NAFO Sci. Coun. Studies, 19: 59–70

Late Winter Distribution of the American Plaice (*Hippoglossoides platessoides*) in St. Pierre Bank, 1978–90

Ph. Moguedet and J. C. Mahé
Institut Français de Recherche pour l'Exploitation de la Mer
B. P. 477, F-97302 Cayenne, Guyane Française

Abstract

The late winter distributions of the American plaice (*Hippoglossoides platessoides*) in St. Pierre Bank (NAFO Subdiv. 3Ps) during the period 1978–90 were analyzed using catches-per-30-min-tow data obtained during the French groundfish surveys which have been conducted annually in February–March. Water temperatures from surface to bottom recorded at the end of each trawling operation were used along with temperature recordings from a standard hydrographic transect.

Largest temperature fluctuations occurred in the two upper depth ranges (0–99 and 100–199 m) and were assessed to be due to the great influence of the Labrador Current. Generally, American plaice was well represented in the Halibut Channel. During cold winters (1982, 1985–87, 1989 and 1990), highest concentrations were observed on the southwest slope of Saint-Pierre Bank, and this was thought to be related to the movement of the cold Labrador Current.

Key words: American plaice, *Hippoglossoides patessoides*,hydrography, late winter distribution, St. Pierre Bank

Introduction

Annual groundfish surveys have been conducted in late winter (February–March, Table 1) in St. Pierre Bank (NAFO Subdiv. 3Ps, Fig. 1) since 1978 by French scientists. Biomass and abundance of American plaice (*Hippoglossoides platessoides*) have been estimated from those survey results. While the distribution of American plaice population which constitute a single stock in this region (Bowering and Brodie, 1991) includes the Halibut Channel and the southwest slope of St. Pierre Bank, some spatial variations in the biomass estimates have been noticed over the studied period.

The objective of this paper was to analyze these variations in the distribution of American plaice through the period 1978–90 and to relate them to year by year fluctuations in temperatures observed in the St. Pierre Bank area in winter, as it had been noted on the Grand Bank (Pitt, 1969; Pitt, 1975).

Materials and Methods

The standard methods of the surveys which were conducted every year are described by Forest and Minet (1981). The sampling design consists of randomly selected trawling stations, their number being proportional to the variance observed in the cod abundance (main species sought) in each stratum of the stratified area (Fig. 2). Trawling operations were standardized to 30 mins at 4 knots.

Catches in numbers and weight were recorded for each tow for the main commercial species (cod, American plaice, redfish, etc.), and the average values were calculated by stratum. For each year, catches of American plaice in weight per tow (kg/30 min) were plotted on maps of Subdiv. 3Ps to depict abundance. For the strata where American plaice was frequently distributed (strata 316, 317, 319, 322, 323, 324), the relationships between bottom temperature (average of temperatures observed on all trawling operations in the stratum) and

TABLE 1. Dates of the French groundfish surveys and transects in NAFO Subdiv. 3Ps from 1978 to 1990 (ERHAPS surveys on R/V Cryos).

	Dates of surveys		Dates of transects	
Year	Beginning	End	Beginning	End
1978	02/21	03/25	03/14	03/19
1979	02/21	03/20	03/07	03/08
1980	03/03	03/12	–	–
1981	02/24	03/31	03/11	03/21
1982	03/05	04/02	03/12	03/19
1983	02/10	03/19	02/26	03/02
1984	02/15	03/19	03/15	03/18
1985	02/09	03/10	03/13	03/14
1986	02/09	03/10	02/21	02/22
1987	02/04	03/06	03/05	03/06
1988	02/09	03/11	03/07	03/08
1989	02/14	03/19	03/09	03/10
1990	02/26	03/28	03/12	03/13

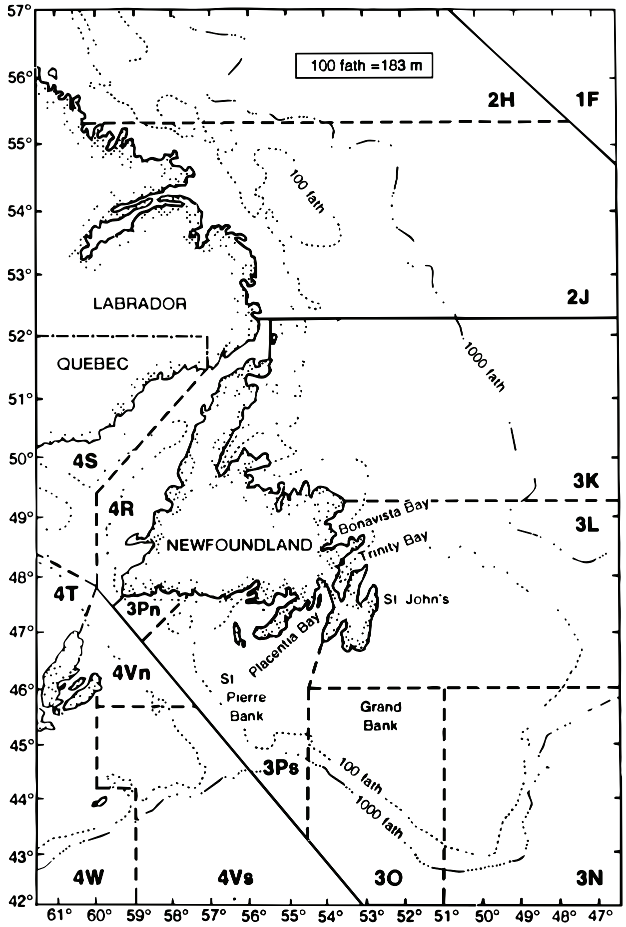

Fig. 1. Map showing NAFO Divisions and Subdivisions referred to in the text.

