	73.03	64.12
6	43821	47955	188.80	154.54	165.77
7	3495	3825	13.37	10.91	11.74
8	296	324	1.08	1.54	0.88
9	381	417	1.18	0.98	1.04
10	299	329	0.84	0.89	0.74
Totals	77429	84733			

[a,c,e] Projection from Sinclair et al. 1982
[b,d] Actual 1982 catch-at-age for "4WX stock"

Juvenile Fisheries

NOVA SCOTIA WEIRS

GRAND MANAN PURSE-SEINE

ST. JOHN BRIT PURSE-SEINE

LIVERPOOL TRAP

N.B. WEIRS & SHUT-OFFS

Adult Fisheries

Pre - spawning aggregations

Spawning

PURSE-SEINE & GILL NET

S.W. NOVA SCOTIA 'FRONT PURSE-SEINE

on summer feeding fish

CHEDABUCTO BAY PURSE-SEINE

on over-wintering fish

FOREIGN FLEETS ON ?

Migrating Fish

GILL NET

S.W. NOVA SCOTIA

FOREIGN FLEETS

on migrating fish

CHEDABUCTO BAY

JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

MONTHS

Figure 1. Schematic representation of approximate seasonal distribution of the various components of the juvenile and adult 4WX herring fishery.
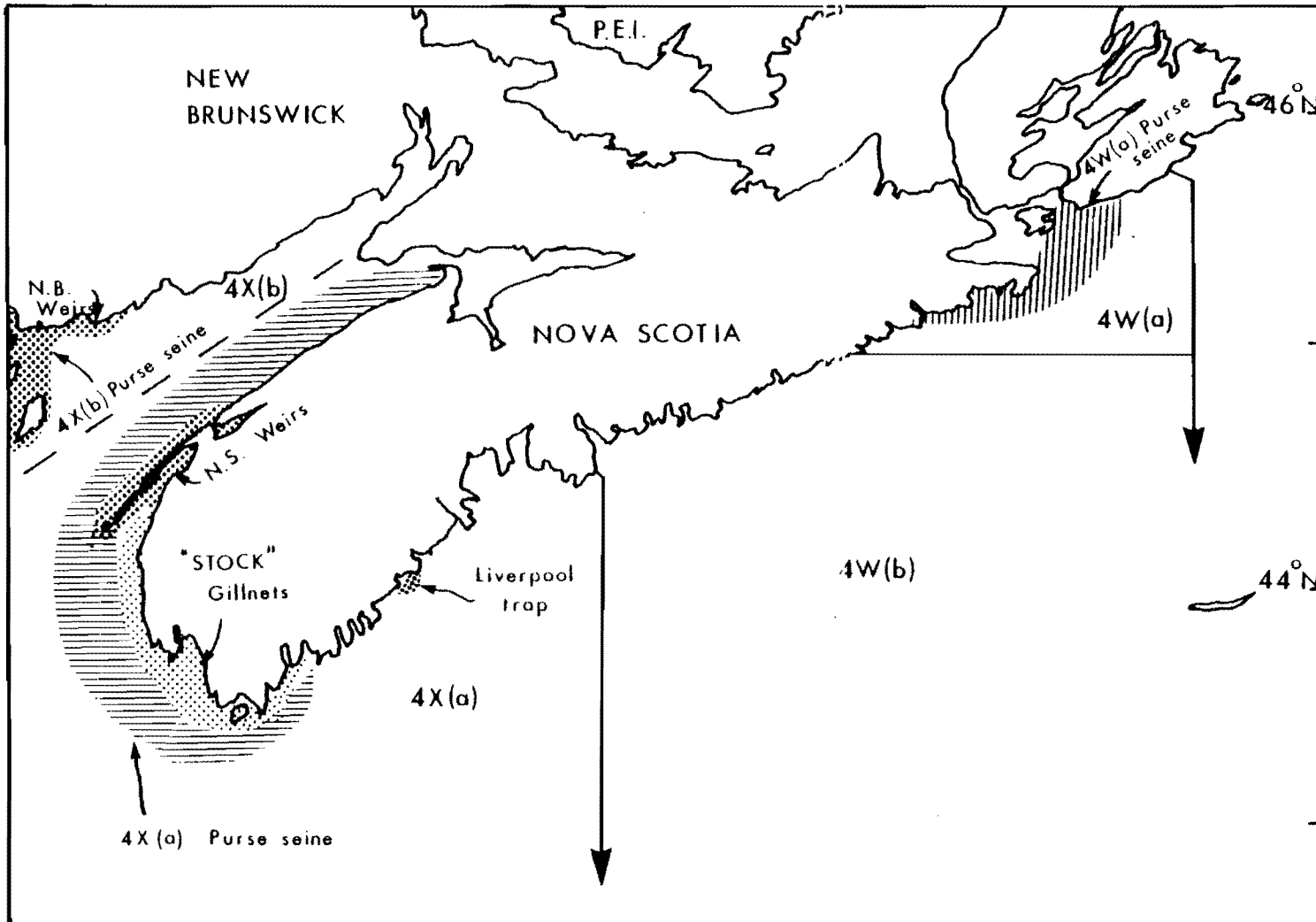
Figure 2. Geographical location of various components of the 4WX herring fishery.
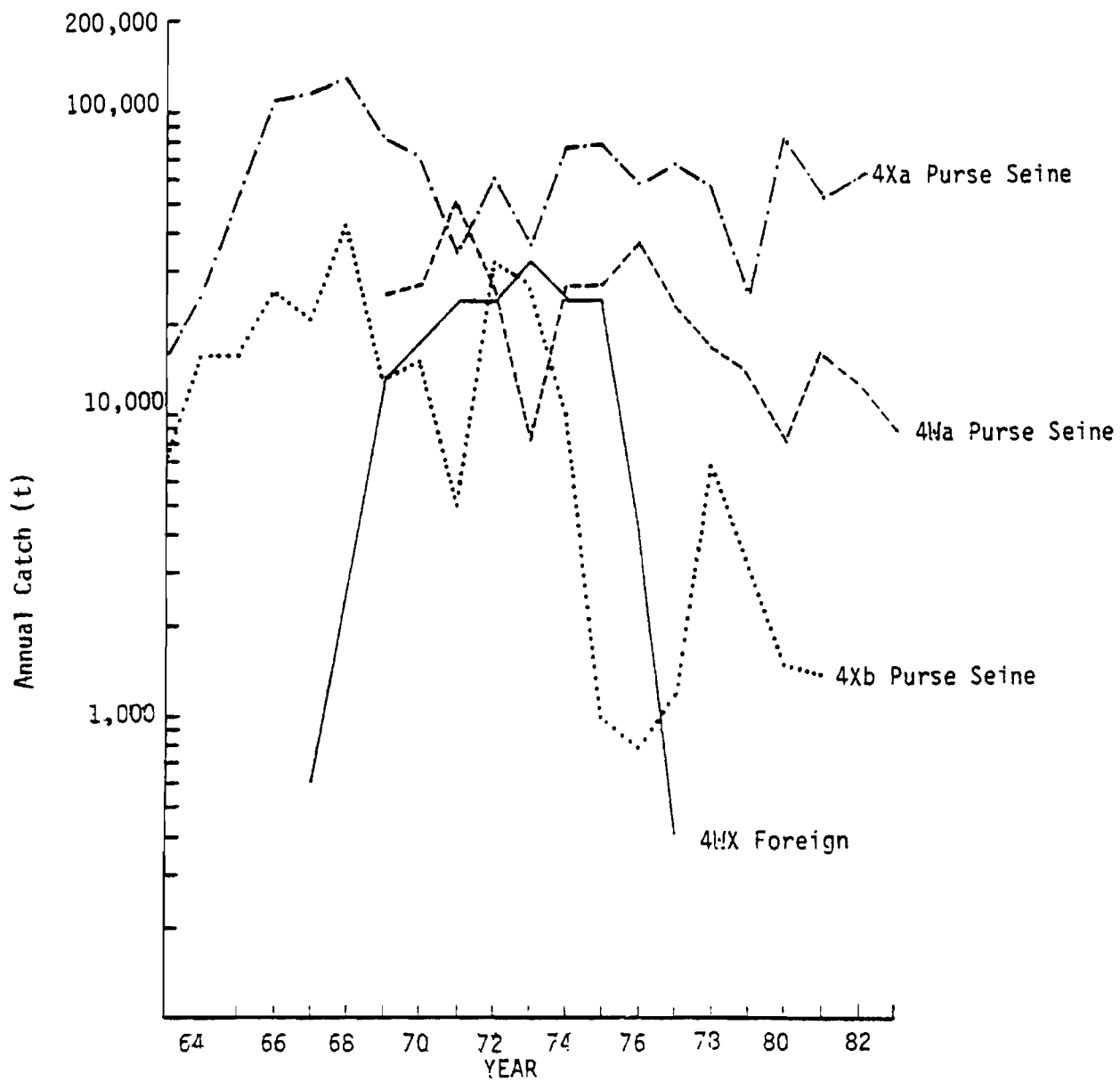
Figure 3. 4WX mobile gear herring catch (1963-1983).
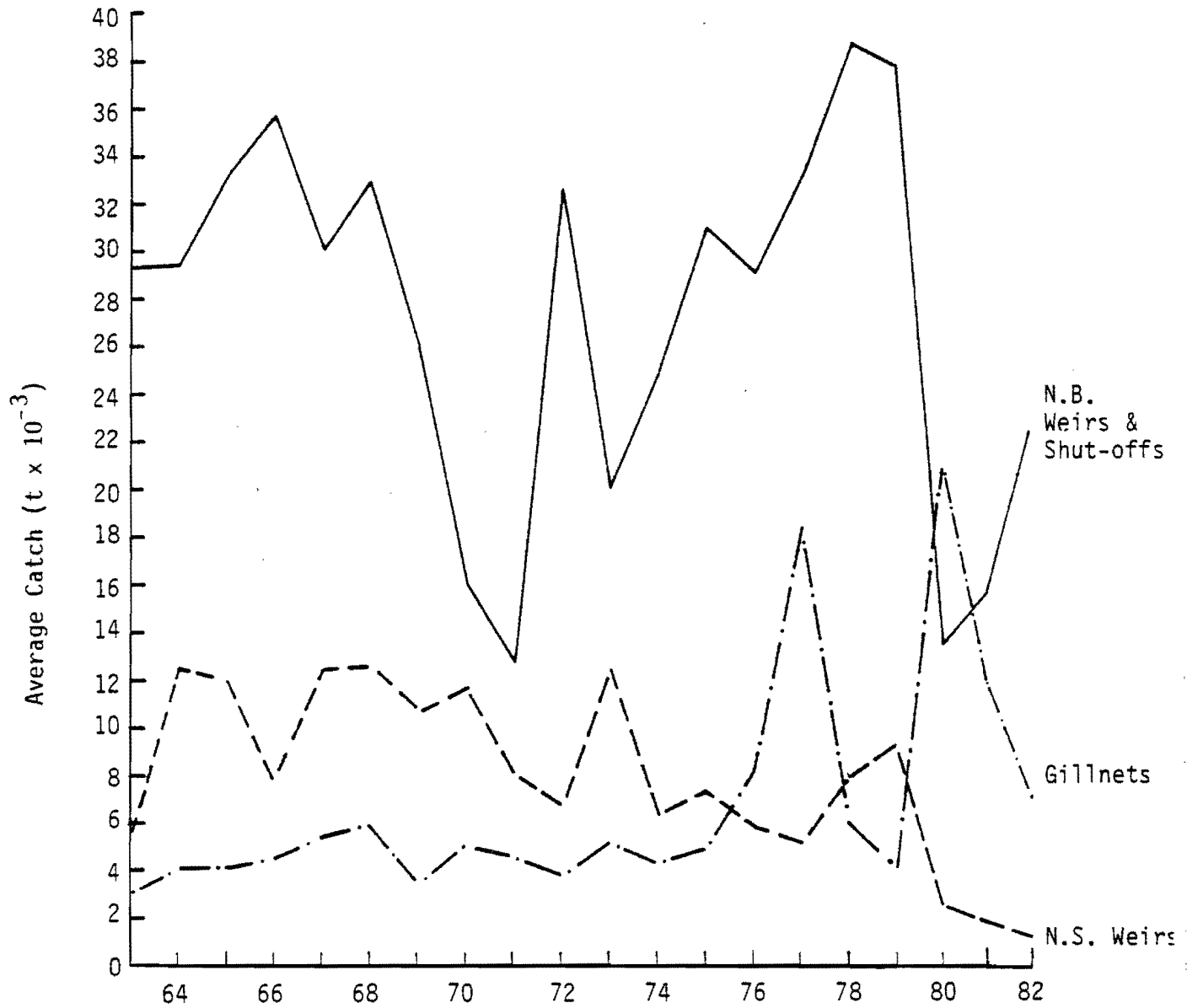
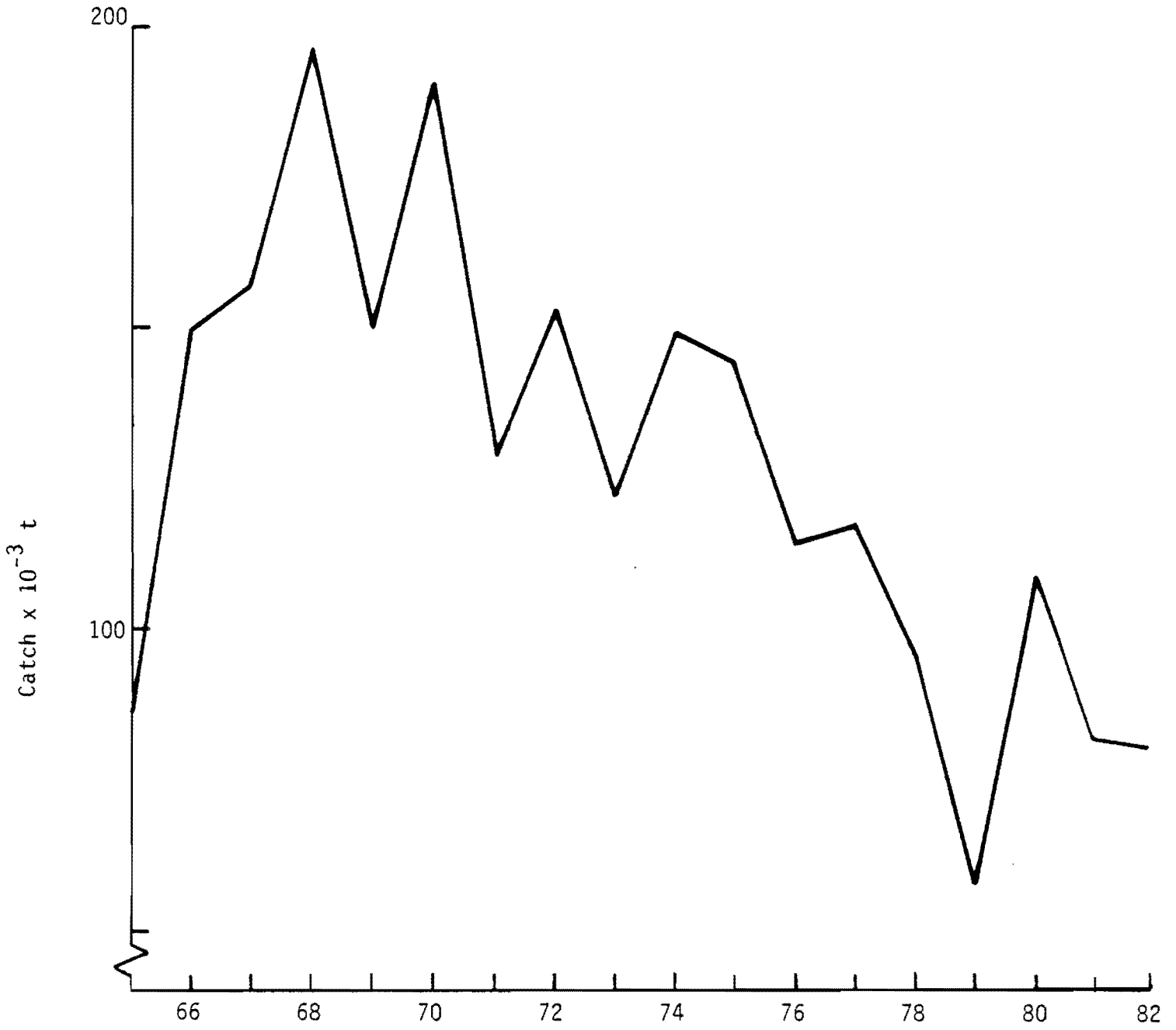Figure 4 . 4X fixed gear herring catch (1963 to 1982).

