CAFSAC
Research Document 80/54

An Evaluation of the Current Status of Southern Gulf Herring

By

G.H. Winters and J.A. Moores
Research and Resource Services
Fisheries and Oceans
Northwest Atlantic Fisheries Center
P.O. Box 5667
St. John's, Newfoundland
A1C 5X1

Abstract

Catches from the southern Gulf of St. Lawrence herring stock complex declined from 52,500 mt in 1978 to 45,900 mt in 1979. This decline can be primarily attributable to the voluntary closure of the "Edge" fishery due to the presence of large quantities of small herring. Younger age-groups comprised the bulk of the 1979 catch with the 1974, 1976 and 1977 year-classes being dominant among spring-spawners and the 1974 and 1975 year-classes among fall-spawners. Fall-spawners were continued to be dominant in the "Edge" fishery comprising 81% of the catch.

An analysis of the commercial catch rate data from the various fisheries gave conflicting results. Purse seiner CPUE showed an increase during the spring "Edge" fishery but declined during the fall southern Gulf fishery. Catch rates also declined in the fall groundfish survey, the Magdalen trap fishery and the Escuminac spring gillnet fishery. Increasing catch rates were reported in the Pictou Island fall gillnet fishery.

Cohort analysis was performed and incorporated new partial recruitment vectors which reflected the increasing contribution from younger age-groups. Given the contradictory nature of the abundance indices the size of the major year-classes (1973-76), comprising the bulk of the population structure, were estimated from regressions of CPUE-at-age in relation to estimates of the 1965-72 year-classes derived from trial runs of cohort analysis. Adjacent year-classes were estimated based on the age distribution observed in the 1979 fall purse seine fishery. These analyses indicate 2+ biomass of this stock-complex has remained relatively stable at about 450,000 mt and that recruitment in most recent years has been improving.

Yield-per-recruit analysis was performed incorporating the revised partial recruitment vector and indicated an $F_{0.1}$ level of 0.30 for both spawning components.

Résumé

Les captures de hareng provenant du complexe de stock du sud du

golfe St. Laurent ont diminué à 45 900 t en 1979 comparé à 52 500 t en 1978. Le déclin est surtout attribuable à la fermeture volontaire de la pêche dite des "Accores (du chenal Laurentien)" (Edge fishery) à cause de la présence de grandes quantités de petits harengs. Le gros des prises de 1979 était formé de jeunes groupes d'âge, les classes d'âge de 1974, 1976 et 1977 étant dominantes chez le hareng de printemps, et celles de 1974 et 1975 chez le hareng d'automne. Ces derniers continuaient d'être dominants dans la pêche "des Accores" représentant 81% des prises.

Une analyse des taux de capture des diverses pêches donne des résultats contradictoires. Les prises par unité d'effort (P.U.E.) des bateaux pêchant à la senne coulissante ont augmenté durant la campagne de printemps sur "les Accores", mais ont diminué durant la campagne d'automne dans le sud du golfe Saint-Laurent. Les taux de capture ont également diminué dans les relevés des poissons de fond des navires de recherche, dans les prises des trappes aux îles de la Madeleine et dans la pêche de printemps aux filets maillants à Escuminac. On signale des augmentations dans la pêche automnale aux filets maillants de l'île Pictou.

Un nouveau vecteur de coefficient de recrutement partiel a été utilisé dans l'analyse des cohortes, réflétant la contribution accrue des jeunes groupes d'âge. Étant donnée la nature contradictoire des indices d'abondance, l'importance des principales classes d'âge (1973-1976), qui constituaient le gros de la population, à été estimée au moyen de régressions des P.U.E. à l'âge sur les estimations des

classes d'âge de 1965-1972 dérivées d'essais préliminaries d'analyse des cohortes. Les classes d'âge adjacentes ont été estimées d'après la distribution des âges observée lors de la campagne d'automne 1979 de pêche à la senne coulissante. D'après ces analyses, la biomasse de hareng de 2 ans et plus de ce complexe de stocks serait demeurée relativement stable à environ 450 000 t et il y aurait eu amélioration du recrutement ces toutes dernières années.

Les rendements par recrue ont été calculés à l'aide du nouveau vecteur de coefficient de recrutement partiel et indiquent un $F_{0.1} = 0.3$ semblable pour les deux groupes reproducteurs.

INTRODUCTION

Landings from this stock complex of spring- and fall-spawning herring reached peak levels of 300,000 m tons in 1970, declining dramatically thereafter to a low of 37,200 m tons in 1974. The imposition of quotas on this stock in 1972 was designed to arrest the precipitous decline in its abundance (Winters and Hodder, 1975) and to initiate conservation measures conducive to stock rebuilding, although it was recognized at the time that stock rebuilding would in large part depend upon improved recruitment over that observed since the large year-classes of the late 1950's. The most recent assessment of southern Gulf herring (Winters and Moores, 1979) indicated that the first management objective had been achieved although at the expense of loss in yield. In addition, improved recruitment in both spawning components for the year-classes produced in the mid-1970's suggested that stock rebuilding may have begun. This document presents new information derived from research studies conducted in 1979.

I. Fishery Removals in 1979

a. Catch Statistics: The availability of reliable official catch statistics broken down into appropriate gear types according to monthly total landings continued to be a difficulty in 1979. Approximately 60% of the purse-seine landings could not be attributed to unit area of capture based on official provisional statistics for 1979 (Table 1). Fortunately, the fidelity of the purse-seine fleet in maintaining their high log-book submission rate (above 85%) in 4T (Table 2) allowed the decomposition of purse-seine catches in 1979 in a similar manner as was done previously (Winters and Moores, 1979) i.e. undefined purse-seine catches were broken down according to the area/month catch key given in Table 2. These statistics are shown in Table 3 and are combined with inshore landings to provide total landings in Table 4.

Total landings of 4T herring in 1979 were 45,900 m tons, a decrease of nearly 7,000 m tons from 1978 (Table 5). This decision occurred mainly in purse-seiner landings due mainly to a voluntary closure of the "Edge" fishery as a result of market constraints. The decrease in the Magdalens inshore fishery in 1979 is difficult to interpret, given the different nature of catch reporting in 1978 and 1979 and the general unreliability of catch statistics from this area (Powles pers. comm.). The inshore spring (April-July) fisheries in the southern Gulf showed a slight increase in 1979 whereas the fall inshore fisheries (Aug.-Dec.) declined slightly. These

statistics are, however, provisional and may not adequately reflect actual landings in 1979.

b. 1979 Age Composition: Commercial sampling data distributed over gear, season and area were used to decompose total catches into age-specific numbers for each spawning component. Some difficulty was encountered in trying to assign the immature fish (generally age-group 3 and younger) to the two general spawning components and in general both otolith morphometry and nuclei type were used as criteria for discrimination. Thus some of the younger age-groups may be incorrectly assigned to a particular year-class, although given the performance of the age-readers in the past, this error is probably not large. Furthermore, a significant number of 2-year-olds were in maturity stage III in the fall purse-seine fisheries (where most young fish were caught), which allowed some confirmation of spawning-group assignment.

The age composition of the spring purse-seine fisheries along the "Edge" changed dramatically in 1979 compared to 1978 (Fig. 2). In both spawning components young fish (age 4 and younger) accounted for about 45-50% of the catch in 1979 whereas in 1978 and previous years old fish (age 10 and older) dominated the catches. Amongst spring-spawners the 1974, 1976 and 1977 year-classes predominated whereas the 1974 and 1975 year-classes were dominant in fall-spawners.

Fall-spawners comprised 81% of the "Edge" fishery in 1979 (Table 6), about the same level as in 1978.

Age composition data for the traditional fall purse-seine fisheries in the southern Gulf also indicated a shift to younger age-groups in 1979. Amongst spring-spawners the 1977 year-class was dominant (nearly 45%) although the 1974 year-class, which predominated in 1978, was also a significant contributor. In fall-spawners the 1975 year-class predominated, followed by the 1974 year-class which was dominant in 1978. The presence of very young fish in both spawning groups (age-group 1 in spring and age-groups 2 and 3 in fall-spawners) represented a significant change from historical data.

The age compositions of the inshore fishery for spring-spawners in the Magdalens in 1979 was very similar to that observed in 1978 (Fig. 3) with the 1974 and 1975 year-classes predominating in both years. In the southern Gulf spring inshore fishery the 1974 year-class continued its substantial contribution to the catches, although 3-year-olds of the 1976 year-class also had a significant presence. In the fall inshore fisheries the 1975 year-class, which comprised the bulk of the fall purse-seine fishery around Souris, P.E.I., in 1978, represented nearly 45% of the total catches and thus superceded the 1974 year-class which dominated in 1978.

The monthly contribution of fall-spawning herring to the purse-seine fisheries in the southern Gulf since 1974 are shown in Table 7. Generally, fall-spawners contribute most heavily during their main spawning period (Aug.-Sept.), following which spring-spawners increasingly predominate as the fishery shifts to feeding aggregations prior to their emigration from the Gulf. This shift from spawning aggregations to emigrating - feeding concentrations is also reflected in a pronounced decrease in the mean age in the catches of both components (Table 8). This may also reflect in part the migration offshore of juvenile herring which are suspected to have a coastal distribution in the southern Gulf during the summer period.

II. Abundance Indices in 1979

a. Commercial Purse-seine CPUE: Detailed catch-per-unit-effort information have been available for the purse-seine fisheries in the southern Gulf since the early 1970's and from the Southwest Newfoundland over-wintering fisheries during the late 1960's and early 1970's. Table 9 illustrates the historical catch-per-set data for the spring "Edge" fishery. The decline in catch rates in this fishery in recent years was arrested in 1979 when the CPUE increased substantially from 19.5 m tons/set in 1978 to 46.9 m tons/set in 1979. The sudden occurrence of large quantities of young fish in this fishery in 1979 suggests that this increase in CPUE is a result of abundance increases rather than an availability change.

In the fall purse-seine fishery in the southern Gulf the CPUE index decreased substantially from 48.4 m tons/set in 1978 to 24.5 m tons/set in 1979 (Table 10) despite the abundance of very young fish in the catches. Given this apparent abundance of young fish and the predicted stock status in 1979 (from the 1978 assessment of this stock) this decline is difficult to interpret although a variety of factors suggest that it was not related to abundance. Communication with purse-seine skippers indicated that there was a substantial avoidance of small fish by the purse-seine fleet in 1979 due to market unacceptability and some dumping of small fish (not quantifiable) did occur. Other possible contributing factors may have been the inshore-purse-seiner gear conflict in 1979, although a comparison of catch rates for all unit areas indicated declines from 1978 to 1979; also the Purse-seiner Coop Club operated in the southern Gulf for the first time in 1979 and since their objective is to regulate catching capacity to industrial processing capacity this may have reduced catch rates somewhat.

b. Other Abundance Indices: A summary of the above indices as well as other commercial and research CPUE indices is given in Table 11. The catch-per-set of herring in the autumn groundfish surveys (log retransformed) declined from 1.9 fish per-set to 1.6 fish per-set in 1979 although the variance of these data are such that this change cannot be considered to be significant. The catch-per-trap in the Magdalens spring fishery remained low in 1979 although given

the general unreliability of catch statistics for this area and the fact that the catch statistics for both 1978 and 1979 have been treated differently compared with previous years, no firm conclusion can be made except that catch rates for this fishery are still low relative to the early 1970's. Catch rates in the spring gillnet fishery in the Escuminac district declined from 1978 to 1979 although no trend is evident in the short time series available. The fall gillnet fishery in the Pictou Island area, however, showed a substantial increase in catch rates from 193 kg/boat/day in 1977 to 230 kg/boat/day in 1978 and to 507 kg/boat/day in 1979. It is worth noting that this fishery is based on fall-spawning herring which also comprised the bulk of the "Edge" fishery in 1979 and in that fishery the substantial increase in catch rates is consistent with the appearance of large quantities of young fish.