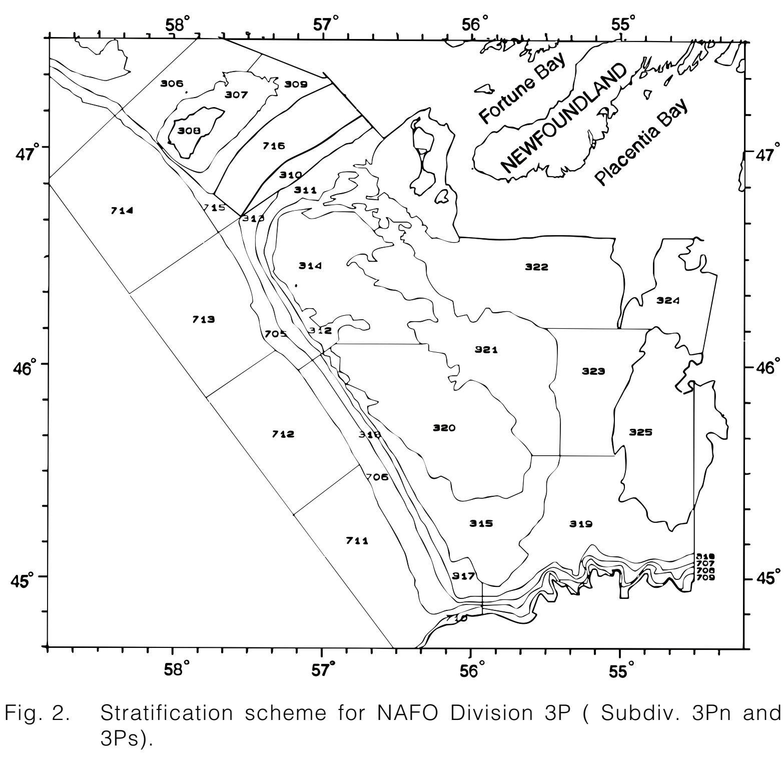

Fig. 2. Stratification scheme for NAFO Division 3P (Subdiv. 3Pn and 3Ps).

TABLE 2. Number of temperature observations near the bottom on locations of trawling sets from 1978 to 1990.

Depth (m)	Year												
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
<100	23	19	11	27	20	27	29	5	17	13	14	22	17
100–199	19	24	11	33	30	32	28	2	31	25	36	46	48
200–299	10	14	12	19	20	24	15	3	25	30	20	27	25
>300	7	9	6	29	12	24	15	4	21	14	13	18	32
Total	59	66	40	108	82	107	87	14	94	82	83	113	122

TABLE 3. Mean temperatures observed near the bottom on locations of trawling sets by depth zones from 1978 to 1990.

Depth (m)	Year												
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
<100	0.3±3.0	–0.4±0.5	–0.1±1.6	1.2±1.4	–0.4±1.0	0.3±1.0	1.5±2.2	–1.1±0.7	–0.1±1.3	–0.2±1.7	0.3±1.0	–0.7±1.4	–1.3±0.0
100–199	1.3±5.2	2.0±5.8	1.3±3.6	1.6±4.8	1.1±2.3	1.0±3.5	4.4±6.9	–0.9±0.3	1.0±5.1	1.5±5.4	1.6±6.6	0.8±3.2	0.6±3.0
200–299	5.9±2.7	6.8±2.2	5.9±3.2	6.4±2.3	4.5±2.9	4.7±1.7	7.0±2.4	5.6±5.7	6.8±2.8	6.2±1.9	3.9±9.0	5.0±2.4	4.5±2.0
>300	5.3±1.0	6.6±0.9	6.1±0.9	5.4±1.1	4.8±1.9	5.0±0.6	6.4±1.3	7.2±0.6	6.2±1.4	5.7±1.2	1.8±2.4	5.2±1.3	5.0±2.0

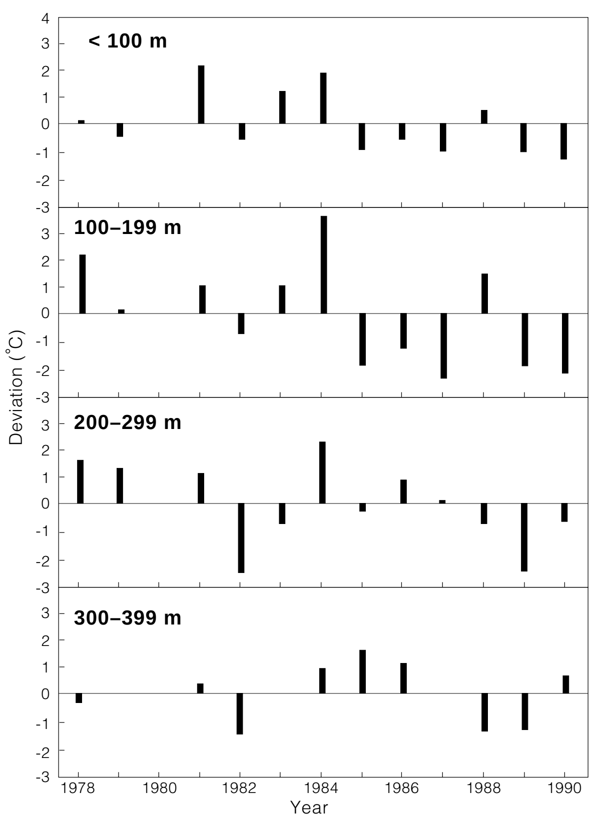

Fig. 3. Yearly deviations to the 1978-90 mean temperature in different depth ranges from the hydrographic transects (1980 excluded).

abundance (average catch weight-per-tow in the stratum) were studied for the period 1978–90, except for the year 1980 where sufficient data were not available.

Water temperature was recorded from surface to bottom at the end of each trawling operation by means of XBT casts. Table 2 shows the number of observations made at each bottom depth stratum. From the hydrographic transect carried out every year, crossing the St. Pierre Bank from the southwestern slope to the north of Green Bank, yearly mean temperatures were obtained by 100 m depth ranges. These means were compared with the average bottom temperatures observed in the groundfish surveys in the same depth ranges over the period studied.

Results and Discussion

Analysis of temperature anomalies by 100 m depth strata showed the largest temperature fluctuations were generally in the two upper ranges (0–99 m and 100–199 m), except for the years 1982, 1984 and 1989 when important variations were encountered in the depth range 200–299 m (Fig. 3, Table 3). Generally, at the deeper ranges (>300 m) the fluctuations were low.

According to Moguedet and Mahé (MS 1991) and Forest and Poulard (MS 1981) the 1982, 1985–87, 1989 and 1990 winters appeared to be cold, while the three winters 1981, 1983 and 1984 were warm. Battaglia and Poulard (MS 1987) suggest that the largest temperature fluctuations occurring in the two upper depth ranges are due to the great influence of the Labrador cold water current. This was confirmed by the observations made on hydrographic section transects carried out during the survey period showing the Labrador cold water masses come from the northeast of Subdiv. 3Ps (Moguedet and Mahé, MS 1991).

TABLE 4. Yearly average catch-per-tow (kg/30 min) of American plaice by stratum from French research surveys in Subdiv. 3Ps for the 1978 to 1990 period (left justified values are when strata were not sampled and were calculated by a multiplicative model.