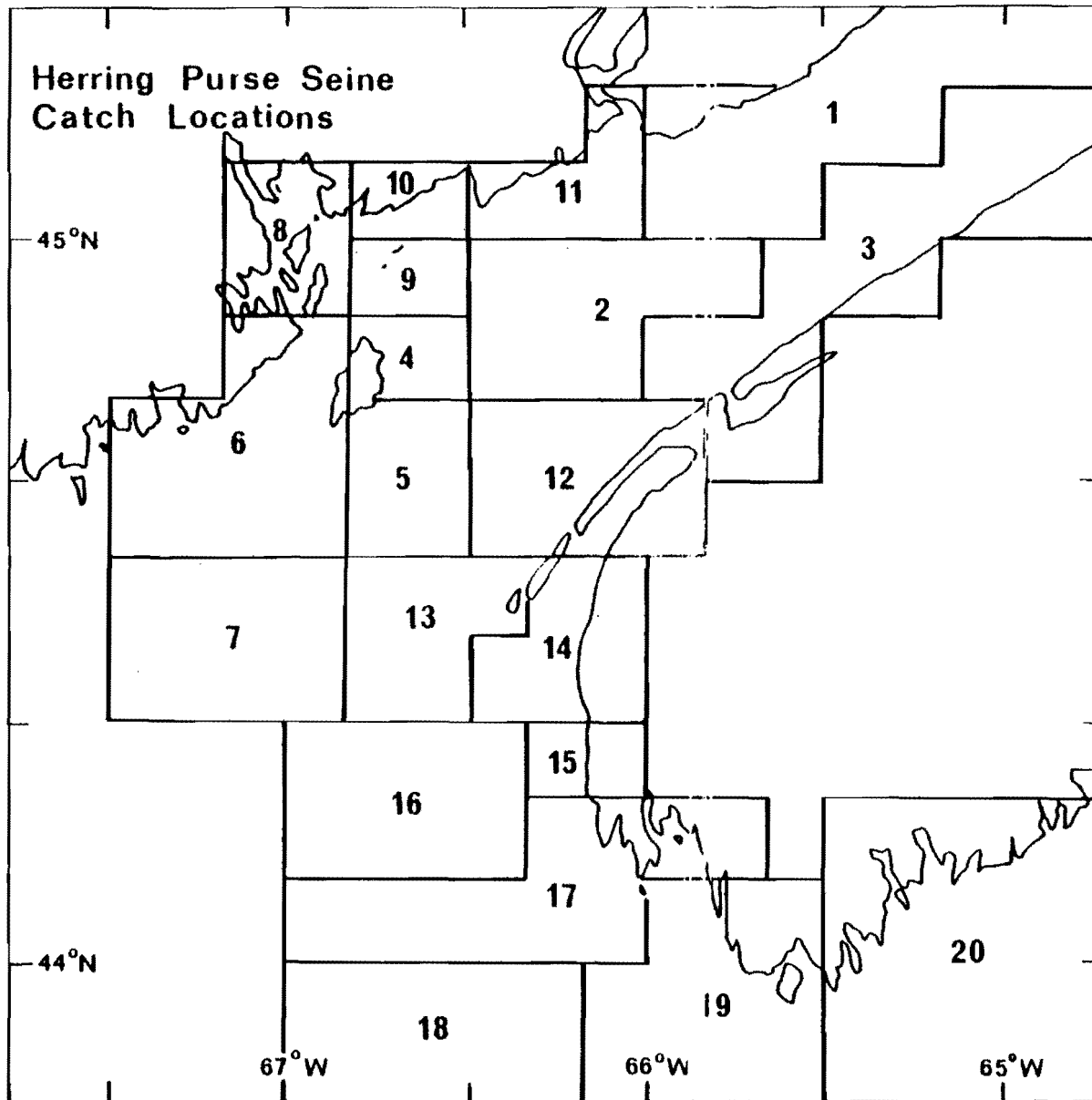Figure 5. 4WX "Stock" annual catch (1965-1982).