III. Calculation of Assessment Parameters

a. Selectivity Factors: The southern Gulf fall purse-seine fishery which historically has exploited a wide spectrum of age-groups (Winters and Hodder, 1975) has been assumed to be representative of the 3+ age-specific population structure. Therefore, the ratio of the relative abundance of an age-group in the total catch to the fall purse-seine catch may be used as an estimate of the selectivity factors for the fishery as a whole. Table 12 illustrates this comparison for the 1979 catch data. The analyses suggest that there was some concentration on the youngest age-groups in both spawning components in 1979, a pattern

similar to that observed in 1978 (Winters and Moores, 1979). These selectivity factors along with an arbitrary value for age-group 2 were used for initial runs of cohort analyses.

b. Average Weights-at-age: The weights-at-age averaged for the first and second quarter are shown below in relation to those used in the 1979 assessment of this stock.

Spawning Group	Year	Weights-at-age (kg)									
		2	3	4	5	6	7	8	9	10	11+
Spring	1979	.062	.138	.181	.234	.262	.288	.328	.341	.345	.373
	1978	.095	.150	.200	.245	.295	.305	.325	.340	.345	.375
Fall	1979	.037	.083	.168	.217	.262	.288	.312	.329	.333	.380
	1978	-	.130	.190	.230	.260	.290	.315	.315	.320	.365

Decreases in growth are evident in both spawning components from 1978 to 1979.

c. Terminal Fishing Mortality (F_T): Given the contradictory nature of the abundance indices in 1979, particularly with regard to the standard CPUE (fall purse-seine catch rates) it was considered inappropriate to utilize conventional methods of fine-tuning cohort analyses. Instead an alternative method of year-class strength estimation similar to that developed by Winters and Moores (1979) was employed based on CPUE indices of year-classes at ages 3 and 4, adjusted for annual changes in partial recruitment, defined as the ratio F_t/F_{5+}. The basic calculations

are shown in Tables 13 and 14, and the relationships between population size-at-age from cohort analyses and the corresponding age-specific CPUE are shown in Fig. 4. The correlation coefficients are statistically significant in each case and a summary of the estimates of the 1973-76 year-classes adjusted to age-group 2 is shown in Table 15. Accepting that the 1979 catch rates are probably biased downwards implies that the strengths of the 1976 (at age-group 3) and 1975 (at age-group 4) year-classes are also biased downwards.

In order to avoid this potential bias, the largest year-class (1974) in each spawning group, estimated at age-groups 3 and 4, independent of the 1979 catch rate data was selected, and adjacent age-groups estimated in 1979 based on the age distribution in the 1979 fall purse-seine fishery. The results are shown below (Method A = prorated from P.S. age components; Method B = predicted from Fig. 4).

Spawning Method	Method	Age-group 2	3	4	5	6	7	8	9	10	11+
SS	A	870	121	44	464	68	59	21	8	13	47
	B	-	39	34	464	97	-	-	-	-	-
AS	A	175	100	257	190	72	50	18	60	14	133
	B	-	86	139	190	89	-	-	-	-	-

It is evident from the above comparisons that these year-classes predicted from the 1979 CPUE index are much weaker than is evident from the relative age compositions in 1979 (Method A). This supports the contention that the 1979 fall CPUE index is anomalous and biased downwards.

IV. Results of Assessment

The population, fishing mortality and catch matrices for the years 1969-79 are shown in Tables 16, 17 and 18, respectively. The 2+ biomass of the Southern Gulf of St. Lawrence stock complex decreased from approximately 1,850 kt in 1969 (Table 6) to a low of 426 kt in 1975, increased to 480 kt in 1977 and has remained at that level since then. The spring-spawning biomass declined to about 150 kt in 1975 and has steadily increased since then to a predicted level of 275 kt in 1980. Amongst fall-spawners the 2+ biomass decreased steadily from 1,429 kt in 1969 to about 225 kt in 1979. The analysis conducted this year confirms the strength of the 1974 year-class in spring-spawners although the 1975 and 1976 year-classes appear to be weak. First estimates of the 1977 year-class of spring-spawners suggest that it is also a very strong year-class and is probably underestimated, given that 2-year-olds do not appear to be fully recruited to the spring-spawning component in the fall purse-seine fishery (Fig. 5). Amongst fall-spawners the 1973, 1974 and 1975 year-classes are moderately good; the 1976 and 1977 year-classes are probably much stronger than shown in Table 15 due also to the partial recruitment of these age-groups to the fall purse-seine fisheries (Fig. 5)

and to the fact that these same year-classes are estimated to be very strong in the adjacent 4XW herring stock.

The relationship between fishing mortality and fishing effort is shown in Fig. 6. All of the most recent points (1976, 1977 and 1978) lie very close to the regression line whereas the 1979 point is anomalous. Similarly, the relationship between 3+ biomass (year t+1) and catch rate (year t) (Fig. 7) also indicates that the most recent years except 1979 lie very close to the regression line. Further evidence which suggests that the 1979 catch rate index is anomalous may be obtained from a comparison of Paloheimo mortality rates and those derived from cohort analyses (Table 19). There is a very good agreement for all years except 1978-79 when Z values by the method of Paloheimo increase substantially to 0.81 from 0.22 in 1977-78. Such a large increase in mortality cannot be attributed to events in the fishery and there is no evidence for such a substantial increase in the natural mortality rate. The authors have, therefore, concluded that the standard 1979 catch rate represents a substantial underestimate of the actual abundance in 1979.

V. Catch Prognosis

a. Calculation of $F_{0.1}$: The dramatic change in the age composition of the "Edge" fishery in 1979 suggests a further change in the pattern of fishing on this stock since 1978. In addition preliminary observations from the 1980 purse-seine fishery along the "Edge" indicates the continued occurrence of significant numbers of young fish. In order to reflect these new events in the fishery the partial recruitment

rates for 1979 have been averaged (spring- and fall-spawners combined) and smoothed to provide the age-specific selectivity factors shown below in comparison to those used by Winters and Moores (1979).

Age/PR	2	3	4	5	6	7	8	9	10	11+
New	.15	.65	1.00	.80	.75	.65	.55	.50	.50	.50
Old	.25	.35	.45	.55	.75	.90	.95	.98	1.00	1.00

The revised yield-per-recruit curve (Fig. 8) indicates an $F_{0.1} = 0.30$.

b. Catch projection for 1980: A catch projection for 1980 has been performed under two options assuming that the 1978 and 1979 year-classes are equal to the geometric mean of the 1968-75 year-classes (about 0.2 billion fish at age-group 2); option (1) - $F_{0.1} = 0.30$, option (2) - 1980 TAC = 1979 TAC (55,000 mt). The results (Table 20) indicate an optimal yield of 90,300 m tons in 1980 which will result in a 1981 biomass of 419,000 m tons compared with 481,000 m tons at the beginning of 1980. Under option (2) the 1981 2+ biomass is predicted to be 451,000 m tons.

DISCUSSION

The analyses of the status of 4T herring presented in this paper confirms previous analyses which indicated that this stock complex has been relatively stable since 1973 with catches averaging about 45,000 - 50,000 mt.

The improved recruitment evident in both spawning components in the 1970's may result in some degree of resurgence of this stock depending upon the strength of the 1976-78 year-classes (which are probably underestimated in this analysis) and the fishing mortality applied to the resource. Since 1973 the stability of this stock has been in large part due to fishing mortality rates substantially less than $F_{0.1}$ levels and subsequent stock rebuilding will undoubtedly be closely related to a continuation of this pattern, unless recruitment levels comparable to those observed in the late 1950's occur. This strategy will of course result in loss of yield.

REFERENCES

Winters, G.H. and V.M. Hodder. 1975. Analysis of the Southern Gulf of St. Lawrence herring stock and implication concerning its future management. ICNAF Res. Bull. 11: 43-59.

Winters, G.H. and J.A. Moores. 1979. An evaluation of recent changes in the population dynamics of southern Gulf herring. CAFSAC Res. Doc. 79/28.

Table 1. Purse-seiner catches (m tons) of herring in 4T in 1979 as reported by the Maritimes Economics Branch.

Area	Month									Total	
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
431 (F)	11046	381								11427	}
432 (G)										-	}
433 (H)										-	}
434 (J)										-	}
435 (K)										-	}
436 (L)						382	176	115		673	}
437 (M)								12	1	13	}
438 (N)					80	831	237	47		1195	}
439 (O)										-	}
Unknown	186				381	2594	4004	7313	1709	16187	} -- (1)
Total (Maritimes)	11232	381	-	-	461	3807	4417	7487	1710	29495	}
431 (F)	1270									1270	} -- (2)
431 (F)	552	733								1285	} -- (3)
438 (N) 439 (O)					199	340	213	354	124	1230	}
Total	13054	1114	-	-	660	4147	4630	7841	1834	33280	

(1) from Leo Brander - Halifax

(2) from Economics Branch - St. John's

(3) from H. Powles - Quebec

Table 2. Purse-seiner catches (m tons) in Area 4T as derived from log book records.

Area	Month									
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
431 (F)	10137									10137
432 (G)	214									214
433 (H)										-
434 (J)										-
435 (K)										-
436 (L)					77	627	361	215		1280
437 (M)							178	1803		1981
438 (N)					109	2058	3431	6430	1552	13580
439 (O)					227	355	65			647
Total	10351	-	-	-	413	3040	4035	8448	1552	27839

Table 3. Purse-seiner catches in 4T for 1979 broken down by month and area according to log records and reported statistics.

Area	Month									
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
431 (F)	12829	1114								13943
432 (G)	225									225
433 (H)										-
434 (J)										-
435 (K)										-
436 (L)					84	685	395	235		1399
437 (M)							195	1969	1	2165
438 (N)					119	2249	3750	7027	1696	14841
439 (O)					248	388	71			707
Total	13054	1114	-	-	451	3322	4411	9231	1697	33280

Table 4. Catch statistics for 4T herring in 1979 (provisional).