Strata	Max. depth (m)	Year 1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
314	0–55	0.00	0.00	3.65	5.67	8.67	0.10	1.67	0.75	2.50	3.00	3.15	0.00	0.00	2.24
320	0–55	2.80	0.33	5.55	2.67	5.67	4.70	3.33	0.10	8.50	5.46	10.00	0.00	0.00	3.78
308	55–91	2.67	0.00	0.00	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59
312	55–91	72.00	0.33	0.05	1.00	2.80	6.33	9.33	0.67	11.83	0.37	0.00	0.65	1.45	8.22
315	55–91	7.02	15.37	7.00	8.25	5.25	8.25	5.50	1.75	23.33	11.00	26.07	8.75	25.05	11.74
321	55–91	1.25	3.25	3.00	7.50	3.00	6.93	40.00	0.80	5.00	7.00	1.87	2.75	7.55	6.92
325	55–91	6.74	6.67	6.70	8.75	8.53	3.30	5.67	0.77	8.00	11.00	3.00	3.15	7.00	6.10
307	91–182	0.20	0.33	1.70	0.13	0.00	0.40	0.43	1.00	1.60	0.18	0.50	0.37	0.11	0.53
311	91–182	30.50	22.00	29.67	21.67	112.50	7.50	12.67	13.25	54.50	30.67	37.01	48.27	12.91	33.32
317	91–182	138.00	229.67	210.88	15.25	680.00	75.67	37.17	1 643.46	440.40	746.00	80.27	332.33	342.47	382.43
319	91–182	40.00	9.00	50.67	178.20	133.03	32.50	21.40	2 004.17	117.68	18.25	50.62	119.30	53.35	217.55
322	91–182	27.50	127.50	514.50	107.57	36.20	307.60	46.00	296.55	66.53	7.73	3.25	28.42	17.30	122.05
323	91–182	267.00	642.25	95.67	406.50	502.33	298.32	447.25	203.00	329.67	128.00	101.40	71.50	163.70	281.28
324	91–182	62.55	62.05	62.27	47.00	77.31	205.00	432.00	173.00	40.50	3.23	44.50	19.20	28.30	96.69
306	182–273	0.73	0.37	0.40	2.33	0.25	0.73	1.07	0.87	1.17	0.83	1.18	0.44	0.70	0.85
309	182–273	6.00	7.00	0.83	2.00	0.37	2.47	0.77	2.03	5.07	0.90	0.17	0.20	2.30	2.32
310	182–273	41.67	6.67	5.67	4.77	12.92	9.57	4.67	19.50	0.45	1.50	21.75	30.00	6.35	10.65
313	182–273	4.50	3.00	1.00	7.00	27.70	7.67	1.63	21.00	20.90	596.00	14.55	289.55	15.70	77.71
316	182–273	1.00	18.33	9.00	72.75	68.33	6.33	4.33	216.50	53.17	96.50	36.52	33.30	26.17	49.40
318	182–273	13.00	7.00	23.06	430.00	4.00	14.33	266.00	41.00	2.67	48.00	14.90	44.70	36.80	72.73
705	273–364	3.50	5.50	0.00	3.67	4.00	4.00	2.70	2.50	1.80	1.27	1.60	7.00	6.60	3.40
706	273–364	2.00	2.00	6.00	4.80	8.67	6.00	3.73	3.00	6.05	11.67	7.77	8.58	8.63	6.07
707	273–364	5.18	0.15	5.15	10.00	0.00	0.47	1.33	272.80	1.90	36.00	1.00	8.50	22.10	28.04
715	273–364	0.50	0.05	0.20	0.55	0.30	0.50	0.33	2.58	0.18	0.65	1.55	0.10	1.85	0.72
716	273–364	1.17	2.83	5.07	3.33	2.43	2.62	8.43	6.97	9.27	2.80	3.07	3.62	7.60	4.55
708	364–546	5.97	5.91	5.94	2.00	32.00	0.05	6.50	0.33	2.25	1.10	35.20	0.15	4.55	7.84
711	364–546	–	–	–	1.50	–	2.00	–	–	–	–	–	–	–	1.75
712	364–546	–	–	–	1.50	–	0.00	–	–	–	–	–	–	–	0.75
713	364–546	–	–	–	0.67	–	–	–	–	–	–	–	–	–	0.67
714	364–546	–	–	–	0.03	–	0.10	–	–	–	–	–	–	–	0.07

