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THE FISHERY OF THE SOUTHERN RED SNAPPER (LUTJANUS PURPUREUS) IN FRENCH GUIANA: ANALYSIS AND PROCESSING OF FISHERY STATISTICS.

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ABSTRACT: The southern red snapper *Lutjanus purpureus* is traditionally exploited by a fleet of Venezuelan handliners in French Guiana's E.E.Z. The processing of fishery statistics supplies a quantitative description of the resource and of the fleet, which is required for management and stock assessment. The model involved is a two factor multiplicative one. It extracts from C.P.U.E. fishing power by boat and an apparent abundance of red snapper by space and time stratum. The algorithm used by the program PUIS2 allows for an important saving of computer worktime, which permits exploratory data analysis on microcomputer. Fishing power variations provide a fleet typology based upon some similitudes about fishing tactics and strategy. Variations of apparent abundance per area-month stratum lead to set a diagram of the vital life cycle stages: juvenile, reproductive adult and recovering adults.

RESUMEN: El pargo colorado *Lutjanus purpureus* de la ZEE de Guayana Francesa es tradicionalmente explotado por embarcaciones de altura venezolana que emplean el cordel. El tratamiento de las estadísticas de pesca de una descripción cuantitativa del recurso y de la flota, la cual es necesaria para la ordenación y evaluación. Un modelo con dos factores multiplicativos ha sido utilizado. Este saca de la CPUE una potencia de pesca por barco y una abundancia aparente de pargo colorado por estrato de espacio y de tiempo. El algorithmo del programa PUIS2 permite un ahorro importante del tiempo de trabajo de la computadora para un análisis exploratorio de los datos. Las variaciones de la potencia de pesca dan una tipología de la flota fundamentada en tácticas y estrategias de pesca. Las variaciones de abundancia aparente por estrato-zona-mes lleva a un diagrama de las fases del ciclo vital juvenil, adulto reproductor, adultos en fase de pausa sexual.

INTRODUCTION

Nowadays it is possible to analyse fishery statistics on a simple microcomputer. Results are used in stock assessments to obtain previsions of catch and effort. They are also used to reach a structural description of the fleet and the resource. Obviously, there are a lot of sources of heterogeneity: gear, ship, target species, port, fishing ground, abundance of age groups, etc.

This study analyses Venezuelan - handliners fleet statistics related to the southern red snapper *Lutjanus purpureus* in the French Guiana's E.E.Z. The model extracts from data, of some fishing power of ships and apparent abundances of red snapper per area-month stratum. The program, named PUIS2, reduces considerably the computer time in relación to other programs.

First, a preliminary process detects and rectifies suspect data, allowing subsequent validation of the statistics. Then the analysis of residuals estimates the divergences of the model.

Secondly, we come to determine a typology of ships based upon differences of fishing power and try to put

forward the explicative factors of these variations.

Finally, the variations of the apparent abundance per area-month stratum lead to determine a diagram of the main vital cicle stages: juveniles, reproductive adults and recovering adults.

THE MODEL

Notation and presentation:

Following LAUREC & PERODOU (1987), we consider a group of Nb ships marked by i (i = 1... Nb). They fish in Ns time-area stratum marked by j (j = 1... Ns).

Each observation (1) refers to the catch per unit of effort (CPUE) for the ith ship on the ith location... (1) varying from 1 to No.

With this notation the classical ROBSON'S' model (1966) can be expressed as: CPUE (1) = Pb. (1) As. (1). E(1).

Using the logarithmic transformation, gives the linear model: $u(1) = pb(1) + as(1) + \Sigma(1)$.

with:

Pb: fishing power for ship b and pb its logarithm.

As: apparent abundance for stratum and as its logarithm.

E (1): stochastic residual and Σ its logarithm.

u(1): logarithmic value of CPUE (1).

Pb is a relative fishing power for ship b in relation to a particular ship number 1 chosen as a reference (pl=0).

Hypothesis

Residuals have to be considered as stochastic according to some assumptions knowm as GAUSS - MARKOV hypothesis: we suppose that Σ have a mean equal to zero, a variance that can be considered as constant and a covariance equal to zero.

$$E(\in(1) = 0\,;\quad \mathrm{var}(\in(1) = \sigma^2\,;\quad \mathrm{cov}(\in(1) \in(1')) = 0$$

No hypothesis was drawn about the distribution law of residuals.

