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Relationships among catches, fishing effort and river morphology for eight rivers in Amazonas State (Brazil), during 1976 - 1978

by

Miguel Petrere, Jr.

Universidade Federal do Maranhão, São Luiz (MA), Brazil

Abstract

For eight rivers in the Amazonas State (Brazil), it is shown that the annual number of fishermen and dummy variables, which identify the rivers, explain 98.8 % of the landings at Manaus market.

Partial correlation analysis suggests that only the most productive floodplains are actively sought by professional fishermen.

Keywords: **river ecology, floodplain fisheries, multiple regression**

Introduction

An extensive literature exists which tries to establish empirical relationships between fish yields and morphological (e. g. area or mean depth) or edaphic (e. g. phosphorus or total dissolved solids) factors in temperate and tropical lakes.

ROUSENFELL (1947) found an inverse relationship between catches and the area of several lakes in North America and RAWSON (1952) established the same kind of relationship between the catches and the mean depth for another set of lakes in North America. FRYER & ILES (1972) also showed an inverse relationship between catch/ha/year and mean depth for several lakes in Africa.

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NORTHCOTE & LARKIN (1956) found a significant positive relationship (in logarithmic scale) between mean weight of fish per gillnet set and total dissolved solids for 100 British Columbian lakes. RYDER (1965) related the quotient of total dissolved solids divided by mean depth, called Morpho-Edaphic Index (MEI), to fish yields from a set of 34 north-temperate lakes.

HENDERSON & WELCOMME (1974) used water conductivity (umho/cm) instead of total dissolved solids, divided by the mean depth for 31 lakes in Africa and established a relationship between catch/ha/year and the MEI. RYDER et al. (1974) and OGLESBY (1982) reviewed the concepts and uses of the MEI.

For rivers, WELCOMME (1976) correlated the catches with river morphology, namely basin area, floodplain area and river length for 17 floodplain rivers in Africa. He also claimed that a positive correlation exists between the ratio of the actual and estimated catch derived from the relationship between catch and river length and water conductivity, but BAYLEY (1981) reanalised these data and failed to establish this. HOLCIK & BASTL (1977) predicted the catches in the Czechoslovakian section of the Danube using an index of its hydrological regime. BAYLEY et al. (1978) presented and discussed the potencial importance of 18 measureable factors most likely to explain fish production in river systems, and later BAYLEY (1979) compared and contrasted the ecology of lacustrine and riverine ecosystems. BAYLEY (1981) used WELCOMME'S (1976) relationship between catches and river length for the potential yield of some rivers in Amazonas State.

The present paper is exploratory, the main objectives being to derive an equation to predict the commercial landings in Manaus and to examine the correlations between four variates believed to determine the catches.

The commercial fishery in the Amazonas State is multigear and multispecific. The main rivers and its associated floodplains are subject to exploitation by 13 different kinds of gears acting upon a total of 32 groups of fishes, although eight species are most sought. (PETRERE 1978).

The distances travelled are limited by the amount of ice in the hold, but may in some cases cover 1700 km from Manaus (capital of the Amazonas State and center of the commercial fishery). The fishery develops during the whole year, but the main bulk of the catches is taken when the water is low and the fish are beginning spawning (August to November), when the diversity of the catches is maximal.

The rivers Negro, Branco, Purús, Juruá, Jutai, Madeira, Solimões (+ Japurá) and Amazonas were selected and a multiple regression analysis undertaken to explain the annual catches C (t) (see description of data collection in PETRERE (1978)) landed by the fishing fleet which operates from Manaus in terms of the annual number of trips per river (T), the annual number of fishermen (F), the maximum length of the river channel (L, km), reached in each river in wach year and its associated floodplain (A, km^2). After using different approaches it was concluded that the number of fishermen (together with dummy variables) explains 98.8 % of the variance of the catches for the first six rivers listed above. A similar relationship was derived separately for the Solimões-Amazonas River which explains 95.5 % of the variances of its catches.

As the independent variates are correlated with each other and because of the inherent non-experimental character of the data, partial correlation analysis was employed to examine the structure of their correlations.

Methods

Calculation of the catches

The calculation of the total catch using the data from Manaus market is explained in PETRERE (1978). The catch does not include the fish caught in subsistence fisheries from towns, villages and riparian populations scattered along the rivers.

River morphology

The length of the channel was taken from PETRERE (1978) and from recent measurements made from the CARTAS PLANIMETRICAS DO PROJETO RADAMBRASIL, some of which were published after PETRERE'S (1978) measurements had been made. The method of measuring the area of the floodplain will be explained elsewhere.

The Amazon river was divided into two parts: (i) above its confluence with the Rio Negro (its largest tributary in discharge), where it is locally known as the Solimões and (ii) below this confluence to the border with Pará State, where it is called the river Amazonas.

This separation, although rather artificial, is made because fishermen tend to fish either up or down the river, not both up and down. Also the smaller boats tend to always fish in one location. Manaus is the natural geographic location separating the two regions. The fishery of the Jutai river was considered only for 1976 because in the two following years the fishery was concentrated almost entirely near its mouth during the main fishing season.

