

Distribution and Abundance of Pre-recruit and Commerical-sized American Plaice on the Grand Bank

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Abstract

Length compositions of American plaice, *Hippoglossoides platessoides* (Fabr.), catches on the Grand Bank from spring stratified-random groundfish surveys during 1971-80 were analyzed to assess the distribution and relative abundance of pre-recruits and commercial-sized fish. Highest concentrations of both groups occurred on the north and northeast slopes of the bank which are strongly influenced by the cold Labrador Current. Both pre-recruit and commercial-sized American plaice were found in the same general areas at very similar depths and near-bottom temperatures, indicating that the nursery grounds for juveniles are not isolated from commercial fishing grounds.

Introduction

The greatest abundance of American plaice in the Northwest Atlantic occurs on the Grand Bank off Newfoundland (NAFO Divisions 3L, 3N and 3O). The fishery, which has consistently yielded approximately 50,000 tons annually in recent years, occurs mainly on the northwestern part of the bank (Div. 3L) in depths of 70-185 m, along the southeastern edge of the bank (Div. 3N) in depths of 70-275 m, and to a lesser extent on the southwestern part of the bank (Div. 3O) in depths of 70-185 m (Fig. 1).

Pitt (1967) concluded that large numbers of juvenile American plaice (ages 3-5 years) live principally on the shallow parts of the Grand Bank and postulated that these areas serve as nursery grounds for the young which are ultimately recruited to the exploitable population located on the slopes of the bank. The purpose of this paper is to investigate Pitt's (1967) hypothesis, to describe in some detail the relative distribution and abundance of "pre-recruit" American plaice less than the minimum commercial size of 30 cm (total length), and to compare the results with the corresponding distribution and abundance of commercial-sized fish (≥ 30 cm).

The American plaice population on the Grand Bank lives mainly under the influence of the cold Labrador Current (Pitt, 1975), which divides when it comes in contact with the shallow northern projection of the bank (about 47°35'N). One branch of the current passes southwestward through the Avalon Channel with some southward flow over the shallow plateau of the bank, and the seaward branch continues southward along the eastern slope of the bank (Smith *et al.*, 1937; Templeman, 1966). The warm Gulf Stream flows eastward south of the Grand Bank, and the mixing of

cold and warm waters creates slope water of intermediate temperature which affects the southwest slope of the bank. Thus, temperature and depth are important parameters in any consideration of the distribution and abundance of both pre-recruit and commercial-sized American plaice on the Grand Bank.

Materials and Methods

The data used in this study were collected during groundfish surveys of the Grand Bank in the spring, with coverage of Div. 3L and 3N in 1971-80 and Div. 3O in 1973 and 1975-80. The surveys were conducted by the Canadian research vessel *A. T. Cameron* with a Yankee No. 41.5 otter trawl, the codend of which was lined with 30-mm mesh netting. The trawl was towed at a speed of 3.5 knots (108 m/min) for 30 min at each fishing station. The fishing locations were determined according to the stratified-random survey design for the Grand Bank (Doubleday, 1981; Pitt *et al.*, 1981).

The American plaice catch at each fishing station was quantified by number and weight (kg). Among the various biological data collected were length frequencies based on the measurement of fish as total length (TL) to the nearest centimeter. For analysis, the length frequencies of American plaice, weighted to the number caught at each fishing station, were divided into two major length groups, termed "pre-recruits" (< 30 cm TL) and "commercial-sized" fish (≥ 30 cm TL), and the first group was further subdivided into three size-groups (2-9 cm, 10-19 cm and 20-29 cm). Distribution and relative abundance of each size-group are based on average catch-per-tow in each stratum after combination of data for 1971-80 (i.e. total number of fish caught per stratum divided by total number of tows per stratum).