This model does not take into account the interactions between Pb and As. That would correspond to disparities of the relative fishing power from one stratum to another.

Least squares estimation:

Unknowns are the Nb - 1 logarithmic fishing power pi (i=2... Nb) and the logarithmic apparent abundance ad (j=1... Ns).

Their determination is achieved by the least squares method which minimizes the sum of square of residuals:

$$\sum_{i=1}^{no} m(1)\,(u(1) - (pb(1) + as(1)))^2$$

a weight m(1) is alloted to each observation (1). First we use the self-weighted factor m(1) = 1.

In matrix notation we have the linear system:

Observations		unknowns		residuals
↓		↓		↓
Y	= X	B	+	E
(n, 1)	(n, q)	(q, 1)		(n, 1)

The X matrix is a "presence-absence" table coded with 1 and 0.

The unknowns are obtained algebraically by reducing to zero the partial derivatives $\frac{d(e'\acute{e})}{dpi}$ and $\frac{d(e'\acute{e})}{daj}$

if (e´e) is the residuals sum of square $\sum_{1=1}^{No} m(1)\,e^2(1)$

Then the best unbiased estimator of the linear system is

$$B = (X'X)^{-1}\,X'Y$$

The unbiased estimator of σ^2 is

$$S^2 = \frac{1}{n - q}\,\Sigma e^2(1)$$

and the unbiased estimator of the variance - covariance matrix of estimators is

$$S^2 = S^2 (X'X)^{-1}$$
$$(q, q)$$

Programming:

If the method is rather easy to draw up from an algebraic point of view it presents some programming difficulties. The program FPOW of BERUDE (in ABRAMSON 1971 and SIMS 1985) inverses the symmetric matrix (X´X) of Nb-1 + Ns dimension. The time required to inverse a matrix increases as much as the cube of its dimension and the computer time can be prohibitive. The method presented by LAUREC & PERODOU (1987) reduces the dimension of the matrix from Nb--1 + Ns to the smaller Nb and Ns. The computer time is reasonable and it becomes possible to use a microcomputer.

Statistical Inferences and bias correction:

The program PUIS2 does not allow to make some inferences which would be required to inverse the complete matrix X´X. Nevertheless it is useful to detect doubtful data and examine the residuals E to check the model´s assumptions.

Besides, our experience has shown us that the error estimations are a small component of the residuals variances, except in cases where few data were given by shipmasters.

The estimations obtained are biased. The retransformation of logarithmic estimations to the original scale produces a bias (LAURENT, 1963).

A correction is possible if the logarithmic variance is estimated.

In practice, this bias correction is negligible σ^2 must be important and estimation are inaccurate, or else σ^2 is low and the bias becomes negligible.

Eventhough, PUIS2 is incomplete from a statistical point of view, it is a useful and practical analytical tool.

Data and material:

The southern red snapper *Lutjanus purpureus* is traditionally exploited by a fleet of Venezuelan handliners in French Guiana's E.E.Z. This article analyses fishery statistic for the year 1988.

The first data source comes from factories which furnished quantities landed in weight by species, ship and trip, and secondly from fishermen who indicated on logbooks the fishing effort and the proportion fished per day and area. The total number of observations is 1840 for 25 ships and 87 locations.

Detection and correction of divergences of the model:

Divergences have been detected by plotting the graph of residuals and parameters.

Detection of doubtful data:

Another assumption is that, the model used is suitable to all data.

We have seen that the number of observations per parameter must be large enough to get a small variation coefficient and a negligible bias. We have discarded ships and locations whose number of observations was smaller than 5.

After having discarded some observations for which residuals were far from mean, more than 3 times the standard deviation (see residuals histogram, Fig. 1). It is at this point where we can check the reliability of our data and discard the coding errors, from whatever source they may come from.

Finally, we have examined the parameters distribution (Fig. 1) and noticed a few isolated values. The origin of the anomaly was a systematic coding error such as the use of a particular scale of measure. It is also possible to detect invented data. Then residuals are abnormally distributed near zero.

