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The Saint-Pierre and Miquelon and Metropolitan France Cod Fishery (3Pn, 4RS) in the Gulf of St. Lawrence from 1978 to 1989

by

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INTRODUCTION

The cod fishery prosecuted by the French commercial fleet (St Pierre and Miquelon and Metropolitan France) in the Gulf of St. Lawrence started in the 16th century (De la Morandière, 1962) and has maintained its tradition to date. Throughout those years an extensive understanding of the cod distribution, migration patterns and methods of harvesting have developped. This very efficient fishery allows to use the fleet deployment as an indicator of the fish movements and behaviour.

The 3Pn, 4RS cod stock has historically been exploited by the French fleet during winter while catch rates are high (roughly three times higher than summer, Fréchet, 1989) as the stock is migrating outside the Gulf into Subdivision 3Pn. Catches from metropolitan France and St. Pierre and Miquelon peaked in 1970 at over 30,000 t (28% of total landings). Since 1977, France is the only foreign country exploiting this stock. Finally, since 1987 only St. Pierre and Miquelon has an allocation for this stock.

The purpose of this paper is to document the deployment of the French fleet since 1978 according to data collected by various observer programs. Although catches from this fleet represent a fraction of the yearly landings, it is well monitored and allows a detailed account of this fishery. Yearly efficiencies of the fleet and migration patterns of cod will be examined and discussed.

MATERIAL AND METHODS

For a given vessel, date, time of day, latitude, longitude, depth, duration and catch were recorded at each fishing station. In order to respect the confidentiality of the information, vessels will not be identified but rather coded by numbers in this document.

Descriptive and statistical analysis of the data were done with the SAS software (1985 a,b,c). Length frequencies were done on individual sets on an opportunistic basis and otoliths collected were aged within DFO laboratories. The ageing of the 1978 to 1982 fishery were done in the Newfoundland region whereas otoliths collected since 1983 were read in the Québec region. Agreement between agers are generally over 85% (Fréchet, 1989). The calculation of the catch at age was done using the CATCH.AWS program (Anon, 1980).

Standardisation of the catch rates was made with the STANDARD.AWS program (Anon, 1980). Categories for the analysis were vessel, month, NAFO division and year. Catch values less than 2 t and effort values less than 0.5 hours were deleted from this analysis in order to reduce the impact of rounding errors. Using the most recent fishing mortality estimates (Fréchet, 1989) the partial fishing mortalities (France and Canadian-mobile gear) were derivedand using the equation:

$$pf_{i,j} = \frac{Cf_{i,j}}{C_{i,j}} \times f_{i,j} \qquad (1)$$

pf = partial fishing mortality
C = catch at age (all fleets)
Cf = catch at age (French fleet)
f = fishing mortality
i = index of age
j = index of year

Based on the 1984 fishery in 4R, covariance of catch rates were examined both in time and space separatly and together. The covariance distribution of each pair is calculated and is associated with some distance between the points.

RESULTS

From 1978 to 1987, catches from the St. Pierre and Miquelon and Metropolitan France were quite stable and accounted for 10 to 20% of the annual landings for the 3Pn, 4RS cod stock (Table 1). Since 1987 only St. Pierre and Miquelon based vessels may fish this stock (Franco-Canadian and Franco-France accords). Successive quotas for this fleet in 1987, 1988, 1989 were 2,300 t, 0 t and 2,640 t respectively. Landings were 1,585 t in 1987 and 2,600 t in 1989, which represent 2% and 6% of the total landings for this stock.

From 1978 to 1989, 18 stern trawlers from France metropolitan and St. Pierre and Miquelon had observer coverage (Table 2). A total of 13,843 fishing stations were monitored between January and May in the Subdivision 3Pn and divisions 4R and 4S with cod as main species. Length and tonnage of vessels based in France are generally higher than those from St. Pierre and Miquelon.

Three new vessels, the St. Denis, the St. Pierre and the Côte St. Jacques started fishing this stock in 1989 (the latter with marginal catches because of numerous breakdowns). However, the Croix de Lorraine has ceased fishing this stock since it has been sold.

Catch at age

The catch at age for this fleet is shown in Table 3. Three of the largest year classes are well represented in the catch at age matrix. These are the 1975, 1977 and 1980 year classes. The resulting partial fishing mortality (Table 4) is low, since the landings for this fleet account for a small part of the total landings. By substracting the catch at age from the French fishery from the catch at age for the total mobile gear fishery, the catch at age for the Canadian mobile gears were produced. Partial fishing mortality was also calculated for the domestic fleet in order to derive partial recruitment vectors for these fleets. Results are shown in Figure 1. Both agree quite well except for age groups 13 to 15 where the partial recruitment for Canada is higher than for the French fishery. This may be due to very small partial fishing mortalities and few fish caught in those ages as can be seen from Tables 3 and 4 and thus of little biological significance.

Distribution of fishing effort

A series of maps of catch rates for the metro France and St. Pierre fleets are shown in Fig. 2. The fishing activity follows a north - south direction roughly along the 180 meter isobath.

Figures 3 and 4 indicate the frequency of the depth fished and duration of fishing. Most sets are done at a modal depth of 175 meters with a duration of three hours. Towing speed is generally of four knots although some have been observed at 3, 3.5 and 4.5.

One area of discontinuity in this latitudinal gradient is situated between Cape Anguille and Cape Ray (i.e. the southern limit of Division 4R). No fishing occurs in these waters because favorable depths for cod are found within the 12 miles exclusive Canadian waters. The bottom topography in this area is steep, and is generally exploited by numerous small otter trawlers from Newfoundland. Many events may influence the typical fishing pattern, some of which may be:

- severe ice cover
- redirection towards fishing in 4Vs or 3Ps
- variation in the winter migration of cod
- local concentrations of cod

- unsuitable size of cod
- winter storms (winds, freezing spray)
- damage to fishing vessels
- high catch rates (processing capacity)
- return for unloading
- by-catch (haddock, pollock)

Despite these factors and given that fish from this stock are known to migrate outside the Gulf into Subdivision 3Pn during winter (Wiles and May, 1968) the metro France and St. Pierre fleets may serve as an indicator of the annual migration. In order to illustrate this, a series of graphs relating latitude, time of the year and catch rates are shown in Fig. 5. A typical fishing season starts in January in the northern part of Division 4R, catch rates being generally low. With time, fishing activity will follow the fish migration southward towards Subdivision 3Pn. This appears as diagonals on certain graphs. By April and May, cod are found more frequently inside the Gulf. Some degree of exploration can be detected in several instances. The largest aggregations of observations are in areas of high catch rates.

Another way of describing annual migration is shown on Figure 6. The weekly position of the fishery shifts gradually from the northern part of the Gulf towards Subdivision 3Pn. By the week 16 (mid-April), the stock migrates to more northerly grounds.

Catch rates

The unstandardized median catch rate for the whole time series is 1.333 t/h and the highest catch rate is 173 t/h. When catch rates are high there is a reduction in the duration of fishing sets. This is thought to be caused by limitations in processing capacity or the trawl being full.