Month	Magdalens - Edge		Eastern P.E.I.		Southern Gulf		Total
	Inshore	P. Seine	Inshore	P. Seine	Inshore	P. Seine	
Apr.	288	12829	65	225	461		13868
May	381	1114	73		5696		7264
June			28		1083		1111
July			11		656		667
Aug.			64		974	451	1489
Sept.			93		2011	3322	5426
Oct.			1		398	4411	4810
Nov.					236	9231	9467
Dec.					82	1697	1779
Total	669	13943[1]	335	225	11597	19112[2]	45881

[1] - Quota Report (15201)

[2] - Quota Report (16305 as of Dec. 5/79)

Table 5 . Component and area catch breakdown of 4T herring 1973-79.

	P. Seine		Inshore				
Year	Edge	S. Gulf	Magdalens	S. Gulf (S)	S. Gulf (F)	Total	TAC
1973	10666	13537	2994	9057	7580	58244**	
1974	8767	11529	2936	5352	5026	36368**	
1975	18612	12604	3071	4112	5500	44212	55000
1976	17689	12147	1168	5848	3123	39975	55000
1977	13594	20897	1865	3289	3023	42668	60000
1978	5131	33572	1842	7947	3805	52479	55000
1979*	13943	19337	669	8073	3682	45881	55000

* provisional

** includes in addition catches from SW Nfld.

Table 6. Percentage of Autumn-spawners in samples taken along the "Edge" area of the Southern Gulf of St. Lawrence, 1970-79.

Year	% Autumn-spawners		
	April	May	June
1970	28	-	-
1971	19	-	
1972	-	-	
1973	32	52	56
1974	31	68	
1975	65	81	
1976	51	60	
1977	55	59	
1978	81	94	
1979	81	81	

Table 7. Relative contribution of fall-spawning herring in purse seine catches in 4T, 1974-79.

Year	% Autumn-spawners					
	July	Aug.	Sept.	Oct.	Nov.	Dec.
1974	68	74	79	98	44	
1975	38	-	75	3	3	
1976			-	48	37	
1977				35	21	
1978		45	50	38	45	
1979		99	96	47	23	21

Table 8. Mean age of purse-seine catches in 4T herring during the fall fishery, 1974-79.

	Year	Mean age of catch			
		Sept.	Oct.	Nov.	Dec.
SS	1974	6.8	6.0	2.6	-
	1975	3.5	5.1	5.4	
	1976	-	3.9	3.0	
	1977	-	3.6	3.4	
	1978	4.2	4.4	4.1	
	1979	6.4	4.3	3.0	2.9
	Average*	5.2	5.0	3.8	
AS	1974	7.7	5.2	4.7	
	1975	6.2	6.4	6.1	
	1976	-	7.4	7.3	
	1977	-	7.1	6.7	
	1978	6.3	5.6	5.4	
	1979	7.6	5.3	5.8	2.7
	Average*	7.0	5.6	5.5	2.7

* common months all years

Table 9. Monthly catch-per-set data from log records of purse-seiners operating on the "Edge" (Area 4TF).

Year	Catch-per-unit-effort		Mean	
	April	May	Unweighted	Weighted
1969	63.7	58.2	61.0	62.3
1970	62.9	32.5	47.7	55.8
1971	38.9	-	-	-
1972	21.6	29.7	25.7	-
1973	21.5	48.8	35.2	43.3
1974	34.8	33.4	34.1	33.6
1975	47.1	61.3	54.2	59.1
1976	44.5	47.1	45.8	45.3
1977	33.3	37.2	35.3	35.3
1978	19.5	35.0	27.3	29.4
1979	46.9	-	-	-

Table 10. Monthly CPUE data (catch/set) as evaluated from log records of purse-seiners operating in the Southern Gulf 1971-79 (excluding unit Areas 431 and 432).

Year	Catch-per-unit-effort (CPUE)							Unweighted Mean (Sept.-Nov.)
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1971	17.3	34.9	25.4	47.2	59.4	(54.9)		53.9
1972		37.0	12.9	37.1	53.9	44.3		45.1
1973		26.4	-	49.1	-	-		-
1974		19.4	40.2	28.3	35.4	50.0		37.9
1975			23.6	32.1	37.8	33.5		34.5
1976				27.3	44.5	50.6		40.8
1977				(41.3)	53.1	40.6		45.0
1978	71.4	-	22.0	45.3	31.7	67.3		48.4
1979	-	-	31.8	31.3	19.9	22.2	26.8	24.5
Unweighted mean	44.4	29.4	26.0	37.7	42.0	45.4	26.8	

Table 11. CPUE indices for the various fisheries exploiting the Southern Gulf stock complex. Research vessel data are from the autumn groundfish surveys and have been log re-transformed (Stobo, pers. comm.).

	CPUE			S. Gulf			
Year	SW Nfld.	Edge	Magdalens	P.S.	R.V.	GN	GN
1969	50.3	61.0[a]	-[c]	(110.2)[a]	12.8		
1970	41.5	47.7	204	(90.9)	7.6		
1971	24.6	-	336	53.9	3.2		
1972	13.4	-	112	45.1	3.2		
1973	9.2	35.2	91	41.0	2.2		
1974	-	34.1	80	37.9	2.1		
1975	-	54.2	59	34.5	2.4		
1976	-	45.8	46	40.8	2.6	267[b]	32.2[d]
1977	-	35.3	65	45.0	2.7	193	29.7
1978	-	29.4	35	48.4	1.9	230	35.8
1979	-	(46.9)	31	24.5	1.6	507	22.9

( ) see Winters (1978)

a - c/set

b - c/boat/day, Pictou Island fall fishery (M. Sinclair, pers. comm.)

c - c/trap, Powles pers. comm.

d - kg/net/day, Escuminac spring fishery (Messieh pers. comm.).

Table 12. Comparison of age compositions (3+) of purse seine catches in the 1979 fall fishery (excluding Unit Area 432) with total age-specific catches for all fisheries in the Southern Gulf.

	Spring-spawners			Autumn-spawners		
Age	%-at-age (PS)	%-at-age (Total)	Selectivity Factor	%-at-age (PS)	%-at-age (Total)	Selectivity Factor
3	14.3	22.3	1.56	13.3	5.4	0.41
4	5.2	9.3	1.79	23.8	34.1	1.43
5	54.9	52.4	.95	18.1	26.7	1.48
6	8.1	3.2	.40	10.1	11.2	1.11
7	7.0	4.7	.67	3.0	2.1	0.70
8	2.5	1.0	.40	2.6	3.1	1.19
9	1.0	0.4	.40	8.4	5.3	0.63
10	1.5	1.1	.73	2.0	0.7	0.35
11+	5.5	5.5	1.00	18.7	11.5	0.62

* Oct.-Dec. samples only

Table 13. Relationship between catch-per-unit-effort of 3-year-old (C_3/E) herring and population estimates at age 3 from cohort analysis. Partial recruitment (PR) is defined as the ratio F_3 / F_{5+}.

Year-class	AS				SS			
	C_3/E	PR	C^1_3/E	N_3	C_3/E	PR	C^1_3/E	N_3
1966	8.59	.40	21.5	290	6.75	.34	19.9	167
1967	12.93	.32	40.4	481	2.57	.28	9.2	77
1968	7.58	.74	10.2	136	15.12	.42	36.0	502
1969	2.67	.30	8.9	87	1.07	.17	6.3	91
1970	2.67	.07	38.1	437	1.76	.27	6.5	51
1971	5.09	.75	6.8	85	8.96	.61	14.7	113
1972	1.73	.48	3.6	50	21.05	.61	34.5	215
1973	.30	.02	15.0	(183)	5.69	.23	24.7	(242)
1974	2.82	.36*	7.8	(99)	66.32	.79*	84.0	(863)
1975	16.51	1.16*	14.23	(174)	14.13	1.60*	8.9	(77)
1976	2.72	0.41	6.6	(85)	8.11	1.56*	5.2	(38)

* derived empirically from ratio of age-specific purse seine catches to total catches

Table 14. Relationship between catch-per-unit-effort of 4-year-old (C_4/E) herring and population estimates at age 4 from cohort analysis. Partial recruitment (PR) is defined as the ratio F_4 / F_5+.

Year-class	AS				SS			
	C_4/E	PR	C^1_4/E	N_4	C_4/E	PR	C^1_4/E	N_4
1965	7.84	.24	32.7	429	7.22	.27	26.7	227
1966	18.08	1.12	16.1	217	12.47	1.02	12.2	121
1967	21.28	.78	27.3	356	1.56	.39	4.0	55
1968	8.00	.97	8.2	81	14.92	.64	23.3	352
1969	3.38	.57	5.9	67	2.11	.23	9.2	72
1970	16.60	.56	29.6	354	3.46	.68	5.1	39
1971	3.22	.69	4.7	65	15.08	1.20	12.6	84
1972	1.97	.43	4.6	39	24.53	.97	25.3	152
1973	7.64	.57*	13.4	(166)	7.95	.58*	13.7	(128)
1974	24.31	.72*	33.8	(446)	64.22	.96*	66.9	(628)
1975	17.25	1.43*	12.1	(149)	3.36	1.79*	1.9	(17)

* derived empirically from ratio of age-specific purse seine catches to total catches

Table 15. Abundance estimates of the 1973-76 year-classes (at age-group 2) of spring and fall spawning herring in 4T as derived by the methods outlined in the text.

Year-class		Estimated strength at age 2 from			
		CPUE (age 3)	CPUE (age 4)	Average	Cohort analyses*
SS	1973	297	201	249	151
	1974	1065	1030	1048	1236
	1975	99	51	75	132
	1976	65	-	(65)	-
AS	1973	226	253	240	306
	1974	126	668	397	521
	1975	215	248	232	150
	1976	106	-	(106)	-

* Winters and Moores, 1979

Table 16. Cohort matrix for 4T herring 1969-80. Recruitment at age-group 2 is the geometric mean of the 1968-75 year-classes.

Spawning Group	Age-Group	Estimated Population Size ($x10^{-6}$)											
		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
SS	2	94	622	126	59	147	283	184	1040	91	164	875	(200)
	3	167	77	509	100	48	115	227	149	843	71	120	695
	4	229	121	56	357	80	37	87	162	117	632	44	85
	5	118	171	62	39	266	63	27	54	111	89	455	30
	6	146	85	129	39	26	176	50	20	37	81	68	340
	7	140	93	54	97	26	15	119	26	14	27	60	54
	8	50	92	47	36	75	18	9	80	21	11	21	46
	9	171	33	43	24	25	54	11	5	56	16	8	17
	10	445	96	18	22	15	18	40	6	3	40	13	6
	11+	43	243	131	57	53	46	49	63	41	24	46	44
Biomass	2+	421	326	228	178	165	153	151	192	225	216	252	275
	5+	351	254	149	96	135	113	92	78	82	81	173	151
AS	2	601	172	144	514	102	165	201	391	405	124	(200)	(200)
	3	293	490	139	113	416	83	131	164	320	331	100	165
	4	439	220	363	84	88	337	64	105	134	260	255	77
	5	452	341	127	213	54	70	261	48	84	103	189	180
	6	912	353	252	72	128	37	50	191	35	66	72	132
	7	497	665	266	152	39	85	27	35	131	26	50	49
	8	237	299	399	137	98	23	61	19	25	88	18	39
	9	294	159	151	222	88	68	16	45	14	18	59	12
	10	584	195	91	71	159	63	51	11	33	10	13	44
	11	1199	1069	684	399	305	345	313	276	215	181	133	109
Biomass	2+	1429	1074	718	450	354	308	275	256	255	250	225	206
	5+	1277	960	624	393	278	225	236	195	167	151	154	159
AS + SS	2+	1850	1400	946	628	519	461	426	448	480	466	477	481
	5+	1628	1214	773	489	413	338	328	273	249	232	327	310

Table 17. F matrix for 4T herring, 1969-79.

