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Recent changes in length and age composition and
length-at-age in herring from purse seine and
gillnet fisheries in the Southern Gulf of St. Lawrence

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Abstract

Following the decrease in 4T herring landings and because of evidence of a decline in population abundance, length frequencies, age composition and length at age of herring caught in purse seine and gillnet fisheries were examined to detect any changes in trends.

Modal length of herring caught in the spring purse seine fishery has dropped from 33 cm between 1973-1977 to 25 cm in 1980. As well the proportion of fish smaller than 27 cm (approximately market size) went from 7% of the catch in 1973 to 52% in 1980. In the fall purse seine fishery however, neither the modal length nor the proportion of small fish show any particular trend with time, but were dependent upon the relative strengths of year-classes. Herring from gillnet catches had a greater modal length than those from seiner catches, and the proportion of fish smaller than 27 cm was almost 0.

Between 1969 and 1980, for both the spring and fall purse seine fishery, there was an increase in the proportion of young fish (≤ 4 years old) caught, and a 50% decrease in mean age of the catch.

Small spring spawners (<27 cm) between the age of 2 and 7 years old were found in the 1975 fall purse seine fishery; but gradually, the proportion of small old fish in the catch as well as their age span decreased, until in 1978 the oldest fish smaller than 27 cm were 3 years old. However, since 1978-1979, the proportion of small spring spawner herring caught at any given age, increased again (during both the spring and fall seiner fishery).

No real trend is observed in the proportion of fall spawners below market-size caught before 1978-1979. At this time, older fish of small size can be noticed in the catch, and the proportion of small fish at any given age started to increase.

The length at age of fish caught in the spring fishery in 1978 was greater than in 1979, but fish caught during the fall fishery show an increasing trend in length at age with time.

The changes observed in the biological parameters are attributed to the fact that seiners seem to have recently directed their fishing effort toward smaller and younger fish. Since there is an economical disadvantage to fishing small fish, it seems possible that the fact few older fish are present in the herring population should be faced.

Résumé

Etant donné la baisse des débarquements de hareng de la zone NAFO 4T, et devant l'évidence du déclin de la population, une étude portant sur les fréquences de longueur, la composition à l'âge et la longueur à l'âge des harengs capturés à la seine bourse et au filet maillant a été entreprise, en vue de détecter tout changement apparu dans ces paramètres biologiques.

La longueur modale des harengs capturés au printemps par les seigneurs a passé de 33 cm en 1973-1977 à 25 cm en 1980. Parallèlement, la proportion dans la

capture de poissons de taille inférieure à 27 cm (approximativement la plus petite taille acceptée par les usines) a augmenté de 7% en 1973 à 52% en 1980. La longueur modale des harengs capturés par les seineurs à l'automne, de même que la quantité relative de petits individus dans la capture, ne suivaient aucune tendance, mais variaient selon la force relative des classes d'âge. Les harengs capturés par les filets maillants sont de longueur modale supérieure à ceux capturés par les seineurs, et la proportion d'individus de taille inférieure à 27 cm était quasiment nulle.

De 1969 à 1980, on a noté une augmentation considérable de la proportion des jeunes poissons (<4 ans) capturés par les seineurs, ainsi qu'une diminution de 50% dans l'âge moyen des poissons capturés.

A l'automne 1975, on a retrouvé dans la capture des seineurs des poissons frayant au printemps dont la taille était inférieure à 27 cm et l'âge variait de 2 à 7 ans. Mais graduellement, la quantité relative pour un âge donné, ainsi que l'âge de ces petits poissons ont diminué, et en 1978, les petits individus les plus âgés avaient 3 ans. Cependant depuis 1978-1979, il y a eu une recrudescence des petits harengs frayant au printemps dans la capture de seineurs, tant au printemps qu'à l'automne.

Avant 1978-1979, les petits poissons frayant à l'automne n'ont montré aucune tendance particulière dans leur distribution d'âge. Depuis, on a noté dans la capture une augmentation de l'âge de ces petits poissons, ainsi qu'une proportion croissante, pour un âge donné, de petits individus.

Les harengs capturés au printemps de 1978 étaient de longueur à l'âge inférieure à ceux capturés en 1979. Mais il y avait une nette tendance à l'augmentation des longueurs à l'âge chez les poissons capturés à l'automne, et ce depuis 1975.

Les changements survenus dans les paramètres biologiques analysés sont attribués au fait que les seineurs ont récemment semblé diriger leur pêche sur des harengs plus petits et plus jeunes. Comme il est économiquement désavantageux de pêcher des petits harengs, la possibilité existe que la population de hareng disponible à la pêche ne serait composée que de petits individus, les plus gros ayant pour la plupart été pêchés.

Introduction

Total landings from the 4T herring stock declined from 53,000 t in 1978 to 47,800 t in 1979 and 40,500 t in 1980 (Cleary, 1981). In 1979, the purse seiner "Edge" fishery was voluntarily closed due to the presence of large quantities of small herring (Winters and Moores, 1980), and in 1980, high incidences of small (below market-size) fish were again noticed (Winters unpublished). Recently, it was shown (Cleary and Worgan, 1981) that the proportion of small and young fish has increased in the catch of the Magdalen Islands spring trap fishery. As well, a trend toward increased length at age of herring was noted. Such changes in the herring fishery could result from many causes, one of which is overexploitation of the stock.

It was of interest to examine whether fish caught by purse seiners, gears whose searching power enables them to select the size of fish caught, would show the same biological trends as the herring caught in the Magdalen Islands traps. Additionally, we wanted to examine the proportion of fish smaller than market-size (267 mm) that were caught.

Length frequencies and age composition samples of herring caught by purse seiners during the spring and fall fishery were examined. Length at age was also calculated to detect any variation which could reflect a population change. Length frequencies for gillnet herring samples were also plotted to establish the proportion of small fish, below market-size, caught by that gear.

Materials and methods

NAFO statistical areas having the maximum catches from purse seiners in the spring (431) and fall (438) fishery were selected as study areas (Figure 1). For similar reasons, area 436 was chosen as study area for the gillnet catches.