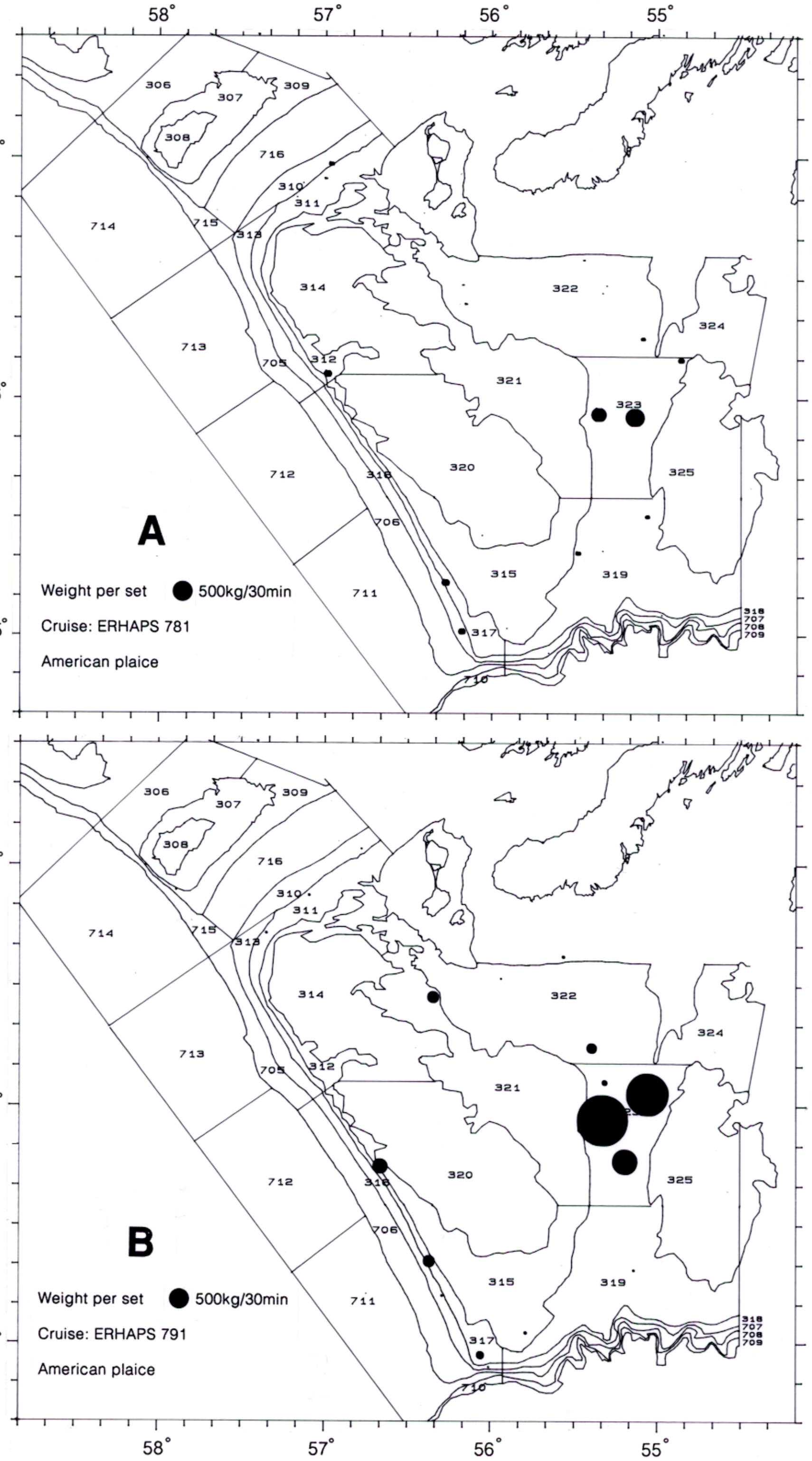

Fig. 4. Catches-per-tow (kg/30 min) for American plaice in Subdiv. 3Ps for: (**A**) 1978, (**B**) 1979, (**C**) 1981, (**D**) 1982, (**E**) 1983, (**F**) 1984, (**G**) 1985, (**H**) 1986, (**I**) 1987, (**J**) 1988, (**K**) 1989 and (**L**) 1990.

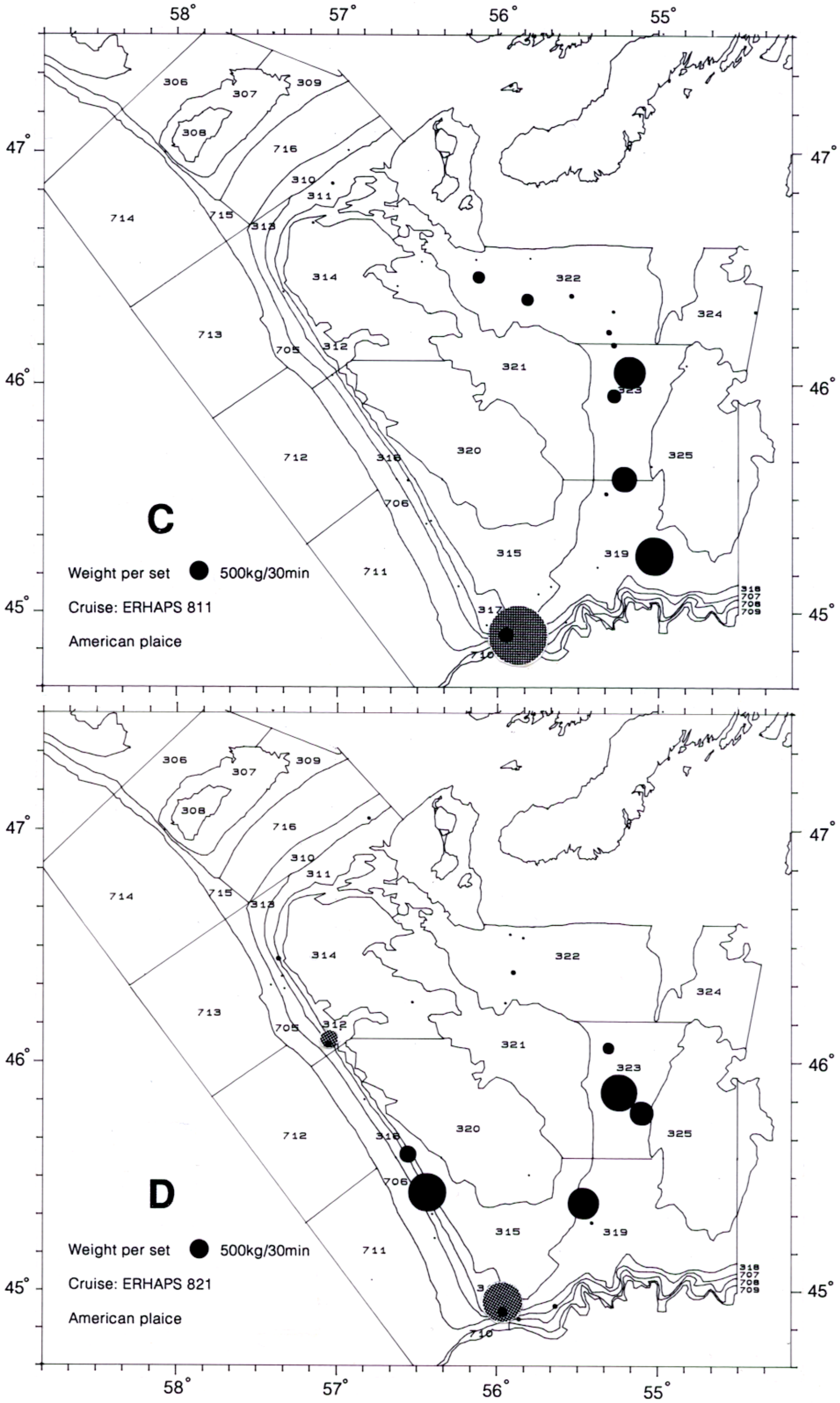

Fig. 4. (Continued). Catches-per-tow (kg/30 min) for American plaice in Subdiv. 3Ps for: (**A**) 1978, (**B**) 1979, (**C**) 1981, (**D**) 1982, (**E**) 1983, (**F**) 1984, (**G**) 1985, (**H**) 1986, (**I**) 1987, (**J**) 1988, (**K**) 1989 and (**L**) 1990.

