The Fisheries and Limnology of the Lower Plata Basin

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Abstract

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The fish community of the lower Plata River Basin (mainly lower Parana, Uruguay and Plata rivers) is a lightly exploited system with a fishery based mainly on age four to six fishes. Fish catches are related to the Parana River flood regime of preceding years and are regulated by fish movements between the main channel and the floodplain. *Prochilodus platensis* is the most notable species. Analysis of relationships between the fishery structure and the system's ecological characteristics showed the proportion of *Prochilodus* in the catch increased with the increase in importance of the floodplain with respect to the main channel, and with the increase in connections between floodplain waterbodies and main and secondary channels. Zooplankton, benthos and fish biomass are influenced by total nutrient levels and organic matter levels in water and sediments.

Résumé

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Les richesses halieutiques du bassin inférieur du Rio de la Plata (il s'agit essentiellement du Parana, de l'Uruguay et du Rio de la Plata, dans leur cours inférieur) sont peu exploitées; on pêche surtout dans ces eaux des poissons de classe d'âge de 4 à 6 ans. Les captures sont liées aux crues du Parana dans les années précédentes et dépendent des déplacements des poissons entre le lit principal et la plaine inondable. *Prochilodus platensis* est l'espèce la plus notable. L'analyse des relations entre la structure des pêches et les caractéristiques écologiques du système a révélé que la proportion de *Prochilodus* capturés s'accroît en fonction de l'importance de la plaine inondable par rapport au lit principal ainsi qu'en fonction de l'augmentation du nombre de voies reliant les plans d'eau de la plaine inondable aux cours d'eau principal et secondaires. La teneur totale des eaux et des sédiments en matières nutritives et en matières organiques influe sur le zooplancton, le benthos et la biomasse des poissons.

Introduction

This paper summarizes ecological features of the lower Plata River Basin and describes the structure of its fishery relative to the flood regime and geomorphology of its tributary, the Parana River. We also summarize studies on fish movements and relate them to fish catches at more than 50 landing sites in the lower Plata Basin. The relationship between flood regime of the Parana River and total fish catches for the lower Basin and subsystems is also presented.

The Plata River Basin drains large parts of Argentina, Uruguay, Paraguay, Brazil, and Bolivia. This paper focuses on its lower part, including the lower reaches of the upper Parana River, the lower Bermejo River and the lower Paraguay, the middle and lower Parana River up to the Plata River, the middle and lower Uruguay and the upper and middle Plata.

The lower Plata River Basin is not a heavily exploited system. Fishery statistics for the lower Plata Basin exist since 1921 with the most important fish landings recorded from 1940. However, the quality of the statistics is poor. The fishery at present is based almost exclusively on fish 4–6 yr old and occasionally older fish. *Prochilodus platensis* is the most notable species and its harvest depends on the demand for industrial processing or export.

The middle Parana ecosystem has been studied intensively by Bonetto and associates (Bonetto et al. 1969b; Bonetto 1975) and by INALI (National Limnology Institute, Santo Tomé, Santa Fé, Argentina). During the last few years there has been renewed interest in these studies as well as in those on fisheries because of several dams that are projected to be built on the middle and upper Parana River. In contrast, the Pàrana River Delta and the Plata River are the least studied ecosystems in the lower Basin. Yacireta dam is near completion on the Upper Parana and several dams have been constructed on the Parana River and its tributaries in Brazil.

Data Sources and Analytical Methods

Information on total catch by sub-basin and by landing, number of fishermen in each region, and the landing sites was provided by the Dirección Nacional de Pesca Continental (Santa Fé 1548, Piso 7, 1060 Buenos Aires, Argentina). Hydrological information on the Parana, Uruguay and Bermejo rivers was provided by the Dirección Nacional de Construcciones Portuarias y Vías Navegables (Alférez Parejas 100, 1107 Buenos Aires, Argentina). Information on catch per unit effort in the main channel and in island lagoons was taken from a study by the Rosario Station of Instituto Nacional de Investigacion y Desarrollo Pesquero (Paseo de la Ribera y Cordiviola, 2000 Rosario, Argentina) during 1957–58.

Throughout this paper the term "lagoons" means permanent or semipermanent standing waters in the plain, while "island lagoons" means the lagoons on the islands within the river channel. The term "secondary channels" means secondary anabranches of the river flowing into the plain and "secondary streams", including the complex and shifting channels that interconnect them.

Information to compare fish size in the fishery with age of fish in the catch by species came from the following: *Prochilodus platensis* (Cabrera and Candia 1964; Vidal 1967; Cordiviola de Yuan 1971), *Pseudoplatystoma coruscans* (Cordiviola 1966a), *Luciopimelodus pati* (Fortuny and Espinach 1982), *Colossoma mitrei* (Andrade Filho 1985), *Leporinus obtusidens* (Candia unpubl. data), *Salminus maxillosus* (Cordiviola 1966b; Sverlij and Espinach unpubl. data).

Principal component analysis (PCA) and cross-correlation analysis were done according to Davis (1973) and correlation-regression analysis following Draper and Smith (1966). The fishery variables employed in the cross-correlation analysis were: TC (total catch), PC (*Prochilodus* catch) and RC (total catch minus that of *Prochilodus*). The hydrological variables used were: L_{mean} (mean annual hydrological level), L_{min} (monthly mean minimum hydrological level), time integral of hydrological level over the bankfull and time integral under the bankfull (Welcomme 1979). Annual catches are by hydrological year for the Parana River, from September to August. Movement of the time series past one another are expressed by the number of years moved preceded by the minus sign (match position, Davis 1973). Hydrological level corresponds to that at Santa Fe City (19)[1] unless otherwise specified. All regression analyses were also performed with $L_{i,j}$ (monthly mean minimum hydrological level within the years i and j previous to the year of the catch) and L_{i-j} (monthly mean minimum hydrological level within the period that goes from i to j years previous to the year of the catch). The results are more regular and consistent with minimum hydrological level in each year (L_{min}). The hydrological regime of the middle Parana is such that minimum levels occur in September, at the beginning of spring, and maxima in March–April, at the beginning of autumn. Mean monthly air temperature (TEMP) at several fish landing sites (Servicio Meteorológico Nacional, 25 de Mayo 658, 1002 Buenos Aires, Argentina) was considered as a climatic variable. Information on flooded areas at different flood return periods was provided by Instituto Forestal Nacional (Av. Pueyrredón 2445, 1110 Buenos Aires, Argentina).

Although the fishery as a whole lightly exploits the resource, local fisheries are moderately intensive. Their intensity is also dependent on fishing gear employed. Human population density was low and variable during the period studied. The human population density in the lower Plata River basin during the period 1914–80 (H) was considered as a variable that might be related to the level of effort. Two or more fish species are sometimes grouped together in the commercial catch records. Therefore, a single variable in the principal component analysis represents a "species" group (Table 1).

The total data base is available on request from the authors (see Appendix).