A map of the region with the floodplain is shown in figure 1.

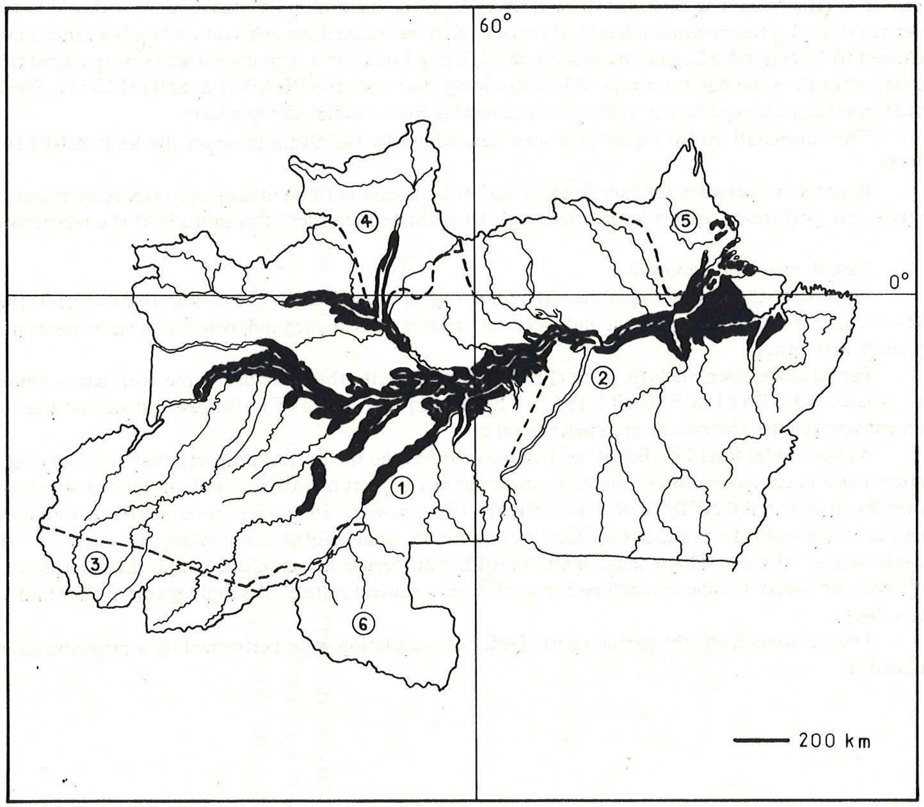

Fig. 1:
The Amazon's Basin floodplain. 1. Amazonas State; 2. Pará State; 3. Acre State; 4. Roraima Territory; 5. Amapá Territory; 6. Rondônia State; (modified from MOREIRA 1977)

Fishing effort

For fishing effort one needs a measure which, if multiplied by the available stock, will give a figure linearly proportional to the catch. The most appropriate units of fishing effort are the number of trips per river and the total number of fishermen who operated in each river throughout the year. These were chosen because they are easy to calculate and fairly free from reporting errors. Both units are used irrespective of the gear employed. Any other more detailed unit (e. g. number of fishermen x days of fishing) seems to be more difficult to relate to the fishing process because of the multigear character of the fishery.

The resulting data set

There are 22 observations taken from 7 rivers over a period of three years and from one river which was sampled just once (Table 1). These data are plotted in arithmetic scale to examine the scatter, and transformed if the arithmetic plot was judged to be unsatisfactory.

The basic statistical model

The basic statistical model adopted after the examination of the scatter plot is:

$$\log C_{ij} = B_0 + B_1 \log T_{ij} + B_2 \log F_{ij} + B_3 \log A_{ij} + B_4 \log L_{ij} + e_{ij} \quad \ldots\ldots\ldots \quad \text{Equation 1}$$

$$i = 1, 2, 3; \quad j = 1, 2, \quad \ldots.., 8$$

C_{ij} is the annual catch in year i from river j; T_{ij} the annual number of trips, per river; F_{ij} is the annual number of fishermen who operated in each river; A_{ij} is the maximum flooded area (km^2) in each year per river; L_{ij} the maximum length (km) of each river reached in each year and e_{ij} is a random variate assumed to be $N(0.\sigma^2)$. During the procedure of fitting Equation 1 dummy variables were added to the model, after their use had been proved by examining the residuals (DRAPER & SMITH 1981). The basic model was later reduced to a simpler one by dropping some independent variates.

The computations for Equation 1 were carried out by the GLIM program (BAKER & NELDER 1978).

Regressions between the independent variates, maximum flooded area and respective channel length were performed using a logarithmic scale to examine the order of magnitude of the relationship.

Partial correlation analysis

Because of the lack of experimental design, one of the effects of the collinearity (which is the presence of correlation between the independent variates) is that each independent variate shares its variance with others.

Partial correlation analysis is a technique used to clarify the structure of the correlation among the variates (KENDALL & STUART 1967). The technique is a kind of statistical control that tries to compensate for the absence of an experimental one.