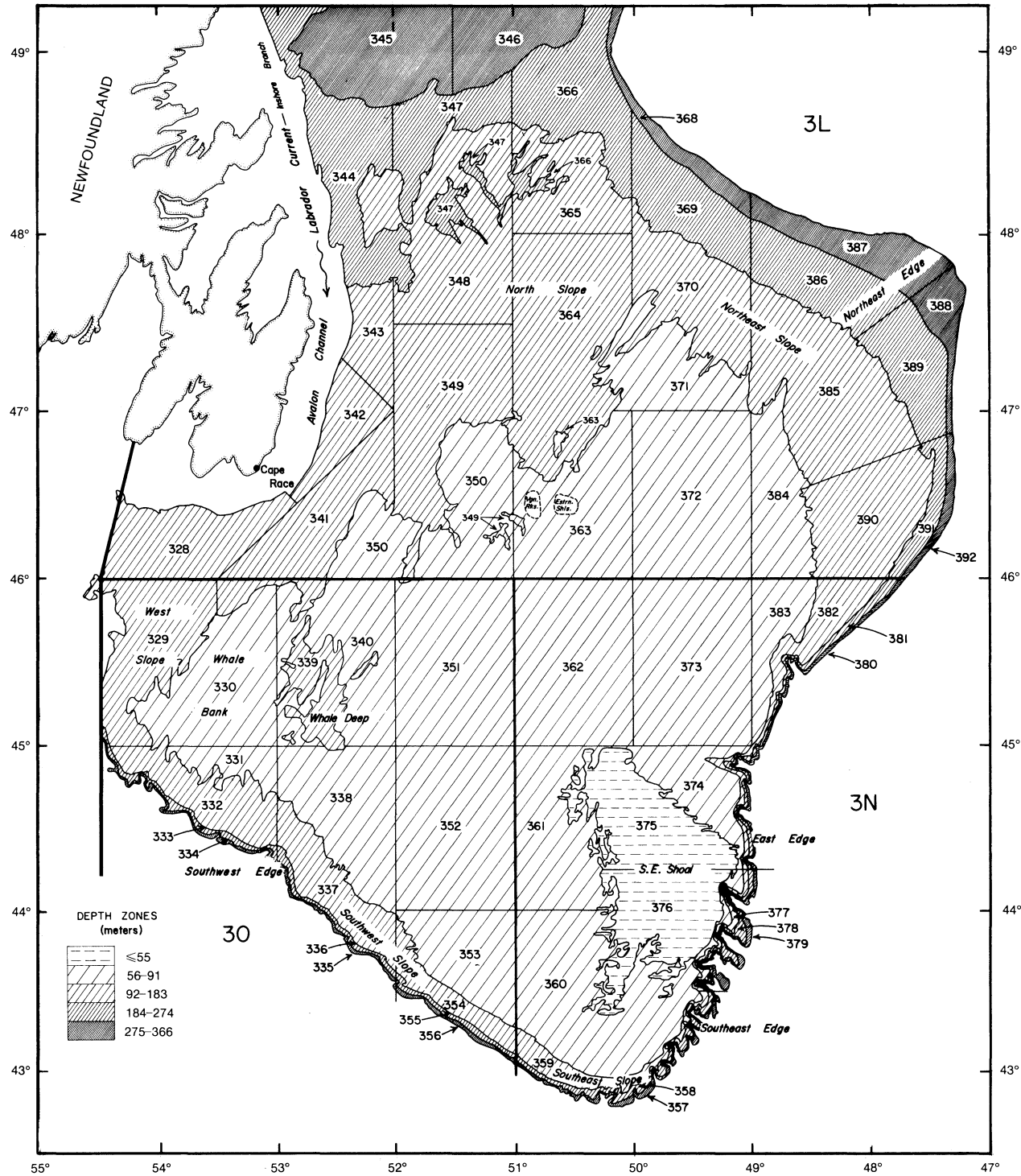


Fig. 1. Stratified-random survey design for the Grand Bank, with place names used in the text.

Bottom depth and near-bottom temperature data collected at each fishing station during the 1971-80 period were averaged for each stratum to examine the relationship between these parameters and the distribution and abundance of American plaice by stratum.

Mean depth and temperature preferences of the various size-groups of fish in each division were examined by calculating the overall average depth and temperature for each size-group using the numbers caught in each stratum during 1971-80 as weighting factors.