Results from the standardisation of catch rates indicate that division and year factors have a significant effect on the variability of catch rates ($P < 0.05$), (Table 5). One of the vessels had few observations and high leverage, and was eliminated from the analysis. The regression coefficients for February and Division 4R are highest. Since vessels from St. Pierre and Miquelon are smaller than those from metro France (Table 2), these show significant variations ($P < 0.05$). Yearly catch rates are variable (Fig. 7). These catch rates may be affected by changes in catchability, typical of winter fishery (Fréchet, 1988). Catch rates may be very high but in localised areas as was the case in 1984. This areal aspect has not been included in the present analysis of catch rates.

In order to illustrate the degree of cohesion of this fishery, corellograms were done. This allows to graphically show how catch rates from individual sets show any ressemblance to the next and how this ressemblance decreases in time or space. To do this, covariance of all possible pairs of observations were calculated, first by sorting all sets by the distance (or time) between them, and then calculating the covariance. This is expected to reach zero as distance and time increase (increased independance of observations). Results (Fig. 8) show that individual sets show little similarity in space but a certain similarity in time. The spatial integrity of catch rates is maintained as the fishery follows the cod in its migration, only sets done in less than 6 to 10 nautical miles show any similarity. However, when time is considered, there is less noise and a similarity in catch rates can be observed from one day to the next, decreasing afterwards.

Time and space being related, a corellogram including both distance between sets and difference in time between sets produces an higher covariance (Fig. 8).

By-catch

Information on by-catch levels are available for this analysis only for a fraction of the St. Pierre and metro France fishery. These indicate low levels of by-catch (Table 6). A large value for redfish by-catch is found in 1982 but is based on a limited amount of observed catch. An allocation of 600 t to allow this by-catch of redfish was in effect until 1986. This is not unrealistic given that cod in winter is distributed in deeper waters and may mix occasionally with redfish. Marginal amounts of pollock were also caught.

DISCUSSION

Even if this fleet currently accounts for a small proportion of the annual landings for this ressource, the fact that detailed observations were done on a set by set basis allows for a fine resolution of the fleet deployment. The monitoring of the totality of the domestic fleet would require enormous amounts of manpower since it is dominated by numerous small vessels (45 to 60 feet). These vessels redirect frequently from fishing for shrimp to flatfish to redfish and to cod, making this monitoring of cod even more difficult.

Fishing activity by the St. Pierre and Miquelon and metropolitan France fleet is very concentrated in both time and space and a constant communication of results of fishing operations allows for an efficient deployment strategy. This fleet has been involved in the cod fishery for centuries and has gained an important knowledge of cod distribution and behaviour.

The approach of using the fleet as an indicator of the locality of a ressource that shows important migrations outside the Gulf has proven to be usefull in a broad sense. Negligible amounts of by-catch have been observed and selectivity of this fleet is similar to that of the Canadian mobile gear fleet. These catch rates show the same yearly variability as what is observed in the regular groundfish surveys conducted in January by Canada. Catch rates from this fleet are very variable from year to year but in general agree with the current perception of the stock status (i.e. a peak biomass in the early 80's).

The covariance analysis indicates that similarity in catch rates are significant for distances less than 6 to 10 nautical miles and in time for delays up to two days. Since time and distance are correlated, the combination of these gave high covariance estimates.

ACKNOWLEDGMENTS

I would like to thank the responsibles of the regionnal observer programs (Dave Kulka, Newfoundland region; Don Waldron, Scotia-Fundy region and France Henry, Quebec region) for supplying the data as well as all observers that have been collecting data on this fishery since 1978. Special thanks to Julie Jean and Philippe Schwab for preliminary computations.

REFERENCES

ANON., 1986. CAFSAC Assessment Software Catalog. CAFSAC Res. Doc. 86/96, 24p.

De la Morandière. C., 1962. Histoire de la pêche française de la morue dans l'Amérique septentrionale. 507p.

Fréchet, A., 1988. Investigation of the effect of ice cover on cod catches in the Gulf of St. Lawrence. NAFO SCR Doc. 88/93 22p.

Fréchet, A. and P. Schwab. 1989. Evaluation du stock de morue de 3Pn, 4RS en 1988. CAFSAC Res. Doc. 89/55.

NAFO, 1988. List of fishing vessels, 1986.

SAS Institute Inc., 1985a. SAS User's guide: statistics, Version 5. Cary NC: SAS Institute Inc. 956p.

SAS Institute Inc., 1985b. SAS User's guide: basics, Version 5. Cary NC: SAS Institute Inc. 1290p.

SAS Institute Inc., 1985c. SAS/Graph User's guide, Version 5. Cary NC: SAS Institute Inc. 596p.

Wiles, G., and A. W. May, 1968. Biology and fishery of the west Newfoundland cod stock. ICNAF Res. Bull. 5:5-43.

Table 1 : Allocation scheme and reported landings (t) for the French fleet fishing the 3Pn, 4RS cod stock.

YEAR	ALLOCATION	REPORTED CATCH	CANADIAN CATCH
1978	15,500	15,771	62,735
1979	17,875	13,769	69,008
1980	12,000	9,396	88,183
1981	13,500	12,508	83,822
1982	13,500	12,013	92,779
1983	13,500	11,410	93,973
1984	13,500	11,623	90,419
1985	13,500	9,185	80,167
1986	13,500	13,122	67,310
1987 [1,2]	2,300	1,585	64,009
1988 [1]	0	0	47,624
1989 [1,2]	2,640	2,600	46,668

[1] Preliminary.
[2] Allocation for St. Pierre and Miquelon only.

Table 2 : List of fishing vessels and their characteristics from France metro and St Pierre fishing cod from the 3Pn, 4RS cod stock (period 1978-89). Fleet, length and tonnage class according to NAFO list of fishing vessels, 1986, 1983, and 1980.

Vessel name	Fleet	Length (m)	Tonnage	Total no. of sets	Years present in the fishery.
Commandant Gué	M	87	1578	2128	78-86
Zélande II	M	87	1594	1411	78-86
Islande 1V	M	87	1702	1264	78-86
Finlande III	M	87	1686	1202	79-83,85-86
Côte St.-Jacques	S	50	N.A.	83	89
Le Dauphin	M	70	1590	1495	78,80-86
Juthand III	M	87	1695	61	80
Névé	M	84	1597	1027	79-83
Capitaine Pléven II	M	91	2413	1410	79-86
Joseph Roty II	M	91	2435	996	79-86
Victor Pléven	M	91	2413	1077	79-86
Grande Hermine	M	62	988	126	86
La Normande	S	50	690	607	81-87,89
Le Marmouset	S	50	634	133	87,89
La Goélette	S	50	690	395	83-87,89
Croix de Lorraine	S	46	422	255	82-87
La Bretagne	S	50	771	94	87
Saint Denis	S	50	N.A.	79	89

S = Licensed in St. Pierre and Miquelon.
M = Licensed in metro France.

