Assessment of the 1987 4WX herring fishery

by

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ABSTRACT

The 1987 4WX herring fishery was predominantly a purse seine fishery and, as in recent years, was dominated by the Japanese roe market. Recorded landings for the stock in 1987 were 101,157 t, approximately 25% higher than in 1986. Purse seine logbook analysis showed higher effort and increased catch rates over 1986. The 1983 year-class (age 4) dominated the 4WX stock in numbers and weight caught while the 1985 year-class (age 2) was the largest component in the non-stock (mostly 4Xs) fisheries.

A revised larval abundance index based upon 79 stations instead of the traditional 115 was presented. This was calibrated against mature biomass as in previous years. Additional calibration undertaken using the Adaptive Framework Method indicated a high variance in the estimate of population size.

RÉSUMÉ

En 1987, la pêcherie de harengs de 4WX a surtout été exploitée à l'aide de la senne coulissante et, comme dans les dernières années, elle a été dominée par le marché japonais de la rogué. Les débarquements enregistrés pour le stock en 1987 ont été de 101 157 t, soit environ 25 % de plus qu'en 1986. L'analyse des journaux de bord des navires senneurs a révélé un effort de pêche accru et une augmentation des taux de prise par rapport à 1986. La classe d'âge 1983 (âge 4) a dominé les poissons du stock de 4WX en nombre et en poids capturés, tandis que la classe d'âge 1985 (âge 2) a été l'élément le plus important de la pêcherie hors-stock (surtout 4Xs).

Un indice d'abondance larvaire révisé fondé sur 79 stations, plutôt que les 115 habituelles, a été présenté. L'étalonnage s'est fait par rapport à la biomasse de poissons matures comme dans les années antérieures. Un étalonnage additionnel entrepris à l'aide de la méthode dite "Adaptive Framework" a révélé une variance élevée dans l'estimation de la taille de la population.

INTRODUCTION

The 1987 herring fishery in NAFO Div. 4WX was similar to that in recent years. The major fishery took place on pre-spawning and spawning aggregations off southwest Nova Scotia (4Xqr; May-October), with smaller fisheries off southern New Brunswick (4Xs; June-January) and off Cape Breton (4W Chedabucto Bay; October-January) (Fig. 1). Purse seine was the major gear type, followed in importance by weir, gillnet, trap, shutoff and midwater trawl (Table 1). The fishery continued to be influenced strongly by markets, and was dominated by the Japanese roe market.

1987 Management Plan

The 1987 Scotia-Fundy Region Herring Management Plan (Appendix 1) established a quota for the purse seine fleet of 117,600 t which was allocated among temporal and spatial components of the fishery in the traditional manner (see Table 1 of Appendix 1). In addition, an allowance of 8900 was made for catches by "inshore components" (gillnets, traps and N.S. weirs) of the summer fishery - for a TAC of 126,500 t. As in previous years, the N.B. weir and shutoff fishery, considered to rely on non-stock fish (i.e. from the Gulf of Maine), was excluded from the TAC. In a change from recent years, all of the fall 4X purse seine fishery catches (around Grand Manan) were included in the quota.

In a continuing effort to decrease the fishing pressure on the Trinity Ledge spawning component, the plan instituted the closure of a 100 sq mi area around the Ledge (Fig. 2) for 3 d per week during the period Aug. 15-Sept. 15.

Description of the Fishery

4W (Chedabucto Bay, Winter) Purse Seine Fishery

The 1987 Management Plan allowed for a fishery of 23,000 t between Nov. 7 (1986) and March 1. The reported catch of 8780 t was considerably lower than the quota because of market limitation. The annual winter acoustic survey of the area (U. Buerkle, pers. comm.) showed a large and persistent group of fish, and purse seine catch rates were high.

4Xs (Bay of Fundy) Fall and Winter Purse Seine Fishery

The Bay of Fundy "fall and winter" fisheries were open from Oct. 15, 1986 to Mar. 31, 1987. A total of 10,500 t was assigned in two segments: 9000 t before Dec. 31, 1986 and 1500 t after Jan. 1, 1976. A total of 3771 t was recorded from the fall fishery and 1368 from the winter fishery after Jan. 1. The total (5139 t) was higher than in the previous year (3365 t), but similar to that in 1984 and 1985 (Table 3).

4Xqr (Southwest Nova Scotia) Summer Fishery

a) Purse seine

The 1987 Management Plan allowed a fishery between May 1 and Oct. 14, 1987, with a quota of 81,500 t plus any uncaught quota from the fall, winter and Chedabucto Bay fisheries. Recorded landings totalled 77,706 t, an increase of approximately 20,000 t over 1986. Approximately 6500 t went to foreign vessels in the Over-the-Side Sales (OSS) program but the fishery was again dominated by the roe market. Logbook analysis indicated higher effort than in the previous year and that catch rates increased (Fig. 3).

b) Gillnet

The gillnet segment of this fishery took only 2289 t, continuing a trend (since 1980) of declining landings. Again, the fishery was hampered by a lack of domestic market.

c) Weirs

Nova Scotia weirs recorded 6786 t, approximately three times the 1986 catch and the highest since 1979. This was due to high catch rates combined with favorable market conditions.

4Xs (New Brunswick) Weir and Shutoff Fishery

The New Brunswick weir and shutoff fisheries recorded 27,320 t, almost what was taken in 1985 and in 1986. Again the weirs of Grand Manan Island dominated and few fish were taken in "inner" weirs (Passamaquoddy Bay, Campobello and Deer Islands and along the shore to Saint John). Fish were generally larger than desirable for the canned sardine market.

Catch Statistics

Reported landings for the 1987 fishery (DFO, Scotia-Fundy Region, Statistics Div. records) are listed by month and gear segment in Table 2 and Fig. 1. Long-term trends in landings by the major gear segments are shown in Table 3 and Fig. 4. Recorded landings for the stock in 1987 were 101,157 t, approximately 25% higher than in 1986 (Table 4).

ASSESSMENT INPUT DATA

Stock Components

As in previous assessments (e.g. Sinclair and Iles 1981; Stephenson et al. 1987), the 4WX fishery is divided into "stock" and "non-stock" components (Table 2). "Stock" fish are considered to belong primarily to the major SW Nova Scotia spawning groups, but this unit also encompases smaller local stocks (e.g. Grand Manan, Scotts Bay). The "non-stock" component is comprised of:

4Xs (N.B.) weirs)	- considered for assessment purposes to be migrants from Division 5 stocks
)	
4Xs (N.B.) shutoffs)	
4X miscellaneous	- small localized Nova Scotia South Shore stocks caught in 4Xm gill, 4Xm trap and bycatches in handline and longline fisheries
4W miscellaneous	- 4W fish taken in gear other than purse seine, on the assumption that the fish are from local stocks.

Also, as in previous assessments, those segments of the fishery which span the winter months (4W and 4Xs purse seine) are considered on a quota year basis (October 15, 1986-October 14, 1987). All other segments are considered for the calendar year 1987.

Biological Sampling

As in previous years, sampling of commercial catches was stratified by area, gear segment and month (Hunt 1987) following the guidelines of:

1) obtaining as many length frequencies from individual catches as possible; and

2) stratified "detail" samples (two fish per half cm size-class above 24 cm; one per half cm size-class below 24 cm) to a level of at least 200 fish per area, gear and month.

Sample coverage was high and resulted in 530 length frequencies (93,486 fish) and 14,995 fish analyzed in detail (including ages); however, some cells (area and gear by month) were undersampled according to the previous criteria (Table 5).

Biological samples were matched to landings by gear component on a monthly basis as in previous assessments. Numbers at age from commercial catches were generated on the St. Andrews HP 3000 in the traditional manner, using programs HERNLW02 and HERNAG09. For all gear components except 4Xqr purse seine, length-frequency samples were applied on a monthly basis.

A correction of 2% was applied to length measurements to account for shrinkage due to freezing. This is within the range values observed in several studies in Scotia-Fundy and Gulf Regions summarized by Hunt et al. (1986).

Since the summer purse seine fishery involves several distinct fishing grounds and markets, including directed effort for ripe (roe) fish, a smaller spatial scale was considered necessary. As in the previous assessment, length frequencies were matched by individual 10' square and month. Catches were partitioned by square on the basis of logbook information and where samples and catches did not coincide, length-frequency information from adjacent squares was used.

Age Composition

The age composition of the nominal catch in major gear segments of the fishery is presented in Table 6. The 1983 year-class (age 4) dominated the 4WX stock by number and dominated by weight. Age 2 fish dominated the 4WX non-stock (primarily 4Xs) fishery in number.

Quality of Catch Information

Previous assessments have dealt at length with changes in the quality of catch information from this fishery. In 1984, (and a few preceeding years) misreporting was considerable and an adjusted catch biomass (1.7 times that reported) was used in assessment (Stephenson et al. 1985). In 1985, drastic measures were taken to curb misreporting including:

- an increase in the TAC (to reduce the need or incentive to misreport)
- increased monitoring including nightly verbal hails before landing, as well as collection of delivery slips, purchase slips and log records.
- fragmented (weekly) license scheme.