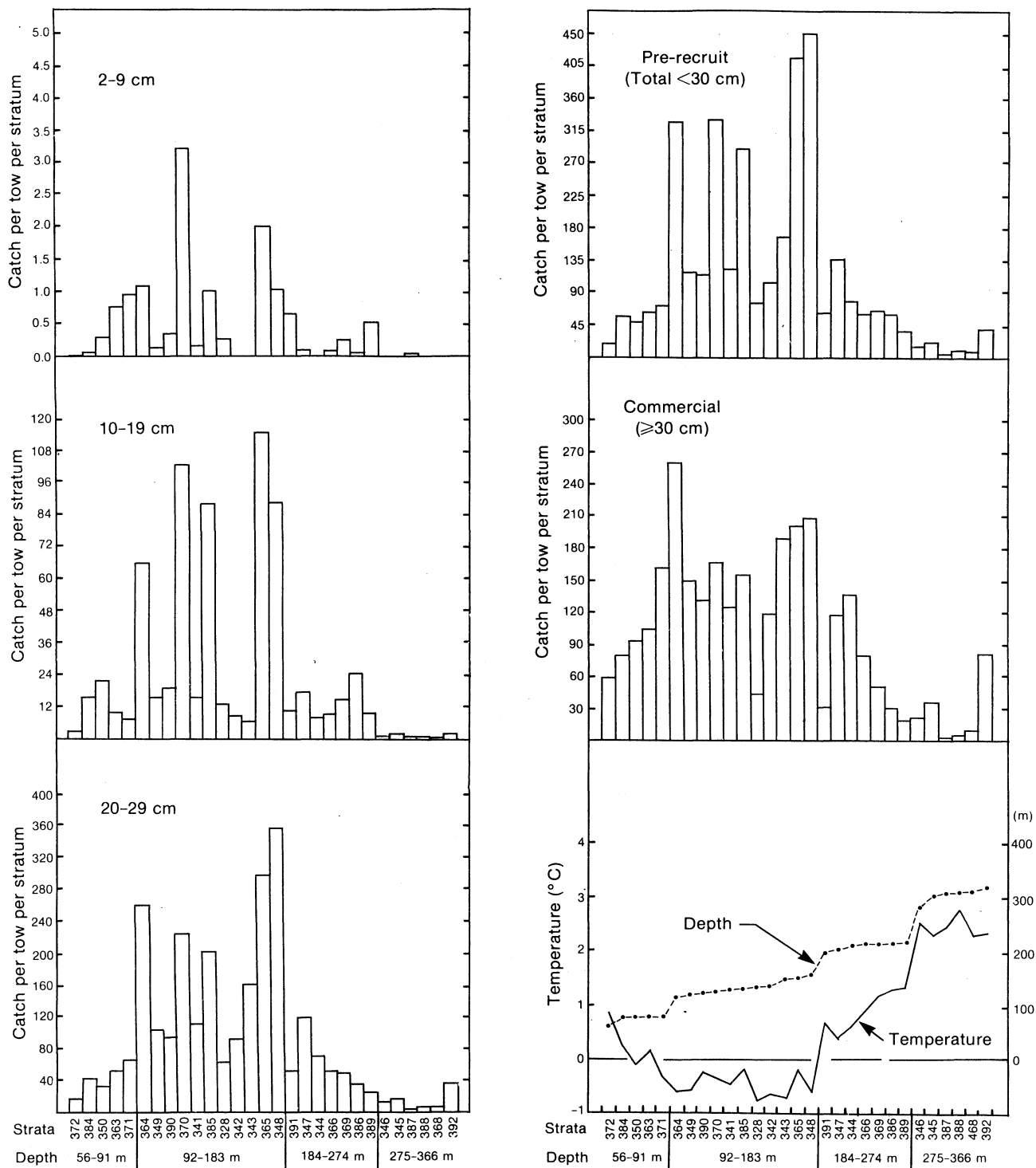


Fig. 2. Mean catch-per-tow by stratum for American plaice size-groups and associated mean depth and temperature trends in Div. 3L, 1971-80.

Results

Distribution and relative abundance

The average number of pre-recruit and commercial-sized American plaice caught per tow on the

Grand Bank (Div. 3L, 3N and 3O) by stratum and depth interval are listed in Appendix Table A, together with the corresponding average depths and near-bottom temperatures. These data are illustrated separately by division in Fig. 2, 3 and 4.