Table 3 : Catch at age ('000) from the French Fleet. No sampling was done in 1978, and no fishery occurred in 1988. Analysis of the sampling from the 1989 fishery still ongoing.

Age	Year								
	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	14	6	5	13	7	1	2		
4	757	220	417	166	118	174	246	137	
5	2542	1534	2367	1769	711	496	1361	787	103
6	2396	2606	3604	1962	2844	1180	1140	2565	206
7	2488	1257	1373	2023	1462	2702	1431	2533	358
8	445	496	474	996	1144	923	1031	969	280
9	225	71	64	409	421	749	359	1140	124
10	80	23	16	122	117	351	265	219	42
11	114	8	5	42	27	61	85	431	24
12	35	7	7	24	19	124	18	40	1
13	17	2		1	3	57	3	42	3
14	10	3	6	5	2	1		2	
15	1	2	1		1				
16		1				19			
17	1				1		2		
18				2					
# Meas.	52800	46167	38478	27236	31236	9395	11626	20570	8438
# Aged	748	957	414	700	804	354	560	399	350

Table 4 : Partial fishing mortality attributable to the French fishery.

Age	Year								
	1979	1980	1981	1982	1983	1984	1985	1986	1987
4	0.006	0.002	0.003	0.002	0.001	0.001	0.002	0.001	0.000
5	0.028	0.016	0.032	0.015	0.010	0.007	0.013	0.010	0.001
6	0.059	0.045	0.058	0.039	0.036	0.026	0.023	0.035	0.004
7	0.097	0.057	0.043	0.056	0.048	0.059	0.053	0.085	0.008
8	0.058	0.040	0.042	0.061	0.055	0.054	0.042	0.065	0.017
9	0.084	0.019	0.010	0.074	0.050	0.064	0.038	0.086	0.015
10	0.062	0.016	0.008	0.039	0.044	0.077	0.042	0.040	0.006
11	0.101	0.013	0.006	0.049	0.020	0.047	0.034	0.132	0.008
12	0.080	0.013	0.022	0.051	0.052	0.207	0.028	0.026	0.001
13	0.035	0.010	0.000	0.007	0.015	0.428	0.010	0.119	0.003
14	0.078	0.010	0.061	0.046	0.025	0.013	0.000	0.010	0.000
15	0.021	0.035	0.006	0.000	0.016	0.000	0.000	0.000	0.000
Fully recruited F (Fréchet, 1989).	0.602	0.526	0.403	0.569	0.320	0.454	0.379	0.412	0.402

Table 5 : Results of the standardisation of the catch rates of the French fleet for the period 1978 to 1989.

R : 0.767
R^2: 0.589

ANALYSIS OF VARIANCE

Source of variation	df	Sum of squares	Mean square	F
Origin	1	85.42	85.42	
Regression	32	175.60	5.49	13.29 **
Vessel	16	18.93	1.18	2.87 **
Division	2	17.53	8.76	21.23 **
Month	4	11.60	2.90	7.02 **
Year	10	101.90	10.19	24.68 **
Residual	297	122.60	0.41	
TOTAL	330	383.70		

** $P < 0.05$

Predicted catch rates

Year	Catch		Catch rates		
	Weight	Prop.	Mean	Std. err.	Effort
1978	15771	0.049	2.303	0.598	6849
1979	13769	0.337	1.189	0.202	11583
1980	9396	0.725	1.391	0.216	6756
1981	12508	0.755	3.805	0.641	3287
1982	12013	0.916	2.093	0.323	5741
1983	11410	0.987	2.729	0.403	4181
1984	11623	1.112	12.333	2.177	942
1985	9185	1.022	3.477	0.531	2642
1986	13122	0.967	8.156	1.537	1609
1987	1585	0.727	2.980	0.821	532
1989	2640	0.269	2.326	1.071	1135

Table 5 : (Continued).

Regression coefficients

Category	Variable	Coefficient	Standard error	Nb. Obs
Intercept		0.662	0.264	330
Vessel	1 *			
	2	-0.169	0.164	28
	3	-0.083	0.169	25
	4	-0.039	0.165	27
	5	-0.019	0.489	2
	6	-0.925	0.185	22
	7	-0.765	0.245	11
	8	-0.783	0.270	9
	9	0.039	0.158	31
	10	-0.547	0.205	17
	11	-0.739	0.780	1
	12	-0.165	0.160	30
	13	-0.112	0.167	27
	14	-0.293	0.154	36
	15	-0.202	0.172	24
	16	0.052	0.539	2
	17	-0.595	0.483	2
Division	3Pn	-0.557	0.086	110
	4R *			
	4S	-0.341	0.317	5
Month	Jan. *			
	Feb.	0.314	0.093	123
	Mar.	-0.035	0.114	61
	Apr.	-0.232	0.133	39
	May	-0.366	0.210	17
Year	1978 *			
	1979	-0.681	0.283	35
	1980	-0.527	0.271	44
	1981	0.482	0.277	29
	1982	-0.118	0.269	43
	1983	0.146	0.267	53
	1984	1.659	0.283	27
	1985	0.389	0.268	53
	1986	1.248	0.289	24
	1987	0.262	0.354	11
	1989	0.094	0.534	4

* Standard

Table 6: Catch composition (in percent) of groundfish species from St. Pierre and Miquelon and France metropolitan fleets. Data are available for only a proportion of the observed catch

	YEAR					
	82	83	84	85	86	87
Cod	83.30	97.40	96.40	95.80	96.40	93.30
Thorny skate		0.35	0.04	0.08	0.03	
Winter skate					0.02	
Spinytail skate		0.05				
Haddock	0.90	0.44	0.39	1.35	0.71	0.92
Pollock		0.37	0.16	0.55	2.65	4.31
Red hake			0.04			
Stripped wolffish		0.02				
Spotted wolffish		0.02				
Redfish	14.90	0.92	2.62	1.84	0.10	0.75
American plaice	0.86	0.20	0.16	0.19	0.02	0.59
Witch flounder		0.01	0.12	0.07		0.06
Greenland halibut		0.03	0.03	0.03		
Atlantic halibut		0.11	0.03	0.06	0.05	0.09
Observed cod catch (t)	151	7,931	5,774	3,660	7,039	2,045