Spawning Group	Age-Group	Age-specific F										
		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
SS	2	.001	.000	.029	.002	.044	.019	.010	.009	.045	.112	.031
	3	.121	.128	.155	.023	.059	.088	.140	.042	.087	.273	.150
	4	.093	.464	.145	.094	.042	.106	.281	.176	.074	.130	.170
	5	.129	.086	.276	.198	.217	.032	.138	.183	.115	.065	.090
	6	.250	.244	.086	.181	.388	.185	.467	.165	.112	.105	.036
	7	.221	.489	.205	.050	.208	.347	.206	.013	.050	.055	.061
	8	.209	.558	.449	.159	.128	.306	.392	.153	.027	.134	.038
	9	.376	.416	.486	.262	.136	.134	.421	.434	.140	.014	.045
	10	.488	.600	.424	.314	.251	.070	.163	.316	.250	.111	.060
	11+	.605	.833	.110	.114	.181	.066	.151	.290	.495	.112	.081
F_3+		.280	.426	.248	.106	.167	.128	.204	.143	.100	.126	.094
F_5+		.350	.454	.371	.148	.201	.142	.234	.187	.150	.084	.079
AS	2	.004	.014	.038	.012	.001	.032	.001	.000	.001	.013	.015
	3	.086	.100	.306	.052	.010	.069	.019	.002	.009	.062	.058
	4	.052	.352	.333	.231	.062	.055	.074	.020	.062	.120	.150
	5	.049	.103	.372	.310	.185	.103	.114	.113	.047	.160	.160
	6	.117	.083	.305	.399	.209	.127	.164	.172	.116	.066	.177
	7	.309	.310	.461	.240	.331	.138	.147	.147	.200	.152	.045
	8	.198	.481	.387	.245	.161	.138	.096	.125	.104	.199	.200
	9	.211	.354	.560	.130	.137	.090	.160	.109	.120	.096	.098
	10	.196	.432	.480	.217	.112	.073	.083	.091	.098	.106	.050
	11+	.378	.549	.467	.228	.088	.060	.076	.096	.087	.091	.095
F_3+		.197	.285	.405	.222	.093	.075	.088	.088	.069	.103	.126
F_5+		.221	.314	.426	.238	.139	.086	.102	.124	.110	.122	.127
AS + SS F_{3+}		.216	.314	.357	.182	.115	.091	.132	.110	.086	.114	.111
F_5+		.248	.339	.418	.223	.161	.108	.135	.141	.125	.105	.101

Table 18. Catch matrix for 4T herring, 1969-79.

Spawning Group	Age-Group	Catch-at-age ($\times 10^{-6}$)										
		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
SS	1	-	-	-	-	-	-	-	-	2.0	1.7	8.0
	2	0.1	0.1	3.2	0.1	5.8	4.7	1.6	8.0	3.6	15.7	24.5
	3	17.2	8.4	66.0	2.1	2.5	8.8	26.8	5.5	63.4	15.4	15.2
	4	18.4	40.7	6.8	29.1	3.0	3.4	19.2	23.7	7.6	70.0	6.3
	5	12.9	12.7	13.6	6.4	46.9	1.8	3.2	8.1	10.9	5.1	35.6
	6	29.3	16.6	9.6	5.8	7.7	26.8	16.8	2.7	3.5	7.3	2.2
	7	25.1	32.6	9.1	4.3	4.5	3.9	20.1	0.3	0.6	1.3	3.2
	8	8.5	35.6	15.3	4.8	7.9	4.2	2.5	10.2	0.5	1.2	0.7
	9	48.6	10.2	15.0	5.1	2.9	6.2	3.3	1.5	6.6	.2	0.3
	10	155.4	39.3	5.6	5.3	3.1	1.1	5.3	1.4	0.5	3.8	0.7
	11+	17.8	121.4	67.8	7.4	7.3	2.7	6.2	14.4	13.2	2.1	3.8
Total		333.3	317.6	212.0	70.4	91.6	63.6	105.0	75.8	112.4	123.8	100.5
AS	1											0.1
	2	2.4	2.2	4.9	5.7	0.1	4.7	0.1	0.1	0.2	1.4	2.8
	3	21.9	42.2	33.1	5.2	3.8	5.0	2.2	0.3	2.7	18.0	5.1
	4	20.0	59.0	92.9	15.6	4.8	16.3	4.1	1.9	7.3	26.5	32.3
	5	19.5	30.2	35.6	51.4	8.3	6.0	25.5	4.7	3.5	13.8	25.3
	6	91.1	25.4	60.0	21.3	21.8	4.0	7.0	27.3	3.5	3.8	10.6
	7	119.7	160.4	88.8	29.4	10.0	9.9	3.3	4.3	21.6	3.3	2.0
	8	38.4	103.2	115.8	27.0	13.2	2.7	5.0	2.0	2.2	14.4	3.0
	9	50.5	42.9	58.6	24.5	10.2	5.3	2.2	4.2	1.4	1.5	5.0
	10	94.0	61.8	31.5	12.5	15.3	4.0	3.7	0.9	2.8	0.9	0.6
	11	338.0	326.5	227.8	76.4	22.3	19.7	21.4	22.3	14.6	14.4	10.3
Total		795.5	853.8	749.0	269.0	109.8	77.6	74.5	68.0	59.8	98.0	97.0

Table 19. Total mortality rates of 4T herring as calculated by the Paloheimo method.

	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79
$\bar{Z}_3+$	.25	.60	.28	.23	0.14	0.16	0.04	0.28	0.22	0.81
$\bar{Z}_3+$ (Cohort A)	.47	.54	.47	.35	.31	0.31	0.32	0.30	0.30	0.31

Table 20. 1980 catch prognoses for 4T herring under two options of fishing strategy.

Age-Group	1980 Catch = 55,000 mt				1980 Catch = $F_{0.1}$ Catch			
	1980			1981	1980			1981
	N_t	F_t	C_t	N_t	N_t	F_t	C_t	N_t
SS 2	(200)	.023	4.0	200	200	.045	8.0	(200)
3	695	.098	58.7	160	695	.195	111.9	157
4	85	.150	10.7	516	85	.300	20.0	468
5	30	.120	3.2	60	31	.240	5.9	51
6	340	.113	32.9	22	340	.225	62.3	20
7	54	.098	4.6	249	54	.195	8.7	222
8	46	.083	3.3	40	46	.165	6.4	36
9	16	.075	1.1	35	16	.150	2.1	32
10	6	.075	0.4	12	6	.150	0.8	11
11+	44	.075	2.9	39	45	.150	5.6	36
2+ Biomass ('000 t)	275		27.5	263	275		52.1	240.0
AS 2	(200)	.031	5.6	(200)	200	.045	8.0	(200)
3	165	.136	19.1	159	165	.195	26.6	157
4	77	.209	13.2	118	77	.300	18.2	111
5	180	.167	25.1	51	180	.240	34.9	47
6	132	.157	17.4	124	132	.225	24.1	116
7	49	.136	5.7	92	49	.195	8.0	86
8	39	.115	3.9	35	39	.165	5.5	33
9	12	.105	1.1	29	12	.150	1.5	27
10	44	.105	4.0	9	44	.150	5.6	9
11	109	.105	9.5	113	109	.150	13.5	105
2+ Biomass ('000 t)	206		27.5	188	206		38.2	179
AS + SS	481		55.0	451	481		90.3	419

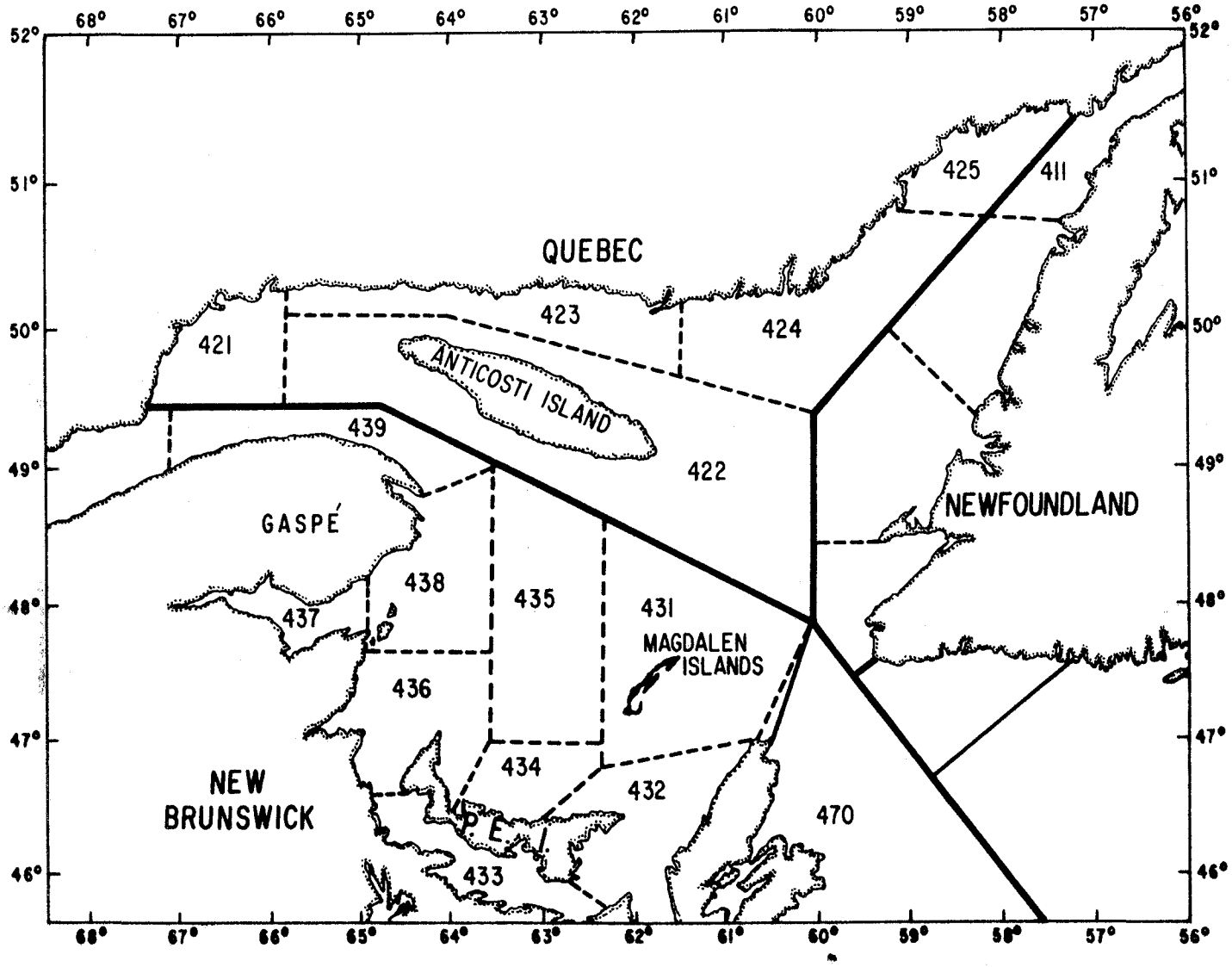


Fig. 1. Map showing statistical unit areas for the Southern Gulf of St. Lawrence.