Description of the Lower Plata River Basin

The Plata River System (Fig. 1) is formed by the Parana, Paraguay and Uruguay river basins. With an area of 3.1×10^6 km^2, it is the second largest drainage system in South America after the Amazon River and the fourth largest in the world. The upper Parana River differs markedly in its geomorphological features from the middle and lower Parana River. Its basin shows a stepped and uneven profile; abundant falls and rapids are interspersed with low gradient reaches and extensive floodplains up to the confluence with the Paraguay River. Except for some tributaries originating in the Andes region, the Paraguay River has extensive floodplains with swampy marginal areas; its upper basin is dominated by the "Gran Pantanal", probably the greatest swampy area subject to sheet flooding in South America (Welcomme 1985).

After the confluence with the Paraguay, the hydrological and limnological characteristics of the Parana change to form the middle Parana with its massive floodplain, covering more than 20 000 km^2 (Bonetto et al. 1969b). The lower Parana forms a delta of more than 10 000 km^2. With southeast storm winds tidal effects are felt up to 300 km upstream. No current reversals are registered as far downstream as the delta distributaries which experience reduced flows at high tide only (Urien 1972).

The Uruguay River with its rocky bed resembles the upper Parana. The lower Uruguay widens and deepens considerably before its confluence with the Parana Delta distributaries; its right bank becomes flat and prone to floods.

The Plata River is formed by the junction of the Parana and Uruguay rivers; average discharge is 25 000 $m^3 \cdot s^{-1}$ (Urien 1972). The upper river is very shallow and has an average depth of about 1.20 m. Near Colonia City the "principal channel" bifurcates and the main channel crosses the estuary towards La Plata City and continues seaward along the middle of the river (Urien 1972).

At the confluence of the Parana and Paraguay rivers, the latter is higher in suspended matter, nutrients and organic matter (due to the Bermejo River) than the Upper Parana (Table 2). From this point southwards the valley widens. After a stabilization zone, suspended solids tend to decrease and dissolved solids, organic matter and phytoplankton, zooplankton and benthos biomass increase along the length of the river until the beginning of the delta (Bonetto 1976; Drago and Vasallo 1980; Ezcurra de Drago 1980; Jose de Paggi 1980; Perotti de Jorda 1980a).

Sediments in the Parana River Delta distributaries are mostly sand and silts, with mean diameters between 2 and 5 phi grade (Urien 1972). Current velocities in the upper Plata are insufficient for a high sand transport, therefore,

[1] Numbers in parentheses throughout this paper refer to geographic sites (Fig. 1).

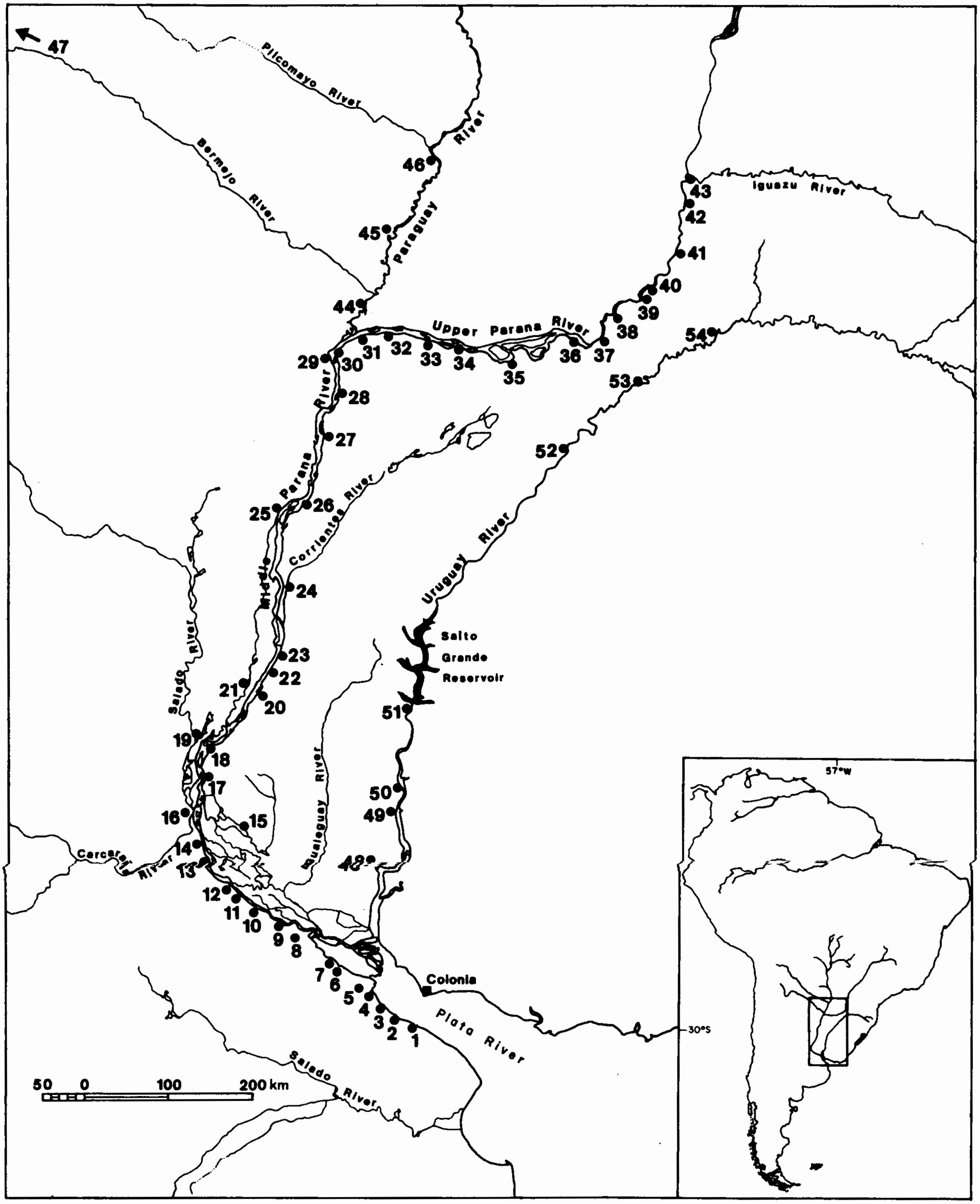

FIG. 1. The lower Plata River Basin. Numbers indicate fish landing sites.

silt and clay comprise the bulk of sediments transported into the Plata River. Silt covers a very extensive area in the upper and middle Plata River. The northern coast is essentially sandy (mean diameters between 1.4 and 2.5 phi grade). On the southern shore sediments are silty sands and clays (3.9 to 7.8 phi grade). The main channel passes against the northern shore where levels of organic matter and nutrients are lower than against the southern bank.

TABLE 1. Fish taxa included in each "species" variable in the principal components analysis.