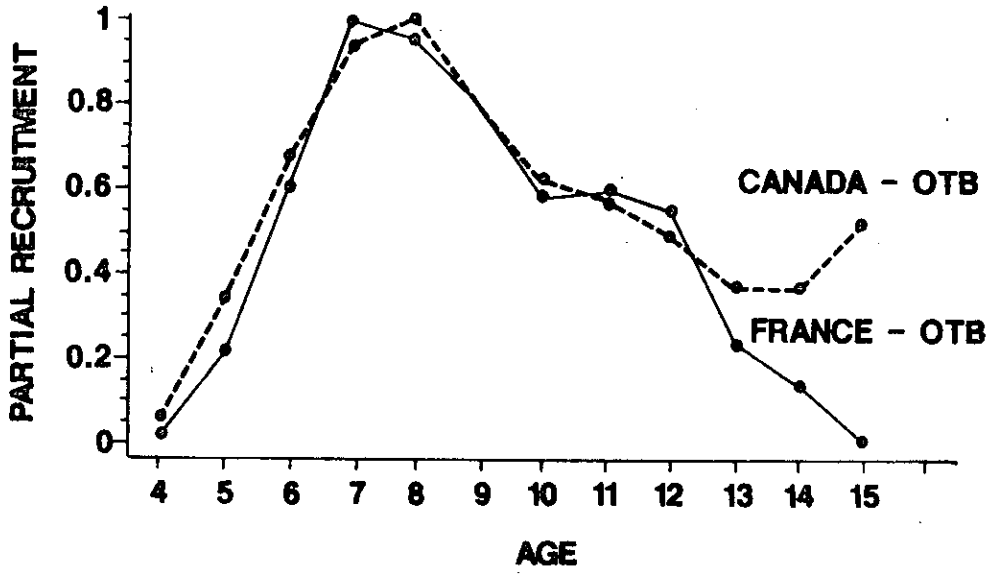

Figure 1 : Partial recruitment of the French fleet and the Canadian mobile gear fleet.

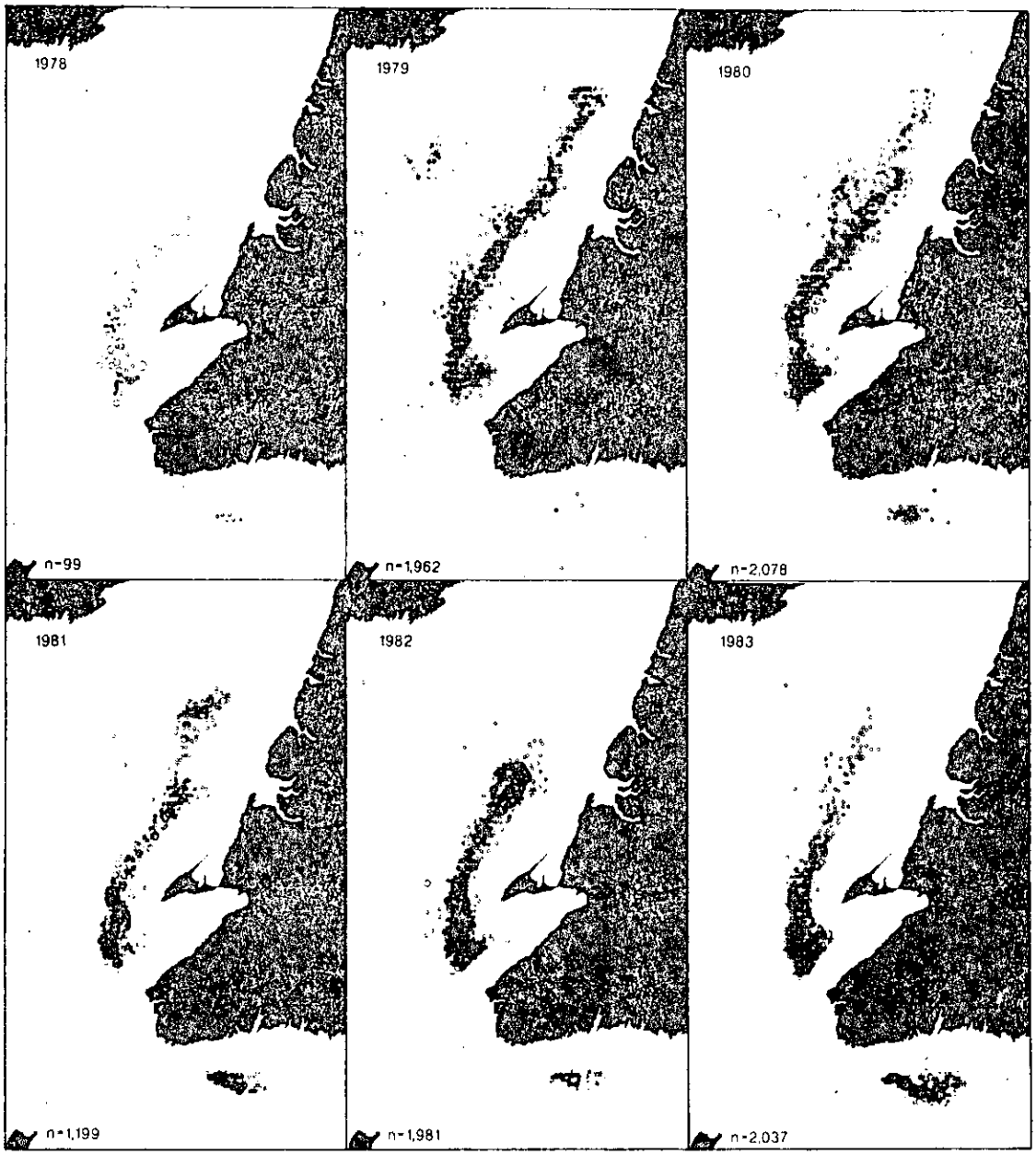

Figure 2 : Location of fishing for the metro France and St. Pierre fleets fishing the 3Pn, 4RS cod stock.