Biological data were obtained from the St. Andrews Biological Station. All the length frequencies available were plotted, and age composition and mean length at age were calculated from ten samples per year, chosen at random. It should be noted that before 1979, all the herring sampled used in the present analysis were aged by the St. John's Nfld. laboratory. From 1979 onward, the St. Andrews laboratory's ages were used.

Results

Length frequencies of herring from purse seine catches

In the spring purse seine fishery in NAFO area 431, the modal length of the herring in the catch has dropped from 33 cm between 1973 and 1977, to 25 cm in 1980. As well, the proportion of fish smaller than 27 cm (approximately market-size) went from 7% in 1973 to a maximum value of 52% in 1980 (Figure 2).

In the fall purse seine fishery (NAFO area 438), the modal length and the proportion of small fish caught have fluctuated with time, following the strength of the year-classes (Figure 3). Relatively more small fish were caught each year in November-December than in September-October, except in 1980; during 1980, 22% of the herring caught in September-October were smaller than 27 cm, which is the highest proportion ever found in those months, for the period 1973-1980 (Figures 4 and 5).

Length frequencies of gillnet caught herring

As expected, considering the selectivity of the gear, modal lengths of fish from gillnets are higher than those from purse seiners, varying between 29 and 33 cm (Figures 6 and 7). The proportion of fish smaller than 27 cm is almost zero in gillnet catches.

Age composition in purse seiner catches

The age composition of purse seiner catches shows a recent increase in the proportion of fish younger than 4 years old, both for the spring (area 431) and fall (area 438) fisheries (Tables 1a, 1b). At the same time, mean age in the catch has dropped from 8 years to 4 years during the spring fishery (1978 to 1980), and from 6 years to 3 years during the fall fishery (1975 to 1980).

In the spring fishery, the proportion of fish younger than 4 years old has more than doubled for both spring and fall spawners, since 1978 (Table 2). In the fall fishery, the proportion of young fall spawners has gone from 15% in 1975 to 87% in 1980 (Table 3). The strong 1974 year-class of spring spawners maintained the proportion of young fish high from 1976 to 1978 in that component; later on (1979 and 1980), the percentage of fish younger than 4 years old went from 46% to 58%, thus showing the same trend as in the spring fishery.

Ages of small fish

The age distribution of herring smaller than market size in the purse seiner catch can be found in Table 4. In the fall fishery of 1975, age of small spring spawners varied from 2 and 7 years. Subsequently, there was a decline in the proportion of older ages among small fish, until 1978, when the maximum age of fish <27 cm was 3 years. In fact, during the 1975-1978 period, the proportion of small fish has slowly decreased in the catch, for any given age. Possible explanations are an increase with time in growth rate, or the gradual disappearance of pygmy herring (herring from the St. Lawrence estuary which are characterized by low length at age (Côté and Powles, 1978)), from the seiner catch. Later, in 1979-1980, this proportion of small fish at any given age increased, going from 12% to 76% for fish of age 2, and from 0% to 22% for 3 year olds. The small spring spawners caught in the spring fishery also show similar trends between 1978-1980: fish of length <27 cm made up 25% of the catch of 3 year

olds in 1978 but increased to 100% in 1980, while small 4 years old went from 53% of the 1979 catch to 71% in 1980. A change in growth rate could cause the phenomenon, but the fact that the fish were aged by two different laboratories, prior to and after 1978, could explain the "irregularities" noted here. Another possibility would be that the bigger herring were fished out, leaving the smaller ones. This could be possible, however, only if herring school by size and seiners can concentrate on large fish in preference to small ones.

No real trend is observed in the proportion of fall spawners below market-size caught before 1978-1979. At this time the appearance in the catch of older fish of small size can be noticed, and the proportion of small fish at any given age started to increase, during both the spring and fall fishery (Table 4).

Length at age in purse seiner catch

Length at age for herring caught by purse seiners was calculated in order to detect any change in growth. Data for the spring fishery were available only for 1978 and 1979. From our calculations (Table 5), it seems that up to age 8, the lengths are smaller at age in 1979 than in 1978, with a negative growth rate for the spring spawners. However, the number of observations is very limited for the spring spawners in 1978, and these data should be taken with caution. These results are in accordance with the recent increase in proportion of old fish smaller than market size.

Spring spawner herring of age 2 to 5 caught during the fall purse seine fishery have shown an increase in length at age with time (Table 6), mainly between 1975-1977, which coincide with the gradual disappearance of smaller fish of a given age (see details given earlier). Fall spawners, up to age 10, have also shown an increase in length at age, which could result from growth changes. A further study of density dependent growth would be worthwhile to clarify the situation.

Conclusion

Herring caught by Purse Seiners have shown new trends in their biological parameters over the last three years. First of all, the modal length has dropped by 8 cm in the spring fishery catch, and the proportion of fish below market-size has increased by 52% in the catch. The appearance of a strong year-class in the fishery could explain these facts, but the age composition of both the spring and fall fishery catch suggests that only the 1977 year-class seems stronger than any other year-class since the 1974 year-class. However, the 1977 year-class did not appear in the spring catch before 1980, and there was a gradual decline in the mean age of the catch from 8 years old in 1978 to 5 years old in 1979 and 4 years old in 1980. Overexploitation of the stock could have resulted in a situation where there is a gradual predominance of young fish in the catch because all the older fish are being fished out. Another possible explanation would be that since they started shifting the spring fishery area (L. Valdron & M. Sinclair, pers. comm.) the seiners are exploiting a herring stock different from the one fished historically.

In the fall fishery, the decrease in mean age of the catch has been gradual since 1975, suggesting a change in exploitation pattern by the fishing fleet rather than the appearance of one or more strong year-class. This hypothesis is supported by the fact that during the last three years more and more small fish (below market-size) of a given age are caught.

