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Comparison of the Relative Fishing Powers of St-Pierre and Miquelon Trawlers from 1986 to 1991 in the NAFO Subdivision 3Ps Limits in the Use of a Multiplicative Model (Robson, 1966)

by

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1. Introduction

Fishing effort being a quantitative measurement of fishing vessel activity, it is of interest to compare fishing powers of different components of a fleet in order to standardize their activity. This standardization has been studied from the activity of the Saint-Pierre and Miquelon fleet in NAFO Subdiv. 3Ps on the period 1986-1991.

The fleet was composed by five to eight bottom trawlers, depending on the year. In 1991 five of them landed "fresh" fishes while the two others were freezers.

The Robson model (1966) has been chosen to estimate and compare individual and relative fishing powers of the trawlers. Models using three factors (Laurec and Le Gall 1975, Garvaris 1980, Laurec and Perodou 1987) didn't appear relevant, the evolution scheme of abundance indices of each stratum within a year couldn't be supposed reproducible from year to year.

Landing statistics disagregated by space and time according to skippers reports (log-books) allowed to calculate catches per unit of effort (C.P.U.E.) for each trawler. These data have been grouped in space-time strata (20° in longitude - 40° in latitude / month) assumed by empiric knowledge to have an homogeneous density.

Classification of the vessels in relationship with their fishing power estimations have a signification only if legitimacy and quality of calculations are controled. The risk in using results without testing the respect of statistical conditions requested by the model is too important. So especially important that experience proves that results are coherent and then auto-justifiable. Beyond the comparison of the efficiency of each trawler from St-Pierre and Miquelon, the purpose of this study is to precise the limits in using multiplicative models and the available means to avoid as far as possible the dangerous practice of auto-justification of results.

2. Materials and methods

Taking into account the weight of cod catches (representing 75% of annual landings since 1980), two data bases have been considered : C.P.U.E. directed on cod or on all species. The C.P.U.E. (kg/hour) doesn't take into account discards. Space-time strata are used in their totality or partially, selecting those carrying 5 observations or more.

The Robson multiplicative model (1966) is based on certain number of hypothesis verifiable or not, necessary or falcutative, mathematical or biological (Tabl.1). They have been classified in 4 groups, each of them corresponding to different levels of keenness in using the model.

The software PUIS2 (Laurec 1987) derived from Abramson (1971) uses a technique reducing matrix sizes (Laurec and Perodou 1987). It has been modified (PUIS2NB) to be able to analyze residues and confidence intervals. It estimates individual fishing powers relatively to a power fixed to 1 for a reference vessel. The use of fishing powers for fisheries analysis is easier in reference to a geometrical mean given egual to1. Results have been transformed. A group of n values (logarithms) of p_i (where $p_1=0$) must then be linearly transform into a group of values noted p'_i (where $p'_1+....p'_n=0$) according to :

$$p'_i=p_i-(\sum_{k=1}^{n} p_k)/n \quad for\ i \in [1;n]$$

and

$$Var\,[p'_i]=Var\,[p_i] + (1/n^2) \sum_{k=2}^{n} \sum_{m=2}^{n} Cov\,[p_k,p_m] - (2/n) \sum_{k=2}^{n} Cov\,[p_k,p_i] \qquad for\ i \in [2;n]$$

$$Var\,[p'_i] = (1/n^2) \sum_{k=1}^{n} \sum_{m=2}^{n} Cov\,[p_k,p_m] \qquad for\ i=1$$

The variance-covariance matrix for the initial estimations p_i has to be known.

Each combination of two variables (one coding a stratum and the other a vessel) appearing once, only the large divergences to the model can be detected. When values of the Durbin-Watson test applied to residues are less than 1.6 (Fig.1) or when the histogram of residues indicates too much points far from the mean, fittings have been rejected. The normality of the residues have been tested looking to asymmetry and flatness coefficients and particularly by their distances to the theoritical critical threshold calculated for normal law samples (Fig. 2 and 3).

No weighting has been assigned to ensure the stability of the variance of the residues. Correction coefficients of bias related to the estimations of the logarithm of the fishing powers are estimated according to the method proposed by Laurent (1963).

From the model $[C] = [X]\,[\beta]$, the estimations of the residues variances are given by $s^2\,(1-h_i)$ where h_i is the diagonal value of the matrix $[X]\,\{[X]^t\,[X]\}^{-1}\,[X]^t$. This formula assumes the orthogonality of the residues to the explanatory variables.

3. Results.

The results (Tabl. 2) are presented in two parts : the first one relative to methodological choices and the second concerning comparison between fishing powers.

3.1. Global results.

Only 21 estimations off 29 are exploitable (Durbin -Watson test). From asymmetrical and flatness coefficients (Fig. 2 and 3), 2 fittings allow confidence interval estimations. They relied on 65 observations for estimating 18 variables (5 fishing powers and 13 abundance indices) and the histograms of their global and proper residues to each explanatory variable cannot be considered in satisfactory statistical conditions.

Some flexibility in the diagnosis, particularly in relation to the flatness coefficient with threshold fixed to 6, allows to access to a larger quantity of results : one third (11) are considered to be in insuficient statistical conditions for calculating confidence intervals and another third (10) allows to propose fishing powers with confidence intervals. Variance analysis (Tabl.3.) were carried out in vain in an attempt to identify a factor related to the methodological choices that could explain a significant part of the variability of the Durbin-Watson's *d*. If the variability of the asymmetrical coefficient seems to be in part explained by the more or less homogeneous repartition of the observations for all vessels, no factor explaining the response of the various bases of C.P.U.E. to the fitting to a multiplicative model has been determined.

The four criteria used to test the quality of the fittings (the Durbin-Watson's *d*, the determination, asymmetrical and flatness coefficients) obtained for each of the 29 fittings have been plotted against the average number of C.P.U.E. compared to estimate fishing powers (Fig. 4). Clear tendancies appear when fittings are based on C.P.U.E. in strata carrying 5 observations or more. Particularly, the higher the number of compared C.P.U.E, the weaker the determination is. In the same time, values of the Durbin-Watson's *d* decrease, the asymmetrical coefficients diverge from 0 and the flatness coefficients draw near 3.

3.2 Comparison in the using of the C.P.U.E. per tow or their monthly means in spatial blocs 20'x40'

From C.P.U.E. directed on cod in Subdiv. 3Ps in 1990, estimations of the confidence intervals and fishing powers have been compared according to whereas data were C.P.U.E. per tow or their monthly means. Criteria used, exception made of the determination coefficient, are numerically better when C.P.U.E. per tow are used. But, in this case, fitting is based on 3554 observations, which is 10 times more than when monthly means are used (372 observations). Quality of these two fittings can therefore be considered similar.

Classification of the trawlers according to their decreasing fishing power remains unchanged (Fig. 5). The distance between extreme fishing power values is higher when estimated from monthly means of C.P.U.E.

Confidence intervals at a 5% threshold are more restrained around the estimations (two times smaller) for C.P.U.E. per tow. In this case, although fishing powers are more homogeneous, overlapping of confidence intervals is weaker. The use of C.P.U.E. per tow allows a better discrimination of the individual fishing powers.

3.3 Comparison of the using of the whole strata or strata carrying 5 observations or more.

No clear tendancy concerning fluctuations in the quality of the fittings has been pointed out (Fig. 4) : high values of the Durbin-Watson's *d* are observed for strata with 5 observations or more and high values for the flatness coefficient are observed when using all the available strata. Among the 29 cases studied, fittings explaining in a lesser way the C.P.U.E.'s variance (determination coefficient) are connected to strata with 5 observations or more.

None of the estimations of the h_i coefficients is greater than 0.9. This is in accordance with Saporta saying that "residues are generally mutually correlated" (Saporta 1990). When strata have 5 observations or more, 95 to 100% of the coefficients are between 0.8 and 0.9. Inversely, for fittings using all strata, the coefficients are between 0.5 and 0.9.

Separating C.P.U.E. directed on cod and C.P.U.E. directed on all species, and when comparison is possible (Fig. 6), discrepancies between estimations for the two types of strata are weak. Classification of the vessels according to their fishing powers is most of the time stable. The variations which have been observed are of small numerical values.

3.4 Comparison of the fishing powers in relation to the target species.

Fishing powers estimated in similar conditions (strata, year) are different according to the target species tested (Fig. 7). No tendancy in their fluctuations has been pointed out. Some trawlers like the "Normande" (ND) or the "Bretagne" (BR) have a fishing power which, in comparaison with the mean for all trawlers, are different depending on the target species. In 1991, the fishing power of the "Normande" is systematically lower when the target species is cod. It has the fourth fishing power when all target species are taking into account but the last one when cod is the target species. Discrepancies observed between target species are superior than those described between various space-time strata.

3.5 Inference of the probalility law for the residues : bias and confidence interval estimations.

Two of the 14 series of estimations with C.P.U.E. for all target species can be calculated with confidence intervals, and 7 from C.P.U.E. for cod as the target species. For the latter, the majority (5) corresponds to the use of the whole of the strata (Fig. 8 and 9). So no significant comparison concerning methodological choices on strata and target species can be made. But in 1986, given identical choice of strata, confidence intervals estimated for cod as target species are lower than those for all target species.

Exception made of the data for the year 1986 (cod as target species, and strata with 5 or more observations), confidence intervals are large, and strongly overlap. Until 1988, before arrival of the "St-Denis" and the "St-Pierre" into the fleet, confidence intervals were quite similar. In 1990 and 1991, the fishing power of the "St Denis" is distinct from a group of four vessels ("Goelette", "Normande", "Marmouset" and "Côte St Jacques"). It is not possible to distinguish with precision which of the "St Denis" or the "St Pierre" has the higher efficiency in fishing. In 1990, the ratio of their fishing power is between 0.6 and 1.28. Confidence intervals are greater than fluctuations pointed out in the results obtained considering distinct target species (cod, all species) and choice of strata. Bias correction coefficients are not presented, their values being systematically 1 or 0.99.