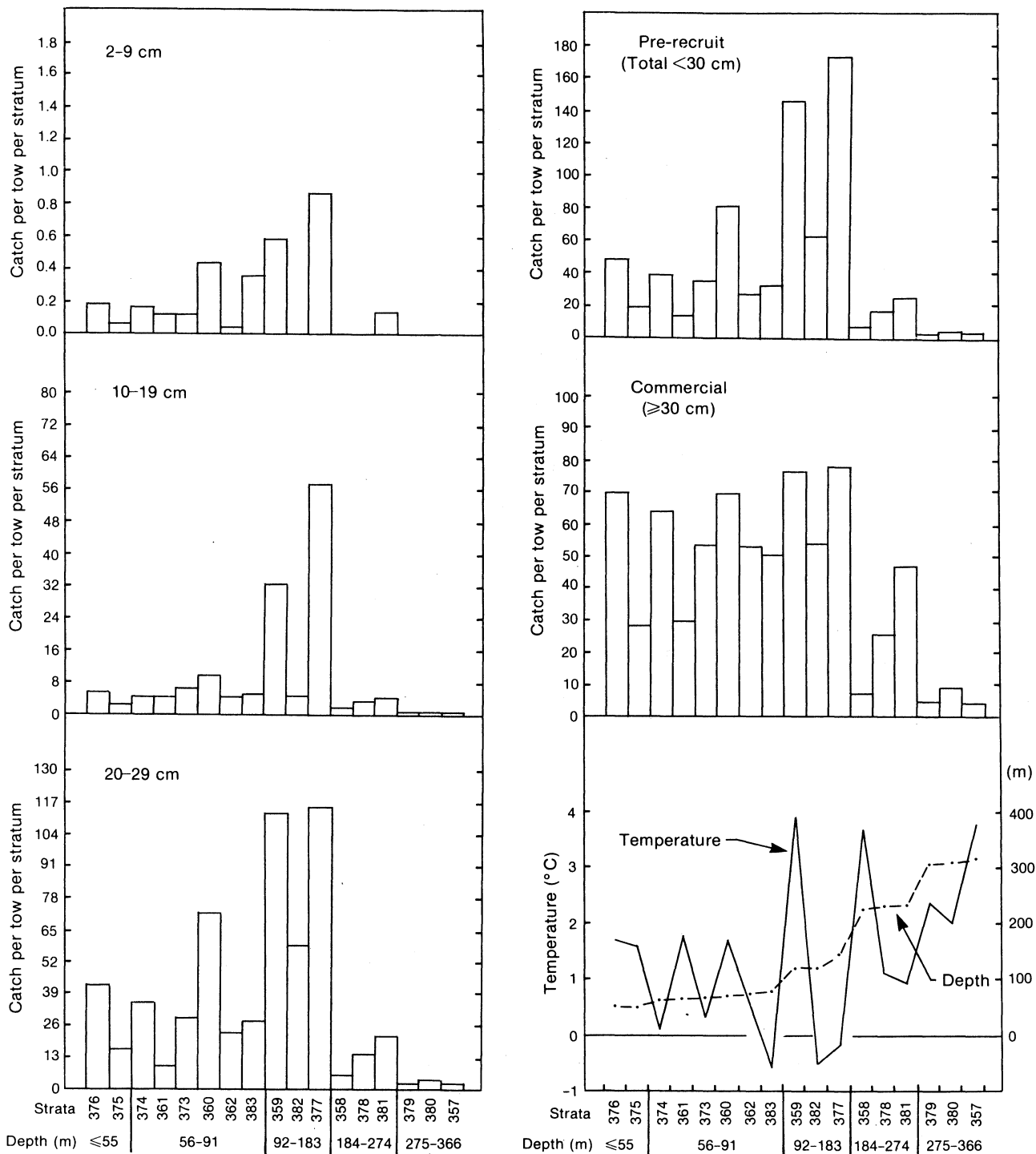


Fig. 3. Mean catch-per-tow by stratum for American plaice size-groups and associated mean depth and temperature trends in Div. 3N, 1971-80.

Division 3L. The highest concentrations of pre-recruit and commercial-sized American plaice were distributed in various strata on the north and northeast slopes of the bank in depths of 92-183 m where temperatures were below 0° C (Fig. 2). Smaller quantities were found at shallower depths (57-91 m) where tempera-

tures varied around 0° C. In deeper strata on the slopes, the catch-per-tow of both size groups (<30 cm and ≥30 cm) declined with increasing depth and temperature, except for the anomalously higher catches in stratum 392 (about 330 m) where the average temperature was 2.4° C. Very few small fish (<20 cm) were taken in the