We thus think that the fishing pattern of the seiner fleet has recently changed, and is now directed towards smaller, as well as younger fish. Since it is economically disadvantageous to fish small herring, it could be concluded that only small fish are available to the fishery. Concern about the scarcity of bigger older fish, as well as the total abundance of the herring stock is justified.

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Table 1a. Age composition (%) of Purse Seiners catch in NAFO area 431 (Spring fishery)

Spring & Fall spawners combined				
Age	1978	1979	1980	
1	0	1	0	
2	1	2	2	
3	4	11	31	
4	8	33	38	
5	13	30	14	
6	9	13	10	
7	15	4	4	
8	11	2	1	
9	4	2	1	
10	8	1	0	
11+	27	1	0	
<4	5	14	33	
n*	776	976	195	
mean age	7.7	4.8	4.2	

* number of observations

Table 1b. Age composition (%) of Purse Seiners catch in NAFO area 438 (Fall fishery, September - December).

Spring and Fall spawners combined						
Age	1975	1976	1977	1978	1979	1980
1	0	0	1	0	4	6
2	2	24	3	3	18	24
3	19	7	43	12	14	47
4	14	14	12	49	15	7
5	24	7	6	11	27	3
6	17	22	2	6	7	6
7	13	4	18	2	4	4
8	3	5	1	8	2	1
9	2	3	2	1	2	2
10	2	1	2	1	2	*
11+	7	13	10	7	5	*
<4	18	31	47	15	36	77
n**	621	960	1093	1000	1183	441
mean age	5.6	5.4	5.1	5	4.6	3.3

* < 1%

** number of observations

Table 2. Age composition (%) of Purse Seiners catch in NAFO area 431 (spring fishery).

<u>Spring spawners</u>			
<u>Age</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
1	0	1	0
2	2	2	0
3	7	17	20
4	10	27	42
5	14	30	18
6	12	13	10
7	18	5	10
8	4	2	0
9	2	1	0
10	10	1	0
11+	<u>21</u>	<u>1</u>	<u>0</u>
<4	9	17	20
n**	57	314	40
mean age	7.1	4.7	4.5

<u>Fall spawners</u>			
<u>Age</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
1	0	0	0
2	*	*	3
3	1	6	34
4	6	39	37
5	12	30	13
6	6	14	10
7	12	3	2
8	19	1	1
9	5	3	1
10	7	1	0
11+	<u>32</u>	<u>2</u>	<u>0</u>
<4	1	6	36
n**	719	662	155
mean age	8.3	5.0	4.1

* < 1%

** number of observations

Table 3. Age composition (%) of Purse Seiners catch in NAFO area 438 (Fall fishery, September - December).

<u>Spring Spawners</u>						
<u>Age</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
1	0	0	1	0	7	10
2	3	48	6	6	28	27
3	20	13	76	10	11	21
4	25	23	6	64	4	4
5	3	4	7	6	32	3
6	27	2	1	8	4	13
7	18	*	*	1	6	12
8	1	7	*	1	2	3
9	1	1	2	*	*	5
10	*	1	0	3	2	1
11+	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>4</u>	<u>1</u>
<4	23	61	83	16	46	58
n**	528	550	785	618	682	151
A	5.1	3.5	3.3	4.3	4.2	4.1
<u>Fall Spawners</u>						
<u>Age</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
1	0	0	0	0	0	4
2	2	*	0	*	7	22
3	13	*	10	14	18	61
4	4	4	18	33	26	9
5	45	9	5	16	22	2
6	7	43	4	5	11	2
7	7	8	37	2	2	0
8	5	4	1	16	2	0
9	2	5	1	1	4	0
10	3	1	4	*	2	0
11+	<u>12</u>	<u>25</u>	<u>20</u>	<u>13</u>	<u>6</u>	<u>—</u>
<4	15	0	10	14	25	87
n**	93	410	308	382	501	290
A	6.0	7.3	6.9	5.8	5.0	2.9

*< 1%

** number of observations

Table 4. Percentage at age of fish smaller than 267 mm in Purse Seiners catches

Age	1	2	3	4	5	6	7
<u>Spring spawners</u>							
Area 438 - Fall fishery							
1975	0	100	80	88	50	17	6
1976	100	69	20	3	23	6	
1977	100	22	1	4			
1978	0	8	2				
1979	100	12	0				
1980*	100	76	22				
Area 431 - Spring fishery							
1978	0	100	25				
1979	100	100	92	53	8		
1980*	0	0	100	71			
<u>Fall spawners</u> - Fall fishery							
Area 438							
1975	0	100	100				
1976	0	100					
1977	0	0	3				
1978	0	0	4				
1979	0	100	4				
1980*	100	98	31	24			
Area 431 - Spring fishery							
1978	0	100	60				
1979	0	100	100	10			
1980*	0	100	98	75	10		

* smaller than 27 cm

Table 5. Mean total length (mm) of herring caught by Purse Seiners in NAFO area 431 (Spring fishery).

Age	1978	1979	1978	1979
	<u>Spring Spawners</u>		<u>Fall Spawners</u>	
1	-	-	-	-
2	242 (1)	178 (10)	-	162.5 (2)
3	272 (4)	229 (59)	250 (6)	222 (39)
4	296 (6)	266 (93)	288 (40)	276 (250)
5	318 (8)	292 (101)	314 (101)	299 (195)
6	332 (7)	308 (45)	322 (43)	309 (86)
7	344 (11)	322 (17)	335 (90)	324 (18)
8	343 (2)	350 (8)	343 (135)	337 (9)
9	353 (1)	362 (5)	346 (33)	356 (20)
10	349 (7)	356 (3)	347 (51)	358 (5)
11	361 (14)	371 (5)	362 (225)	367 (12)

* () number of observations

Table 6. Mean total length (mm) at age of herring caught by Purse Seiners in NAFO area 438 (Fall fishery).