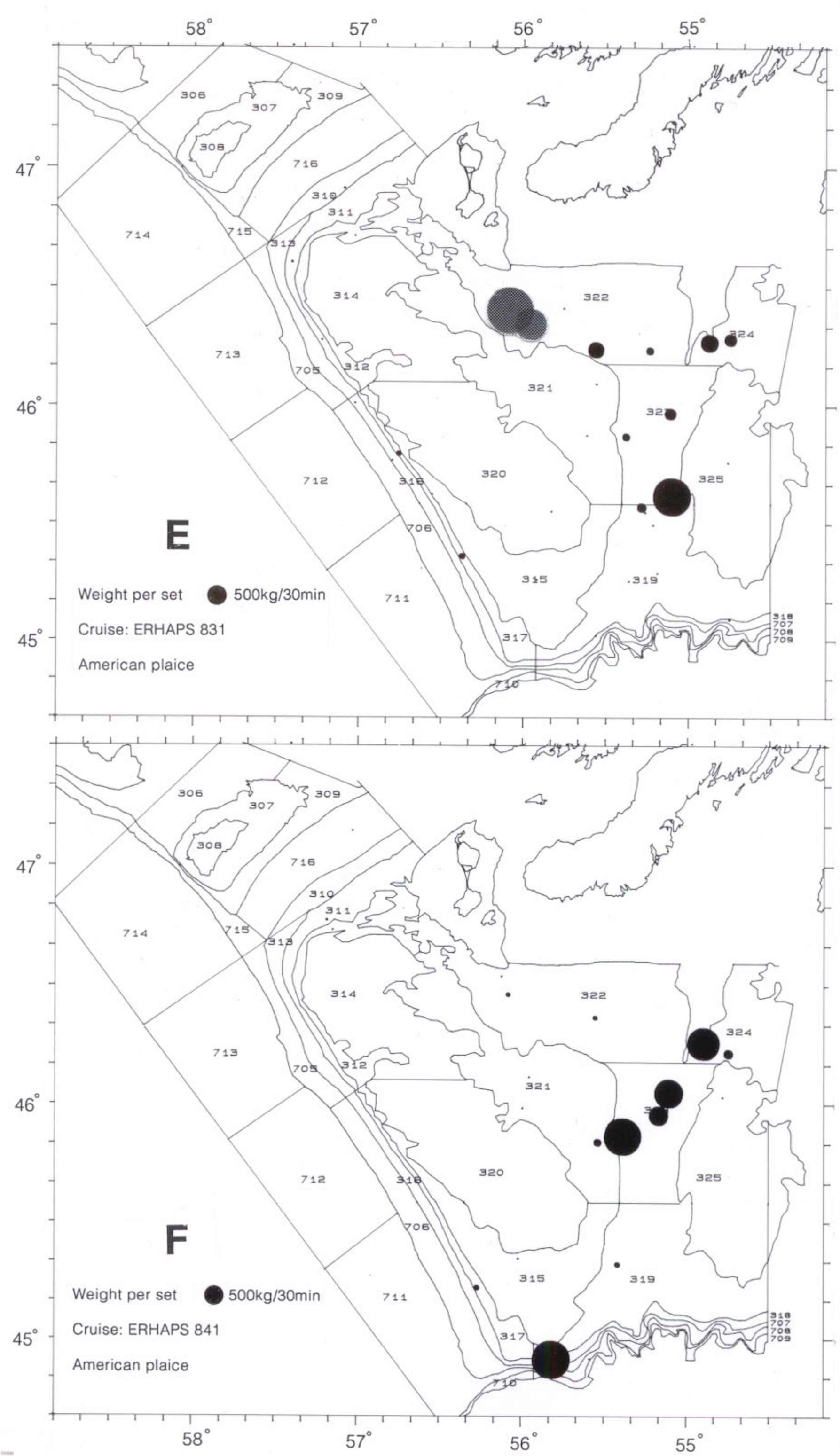

Fig. 4. (Continued). Catches-per-tow (kg/30 min) for American plaice in Subdiv. 3Ps for: (**A**) 1978, (**B**) 1979, (**C**) 1981, (**D**) 1982, (**E**) 1983, (F) 1984, (**G**) 1985, (**H**) 1986, (**I**) 1987, **(J**) 1988, (**K**) 1989 and (**L**) 1990.