The result was a significant improvement in the amount and quality of statistical information on which to base the assessment, and it was considered unnecessary to adjust the 1985 catch figures (Stephenson et al. 1986).

In 1986, a monitoring structure similar to that in 1985 (including nightly verbal hails prior to landing and a fragmented license scheme) was implemented, but wharf monitoring was lower. Misreporting was higher than in 1985 (particularly early in the summer purse seine fishery) but decreased later when it was apparent that the TAC and, more importantly, individual vessel quotas would not be met. It was not considered necessary to adjust 1986 catch figures (Stephenson et al. 1987).

The 1987 TAC was the highest in over a decade and should have eliminated the need to misreport. Still, there were reports (from Fishery Officer hails) of underreporting, particularly in New Brunswick landings. There is again evidence that misreporting decreased as the season progressed. Logbook records of catch for May and June exceeded Statistics totals.

Abundance Indices

a) Larval abundance

The 1986 larval survey of the Bay of Fundy and eastern Gulf of Maine was undertaken between Oct. 19 and Nov. 13 (E.E. PRINCE 361). Approximately 175 sets were completed (Fig. 5).

The traditional larval abundance index was changed in two ways:

i) Stations were removed from the calculations because they were southwest of Grand Manan (and contained larvae of 5Y origin) or were not sampled in the 1987 survey.

ii) The index was recalculated as an arithmetic mean which was considered more appropriate than the geometric mean for the survey design.

The resulting index, based upon 79 stations and the traditional one (geometric means of 115 stations) are:

	1972	1973	1974	1976	1977	1978	1979	1980	1981	1982
Arith. mean 79 sta	9.4	6.6	49.5	13.5	6.3	4.5	7.1	26.2	2.7	12.4
Geom. mean 115 sta	2.6	2.3	7.6	4.4	1.8	1.2	2.2	4.6	1.4	3.8
Ratio new/old	3.6	2.9	6.5	3.1	3.5	3.8	3.2	5.7	1.9	3.3

1983	1984	1985	1986	1987
13.1	12.6	41.8	21.3	31.2
3.3	4.3	6.6	6.8	-
3.9	2.9	6.3	3.1	-

The pattern of the two indices is similar. The 1987 value is the third highest in the 16-yr series.

b) Purse seine catch rates

The detailed purse seine logbook introduced in 1985 (Power and Stephenson 1986, 1987) was used for the third consecutive year. Coverage was good (84% of catch) as logbook submission was again a condition of license, and information was similar in quality to the previous years. 1987 logs (Table 7) showed an increase in total effort (as measured by searching hours and number of sets) and a slight increase in catch per hour searched over 1986. However, set rate (sets/hour) and catch per set per hour have decreased slightly over 3 yr. The usefulness of CPUE indices could not be evaluated further because of the short time series.

c) Acoustic survey

An acoustic survey of overwintering herring in Chedabucto Bay, N.S. was undertaken in January 1988, as in previous years (e.g. Buerkle 1987); however, an equipment fault, diagnosed after the survey, rendered the results unreliable and they were not used in the assessment.

Weights at Age

We have extended the series using average fishery weighted weights at age (Table 8). The 1987 weights at age (mean for stock fish weighted by gear) are:

Age	1987 weights at age (kg)								
	2	3	4	5	6	7	8	9	10
	.050	.098	.153	.199	.245	.274	.290	.318	.350

Catch Matrix

The catch matrix (Table 9, 10) is an extension of the "adjusted" matrix (1973-84 adjustment to account for misreporting, omissions and previous errors: Mace (1985)) used in the previous three assessments (Stephenson et al. 1985, 1986, 1987).

ESTIMATION OF STOCK SIZE

Traditional Sequential Population Analysis

Examination of the pattern of fishing mortality in recent years indicated a different partial recruitment pattern than has been used in previous assessments (Table 11). A new partial recruitment vector was chosen. As in last year, a value at age 1 was set to give geometric mean recruitment. PRs for ages 2, 3 and 4 were derived from examinations of F at age in recent years of a preliminary cohort run. The old (1986) and new partial recruitment vectors are:

		Age										
		1	2	3	4	5	6	7	8	9	10	11
PR	New	0.003	0.2	0.34	0.9	1	1	1	1	1	1	1
	Old (1986)	0.003	0.36	0.75	1	1	1	1	1	1	1	1

It is clear that a PR of 0.75 is high for age 3 in recent years. The SPA based on the new, lower, age 3 PR projected an age structure similar to that in trawl samples from the 1988 acoustic survey.

	% age 3 of 3+
SPA @ PR 0.75	61.8
SPA @ PR 0.34	28.4
Survey trawl	20.9

Natural mortality was assumed to be 0.2

Sequential population analysis was calibrated with larval abundance and mature biomass as in previous assessments. However, the larval abundance index was treated as the dependent variable. Tuning, based upon the minimum residual sum of squares from a regression through the origin, indicated a fully recruited 1987 F of 0.1.

Adaptive Framework Method (AFM)

Additional calibration was undertaken using the Adaptive Framework Method (Gavaris 1988), assuming a linear relationship between larval abundance and SPA derived mature biomass. Five formulations were attempted. The first used the larval abundance index to estimate 10 parameters: 1988 numbers for ages 3-10 and the slope and intercept of regression. Age 10 fishing mortality for 1972-86 was assumed to be the weighted (by numbers) average of those on ages 5-8. Subsequent formulations eliminated the intercept and older ages as estimated parameters. All of these were characterized by high coefficients of variation, and high correlation between adjacent year-classes. A final formulation estimated only two parameters - age 4 population numbers and slope. The 1987 partial recruitment was fixed at that described in the previous section. This is analogous to the traditional tuning method.

The relationship:

Larval abundance = 1.82×10^{-5} * mature numbers

had CVs of 20% and 42% on the slope and age 4 numbers, respectively. SPA results are shown in Table 12. 1987 estimates are:

Age:	2	3	4	5	6	7	8	9	10
Pop no ('000)	3024	2728	4421	1833	347	147	55	25	24
F	0.02	0.03	0.08	0.09	0.09	0.09	0.09	0.09	0.09

Assessment results

The 2+ population numbers (numbers x 10^6) from the AFM in this and from last year's assessment are:

	77	78	79	80	81	82	83	84	85	86	87
This yr	1.8	3.5	3.0	2.3	2.4	2.6	3.1	6.1	11.6	12.2	12.6
Last yr	2.1	4.5	3.9	3.0	3.1	3.0	3.4	4.6	5.5	5.4	-

The Adaptive Framework Method indicated the high variance in the SPA results tuned with the larval abundance index. Assuming the model is correct, the 1987 population size could be almost 50% lower or higher.

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Table 1. Gear types involved in the 1987 4WX herring fishery.

Gear	Landings nominal (t)
Purse seine	91,625
Weirs	33,408
Gillnet	2,919
Traps	440
Shutoffs	698
Midwater trawl	17
Misc.	74

Table 2. Catch (t) by gear component and month for the 1987 4WX herring fishery (data from DFO, Scotia-Fundy Region, Tape MFD ØØ451).

Gear component	1986 Oct	1986 Nov	1986 Dec	1987 Jan	1987 Feb	1987 Mar	1987 Apr	1987 May	1987 June	1987 July	1987 Aug	1987 Sept	1987 Oct	1987 Nov	1987 Dec	1987 Total	Quota year total
4WX stock																	
4W purse seine	434	2895	1598	3853										3420	1177	8450	8780[1]
4Xa purse seine																	
(domestic)	3199							24	3817	10723	21824	27893	6968			71249	71249[2]
(over side)										4893	1564					6457	6457[2]
4Xb (NB) purse	3188	583		1368									1438	854	140	3800	5139[1]
4Xa gillnet																	
(domestic)							2	20	72	9	857	933				1893	1893[3]
(over side)											381	15				396	396[3]
4X NS weirs																	
(domestic)	5							1503	2531	1121	993	367				6515	6515[3]
(over side)										97	174					271	271[3]
4X traps																	
(domestic)		2					0	216	125	18	34	7	16	1		417	417[3]
(over side)									13	10						23	23[3]
4Xb (NB) midwater															17	17	17[3]
Stock total	6826	3480	1598	5221	0	0	2	1763	6558	16871	25827	29215	8422	4275	1334	99488	101157
4WX non-stock																	
4Xb (NB) weirs	6233	2564	67	39	21	6	12	10	168	2575	10893	6711	5362	703	122	26622	
4Xb (NB) shutoffs	83									17	110	112	459			698	
4Xab misc.	1	7						2	62	123	11	53	3	2		256	
4W gillnett				2			331	81	45	112	44	7	7	0	1	630	
4W misc.	1							0	4	12	46	2	6	3		73	
Non-stock total	6318	2571	67	41	21	6	343	93	279	2839	11104	6885	5837	708	123	28279	
4WX total all gears	13144	6051	1665	5262	21	6	345	1856	6837	19710	36931	36100	14259	4983	1457	127767	

[1]October 1986-March 1987.
[2]January-October 1987.
[3]January-December 1987.

Table 3. Historical series of annual landings (t) by major components of the 4WX herring fishery (1963-85 from Stephenson et al. 1986).