Age	1975	1976	1977	1978	1979	1980
<u>Spring Spawners</u>						
1	-	207 (1)	214 (5)		231 (47)	
2	221 (12)*	263 (263)	274 (44)	275 (38)	277 (194)	
3	245 (110)	278 (76)	293 (525)	295 (62)	292 (71)	
4	252 (130)	297 (128)	300 (44)	306 (393)	302 (27)	
5	269 (16)	295 (22)	313 (52)	299 (36)	217 (170)	
6	277 (144)	300 (9)	326 (3)	308 (48)	300 (18)	
7	287 (97)	324 (1)	320 (2)	321 (8)	321 (28)	
8	292 (5)	334 (39)	332 (1)	332 (7)	324 (8)	
9	321 (5)	339 (4)	338 (17)	327 (1)	307 (2)	
10	309 (2)	349 (1)	344 (1)	340 (19)	329 (8)	
11	340 (10)	350 (10)	349 (12)	363 (3)	344 (21)	
<u>Fall Spawners</u>						
1	-	-	-	-	-	
2	197 (1)	216 (1)	-	307 (1)	249 (35)	
3	237 (8)	288 (3)	278 (31)	285 (52)	282 (90)	
4	302 (3)	301 (18)	307 (54)	305 (127)	310 (130)	
5	307 (44)	311 (38)	318 (14)	321 (58)	323 (112)	
6	323 (6)	323 (186)	326 (18)	323 (19)	330 (54)	
7	328 (6)	329 (30)	335 (99)	339 (9)	340 (12)	
8	327 (5)	332 (15)	347 (1)	344 (61)	349 (7)	
9	338 (2)	345 (23)	338 (2)	330 (4)	350 (25)	
10	355 (2)	351 (4)	334 (10)	347 (1)	349 (7)	
11	358 (13)	359 (102)	364 (57)	364 (49)	364 (27)	

* () number of observations

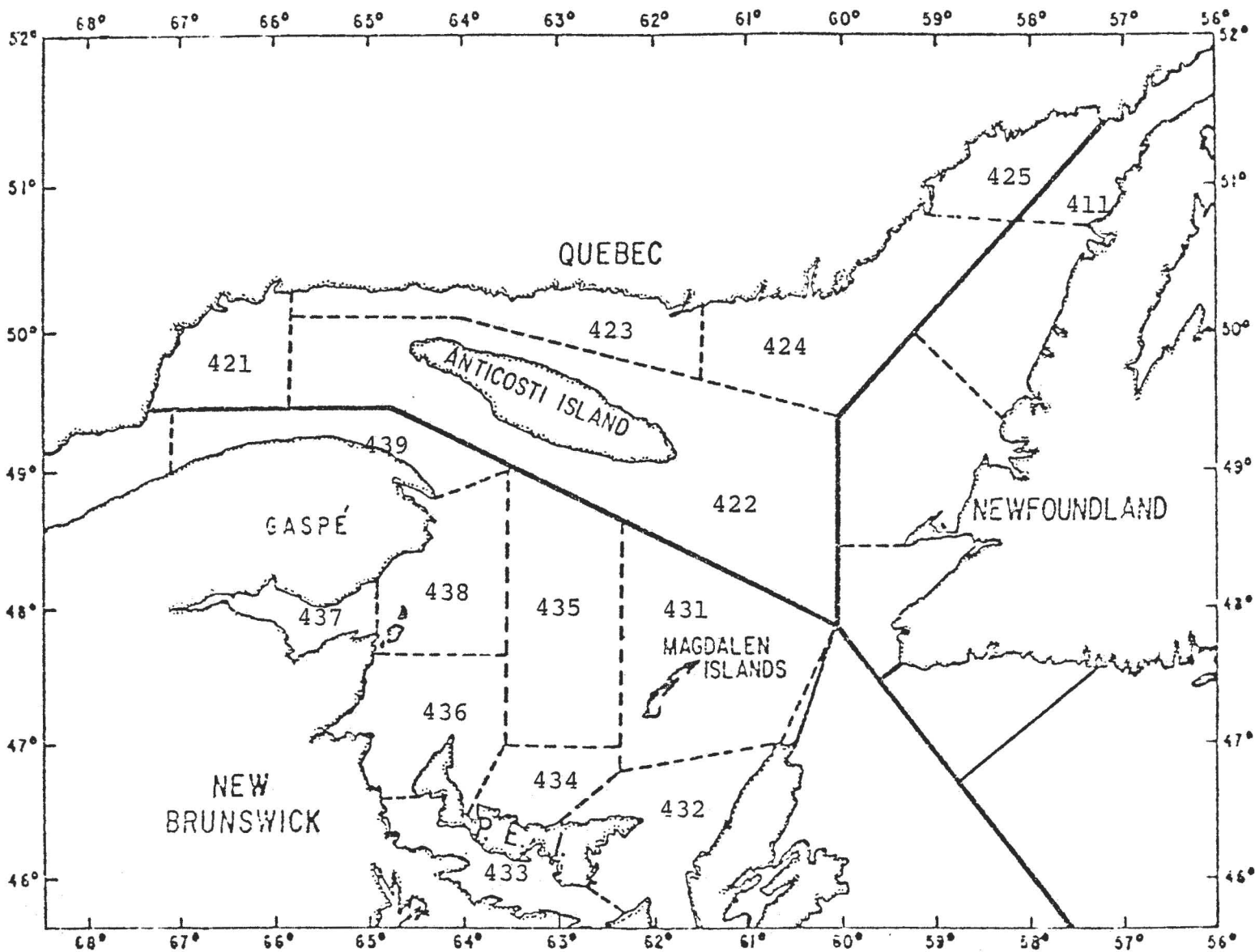


Fig. 1. NAFO statistical unit areas.