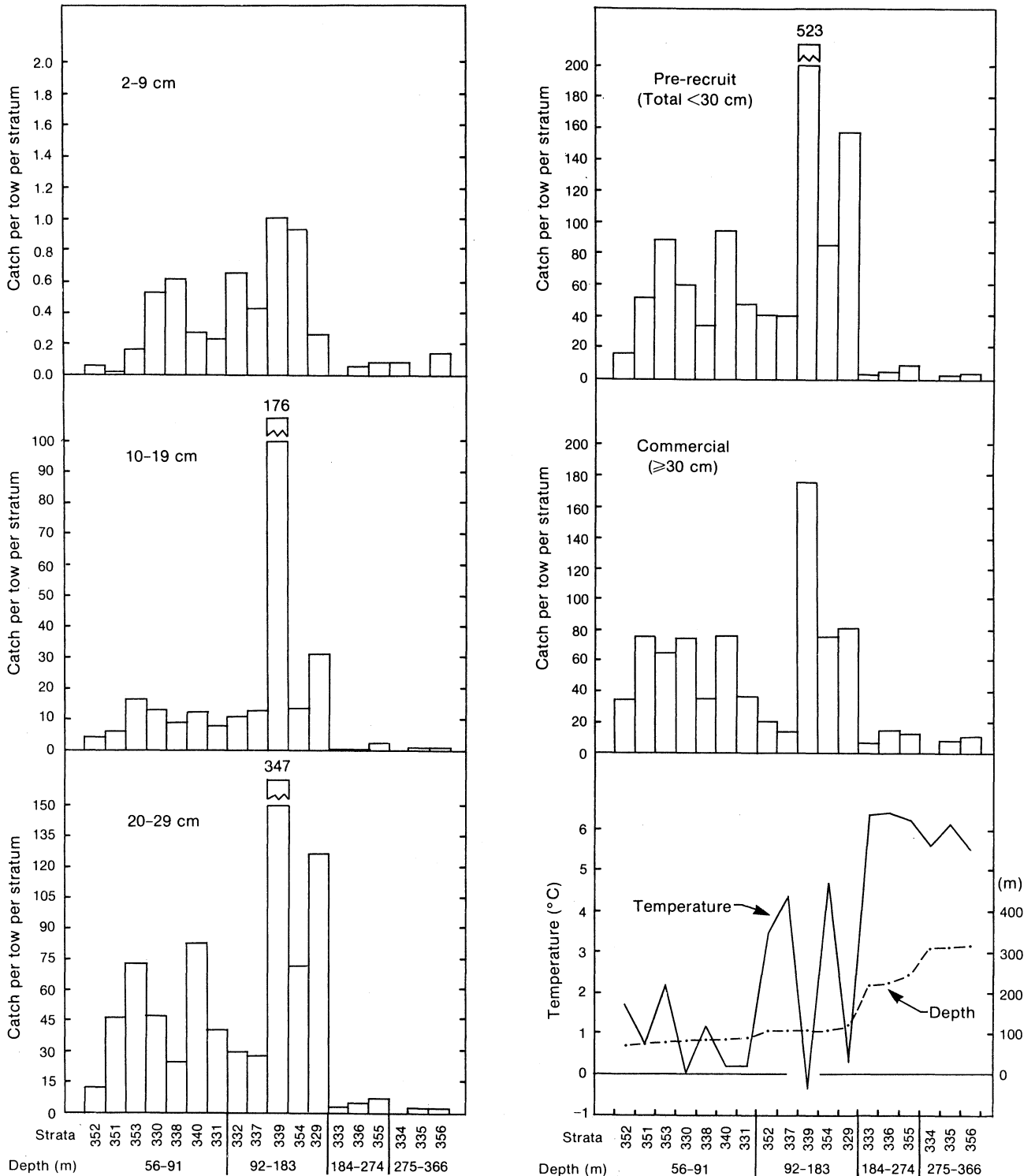


Fig. 4. Mean catch-per-tow by stratum for American plaice size-groups and associated mean depth and temperature trends in Div. 30, 1973-80.

deepwater strata (≥ 275 m). Among the three size-groups of pre-recruits, there was great variation in catch-per-tow per stratum, particularly for the two smallest size-groups, but the distribution patterns show no obvious trends that could be construed as indicative of differences.

Division 3N. The highest concentrations of pre-recruit American plaice of all three size-groups were found on the eastern slope in stratum 377 (143 m), where the mean temperature was slightly less than 0°C , and on the southeast slope (118 m), where the temperature averaged 3.9°C (Fig. 3). Pre-recruits

occurred in somewhat lesser abundance at shallower depths (<92 m), where the mean temperature generally ranged from 0° to 1.8° C, but commercial-sized fish were almost as abundant at most of these shallower strata as in the deeper strata (92–183 m). Along the eastern and southern slopes of the bank in depths greater than 183 m, with characteristically warm bottom water below the cold core of the Labrador Current, concentrations of pre-recruit and commercial-sized American plaice were small, except in strata 378 and 381 (230 m) where the bottom temperature was about 1° C in each case. The trends in distribution of the three size-groups of pre-recruits by stratum were generally similar.