Year	4Wa	4Xa			4Xb		Stock[1]
	Purse seine	Purse seine	Gillnet	Weir	Purse seine	shutoff & weirs	total
1963		15093	2955	5345	6871	29366	
64		24894	4053	12458	15991	29432	
65		54527	4091	12021	15755	33346	86394
66		112457	4413	7711	25645	35805	150226
67		117382	5398	12475	20888	30032	156741
68		133267	5884	12571	42223	33145	196362
69	25112	84525	3474	10744	13202	26539	150462
70	27107	74849	5019	11706	14749	15840	190382
71	52535	35071	4607	8081	4868	12660	129101
72	25656	61158	3789	6766	32174	32699	153449
73	8348	36618	5205	12492	27322	19935	122687
74	27044	76859	4285	6436	10563	20602	149670
75	27030	79605	4995	7404	1152	30819	143897
76	37196	58395	8322	5959	746	29206	115178
77	23251	68538	18523	5213	1236	23487	117171
78	17274	57973	6059	8057	6519	38842	95882
79	14073	25265	4363	9307	3839	37828	59021
80	8958	44986	19804	2383	1443	13525	79584
81	18588	53799	11985	1966	1368	19080	87706
82	12275	64344	6799	1212	103	25963	84733
83	8226	63379	8762	918	2157	11383	84385
84	6336	58354	4490	2684	5683	8698	78083
85	8751	87167	5584	4062	5419	27863	112385
86	8414	56139	3533	1958	3365	27883	73733
87	8780	77706	2289	6786	5139	27320	101157

[1]Includes all purse seine, 4Xa gillnet, 4Xa weir, 4Xa traps, 4Xb midwater trawl (see Table 2).

Table 4. TAC, reported stock, adjusted stock and total 4WX (stock + non-stock) landings ('000 t).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
TAC	-	-	-	-	109.0	110.0	99.0	65.0[1]	100.0	80.2	82.0	80.0	125.0	97.6[2]	126.5
Reported stock[3] catch	122.7	149.7	143.9	115.2	117.1	95.9	59.0	79.6	87.7	84.7	84.4	78.1	112.4	73.7	101.2
Adjusted stock[4] catch						114.0	77.5	107.0	137.0	105.8	117.4	135.9	-	-	-
Reported total catch	142.6	170.3	174.7	143.9	150.7	134.7	96.2	93.1	106.8	110.7	94.1	88.7	141.9	101.8	130.2

[1]TAC raised from 60.0 t to 65.0 t in mid-season.
[2]Excludes an allowance of 13,000 t for inshore 4Xn fixed gear.
[3]Excludes 4Xb wier + shutoff, 4Xn gill + trap, 4W inshore gear.
[4]Includes 1978-1984 adjustment for misreporting and omissions.

Table 5. Distribution of biological samples from the 1987 4WX commercial herring fishery; detail fish = number of fish taken for detail analysis including ageing, LF samples = number of length-frequency samples, LF fish = number of fish measured.

Gear component		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
4Wa purse seine	- detail fish		521	256	534											
	- LF fish		3815	3076	6439											
	- LF samples		19	15	40											
	- catch (t)	434	2895	1598	3853											
4Xa purse seine	- detail fish									518	1109	525	446	~740		
	- LF fish									3074	7286	4442	2684	~4892		
	- LF samples									17	44	26	15	~26		
	- catch (t)								24	3817	15616	23388	27893	6968		
4Xb purse seine	- detail fish		57*		129*											
	- LF fish		438		733											
	- LF samples		2		4											
	- catch (t)	3188	583		1368											
4Xa gillnet (4XOQR)	- detail fish									*		56*	33*			
	- LF fish											521	355			
	- LF samples											3	2			
	- catch (t)							2	20	72	9	1238	948			
4Xa NS weir (4XR)	- detail fish								422	775	428	218	140*			
	- LF fish								2447	4272	2163	1109	661			
	- LF samples								14	23	14	6	4			
	- catch (t)								1503	2531	1218	1167	367			
4Xa NS trap (4XMOQ)	- detail fish								69*	31*						
	- LF fish								551	374						
	- LF samples								4	3						
	- catch (t)								216	138	28	34	7	16	1	
4Xb mid trawl	- detail fish															45
	- LF fish															734
	- LF samples															4
	- catch (t)															17
4Xb weirs	- detail fish								36	183*	1053	2046	1426	1235	140*	67*
	- LF fish								323	1774	6386	12094	8804	7940	863	711
	- LF samples								2	9	36	70	49	45	5	4
	- catch (t)				39	21	6	12	10	168	2575	10893	6711	5362	703	122
4Xb shutoff	- detail fish											*	111*	27*		
	- LF fish												570	336		
	- LF samples												3	2		
	- catch (t)										17	110	112	459		

*Cells undersampled according to criteria of 200 detail fish per gear type per month with >50 t catch.

Table 6. 1987 4WX herring numbers at age by gear component (thousands).

		1	2	3	4	5	6	7	8	9	10	11
Stock												
1	4W purse	0	68	3603	28289	17980	3147	3022	1689	764	555	263
2	4X purse by month	0	37500	53180	234325	106439	20605	7819	2468	1125	1341	81
3	4XB NB purse	0	3343	12491	23506	8183	2036	367	160	26	0	0
4	4X gillnet stock	0	0	104	7601	3588	497	180	34	17	10	0
5	4X NS weir stock	0	10710	9717	19599	11165	2281	614	163	126	69	22
6	4X trap stock	0	7	176	1256	902	214	76	29	18	14	0
7	4XB midwater	1398	2	0	0	0	0	0	0	0	0	0
Non-stock												
8	4XB NB weir	29919	123163	47127	52542	22758	7048	2453	602	171	96	0
9	4XB NB shutoff	5758	6185	854	608	183	49	19	4	2	0	0
10	4WX misc. gears	37	2316	1550	2930	1250	333	97	36	18	13	0
PS	4X purse by SQR	0	36292	50774	240400	105665	19749	7584	2358	1092	1249	110

Table 7. 4X summer purse seine effort and CPUE by fishing ground for 1985-87.

Area	Total Catch			Search Hours			Number of Sets			Catch per Hours Searched			No Sets per Hours Searched		
	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
Trinity															
June	.00		104.30	7.50		15.60			3.00			16.48			.50
July	156.10	604.90	278.20	94.20	130.30	77.40	15.00	33.00	23.00	3.00	10.86	4.41	.17	.46	.36
August	11034.10	6324.10	8992.40	1046.80	897.80	920.60	406.00	253.00	340.00	16.84	11.40	11.67	.54	.40	.42
September	24531.60	6381.20	8850.80	957.90	607.80	633.30	607.00	228.00	226.00	36.06	10.80	15.70	.82	.42	.51
Total all months	35721.80	13310.20	18225.70	2106.40	1635.90	1646.90	1028.00	514.00	592.00	55.90	33.06	48.26	1.53	1.28	1.79
German Bank															
June	195.70	49.00	1472.90	9.20	2.00	60.10	4.00	1.00	50.00	23.25	24.50	25.34	.44	.50	.67
July	2691.00	42.60	2098.30	213.50	15.50	159.70	90.00	1.00	80.00	29.01		13.25	.66		.53
August	6519.20	2740.20	200.80	242.30	262.30	133.60	138.00	104.00	20.00	31.64	16.14	14.92	.62	.51	.43
September	5382.80	10383.60	11096.20	165.30	578.30	547.50	122.00	361.00	272.00	35.93	22.61	37.85	.65	.64	.76
Total all months	14788.70	13215.40	14868.20	630.30	858.10	900.90	354.00	467.00	422.00	119.83	63.25	91.36	2.37	1.65	2.39
Seal Island															
June			.00			8.80									
July	2458.30	2719.20	2678.50	166.90	203.10	250.30	62.00	89.00	116.00	30.08	19.43	16.11	.56	.65	.68
August	7338.80	4366.70	7518.80	384.60	223.80	665.10	187.00	144.00	250.00	28.43	22.18	16.37	.60	.63	.52
September	986.00	1334.60	849.90	59.20	68.30	104.90	24.00	50.00	34.00	22.17	10.28	13.52	.43	.32	.36
Total all months	10783.10	8420.50	11047.20	610.70	495.20	1029.10	273.00	283.00	400.00	80.68	51.89	46.00	1.59	1.60	1.56
Year Total For All Areas	83317.00	51571.00	64957.00	5157.00	4519.00	5753.00	2295.00	1850.00	2213.00	26.60	18.00	19.50	.62	.58	.56

Table 8. Average weights at age for the 4WX herring fishery (stock portion) 1965-87.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	10	10	10	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	0	0	0	12
2	41	41	41	33	37	32	66	44	29	48	21	33	65	28	41	41	41	41	41	38	53	55	50
3	112	112	112	112	106	119	143	138	106	110	94	114	113	112	112	112	112	112	112	132	118	124	98
4	172	172	172	148	162	169	199	192	143	175	179	159	174	181	172	172	172	172	172	191	204	182	153
5	218	218	218	185	207	211	230	225	225	206	216	233	214	229	218	218	218	218	218	229	249	239	199
6	254	254	254	244	242	257	254	262	252	240	240	249	274	259	254	254	254	254	254	259	278	271	245
7	286	286	286	276	282	292	293	292	279	277	268	277	293	302	286	286	286	286	286	280	315	306	274
8	323	323	323	399	306	332	329	322	331	322	333	317	325	330	323	323	323	323	323	296	334	329	290
9	354	354	354	338	334	369	362	345	360	342	358	382	328	351	354	354	354	354	354	309	344	360	318
10	389	389	389	410	390	389	388	380	389	352	379	404	416	397	389	389	389	389	389	364	440	400	350

Table 9. 4WX herring stock catch at age in numbers (thousands).