As the model stated by Equation 1 is linear, it has the theoretical property that any explanatory variate has a linear regression on another variate (or any subsets of variates) with deviations which are normally distributed (SNEDECOR & COCHRAN 1967; p. 400). In this way using partial correlation analysis it is possible to examine the effect of one variate upon another, controlling the effect of a third variate or a set of them. The technique allows for the difference between calculating the correlation between two variates while controlling for a third (or a subset) instead of simply ignoring the third (or the subset).

The calculations of the partial coefficientes of correlation were performed by a programmable calculator.

Tab. 1: Distribution of the annual number of trips (T), the annual number of fishermen (F) who operated in each river in its channel (L, km), the associated area of the floodplain (A, km^2) and the catches (C, t) during the years of 1976, 1977 and 1978 in 8 rivers of the Amazonas State. The points marked with a * were used for the regression between A and L. (Equations 2, 3).

Year	1976					1977					1978				
River	T	F	A	L	C	T	F	A	L	C	T	F	A	L	C
Negro	203	1546	6129*	466*	608.6	153	1194	7815*	551*	398.9	207	1713	6129	466	759.0
Branco	1	18	200*	35*	2.3	20	179	1250*	368*	21.3	12	90	1016*	168*	20.6
Solimões + Japurá	2878	20610	47913*	1323*	11382.0	2261	17461	51955*	1535*	8235.0	2116	16758	47913	1323	8603.9
Purús	906	6713	9414*	910*	4755.7	896	6936	10513*	1123*	4036.7	751	6452	10513	1123	3893.9
Juruá	108	1258	7451	773	1555.9	107	1184	5447*	530*	1166.1	112	1301	5447	530	1204.2
Jutai	72	868	3076*	470*	1428.3	–	–	–	–	–	–	–	–	–	–
Amazonas	1704	12387	16865*	458*	4235.0	1351	10707	16865	458	2700.6	1367	12231	16865	458	2935.2
Madeira	252	1753	2478*	423*	1484.6	263	1814	789*	135*	1082.4	221	1573	2478	423	1180.8

Results

The data

Table 1 shows the raw data which were utilized in the analysis and Figures 2, 3, 4, 5 show plots of the catch (t) with each independent variate, in logarithmic scale because the logarithmic transformation reasonably linearized the data. Note that the plots of the data in Figures 2 and 3 seem to split into two distinct sets. This is perhaps a consequence of river morphology. The points marked with triangles correspond to the data from the Solimões-Amazon River, which can be classified (following WELCOMME 1976) as having an 'extensive' floodplain; the points marked by squares correspond to the remaining set of rivers which can be classified as having a "normal" floodplain.

Morphological characteristics of the rivers

For the rivers with a "normal" floodplain regressing floodplain area against channel length in logarithmic scale in Table 1 using the values marked by a "*", we obtain:

$A = 2.1427 . L^{1.2176}$ (n = 12) Equation 2

$s^2 A. L = 0.0270$, $r = 0.96$**

The same procedure adopted for rivers with "extensive" floodplains gives:

$A = 50.1179 . L^{0.9503}$ (n = 3) Equation 3

$s^2 A. L = 0.0003$ $r = 0.999$*

Thus, for each 1000 km of river channel, rivers with "normal" floodplains would inundate 9,633 km^2 of floodplain area and rivers with "extensive" floodplains would inundate 35,554 km^2. The ratio between the theoretical inundated area of the two types of rivers is therefore 3.7 : 1 for each 1,000 km of channel length. Figure 6 illustrates the logarithmic relationship between A and L.

Application of the regression model

As the logarithmic transformation tends to linearize the data, Equation 1 was chosen for the analysis. In some cases the distinction between the two sets of data is less obvious (as in figures 4, 5), and so the analysis is done in two ways:

(i) by considering the full set of data given in Table 1 without making a distinction between the two sets, and

(ii) by considering the two sets separately.

In case (i) after performing a stepwise procedure in which each independent variate is dropped in turn, the most important variate appears to be the number of fishermen. However, none of the versions of Equation 1 is satisfactory since all give an abnormal residual structure. Although for some rivers the sets of data give evenly distributed residuals, many others produce residuals that are entirely positive or entirely negative. One device to improve the residuals' structure is to add dummy variables, but this was not effective since some residuals which were entirely negative became entirely positive and vice-versa and some which were evenly distributed assumed uniform sign.

In case (ii) the analysis was repeated using only the data set for rivers with "normal" floodplains, tributaries of the Solimões-Amazonas because there are more observations