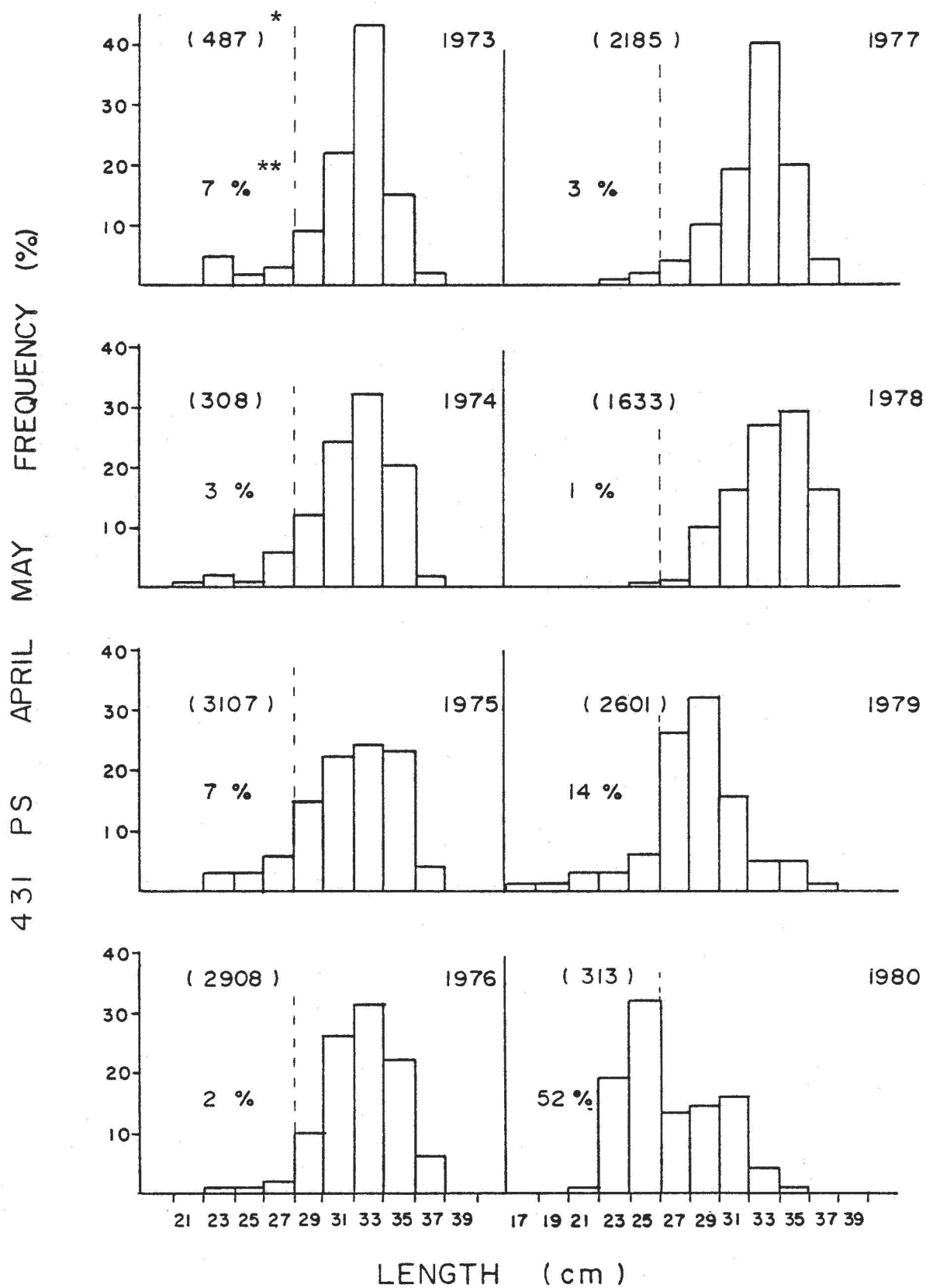


Fig. 2. Length frequency of herring caught by purse seiners in NAFO area 431 (spring fishery).