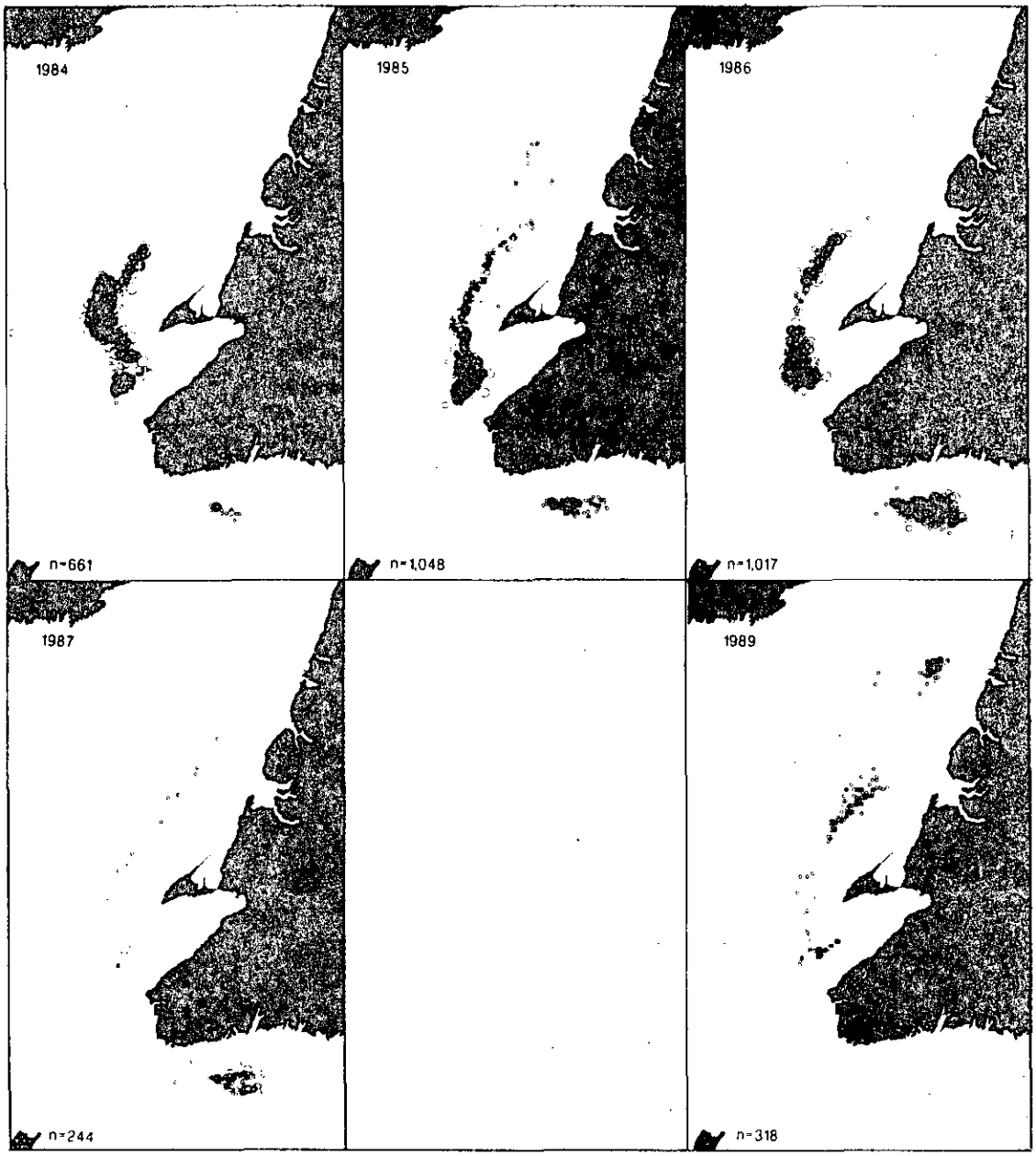

Figure 2 : (Continued).

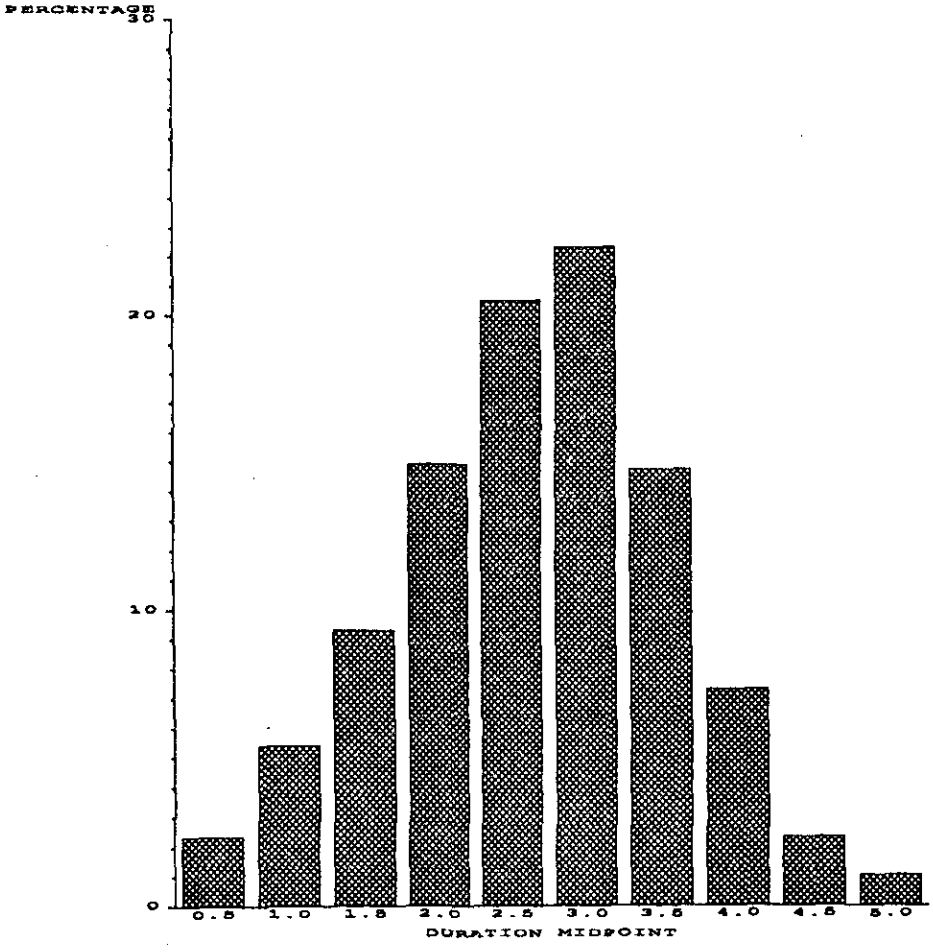

Figure 4 : Frequency histogram of the average duration (hour) of fishing sets by the French fleet (all years).

