Spawning Groups of Atlantic Herring in the Southern Gulf of St. Lawrence

by

S. N. Messieh and C. MacDougall
Fisheries Research Branch
Department of Fisheries & Oceans
Gulf Region
P.O. Box 5030
Moncton, NB E1C 9B6

ABSTRACT

The discreteness of spring and autumn spawning herring in the Gulf of St. Lawrence (Division 4T) is well established. The two spawning groups differ in their growth, maturation cycle, meristics and otolith characteristics. During the course of otolith examination for fish assignment to spawning groups, another type of otolith was detected which appeared to be associated with summer spawning. Fish with this type of otolith were located in Souris/Pictou fishery (Division 4T) during July and August and in Cape Breton (Division 4Vn) during the winter fishery.

The distinction of summer spawning group with different otolith characteristics was further substantiated by differences in fish length at age, back-calculated lengths, maturation stages, spawning time and larval herring distribution. The location of this fish group in Division 4Vn during five consecutive winters (1979-1983) indicate that the Souris/Pictou herring (or at least part of it) overwinter in Division 4Vn. This would agree with results of tagging experiments.

RESUME

Il est maintenant bien établi que les harengs qui frayent au printemps dans le golfe du Saint-Laurent (div. 4T) forment un groupe distinct des reproducteurs d'automne. Les deux groupes diffèrent sous le rapport de la croissance, du cycle de développement des gonades, des caractères numériques et des otolithes. Au cours d'un examen d'otolithes de harengs dans le but de les classer dans un groupe ou l'autre, on a détecté un autre type d'otolithes associé, semble-t-il, à une ponte d'été. Les poissons ayant des otolithes de ce type avaient été pêchés dans la région de Souris/Pictou (div. 4T) en juillet et août et au Cap-Breton (div. 4Vn) en hiver.

L'existence d'un groupe distinct frayant en été, avec caractéristiques d'otolithes différentes, a été confirmée par des différences de longueur à un âge donné, de longueurs obtenues par rétrocalculs, de stades de maturation, de période de ponte et de distribution des larves. La présence de ce groupe de harengs dans la div. 4Vn pendant cinq hivers consécutifs (1979-1983) indique que le hareng de la région de Souris/Pictou (ou du moins une partie) hiverne dans la div. 4Vn. Ceci s'accorderait avec les résultats d'expériences de marquage.

INTRODUCTION

The identification of herring stocks in the Gulf of St. Lawrence has been subject to various investigations for many years. The first documented study was by Lea (1919) who concluded that "several local tribes of herring exist, each having its own particular area of distribution". More recently, the discreteness of spring and autumn herring populations was established (Messieh and Tibbo, 1971; Parsons, 1972; Messieh, 1975; Messieh and Longmuir, 1978; Karnfield et al, 1982).

Based on otolith characteristics (Messieh, 1972) and multivariate analyses of herring meristics (Messieh and Longmuir, 1978), it was concluded that each of the spring and autumn herring populations most likely comprises more than one stock. Ware and Henriksen (1978) reached a similar conclusion, on the basis of landings trends and larval sizes. They suggested that each of the spring and autumn stocks segregate into two or more runs.

For the purpose of herring stock assessment, the determination of age is carried out by examination of otoliths. Each fish is assigned a spawning group; spring or autumn based on otolith characteristics and maturity stage. During the course of herring otolith examination, a different type of otolith with a peculiar first annulus which differs in appearance and location from the regular spring and autumn type was observed. The new otolith type is believed to belong to a summer spawning group.

Herring otolith types were previously described by Messieh (1972). In this report, a description of the new type, its origin and possible use in stock identification is presented. Further evidence of distinction of the three spawning types, i.e. spring, summer and autumn, is provided from examination of maturity stages, spawning time, back-calculated lengths and larval distribution.

MATERIALS AND METHODS

For the purpose of this study, a total of 3,267 fish collected in 1979-83 were examined. Of these samples, 3,085 fish were aged and identified for spawning type. Fish have been classified into spring and autumn spawning on the basis of their otolith characteristics and maturity stages. During spawning season, when fish are ripe and running, the criterion for separation of the group is maturity stage. Outside the spawning season, however, fish are classified into spring and autumn spawning on the basis of their otolith characteristics.

During otolith examination, a different otolith type was observed. Otoliths of this type were separated and their proportion in fish samples by area and year were estimated. Maturity stages by otolith type were compared. Length at age for fish with different otolith types was estimated.

Back-calculation of fish lengths was carried out on subsamples randomly collected. Measurements of otoliths were taken by a bionocular and a camera

lucida on a longitudinal and transverse axes of the otolith in a manner shown in Figure 1. Based on a linear relationship between fish length and otolith size, back-calculated length (ln) was expressed as follows:

$$l_n = L.\left(\frac{x_n + y_n}{X + Y}\right)$$

where L = fish length at time of capture
x_n = radius from center to annulus "n" on transverse axis
y_n = radius from center to annulus "n" on longitudinal axis
X = radius from center to otolith margin on transverse axis
Y = radius from center to otolith margin on longitudinal axis

To elucidate the relationship between the spawning groups and otolith types, data on spawning time and larval distribution were analyzed. Spawning time and spawning locations of herring were updated from several interviews with fishermen involved in herring fisheries for many years. Larval herring distribution were recorded from two larval herring cruises conducted in 1979.

RESULTS

Figure 2 shows the three types of herring otoliths identified and described in this report:

A-type: Otolith usually has a defined nucleus with hyaline or translucent appearance. The first annulus which represents the second winter is large and with well-developed rostrum and antirostrum. This type is characteristic of autumn spawned fish.

P-type: Otolith has an opaque center with no nucleus. The first annulus is intermediate in size between A-type ad P-type. The annulus has a well developed rostrum, but the antirostrum is less developed. This type is characteristic of spring spawned herring.

E-type: The first annulus is noticeably small compared to A-type and P-type. The annulus is oval or pear-shaped with a rostrum, but the antirostrum is not developed. This type is characteristic of summer spawned herring.

Distribution of Otolith Types

The distribution of otolith types differed by area and month. The spring and autumn types (P and A) were well represented throughout the Gulf in spring and autumn fisheries, respectively. The summer type (E) however, was restricted to an area south of Northumberland Strait, namely between Souris, PEI and Pictou NS (Statistical Dist. 432 and 433) in 4T Division, and in Cape Breton Island area (NAFO Divison 4VN).

Percentages of different otolith types in 4Vn fishery in the past five years (1979-83) are presented in Table 1. The A-type ranged between 10.3% in 1982 and 51.2% in 1980. P-type ranged between 15.8% in 1983 and 39.9% in 1981. E type ranged between 23.9% in 1980 and 52.4% in 1982. Average percentages for the three types over the five year period were 38.9%, 28.9% and 32.2% for the A, P and E-type, respectively.

Percentages of otolith types in fish samples collected from Souris-Pictou area (areas 432 and 433) during July and August, 1983 are presented in Table 2. No fish with otoliths of P-type were found. Percentage of A-type was higher than E-type in both Souris, P.E.I. and Pictou, N.S. (85.2% and 78.6%). E-type otoliths were 14.8% and 21.4% in these areas respectively.

Spawning Origin of Otolith Types

In order to find the spawning origin of different otolith types, the maturation stages of fish samples collected from 4T and 4Vn were examined. In April, May and June, fish samples at maturity stages 5, 6 and 7 indicate spring spawning condition (Table 3). The majority of these samples were of P-type otolith. In September and October, fish samples at maturity stages 6 and 7 (autumn spawners), were dominated by A-type otolith. Fish of E-type otolith were not located in these samples.