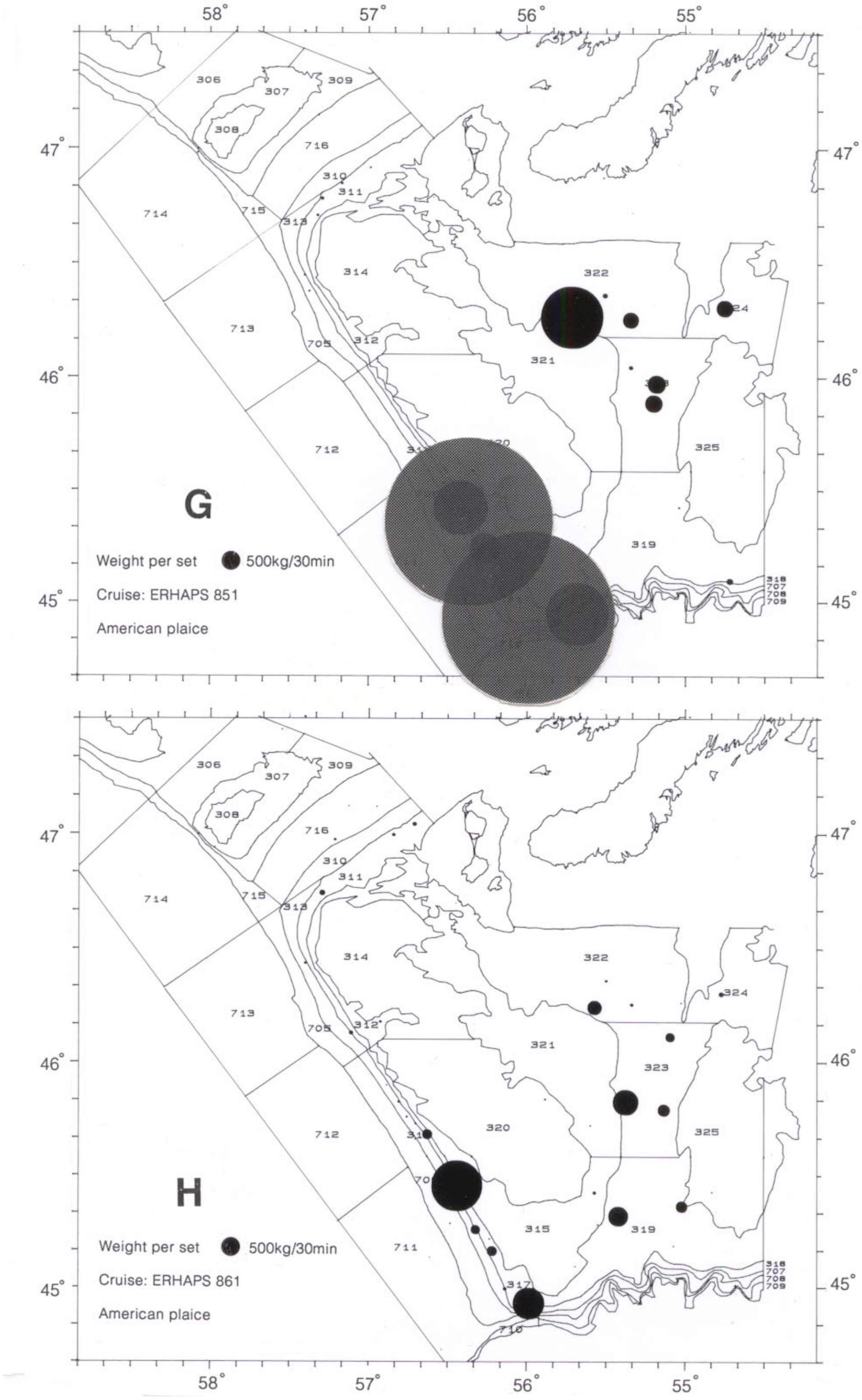

Fig. 4. (Continued). Catches-per-tow (kg/30 min) for American plaice in Subdiv. 3Ps for: (**A**) 1978, (**B**) 1979, (**C**) 1981, (**D**) 1982, (**E**) 1983, (**F**) 1984, (**G**) 1985, (**H**) 1986, (**I**) 1987, (**J**) 1988, (**K**) 1989 and (**L**) 1990.

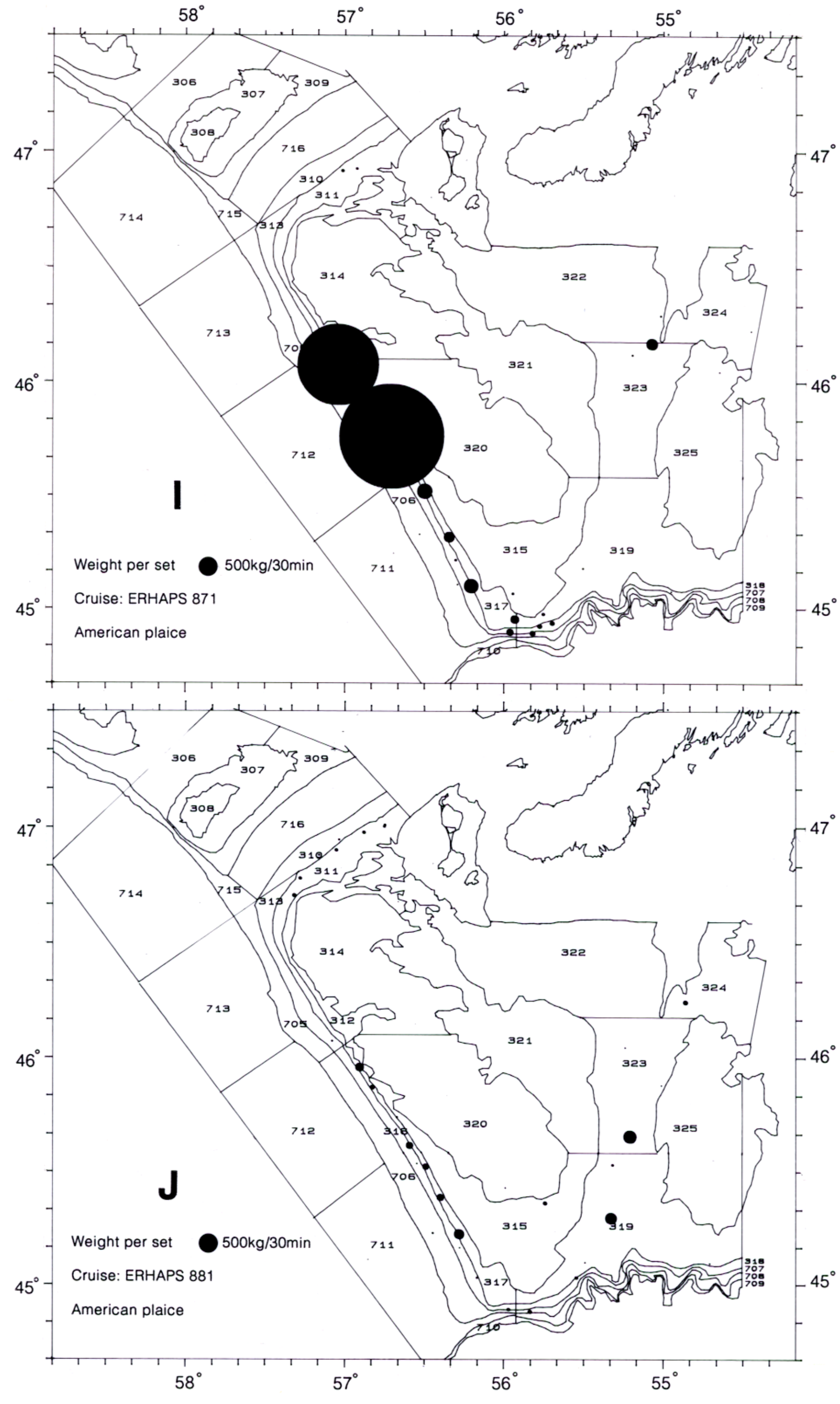

Fig. 4. (Continued). Catches-per-tow (kg/30 min) for American plaice in Subdiv. 3Ps for: (**A**) 1978, (**B**) 1979, (**C**) 1981, (**D**) 1982, (**E**) 1983, (**F**) 1984, (**G**) 1985, (**H**) 1986, (**I**) 1987, (**J**) 1988, (**K**) 1989 and (**L**) 1990.