	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	270378	154323	722208	164703	108875	699720	87570	0	754
2	1084719	914093	613970	2389061	290329	576896	404224	649254	126421
3	34835	448940	153626	224956	531812	76532	183896	71984	595992
4	234383	73382	266454	83109	132319	286278	106630	148516	109530
5	49925	321857	110051	290285	162439	201215	113566	77207	34422
6	10592	45916	159203	73087	112631	120280	75593	75384	25562
7	1693	13970	57948	90617	62506	111937	93620	49065	19361
8	561	7722	4497	31977	22595	41257	50022	48700	17604
9	54	1690	409	15441	6345	21271	36618	26055	19836
10	37	215	296	5668	2693	7039	7536	13792	9661
11+	1	1	148	1175	722	2674	5695	11679	11120

	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	14151	2870	240	1164	35381	311	1623	0	3589
2	596153	264491	48470	140494	346719	170523	9566	75713	72591
3	72381	180898	176226	28659	36177	226442	60559	33174	122380
4	616622	92487	130598	192958	11338	47200	359484	68816	17756
5	53199	384646	72334	106061	107627	4639	21958	306716	73025
6	15254	50599	219788	55066	60431	19695	3583	21728	154542
7	8120	9357	18960	150588	27286	15521	3507	1631	10910
8	5313	3238	4967	12466	96741	9981	4951	1914	1535
9	10964	3481	3556	2873	9838	35386	2009	1366	977
10	5787	2842	1835	1253	2169	3834	8179	361	886
11+	7359	4599	3071	3448	1499	2042	2105	1442	719

	1983	1984	1985	1986	1987
1	3367	0	5762	40	1398
2	128378	72301	138419	80019	50422
3	101017	141067	215599	176197	76865
4	168379	131251	193369	186983	320651
5	16946	84920	94308	36361	147483
6	41607	13633	27081	20180	27924
7	63468	13803	8989	6878	11843
8	7334	16299	11609	2759	4433
9	1351	5418	5107	1879	2043
10	434	1263	767	866	1897
11+	895	5207	300	223	395

Table 10. 4WX herring catch weight (mt) at age.

	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	2704	1543	7222	0	0	0	0	0	0
2	44473	37478	25173	78122	10800	18288	26719	28762	3641
3	3902	50281	17206	25195	56106	9123	26224	9905	62996
4	40314	12622	45830	12300	21475	48295	21230	28560	15696
5	10884	70165	23991	53587	33657	42376	26132	17333	7731
6	2690	11663	40438	17862	27234	30888	19170	19751	6429
7	484	3995	16573	24983	17627	32708	27403	14302	5404
8	181	2494	1453	12759	6910	13697	16447	15667	5830
9	19	598	145	5216	2117	7840	13256	8989	7139
10	14	84	115	2321	1051	2740	2922	5246	3757
11+	0	0	58	481	282	1041	2208	4443	4325

	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0	0	0	0	0	3	16	0	36
2	28436	5501	1585	9160	9812	6991	392	3104	2976
3	7976	17059	20107	3247	4055	25362	6783	3715	13707
4	108155	16555	20778	33613	2050	8118	61831	11836	3054
5	10938	82930	16883	22665	24604	1011	4787	66864	15919
6	3659	12124	54815	15099	15627	5003	910	5519	39254
7	2251	2503	5256	44122	8243	4439	1003	466	3120
8	1711	1079	1576	4055	31944	3224	1599	618	496
9	3754	1246	1360	943	3453	12527	711	484	346
10	2037	1077	742	521	861	1491	3182	140	345
11+	2590	1743	1241	1433	595	794	819	561	280

	1983	1984	1985	1986	1987
1	34	0	0	0	17
2	5263	2713	7313	4400	2539
3	11314	18630	25442	21781	7501
4	28961	25122	39432	34032	48975
5	3694	19418	23516	8704	29294
6	10568	3533	7536	5469	6843
7	18152	3863	2833	2102	3245
8	2369	4828	3879	907	1287
9	478	1674	1757	677	650
10	169	460	337	346	664
11+	348	1895	132	89	138

Table 11. Historical summary of partial recruitment values used in 4WX herring assessments.

Fishery year	PR 1	2	3	4	5	6	7	8	9	10	Notes	Reference (Res. Doc. #)
1986	.003	.36	.75	1	1	1	1	1	1	1	Ages 4+ considered to be fully recruited. Age 3 (.75) based upon partial maturity and consistent with previous years.	Stephenson et al. (1987) (87/75)
1985	.003	.4	.75	1	1	.5	.5	.5	.5	.5	"Chosen after consideration of the historical F matrix. This indicated a dome-shaped partial recruitment pattern with full recruitment at age 4."	Stephenson et al. (1986) (86/43)
1984	.002	.5	1	1	1	1	1	1	1	1	"changed from previous years after consideration of the population structure of the overwintering aggregation of herring in Chedabucto Bay, the pattern of the fishing mortality matrix and the increase in directed effort for small fish (as a result of low 4Xb weir landings in 1983 and 1984)."	Stephenson et al. (1985) (85/78)
1983	.01	.22	.53	1	1	1	1	1	1	1	Ages 1-2; F's fixed to generate mean recruitment Ages 3-10: "assumed to be identical to the last assessment."	Iles et al. (1984) (84/72)
1982	.01	.22	.53	1	1	1	1	1	1	1	"conform more closely with the pattern of recruitment at age for herring generally."	Iles and Simon (1983) (83/89)
1981	.001	.5	.53	.77	1	1	1	1	1	1	Using average F values for years 1975-78; "The mean F's for ages 5.10 for this time period were averaged and divided into the mean F's for ages 1, 2, 3 and 4, respectively."	Sinclair et al. (1982) (82/36)
1980 a	0	.8	.6	.9	1	1	1	1	1	1	Average conditions	Sinclair and Iles (1981) (81/10)
b	.006	.4	.23	.9	1	1	1	1	1	1	"appears more representative of the most recent years 1978 to 1979."	

Table 12. 4WX herring: a) population numbers, and b) table of F values from sequential population analysis.

a)

	1973	1974	1975	1976	1977	1978	1979	1980
1	1909255	1410412	207903	584968	3180137	1067468	357473	1183755
2	802933	1562483	1141944	167619	478714	2602623	841954	292393
3	3517247	542996	739832	695623	93378	264814	1817123	535038
4	404914	2340403	379074	442040	410072	50519	184077	1282841
5	100391	232409	1358217	226674	243741	161143	31103	108001
6	58704	51047	142144	763972	120135	103591	34548	21267
7	45622	24933	27991	70593	426615	48532	30133	10465
8	48712	19834	13067	14451	40641	213025	15045	10627
9	50190	23953	11431	7768	7337	21995	86875	3287
10	24656	23144	9691	6209	3142	3407	9106	39109
11+	53035	47762	36900	29688	23009	17992	20518	50591

	1981	1982	1983	1984	1985	1986	1987
1	1310183	1832184	4913257	8533498	4184680	3693029	5539446
2	967708	1072687	1496818	4019588	6986637	3420912	3023560
3	230735	723785	812559	1109329	3225540	5594928	2728402
4	383256	158893	481851	573863	780599	2445766	4421310
5	725027	251516	114024	242150	351078	464133	1833235
6	68556	316074	139849	78022	121417	202105	347099
7	14170	36468	118944	76851	51543	74904	147210
8	5394	10126	19986	39955	50431	34066	55103
9	4220	2685	6901	9727	17964	30785	25395
10	873	2219	1314	4428	3061	10087	23504
11+	32988	27596	22456	21611	14900	21321	39975

b) FISHING MORTALITY

	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87
1	.00	.01	.02	.00	.00	.04	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.19	.55	.30	.39	.39	.16	.25	.04	.09	.08	.10	.02	.02	.03	.02
3	.21	.16	.32	.33	.41	.16	.15	.13	.17	.21	.15	.15	.08	.04	.03
4	.36	.34	.31	.40	.73	.29	.33	.37	.22	.13	.49	.29	.32	.09	.08
5	.48	.29	.38	.43	.66	1.34	.18	.25	.63	.39	.18	.49	.35	.09	.09
6	.66	.40	.50	.38	.71	1.03	.99	.21	.43	.78	.40	.21	.28	.12	.09
7	.63	.45	.46	.35	.49	.97	.84	.46	.14	.40	.89	.22	.21	.11	.09
8	.51	.35	.32	.48	.41	.70	1.32	.72	.50	.18	.52	.60	.29	.09	.09
9	.57	.70	.41	.71	.57	.68	.60	1.13	.44	.51	.24	.96	.38	.07	.09
10	.57	.32	.39	.40	.58	1.22	.63	.26	.61	.58	.45	.38	.32	.10	.09
11+	.57	.36	.25	.20	.26	.26	.38	.25	.06	.07	.07	.40	.08	.06	.07