Division 3O. The highest concentrations of both pre-recruit and commercial-sized American plaice were found in stratum 339 (Whale Deep, mean depth 107 m) and in stratum 329 (West Slope, mean depth 115 m) where the average temperatures were -0.3° and 0.3° C respectively (Fig. 4). Catches were moderate in shallower strata adjacent to Whale Deep (i.e. strata 351, 330 and 340), where the mean temperatures ranged from 0.1° to 0.8° C, and surprisingly also in stratum 354 (107 m) on the southwest slope where the temperature averaged 4.8° C. The deepwater strata along the southwest slope (≥ 184 m), where temperatures were higher than 5° C, yielded very small catches of both pre-recruit and commercial-sized American plaice. No obvious difference in distribution was evident among the three size-groups of young fish.

Depth and temperature preferences

In each of the three major divisions of Grand Bank, pre-recruits tended to prefer slightly greater depths, on the average, than commercial-sized American plaice (Table 1), but the differences are not considered significant in view of the apparently large variances associated with the weighted mean depths. However, on the northern half of the bank (Div. 3L), both pre-recruit and commercial-sized fish tended to prefer considerably greater depths than those inhabiting the southern half of the bank (Div. 3N and 3O).

Temperature preferences of all size-groups of American plaice were, on the average, slightly below 0° C in Div. 3L, with little variation among the weighted mean values. They were somewhat higher around 1° C, on the average, in Div. 3N and 3O, with considerably greater variation among the weighted mean values. The greater temperature variation and the shallower preferred depths on the southern half of the Grand Bank implies that American plaice tend to avoid the deeper areas along the slopes which are more influenced by warm slope water than on the northern part of the bank which is directly influenced by cold water of the Labrador Current.

TABLE 1. Mean depth and temperature patterns for different size-groups of American plaice on the Grand Bank, weighed by the catches of the size-groups in the various strata, 1971–80.

Div.	Length group (cm)	Depth (m)		Temperature (°C)	
		Mean	SD	Mean	SD
3L	2–9	133.1	39.8	-0.06	0.89
	10–19	141.6	36.9	-0.09	0.76
	20–29	147.2	43.7	-0.15	0.82
	<30	145.9	42.4	-0.14	0.81
	≥ 30	139.7	54.4	-0.04	0.93
3N	2–9	99.2	45.2	1.81	2.69
	10–19	113.8	49.6	1.11	2.03
	20–29	100.4	50.1	1.28	2.18
	<30	102.9	50.3	1.25	2.16
	≥ 30	94.2	55.8	0.91	1.68
3O	2–9	100.1	38.2	2.25	3.61
	10–19	103.0	24.8	0.77	2.17
	20–29	97.5	25.5	0.88	2.13
	<30	98.7	25.5	0.87	2.15
	≥ 30	93.3	33.5	1.07	2.04

Discussion and Conclusions

The analysis of the survey data for 1971–80 indicates that pre-recruit and commercial-sized American plaice occupy the same general areas of the Grand Bank. This does not support Pitt's (1967) hypothesis that the shallower parts of the bank serve as nursery grounds for the Grand Bank population, with the young fish (ages 3–5) moving deeper as they grow older. However, the areas of high abundance of American plaice are in agreement with Pitt's (1975) description of the sites of the commercial fishery.

The research vessel surveys were carried out only during the spring of each year, and, consequently, there are no data for comparison of concentrations of pre-recruit and commercial-sized American plaice during other seasons. Powles (1965) found mixtures of immature and mature American plaice along the southern slope of the Laurentian Channel (Gulf of St. Lawrence) at depths of 75–150 m (temperature range from -1.7 to 5.0° C) during the spring, and both groups were found together at shallower depths (40–100 m) during the summer. McCracken (1963) reported that both immature and mature winter flounder, *Pseudopleuronectes americanus*, in the Bay of Fundy are found together in shallow water during the spring and also throughout a wider depth zone during the summer.

The distributional patterns evident from the overall weighted mean depths by size-groups for the three divisions (Table 1) indicate slightly greater mean

depths for pre-recruit than for commercial-sized American plaice. Since the data base with respect to depth and temperature is a coarse one when considered over a 10-year period, it does not lend itself to tests of significance by standard statistical methods due to lack of homogeneity of variances. However, the magnitudes of the standard deviations in relation to the means indicate that the differences in mean depths are unlikely to be statistically significant. The smaller variation in the weighted mean temperatures on the northern part of the bank in contrast to the greater temperature variation found on the southern part of the bank indicates that American plaice have a relatively wide temperature tolerance, which Powles (1969) also found for the same species in the southern Gulf of St. Lawrence. The overall mean depths and temperatures for the various size-groups are within the ranges cited by Pitt (1967) and Powles (1969) in their studies of American plaice on the Grand Bank and in the southern Gulf of St. Lawrence respectively during the spring period.