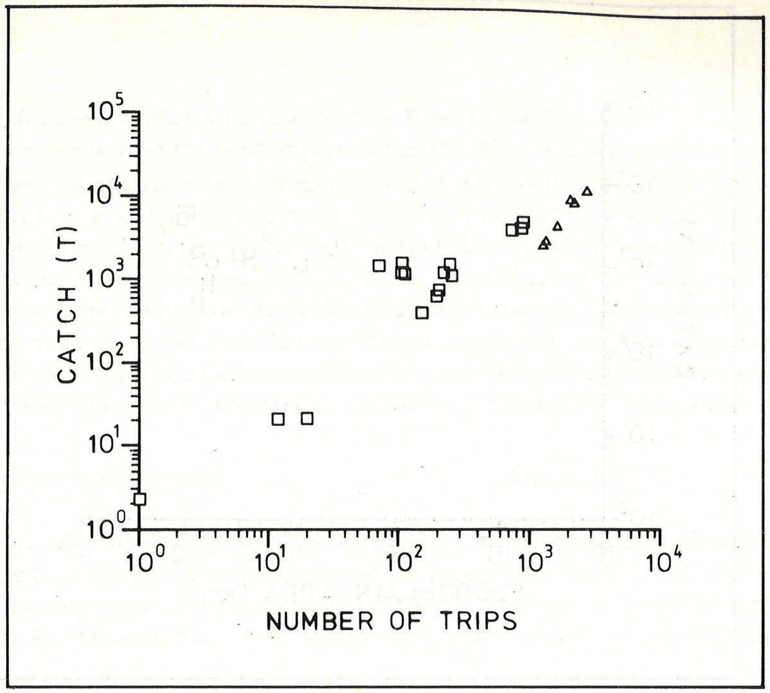

Fig. 2:
Logarithmic plot of the annual catches (t) of all fish caught in 8 rivers in Amazonas State during 1976, 1977 and 1978 by the Manaus fishing fleet, versus the annual number of trips travelled in the rivers. Triangles correspond to the Solimões (+ Japurá)-Amazonas River and squares to the remainder of the rivers listed in Table 1.

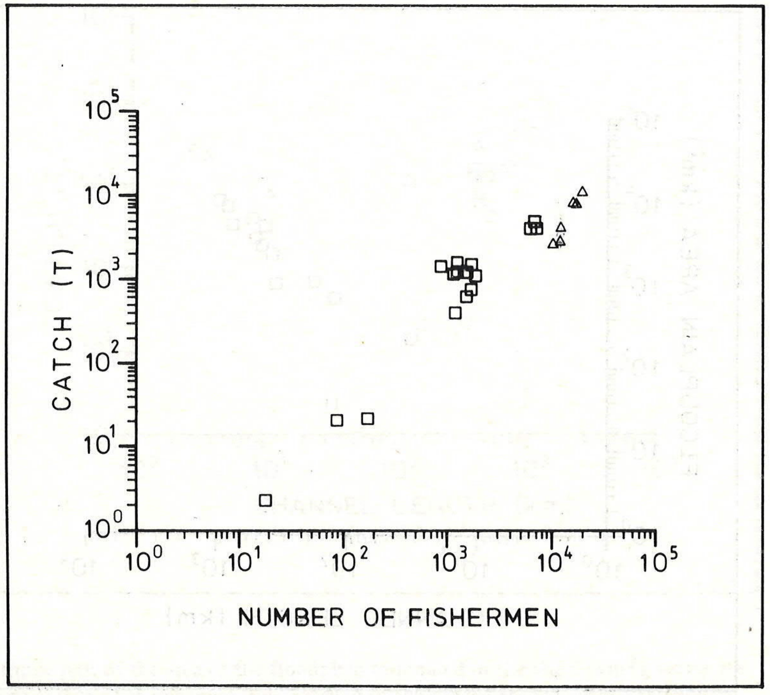

Fig. 3:
Logarithmic plot of the annual catches (t) of all fish caught in 8 rivers in Amazonas State during 1976, 1977 and 1978 by the Manaus fishing fleet, versus the annual number of fishermen who operated in the rivers. Triangles correspond to the Solimões (+ Japurá)-Amazonas River and squares to the remainder of the rivers listed in Table 1.

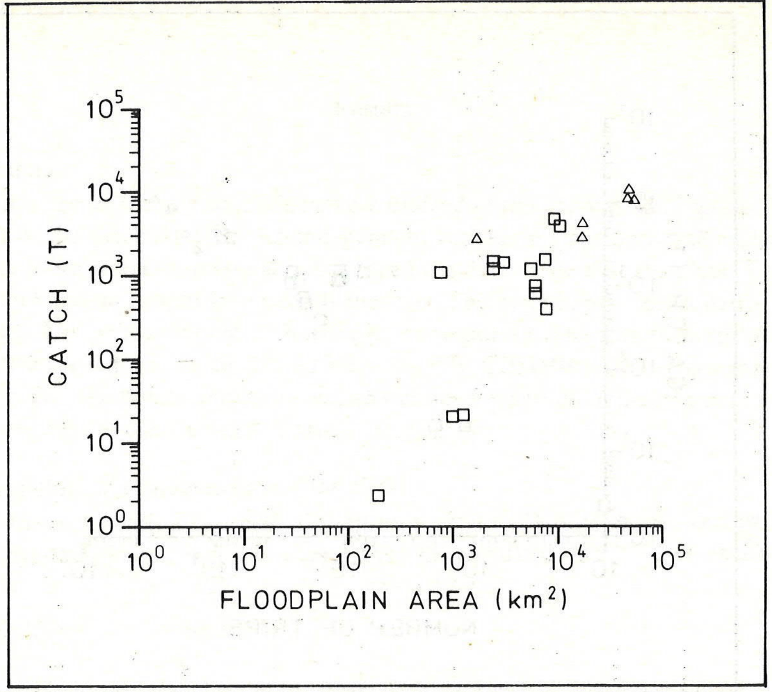

Fig. 4:
Logarithmic plot of the annual catches (t) for all fish caught in 8 rivers in Amazonas State during 1976, 1977 and 1978 by the Manaus fishing fleet, versus the area of the floodplain (km^2) inundated in the rivers. Triangles correspond to the Solimões (+ Japurá)-Amazonas River and squares to the remainder of the rivers listed in Table 1.