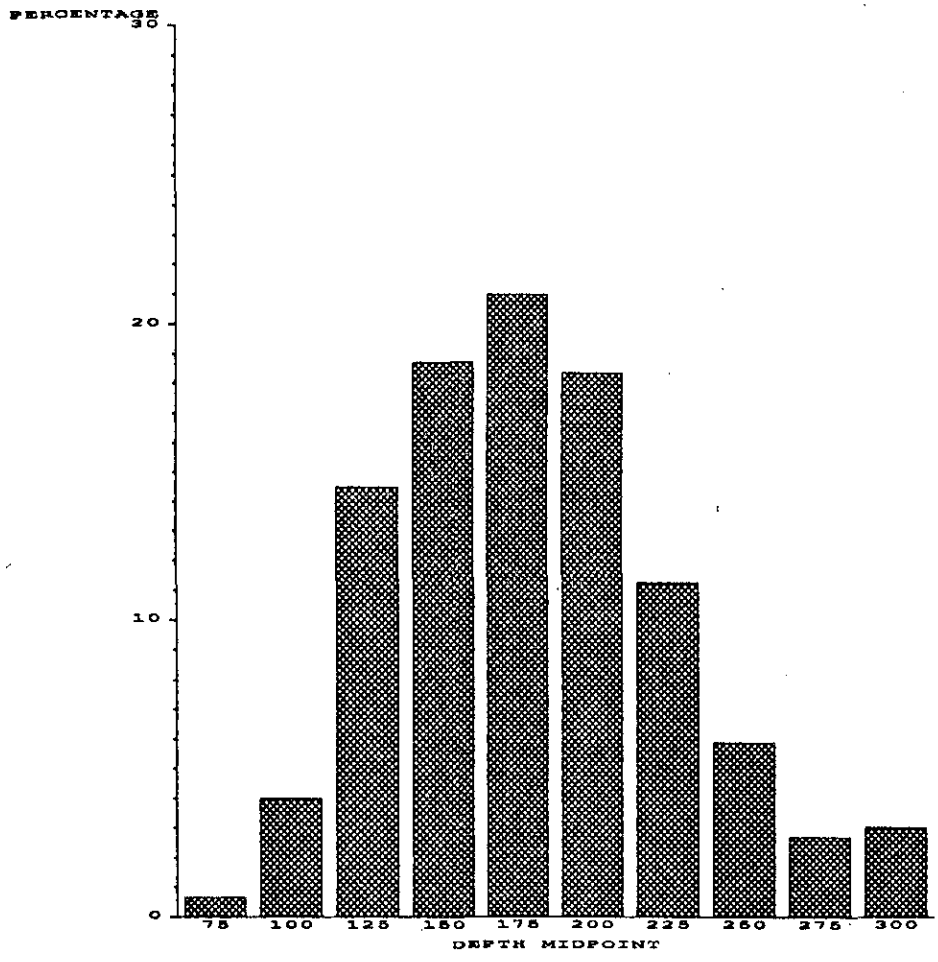

Figure 3 : Frequency histogram of the average depth (m) fished by the French fleet (all years).

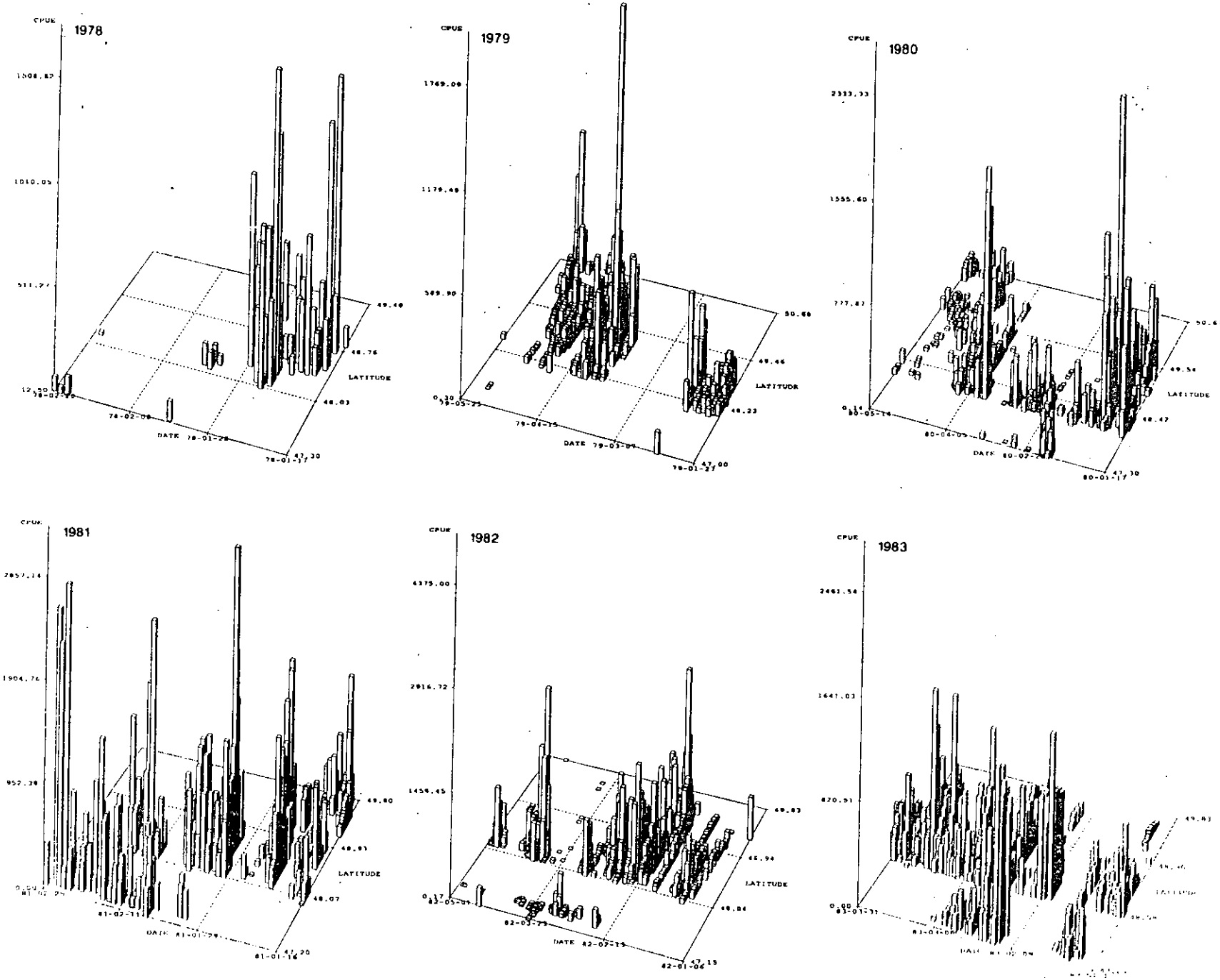

Figure 5 : Distribution of catch rates (Z) for the metro France and St. Pierre fleets fishing the 3Pn, 4RS cod stock by date (X) and latitude (Y).