Non constant variance (Fig. 2):

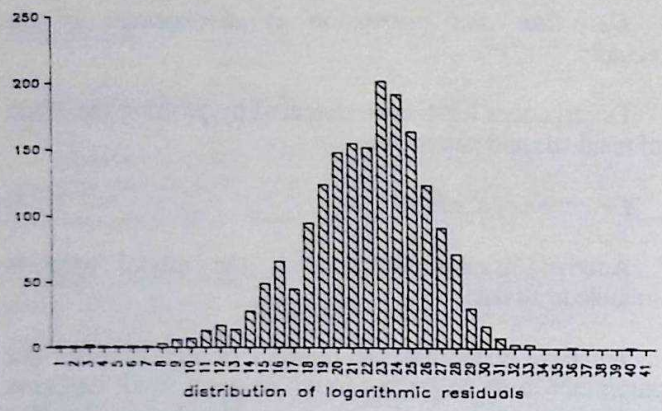
The second assumption studied is that σ^2 is constant for all cases in the data. A simple procedure to check the assumption of constant variance is to go through the plots of residuals against parameters.

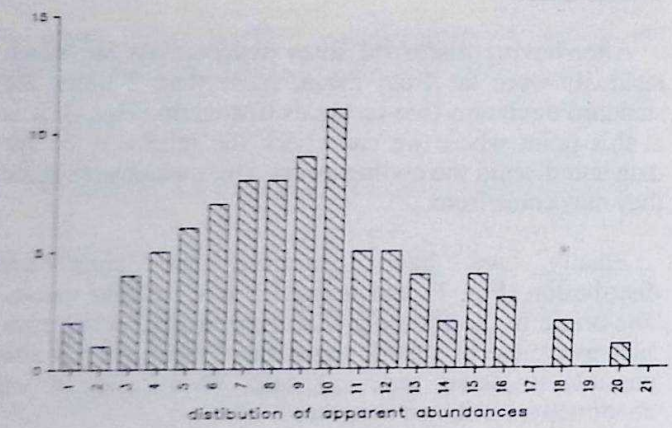
In Fig. 2 we can see that standart deviations of residuals decrease when the parameters fishing power and apparent abundance increases. We also can see that the number of observations per parameter is not connected with it, the heterogeneity of the experience plan does not explain the nonconstant variance. First weighed least squares could be used with an empirically chosen weight. The second alternative could be to transform the response through a variance stabilising

transformation.

Explicative factors of fishing power variations:

Fishing power of handliners are given in the annex





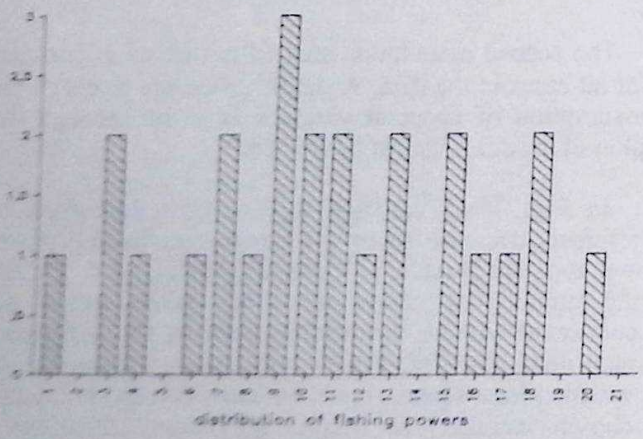


Fig. 1.- Detection of suspect data.

are we and presented in Fig. 3. Al first sight, fishing powers between ships would seem to be homogeneous. The variation coefficient being 23%. Many factors might explain the variation in fishing power of the different handliners.

We see in Fig. 3 that the overall length, correlated with the other physical characteristics as engine power and tonnage, does not appear as an explicative factor of fishing power variations.

Each vessel is bound by an agreement with a factory. The mean fishing power of boats in connexion with factory 1 is equal to 1.09 whereas it is equal to 95 for boats in connection with factory 3. Our knowledge of the fishery allows us to conclude that there is a real difference between the two groups, eventhough it is not statistically different. The relative difference of the mean fishing power between these two groups of vessels is 14%.

We haven't found other factors which could explain the variations of the fishing power. The fishing port is well known to be a main factor of heterogeneity