The distribution of American plaice on the Grand Bank is closely linked to the early life history stages and the water circulation in the area. Spawning occurs during March–September over most of the Grand Bank, being most intense during April–May (Pitt, 1966; Nevinsky and Serebryakov, 1973). Unlike the same species (long rough dab) in the Barents Sea (Milinsky, 1944) and the European plaice, *Pleuronectes platessa*, in the North Sea (Bannister *et al.*, 1974) which make fairly extensive spawning migrations, American plaice on the Grand Bank do not do so, according to the conclusion of Pitt (1969) from tagging experiments. After spawning, American plaice eggs and larvae are planktonic and drift with the currents until metamorphosis (24–30 mm) when the small juveniles descend to the bottom (Bigelow and Schroeder, 1953). Although the Labrador Current flows strongly southward along the western and eastern slopes of the Grand Bank, low current velocities and eddies over most of the shallow areas of the bank tend to retain the eggs and larvae over or near the spawning grounds (Nevinsky and Serebryakov, 1973). There is no evidence of larval drift to coastal nursery sites, as occurs for European plaice in the North Sea (Harding *et al.*, 1978). Hence, the newly-metamorphosed juveniles (>20 mm) tend to occupy the same areas of the bank as the adults which produced them several weeks earlier. Exceptions apparently occur in certain strata on the slopes around the bank where the occurrence of large juveniles and adults in the catches was not accompanied by the presence of 2–9 cm juveniles. Current velocities tend to be higher around the fringes of the bank, so that eggs and larvae may be transported by eddies away from the bank over oceanic depths or onto the shallow areas of the bank.

Relative to the catches of the large juveniles (10–29 cm), the small catches of 2–9 cm juveniles undoubtedly do not reflect the abundance of this size-group. This may in part be attributed to inefficiency of the trawl in sampling over the entire range of this length-group, because the catches consisted mainly of 6–9 cm fish. The inadequacy of the Yankee No. 41.5 otter trawl for sampling very small flatfish has been reported for yellowtail flounder, *Limanda ferruginea*, by Pitt (1970), who found no 1-year-old and 2-year-old fish (<12 cm) in surveys of the Grand Bank. However, the relatively high catches of 10–19 cm and 20–29 cm juveniles and the similarity of their distributions by strata to those for adult American plaice in all three major divisions of the Grand Bank support the view that the nursery grounds for juveniles are not isolated from the commercial fishing grounds. A similar conclusion was expressed by Powles (1969) for the American plaice population in the southern Gulf of St. Lawrence. The concentration of juveniles in the same areas as commercial-sized fish was also clearly evident from the study of Stevenson (MS 1980), who estimated that the Canadian fishing fleet discarded 17 million and 29 million undersized American plaice on the Grand Bank in 1978 and 1979 respectively.

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APPENDIX

TABLE A. Average catch (numbers) per tow per stratum of American plaice by depth on the Grand Bank (Div. 3L, 3N and 3O) from research vessel surveys, 1971-80.