The E-type otoliths were restricted to Souris, P.E.I./Pictou, N.S. area during July and August. Age, length and maturity stages of these fish are presented in Table 4 and 5. Distribution of maturity stages of A-type and E-type is presented in Table 6. As shown in this Table, no otoliths of P-type were found. This would indicate the absence of spring spawners from this area during July and August. As would be expected, the maturity stages of A-type and E-type were overlapping. However, the percentages of spawning fish of E-type were higher than those of A-type (Table 6).

In Division 4Vn, the fishery is conducted in winter, and only samples during January and December were taken. Percentage distritution of maturity stages of fish of different otolith types is presented in Table 7. Differences of maturation stages between A-type and E-type on one hand and P-type on the other hand are shown. Excluding immature fish (maturity stages 1 and 2), most fish of A-type and E-type were in a recovering stage. Percentages of these fish were 61% and 54% for the two types respectively. Of the P-type, only 9% were recovering, and 40% were in stages 3 and 4.

The separation of spring and autumn spawning populations on the basis of maturity stages is demonstrated in Figure 3. This Figure shows the distribution of maturity stages of herring samples in the southern Gulf in 1970 and 1983. In 1970, two distinct maturation cycles representing spring and autumn spawning were well separated. During summer (July and August), there was a small percentage of summer spawning fish as shown from the distribution of maturity stage 6. In 1983, summer spawning fish were more represented in the samples. Ripe and running fish were found in May through September (Figure 3).

Length at age and Back-calculated Lengths

A comparison of length-at-age showed different values for fish with different otolith types (Table 8). Differences were more obvious for younger age groups (ages 2 and 3). Length at age 2 ranged from 180 to 190 mm for A-type with an average of 182 mm. For P-type, lengths ranged between 230 and 239 mm with an avarage of 235 mm. For E-type, the range was 205 to 224 mm with an average of 216 mm. Average lengths at age 3 were 246, 274 and 258 mm for A, P and E-types, respectively.

Estimates of back-calculated length-at-age (Table 9) showed an average of 50 mm $\pm$ S.D. 6 mm to 62 $\pm$ 8 mm for l_0, 114 $\pm$ 22 mm to 193 $\pm$ 14 mm for l_1, and 206 $\pm$ 16 mm to 249 $\pm$ 14 mm for l_2. In all cases, the differences between the back-calculated lengths for different otolith types were statistically significant. Values of l_1 of A-type were 174 mm and 193 mm for Cape Breton Island and Pictou/Souris areas respectively. For E-type these values were 127 mm and 114 mm for the same areas. Value of P-type was 162 mm. The distributions of back-calculated l_0 and l_1 are shown in Figure 4. A good agreement between observed length-at-age and back-calculated lengths was shown (Table 10).

Based on observed and back-calculated lengths at first and second year summer growth, growth model for herring of the three otolith types was constructed (Figure 5). This model demonstrates the seasonal growth of the autumn, spring and summer spawning groups, and explains the polymodality of size distribution of younger age-groups.

DISCUSSION

In this study, evidence was provided for the presence of three otolith types characterizing spring, summer and autumn spawning groups. Distribution of maturity stages of herring of different otolith types showed good separation between the spring (P-type) on one hand, and summer and autumn (E and A-type) on the other hand. Maturity stages of the summer and autumn types, however, are overlapping. This would be expected because the summer and autumn spawning seasons are only separated by 3-6 weeks.

In division 4Vn winter herring fishery, more fish (40%) with P-type otolith were maturing (stages 3 and 4), while 9% were recovering from spawning. In contrast, more fish (61% and 54%) with A and E-type were recovering (Table 7).

The identification of E-type otolith characterizing a summer spawning group does not contradict our previous knowledge of herring stock structure in the Gulf. Herring were collectively classified into spring and autumn group, but there were indications that each spawning group comprises more than one stock (Messieh and Longmuir 1978; Ware and Henriksen 1978). Messieh (1975) reported that the autumn spawning in the southern Gulf was prolonged, extending from July to September.

The presence of higher percentage of spawning fish during summer in the 1983 samples (Figure 3) most likely reflect a sampling bias. Most samples in the 1980s were taken from inshore fisheries near herring spawning grounds, whereas many samples in the early 1970s were from offshore catch by purse seiners. It is also important to note that the higher percentages of summer spawners were mainly found in Pictou samples (Area 433, Table 3) during July. The Pictou fishery has gained an increasing importance in recent years and more herring samples were taken from this fishery in 1983.

An updated map of spawning locations and times in the southern Gulf of St. Lawrence (Figure 6) show that spawning extends from April to September. The distribution of spawning seasons shown in this map is based on interviews with experienced fishermen, and collection of spawning fish samples from different locations. The existence of summer spawning during June and July agrees with results of a survey on spawning activity during 1978-79 (O'Boyle and Cleary 1981). Crawford (1980) also reported a late summer-fall spawning component in Caribou-Pictou fishery. His data on maturation showed a relatively constant gonadal state for about a two and a half month period (stage 5 and 6).

It is interesting to note that the summer spawning is restricted to the southern end of Northumberland Strait (Figure 6). This coincides with the distribution of the summer otolith type (E-type) which is also restricted to the same area (Souris, P.E.I. and Pictou, N.S.) of 4T in addition to 4Vn.

The presence of the summer otolith type in 4Vn in winter demonstrates that herring migrate from the Souris/Pictou to 4Vn for overwintering. This agrees with herring tagging results (Figure 7) where fish tagged in Souris were recoverd in 4Vn, and vise versa. Simon and Stobo (1983) summarized herring tagging results in 4Vn, and reported that the majority of recoveries were made in Sydney Bight in 4Vn. Messieh (1974) discussed the heterogeneity of herring populations in 4Vn and reported that the herring stock complex contains at least two components: one component is composed of adult fish, and the other composed of immature fish of different origin - both components are overwintering in the same area. Yearly percentages of E-type otolith in 4Vn (Table 7) indicates changes in the contribution of this groups to 4Vn fishery from year to year.

The presence of a summer herring group in Souris/Pictou area was further substantiated by the presence of herring larvae in this area earlier than the other areas in the Gulf. Water currents in the southern Gulf are south-eastward (Messieh and El-Sabh 1979, Figure 8). Larval herring movement takes similar direction as water currents. Results of two larval cruises conducted in autumn 1979 (Figures 9 and 10) show the presence of herring larvae in Souris/Pictou area three weeks earlier than in northern areas. There is no way that larvae found in September 19 - October 1 (Figure 9) could have moved northward as shown in October 10-14 larval cruise (Figure 10). This would lead us to the only reasonable explanation that these larvae were the progeny of summer spawning stock in Souris/Pictou area, and they were definitely different from those of autumn herring larvae spawned in Caraquet three weeks later.

The identification of E-type otolith as a biological tag for the Souris/Pictou summer spawning group could provide a useful method for estimating the relative contribution of this group to the winter fishery in 4Vn. This would be particularly important since the identification of spawning groups by maturity stages alone is of little use during winter due to overlap between the prevailing maturity stages 3, 4 and 8.

REFERENCES

Crawford, R. 1980. A biological analysis of herring from the Atlantic Coast of Nova Scotia and Eastern Northumberland Strait. N.S. Ms Rept. No. 3, 45p.