4. Discussion

Cod which is the main species sought in the region of Newfoundland is benthic and generally gregarious. This is one of the reasons which allowed us to consider the fish density to be homogeneous in the space-time strata used. It has been noticed that the more important the average number of C.P.U.E. compared in the estimation, the less the model explains the variability of the data (decrease of the determination coefficient). This may indicate that either the fleet of Saint Pierre and Miquelon trawlers is too heterogeneous to be described by a simple multiplivative model, either the strata are not well defined with respect to the hypothesis of fish density homogeneity. Smaller strata in space and time scales could provide some more relevant results.

Coming from the gregarious behavior of cod, it is obvious that catches, and thereby C.P.U.E., are space correlated. The Robson model does not take into account the spatial structures. Hence, as one of the basic hypothesis of the model is not verified, the interpretation of the results is seriously affected.

The Robson model has only been used for the purpose of estimating fishing powers, and not abundance. That is the reason why the results are roughly the same whether the discards are used or not.

Although fishing effort is generally directed, it is possible to consider that fish and gear run accross each other at random (Laurec et Le Guen, 1981). Then we can reasonably consider that C.P.U.E. are the outcomes of a random variable $\mathcal{C}$. While nothing makes us guess the values of both of the two variables $\mathcal{B}$ and $\mathcal{S}$ (representing the vessels ans strata numbers) they can be considered as being random. Their indicators are also two random variables. Moreover, they are disjunctive, negatively correlated and linearly independant as it is requiered to use multiple linear regressions. As they are disjunctive, each arrangement of two different variables (one coding the trawler and the other the stratum) occures only once. The classical tests used to check hypothesis of the model are unusable in this case.

The independance of residues is a quite strong hypothesis since it must be effective to allow the fitting. The Durbin-Watson statistics can only test the one degree correlation of residues. Its use has rejected one third of the fittings. This indicates how bad the average statistical conditions of the estimations are.

The hypothesis dealing with the homogeneity of the variances of the residues is theoretically a more flexible one as long as the discards that may occur can be rectified by an adequat weighting; particularly when C.P.U.E. are weighted by the variances estimated in a first fitting. Nevertheless, the way the results are interpreted as fishing powers is based on the fact that we have compared C.P.U.E. one to another and them only. What does represent C.P.U.E. weighted by the variance of residues assessed in a previous fitting? What does their comparison represent? Being unable to keep control of the physical meaning of the fitting of weighted C.P.U.E., data were unweighted. Variance heterogeneity has been interpreted as a non suitable situation for the use of the Robson model. Besides, this hypothesis is rather hard to verify within the framework of Robson model (no duplication of residue).

One of the solutions is to look at the histograms or the standard errors of residues for each variable. Assuming that residues and explanatory variables are independant, another method consist in estimating the variances by using the "h_i" coefficients. But the number of variables ranges from 18 to 567. It is then quite illusory to compute and observe so many histograms; more especially for those corresponding to the abundance which are made with 2 to 8 observations (number of C.P.U.E.). Furthermore this is one of the justifications for using only strata containing several observations (5 or more for example) to ensure the physical meaning of standard errors as good as possible. Then the non respect of homoscedasticity could be appreciated.

No factor related to the more or less good statistical conditions of the fittings has been pointed out. However the cases for which it has been decided to compute confidence intervals are mainly corresponding to C.P.U.E. directed on cod when using all the available strata of the Subdiv. 3Ps. This is probably the situation where C.P.U.E. fit the best to the Robson linear model. Keeping in mind all the limitations above described, this may be due to the fact that the fleet is more homogeneous when tows are directed on cod than when fishermen are looking for various species.

Generally, estimations have to be associated to a variance or a confidence interval. Nevertheless in every case, whatever the statistical conditions are, estimations are coherent. No significant differences occures between the years, the type of strata and the target species used. Estimations seem to be quite robust according to the methodological choices. Then, even if the statistical conditions are not as good as necessary, the Robson model is useful for giving a good approximate value of the fishing powers.

In the matter of approximations, a first analysis concerning the trawlers activity in 1991 which argues for the coherence of results, indicates that vessels are roughly identically ordered in terms of their fishing powers or their gross tonnage (Tabl. 4). This illustrates why the estimations have been previously qualified as autojustificative. Estimations do not discriminate the two freezers ("St-Pierre", "Bretagne") from the other fresh trawlers. The two more recent trawlers ("St-Denis", "St-Pierre") have the highest fishing powers while old vessels like "Marmouset" and "Côte St-Jacques" have the two lowest ones (Fig. 6). According to recent analysis of catches, it has been pointed out that "cod is going deeper and deeper during winter" (Anonyme, 1991; Bishop et al, 1991; Moguedet, 1991). This biological behavior could amplify the consequences of a difference between engine powers in terms of fishing powers.

In other situations (1986, 1988 and 1991) with regards to the other trawlers, the "Normande" and the "Goelette" are differently ordered whether the target species is cod or all species. Compared to the mean fishing power of all the trawlers, they have a lower efficiency than the others when they are looking for cod. As it was already mentionned (Bertrand, 1988) in 1986 the fleet of St-Pierre and Miquelon trawlers is quite homogeneous. This point of view is confirmed since the estimations are close one to the other and differences of fishing powers are too short to be significant. In any case, no good biological or technical explaination had been found.

Even if are exactly the same vessels (Tabl. 3) the "Normande" and the "Goelette" don't have the same fishing power. Even if estimations are not taken into account with their confidence intervals, that indicates how necessary the standardization of fishing efforts is. But in the same time, it points out how important the use of confidence intervals is.

The computation of confidence intervals is quite revealing. It shows that the differences in fishing powers estimated for various target species, strata or trawlers ordering are smaller than the incertitudes on the estimations themselves. That's why even if the Robson model is able to propose approximate values, its use is quite unrelevant for computing some precise index of standardization of fishing efforts. However, in one case (1986) confidences intervals are disjoined. This is providing a clear discrimination between vessels. As estimations are quite similar and confidence intervals very short, that proves that the fleet is as homogeneous as it was mentionned by Bertrand (1988). However showing little differences, the trawlers could be separated in three classes (Fig. 8) : the "Bretagne" and the "Marmouset" with the highest fishing efficiency (1.25), the "Normande" with the lowest one (0.6) and the "Goelette" and the "Croix de Lorraine" two intermediate vessels (1). This global homogeneity between those 5 trawlers seems to be roughly constant taking into account the confidence intervals of their estimations.

In 1991 the fleet is composed of three groups : one with the 5 previous vessels for which fishing efficiency range from 0.5 to 1.1 and two other of one trawler each, the "St-Pierre" for the intermediate one (fishing power between 1.1 and 1.8) and the "St-Denis" for the third one (fishing power from 1.3 to 2). As a consequence, with 5% error on the diagnosis the two freezers don't have the same fishing power when they are looking for cod (0.7 to 1.1 for the "Bretagne" and 1.1 to 1.8 for the "St-Pierre"). Which factor between the year of construction, the power of engine or the gross tonnage is related to that situation? Not enough releavant data are available to formulate a satisfying explanation.

In so far as the standardization of fishing effort is necessary, whatever the model is, the estimations are faced to the important part of local irregularities that always exist in the matter of fish exploitations. Eventhough the models were well defined, they have to deal with the situation where two identical trawlers, fishing in the same conditions, may not have the same catches. This fact is taken into account by the geostatistics (Matheron, 1965) and Laurec (1977) has already proposed a model based on the computation of variograms which is said to be releavant.

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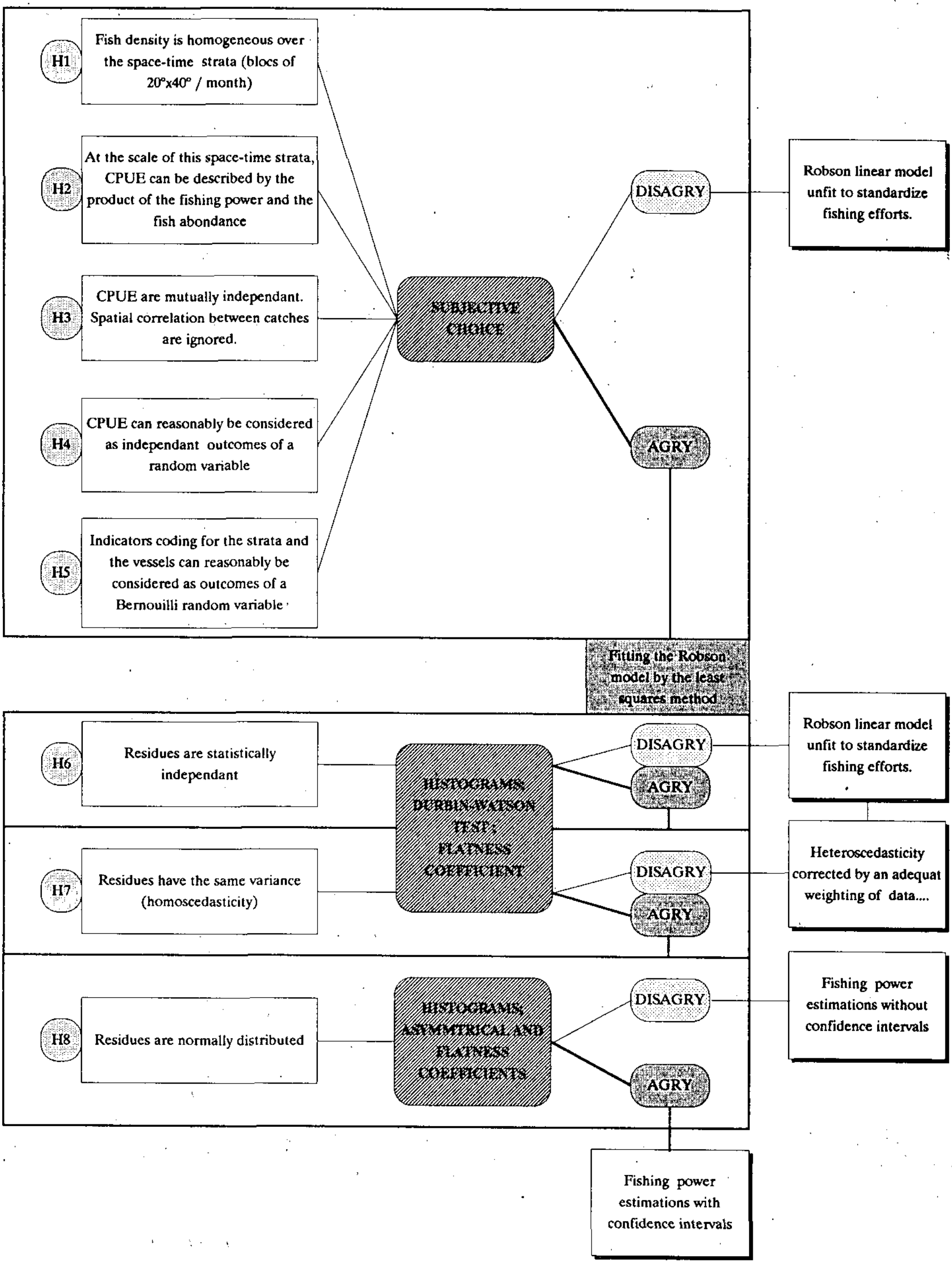