Fish taxa	Variable
Oxydoras kneri	ARM
Pterodoras granulosus	
Rhinodoras d'orbignyi	
Lycengraulis olidus	ANCH
Parapimelodus valenciennensi	BGTO
Leporinus spp.	BOGA
Pimelodus clarias	BAMAR
Salminus maxillosus	DOR
Ageneiosus spp.	MAND
Sorubim lima	
Paulicea lutkenii	MANG
Pseudopimelodus zungaro	
Pimelodus albicans	MONCH
Luciopimelodus pati	PATI
Megalonema platanum	
Basilichthys bonariensis	PEJ
Brycon orbignyanus	PIRA
Brycon sp.	
Colossoma mitrei	PACU
Prochilodus platensis	SAB
Prochilodus sp.	
Pseudoplatystoma fasciatum	SUR
Pseudoplatystoma coruscans	
Hoplias malabaricus	TAR

Biological Characteristics of the Lower Plata River Basin

In a cross-section of the river, the floodplain is structured such that the density of biotic components increases from the main channel toward the edge of the plain (Table 2). In addition to increases in dissolved solids, biomasses increase for phytoplankton, zooplankton, benthos and fish in the order of: main channel, secondary channels, secondary streams and lagoons. Particularly for fish, banks of the main channel tend to be zones of intermediate biomass between the main channel and secondary streams (Table 2) (Poddubnyi et al. 1981). Fish biomass appears highest in lagoons farthest from the main channel (Cordiviola de Yuan unpubl. data; Quiros and Baigun 1985).

Mean levels of nutrients, total organic matter, and biomass of phytoplankton, zooplankton and benthos of tributaries are generally higher than those of secondary streams (Table 2). Particle size of sediment decreases from the main channel towards floodplain lagoons while organic matter in the water column and sediment increases. As particle size decreases, levels of organic carbon per unit mass of sediment increase (Emiliani 1977; Marchese and Ezcurra de Drago 1983; Copes 1984). Table 2 compares subsystems and is not exhaustive with respect to mean values and variation in time and space. For example, chlorophyll *a* values have been reported at up to 660 mg$\cdot$ m^{-3} in lagoons at the mouth of the Salado River (Bonetto et al. 1969b) with mean values between 9.7 and 12.6 mg$\cdot$ m^{-3} for secondary streams (Perotti de Jorda 1981, 1985). Secondary channels and streams have lower levels of dissolved oxygen and lower pH at high water than does the main channel due to the macrophyte decay cycle in lagoons (Bonetto 1975).

Phytoplanktonic production in the main channel of the middle Parana River does not reach levels attained in the upper Parana and in the Paraguay River north of the Bermejo River mouth (Table 3). In the upper Plata River, levels of chlorophyll *a* and organic matter are higher than in the main channel of the Parana and Uruguay rivers (Quirós and Senone 1985). In addition to phytoplankton biomass, primary production depends on the flood regime, being generally higher at low water. However, net primary production (P) is generally low and since the respiration (R) levels in the water column are relatively high (Perotti de Jorda 1980a) the P/R rate is less than one. In floodplain lagoons production levels (oxygen method) are between 50 and 1 000 mg C$\cdot$m$^{-2}\cdot$d^{-1} (Bonetto et al. 1969b) with an average of 510 mg C$\cdot$m$^{-2}\cdot$d^{-1} as gross production for a whole annual cycle (Perotti de Jorda 1977). The reported net primary production of floating macrophytes varies between 530 and 1 286 mg C$\cdot$m$^{-2}\cdot$d^{-1} of covered surface; values of the same order and magnitude (Table 3) or higher correspond to the "swampy" areas of the floodplain (Neiff 1981).

Although, the contribution of aquatic macrophytes to energy input of the system seems to be far more important than that of the phytoplankton (Table 3), annual production cycles of each are out of phase in the middle Parana River. Macrophyte production follows the thermal regime, with maxima in high falling waters (Lallana 1980; Sabattini unpubl. data). Floating macrophytes particularly *Eichhornia crassipes* can completely cover lagoons. The degree of cover depends on the hydrological cycle, the position and the size of the lagoon within the floodplain. Macrophyte decay could be a key factor in the spatial and temporal organization (Table 2) of biota in the floodplain and in the delta and Plata River.

The major ecological features of the Uruguay River are similar to those of the upper Parana (Bonetto 1975) and follow the same trends as in the main channel of the Parana River. Uruguay River nutrient levels are lower but phytoplankton biomasses are similar (Comisión Técnica Mixta de Salto Grande 1982; Quirós and Cuch 1988).

Structure of the Fishery

The total fish catch from the Parana River for the period 1945–84 was 3 679 t$\cdot$yr^{-1}, of which 40 % was *Prochilodus*. In the Uruguay and Plata rivers, the catches were 2 560 t$\cdot$yr^{-1} (95 % *Prochilodus*) and 4 960 t$\cdot$yr^{-1} (86 % *Prochilodus*), respectively. The total catch from the lower Plata River Basin was 11 119 t$\cdot$yr^{-1} of which 73 % was *Prochilodus*. Large catches of *Prochilodus* in the Uruguay River came from a single fish landing (Gualeguaychú, 48) in the lower Uruguay. In the middle and upper Uruguay, the catch of *Prochilodus* was proportionally much less. There are also relatively important sport and subsistence fisheries which have not been evaluated.

From Puerto Iguazú (43) to slightly south of the confluence with the Paraguay River, the most common fishing gear is the "espinel" (long-line with numerous fish-hooks), although gill nets are also used. South of the Paraguay confluence the use of long-lines diminishes and the "mallon" (a net panel of stretched mesh of 32 to over 40 cm) and trammel net becomes dominant. Both gears are used in the main channel or in secondary streams; the current drags the fishing gear in places especially prepared for fishing. The "mallon" is used to catch large specimens of *Pseudoplatystoma*

TABLE 2. Phytoplankton, zooplankton, benthos, and fish biomass, bottom sediment, and organic matter in the water column in the lower Plata River Basin.

	Upper Paraná	Paraguay	Middle Paraná	Tributaries	Secondary courses	Lagoons
Phytoplankton[a]						
Chl*a* (mg• m^{-3})	5.8	4.1	6.5 (3.0–8.5)	6.7 (5.4–8.4)	—	8.9 (2.7–91.9)
Biomass (g• m^{-3})	—	—	0.5 (0.1–1.1)	2.3 (1.1–2.6)	1.6 (0.7–5.2)	—
Zooplankton[b]						
Biomass (mg• m^{-3})	—	—	1.4 (0.4–2.6)	—	—	94.0 (8.3–421.6)
Numbers (L^{-1})	1.1	13.0	5.6 (0.7–12.0)	(1.0–23.0)	—	232.0 (11.0–1115.0)
Numbers (L^{-1})	—	—	54.4	151.0	122.3	—
Benthos biomass[c]						
Channel (mg• m^{-2})	0.2	0.7	1.9 (0.0–8.2)	—	—	7180.0
Bank (mg• m^{-2})	—	—	128.1	—	—	—
Channel (mg• m^{-2})	—	—	1.5 (0.01–4.7)	473.0 (0.01–4324.0)	237.0 (0.01–2340.0)	— —
Bottom sediment[d]						
Channel (*phi* grade)	1,2	1,2,3	2,3	2,3,4–4,5,6	2,3,4	7,8
Bank (*phi* grade)	—	2,3,4	2,3,4,5	—	—	—
Organic matter[e] (mg 0_2• L^{-1})	2.6 (1.2–5.9)	9.2 (3.0–16.4)	3.9 (2.4–7.5)	— —	4.4 (2.4–9.2)	5.7 (2.8–27.0)
Organic matter[f] (mg 0_2• L^{-1})	—	—	—	15.0 (6.4–28.8)	—	15.7 (7.7–28.3)
Fish biomass[g]) (kg• L^{-1})	150[h] (50–250)	— —	193[h] (85–370)	—	313[h] (11–1500)	876 (66–6700)