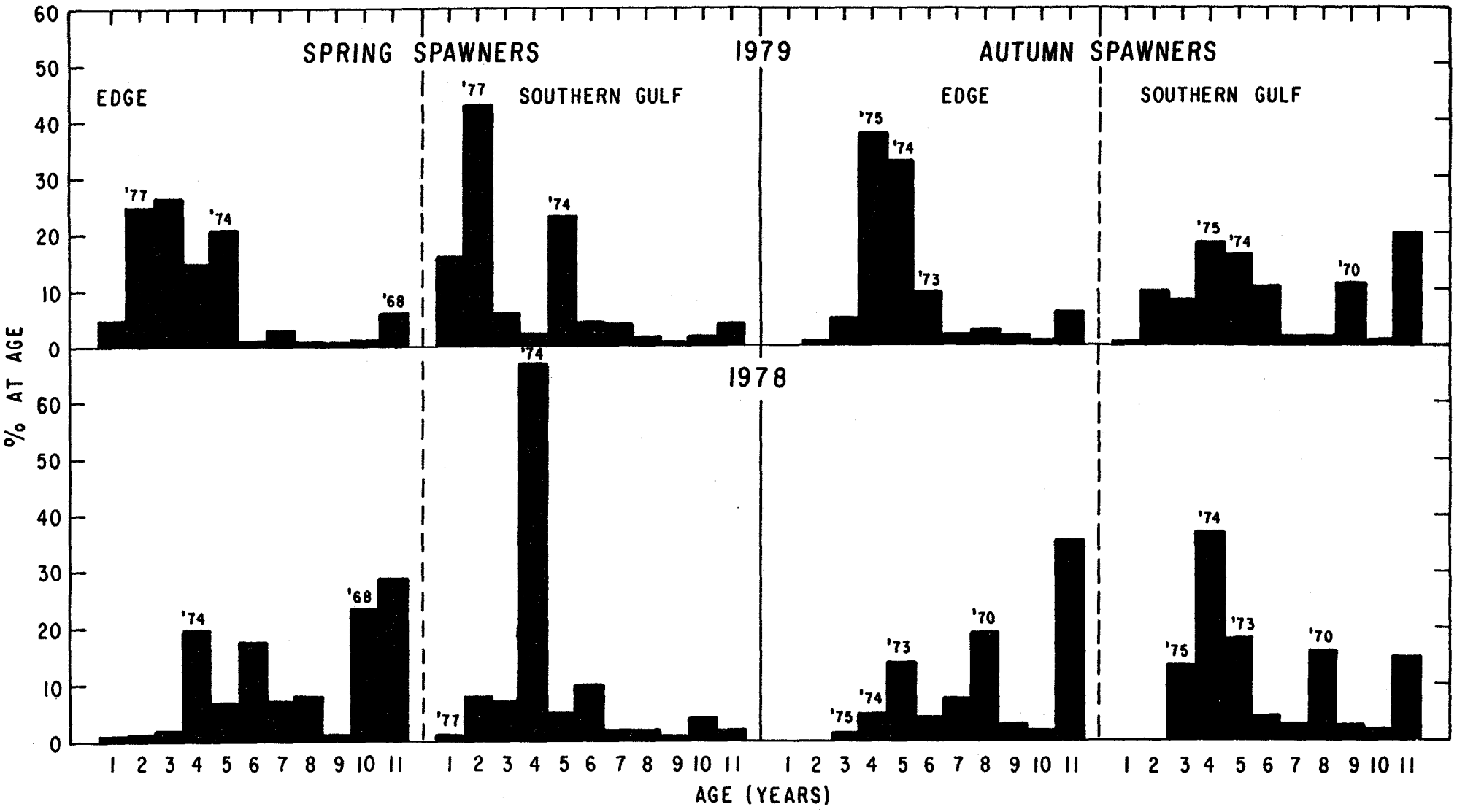


Fig. 2. Age composition data for the purse-seine fisheries operating along the "Edge" and in the southern Gulf of St. Lawrence during 1978 and 1979.

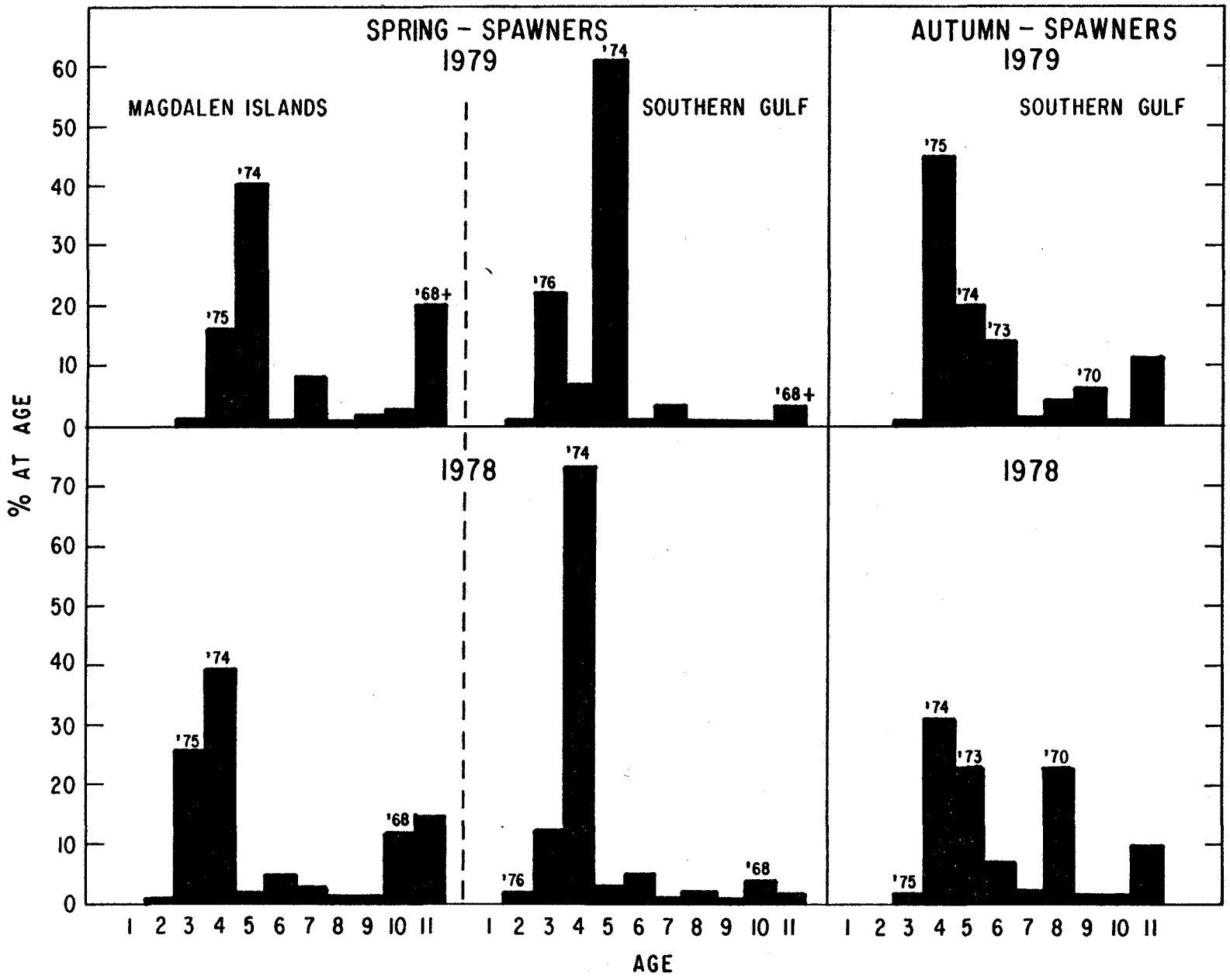


Fig. 3. Age composition data for the various inshore fisheries (all gears combined) in 4T in 1978 and 1979.