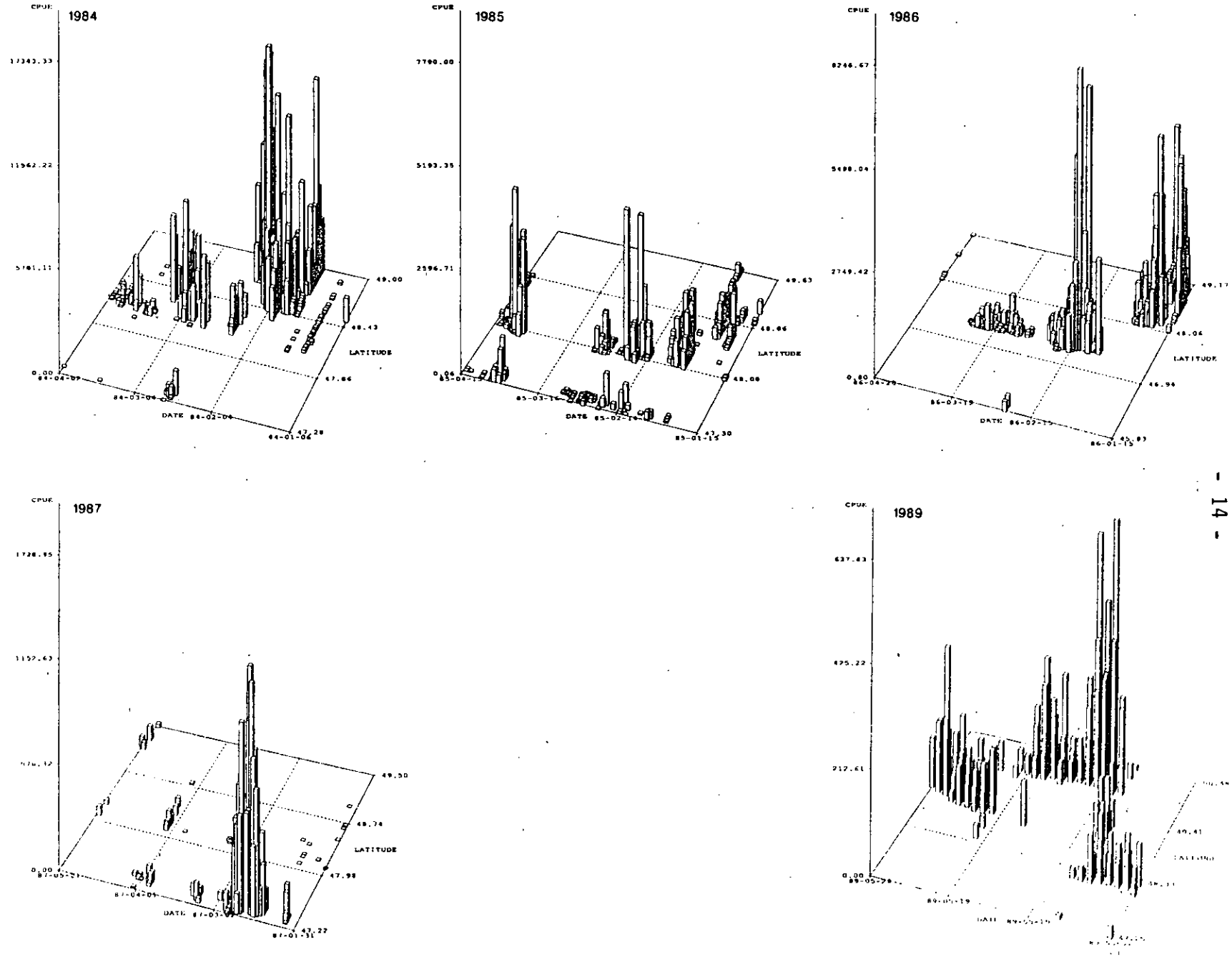

Figure 5 : (Continued).

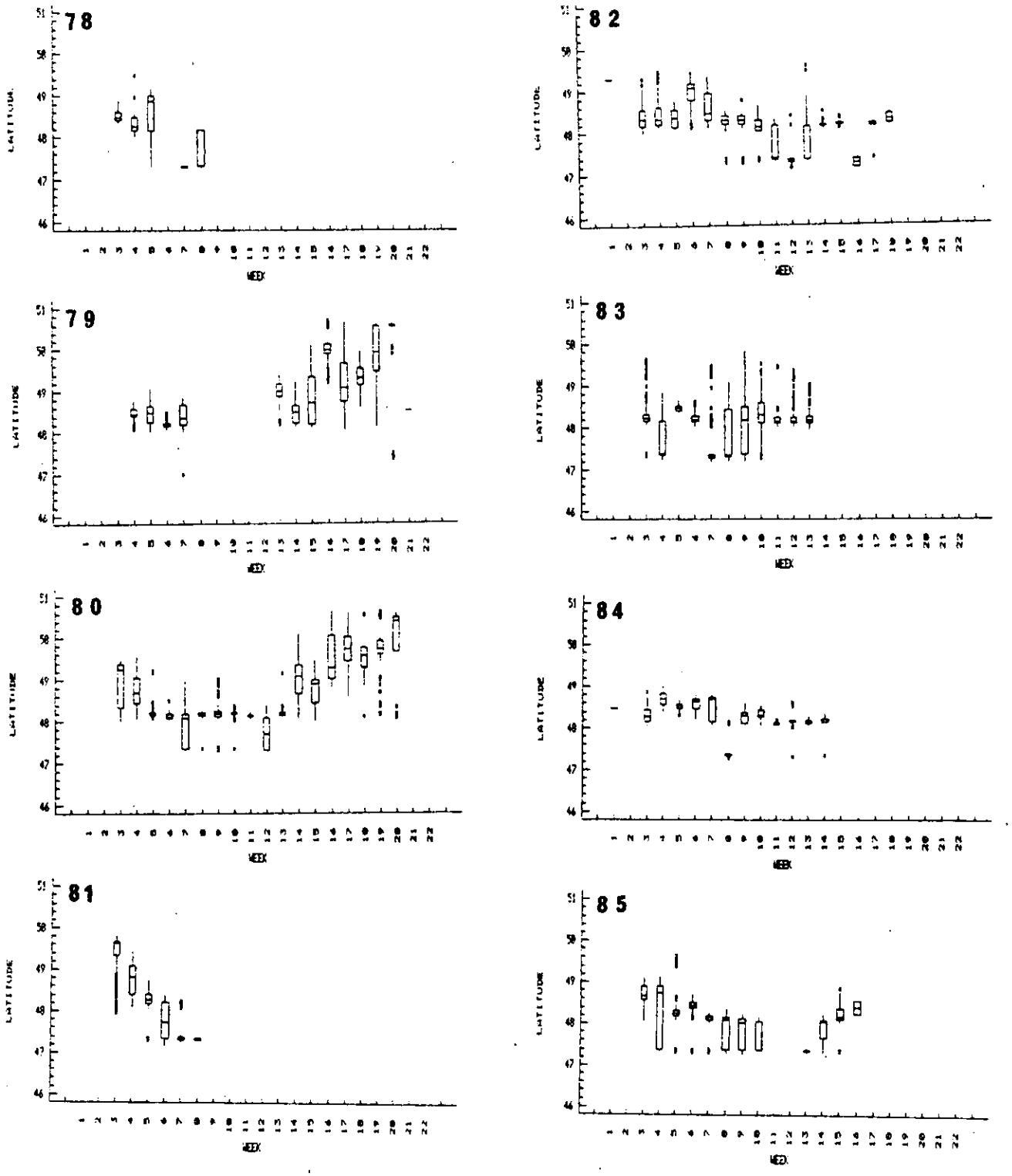

Figure 6 : Box and whisker plots of the weekly distribution of catch with latitude.