Table 1 : Description of hypothesis underlying the use of the Robson linear model (1966).

I- CARACTERISTICS OF THE CPUE USED FOR ESTIMATIONS OF THE RELATIVE FISHING POWER PER VESSEL :

[a] year of the catches 1986

[b] target species : all species from the Subdivision 3Ps ALL

or cod only COD

[c] type of space-time strata used for the assesments : all the *available strata* ALL

or strata containing 5 observations or more 5OBS

[d] strata of a different type : CPUE per tow in blocs 20°x40° TOW

II- CARACTERISTICS OF THE FITTING :

[a] total number of observations **(total)**

[b]Durbin -Watson test value **(d)**

[c] determination coefficient of the fitting **(R2)**

[d] asymmetrical coefficient (skewness) of the histograms of the empirical residues **(asym)**

[e] flatness coefficient (kurtosis) of the histograms of the empirical residues **(flat)**

III- RESULTS OF THE FITTING :

[a] number of observations per vessel **(pds)**

[b] sorting out of the vessels according to their fishing powers **(order)**

[c] minimum of the confidence interval (5%) in the estimations of the fishing powers **(inf)**

[d] estimations of the individual fishing powers with respect to a unit geometrical mean **(FP)**

[e] maximum of the confidence interval (5%) in the estimations of the fishing powers **(sup)**.

Bad statistical conditions for the fitting : estimations are noted but not tint.

Good statistical conditions for the fitting but not for the inference of a model : estimations are noted and tint.

Good statistical conditions for the fitting and the inference of a model : *estimations and confidence intervals* are noted and tint.

CODE FOR TRAWLERS

BR : Bretagne

SP : Saint Pierre

CX : Croix de Lorraine

GT : Goëlette

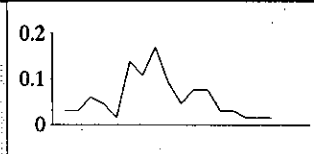
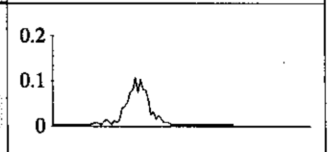
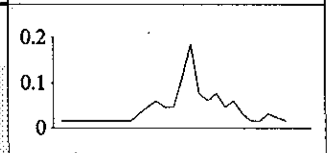
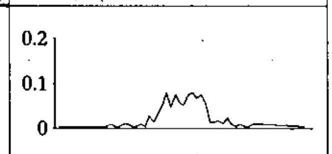
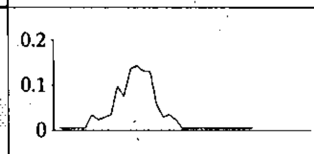
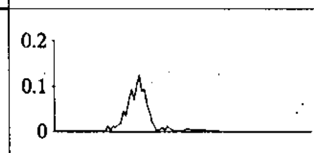
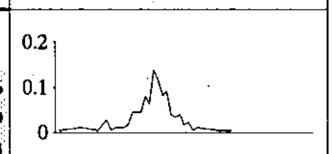
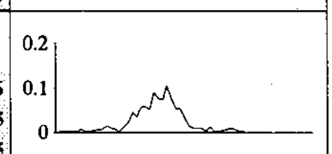
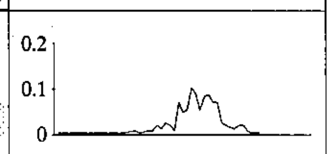
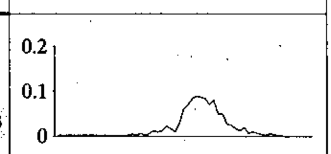
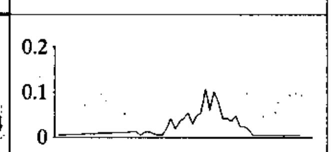
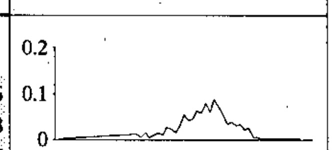
ND : Normande

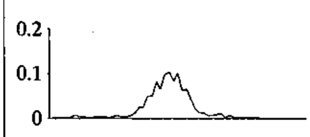
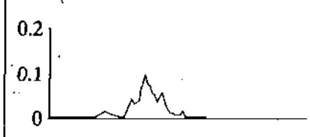
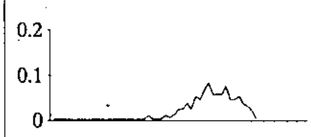
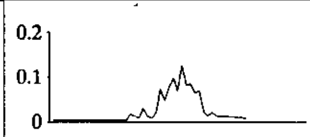
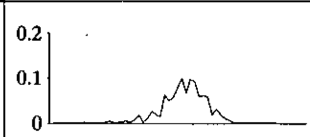
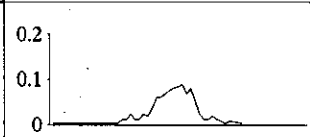
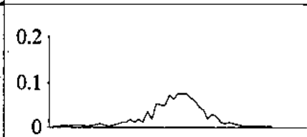
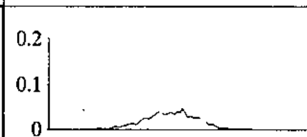
SD : Saint Denis

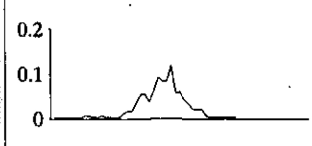
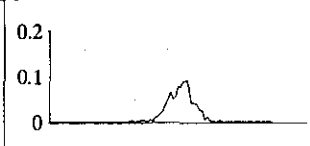
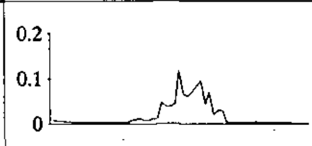
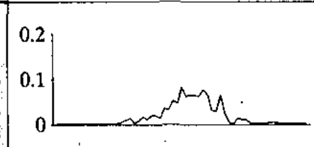
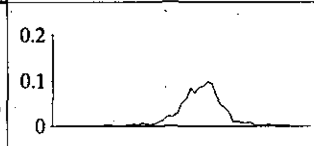
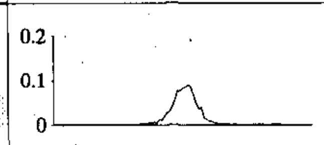
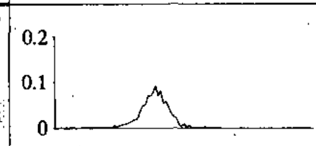
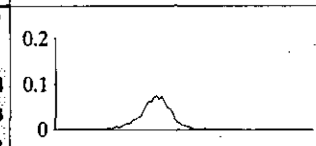
MS : Marmouset

CJ : Côte Saint Jacques

Table 2 : Results of the Robson model *using the least squares* method applied to the CPUE from 1986 to 1991 in the Subdiv. 3Ps.