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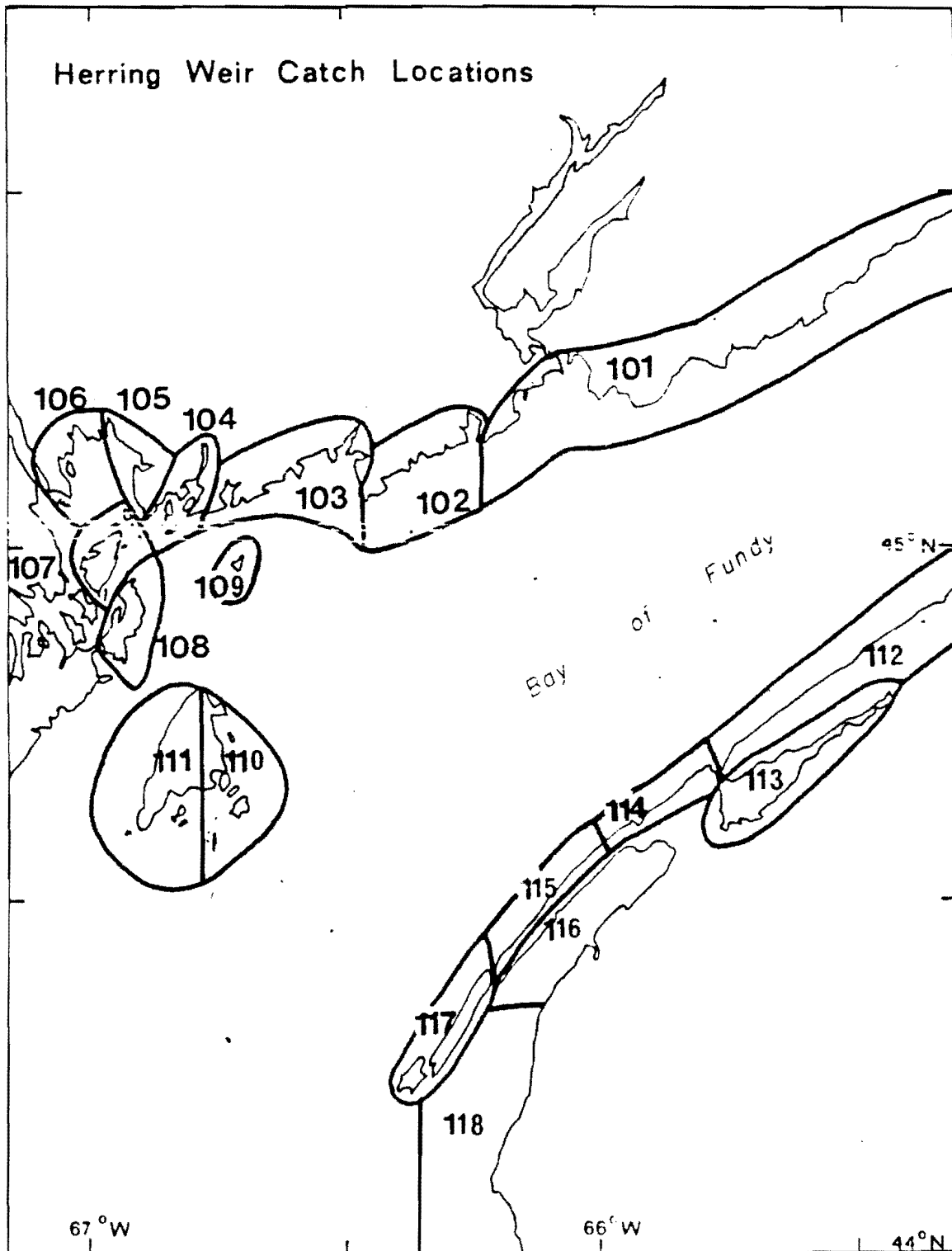matching of catch and samples for the generation of numbers-at-age.