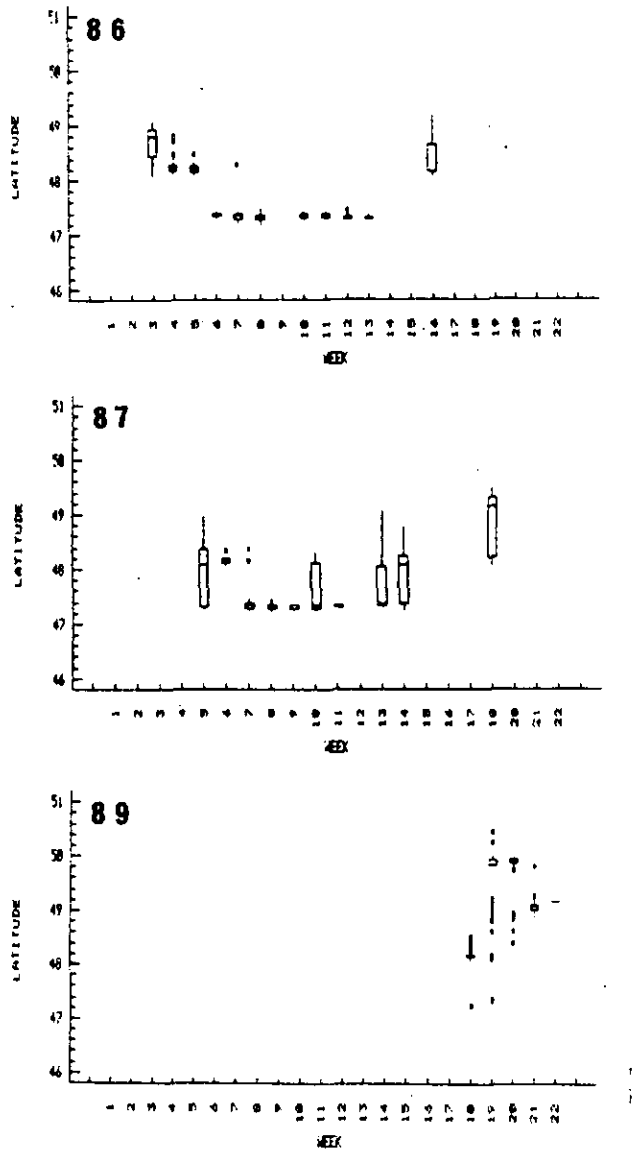

Figure 6 : (Continued).

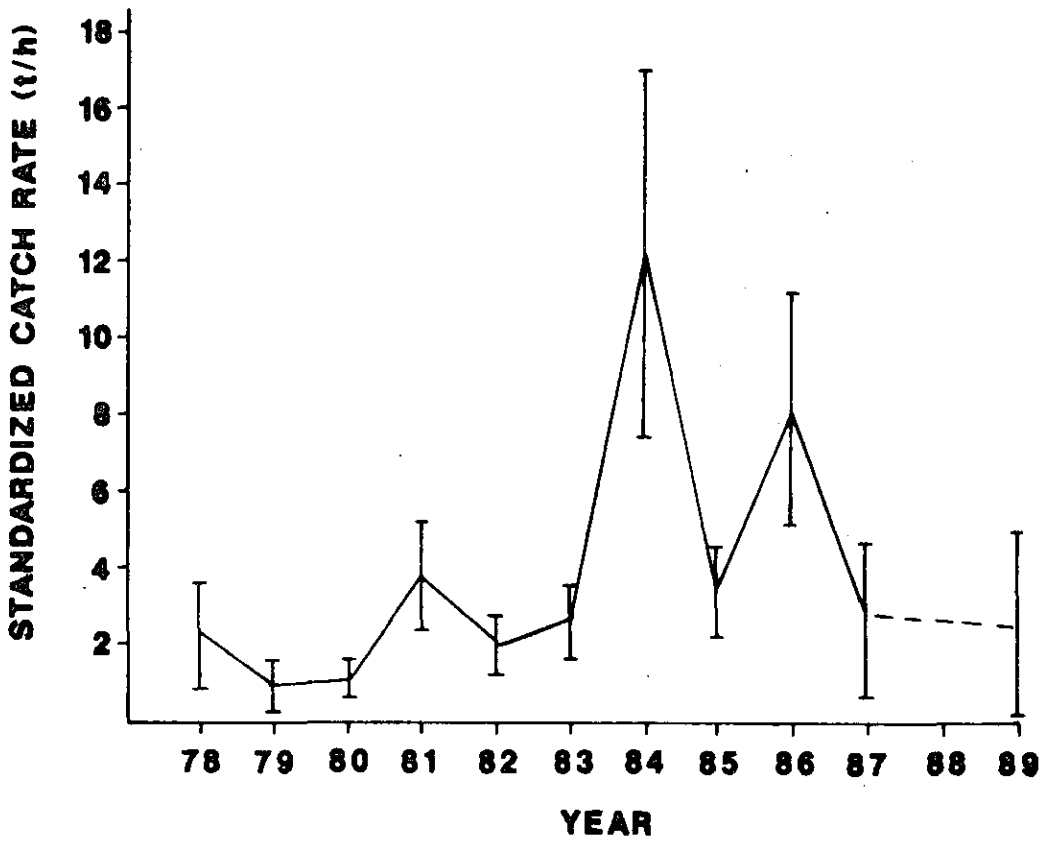

Figure 7 : Standardized catch rates (t/h) from multiplicative model.

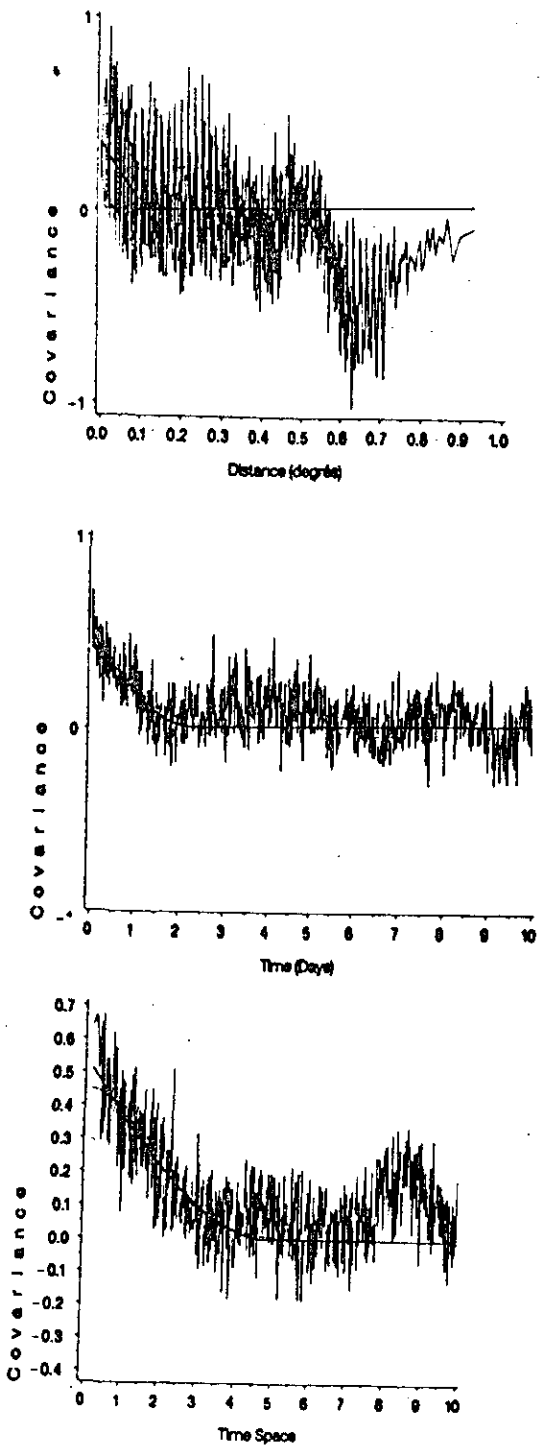

Figure 8 : Correlograms of catch rates in space (a) and time (b) and time and space (c).