Karnfield, I., B. Sidell, and P. Gagnon. 1982. Stock definition in Atlantic herring: genetic evidence for discrete fall and spring spawning populations. Can. J. Fish. Aquat. Sci. 39: 1610-1621.

Lea, E. 1919. Age and growth of the herring in Canadian waters. Canadian Fisheries Expedition, 1919.

Messieh, S. N. 1972. Use of otoliths in identifying herring stocks in the southern Gulf of St. Lawrence and adjacent waters. J. Fish. Res. Bd. Can. 29: 1113-1118.

Messieh, S. N. 1974. The structure of herring populations in the Atlantic Coast of Cape Breton Island. Fish. Res. Bd. Can. Ms Rep. 1321, 23p.

Messieh, S. N. 1975. Maturation and spawning of Atlantic herring in the southern Gulf of St. Lawrence. J. Fish. Res. Board Can. 32: 66-68.

Messieh, S. N. and M. El-Sabh. 1979. Répartition des températures au fond et à la surface et circulation dans le Golfe Saint-Laurent. Cahier d'information No. 4, 139p.

Messieh, S. N. and J. Longmuir. 1978. The interrelationships between herring stocks in the Canadian Atlantic Fisheries as revealed by multivariate analyses of their meristic characters. CAFSAC Res. Doc. 78/45, 25p.

Messieh, S. N. and S. N. Tibbo. 1971. Discreteness of Atlantic herring populations in spring and autumn fisheries in the southern Gulf. J. Fish. Res. Bd. Can. 28: 1009-1014.

O'Boyle, R. and L. Cleary. 1981. The herring gillnet fishery in the southern Gulf, 1970-79. Canadian Tech. Rept. 1065.

Parsons, L. S. 1972. Use of meristic characters and a discriminant function for classifying spring and autumn spawning Atlantic herring. ICNAF Res. Bull. No. 9: 1-9.

Simon, J. and W. Stobo. 1983. The 1982-83, 4Vn herring update. CAFSAC Res. Doc. 83/49.

Ware, D. and B. Henriksen. 1978. On the dynamics and structure of the southern Gulf herring stock. Fish. Mar. Serv. Tech. Rept. 800: 83p.

TABLE 1 - Percentage of different types of otoliths in fish samples collected in 4Vn, 1979-83. All fish samples were collected during December and January.

Year	A-type	P-type	E-type	Number of fish sampled
1979	31.3	33.9	34.8	454
1980	51.2	24.8	23.9	1663
1981	16.0	39.9	44.1	381
1982	10.3	37.3	52.4	378
1983	50.7	15.8	33.5	209
Total	38.9	28.9	32.2	3085

TABLE 2 - Percentage of different types* of otoliths in fish samples collected from areas 432 and 433 in 1983.

Fishery	Stat. Area	Sampling Period	% otolith type		
			A	E	Total
Souris, PEI	432	Jul-Aug	85.2	14.8	284
Pictou, NS	433	Jul-Aug	78.6	21.4	673

*No fish with P-type otoliths were found during the sampling period in these areas.

TABLE 3 - Number of fish at different maturity stages in 4T, 1983.

Month	Area	Maturity Stage								
		1	2	3	4	5	6	7	8	Total
Apr	433			3	4	11	2			20
	436			7	52	33	1			93
May	436		5	48	236	233	51	29	7	609
	437			3	28	40	17			88
	438		1	3	9	36	21			70
Jun	437		1	8	23	13	30	52	14	141
	438	5	30	13	23	44	94	59	13	281
Jul	433				26	73	174	16		289
Aug	432	4	3	1	142	114	12	4	4	284
	433			1	25	92	255	11		384
	436		5	15	102	60	3	1	2	188
	438			2	14	124	312	83	19	554
Sep	438			7	18	98	141	39	39	342
Oct	438	45	258	214	113		1	13	95	739

TABLE 4 - Age, length and maturity stages frequency distributions of herring samples in Pictou, N.S. (Area 433), July 1983.

Age	0	1	2	3	4	5	6	7	8	9	10	11	Total
# fish	26	0	0	2	58	78	37	22	46	16	2	2	289
%	9.0	0.0	0.0	0.7	20.1	27.0	12.8	7.6	15.9	5.5	0.7	0.7	
Avg Ln	331	0	0	274	296	310	317	332	342	343	357	367	319
St Dev	26.7	0.0	0.0	1.4	9.0	8.9	9.5	10.0	11.4	13.4	17.7	3.5	21.5

Mat St	0	1	2	3	4	5	6	7	8
# fish	0	0	0	0	26	73	174	16	0
%	0.0	0.0	0.0	0.0	9.0	23.3	60.2	5.5	0.0

Average Weight / Fish : 290.439

0 = unknown age or maturity

TABLE 5 - Age, length and maturity stages frequency distributions of herring samples in Souris, P.E.I. (area 432), August 1983.

Age	0	1	2	3	4	5	6	7	8	9	10	11	Total
# fish	11	0	0	5	123	79	43	12	6	4	0	1	284
%	3.9	0.0	0.0	1.8	43.3	27.8	15.1	4.2	2.1	1.4	0.0	0.4	
Avg Ln	309	0	0	268	301	315	325	339	344	349	0	353	311
St Dev	22.6	0.0	0.0	10.2	7.8	9.1	8.8	10.1	10.8	7.8	0.0	0.0	24.8

Mat St	0	1	2	3	4	5	6	7	8
# fish	4	0	3	1	142	114	12	4	4
%	1.4	0.0	1.1	0.4	50.0	40.1	4.2	1.4	1.4

Average Weight / Fish : 290.873

0 = Unknown age or maturity

TABLE 6 - Distribution of maturity stages in herring samples collected in Souris, P.E.I./Pictou, N.S. Area 432 and 433 in July and August, 1983

Area	Otolith Type	Maturity Stage 1&2	3	4	5	6	7	8	Total
432	A	6		124	92	12	4	4	242
	% spawners = 45%								
	E	1	1	18	22				42
	% spawners = 52.4%								
433	A		1	45	136	326	21		529
	% spawners = 91.3%								
	E			6	29	103	6		144
	% spawners = 95.9%								

*No fish with P-type otolith were found during this sampling period.

TABLE 7 - Percentage distribution of maturity stages in herring samples from 4Vn, 1979-83

Otolith Type	Sampling Year & Month		% Maturity Stage 1&2	3	4	5	6	7	8	Total Samples
A	1979	Jan								
		Dec	56	16			1		28	142
	1980	Jan	20	22	1			4	54	151
		Dec	19	10	1			1	69	701
	1981	Jan	18	21					61	61
		Dec	5	13					82	39
	1982	Jan								
		Dec	32	12		1		1	54	182
	1983	Jan								
		Dec	15	2					83	106
E	1979	Jan								
		Dec	52	17	2	1		1	27	158
	1980	Jan	22	20	8	2		2	47	93
		Dec	30	9	6	2			53	305
	1981	Jan	16	30	9	1			44	112
		Dec	13	23					64	56
	1982	Jan								
		Dec	20	13	1				66	198
	1983	Jan								
		Dec	21	4					74	70
P	1979	Jan								
		Dec	63	29	5	1			3	154
	1980	Jan	50	29	6	3			11	121
		Dec	39	32	10				18	292
	1981	Jan	58	33	5	1			4	125
		Dec	37	41	22					27
	1982	Jan								
		Dec	53	32	5	2			9	141
	1983	Jan								
		Dec	46	30		3			21	33

TABLE 8 - Length at age (mm) of herring with different otolith types sampled in 4Vn, 1979-83.