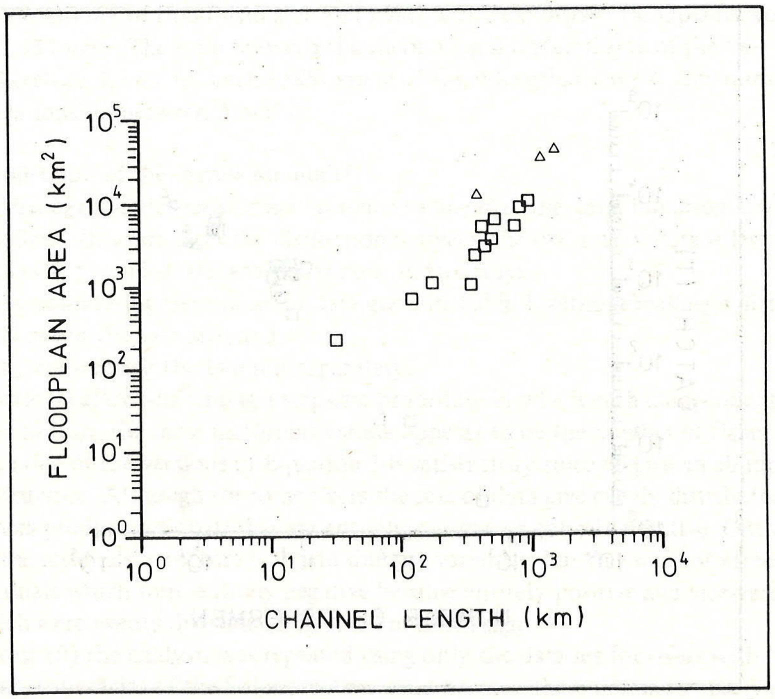

Fig. 5:
Logarithmic plot of the annual catches (t) for all fish caught in 8 rivers in Amazonas State during 1976, 1977 and 1978 by the Manaus fishing fleet versus the length of the channel (km) reached in the rivers. Triangles correspond to the Solimões (+ Japurá)-Amazonas River and squares to the remainder of the rivers listed in Table 1.

(n = 16) than for the Solimões-Amazonas (n = 6). When fitting Equation 1 the number of fishermen again seems to be the most important variate. When it is included in the model, the slopes of any other variates become nonsignificant. The coefficients of the logarithms of the floodplain areas and the logarithms of the number of trips are negative, but not statistically significant. Dummy variables were adopted because all the residuals of the Negro, Branco and Purús rivers have negative values, the residuals of the Juruá river have positive values and the residuals of the rio Madeira are positive and negative as expected. Use of dummy variables allows individual differences among rivers to be accommodated within the analysis. Dummy variables were therefore incorporated into Equation 1, and a final model was obtained with satisfactory allocation of the signs of the residuals. This is,

$$\log C = a + b_1 Z_1 + b_2 Z_2 + b_3 \log F \qquad \text{Equation 4}$$

Where (Z_1, Z_2) are dummy variables of type (0,1) indicating the rivers Negro, Branco and Purús, and (Z_1, Z_2) are dummy variables of the type (1,0) indicating the rivers Juruá and Jutai. The compliment of these dummy variables is one of type (0,0) which applies in the case of the Rio Madeira. Note that there is only one observation for the Jutai River