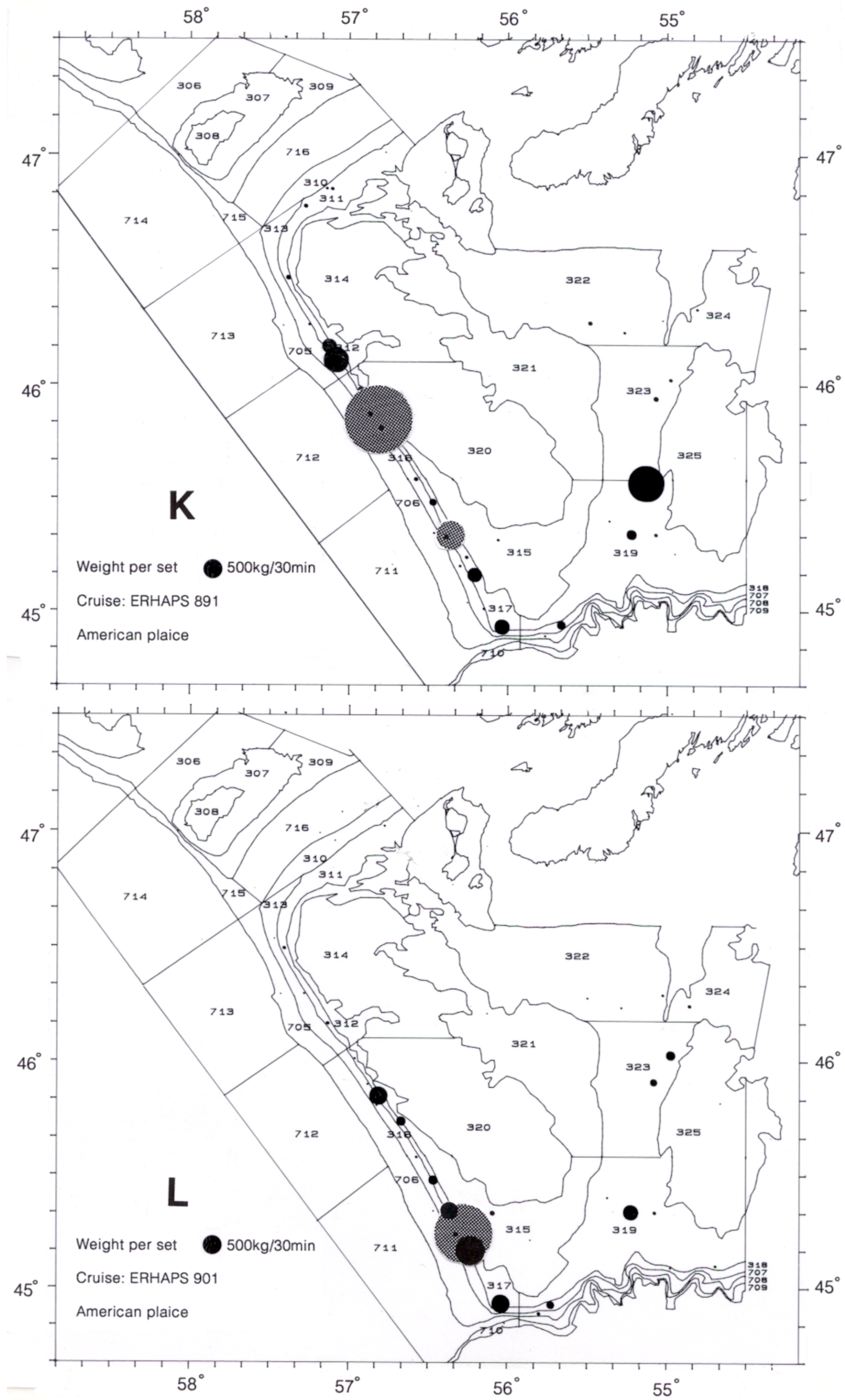

Fig. 4. (Continued). Catches-per-tow (kg/30 min) for American plaice in Subdiv. 3Ps for: (**A**) 1978, (**B**) 1979, (**C**) 1981, (**D**) 1982, (**E**) 1983, (**F**) 1984, (**G**) 1985, (**H**) 1986, (**I**) 1987, (**J**) 1988, (**K**) 1989 and (**L**) 1990.