	Sampling Year	AGE 2	AGE 3	AGE 4	# of fish aged
A-Type	1979		246	286	142
	1980		251	280	852
	1981		248	289	61
	1982		249	289	39
	1983	182	241	283	106
	Average	182	246	286	
P-Type	1979	230	274	289	154
	1980	236	273	302	413
	1981	237	273	290	152
	1982	237	273	302	141
	1983	239	274	298	33
	Average	235	274	297	
E-Type	1979	224	255	288	158
	1980	219	254	295	398
	1981		259	290	168
	1982	205	266	293	198
	1983		262	291	70
	Average	216	258	290	

TABLE 9 - Estimates of back-calculated lengths at age (mm) for fish with different otolith types.

Fishery	Otolith Type	Number of fish	l_0		l_1		l_2	
			mean	S.D.	mean	S.D.	mean	S.D.
Pictou-Souris	A	28	50	6	193	14	247	14
	E	56			114	22	206	16
Cape Breton Island	A	70	62	8	174	17	249	14
	P	101			162	17	232	14
	E	45			127	20	212	21

TABLE 10 - Comparison of observed and back-calculated lengths of herring with different otolith types.

	l_0(mm)		l_1(mm)		l_2(mm)	
	Observed	Back-Calc.	Observed	Back-Calc.	Observed	Back-Calc.
A-type	60	50	182	193	246	248
P-type			169	162	235	232
E-type			120	127	216	212

A = autumn spawned; P = spring spawned; E = summer spawned

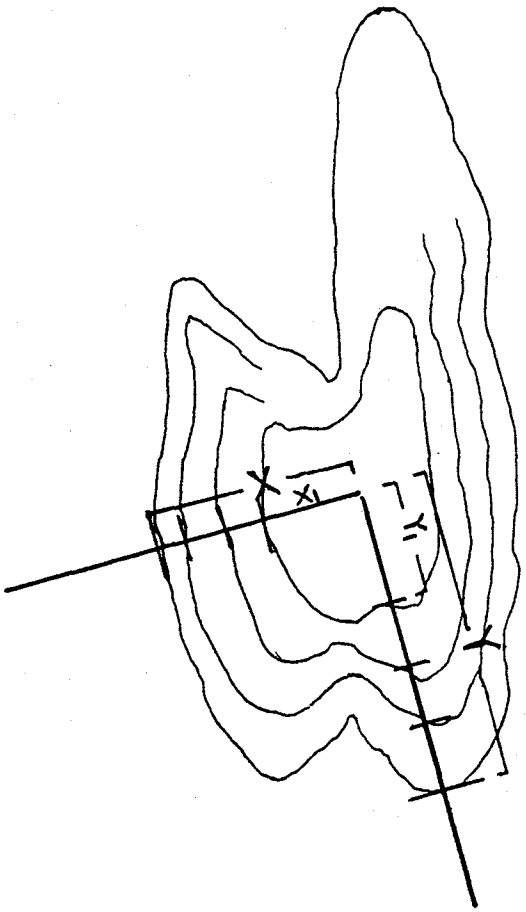

Figure 1. Diagram showing herring otolith and measurements taken for back-calculating fish lengths.

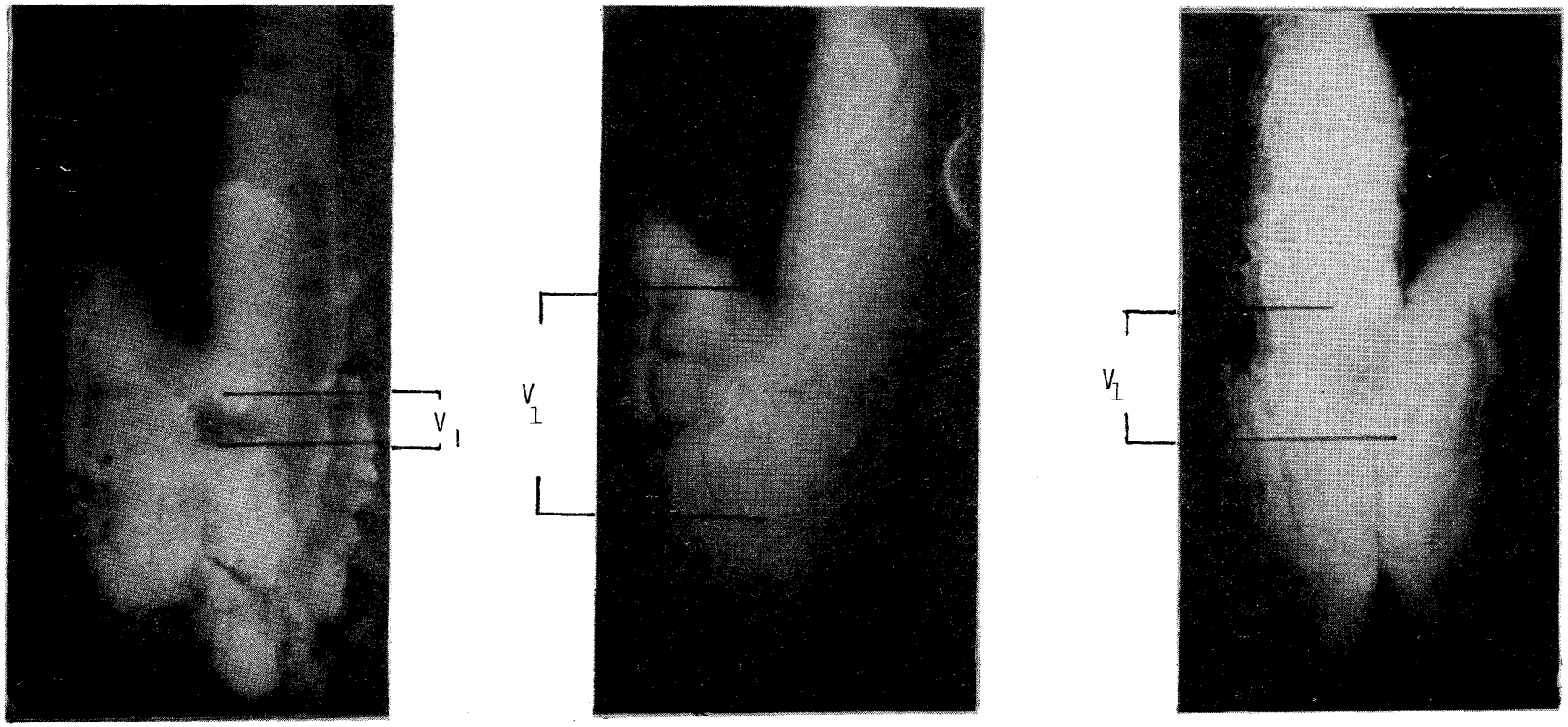

Figure 2. Herring otoliths showing 3 types: A-type = autumn spawning
P-type = spring spawning
E-type = summer spawning