[a] Perotti de Jorda (1980a, b); García de Emiliani (1981, 1985); García de Emiliani and Anselmi de Manavella (1983).
[b] José de Paggi (1980, 1983); Paggi (1980).
[c] Ezcurra de Drago (1980); Marchese and Ezcurra de Drago (1983).
[d] Bertoldi de Pomar (1980, 1984) and unpubl. data. Wentworth scale; *phi* grade 2, medium sand; *phi* grade 8, silty clay.
[e] Maglianesi (1973); Bonetto (1975); permanganate oxidability.
[f] Maglianesi and Depetris (1970), INALI files (Inst. Nac. de Limnología, J. Maciá 1833, 3016 Santo Tomé, Santa Fe, Argentina). Only the Salado River.
[g] Ponds: Bonetto et al. (1969, 1970a, 1970b); Cordiviola de Yuan (1977) and unpubl. data. Main channel: Upper Paraná River, Biosonics Inc. 1985 (4520 Union Bay Place NE, Seattle, Washington 98105), Middle Paraná River and secondary courses; Poddubnyi et al. (1981) (Agua y Energía Eléctrica, Ger. Paraná Medio, Hipólito Irigoyen 2856, Santa Fe, Argentina).
[h] Only for comparisons, we assume: one count, one fish, 1 kg.

spp., *Paulicea lutkenii*, *Salminus maxillosus* and *Brycon orbignyanus* (Cordini 1955). At the latitude of Parana City (18) and up to the start of the delta at Rosario City (13), the trammel net is the most frequently used gear in the main channel; long-lines are also used. The gill-net is used in floodplain lagoons. South of Rosario (13) long-lines are the most common gear in the main channel; trammel nets are also used. On the floodplain (Victoria, 15) gill nets and beach seines are used. In the Plata and lower Uruguay rivers (Gualeguaychú, 48) beach seines are used for industrial fisheries. In the rest of the Plata River long-lines, gill nets and encircling nets are used. In the middle and upper Uruguay River long-lines are used except in Salto Grande Reservoir where gill nets are employed.

Most fishermen use small boats. In the Plata River small craft 10 to 15 m long are used. This type of ship is also used in the Parana, mainly south of Parana City (18), for collecting catches of the individual fishermen (Cordini 1955).

The only information on effort available is the somewhat unreliable estimate of the number of fishermen per month per fish landing for the period 1982–84. For this period 1543 fishermen are reported for the whole system which would give a catch of 22.8 kg• $fisherman^{-1}$• d^{-1} for the period 1982–84. The information on catch per unit effort per fish landing (considering the full-time fisherman as the unit effort) varies between 3 and 382 kg• $fisherman^{-1}$• d^{-1} in the Parana River and from 28 to 411 and 2 to 138 kg• $fisherman^{-1}$• d^{-1} in the Plata and Uruguay rivers, respectively. These differences reflect different types of fishery in different parts of the system and also the low quality of information available. One consistent observation is that the largest catches per unit effort come from fish landings with a greater proportion of *Prochilodus* in the catch (Table 4).

The relationship of catch per unit effort and *Prochilodus* frequency in the catch is also correlated with morphology of the Parana floodplain and the Parana Delta. There seems to be a positive relationship of both variables with the relative size of the floodplain with respect to the channel (floodplain width divided by channel width) and the drainage characteristics of the plain.

The proportion of *Prochilodus* in the catch and catch per unit effort increases with the degree of importance of the floodplain with respect to the main channel, and with the

TABLE 3. Macrophyte and phytoplankton primary production in the lower Plata River Basin (in mg C• m^{-2}• d^{-1}).

	Upper Paraná	Paraguay	Middle Paraná	Lagoons	Swamp
Phytoplankton					
C^{14} method[a]	240	343	31–99[d]		
	(7–960)	(60–750)	(2–285)		
		18			
		(5–61)			
Oxygen method[d]			102[e]	510[f]	
(gross production)			(1–800)	(25–1270)	
Macrophyte[c]				880	680[g]
(net production)				(530–1286)	

a. Bonetto et al. (1979, 1981, 1983). Without respiration correction.
b. Perotti de Jorda (1977, 1984).
c. Poi de Neiff and Neiff (1977); Lallana (1980); Bayo et al. (1981); Sabattini (unpubl. data).
d. Near confluence with Paraguay River, right and left margin respectively.
e. At Paraná City.
f. Only one lagoon.
g. Aerial production.

TABLE 4. Catch per unit effort in the lower Plata River Basin (1982–84) and frequency of *Prochilodus* in the catch (1972–84). Mean value and range of each variable.

		Middle Paraná				
	Upper Paraná	Up to Hernandarias (20)	Up to Diamante (17)	Up to San Nicolás (11)	Lower Paraná	Plata River
Catch per unit effort	18.3	11.8	120.9	133.9	12.1	614.5
(kg• $fisherman^{-1}$• d^{-1}	(2.5–64.6)	(6.6–30.1)	(66.0–230.1)	(7.9–381.6)	(5.5–20.5)	(109.0–1127.4)
Prochilodus Frequency in the catch	0.23	0.09	0.32	0.45	0.21	0.73
	(0.003–0.54)	(0.02–0.25)	(0.22–0.43)	(0.25–0.95)	(0.00–0.46)	(0.56–0.98)

number of connections between floodplain waterbodies and channels. These relationships would operate through accessibility to fish by the fishermen, as well as accessibility to floodplain waterbodies by fish to reach adequate feeding and spawning grounds.

The catch per unit area for the system is 3.5 kg• ha^{-2}• yr^{-1} for the period 1945–84 and 7.5 kg• ha^{-2}• yr^{-1} for the period 1982–84, excluding the Paraguayan upper Parana catch (Bayley 1984). This last value is 25 % or less of the potential estimated for the system using Welcomme's equations (1979, 1986). It is possible that actual catches are at least twice those reported for Argentina, although the fish community as a whole is lightly exploited. The Paraguay River with a floodplain area of 10 500 km^2, produces a yield per maximum flooded area of 11 kg• ha^{-2}• yr^{-1}, about 25 % of Welcomme's lower limit of his 40–60 norm (Bayley, Illinois Natural History Survey, University of Illinois, 607 East Peabody Drive, Champaign, IL 61820, USA, pers. comm.).