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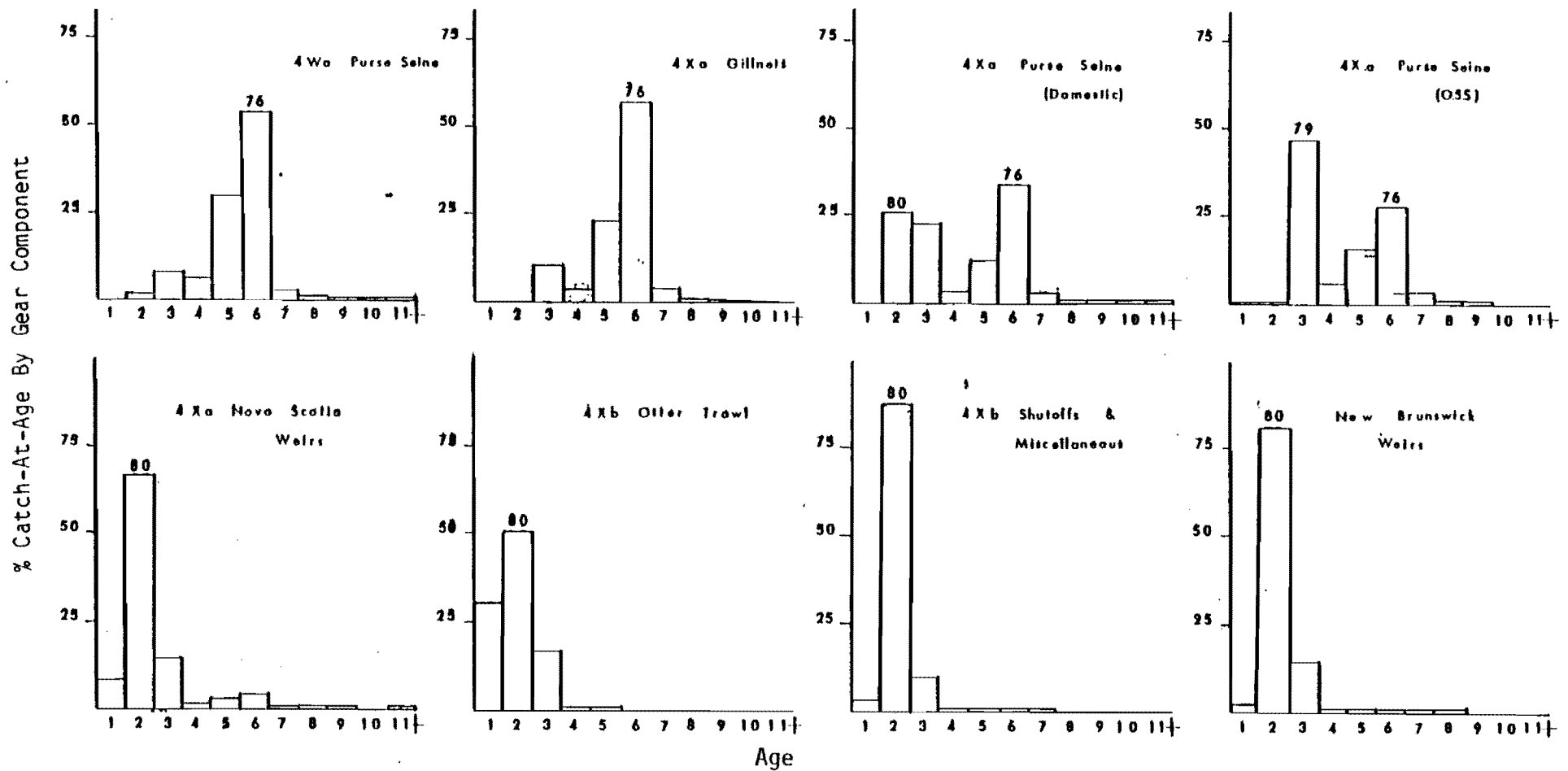catch and samples for the generation of numbers-at-age.