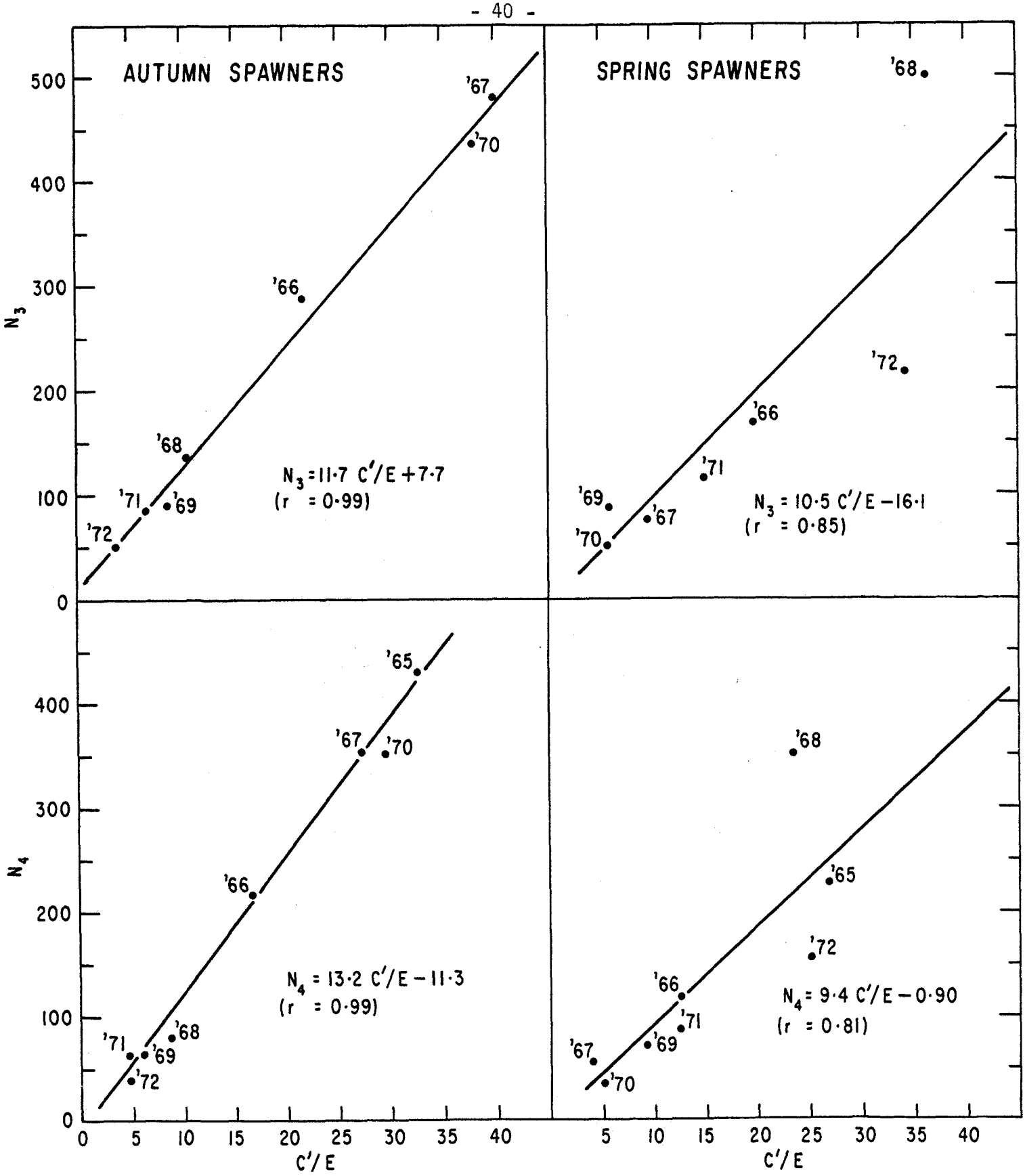


Fig. 4. Relationship between population size-at-age from cohort analysis and CPUE indices of abundance at age-groups 3 and 4. (see text for explanation)

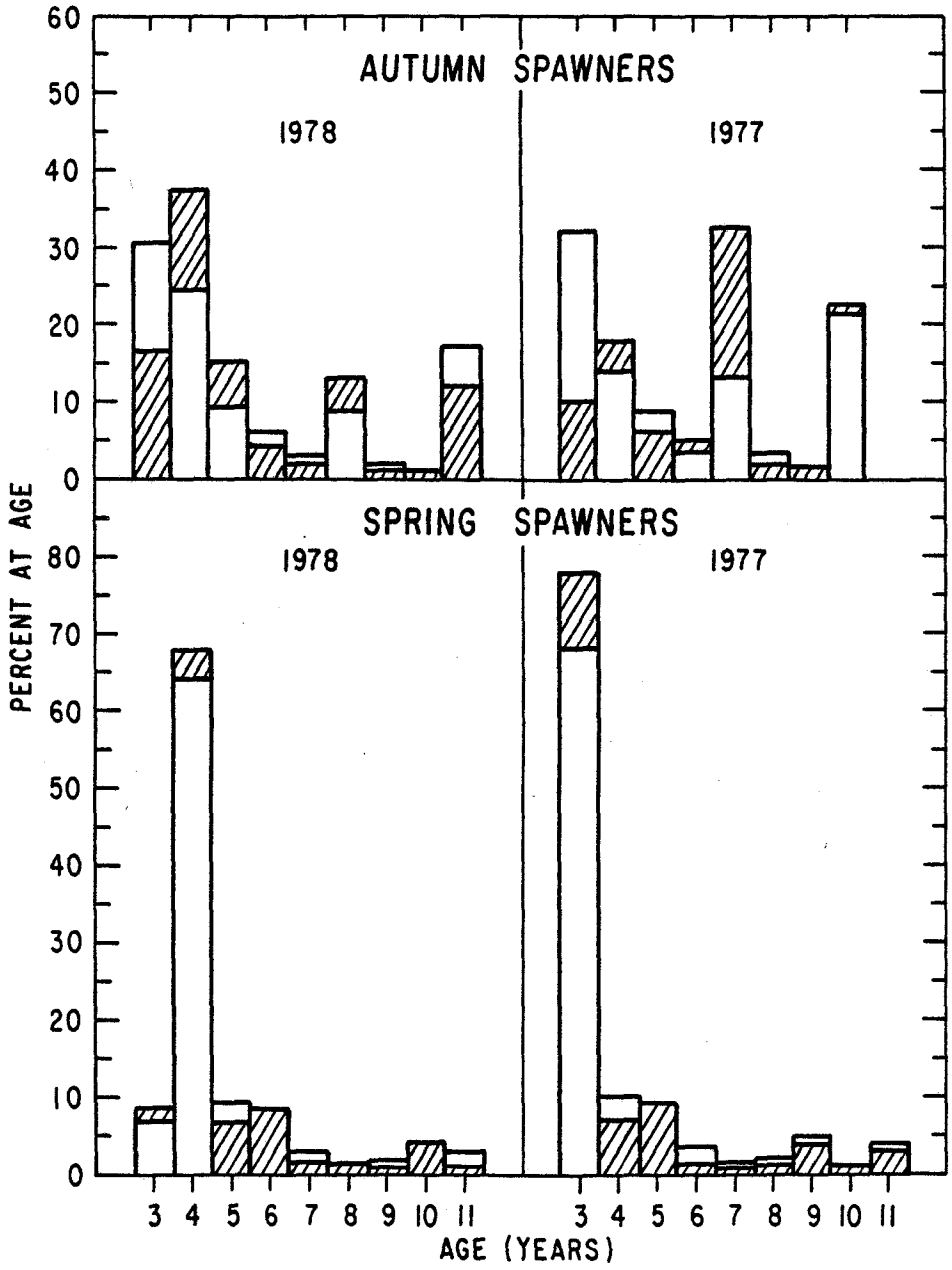


Fig. 5. Comparison of population structure from cohort analyses (unshaded) and relative age distribution in the fall purse-seine fisheries (shaded).

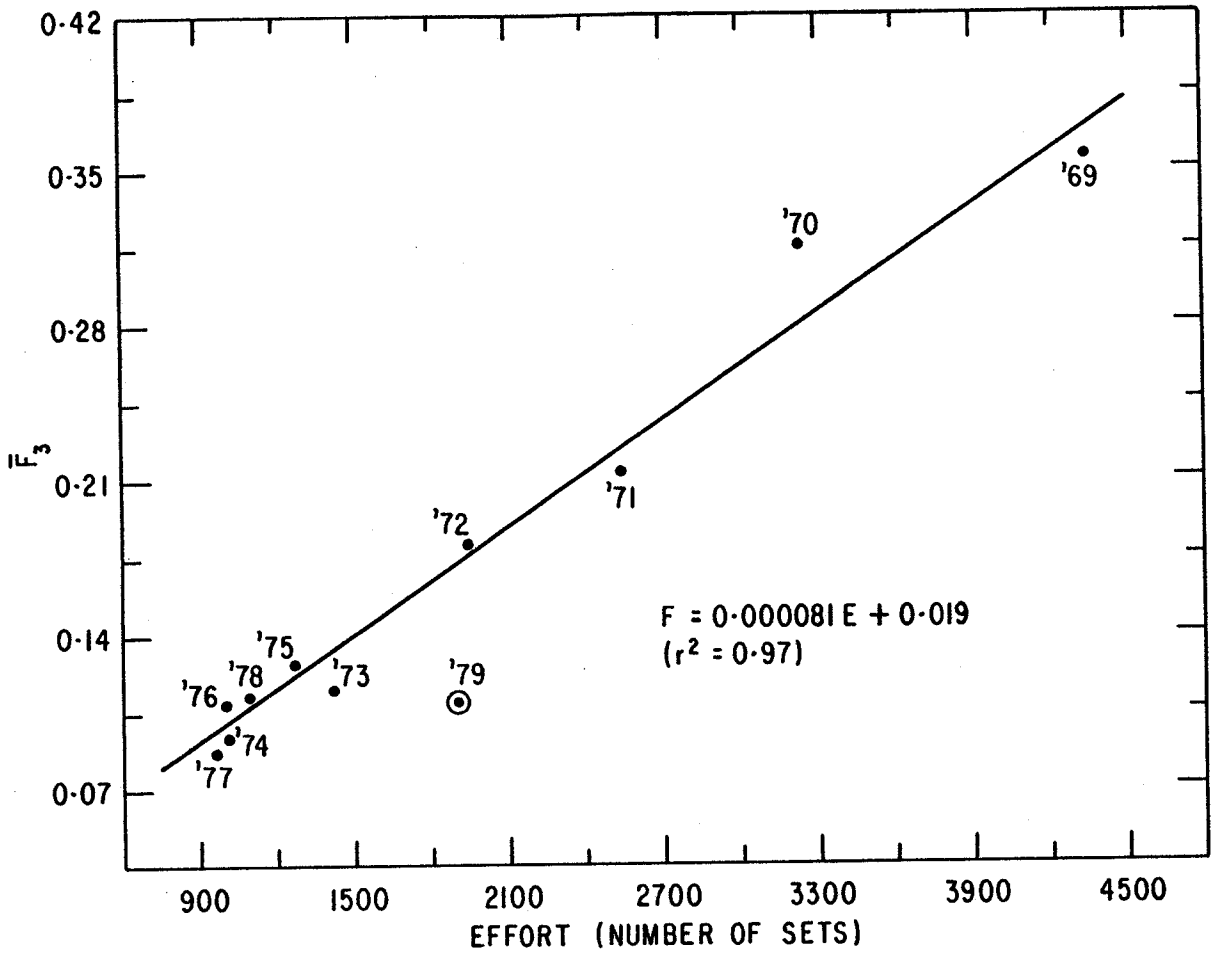


Fig. 6. Relationship between fishing effort and fishing mortality (3+) for southern Gulf herring, 1969-79.