NAFO Div.	Depth range (m)	Stratum number	No. of tows	Average number per tow by size group (cm)					Average depth (m)	Average temp. (°C)
				2-9	10-19	20-29	<30	≥30		
3L	57-91	372	47	0.02	2.60	16.66	19.28	58.81	69.3	0.89
		384	22	0.05	15.18	42.68	57.91	80.27	78.4	0.25
		350	48	0.29	21.52	30.92	52.73	93.31	80.4	-0.07
		363	46	0.76	9.57	52.76	63.09	104.26	81.5	0.18
		371	21	0.95	7.19	65.67	73.81	162.81	81.6	-0.33
	92-183	364	43	1.09	65.77	260.88	327.74	261.53	115.2	-0.59
		349	45	0.11	14.78	102.78	117.67	149.80	122.1	-0.53
		390	29	0.34	19.17	94.69	114.21	128.00	125.1	-0.21
		370	27	3.19	102.70	223.48	329.37	166.81	129.4	-0.34
		341	21	0.14	15.10	110.95	126.19	123.52	134.1	-0.42
		385	43	1.00	87.77	200.65	289.42	154.88	134.3	-0.16
		328	8	0.25	13.00	62.25	75.50	44.88	137.9	-0.73
		342	12	0.00	8.42	92.58	101.00	119.50	140.1	-0.63
		343	13	0.00	6.54	161.23	167.77	189.46	153.5	-0.67
		365	27	2.00	115.00	296.37	413.37	204.85	155.1	-0.20
	348	47	1.04	88.40	356.60	446.04	211.04	163.3	-0.60	
	184-274	391	20	0.65	11.15	50.50	62.30	31.20	201.7	0.73
		347	25	0.08	17.24	118.96	136.28	116.60	209.9	0.44
		344	18	0.00	7.72	71.06	78.78	136.39	212.6	0.68
		366	28	0.07	9.21	50.89	60.18	75.57	218.3	0.97
		369	25	0.24	14.56	48.08	62.88	47.88	220.7	1.24
		386	23	0.04	24.70	34.39	59.13	29.61	221.4	1.30
		389	27	0.52	9.63	25.00	35.15	18.59	222.5	1.37
	275-366	346	16	0.00	1.19	12.94	14.13	20.50	287.8	2.57
		345	20	0.00	1.65	17.60	19.25	35.55	308.6	2.33
		387	24	0.04	0.83	3.88	4.75	1.67	316.1	2.50
		388	21	0.00	0.71	5.81	6.52	4.14	317.9	2.83
		368	19	0.00	0.47	5.37	5.84	10.21	321.7	2.33
		392	20	0.00	1.35	37.40	38.75	81.15	325.6	2.39
	3N	<57	376	22	0.18	5.41	42.45	48.05	69.68	50.3
375			36	0.06	2.36	16.11	18.53	28.06	51.1	1.56
57-91		374	25	0.16	4.24	34.84	39.24	63.64	60.7	0.10
		361	49	0.12	4.29	9.06	13.47	29.35	62.9	1.77
		373	50	0.12	6.52	28.44	35.08	53.48	65.2	0.33
		360	46	0.43	9.59	71.52	81.54	69.28	66.8	1.67
		362	56	0.04	4.36	22.66	27.05	52.73	70.3	0.61
		383	23	0.35	4.91	27.39	32.65	50.26	76.5	-0.58
92-183		359	19	0.58	32.42	112.63	145.63	75.95	117.8	3.87
		382	28	0.04	4.29	58.14	62.46	53.82	122.0	-0.55
		377	22	0.86	57.18	114.91	172.95	77.27	143.1	-0.19
184-274		358	14	0.00	1.57	5.36	6.93	6.71	221.6	3.66
		378	20	0.00	3.20	13.65	16.85	25.70	230.2	1.08
		381	30	0.13	4.03	20.63	24.80	46.60	230.5	0.93
275-366		379	16	0.00	0.44	2.25	2.69	4.19	307.5	2.37
		380	16	0.00	0.44	3.75	4.19	8.56	309.5	1.97
		357	10	0.00	0.40	2.50	2.90	3.70	314.8	3.78
3O		57-91	352	51	0.06	4.06	12.18	16.29	34.67	69.9
	351		46	0.02	5.89	45.91	51.83	75.22	74.6	0.76
	353		25	0.16	16.64	72.44	89.24	64.80	75.2	2.14
	330		29	0.52	13.10	47.14	60.76	73.93	79.3	0.07
	338		31	0.61	9.00	24.94	34.55	34.58	80.7	1.16
	340		26	0.27	12.19	82.31	94.77	75.62	83.3	0.14
	331		13	0.23	7.77	40.54	48.54	35.85	87.5	0.14
	92-183	332	17	0.65	10.88	30.12	41.65	20.65	104.4	3.46
		337	19	0.42	12.79	28.05	41.26	13.47	106.7	4.39
		339	10	1.00	175.60	346.60	523.20	175.80	107.2	-0.27
		354	15	0.93	13.67	71.60	86.20	75.13	107.7	4.75
		329	19	0.26	31.42	126.11	157.79	80.84	114.5	0.34
		333	13	0.00	0.31	3.23	3.54	654.00	220.8	6.39
	184-274	336	18	0.06	0.22	4.89	5.17	14.72	225.6	6.44
		355	12	0.08	2.25	6.67	9.00	11.75	244.5	6.23
		334	13	0.08	0.08	0.38	0.54	0.31	311.1	5.63
	275-366	335	13	0.00	0.62	2.15	2.77	8.08	311.6	6.15
		356	7	0.14	0.71	2.29	3.14	10.71	311.9	5.50