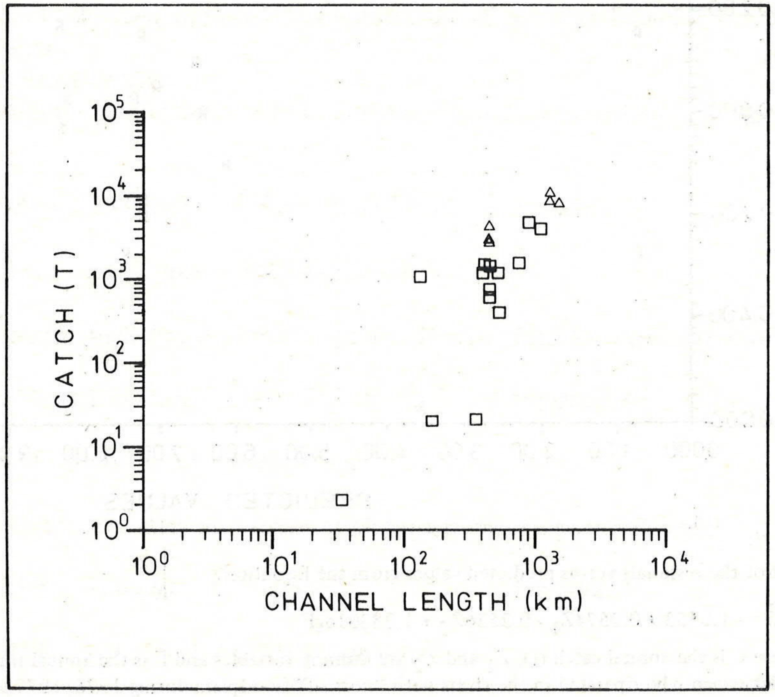

Fig. 6:
Logarithmic plot of the area of the floodplain inundated in the rivers (km^2), versus the respective length of the channel (km) reached in the rivers for each year. Triangles correspond to the Solimões (+ Japurá)-Amazonas River and squares to the remainder of the rivers listed in Table 1.

which can be tentatively allocated to any of the three groups. Repeating the computations each time, the model with the smallest variance was the one which included the observation for the Jutai River together with the data from the Juruá River. Therefore the final model is:

$\widehat{\log C} = -1.0553 + 0.2574Z_1 - 0.2536Z_2 + 1.2830\log F$ Equation 5

Where $s^2 = 0.0131$, $sa = 0.1561$, $sb_1 = 0.0876$, $sb_2 = 0.0773$, $sb_3 = 0.0438$, $R^2 = 0.988$, $df = 12$.

The slopes of all the independent variates were significant ($tb_1 = 2.94^{*}$, $tb_2 = 3.28^{**}$, $tb_3 = 29.29^{**}$); the equation explains 98.8 % of the variance in the catches.

The distribution of the residuals is normal ($z = -0.894$, $b_2 = 3.75$), D'AGOSTINHO (1970), D'AGOSTINHO & TIETJEN (1971). No clear pattern to nonlinearity exists, as can be seem in figure 7. The distribution of the signs of the residuals is fairly even within each group of rivers. One value of logC differs more than two standard deviations from its observed value. Considering the small sample size, the stepwise process is rather speculative. Equation 5 is accepted as reasonably fitting the data.

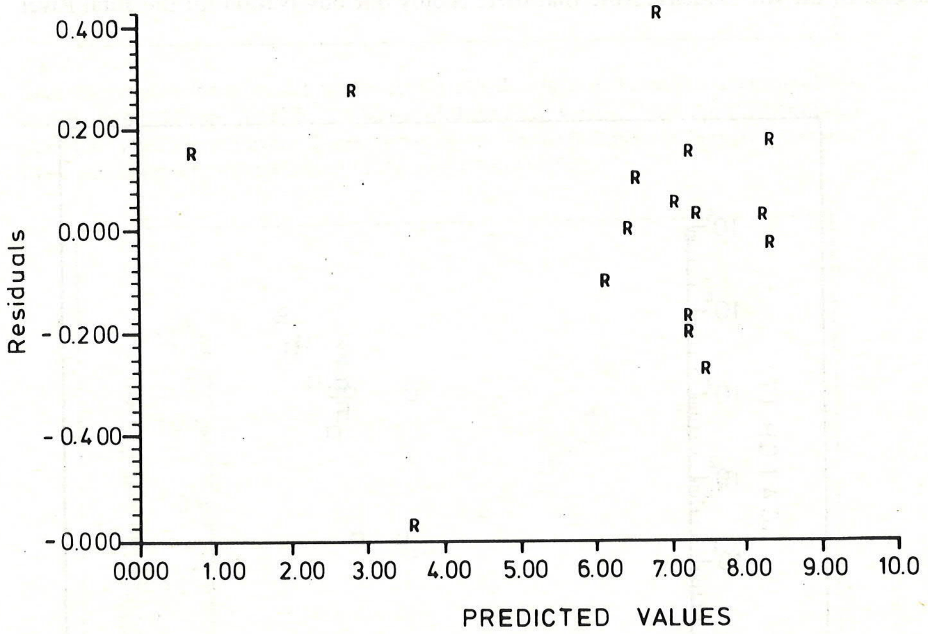

Fig. 7:
Plot of the residuals versus predicted values from the Equation:

$\widehat{\log C} = -1.0553 + 0.2574Z_1 - 0.2536Z_2 + 1.2830\log F$

where C is the annual catch (t), Z_1 and Z_2 are dummy variables and F is the annual number of fishermen who operated in the rivers with "normal" floodplain during 1976, 1977 and 1978 (Table 1). The residuals and the predicted values are in natural logarithm scale as given by the GLIM program (BAKER & NELDER 1978).

As there are not enough degrees of freedom when fitting 6 independent variates using the data of river Solimões-Amazon ($n = 6$), it is assumed that logF is the most important variate based on the results from the other set. An examination of the residuals does not suggest anything unusual. There are three positive and three negative residuals evenly distributed within the data set for the Solimões and within the data set for the Amazonas River. It is not possible to test the normality of these residuals because of the smallness of the sample.