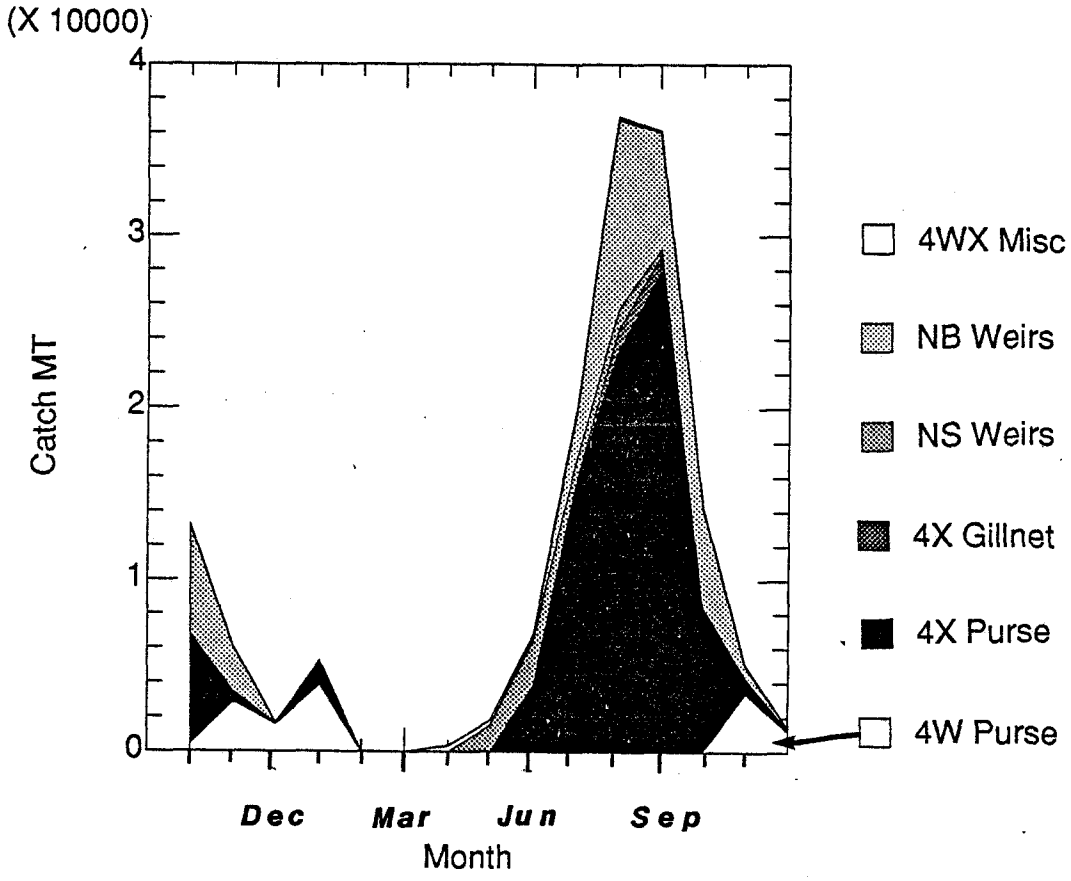


Fig. 1. 1987 4WX herring catches by gear and month.

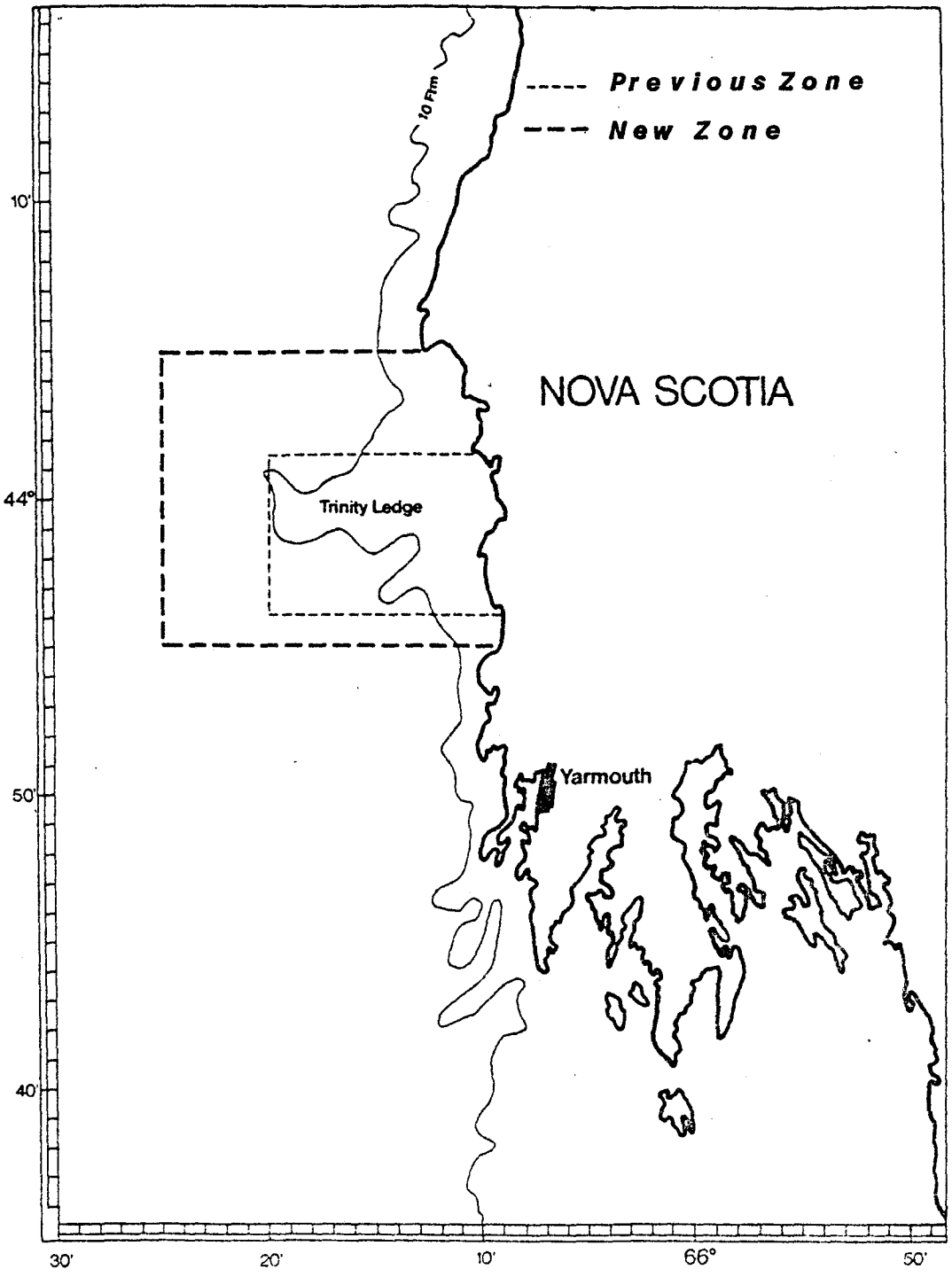


Fig. 2. Position of Trinity Ledge closure BOX for the 1987 4WX herring fishery.