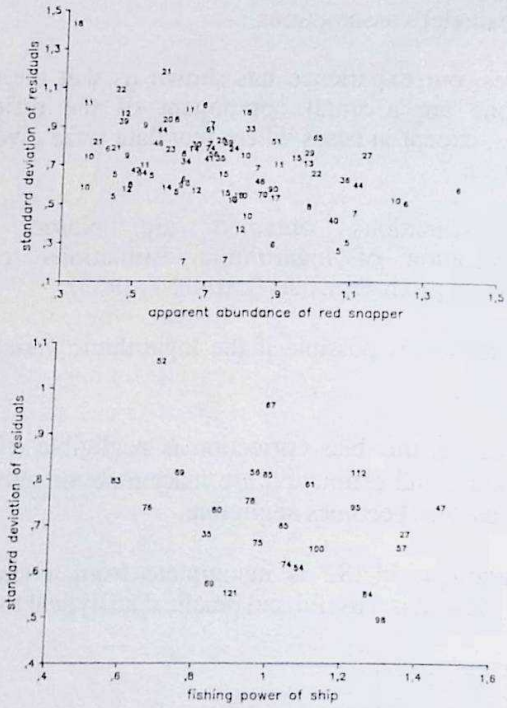


Fig. 2.- Diagnostic for nonconstant variance (xx: observations number)

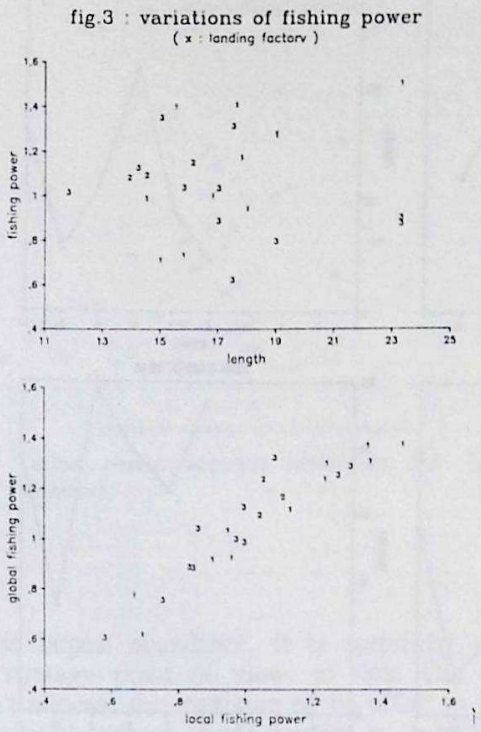


Fig. 3.- Variations of fishing power (x: factory landing).

between ships, but all the handliners are located in Margarita Island.

To show the ability of boats to detect the rich fishing grounds, computation has been recast without distinctionss between fishing grounds. Thus we obtain a new fishing power called "global fishing power" in opposition to "local fishing power" (LAUREC, 1977). This new index is closely related to the other (see Fig. 3) and this means that all ships fish on the same fishing grounds. In this case, according to our scale of observation, the fishing ground is not a discriminating factor of the fleet.

Finally, without any factor to check we migh explain the variations of fishing power by the "know-how" of fishermen. Ships fish in groups. When a ship has detected a school, other ships draw in next to it.

This cooperation can be voluntary or not. We can distinguish two components in the "know-how" of fishermen: the search for schools and the angling once a school is detected. The latter depends on the fishing skills of fishermen. In the search of schools, the shipmaster waves between two extreme attitudes: either he leaves the fishing ground and runs the risk to obtain better yields, or he remains on the same fishing ground to assure the profit-earnings of the trip.

Apparent abundance:

Abundance is said to be "apparent" when it combines two factors: the real density of fishes and the behaviour of fishermen, his tactics and strategy of fishing. We think that the variations of density prevail over the variations of fishing efficiency, which are considered negligible. Thus it is possible to explain variation of apparent abundance by variations of density in connection with recruitment, spawning grounds ands seasons.

Variations of handlines effectiveness can also have and influence on the apparent abundance: influence of depth, strength of current, turbidity of water and also influence of fish appetite.

The fishing effort is located between areas 1 and 3, the area 2 being the center of fishing grounds. We observe a lack of fishing data from December up to and including February, masking a part of the life cycle of red snapper.

In Fig. 4 we can observe an important background noise of apparent abundance between strata. Nevertherless we could observe two peaks of apparent abundance, the first in the 2nd quarter and the other from August to October.

These maximum values of abundance could be in connexion with the bi annual reproduction as observed by GESTEIRO & IVO (1973) who found out that the largest spawn occurs in February and the second on October. IVO & HANSEN (1982) have studied the diagram of the red snpapper's vital life cycle. It is a demersal and sedentary species. It migrates towards the coral reefs near the slope, off the continental shelf to spawn and goes back to the feeding on the continental shelf. Eggs and larvae drift with the Guiana current from the spawning grounds to the inshore.