The equation for predicting the catches for the Solimões-Amazonas is:

$\widehat{\log C} = -6.0114 + 2.34091\log F$ Equation 6

Where $s^2 = 0.0039$, $sa = 1.0527$, $sb = 0.2527$, $r^2 = 0.955$, $df = 4$, $ta = 5.71^{**}$, $tb = 9.26^{**}$. Therefore, logF accounts for 95.5 % of the variances in the catches for the data set for Solimões and Amazonas Rivers.

Prediction of catches using Equation 5 and 6

If one wishes to predict the catches for the Rivers Negro, Branco or Purús for a given number of fishermen, one must substitute Z_1 by zero, Z_2 by 1, and F by the number of fishermen, using Equation 5. When predicting catches for rivers Juruá or Jutai, one substitutes Z_1 by 1, Z_2 by zero, and F by the number of fishermen using Equation 5. For the Rio Madeira substitute both Z_1 and Z_2 with zero and F by the number of fishermen in Equation 5.

If one wishes to predict the catches for the Solimões or the Amazonas Rivers from a given number of fishermen, one needs to substitute the value of F in Equation 6 by the number of fishermen.

Summarizing we have:

Equations for predicting the catches of rivers Negro, Branco, or Purús for a given value of F:

$\widehat{\log C} = -1.3089 + 1.2830 \log F \therefore \hat{C} = 0.0491 . F^{1.2830}$ Equation 7

$(s^2_{\widehat{\log C}} = 0.0313 - 0.0133 \log F + 0.0019 (\log F)^2)$

Equation for predicting the catches of rivers Juruá or Jutai for a given value of F:

$\widehat{\log C} = -0.7979 + 1.2830 \log F \therefore \hat{C} = 0.1593 . F^{1.2830}$ Equation 8

$(s^2_{\widehat{\log C}} = 0.0335 - 0.0115 \log F + 0.0019 (\log F)^2)$

Equation for predicting the catches of Madeira river for a given value of F:

$\widehat{\log C} = 1.0553 + 1.2830 \log F \therefore \hat{C} = 0.0880 . F^{1.2830}$ Equation 9

$(s^2_{\widehat{\log C}} = 0.0337 - 0.0125 \log F + 0.0019 (\log F)^2)$

Equation for predicting the catches of rivers Solimões or Amazonas for a given value of F:

$\widehat{\log C} = -6.0114 + 2.3409 \log F \therefore \hat{C} = 9.7409 . 10^{-7} . F^{2.3409}$ Equation 10

$(s^2_{\widehat{\log C}} = 1.1122 - 0.5319 \log F + 0.0638 (\log F)^2)$

The problem of predicting the catch of a river not included in the list given in Table 1 can be resolved. The only two large rivers in Amazonas State which are not being reached by the Manaus fishing fleet are the rivers Iça and Javari. An examination of CARTAS PLANIMETRICAS DO PROJETO RADAMBRASIL suggests that these rivers are similar to the rivers Juruá and Jutai: they are located far from Manaus and are both tributaries of the Solimões river, (as are the rivers Juruá and Jutai), they would be probably exploited using a similar fishing strategy, i. e. by big boats looking for tambaqui (*Colossoma macropomum*). Equation 8 is therefore the first choice for predicting the catches of these two rivers.

The remaining rivers are blackwater rivers which are broadly exploited with the same strategy as in the Rio Negro, with beach seines being used to catch jaraqui (*Semaprochilodus* spp.) during its migrations. So, for these, Equation 7 would be appropriate.

Partial Correlation Analysis

The zero order correlation matrix between the logarithms of independent and dependent variates of table 1 is given in table 2. Note that all of the correlations are highly significant ($P < 0.01$) and that any of the independent variates taken alone could be used to predict the catches with different degrees of accuracy.

The second order partial correlation coefficients between the logarithms of variates representing effort (T and F) and morphology (A and L) are given in table 3. Looking at the results of table 3, we see that some correlations (r_{AT}, r_{AF}, r_{LT}, r_{LF}) which are significant in table 2 when calculated ignoring the other variates, become non-significant ($r_{AT,LF}$; $r_{AF,LT}$; $r_{LT,AF}$; $r_{LF,AT}$) after the introduction of the statistical control. Such spurious correlations can be very misleading (GORDON 1968).

So we see that our 4 independent variates which are supposed to affect the catches can be put into two groups: one composed by the morphological variates (area of the floodplain and length of the river channel) related to the characteristics of the river, and the other composed of the fishing effort variates (annual number of trips and number of fishermen).

Discussion and Conclusions

With the aim of deriving a simple procedure for predicting catches for the fisheries in the main rivers of Amazonas State, Equations (7 - 10) were developed and applied to each situation.

Equation 1 can be considered as a beginning in that, as more biotic and abiotic information can be incorporated into the data set of table 1, as is gathered over the years. The exploratory process can be repeated again, and a reduction of the model can be attempted. Although this procedure is rather mechanistic, it is the only one available with our present lack of understanding of the basic biological processes determining the catches. The main difficulty in the present context is that we are largely unable to experiment with natural populations of fishes, but can only observe the whole system passively (BOX 1966). RIGLER (1982) presents an interesting discussion about the characteristics of empirical models.