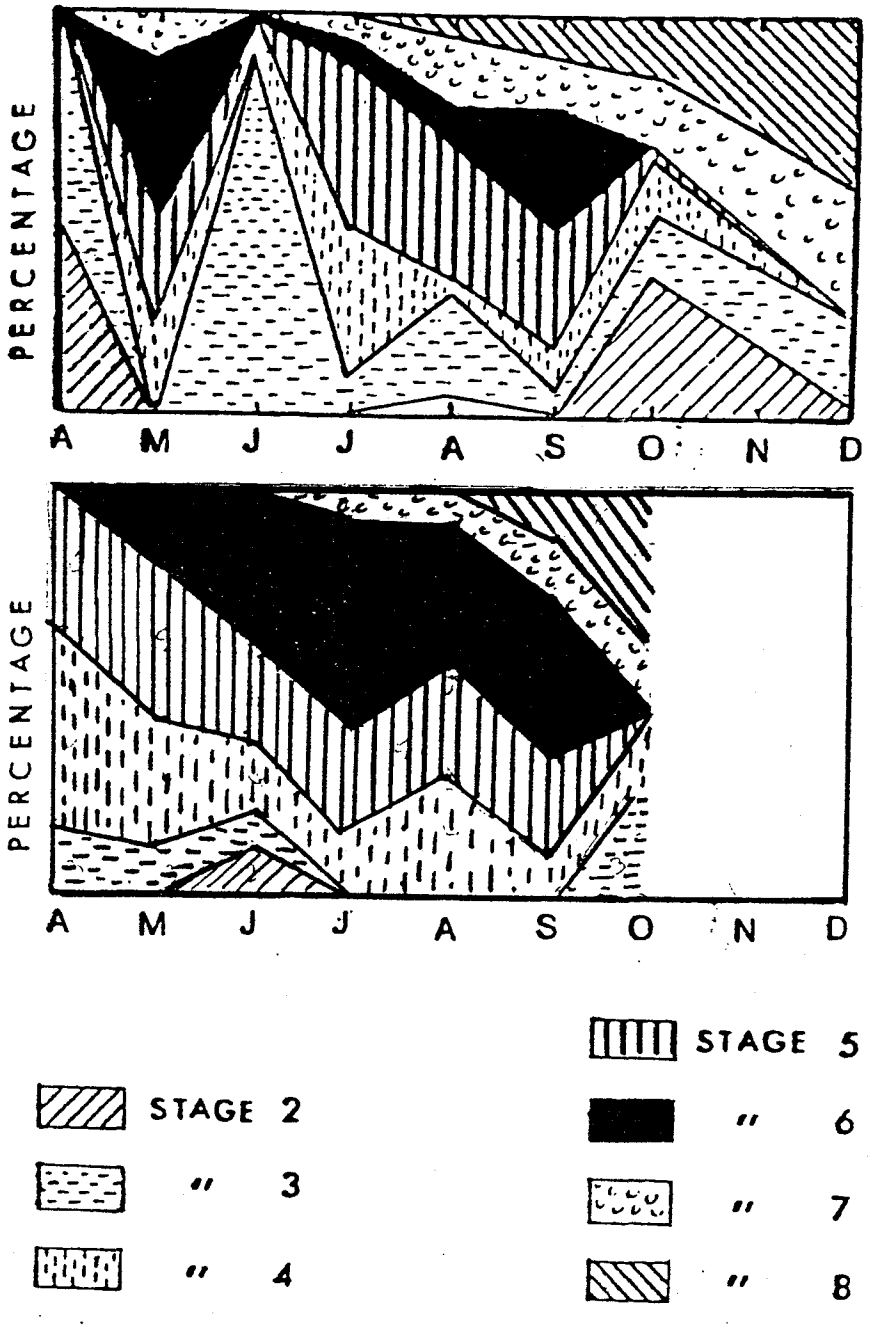

Figure 3. Relative monthly frequency of maturation stages from commercial samples of herring in 1970 (upper Figure) and in 1983 (lower figure).

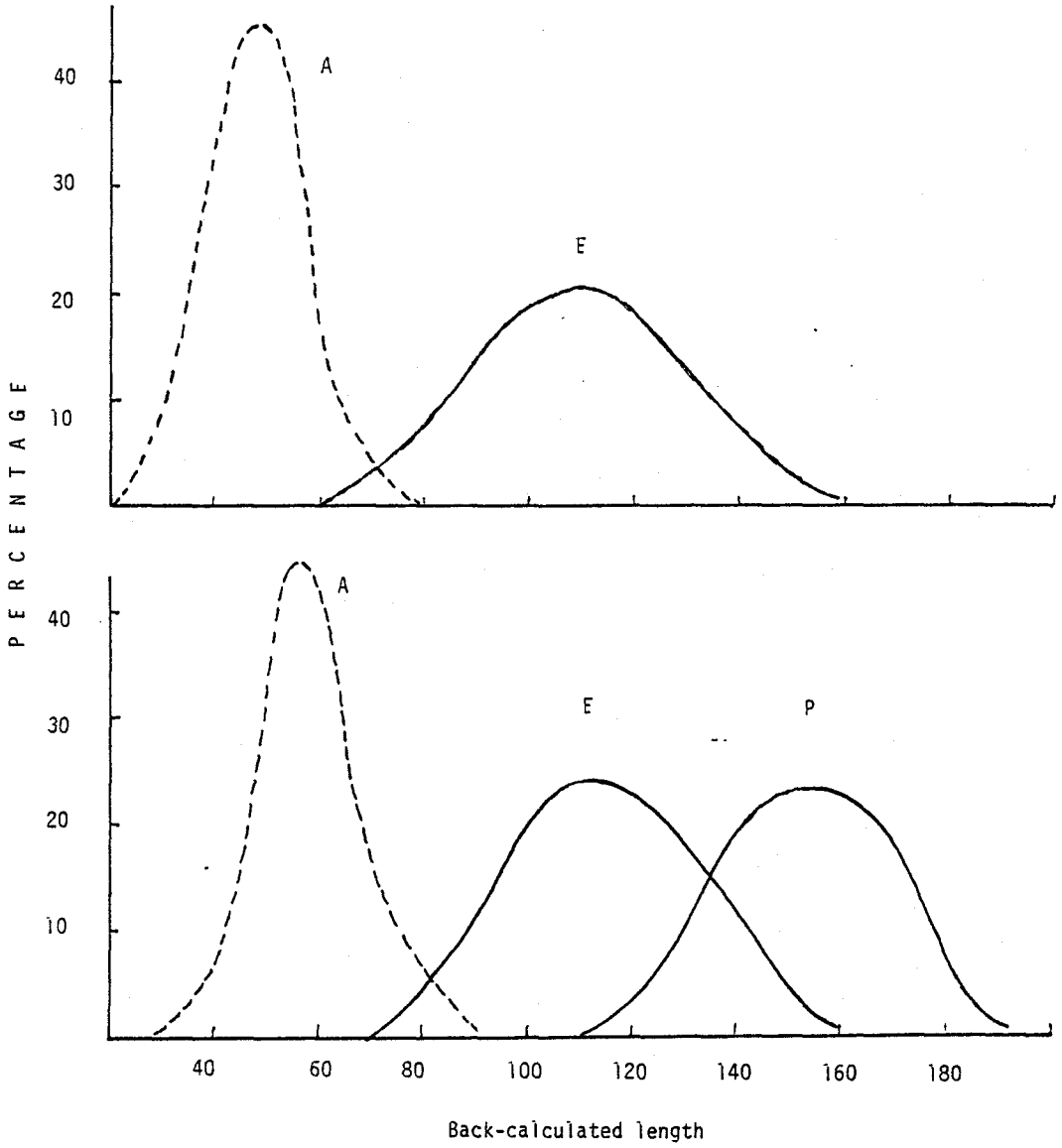

Figure 4. Frequency distribution of l_0 (---) and l_1 (—) of hering of different otolith types in 4Vn (upper Figure) and Souris/Pictou (lower Figure).