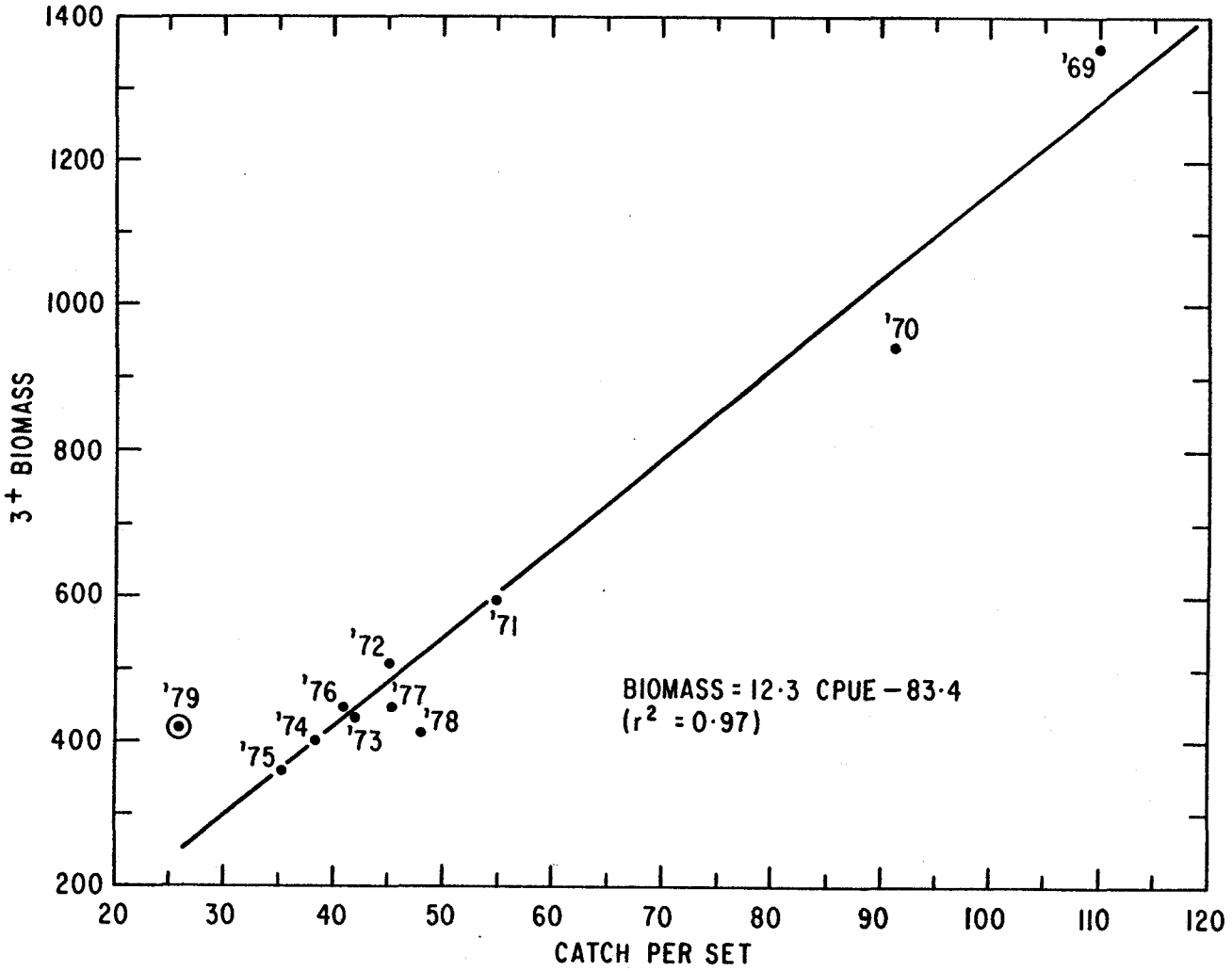


Fig. 7. Relationship between the 3+ biomass (year t+1) of herring in the southern Gulf (spring-spawners and fall-spawners combined) and purse-seiner catch rate (year t).

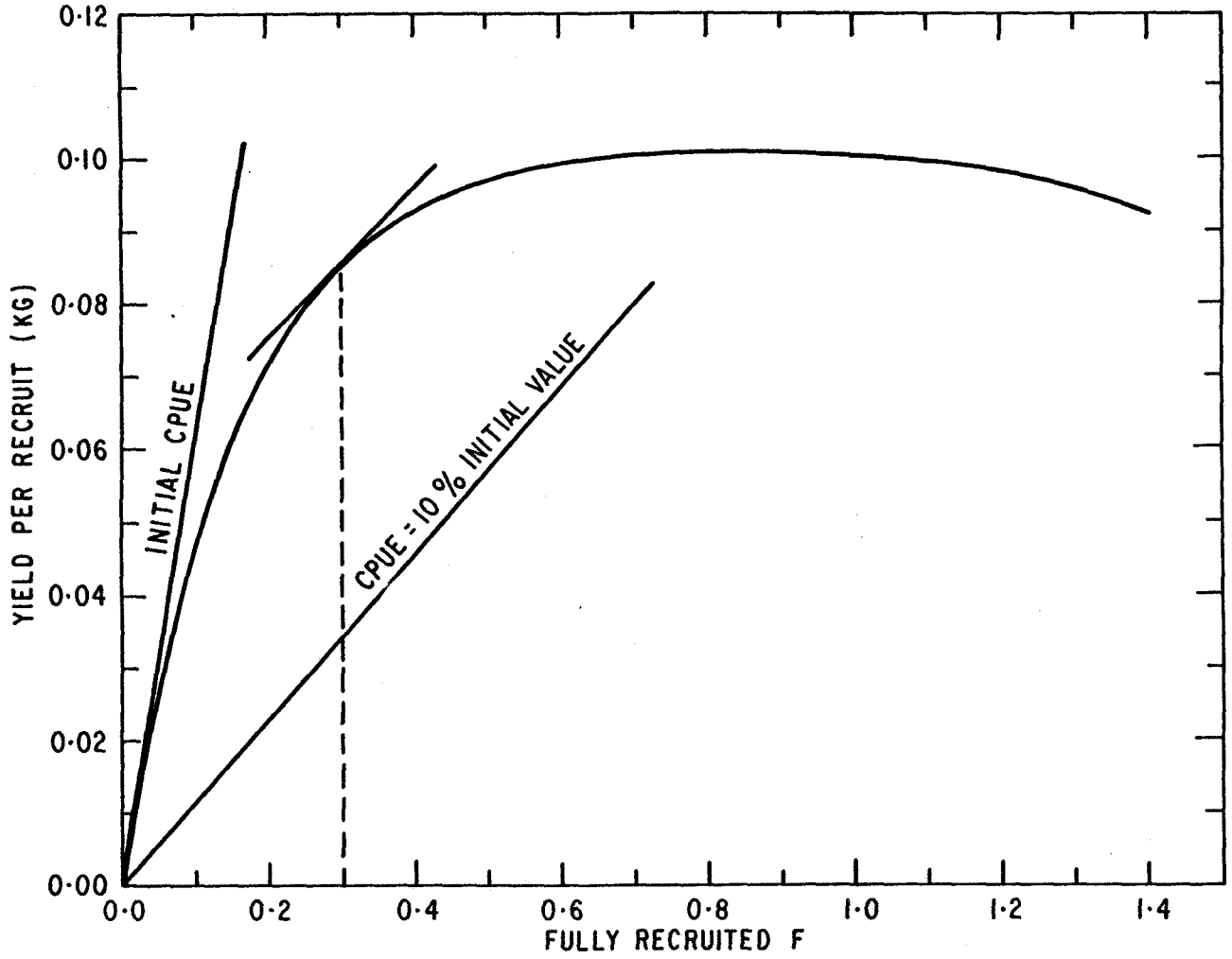


Fig. 8. Yield-per-recruit curve for the southern Gulf of St. Lawrence stock complex of herring.

ADDENDUM 1
CAFSAC Research Document 80/54

SOUTHERN GULF HERRING

by

G.H. Winters and J.A. Moores
Department of Fisheries and Oceans
P.O. Box 5667
St.John's, Newfoundland
A1C 5X1

Table 1. F_T (AS) = 0.35 F_T(SS) = 0.35 Recruitment + Biomass

			1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Recruitment (Age 2)	SS		88	500	73	33	87	153	50	451	60	145	399
	AS		507	141	88	350	79	48	128	219	354	103	178
Biomass	SS	2+	400	299	203	140	123	102	89	88	91	80	87
		3+	395	268	199	138	118	93	85	60	88	71	63
		5+	337	237	133	81	106	80	60	41	33	21	44
	AS	2+	1257	910	568	309	220	179	150	131	131	132	121
		3+	1231	903	564	291	216	176	144	121	113	127	112
		5+	1128	812	492	271	170	125	130	102	74	62	59
	AS+SS	2+	1657	1209	771	449	343	281	239	219	222	212	208
		3+	1626	1171	763	429	334	269	229	181	201	198	175
		5+	1465	1049	625	352	276	205	190	143	107	83	103

Table 2. $F_T = 0.35$

	Age/Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
SS	2	-	-	.05	-	.08	.04	.04	.02	.07	.13	.07
	3	.13	.14	.20	.04	.11	.16	.28	.17	.21	.47	.18
	4	.11	.49	.16	.12	.08	.21	.61	.43	.37	.39	.35
	5	.15	.10	.30	.22	.30	.06	.31	.57	.36	.45	
	6	.26	.28	.10	.20	.45	.28	1.25	.48	.52	.44	
	7	.23	.53	.25	.06	.24	.43	.36	.06	.18	.37	
	8	.24	.60	.51	.20	.15	.36	.54	.31	.13	.68	
	9	.39	.52	.56	.31	.18	.17	.54	.74	.33	.07	
	10	.50	.65	.60	.39	.32	.09	.22	.46	.59	.33	
	11+	.63	.84	.94	.20	.22	.09	.21	.46	.88	.30	
	F_3^+	.30	.47	.30	.14	.24	.20	.38	.37	.27	.40	.29
	F_5^+	.37	.50	.43	.18	.27	.21	.40	.41	.45	.38	.35
AS	2	-	.02	.06	.02	-	.12	-	-	-	.02	.02
	3	.10	.12	.39	.09	.02	.09	.07	-	.02	.07	.07
	4	.06	.40	.42	.32	.11	.08	.10	.08	.10	.23	.18
	5	.06	.13	.44	.43	.28	.20	.18	.16	.21	.28	.35
	6	.14	.10	.41	.52	.33	.21	.37	.30	.17	.38	
	7	.34	.39	.61	.36	.50	.24	.27	.41	.41	.24	
	8	.22	.55	.55	.37	.27	.24	.19	.26	.38	.53	
	9	.23	.42	.72	.21	.23	.17	.32	.24	.29	.48	
	10	.27	.50	.63	.32	.20	.13	.17	.21	.25	.31	
	11+	.40	.51	.64	.39	.16	.13	.16	.21	.21	.25	
	F_{3+}	.23	.35	.54	.34	.15	.13	.17	.18	.14	.18	.22
	F_5^+	.26	.38	.58	.36	.24	.16	.19	.25	.27	.32	.35
AS+SS	F_3^+	.25	.39	.48	.28	.18	.15	.25	.24	.20	.27	.24
	F_5^+	.29	.41	.55	.32	.25	.18	.26	.30	.33	.34	.35

Table 3. F_T (AS) = 0.16 F_T (SS) = 0.09 RECRUITMENT & BIOMASS

			1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Recruitment	SS		95	632	104	44	109	232	95	1040	145	483	1515
(Age 2)	AS		549	155	99	425	116	68	216	390	715	220	388
Biomass	SS	2+	423	328	239	177	161	143	132	168	204	218	312
		3+	417	288	232	174	154	128	126	104	195	188	218
		5+	352	256	151	97	137	112	89	70	68	58	151
	AS	2+	1334	983	634	370	279	236	207	196	218	243	248
		3+	1306	975	629	349	274	233	196	176	182	232	229
		5+	1194	877	550	325	218	168	176	145	113	107	118
	SS+AS	2+	1757	1311	873	547	440	379	339	364	422	461	560
		3+	1723	1263	861	523	428	361	322	280	377	413	447
		5+	1546	1133	701	422	355	280	265	215	181	165	269