To summarize the structure of the fishery in the lower Plata River Basin, we performed a principal component analysis of the catch composition as a function of the fish landings. Results were later related to the type of fishery that was regionally dominant. To make data independent of the effect of effort on total yield we transformed all the "species" variables to catch-frequencies and the analysis was linearly performed according to the variance-covariance matrix (Davis 1973). The first eigenvector (Table 5) explained 63 % of the total variation and weighted *Prochilodus* positively and *Pseudoplatystoma* spp. negatively. The second eigenvector weighted *Pseudoplatystoma* spp. and *Prochilodus* positively and *Pimelodella* spp. and to a lesser extent *Luciopimelodus pati* negatively. In the principal components space three main groups were separated (Fig. 2). Two of them, A and C, represent extreme cases of unspecific fisheries. In the case of A, the fish landing sites were clustered with fishing gears selective for *Pseudoplatystoma* spp., such as hooks and "mallon". These sites are located on the main channel where most of the effort seems to be concentrated. Also, these sites include the middle Parana north of Helvecia City (21) and the upper Parana and Paraguay rivers. In the case of C, two fish landing sites are represented on the middle Plata River, one in the Parana Delta away from the main channel and one in the lower Uruguay, some distance north of the Parana mouth. These are regions of high captures of *Prochilodus* (over 95 %) by an industrial fishery. Fishing gear employed was mainly seines, and some gill nets.

The remaining sites were grouped in B, within which three subgroups can be distinguished. B_1 gathered all landing sites of the middle Parana south of Santa Fe Parana (18–19) and landing sites on the upper Parana and upper Uruguay rivers. Catches of *Prochilodus* from these sites varied between 25 and 50 % of the total catch because fishing gear of trammel nets, gill nets and hooks was less selective.

The three remaining fish landing sites of the Plata River, two of them located almost at the mouth of the delta, were

TABLE 5. Eigenvalues, % variance explained, and eigenvectors for species catch frequency PCA.

Species Variable (See Table 1)	(Principal Component		
	1	II	III
ARM	−0.00	−0.11	0.14
ANCH	0.01	−0.02	−0.02
BGTO	0.01	−0.52	−0.18
BOGA	0.03	−0.13	−0.03
BAMAR	0.01	−0.02	−0.01
DOR	0.02	−0.05	−0.05
MAND	0.01	−0.05	0.04
MANG	−0.06	0.03	0.34
MONCH	0.00	−0.02	−0.04
PAT	−0.09	−0.23	−0.46
PEJ	0.02	−0.03	−0.04
PIRA	−0.01	−0.01	0.22
PACU	−0.10	0.13	0.65
SAB	0.77	0.50	−0.19
SUR	−0.62	0.62	−0.31
TAR	0.01	−0.07	−0.05
Eigenvalue	1120.7	332.4	116.6
% variance explained	63.3	18.8	6.6

grouped in B_2. One of them gathers fish from the Delta and from the lower Uruguay River (Tigre, 5), where *Prochilodus* is over 55 % of the total catch. Group B_3 clustered fish landing sites in the lower Parana, the main channel where *Prochilodus* catches were low or nonexistent but those of *Luciopimelodus pati* and *Pimelodella* spp. were high. The rest of B included fish landing sites on the middle Parana with high historical catches of *Prochilodus* (Diamante, 17), and landings on the upper Parana, upper Uruguay and middle Bermejo rivers.

The third axis (Table 5) separated into B and C the fish landings of the middle Parana from those of the upper Parana and upper Uruguay. For those on the upper Parana the proportion of *Colossoma mitrei*, *Paulicea lutkenii* and *Brycon orbignyanus* is higher than in the middle Parana. In the upper Uruguay the proportion of *Brycon orbignyanus* and *Pseudopimelodus zungaro* is larger (Fig. 3). The composition of the catch at present in the three fish landing sites in the region of Rosario (13) agrees with the results of this ordination (Vidal unpubl. data). The composition in five landing sites in the Brazilian Gran Pantanel (Paiva 1984) are distributed in clusters A and B of our principal components space (Fig. 2). Although all catches include *Colossoma* and *Paulicea*, in three of them *Pseudoplatystoma* surpasses 50%. Studies of catch and effort in the main channel and floodplain show *Colossoma*, *Paulicea* and *Brycon* are available only in late spring and summer at low rising waters and high waters in the middle Parana south of Santa Fe-Parana (18–19) (Anonymous 1958; Oldani and Oliveros 1984).