Figure 8a. Age composition (%) of various components of the 4WX herring fishery during 1982.
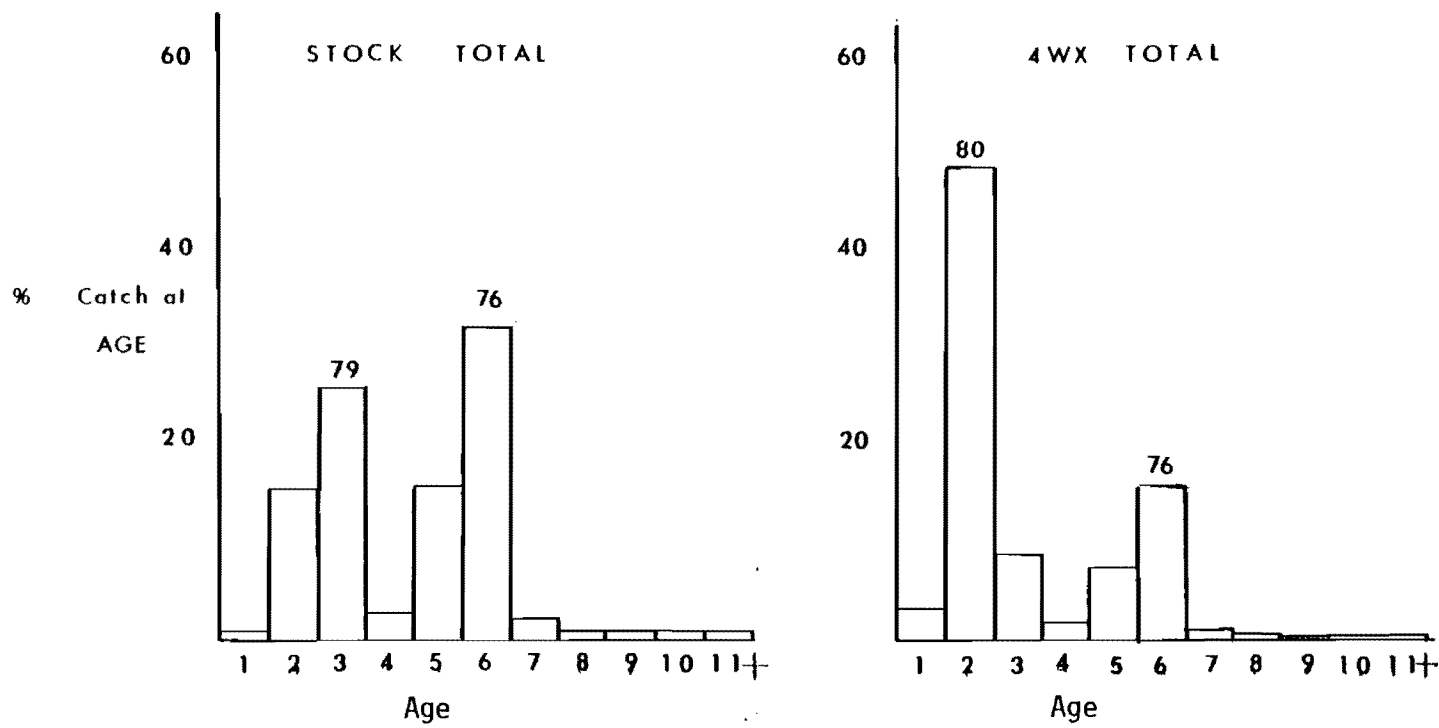
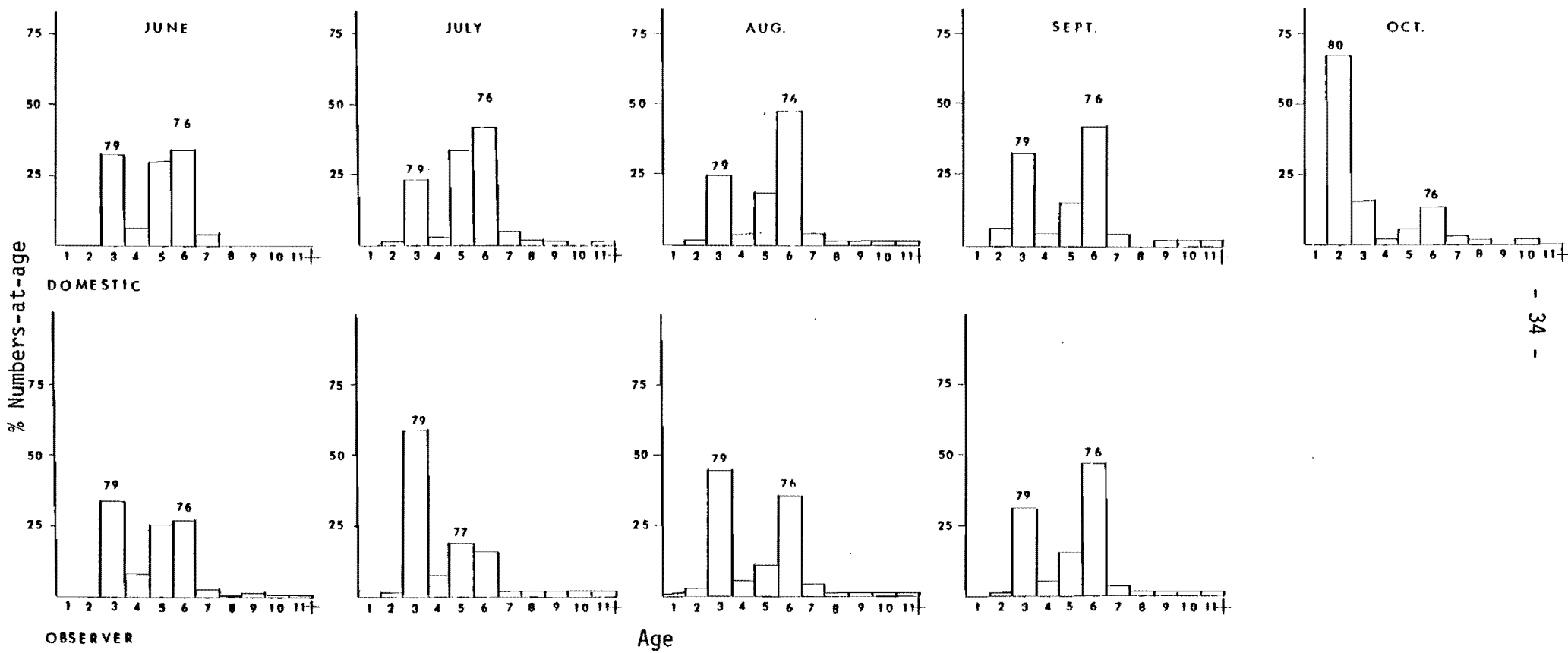Figure 8b. Age composition (%) of the overall 4WX herring fishery during 1982.