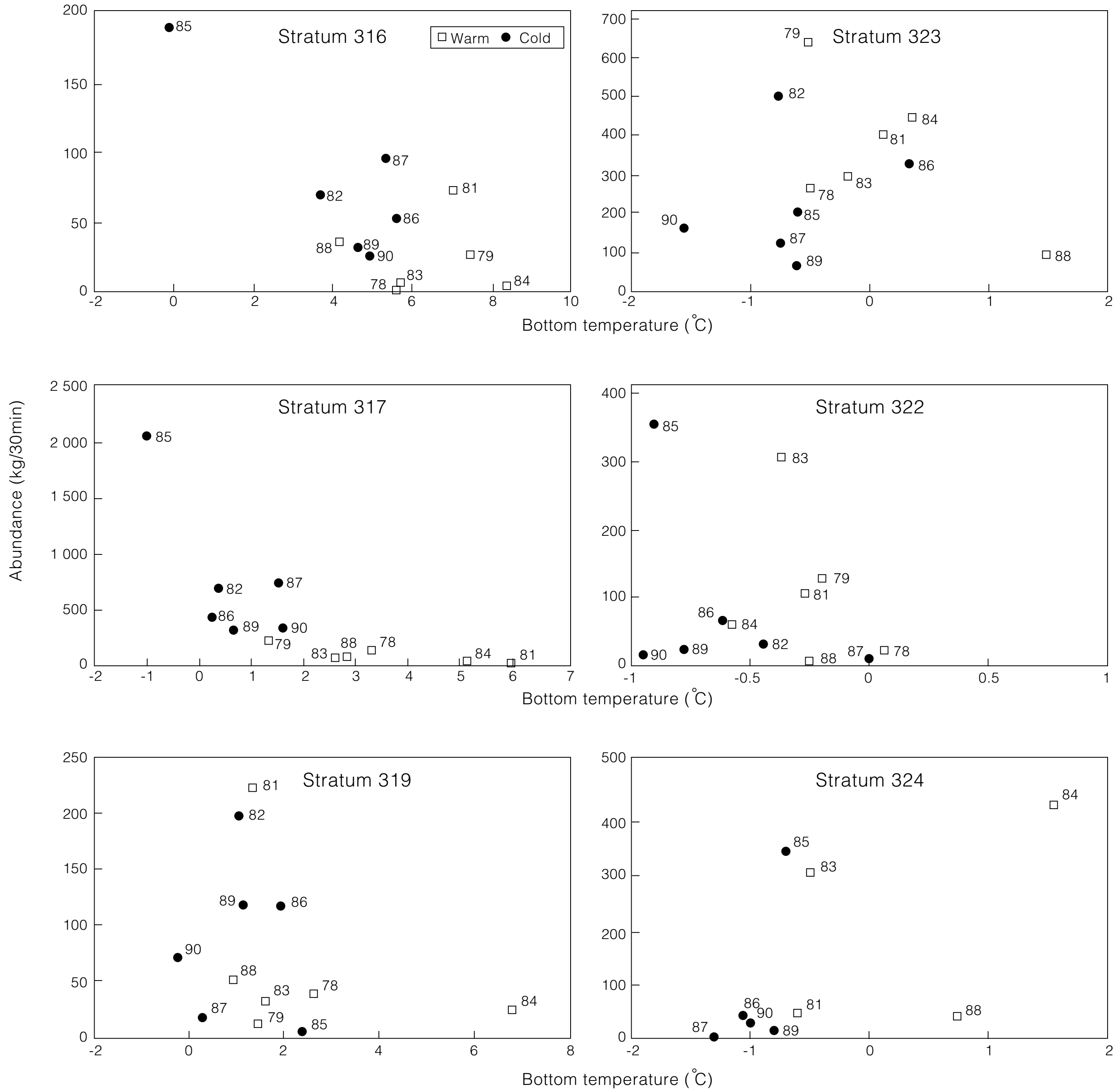

Fig. 5. Relationships between bottom temperature (average for the stratum) and average catch per tow (kg/30 min) for American plaice in strata 316, 317, 319, 323, 322 and 324 from 1978 to 1990 (1980 excluded).

Average catch-per-tow of American plaice (kg/30 min) calculated by stratum for each year is presented in Table 4. When certain strata were not sampled, values were calculated using a multiplicative model (e.g. stratum 325 in 1978). Catch-per-tow data as represented in the maps (Fig. 4A to 4L) show distribution and abundance of American plaice in Subdiv. 3Ps. The patterns revealed that while this species was generally well represented in the Halibut Channel (strata 322, 324, 323, 319), the highest concentrations were observed in the coldest late winters (1982, 1985–87, 1989 and 1990) on the southwest slope of St. Pierre Bank (strata 316, 317). This pattern can be related to the movement of cold water masses in Subdiv. 3Ps, inducted by the Labrador Current from northeast to southwest. American plaice followed this water current and in the coldest winters, when these cold water masses reached the slopes of St. Pierre Bank, they were distributed in this area in the largest abundances.

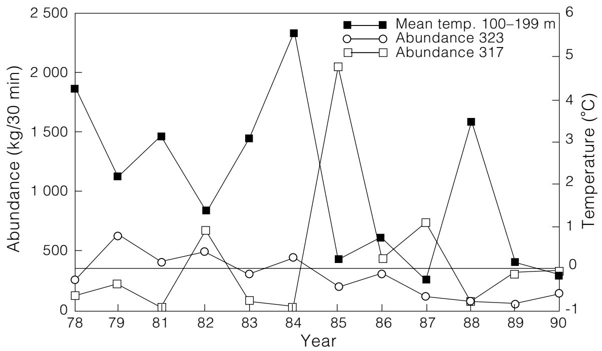

Fig. 6. Average catch-per-tow (kg/30 min) in strata 317 and 323 and water temperature in the 100-199 m depth range calculated from the hydrographic transects over the 1978-90 period (1980 excluded).

The relationships between bottom temperature and abundance (Fig. 5) for strata in the Halibut Channel (strata 319, 323, 322, 324) did not show significant correlations, while the same analysis on the strata of the southwest slope of St. Pierre Bank (strata 316, 317) showed significant correlations, especially in stratum 317. The largest fluctuations in bottom temperatures were observed in the strata on this slope of the Bank, and the average catches-per-tow were highest when the bottom temperature was 2°C and less, which is usual for this species (Wells *et al*., MS 1988). In strata of the Halibut Channel, temperatures are almost always in this preferred range, even in the warmer late winters.

A closer look at the abundances observed in strata 317 and 323 (strata showing the greatest densities over the studied period) and relating them to the average temperature in the 100–199 m depth range of these strata calculated from the hydrographic transects (Fig. 6), three observations can be made: (i) correlation between abundance in the stratum 317 and temperature can again be identified, (ii) there is a general lowering trend in the average temperature over the studied period, and (iii) abundances in stratum 323 to some extent follows this trend while, to a lesser extent, abundance in stratum 317 follows an opposite trend.

Conclusions

Changes and trends in the hydrographic conditions in Subdiv. 3Ps, observed over the last 13 years, had an effect on the distribution of American plaice in the area. The succession of cold winters (especially since 1985) have induced a dispersion of this species from the Halibut Channel to the southwest slope of St. Pierre Bank, which was clearly identified during the coldest winter. This change in behaviour may affect the biological parameters like spawning, feeding and growth as noted for American plaice stock on the Grand Bank (Pitt, 1975; Bowering and Brodie, 1991) . Complementary studies in those fields would certainly be of interest, as will the monitoring of the evolution of the situations described in this paper over the next few years.

References

BATTAGLIA, A., and J. C. POULARD. MS 1987. Year to year variations in water temperature in NAFO Subdivision 3Ps. *NAFO SCR Doc.*, No. 26, Serial No. N1310, 16 p.

BOWERING, W. R., and W. B. BRODIE. 1991. Distribution of commercial flatfishes in the Newfoundland-Labrador region of the Canadian Northwest Atlantic and changes in certain biological parameters – application. *Neth. J. Sea Res.*, **27**(3/4): 407–422.

FOREST, A., and J. P. MINET. 1981. Abundance estimates of the trawlable resources around the islands of Saint-Pierre and Miquelon (NAFO Subdiv. 3Ps): Methods used during the French research surveys and discussion of some results. *Can. Spec. Pub. Fish. Aquat. Sci.*, **58**: 68–81.

FOREST, A., AND J. C. POULARD. MS 1981. Water temperature distribution in NAFO Subdivision 3Ps in autumn 1980 and late winter 1981. *NAFO SCR Doc.*, No. 45, Serial No. N327, 9 p.

MOGUEDET, Ph., and J. C. MAHÉ. MS 1991. Yearly variations in water temperature in NAFO Subdivision 3Ps from 1978 to 1990. *NAFO SCR Doc.*, No. 24, Serial No. N1904, 11 p.

PITT, T. K. 1969. Migrations of American plaice on the Grand Bank and in St. Mary's Bay, 1954, 1959, and 1961. *J. Fish. Res. Board. Can.*, **26**: 1301-1319.

1975. Changes in abundance and certain biological characteristics of Grand Bank American plaice, *Hippoglossoides platessoides*. *J. Fish. Res. Board. Can.*, **32**: 1383–1398.

WELLS, R., W. B. BRODIE, C. A. BISHOP, and J. W. BAIRD. MS 1988. Distribution and abundance of three fish species on the Grand Bank in relation to depth and temperature of the water. *NAFO SCR Doc.*, No. 94, Serial No. N1546, 26 p.