Seasonal arrivals of recruits must exist. But apparent abundance is a combined index over age groups. So it would be hazardous to separate seasonal peaks of recruitement and spawn. The use of desaggregated CPUE by age group would be recommended.

The relationship between fishing effort and apparent abundance is displayed in Fig. 5. At first, fishing effort increases with abundance, then, it decreases to near zero

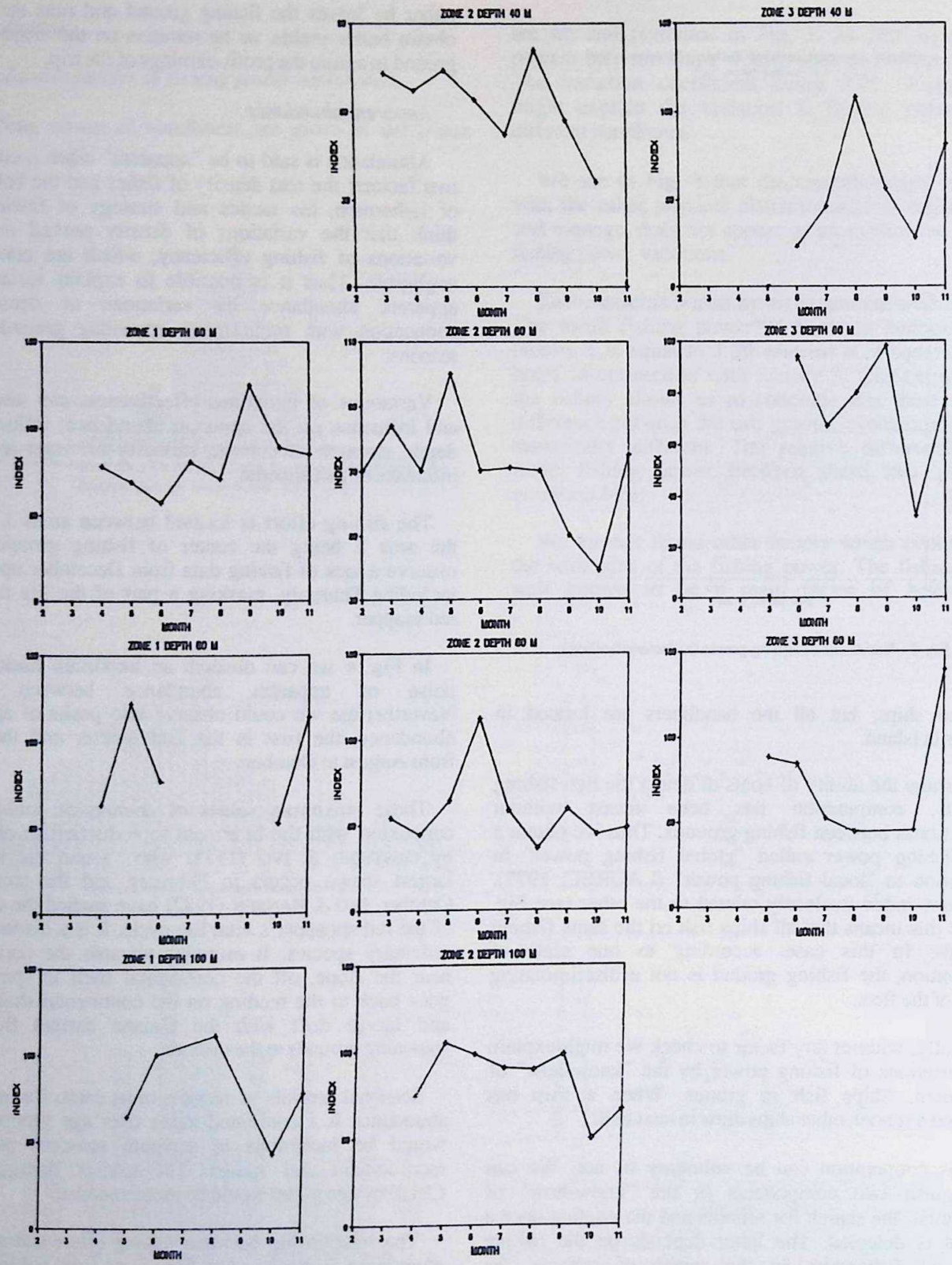


Fig. 4.- Apparent abundance index per month - area stratum.

fig. 5 : effort versus apparent abundance
(xx : observations number)