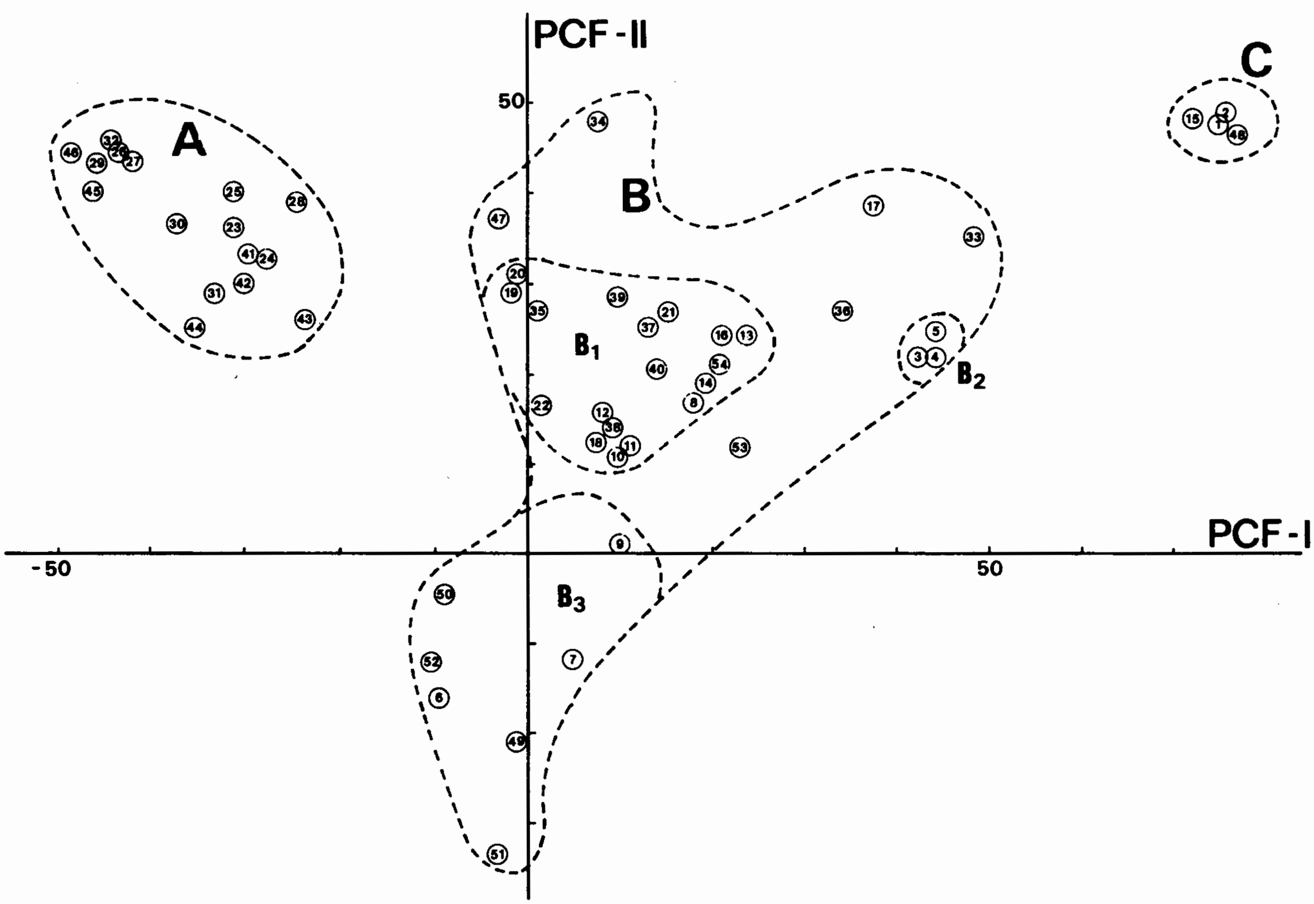

FIG. 2. Position of each fish landing site in the two first axes principal components space.

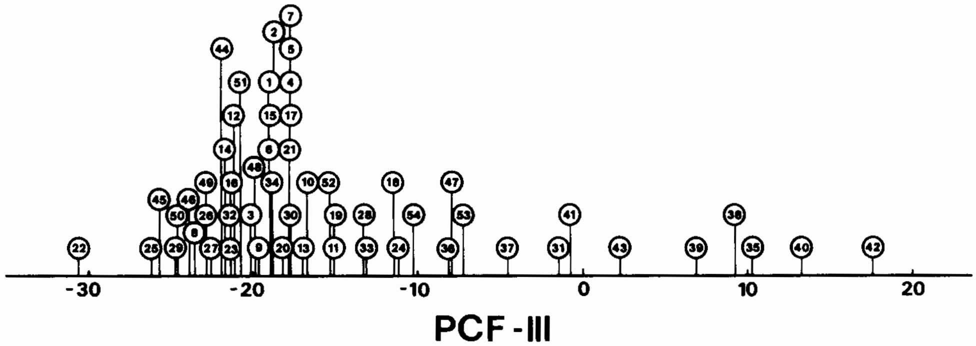

FIG. 3. Position of each landing site in the third principal components axis.

Catch and Flood Regime

Hydrological levels of previous years, especially mean annual (L_{mean}) and monthly mean minima (L_{min}) appear to influence catches in the Parana River (Table 6). This relationship holds for total catch, catch of *Prochilodus*, total catch minus that of *Prochilodus*, and catches of *Pseudoplatystoma* spp., *Salminus maxillosus* and *Luciopimelodus pati*. The relationships are generally better with L_{min} and time integral of water level under bankfull. The relationship between L_{min} and TC increases from one year before the catch, being highest in the years -5, -6 and -7. The relationship with RC follows the same tendency and is highest for years -6 and -7.

The mean L_{min} for years -5, -6 and -7 explains 35 % of the variation in TC, and for the years -6 and -7 explains 47 % of the variation in RC (Table 7).

Data were divided into two periods to assess the influence of effort. In general, for the first period, the explained variance was lower. However, in the one exceptional case of $L_{5,6,7}$ for TC both regression lines do not have significantly different slopes and their intercepts differ by 40 % (Table 7). Human population increase (H) added to the regression explained 50 % and 61 % of the variation in TC and RC, respectively (Table 7). Nevertheless, the increase is smaller if both periods are analyzed separately. If the average L_{min} for the previous years -1 to -9 ($L_{1\text{-}9}$) is considered as the independent variable then 57 and 61 % of the respective variations in TC and RC are explained. In this case the explicative value of (H) becomes non significant. This last fact, together with its low explicative value in each subset taken separately would lead us to reject H as an important explanatory variable. The explicative value of the hydrological levels in the previous years -8 and -9 might be due to the fact that age classes, mainly of the big silurids, are actually taken by the fishery (Oldani and Oliveros 1984). In Table 7, the best explanatory relationships obtained for TC, RC and PC are presented. The low explanatory value of the hydrologic variables on PC would indicate the industrial fishery of *Prochilodus* depends on other factors.

Although the effort applied in open zones by the fishery is relatively high, the great mobility of the fish stocks makes the fishery very sensitive to the management regulation

TABLE 7. Paraná River. Regressions of total catch (TC), total catch minus that of *Prochilodus* (RC), and *Prochilodus* catch (PC) against the monthly mean minimum hydrological level (L) and human population density (H).

N	Regression	R^2	P<
36	$TC = 2394 + 763\ L_{5,6,7}$	0.35	0.001
18 (1)	$TC = 2181 + 595\ L_{5,6,7}$	0.21	0.03
18 (2)	$TC = 3056 + 568\ L_{5,6,7}$	0.29	0.01
36	$TC = -78.7 + 608.2\ L_{5,6,7} + 0.5\ H$	0.50	0.001
36	$RC = 1423 + 479\ L_{6,7}$	0.47	0.001
36	$RC = -83.5 + 417.1\ L_{6,7} + 0.31\ H$	0.61	0.001
36	$TC = 1365 + 1625\ L_{1\text{-}9}$	0.57	0.001
36	$RC = 914 + 907\ L_{3\text{-}8}$	0.67	0.001
36	$PC = 768 + 434\ L_{1\text{-}6}$	0.23	0.005

TABLE 6. Correlation of total catch (TC), total catch minus that of *Prochilodus* (RC), *Prochilodus* catch (PC), *Salminus* catch (DOR), *Pseudoplatystoma* catch (SUR), and *Luciopimelodus* catch (PAT) against monthly mean minimum hydrological level in previous years. Analysis was performed for the total period 1945–81 (T, $n=36$), first period 1945–63 (1P, $n=18$), second period 1963–81 (2P, $n=18$) and match position (Year).