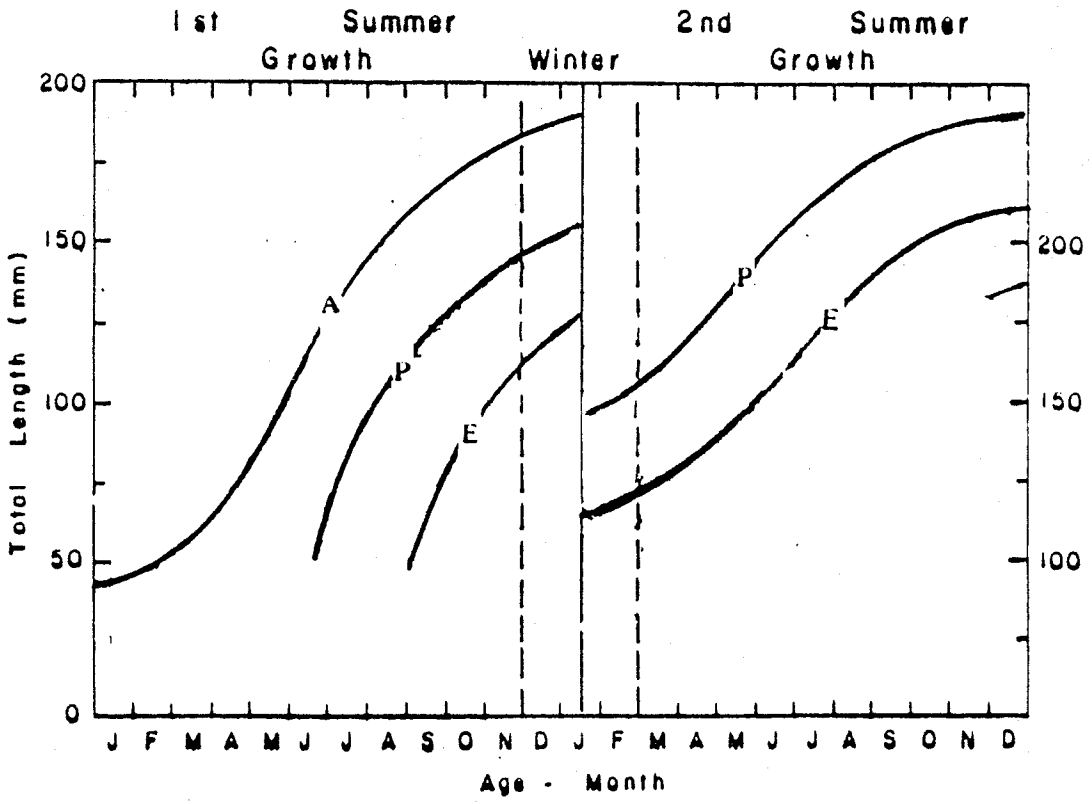

Figure 5. Growth model of three spawning groups of herring in the southern Gulf of St. Lawrence: Fall spawning (A-type otolith); Spring spawning (p-type otolith); Summer spawning (E-type otolith). Initial sizes at 1st and 2nd annuli were adjusted by back-calculation.

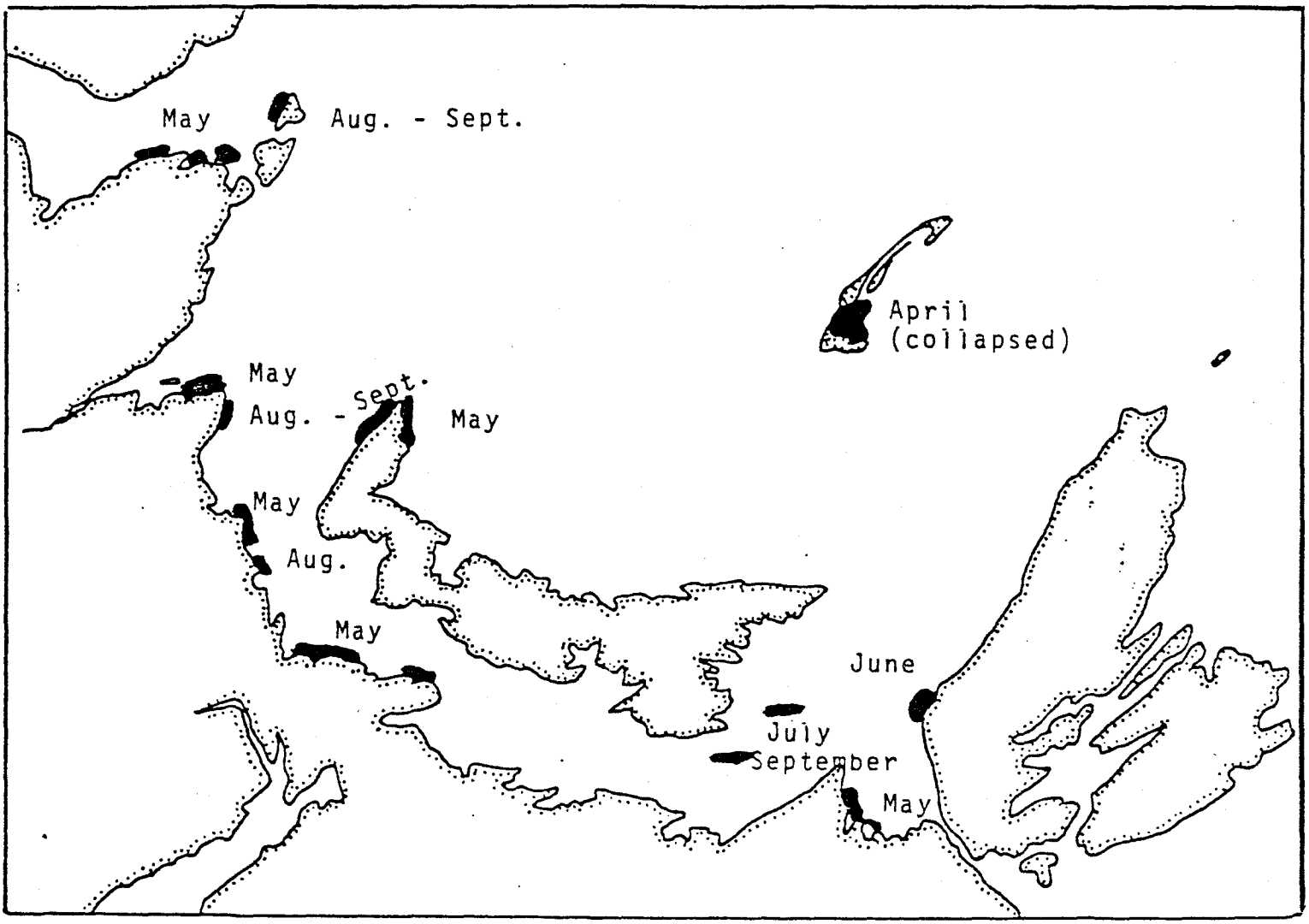

Figure 6. Map of southern Gulf of St. Lawrence showing location and time of herring spawning in recent years (1980-83)