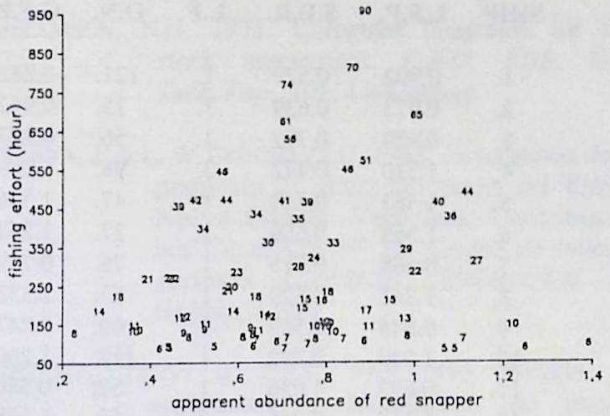


Fig. 5.- Effort versus apparent abundance (xx: observations number).

for the largest abundance. It is surprising, from the fleet strategy point of view, to note that the fleet doesn't allocate the maximun of its effort in the strata of largest abundance of red snapper, in spite of the fact that it is a target species.

CONCLUSIONS

Fishing statistics and the model used lead to a structural description of the fleet and the resource from the comparison of fishing power index on one side and apparent abundance on the other.

The model used is a multiplicative one with two factors (ROBSON, 1966). The algorithm used in the program PUIS2 decreases the dimension of matrix and computer working time. In this example the program PUIS2 is $(4.5)^3$=91 times faster than the program FPOW.

Fishing power between handliners are relatively homogeneous, this is a characteristic point of the fleet studied: ships belong to the same port, they have similar dimensions, same fishing grounds and use the same fishing tactics. A more careful analysis of the situation reveals two groups of ships in relation to the landing factories, the difference of fishing power between two of them being 14%.

Fishing grounds are located in area 2, between 40 and 100 m depth. The variations of apparent abundance for one stratum to another seems to be chaotic. A closer look at the facts reveals two peaks of reproductive concentration, the first one occurring during the 2nd quarter and the other between August and October. However this interpretation needs to be validated in the future.

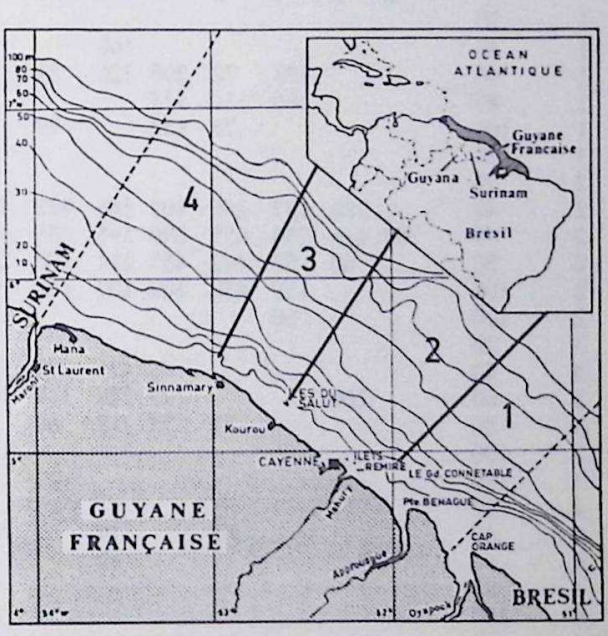
The prime cause of confusion is that the area scale is too small. The small scale produces an important background noise. To remove the difficulty, it would be advisable to draw a spatial structure with squares, one degree sided.

Secondly, the apparent abundance is a combined index over all age groups. It is uncertain to separate seasonal peaks of recruitement on one side and seasonal peaks of spawn on the other.

The possibility to turn some desegregated CPUE per commercial category would be an useful progressive step in the description of the resource and would satisfy the demand of stock assessments.

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Delimitación of the geografical areas.

ANNEXURE

		2	3	4	5	6	7	8	9	10	11
1	20										
1	40						63				
1	60			78	69	57	81	71	125	89	85
1	80			63	122	77				52	114
1	100				64	100		111		42	77
1	120										
2	20									20	
2	40		73	67	74	64	52	81	57	36	
2	60	70	84	70	100	70	71	70	50	39	75
2	80		54	44	64	112	58	36	59	44	48
2	100			74	105	98	90	89	98	49	66
2	120			109							
3	20										
3	40					23	46	108	56	28	81
3	60		80			94	67	80	98	32	77
3	80				88	84	52	44		45	139
3	100								47	75	
3	120								107		
4	20										
4	40				76		80		59	47	
4	60						63				
4	80									64	
4	100									79	
4	120										

TABLE OF APPARENT ABUNDANCE.