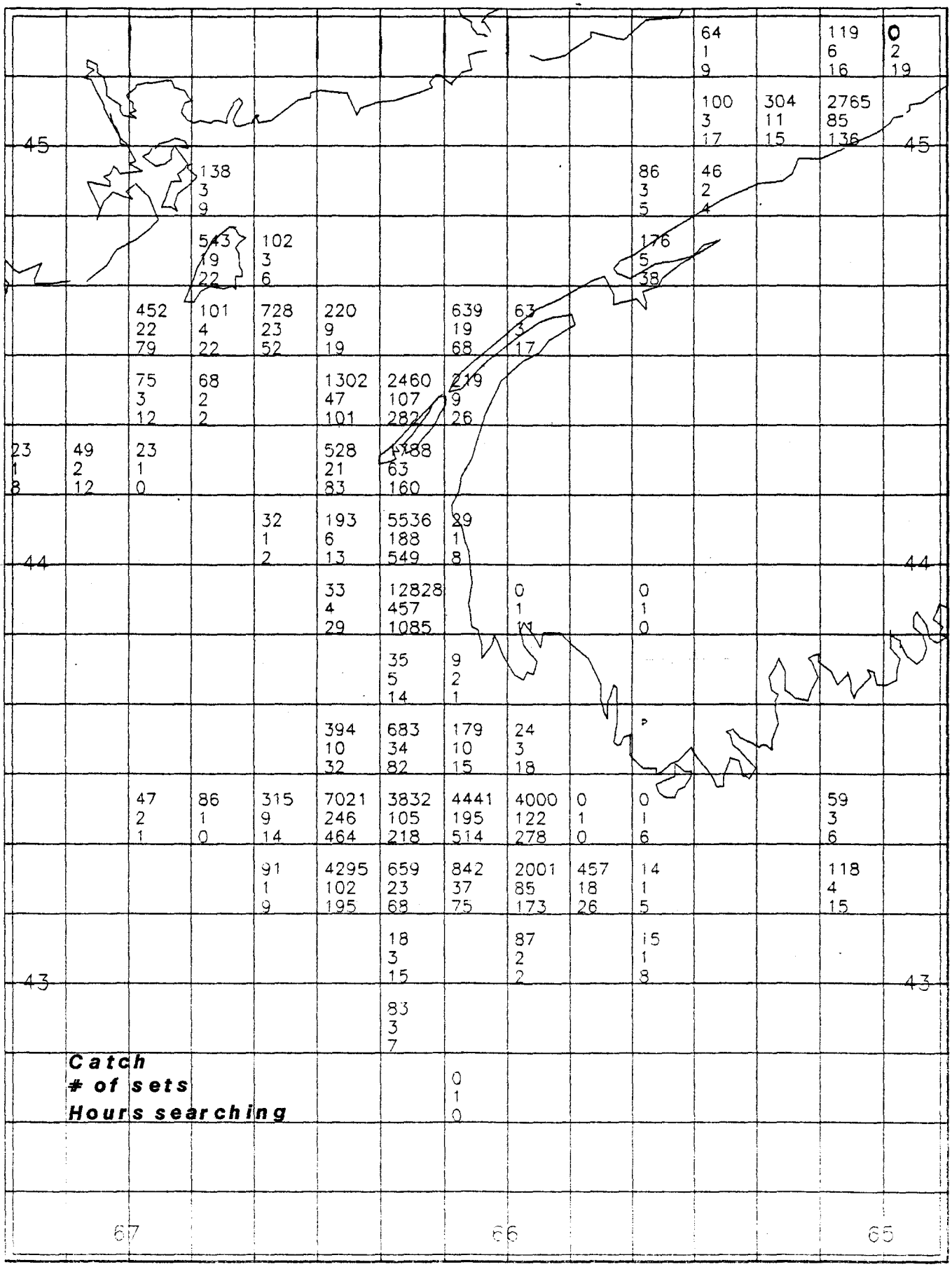


Fig. 3. 1987 4Xa purse seine log data for year.

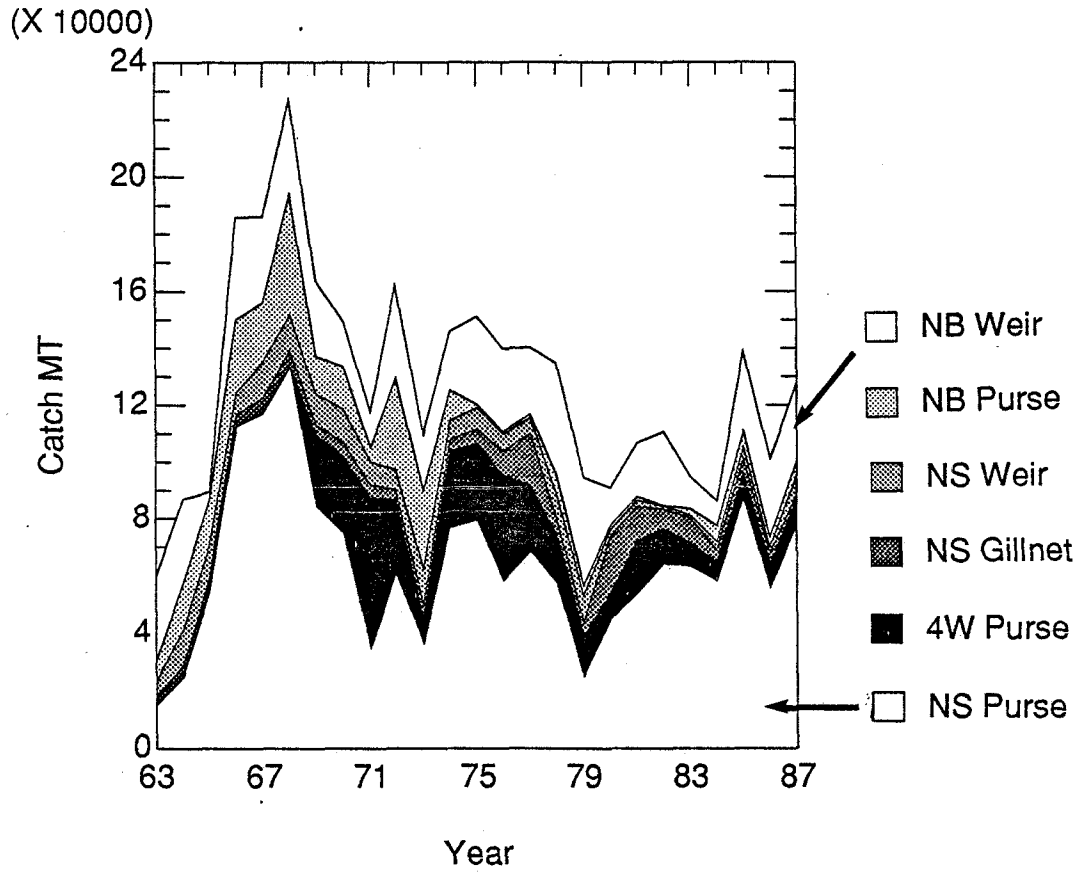


Fig. 4. 4WX herring stock catches by gear.

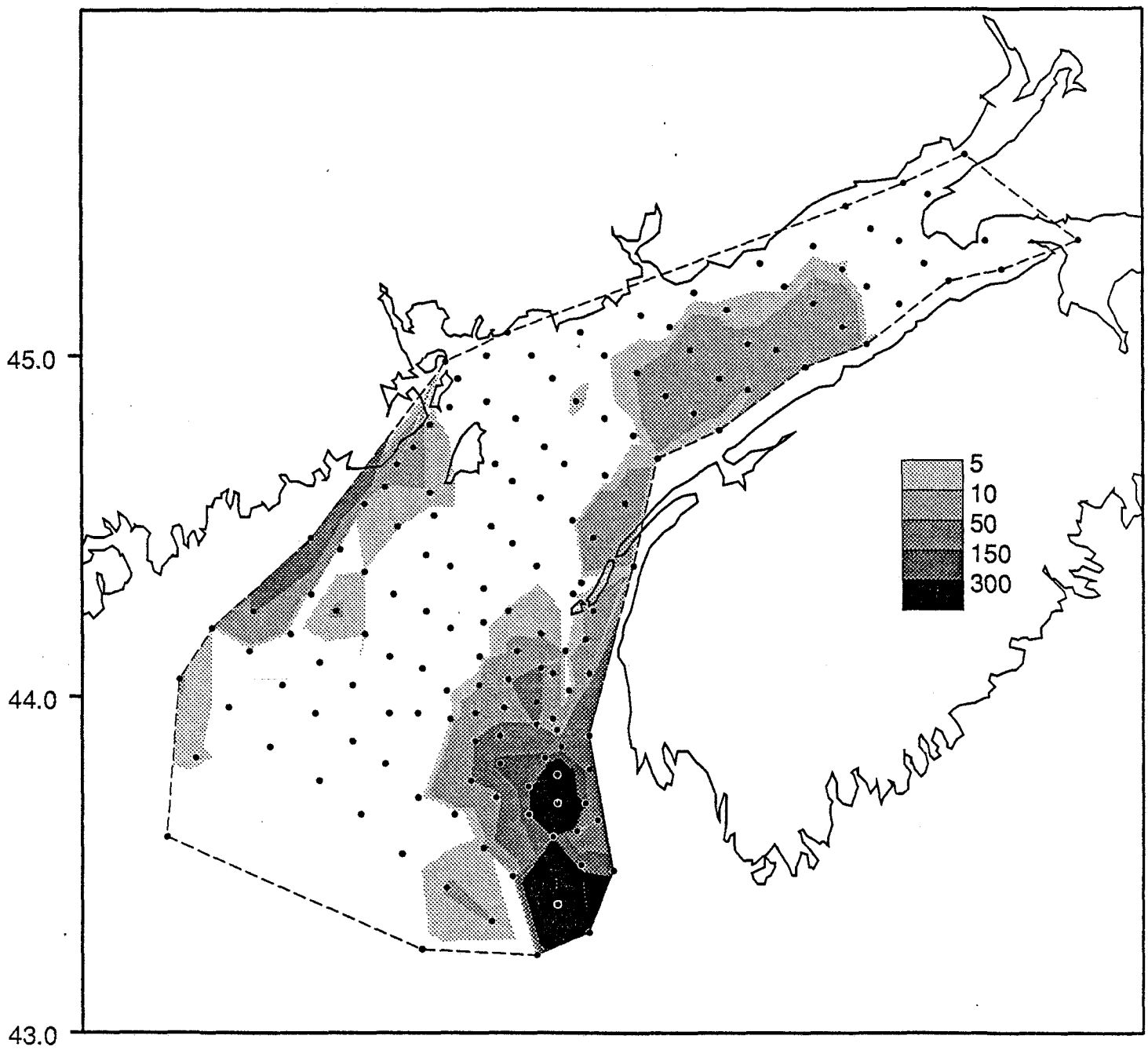


Fig. 5. 1987 fall larval herring abundance (#'s per m^2 to bottom).