Figure 9. Comparison of numbers-at-age (%) by month for the domestic and O.S.S. purse seine fishery during 1982.
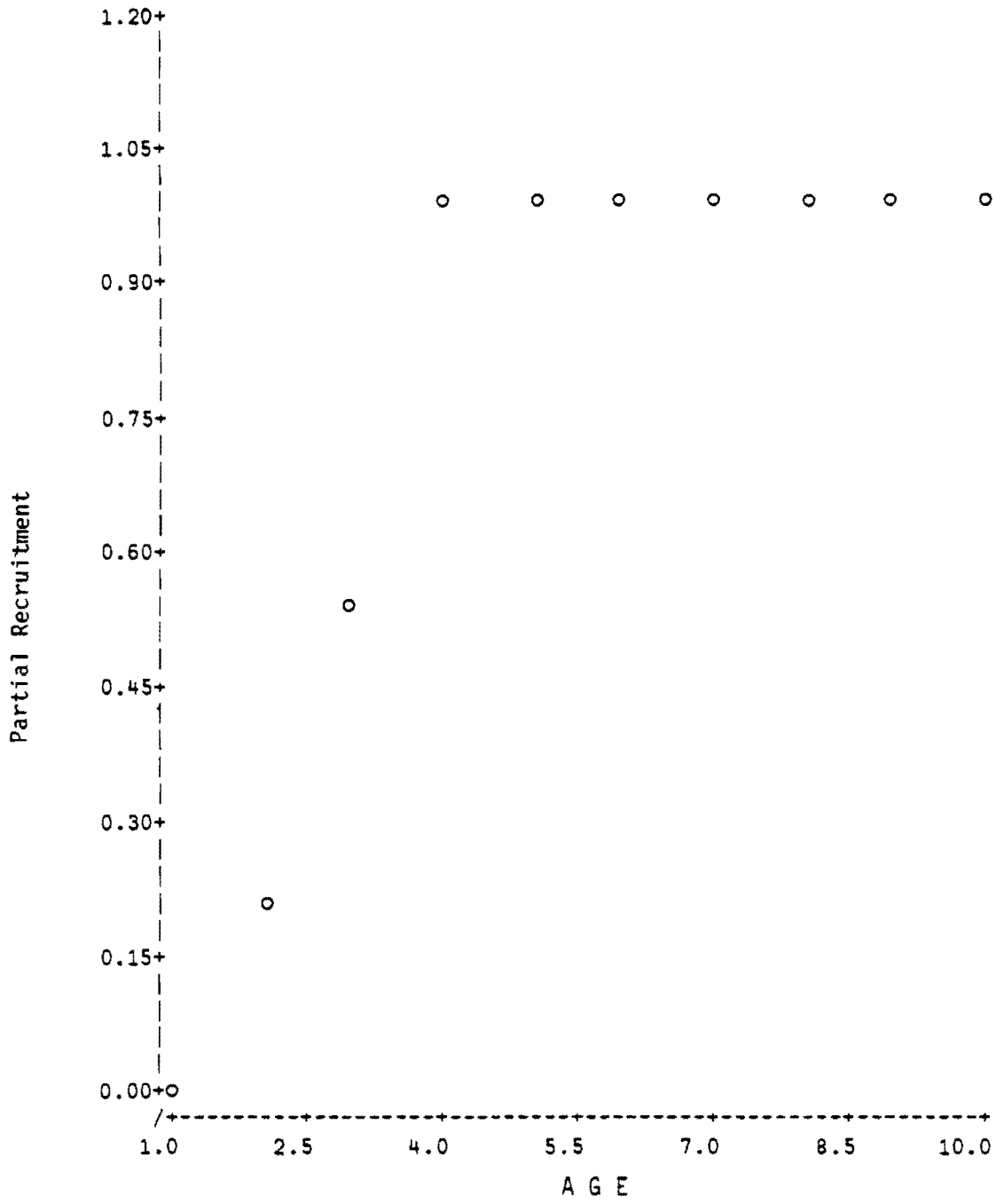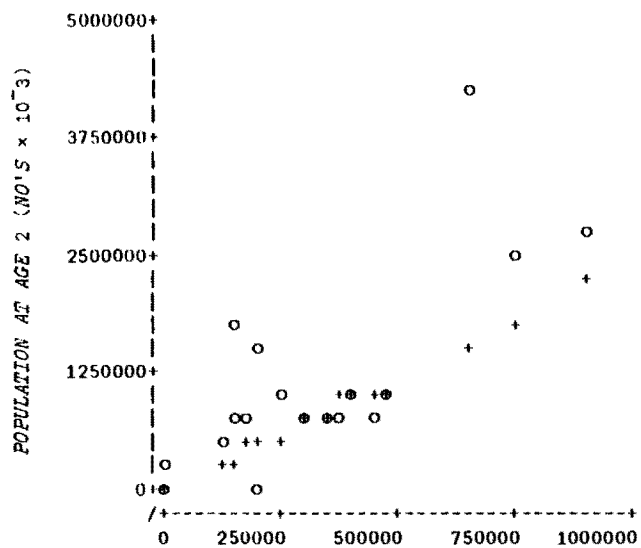
Figure 10. Recruitment ogive used in cohort analysis.