Year	Species	Data	Stat	Value		BR	SP	CX	GT	ND	SD	MS	CJ	distribution of residues
1986	ALL	5 OBS	total	65	pds	13	-	13	13	13	-	13	-	
			d	2.09	order	2	-	4	3	5	-	1	-	
			R2	0.79	inf	0.85	-	0.8	0.82	0.65	-	0.99	-	
			asym	0.165	FP	1.04	-	0.98	1.01	0.8	-	1.21	-	
			flat	2.82	sup	1.28	-	1.21	1.24	0.98	-	1.48	-	
		ALL	total	250	pds	60	-	47	41	56	-	46	-	
			d	1.61	order	3	-	4	2	5	-	1	-	
			R2	0.66	inf	-	-	-	-	-	-	-	-	
			asym	0.17	FP	0.96	-	0.91	1.05	0.89	-	1.21	-	
			flat	13.5	sup	-	-	-	-	-	-	-	-	
	COD	5 OBS	total	65	pds	13	-	13	13	13	-	13	-	
			d	2.41	order	1	-	3	4	5	-	2	-	
			R2	0.84	inf	1.2	-	0.9	0.89	0.6	-	1.16	-	
			asym	-0.36	FP	1.3	-	0.98	0.96	0.66	-	1.26	-	
			flat	4.25	sup	1.41	-	1.06	1.04	0.71	-	1.36	-	
		ALL	total	212	pds	48	-	42	34	48	-	40	-	
			d	1.45	order	2	-	4	1	5	-	2	-	
			R2	0.8		-	-	-	-	-	-	-	-	
			asym	-0.1	FP	1.13	-	0.76	1.38	0.76	-	1.13	-	
			flat	5.5		-	-	-	-	-	-	-	-	
1987	ALL	5 OBS	total	176	pds	33	-	33	29	32	-	33	16	
			d	1.89	order	4	-	6	3	5	-	2	1	
			R2	0.72		-	-	-	-	-	-	-	-	
			asym	0.69	FP	0.92	-	0.86	1.02	0.91	-	1.15	1.2	
			flat	7.1		-	-	-	-	-	-	-	-	
		ALL	total	329	pds	61	-	65	54	68	-	60	21	
			d	1.4	order	6	-	5	4	2	-	3	1	
			R2	0.74		-	-	-	-	-	-	-	-	
			asym	0.05	FP	0.79	-	0.95	1.05	1.09	-	1.07	1.1	
			flat	11.15		-	-	-	-	-	-	-	-	
	COD	5 OBS	total	174	pds	33	-	33	27	32	-	33	16	
			d	1.88	order	3	-	5	4	6	-	2	1	
			R2	0.745	inf	0.84	-	0.68	0.81	0.64	-	0.9	1.06	
			asym	-0.62	FP	1.02	-	0.83	1	0.78	-	1.1	1.39	
			flat	5.7	sup	1.29	-	1	1.24	0.95	-	1.33	1.83	
		ALL	total	312	pds	59	-	62	49	63	-	59	20	
			d	1.74	order	5	-	4	2	6	-	3	1	
			R2	0.81	inf	0.76	-	0.78	0.92	0.71	-	0.89	0.86	
			asym	0.25	FP	0.92	-	0.93	1.13	0.85	-	1.06	1.15	
			flat	4.9	sup	1.1	-	1.11	1.38	1.01	-	1.28	1.55	
1988	ALL	5 OBS	total	240	pds	41	-	40	39	37	-	43	40	
			d	1.65	order	5	-	6	3	1	-	2	4	
			R2	0.68		-	-	-	-	-	-	-	-	
			asym	-1.2	FP	0.83	-	0.79	1.07	1.25	-	1.13	1.01	
			flat	8.1		-	-	-	-	-	-	-	-	
		ALL	total	404	pds	75	-	50	74	86	-	63	56	
			d	1.8	order	5	-	6	1	2	-	3	4	
			R2	0.69		-	-	-	-	-	-	-	-	
			asym	-0.77	FP	0.86	-	0.79	1.13	1.13	-	1.11	1.03	
			flat	7		-	-	-	-	-	-	-	-	
	COD	5 OBS	total	167	pds	30	-	28	26	25	-	30	28	
			d	1.7	order	4	-	6	5	3	-	1	2	
			R2	0.71		-	-	-	-	-	-	-	-	
			asym	-0.97	FP	0.93	-	0.86	0.9	0.97	-	1.38	1.04	
			flat	7.2		-	-	-	-	-	-	-	-	
		ALL	total	329	pds	71	-	37	54	71	-	57	39	
			d	1.8	order	3	-	6	5	4	-	1	2	
			R2	0.79	inf	0.82	-	0.69	0.75	0.79	-	1.03	0.86	
			asym	0.53	FP	0.98	-	0.87	0.92	0.94	-	1.26	1.08	
			flat	5.3	sup	1.17	-	1.09	1.13	1.13	-	1.52	1.36	

Year	Set	Subset				BR	SP	CX	GT	ND	SD	MS	CJ	distribution of residues
1989	ALL	SOBS	total	266	pds	41	25	10	44	43	23	45	35	
			d	1.61	order	2	3	7	5	4	1	8	6	
			R2	0.59		-	-	-	-	-	-	-	-	
			asym	0.9	FP	1.15	1.14	0.84	0.95	1.08	1.47	0.72	0.84	
			flat	7.34		-	-	-	-	-	-	-	-	
		ALL	total	459	pds	76	43	16	84	77	33	74	56	
			d	1.8	order	2	3	7	5	4	1	8	6	
			R2	0.68		-	-	-	-	-	-	-	-	
			asym	-0.74	FP	1.22	1.16	0.82	1.02	1.1	1.33	0.7	0.83	
			flat	7		-	-	-	-	-	-	-	-	
	COD	SOBS	total	242	pds	37	23	9	38	39	21	42	33	
			d	1.51	order	2	4	8	3	5	1	6	7	
			R2	0.65		-	-	-	-	-	-	-	-	
			asym	-1.12	FP	1.55	0.92	0.69	0.96	0.92	1.63	0.88	0.8	
			flat	7.75		-	-	-	-	-	-	-	-	
		ALL	total	427	pds	73	41	14	73	71	30	71	54	
			d	1.58	order	1	4	8	3	7	2	5	6	
			R2	0.72		-	-	-	-	-	-	-	-	
			asym	-0.76	FP	1.68	0.95	0.68	1.05	0.81	1.49	0.88	0.83	
			flat	6.95		-	-	-	-	-	-	-	-	
1990	ALL	SOBS	total	236	pds	36	34	-	36	33	33	36	28	
			d	1.45	order	4	2	-	3	5	1	6	7	
			R2	0.55		-	-	-	-	-	-	-	-	
			asym	-0.9	FP	1.03	1.34	-	1.13	0.94	1.64	0.76	0.58	
			flat	7.5		-	-	-	-	-	-	-	-	
		ALL	total	380	pds	63	64	-	57	64	48	48	36	
			d	1.58	order	4	2	-	3	5	1	6	7	
			R2	0.65		-	-	-	-	-	-	-	-	
			asym	-0.56	FP	1	1.17	-	1.11	0.91	1.76	0.71	0.67	
			flat	6.7		-	-	-	-	-	-	-	-	
	COD	SOBS	total	248	pds	38	36	-	37	35	34	38	30	
			d	1.47	order	3	2	-	4	5	1	6	7	
			R2	0.6		-	-	-	-	-	-	-	-	
			asym	-0.8	FP	1.13	1.48	-	1.03	0.88	1.68	0.71	0.56	
			flat	5.8		-	-	-	-	-	-	-	-	
		ALL	total	372	pds	59	63	-	57	62	47	48	36	
			d	1.61	order	3	2	-	4	5	1	6	7	
			R2	0.72		1.02	1.2	-	0.82	0.67	1.34	0.58	0.48	
			asym	-0.62	FP	1.22	1.44	-	0.99	0.81	1.64	0.71	0.61	
			flat	4.9		1.47	1.72	-	1.19	0.97	2.01	0.87	0.77	
		TOW	total	3554	pds	679	623	-	589	513	499	328	323	
			d	1.72	order	3	2	-	4	5	1	6	7	
			R2	0.41	inf	1.1	1.2	-	0.94	0.72	1.41	0.69	0.62	
			asym	-0.42	FP	1.19	1.3	-	1.02	0.78	1.54	0.77	0.69	
			flat	3.65	sup	1.28	1.41	-	1.11	0.85	1.67	0.85	0.77	

Year	Species	Strata				BR	SP	CX	GT	ND	SD	MS	CJ	distribution of residues
1991	ALL	5 OBS	total	237	pds	33	32	-	38	35	29	37	33	
			d	1.89	order	5	2	-	3	4	1	6	7	
			R2	0.6	inf	**0.66**	**1.09**	-	**1.03**	**0.8**	**1.23**	**0.59**	**0.57**	
			asym	-0.6	FP	**0.8**	**1.35**	-	**1.24**	**0.97**	**1.53**	**0.72**	**0.7**	
			flat	4.2	sup	**0.99**	**1.66**	-	**1.51**	**1.19**	**1.91**	**0.87**	**0.85**	
		ALL	total	381	pds	51	46	-	66	61	50	57	50	
			d	1.77	order	5	2	-	3	4	1	6	7	
			R2	0.65		-	-	-	-	-	-	-	-	
			asym	-1.2	FP	**0.83**	**1.25**	-	**1.11**	**1.04**	**1.65**	**0.73**	**0.69**	
			flat	15.3		-	-	-	-	-	-	-	-	
	COD	5 OBS	total	232	pds	32	31	-	37	34	29	37	32	
			d	2.03	order	4	2	-	3	7	1	6	5	
			R2	0.61		-	-	-	-	-	-	-	-	
			asym	-0.88	FP	**0.88**	**1.56**	-	**1.06**	**0.66**	**1.56**	**0.82**	**0.83**	
			flat	7.3		-	-	-	-	-	-	-	-	
		ALL	total	365	pds	51	46	-	57	58	49	56	48	
			d	1.84	order	5	2	-	3	7	1	4	6	
			R2	0.71	inf	**0.7**	**1.09**	-	**0.74**	**0.56**	**1.3**	**0.72**	**0.66**	
			asym	-0.61	FP	**0.89**	**1.39**	-	**0.93**	**0.69**	**1.65**	**0.91**	**0.84**	
			flat	5.8	sup	**1.12**	**1.77**	-	**1.16**	**0.86**	**2.1**	**1.13**	**1.07**	
86-91	ALL	5 OBS	total	1213	pds	197	91	96	192	193	85	207	152	
			d	1.57	order	5	2	8	3	4	1	6	7	
			R2	0.635		-	-	-	-	-	-	-	-	
			asym	-0.96	FP	0.91	1.32	0.76	1.03	0.98	1.61	0.85	0.79	
			flat	7.8		-	-	-	-	-	-	-	-	
		ALL	total	2203	pds	386	153	178	376	412	131	348	219	
			d	1.61	order	5	2	8	3	4	1	6	7	
			R2	0.69		-	-	-	-	-	-	-	-	
			asym	-0.6	FP	**0.9**	**1.2**	**0.8**	**1.04**	**0.99**	**1.62**	**0.85**	**0.81**	
			flat	10.3		-	-	-	-	-	-	-	-	
	COD	5 OBS	total	1128	pds	183	90	83	178	178	84	193	139	
			d	1.62	order	3	2	8	4	7	1	5	6	
			R2	0.66		-	-	-	-	-	-	-	-	
			asym	-0.94	FP	**1.06**	**1.36**	**0.75**	**0.96**	**0.78**	**1.68**	**0.91**	**0.81**	
			flat	7.7		-	-	-	-	-	-	-	-	
		ALL	total	2017	pds	361	150	155	324	373	126	331	197	
			d	1.6	order	3	2	8	4	7	1	5	6	
			R2	0.753	inf	**0.98**	**1.13**	**0.66**	**0.91**	**0.71**	**1.43**	**0.84**	**0.74**	
			asym	-0.55	FP	**1.07**	**1.28**	**0.76**	**0.99**	**0.78**	**1.64**	**0.92**	**0.83**	
			flat	5.96	sup	**1.16**	**1.46**	**0.87**	**1.09**	**0.85**	**1.89**	**1**	**0.92**	