* number of observations

** percentage of fish smaller than 270 mm.

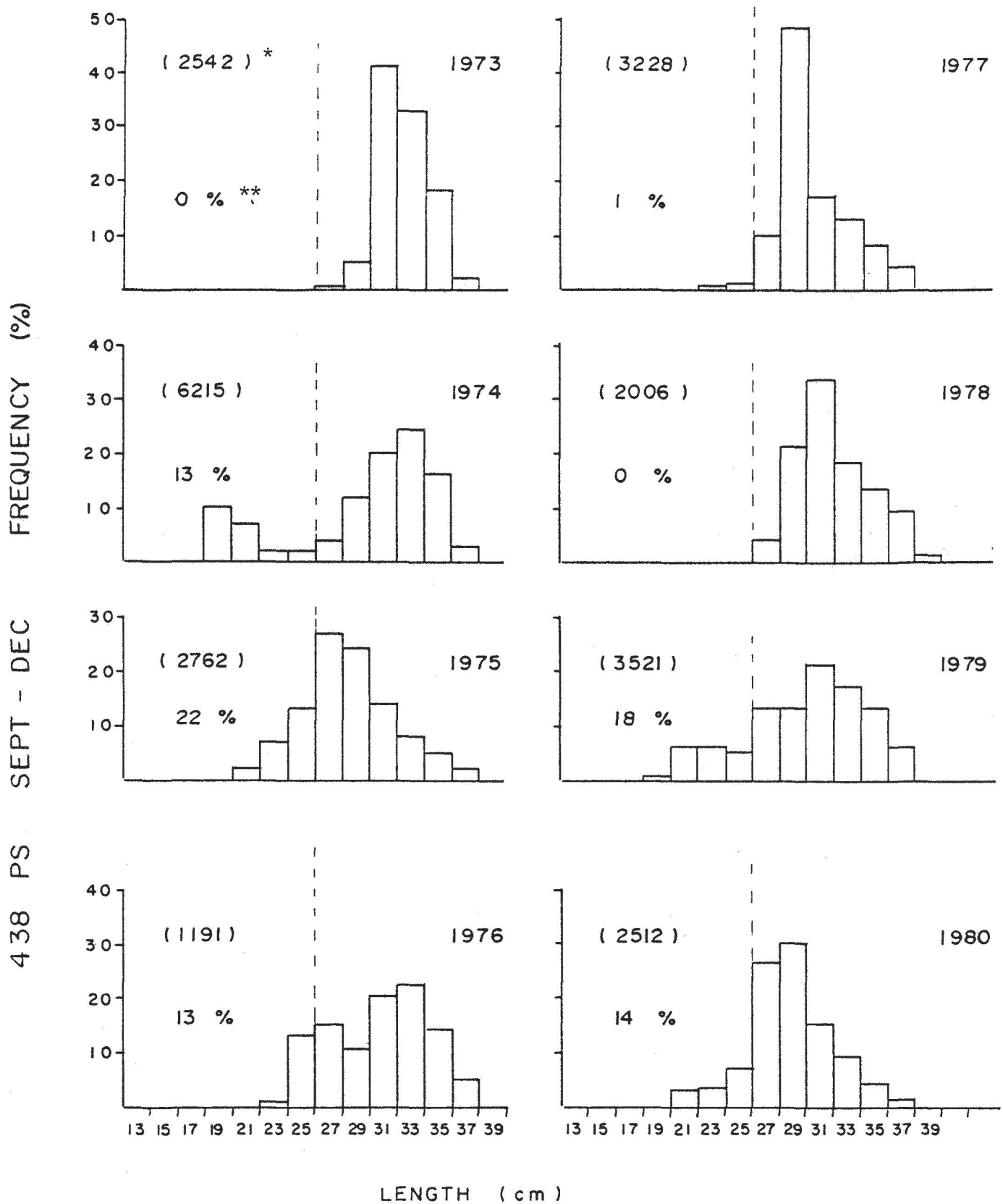


Fig. 3. Length frequency of herring caught by purse seiners in NAFO area 438 (fall fishery)

* number of observations

** percentage of fish smaller than 270 mm.

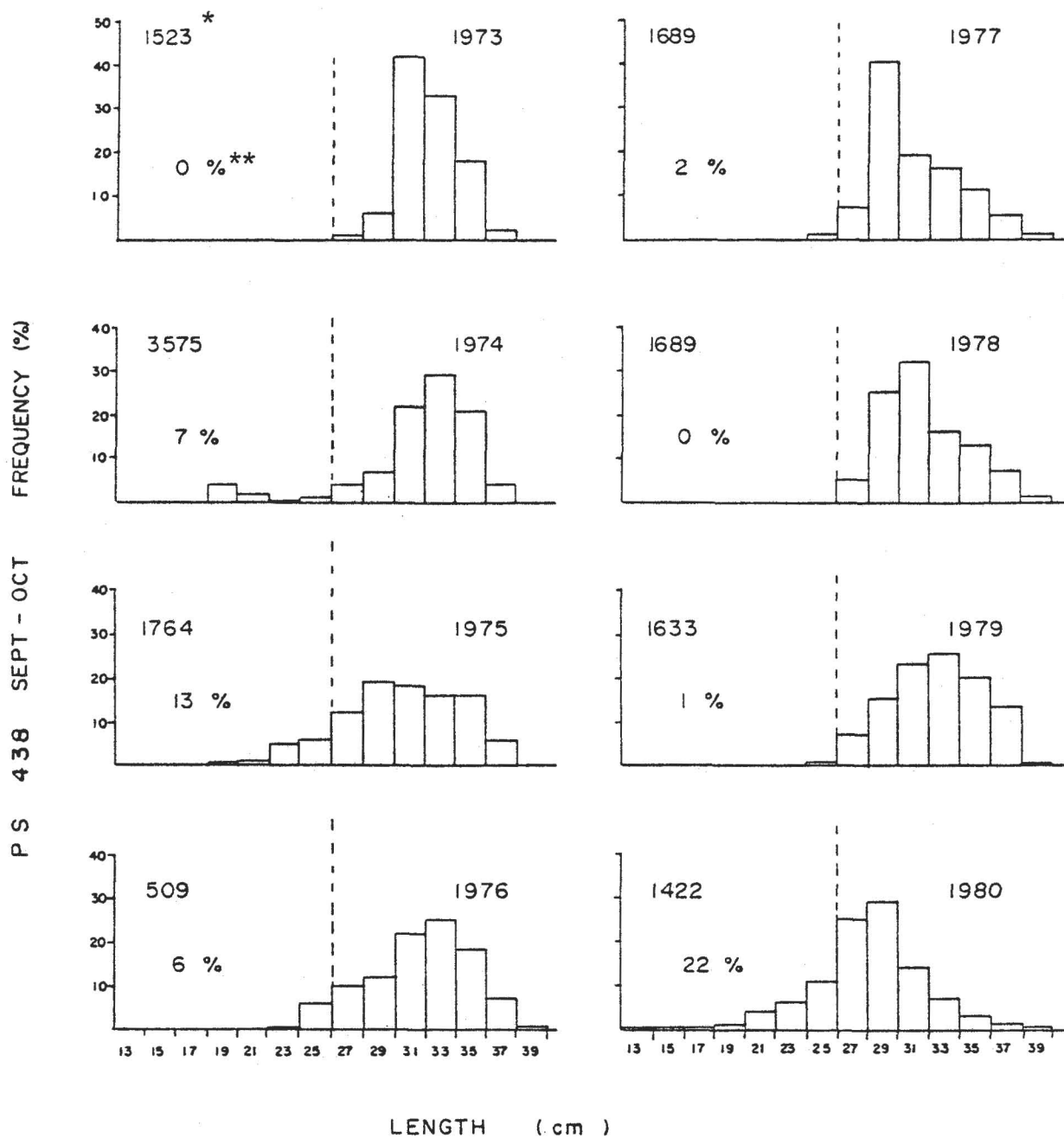


Fig. 4. Length frequency of 4T herring caught by purse seiners in NAFO area 438, in September-October.