Table 4. F_T (SS) = .09 F_T(AS) = .16

	Age/Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AS	2	-	.02	.06	.02	-	.08	-	-	-	.01	.01
	3	.09	.11	.35	.08	.01	.06	.05	-	.01	.04	.03
	4	.06	.38	.38	.27	.10	.07	.06	.05	.06	.12	.08
	5	.05	.12	.41	.37	.23	.17	.14	.10	.13	.15	.16
	6	.13	.09	.36	.46	.26	.16	.30	.22	.10	.21	
	7	.33	.35	.53	.30	.41	.18	.20	.30	.28	.13	
	8	.21	.52	.46	.30	.21	.18	.13	.18	.25	.30	
	9	.22	.39	.64	.17	.18	.12	.22	.16	.18	.27	
	10	.23	.47	.55	.27	.15	.10	.12	.13	.15	.17	
	11+	.39	.46	.54	.30	.12	.09	.11	.14	.12	.13	
	F_3+	.21	.32	.47	.28	.12	.10	.12	.12	.08	.09	.10
	F_5+	.24	.35	.50	.30	.18	.12	.14	.17	.17	.17	.16
SS	2	-	-	.04	-	.06	.02	.02	.01	.03	.04	.02
	3	.12	.13	.15	.03	.08	.12	.17	.08	.08	.16	.05
	4	.09	.46	.14	.09	.05	.15	.43	.23	.16	.13	.09
	5	.13	.09	.27	.20	.21	.04	.20	.33	.16	.15	
	6	.25	.24	.09	.18	.38	.18	.62	.27	.23	.15	
	7	.22	.49	.20	.05	.21	.34	.20	.02	.09	.12	
	8	.21	.56	.45	.16	.12	.30	.38	.15	.04	.25	
	9	.38	.41	.48	.26	.13	.13	.41	.42	.13	.02	
	10	.49	.60	.42	.31	.25	.07	.16	.31	.24	.11	
	11+	.60	.80	.83	.15	.16	.07	.15	.29	.41	.10	
	F_3+	.28	.42	.25	.11	.17	.14	.24	.20	.11	.13	.07
	F_5+	.35	.45	.37	.15	.20	.14	.25	.22	.19	.13	.09
AS+SS	F_3+	.23	.34	.41	.22	.18	.11	.17	.14	.10	.11	.09
	F_5+	.26	.37	.47	.26	.21	.13	.17	.18	.18	.15	.12

Fig 1.

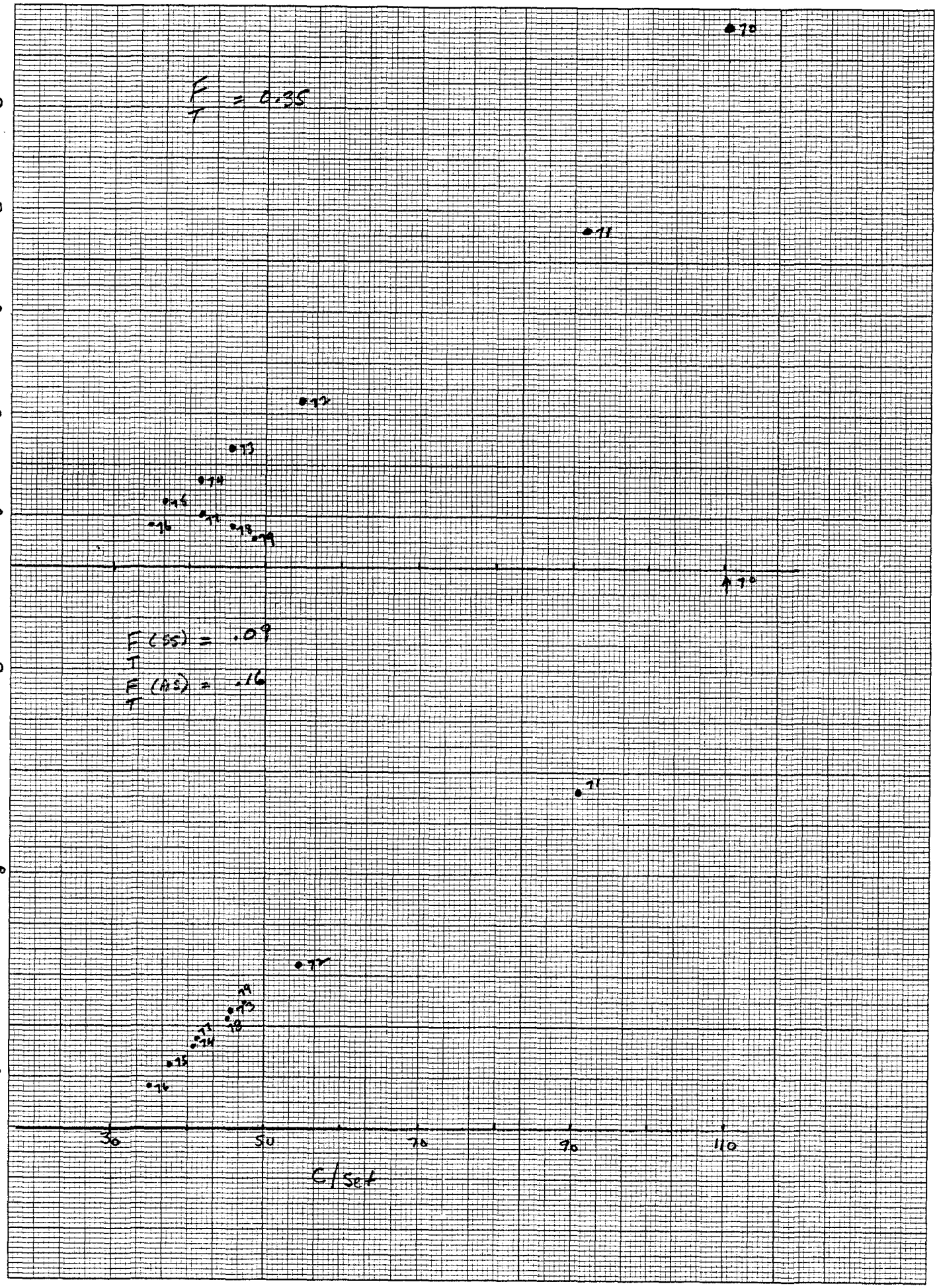
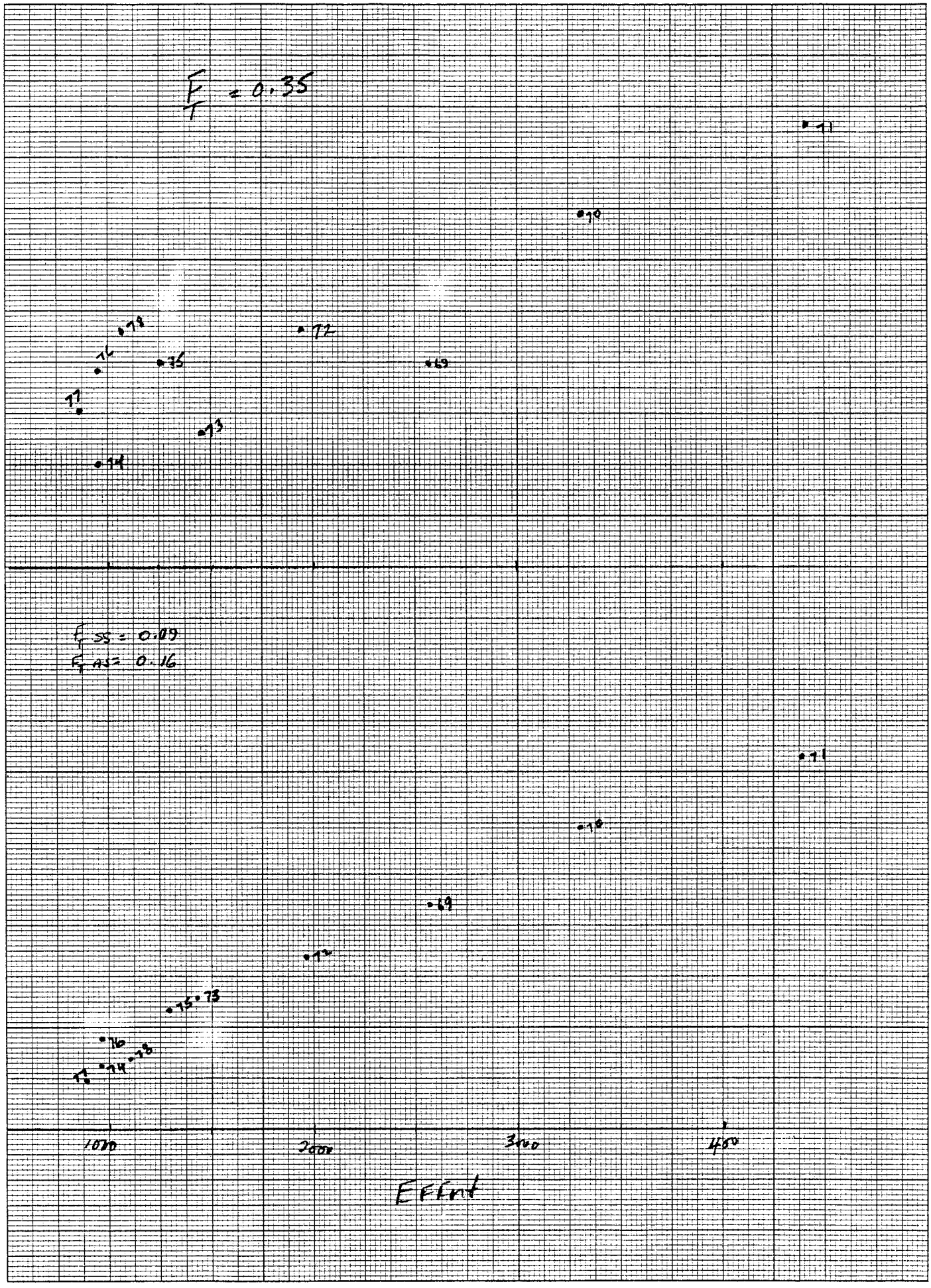


FIG. 2.


$F_T = 0.35$
.50
.40
.30
.20
.10
F_{3t}
F_T SS = 0.09
F_T AS = 0.16
.50
.40
.30
.20
.10
F_{3t}
1000
2000
3000
4000
Effrt
DIETZGEN CORPORATION
MADE IN U.S.A.
NO. 341-M DIETZGEN GRAPH PAPER
MILLIMETER