ZONE	DEPTH (m)	MONTH									
		2	3	4	5	6	7	8	9	10	11
1	20										
1	40						108				
1	60			178	72	205	326	81	54	539	777
1	80			60	114	111				105	277
1	100				78	252		77		55	288
1	120										
2	20									84	
2	40		389	137	266	101	365	922	439	115	
2	60	54	116	734	655	640	595	435	439	237	432
2	80		60	57	402	455	214	100	252	239	138
2	100			159	430	309	109	151	84	84	142
2	120			50							
3	20										
3	40					96	423	393	512	153	96
3	60		200			178	328	110	129	191	78
3	80				72	78	118	60		238	63
3	100								135	181	
3	120								50		
4	20										
4	40				65		119		151	96	
4	60						90				
4	80									189	
4	100									122	
4	120										

TABLE OF FISHING EFFORT (in hour)

SHIP	L.F.P.	S.D.R.	L.F	O.N.	G.F.P.
1.	0.902	0.529	1.	121.	0.882
2.	0.973	0.639	3.	75.	0.962
3.	0.959	0.792	1.	56.	0.887
4.	1.310	0.472	3.	98.	1.249
5.	1.463	0.718	1.	47.	1.336
6.	1.368	0.659	1.	27.	1.268
7.	0.668	0.715	1.	76.	0.739
8.	1.361	0.629	1.	57.	1.332
9.	0.845	0.549	3.	69.	0.847
10.	1.240	0.792	1.	112.	1.260
11.	0.692	1.036	1.	52.	0.580
12.	1.110	0.766	2.	61.	1.128
13.	0.753	0.791	3.	89.	0.718
14.	0.833	0.657	3.	35.	0.851
15.	0.859	0.710	3.	80.	1.004
16.	0.948	0.730	1.	78.	0.996
17.	0.579	0.773	3.	83.	0.567
18.	1.273	0.527	3.	84.	1.214
19.	0.996	0.940	3.	67.	0.949
20.	1.052	0.592	2.	74.	1.199
21.	1.041	0.676	2.	65.	1.056
22.	0.994	0.787	3.	85.	1.082
23.	1.085	0.584	3.	54.	1.284
24.	1.132	0.676	1.	100.	1.077
25.	1.234	0.717	1.	95.	1.199

TABLE OF FISHING POWER.

L.F.P. Local Fishing Power.
S.D.R. Standar deviation of residuals.
L.F Landed factory.
O.N. Observations number.
G.F.P. Global Fishing Power.

REFERENCES

ABRAMSON, N.N. 1971. Computer programs for fish stock assessment. *F.A.O. Fish, Biol. Tech. Pap.*, 101: 4 p + unpag.

CELAYA, J. & L. W. GONZALEZ C. 1988. Descripción de la pesquería de altura del pargo del Estado Nueva Esparta, Venezuela. Contribuciones Científicas Nº 17. *Centro de Investigaciones Científicas, Universidad de Oriente*, 77 pp.

GESTEIRA, T.C.V. & C.T.C. IVO 1973. Estudo da reproducao e fecundidade do pargo, *Lutjanus purpureus* Poey, do norte e nordeste do Brazil. *Arq. Cien. Mar.*, 13 (2): 109-112.

IVO, C.T.C. & A.J. HANSEN 1982. Aspectos da biología e dinamica populacional do pargo, *Lutjanus purpureus* Poey, do norte e nordeste do Brazil. Arq. Cien. Mar., 22 (1/2): 1-41.

LAUREC, A. & J. B. PERODOU 1987. Regards statistiques et informatiques sur 1' analyse des puissances de peche et des abondances apparentes. *Cons. Int. Explor. Mer.*, D: 9, 27 pp.

LAUREC, A. G. 1963. Lognormal distribution and translation method: description and estimation, *J. Amer. Statist. Assoc.*, 58: 231-235.

ROBSON, D.S. 1986. Estimation of the relative fishing power of individual ships. *Icnaf. Res. Bull*, 3: 14 pp.

SIMS, S.E. 1985. Selected computer programs in Fortran for fish stock assessment. *F.A.O. Fish. Tech. pap.* Nº 259, 193 pp.