* number of observations

** percentage of fish smaller than 270 mm.

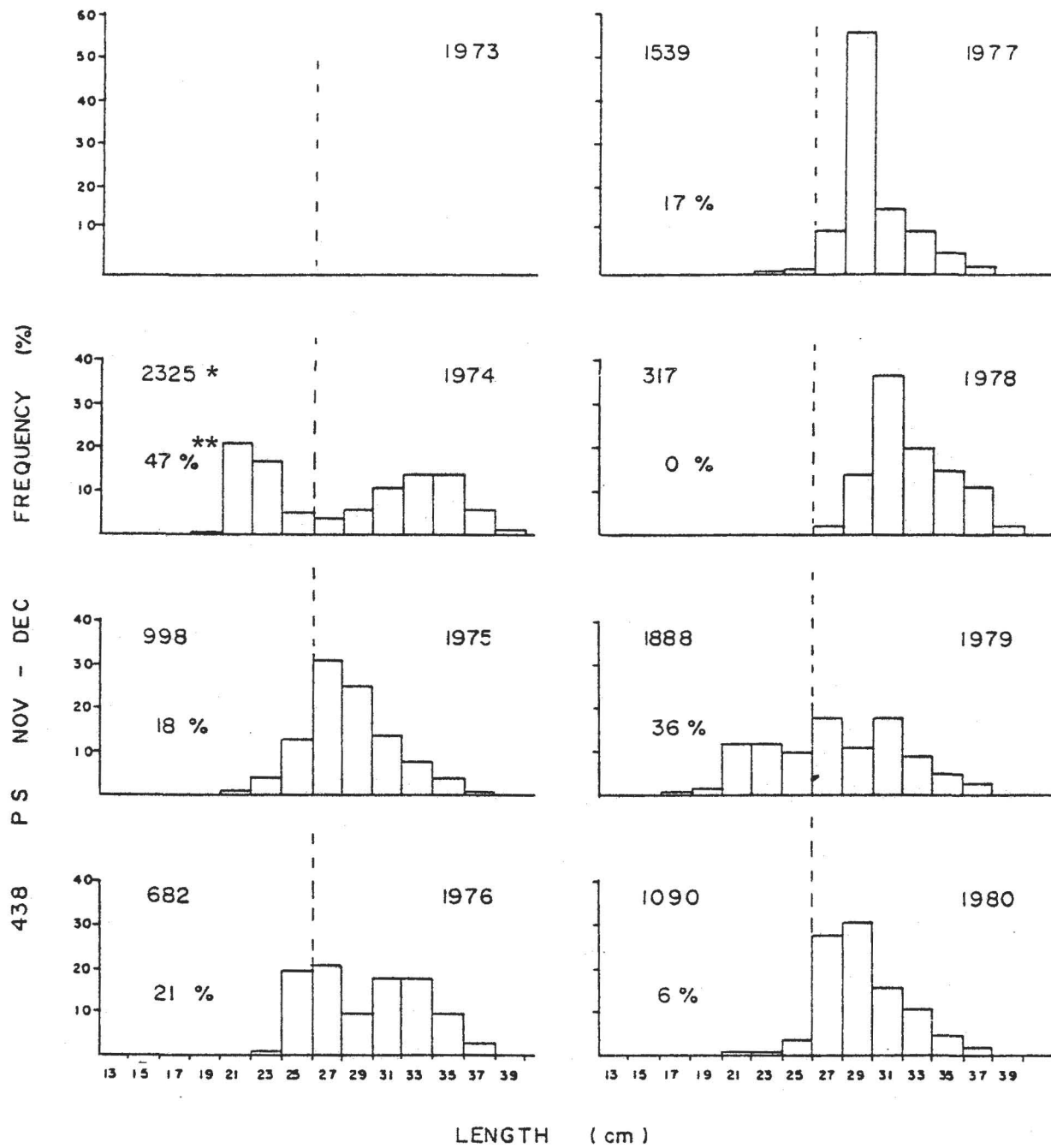


Fig. 5. Length frequency of herring caught by purse seiners in NAFO area 438, in November- December.