POPULATION AT AGE 2 (NO'S × 10⁻³)

```
5000000+
        |
        |
        |                           o
3750000+
        |
        |
        |
2500000+                                      o
        |                              o
        |                                      +
        |
        |        o                          +
        |          o                 +
1250000+
        |            o        +o +o
        |         oo       o oo  o
        |        o ++  +
        |o      ++
     0+o           o
        /+---------+---------+---------+---------+
        0    250000    500000    750000   1000000
```

N.B. WEIR RECRUITS AT AGE 2 (NOS × 10⁻³)

Y.C. :	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
POP2 :	1865117	1561416	2484655	640313	854340	806651	4143094	663850	1081207	896173	112307	375348	2844094	693978	129320	860439	876972
POP2P :	366810	472368	1842129	911847	847098	445963	1603673	361867	597346	1124014	483783	301760	2171352	1087211	13100	715521	959990
REC :	151087	194566	758766	375586	348916	183690	660547	149051	246044	462977	199268	124293	894372	447818	5395	294720	395416

$Y = 252753.4 + 2.43 \times REC$

$R2 = 0.535$

Figure 11. Population size (age 2) vs. recruitment index (catch at age 2 in N.B. weirs).

Figure 12. 5+ biomass estimates vs larval abundance.
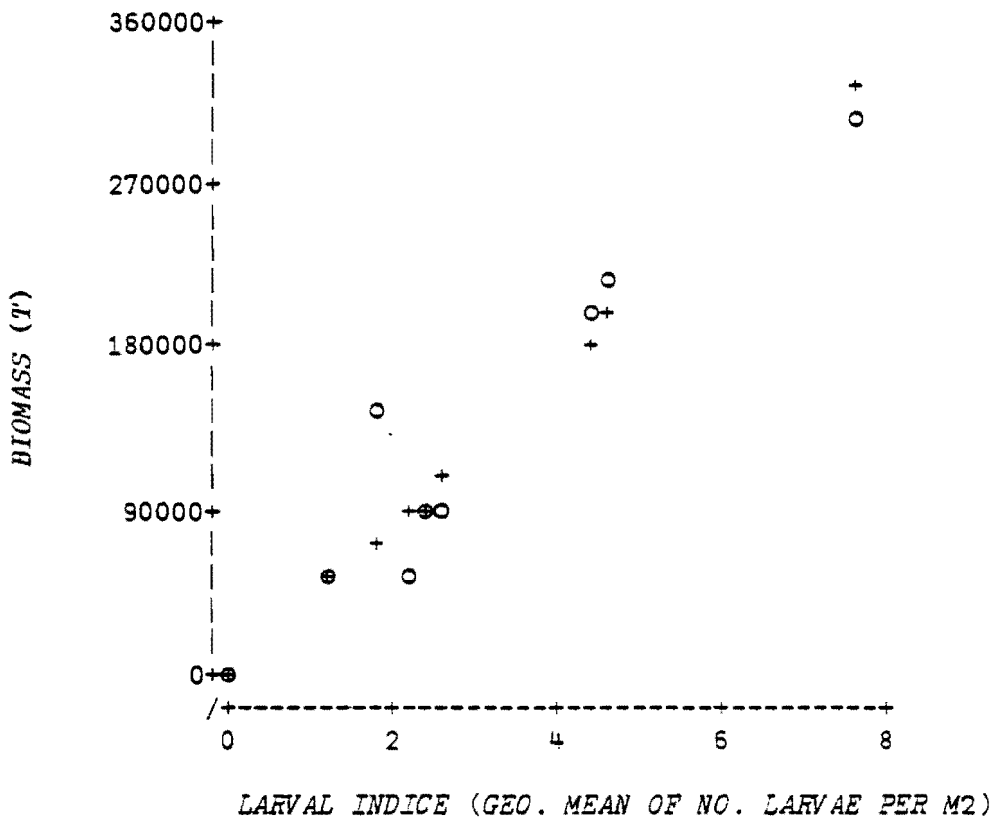
YEAR :	1973	1974	1976	1977	1978	1979	1980	1981
BMASS :	85251	85060	310051	201883	138372	54394	45512	218370
BMASSP :	112452	98230	319935	137749	78569	53889	93210	194860
SPAWN :	2.64	2.30	7.60	4.44	1.83	1.24	2.18	4.51

$Y = 2018.0 + 41831.2 \times SPAWN$

$R2 = 0.875$