Tab. 2: Simple Pearson correlation coefficients (df = 14) between:
T = annual number of trips per river
F = annual number of fishermen who operated in each trip per river
A = the maximum flooded area (km^2) in each year per river
L = the length (km) of each river reached in each year by the Manaus fishing fleet
C = total annual catch (metric tons) per river
The calculations were performed in logarithmic scale as stated by Equation 1, with "normal" floodplain rivers.
df = degress of freedom; ** = $P < 0.01$

	T	F	A	L	C
T	1				
F	0.9917**	1			
A	0.8092**	0.8367**	1		
L	0.8214**	0.8402**	0.9513**	1	
C	0.9406**	0.9651**	0.8103**	0.8140**	1

Tab. 3: Partial correlation coefficients of second order between the logarithms of the explanatory variates of rivers with "normal" floodplain (see table 1)
T = annual number of trips per river
F = annual number of fishermen who operated in each trip per river
A = the maximum flooded area (km^2) in each year per river
L = the length of each river reached (km) in each year by the Manaus fishing fleet
df = degress of freedom; ** = $P < 0.01$

$r_{TF,AL} =$ 0.976**
$r_{TA,FL} = -$ 0.279
$r_{TL,FA} =$ 0.144
$r_{FL,TA} = -$ 0.084
$r_{FA,TL} =$ 0.319
$r_{AL,TF} =$ 0.835**; df = 12

The regression analysis procedure which resulted in Equations 7 - 10 is a statistical solution to the important problem of predicting the catches for management purposes. The application of Equations 7 - 10 is a very efficient tool for immediate use.

The need for applying dummy variables means that there are qualitative differences between the rivers of table 1. These differences can be placed in three main groups (see also WELCOMME 1976, 1979).

(i) Differences due to edaphic factors. These are responsible for water richness, which in turn will reflect the differential fish productivity of similar fish species in each river.

(ii) Differences due to morphological factors. The fact that the morphological variates (length of the channel and area of the floodplain) were dropped from the basic equation (Equation 1) only means that they do not significantly increase the accuracy of the predicted catches. It is incorrect to conclude that they do not play some kind of biological role in rivers with similiar edaphic characteristics.

(iii) Differences due to the fishing strategy. These are reflected in the species composition of the total catch from different rivers because of the multigear character of the fishery (PETRERE 1978).

The fact that rivers Negro, Branco and Purús belong to the same category in Equation 7, although they have different characteristics related to the three features mentioned above, may be due to chance and the smallness of the sample.

Because the second order correlation coefficient crossed between the morphological and fishing effort are not significant (at $P < 0.05$) in table 3, it can be said that fishermen are not always looking for larger floodplains (or longer rivers). This is not due to the fact that they are looking for the rivers which are closer to Manaus, because the rivers Negro and Branco (easily accessible to the Manaus fishing fleet) have the lowest concentrations of fishermen per square kilometer of floodplain in table 3. The biological meaning is that fishermen are visiting floodplains irrespective of their sizes because they must have different productivities.

The present analysis shows that any empirical model intended to predict the commercial catches in Amazonas State must take the fishing effort into consideration. Fisheries managers in the region might close a whole river system to all fishing for a period of years, or introduce closed seasons in selected rivers hoping to protect the spawning stock and prerecruits. This policy is also designed to cope with the side effects of the multigear fishery in the Amazon in which there is an unknown (and probably large) catch of small and immature fishes which are discarded or sold on the black market because they cannot be legally landed. Such a policy is sometimes suggested so as to avoid conflicts between professional fishermen and local residents who compete for the same fish stock. Thus the use of Equations 7 - 10 could give an estimate of expected changes in fish landings at Manaus if such a policy were adopted, with the consequent redistribution of the fishing effort. This study may thus prove to be of practical significance while still leaving many fundamental problems open to future solution.

Resumo

Neste trabalho é discutido o papel desempenhado por 4 variáveis que supostamente determinam a captura total num modelo de regressão múltipla. Conclui-se que o número anual de pescadores é a mais importante dessas variáveis, ao se tomar a captura total para 8 rios no Estado do Amazonas, durante 1976, 1977 e 1978. A técnica da análise de correlação parcial sugere que os pescadores estão procurando os rios de várzea mais produtiva para a pesca.

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Author's address:

Dr. Miguel Petrere, Jr.
Universidade Federal do Maranhão
Departamento de Biologia
Largo dos Amores, 21
65000 - São Luiz (MA), Brazil

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ERRATA

Relationships among catches, fishing effort and river morphology for eight rivers in Amazonas State (Brazil), during 1976 - 1978

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Miguel Petrere, Jr.
Universidade Federal do Maranhão, São Luis (MA), Brasil

The figures 5 and 6 on pages 288 and 289 were transposed. The legends are in the correct places.

The first term of Equation 9 on page 291 must be negative:

$$\widehat{\log C} = - 1.0553 + 1.2830 \log F \therefore \hat{C} = 0.0880 \,.\, F^{1.2830}$$