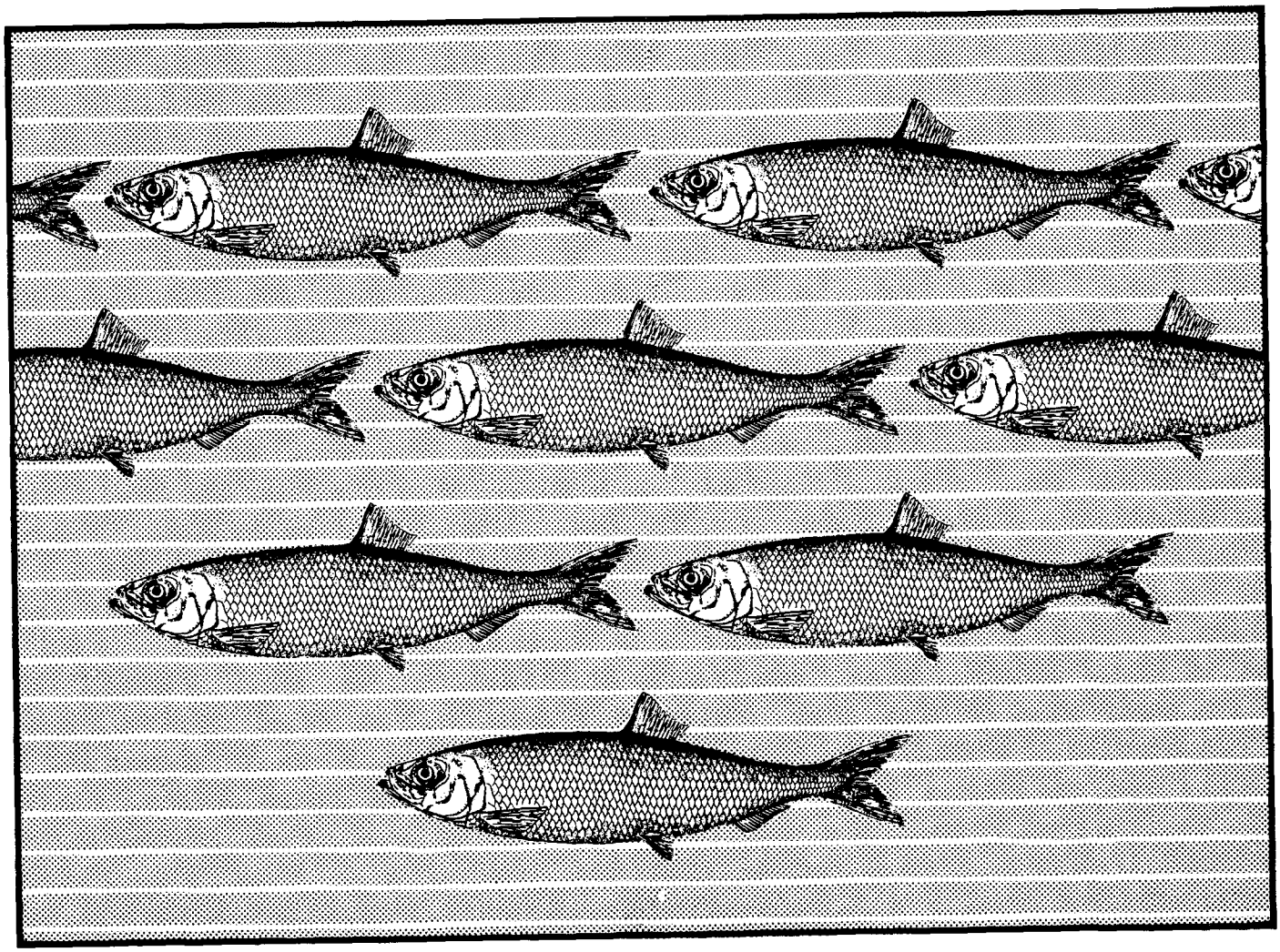
APPENDIX I

Fisheries and Oceans | Pêches et Océans

Fisheries Management Plan: 1987

Scotia - Fundy Region

4WX Herring



Canada

1987 SCOTIA-FUNDY HERRING MANAGEMENT PLAN

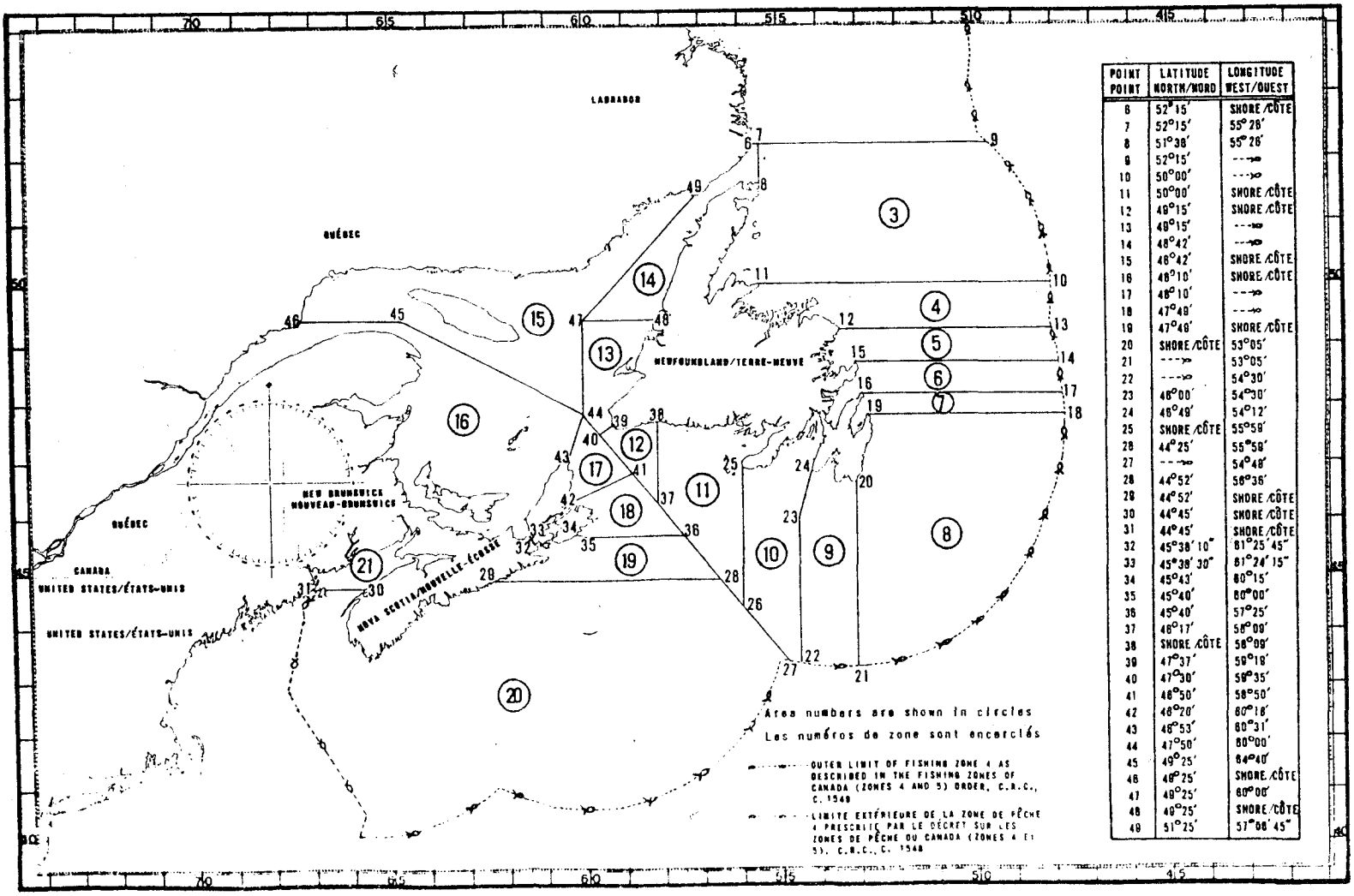
PART I

This Plan has been developed in consultation with representatives of the herring fishing industry, the two provincial governments and the Department of Fisheries and Oceans through the Scotia-Fundy Herring Advisory Committee. This Plan will apply to the 1987 herring fishery which begins on October 15, 1986, and ends on October 14, 1987.

Monitoring of all herring landings will be carried out under the provisions of Section 48 of the Fisheries Act, in accordance with existing regulations and subject to any new regulations which may come into effect in 1987.

The total allowable catch (TAC) will be 126,500t in Herring Fishing Areas 17 to 21 which will be allocated as set out in Table I.