* number of observations

** percentage of fish smaller than 270mm.

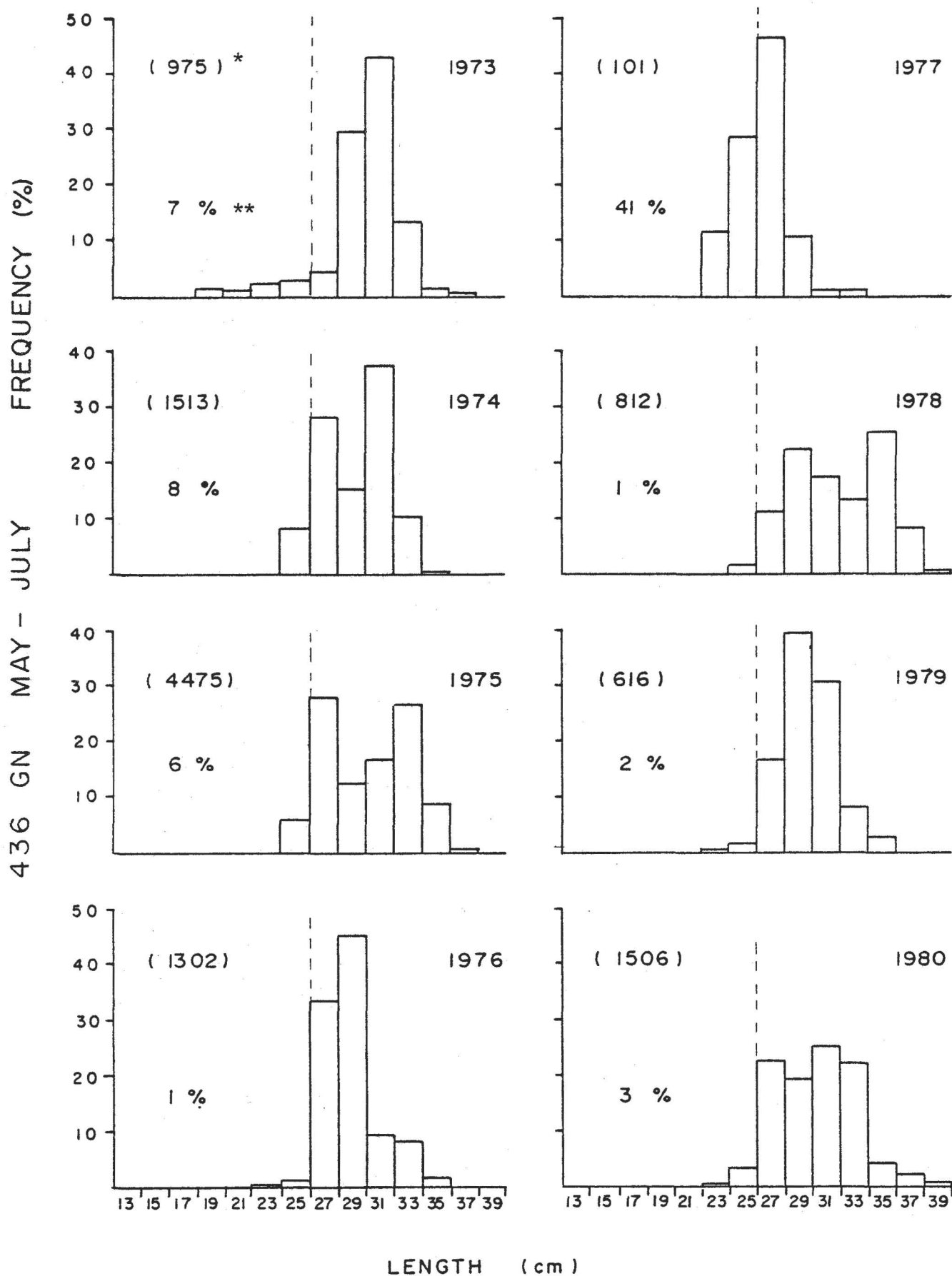


Fig. 6. Length frequency of herring caught by gillnets in NAFO area 436, in May - July.

* number of observations

** percentage of fish smaller than 270 mm.

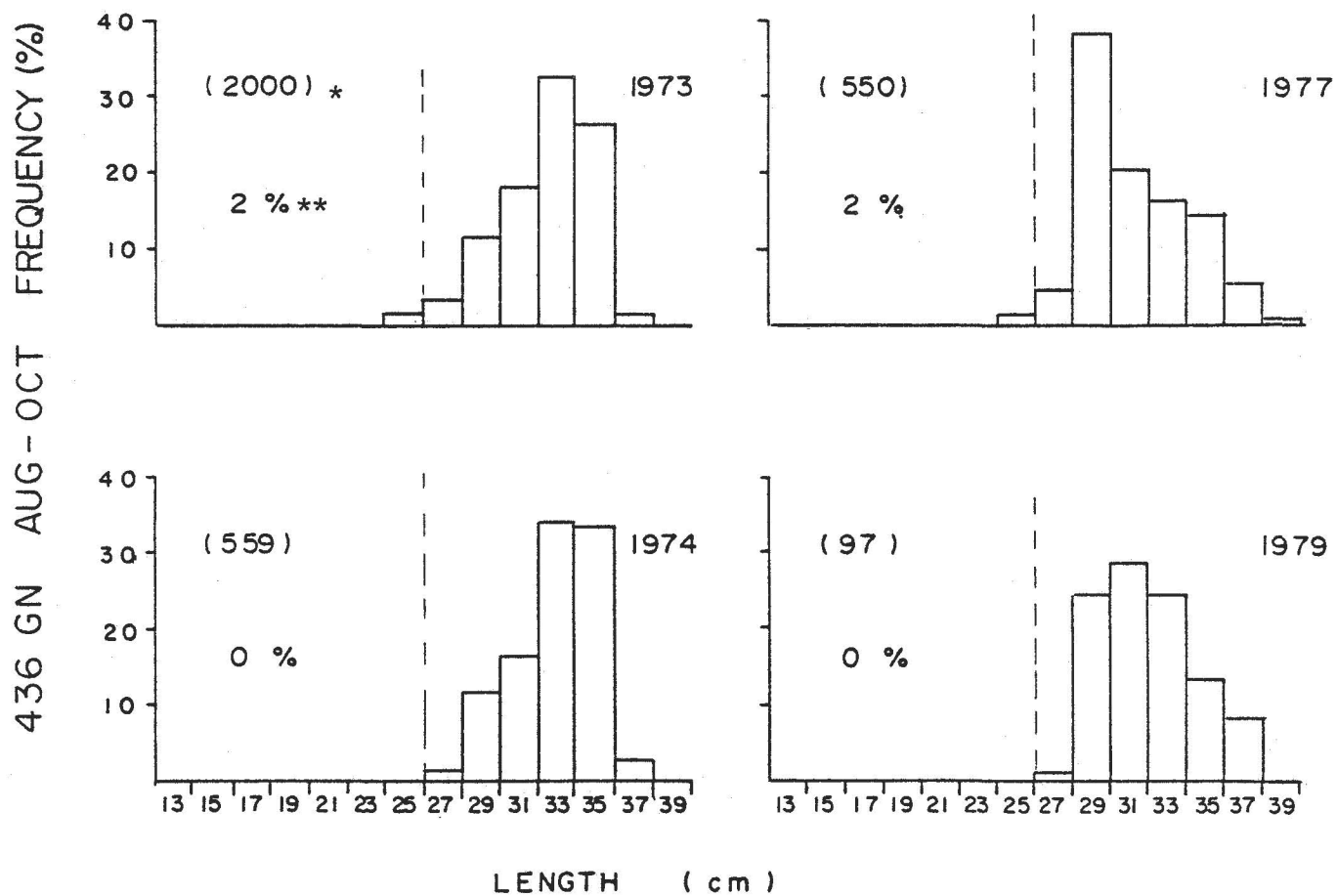


Fig. 7. Length frequency of herring caught by gillnets in NAFO area 436 in August-October.

* number of observations

* * percentage of fish smaller than 270 mm.