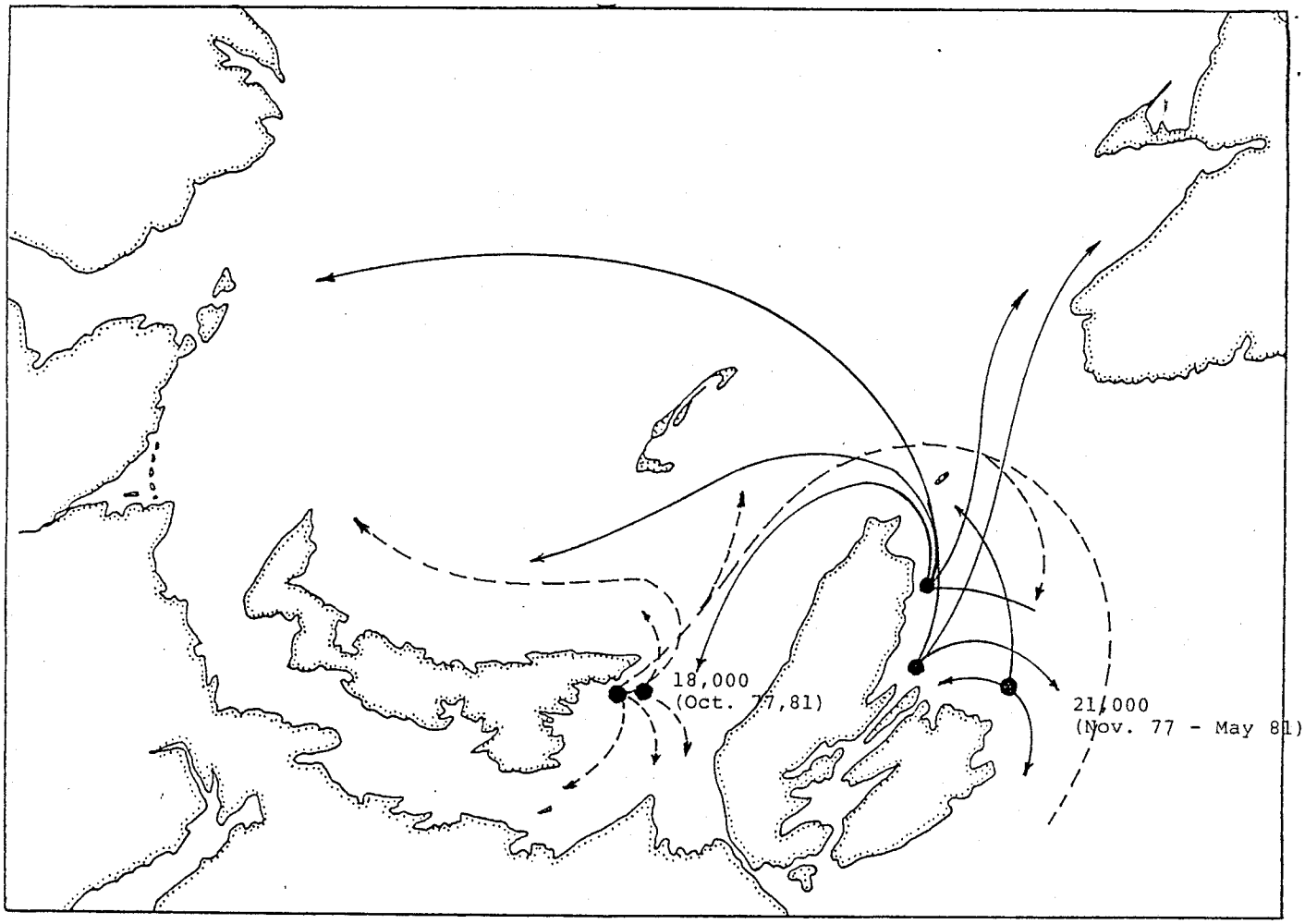

Figure 7. Herring tag releases in Divisions 4Vn and Souris, PEI (4T) in 1977-81.

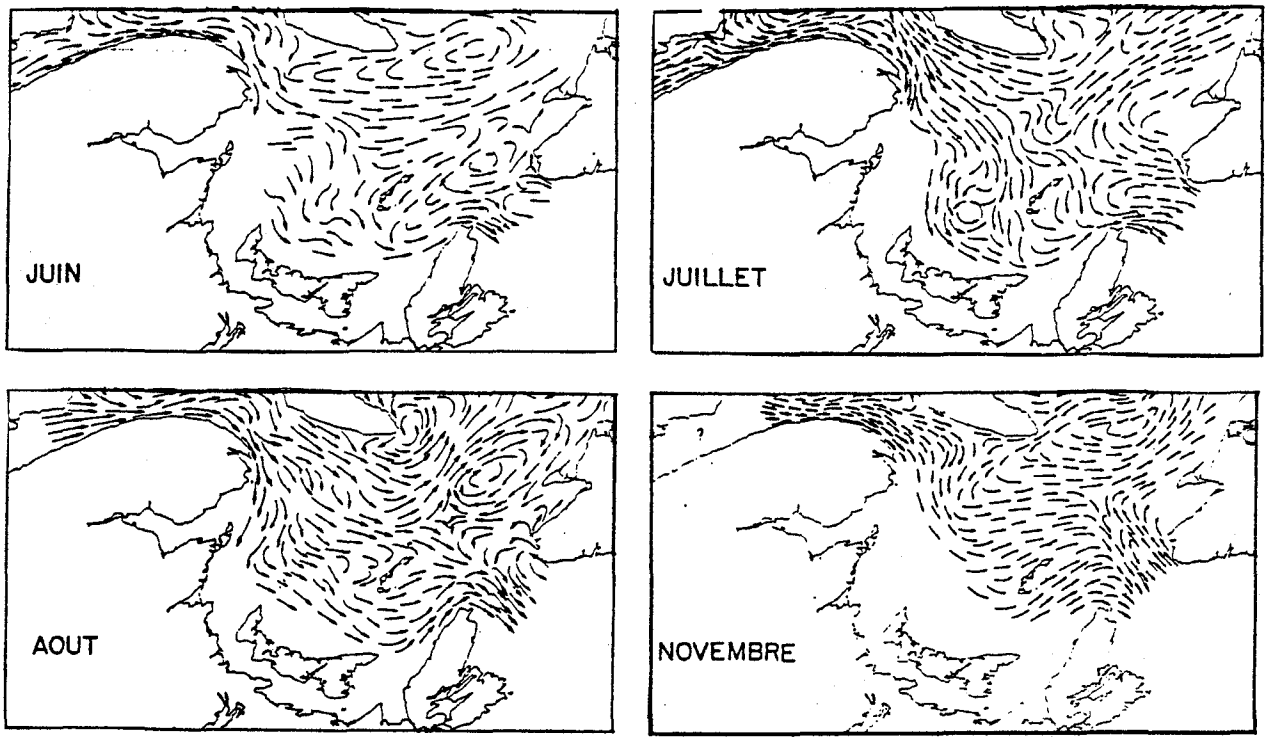

Figure 8. Surface drift in the southern Gulf of St. Lawrence in June-November (from Messieh and El-Sabh, 1979).