Year	TC			RC			PC			DOR	SUR			PAT		
	T	1P	2P	T	1P	2P	T	1P	2P	T	T	1P	2P	T	1P	2P
0	0.23	−0.18	0.23	0.15	−0.35	0.12	0.25	0.02	0.31	0.11	0.12	−0.34	−0.14	0.18	−0.24	−0.10
−1	0.35	0.22	0.27	0.20	−0.30	0.26	0.41	0.50	0.21	0.10	0.21	−0.04	0.02	0.20	−0.23	0.05
−2	0.37	0.11	0.46	0.27	−0.08	0.37	0.36	0.20	0.45	−0.10	0.34	0.35	0.24	0.22	−0.16	0.24
−3	0.38	−0.17	0.67	0.38	−0.06	0.56	0.27	−0.17	0.63	−0.21	0.39	0.26	0.39	0.28	−0.22	0.49
−4	0.32	−0.05	0.45	0.38	0.07	0.48	0.16	−0.11	0.30	−0.20	0.36	0.36	0.26	0.34	0.07	0.44
−5	0.46	0.33	0.47	0.43	0.30	0.40	0.36	0.20	0.44	0.11	0.35	0.44	0.17	0.43	0.38	0.49
−6	0.50	0.27	0.55	0.62	0.63	0.58	0.22	−0.11	0.40	0.43	0.49	0.43	0.49	0.51	0.66	0.49
−7	0.44	0.39	0.32	0.59	0.57	0.52	0.15	0.09	0.02	0.44	0.38	0.22	0.24	0.49	0.55	0.42
−8	0.26	0.49	0.02	0.37	0.46	0.33	0.06	0.34	−0.33	0.16	0.24	0.25	0.16	0.36	0.40	0.30

implemented, be it locally or regionally. For example, one of the points farthest removed from the regression line with exceptionally high catch corresponds to the hydrological year that follows the closing of the *Prochilodus* processing factories during the period 1970–74.

Age classes in the Parana River fishery coincide with maxima in the correlation coefficients observed in the cross-correlation analysis (Table 6) (Anonymous 1958; Oldani and Oliveros 1984). In the period 1978–79 the fishery took mainly 4–6 yr old fish for most species (Oldani and Oliveros 1984); as well, in 1957–58 mean sizes corresponded to older specimens (Anonymous 1958).

The results of the analysis by "species" coincide with those obtained for total catch (Table 6) with maximum relationships for years -6 and -7. *Prochilodus* is an exception for two reasons: (i) the relationship of its catch with L_{min} is lower than for TC, RC and the catch of the other considered "species" and (ii) other maxima occur in years following high values of L_{min}. The analysis of each of the 18 yr subsets (Table 7) approximately coincides with those obtained from the whole data base. For the second period a displacement of the maximum correlation coefficient towards zero year is observed. Once again *Prochilodus* is an exception, in the first period the highest "r" corresponds to the year -1 and in the second period it occurs in the years -2 and -3, although with a more even distribution up to the years -5 and -6. This last observation is also reflected in the analysis of the total catch. The catch of *Salminus*, a top predator, is related to L_{min} as well as to L_{min} for years -6 and -7.

The analysis of the mean catch time series corresponding to the Uruguay and Plata rivers gives similar results to those observed for the Parana River, but the percentage of variation in their respective TC and RC explained by the hydrological regime of the Parana River is noticeably lower. In the Plata River the highest values for RC are displaced towards the years -7 and -10. In the Uruguay River, the relationship of catch with the flood regime of the Parana River is appreciably higher than with its own (Quirós unpubl. data). In the Bermejo River the maximum correlation between TC and hydrological regime of the Parana River is given in the years -3 and -4 and has no relation at all with its own, coinciding with observations of *Prochilodus* in the Pilcomayo River by Bayley (1973).

The joint analysis of catch in the three big rivers, Parana, Uruguay and Plata, presents a similar pattern with maxima in "*r*" for the years -5 and -6 for TC, RC and PC. Relative maxima appear in the years -1 and -2 for TC and PC with L_{mean} but these disappear for L_{min} (Fig. 4). This indicates a relationship between the abundance of *Prochilodus* in the system as a whole in the two years following a big flood and the total amount of water in the floodplain, rather than with the amount of water left in the low water season.

In all the cases the inclusion of the period 1982–84 improves the explained variance in the catch (Fig. 5). In this period exceptionally high maximum and minimum hydrological levels in the Parana River coincided with a noticeable increase in the catch of *Prochilodus*.

Information from the catch and effort studies undertaken in the Rosario (13) zone during the hydrological year 1957–58 (Anonymous 1958) indicates that as hydrological level increases, total fish abundance on the floodplain increases and decreases in the main channel (Fig. 6). This pattern is mainly due to the abundance of *Prochilodus*. This result is repeated for the main channel in studies of catch and effort of the commercial fishery undertaken at the lati-

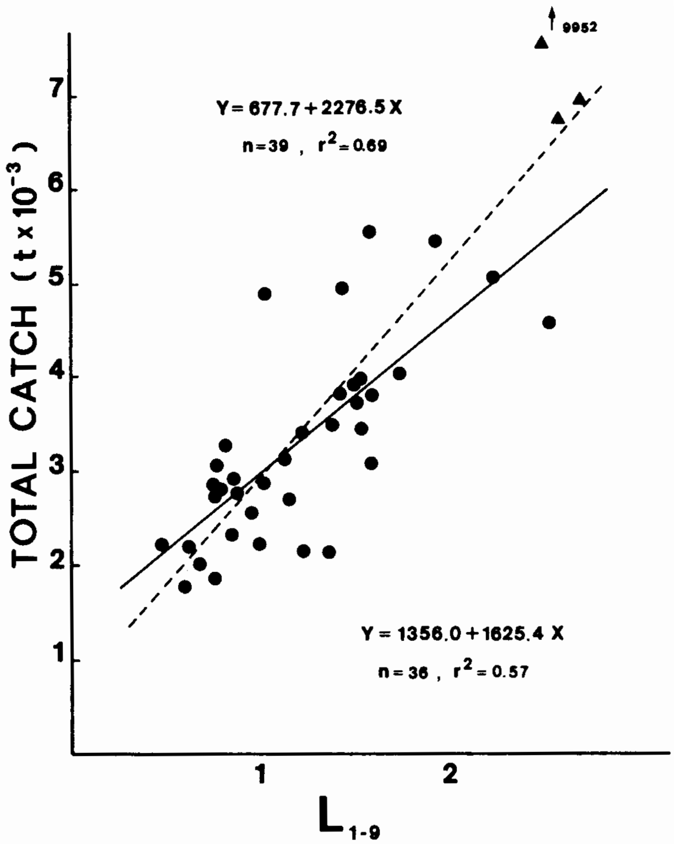

FIG. 4. Time lagged correlation of the mean annual total catch (TC) time series in the Paraná, Uruguay and Plata rivers against the mean annual (●) and monthly mean minimum (▲) hydrological level time series. Time-lagged correlation coefficient versus match position.