Factor	Number of classes	Durbin-Watson test value	asymmetrical coefficient	F(k-1,n-k) 10%	F(k-1,n-k) 5%
Target species	2	0.191	0.417	2.91	4.23
Type of strata	2	1.88	0.457	2.91	4.23
Dispersion of the observations	4	1.54	2.66	2.33	3.01
Year	6	1.7	1.93	2.13	2.66

Table 3 : One way analysis of variance of Durbin-Watson test values and the asymmetrical coefficients of the histograms of residues.

	Name	Type	Year of construction	Length (m)	Engine power (KW)	Gross tonnage (tx)
1	Bretagne	Freezer	1983	50	1808	771
2	Côte St-Jacques	Fresh	1972	48.8	1472	451.7
3	Croix de Lorraine	Fresh	1970	46.6	1178	422.9
4	Goélette	Fresh	1974	46.3	1472	690
5	Marmouset	Fresh	1971	50	1325	634
6	Normande	Fresh	1974	46.3	1472	690
7	St-Denis	Fresh	1989	50	2208	837.1
8	St-Pierre	Freezer	1989	50	2208	837.1

Table 4 (a)

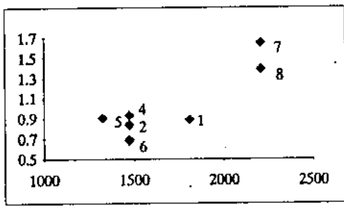


Table 4 (b)

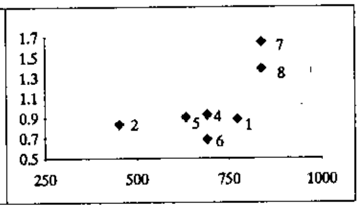


Table 4 (c)

Table 4 : (a) St-Pierre and Miquelon trawlers caracteristics.
(b) Fishing powers estimated in 1991 with C.P.U.E. directed on cod against engine powers
(c) Fishing powers estimated in 1991 with C.P.U.E. directed on cod against gross tonnage

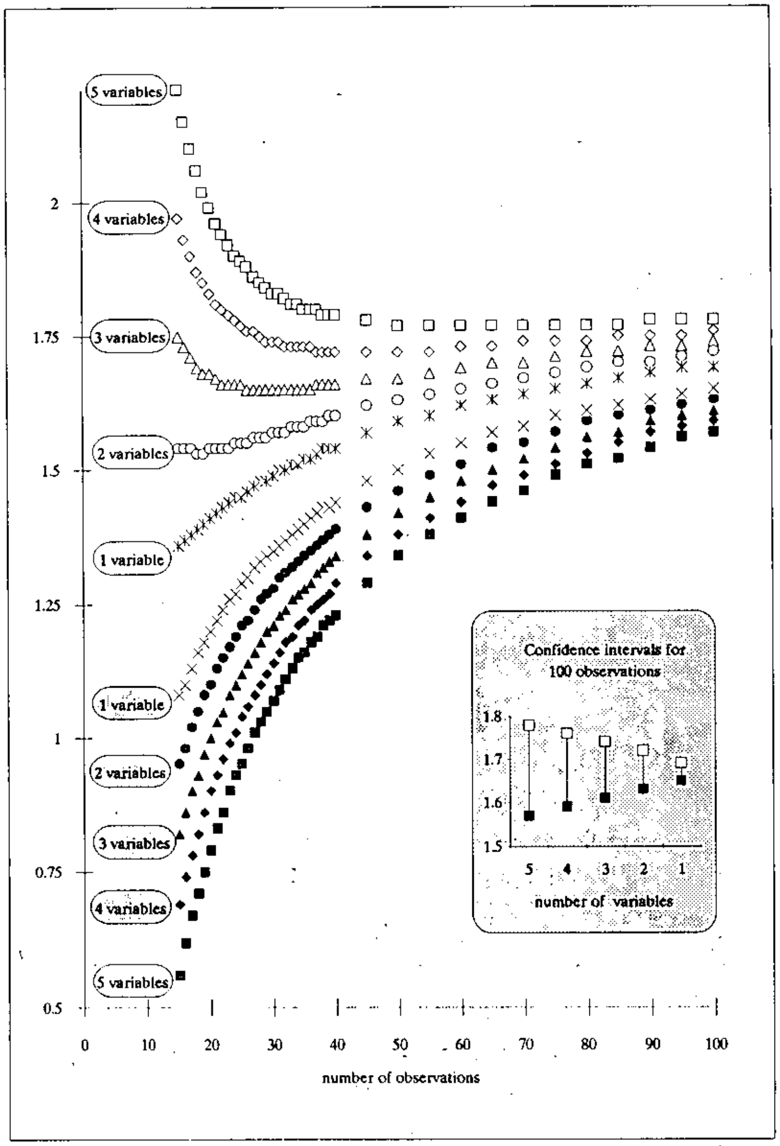


Figure 1 : Confidence intervals (5%) for the Durbin-Watson test with various numbers of observations (15 to 100) and various numbers of variables (1 to 5) (Saporta, 1990)

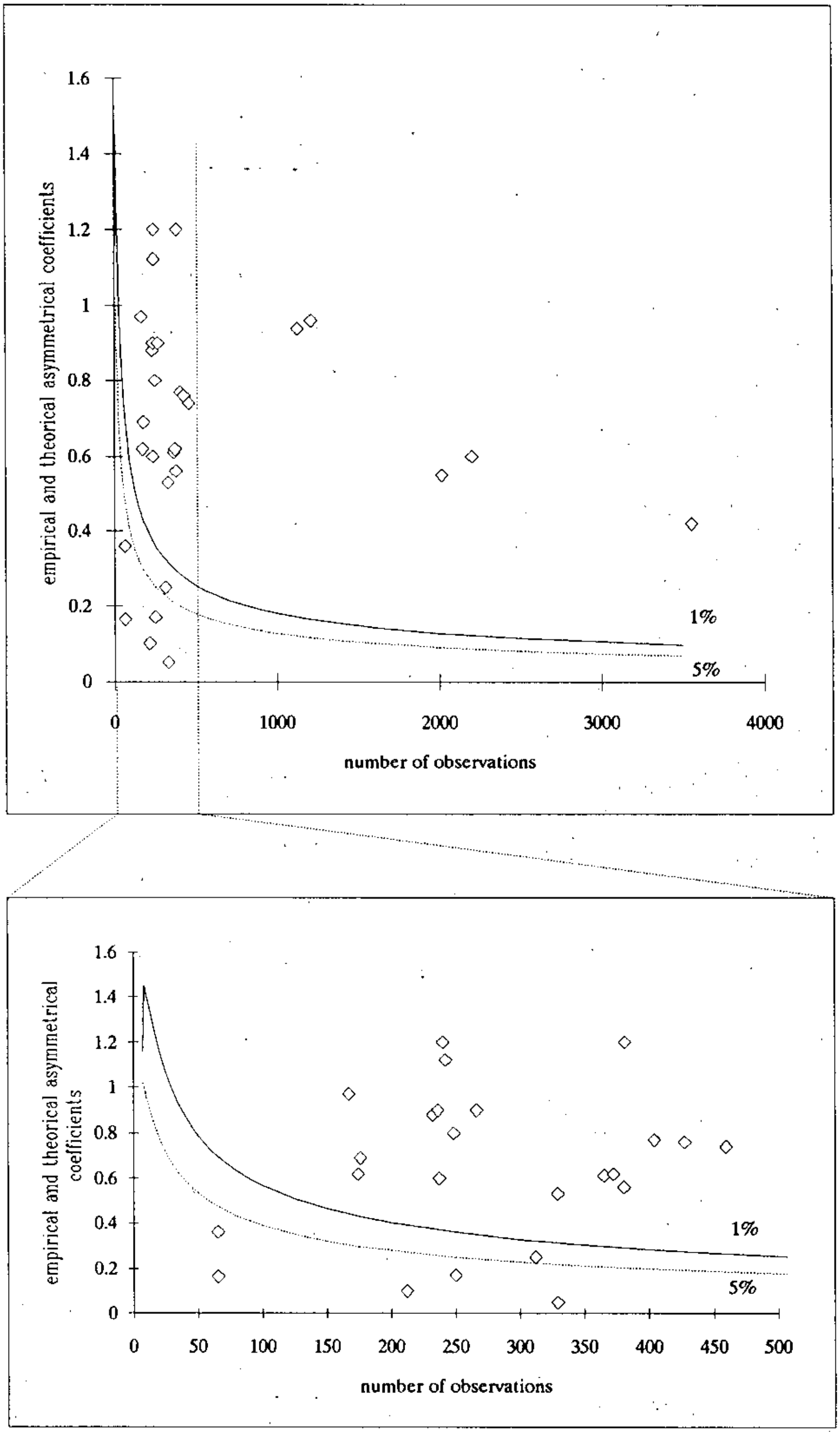


Figure 2 : Asymmetrical coefficients (absolute value) of residues in relation with the number of observations . Correspondance with the theorical critical threshold (1% and 5%) calculated for normal law samples (Saporta, 1990)