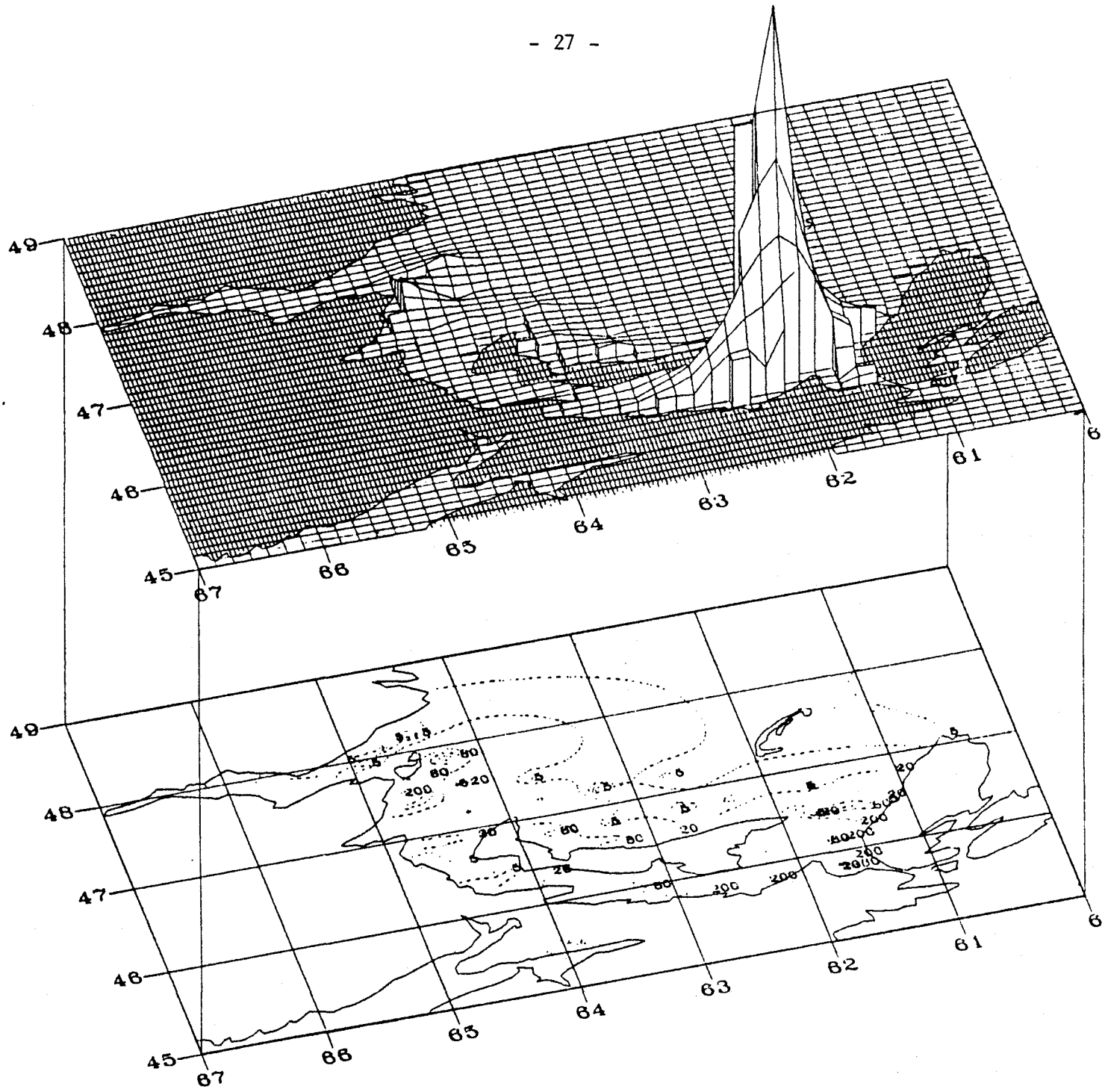

Figure 9. Distribution of herring larvae per 10m square as found in Larval Herring Cruise conducted in the Gulf of St. Lawrence, September 19 - October 1, 1979.

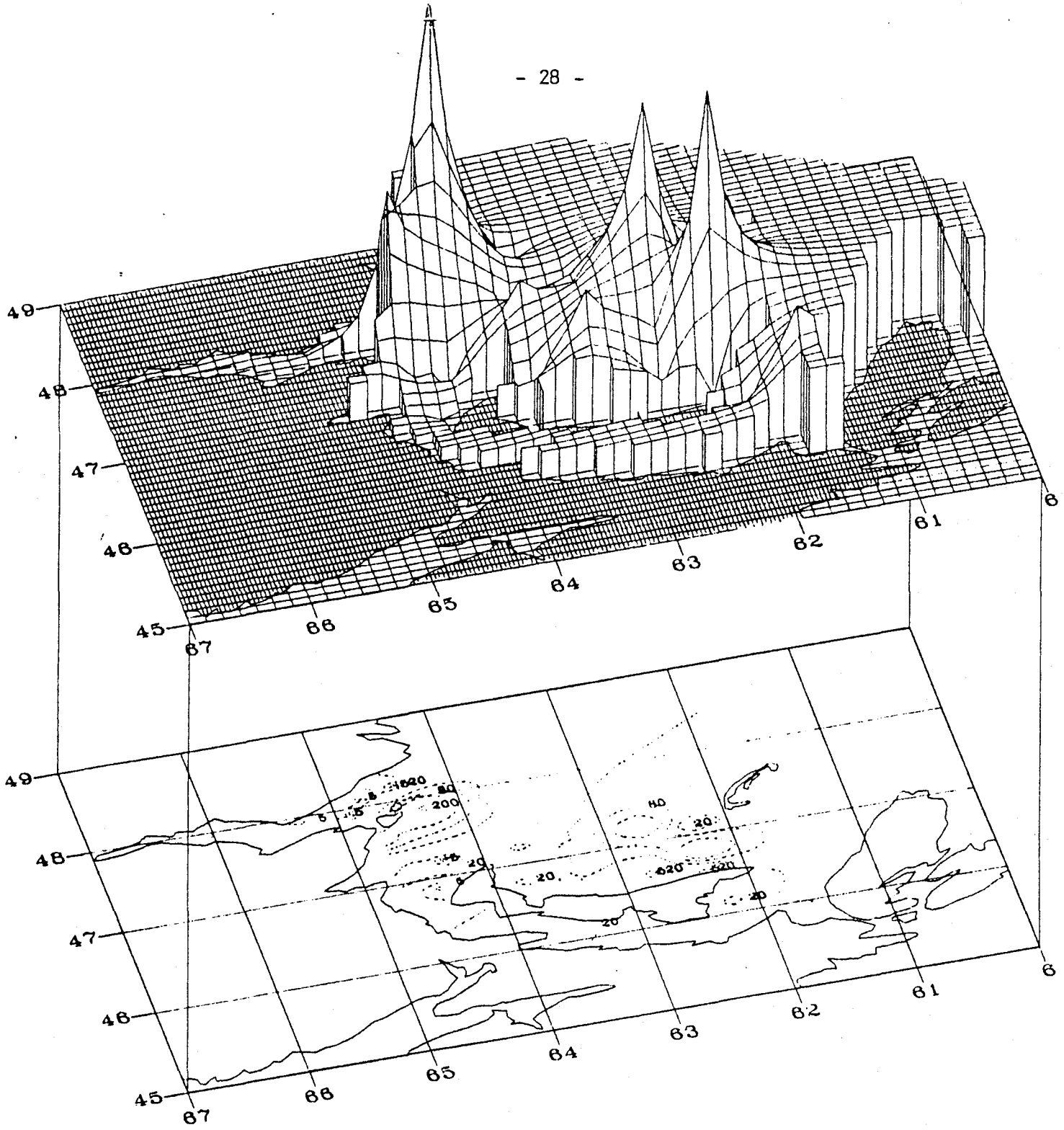

Figure 10. Distribution of herring larvae per 10m square, as found in Larval Herring Cruise conducted in the Gulf of St. Lawrence, October 10 - 14, 1979.