HERRING FISHING AREAS



POINT POINT	LATITUDE NORTH/NORD	LONGITUDE WEST/OUEST
6	52°15′	SHORE/CÔTE
7	52°15′	55°28′
8	51°38′	55°28′
9	52°15′	---»
10	50°00′	---»
11	50°00′	SHORE/CÔTE
12	48°15′	SHORE/CÔTE
13	48°15′	---»
14	48°42′	---»
15	48°42′	SHORE/CÔTE
16	48°10′	SHORE/CÔTE
17	48°10′	---»
18	47°48′	---»
19	47°48′	SHORE/CÔTE
20	SHORE/CÔTE	53°05′
21	---»	53°05′
22	---»	54°30′
23	46°00′	54°30′
24	46°49′	54°12′
25	SHORE/CÔTE	55°58′
26	44°25′	55°58′
27	---»	54°48′
28	44°52′	56°36′
29	44°52′	SHORE/CÔTE
30	44°45′	SHORE/CÔTE
31	44°45′	SHORE/CÔTE
32	45°38′10″	61°25′45″
33	45°38′30″	61°24′15″
34	45°43′	60°15′
35	45°40′	60°00′
36	45°40′	57°25′
37	46°17′	58°09′
38	SHORE/CÔTE	58°09′
39	47°37′	59°18′
40	47°30′	59°35′
41	48°50′	59°50′
42	48°20′	60°18′
43	48°53′	60°31′
44	47°50′	60°00′
45	49°25′	64°40′
46	49°25′	SHORE/CÔTE
47	49°25′	60°00′
48	49°25′	SHORE/CÔTE
49	51°25′	57°08′45″

.../2

TABLE I

GEAR TYPE	HERRING FISHING AREA	SEASON	QUOTA(t)	ALLOWANCE(t)
Purse Seine	Area 17	Nov.07/86-Mar.01/87	4,200 [1]	
Purse Seine	Area 18	Closed All Year	N/A	
Purse Seine	Area 20 and 21 (Fall Fishery)	Oct.15/86-Dec.31/87	9,000	
	Area 20 and 21 (Winter Fishery)	Jan.01/87-Mar.31/87	1,500 [2]	
	Area 19 (Chedabucto Bay)	Nov.07/86-Mar.01/87	23,000 [3]	
	Area 20 and 21 (Summer Fishery)	May 01/87-Oct.14/87	81,500 [4]	
		TOTAL	115,000	
	Area 19, 20 & 21 (Bait Fishery)	N/A	2,600 [5]	
		TOTAL	117,600	117,600
Drift Gill Nets	Area 20	N/A		5,000(OSS)
Set Gill Nets	Areas 17, 18, 19, 20 and 21	N/A		3,900
Weirs	Areas 20 and 21	N/A		
Trap Nets	Areas 19, 20 and 21	N/A		
		TOTAL		8,900 [6]
			TAC	126,500

1. To be fished by Gulf purse seine vessels only; the 4,200t does not count toward the Scotia-Fundy TAC.

2. No more than 500t of the 1,500t winter fishery quota will be taken inside a line, yet to be defined, along the south coast of New Brunswick near Saint John.

3. Up to 9,200t (40% of the 23,000t quota) may be taken in waters of Chedabucto Bay in Area 19 lying inside of a straight line from Cape Canso to Green Island, after December 31, 1986.

4. Uncaught quotas from the fall, winter and Chedabucto Bay fisheries will be made available to the summer fishery within the 1987 fishing year only.

5. The 2,600t bait quota will be allocated to each purse seine vessel based on its existing percent share of the purse seine TAC, i.e., 1.6%, 2.7%, etc.

6. Allowances are applied only to inshore gear licensed for waters adjacent to Nova Scotia. This catch approximated 7,500t in 1984, 10,500t in 1985 and 5,000t in 1986. No quotas or allowances are applied to inshore gear licensed for waters adjacent to New Brunswick.

PART II

Part II applies to the purse seine fleet.

1. Participation

Any Scotia-Fundy purse seine vessel may participate in any or all of Herring Fishing Areas 19, 20 and 21 subject to season, area quota and vessel quota restrictions.

2. Vessel Quotas

a) All purse seine vessels shall operate on an annual vessel quota. This quota is determined on the basis of a 1.6% share of the TAC for Class A vessels and a 2.7% share of the TAC for Class B vessels.

These percentage shares also apply to processor-owned vessels (Class C) but do not account for quota purchases. Subject to additional authorized quota purchases for the 1987 fishery, individual vessel quotas will be allocated as set out in Table II and issued as a licence condition.

b) All documented individual vessel quota overruns in the 1986 fishery will be deducted from the 1987 individual vessel quotas.

3. Trinity Ledge Closure

That area of Trinity Ledge off Southwest Nova Scotia bounded on the north by latitude 44°05', on the south by latitude 43°55' and on the west by longitude 66°25' will be closed to purse seine vessels for three days (Thursday noon until Sunday noon) each week during the period August 15 to September 15, 1987.

4. Scotts Bay Closure

A more appropriate Area 21 boundary line, to be established prior to commencement of the summer fishery, will be in place to protect a herring spawning area in the upper Bay of Fundy. This closure will be effected by removing the existing Area 21 boundary line by variation order and establishing the new line as a licence condition.

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5. Georges Bank

A Georges Bank purse seine fishery will be authorized under the following conditions:

a) fishing to occur only in Canadian fisheries waters within 5Ze;
b) a DFO observer must be present on all trips;
c) 24 hours' notice must be given to DFO prior to departure; and
d) failure to comply with parts (a), (b) and (c) will result in any catch being attributed to that vessel's quota.

6. Over-the-Side Sales (OSS)

Ministerial approval in principle may be sought, with industry consensus, for an over-the-side sales program consistent with government policy, at a later date.

7. Over-the-Wharf Sales (OTW)

Same as item 6.

TABLE II

1987 SCOTIA-FUNDY PURSE SEINE VESSEL QUOTA ALLOCATIONS

CLASS A (NON-MOBILE)	(% SHARE)	CLASS B (MOBILE)	(% SHARE)	CLASS C (PROCESSOR-OWNED)	(% SHARE)
1. CAPE SHOAL	1.6%	25. CANADA 100	4.0%	38. CPRD - non-mobile	1.9%
2 CHELTOM	1.6%	26. CENTENNIAL III	3.0%	39. EASTERN PHOENIX	2.7%
3. CLELAND G.	1.6%	27. DUAL VENTURE	4.0%	40. LADY MELISSA	4.0%
4. CRAIG & DIANNE	1.6%	28. EASTERN FISHER	2.7%	41. LADY NOREEN	2.7%
5. DAUGHTERS THREE	1.6%	29. ISLAND PRIDE #1	2.7%	42. MATTUNA MARINER	4.0%
6. DEBORAH & RUTH	1.6%	30. LEROY & BARRY II	4.0%		
7. FIVE LADIES	3.2%	31. MARGARET ELIZABETH	4.0%		
8. FLYING SWAN IV	1.6%	32. MARIE LYNN ANITA	4.0%		
9. FUNDY MISTRESS	1.6%	33. NOVA STAR	2.7%		
10. GAIL & TROY	1.6%	34. PUBNICO GEMINI	2.7%		
11. GOLDEN DAWN	1.6%	35. SANDY G	2.7%		
12. INGALLS SANDS	1.6%	36. SEALIFE II	2.7%		
13. LISA ANN	3.2%	37. SEALIFE III	2.7%		
14. MISS JENNIFER	1.6%				
15. NORCHA	1.6%				
16. POLLY B.	1.6%				
17. PUBNICO VIRGO	1.6%				
18. RICHARD B.	1.6%				
19. SARAH & STEWART	1.6%				
20. SEACO	1.6%				
21. SEAFOAM	1.6%				
22. SEVEN L'S	1.6%				
23. TODD & CARLA	1.6%				
24. TOMMIE & ARNIE	3.2%				

For 1987, the percentage share of the purse seine TAC and the separate bait quota equate to the following tonnages:

1.6% = 1,840t and 41.6t bait
1.9% = 2,185t and 49.4t bait
2.7% = 3,105t and 70.2t bait
3.0% = 3,450t and 78.0t bait
3.2% = 3,680t and 83.2t bait
4.0% = 4,600t and 104.0t bait

PART III

Part III applies to inshore gear which is comprised of weirs, trap nets and gill nets.

1. General

Effort limitations in all inshore fisheries will be governed by current regulations and licensing policy.

2. Weir Fishery

The Split Rock to Gannet Rock Light closure will be in effect from April 15, 1987, to September 30, 1987. An extension of this closure may be granted up to October 15 after consultation with industry.

3. Herring Drift Net Fishery

a) An OSS program for 5,000t is to occur. This program will be made up of gill net herring only and no portion of that allowance can be transferred to a purse seine OSS program.

b) Ministerial approval in principle may be sought for an OTW program, consistent with government policy, at a later date.

c) If a purse seine OSS program is approved, a cooperative agreement may occur between the Maritime Fishermen's Union representing the drift netters and a purse seine group coordinator to ensure daily OSS capacity is filled.

PART IV

Regulatory Requirements

1. Until such time as new regulations can be promulgated to control:

   a) the Trinity Ledge area closure;
   b) the Scotts Bay area closure; and
   c) the 500t limit on herring to be caught along the shore near Saint John in the winter fishery.

   these restrictions can be implemented and legally enforced as licence conditions pursuant to section 33 of the Atlantic Fishery Regulations, 1985.

2. In accordance with the Annual Regulatory Plan and consistent with the Committee's advice (1984), it is anticipated that regulations requiring mandatory weighing of herring at the time of landing could be in place by April 1, 1987.