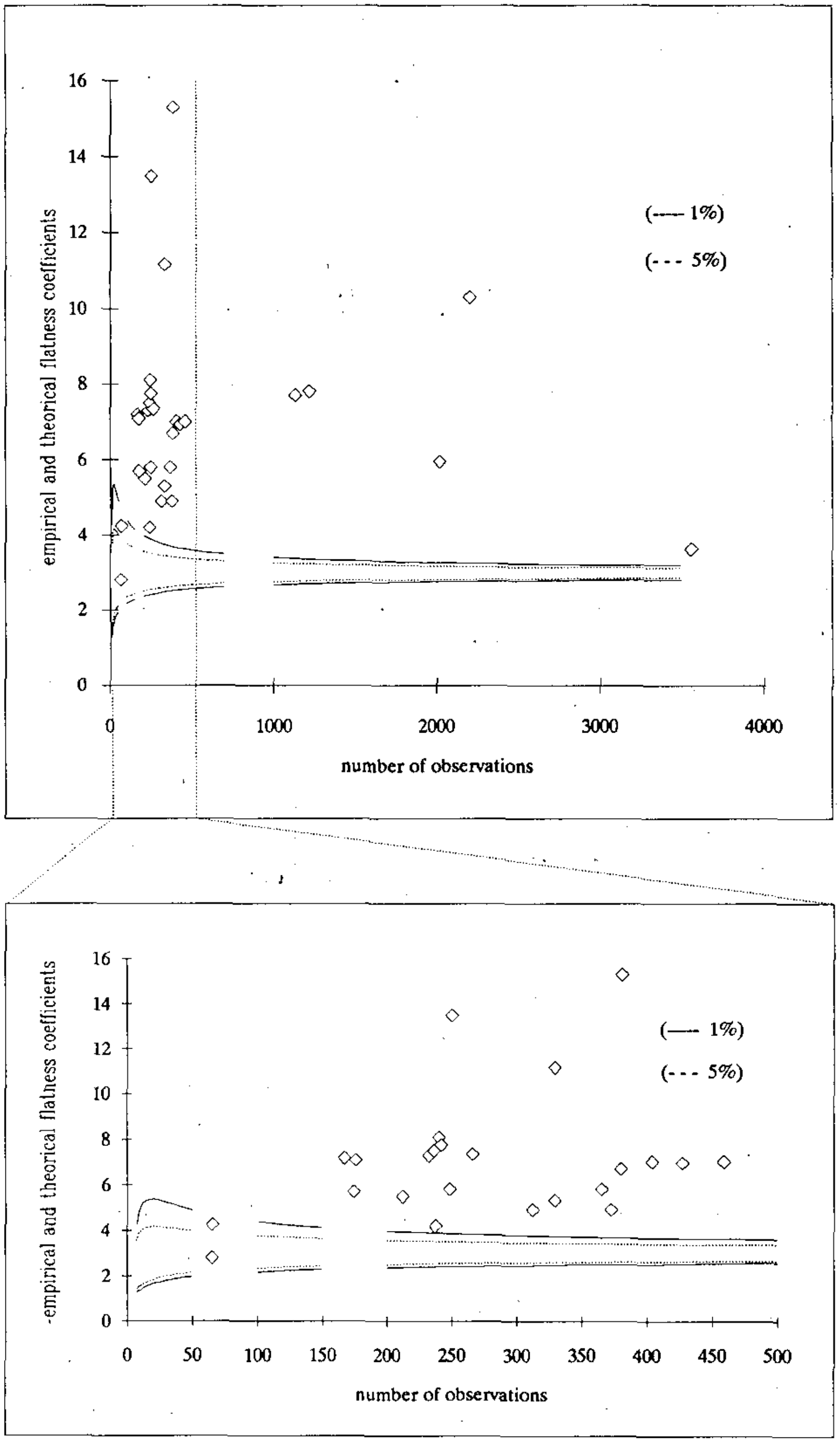


Figure 3 : Flatness coefficients of residues in relation with the number of observations. Correspondance with the theorical critical threshold (1% and 5%) calculated for normal law samples. (Saporta, 1990)

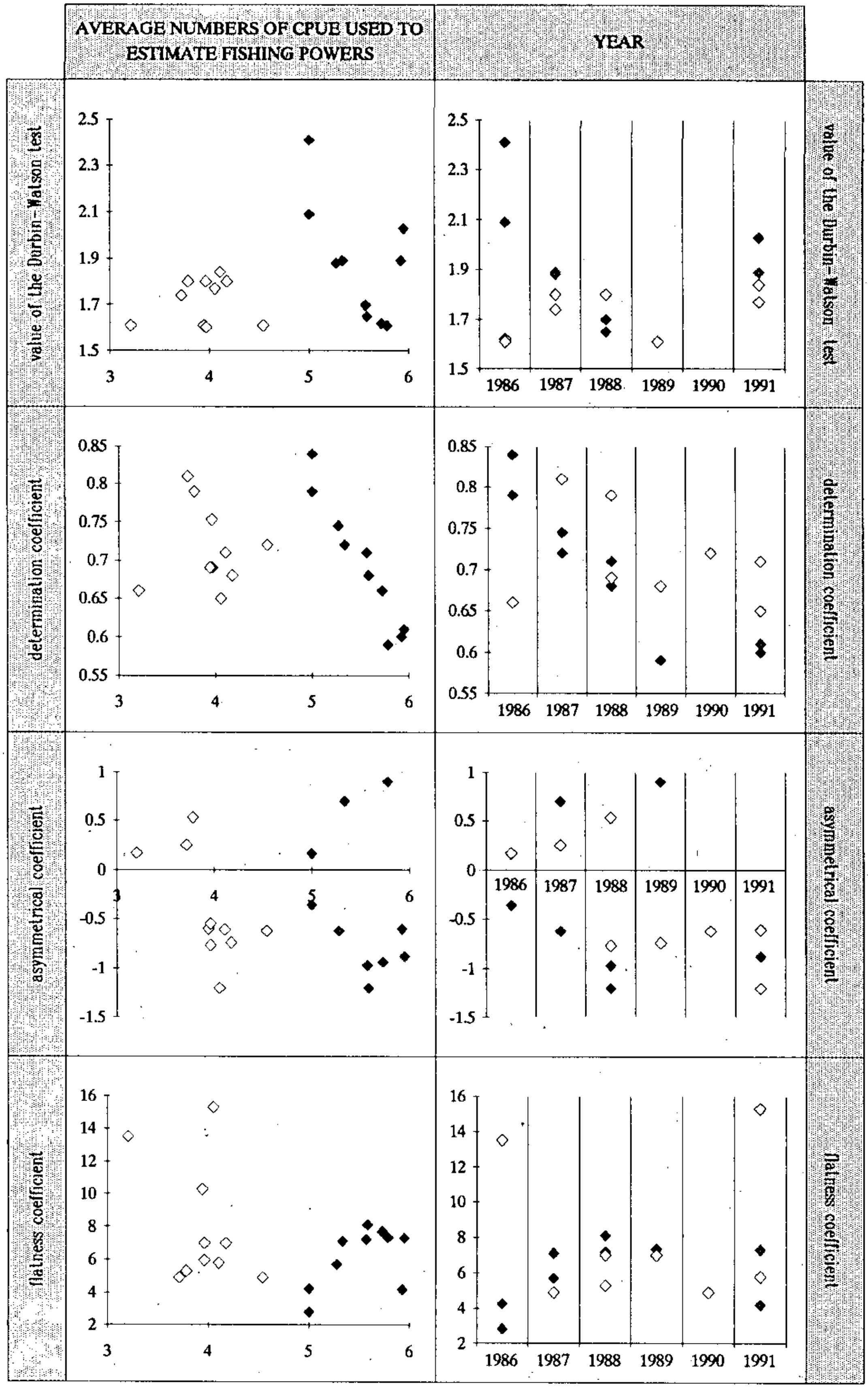


Figure 4 : Values of the Durbin-Watson test, determination,asymmetrical and flatness coefficients against the average numbers of CPUE used to estimate fishing powers and against the year. Results of the fitting using :

1- strata containing 5 observations or more

2- all the available strata

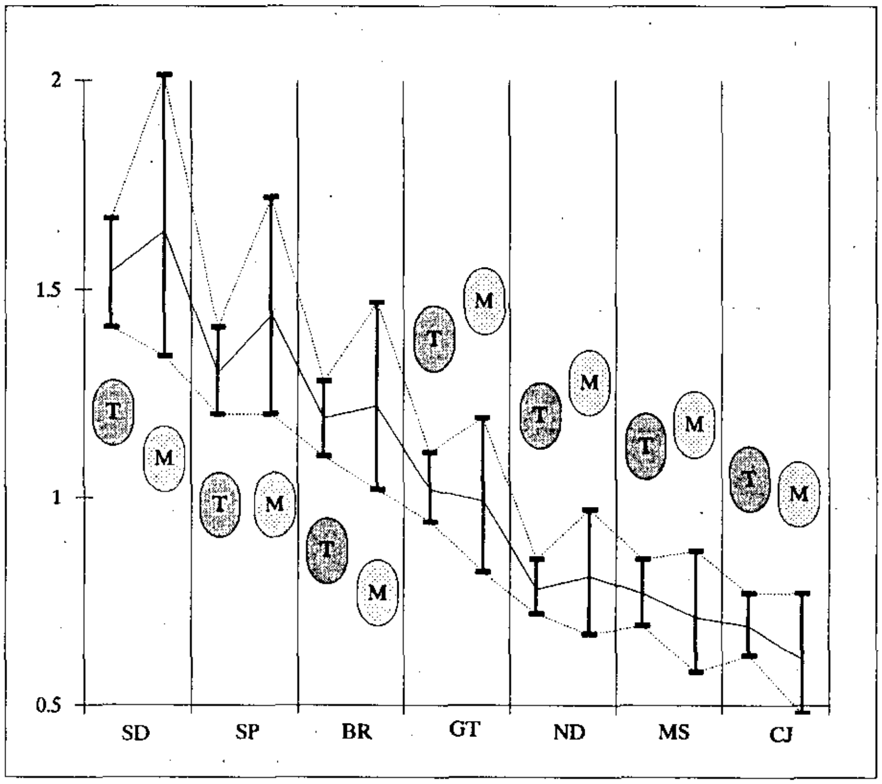


Figure 5 : Fishing powers by vessels and confidence intervals (5%) estimated by the Robson model. CPUE directed on cod in the Subdiv. 3Ps in 1990. Comparison of the results from different data bases :

1- CPUE per tow in blocs of 20°x40° (T)

2- monthly means of the CPUE in blocs of 20°x40° (M)

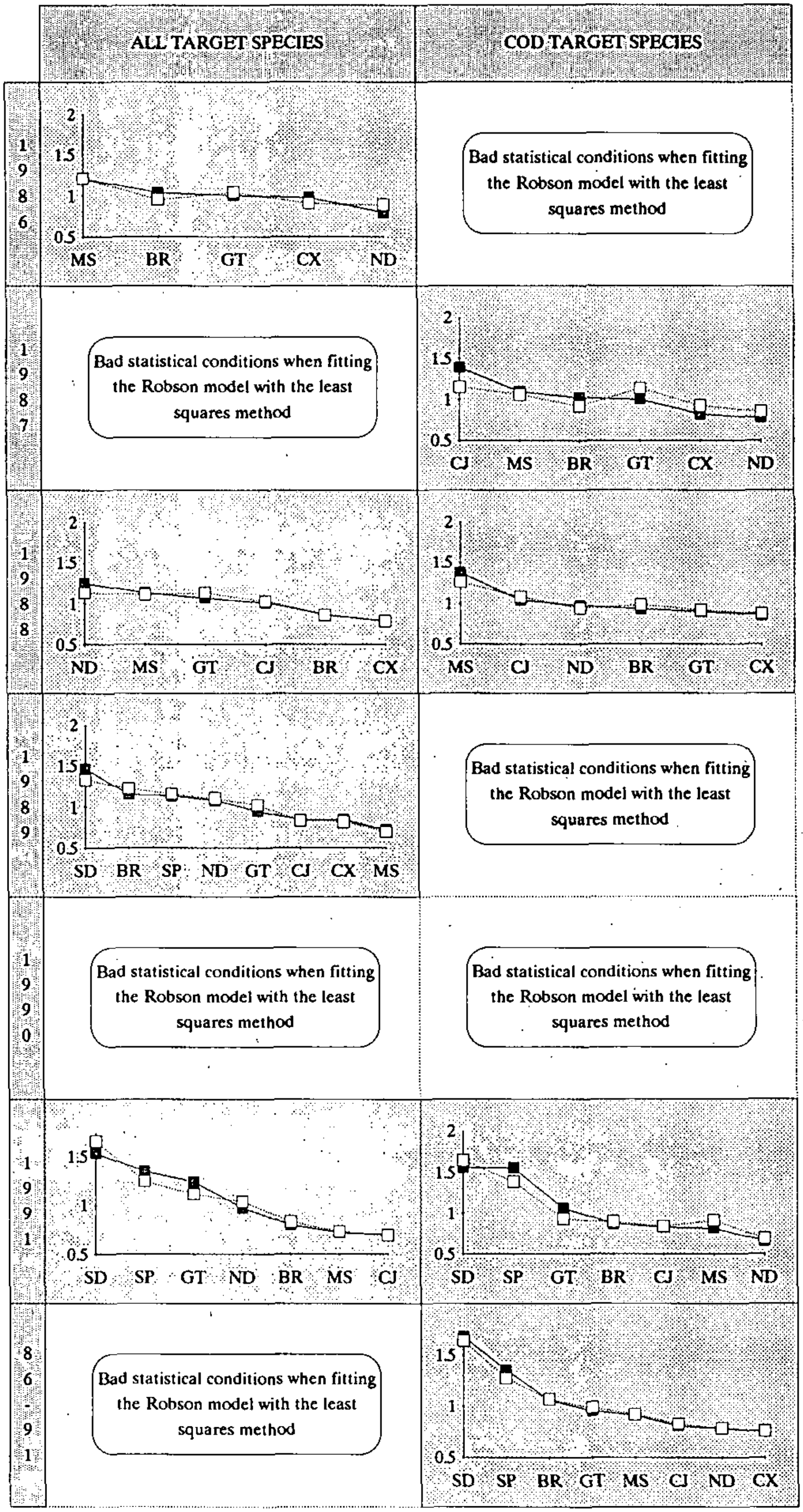


Figure 6 : Comparison of the fishing powers (relative to a unit geometrical mean) in relation with the type of the strata used for fixed target species and fixed year.
1- strata containing 5 observations or more ■
2- all the available strata □

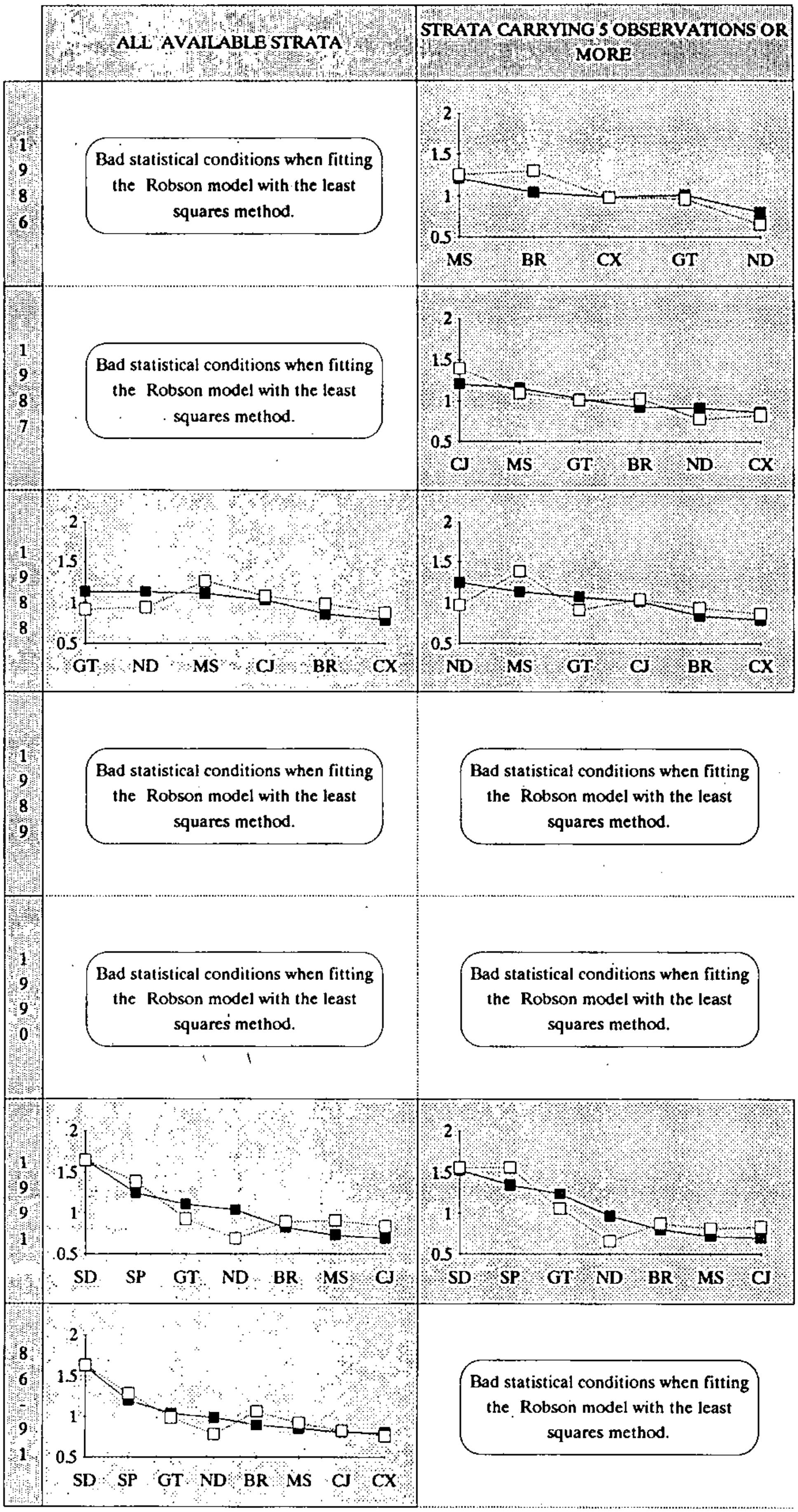


Figure 7 : Comparison of the fishing powers (relative to a unit geometrical mean) in relation with the type of target species.

1- CPUE directed on all the species of the subdivision 3Ps ■

2- CPUE directed on cod only □

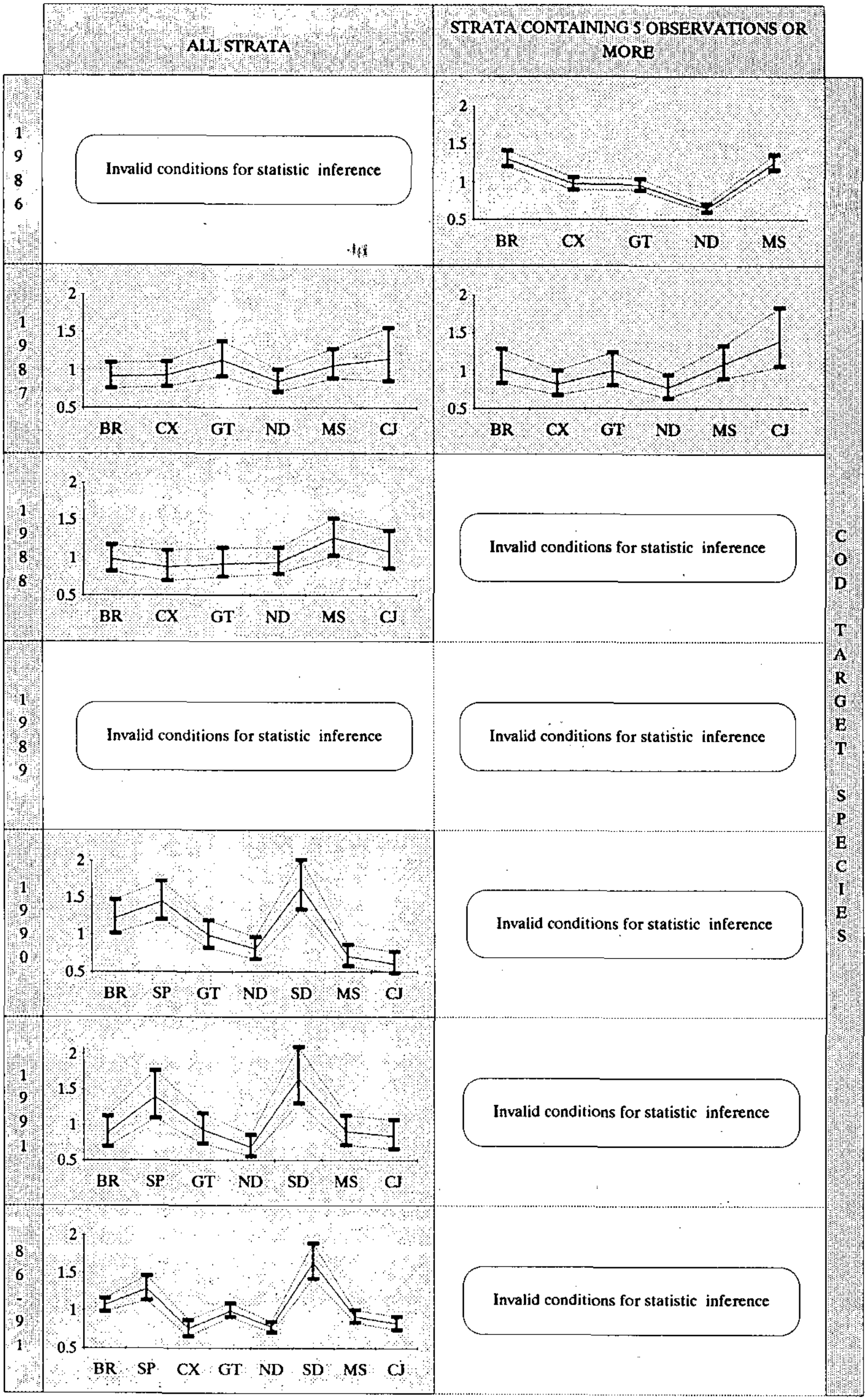


Figure 8 : Fishing powers by vessel (relative to a unit geometrical mean) and confidence intervals (5%) estimated by the Robson model. CPUE are directed on cod in the Subdiv. 3Ps.

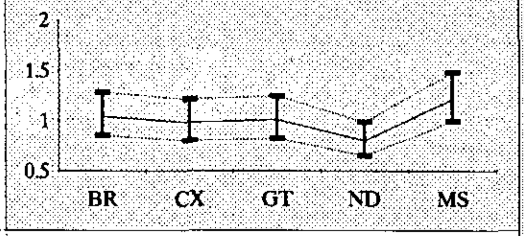
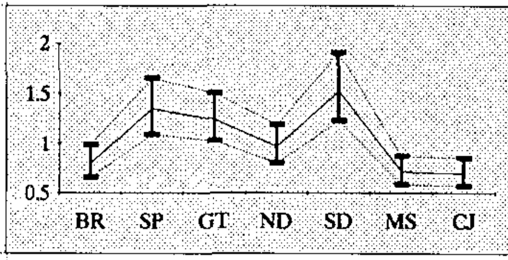
	ALL AVAILABLE STRATA	STRATA CONTAINING 5 OBSERVATIONS OR MORE	
1986	Invalid conditions for statistic inference		ALL TARGET SPECIES
1987	Invalid conditions for statistic inference	Invalid conditions for statistic inference	
1988	Invalid conditions for statistic inference	Invalid conditions for statistic inference	
1989	Invalid conditions for statistic inference	Invalid conditions for statistic inference	
1990	Invalid conditions for statistic inference	Invalid conditions for statistic inference	
1991	Invalid conditions for statistic inference		
86-91	Invalid conditions for statistic inference	Invalid conditions for statistic inference	

Figure 9 : Fishing powers by vessels (relative to a unit geometrical mean) and confidence intervals (5%) estimated by the Robson model. CPUE are directed on every species of the Subdiv. 3Ps.

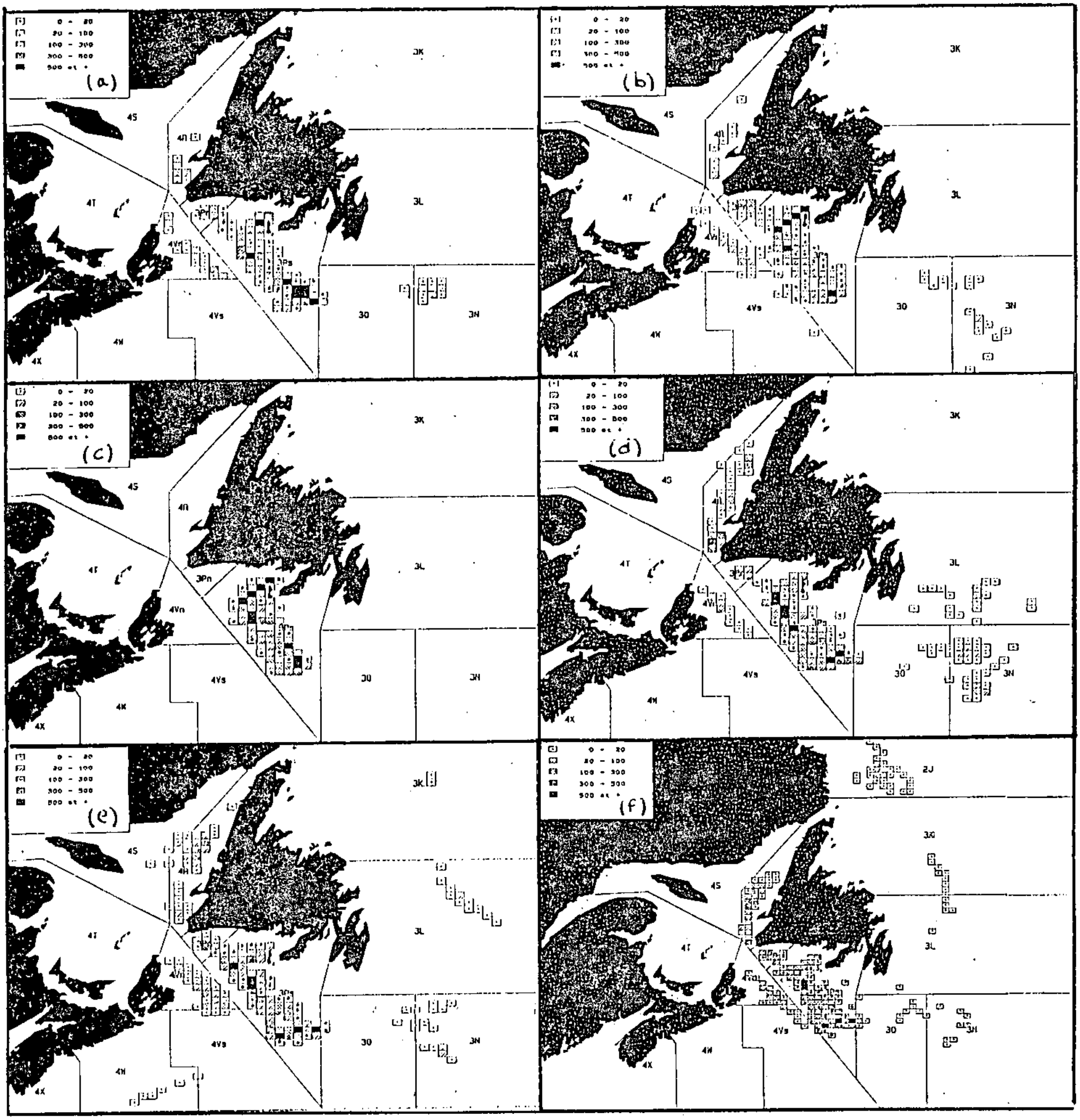


Figure 10 : Average fishing effort (hours of trawling) in blocs of 20'x40' from 1986 to 1991. Saint-Pierre and Miquelon trawlers in the Subdivis. 3Ps.
(a) : 1986; (b) : 1987; (c) : 1988; (d) : 1989; (e) : 1990; (f) : 1991.