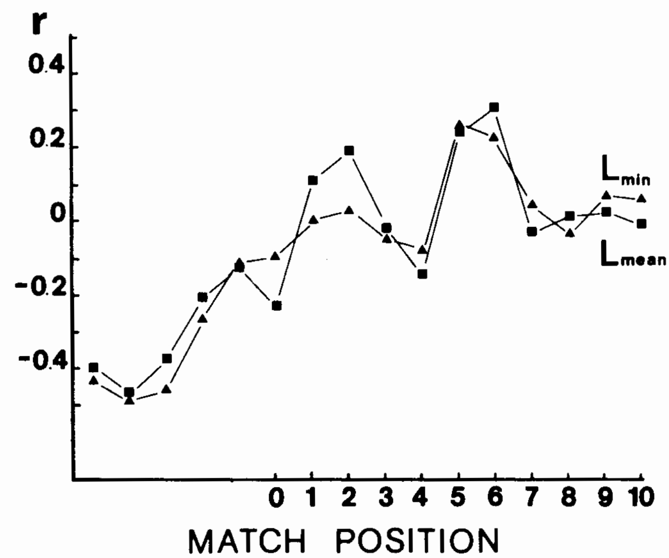

FIG. 5. Paraná River. Regression of total catch (TC) against monthly mean minimum hydrological level within the period that goes from 1 to 9 years previous to the year of the catch (L_{1-9}). (■) years 1945–81, (▲) years 1982–84.

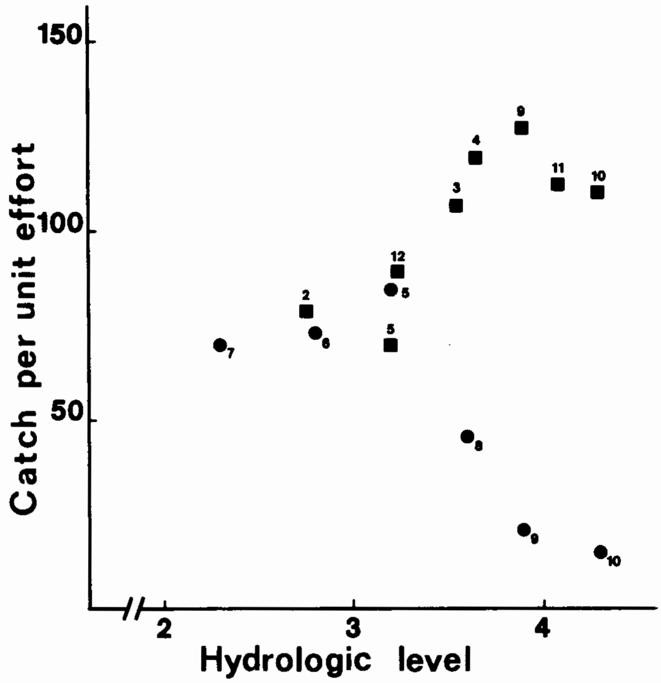

FIG. 6. Paraná River at Rosario (13). Catch per unit effort against monthly mean hydrological level at Rosario (13), 1957–58 hydrological year. (●) main channel catch, (■) floodplain lagoons catch.

TABLE 8. *Prochilodus* frequency recaptured during 6 months after tagging in the Lower Plata River Basin. Upstream (↑) and downstream (↓) main channel migration, upstream, (→) and downstream (←) movement and recapture in the plain, local movement (← →).

Month	Tagging Place	Migration or movement ↑	↓	←	→	← →
1	middle Paraná plain[c]	—	—	0.29	—	0.71
3	middle Paraná plain[b]	—	—	0.24	0.22	0.54
	middle Paraná plain[b]	—	—	1.00	—	—
4	Plata River (2)[a]	1.00	—	—	—	—
5	main channel (27)[a]	0.80	—	—	—	0.20
6	middle Paraná plain[b]	—	0.22	—	0.63	0.15
7	middle Paraná plain[a]	—	0.44	—	0.13	0.43
	middle Paraná plain[a]	—	0.20	—	0.05	0.75
8	middle Paraná plain[a]	—	0.20	—	0.05	0.75
	main channel (18)[c]	0.06	0.47	—	—	0.47
9	middle Paraná plain[a]	—	0.20	—	0.05	0.75
	middle Paraná plain[b]	—	—	0.24	0.22	0.54
	main channel (18)[c]	0.06	0.47	—	—	0.47
	main channel (31)[a]	0.29	0.12	—	—	0.58
10	Plata River (2)[a]	0.60	—	—	—	0.40
11	Plata River (2)[a]	0.60	—	—	—	0.40
12	Middle Paraná plain[b]	—	—	1.00	—	—

[a] Bonetto and Pignalberi (1964).
[b] Bonetto et al. (1971).
[c] Espinach et al. (1982).

tude of Parana City (18) in the period 1967–77 (Oldani and Oliveros 1984) and in studies of experimental fishing during the period 1978–80 (Virasoro unpubl. data). Other species comprise less than 50 % of the catch and do not show such defined behaviour with regard to the floodplain. Their abundance both in the main channel and in the floodplain appears linked to movements along the principal axis of the river (Quirós unpubl. data).

The analysis of commercial catches during the period 1961–81 in the Parana River from the Delta up to the north of the axis Parana–Santa Fe (18–19) gives similar results to those described for catch per unit effort. The distribution of catch of *Prochilodus* at fish landings of the middle and lower Parana follows a similar pattern (Fig. 7); catch maxima are in the periods of falling and low waters and decrease as the hydrological level increases. Minimum catches are obtained during rising high waters and at peak flood. This pattern coincides with the migration pattern reported for *Prochilodus* (Table 8). Tagged fish moved out of the middle Parana in the period of low water and rising low water and returned at falling high water from the Plata River. The catch pattern at all of these fish landings followed that of a fishery on main and secondary channels and not on floodplain lagoons (Fig. 7). Landings in the Parana Delta followed the same pattern almost to the mouth near the Plata River (Tigre, 5). For the rest of the catch, maxima seem to depend on movements of fish along the main axis of the river in response to flood and possibly thermal regimes (Quirós unpubl. data).

Catch patterns for *Prochilodus* in the middle Plata River (Quilmes, 2) are opposite to those for the middle Parana River and its delta (Fig. 8). The catch increases in October but then begins to decline in March (Bonetto 1963; Bonetto and Pignalberi 1964). Its pattern of variation is similar to that for floodplain lagoons (Fig. 6) (Anonymous 1958). The catch north of the mouth of the Parana on the lower Uruguay River (Gualeguaychú, 48) varied like that for the middle Plata River (Quilmes, 2). However, in the Uruguay River the period of high catch may last longer.

Temperature is the principal factor determining the disappearance of big shoals of *Prochilodus* from the Plata River in winter (Bonetto 1963). Catches in the middle Plata River (Quilmes, 2) are positively related with mean monthly air temperature (Fig. 9). However, catches at the mouth of the Parana Delta (Tigre, 5) at a fish landing scarcely 50 km north of Quilmes (2) are negatively related to temperature (Fig. 9). Catches at fish landings of the Parana Delta and the middle Parana correlate negatively with temperature; however, on the lower Uruguay River (Gualeguaychú, 48) catches of *Prochilodus* present a positive relationship with temperature similar to that of middle Plata River. Migrations of *Prochilodus* seem to be linked more to the flood regime of the Parana River, although we cannot reject the effect of temperature.

Changes in catches for the rest of the species in the middle Parana River and its delta seem to be more closely linked to their migrations along the main axis of the river (Quirós unpubl. data). Nevertheless, as in the middle Plata River, they follow similar patterns to those of catches of *Prochilodus*. Catches in the lower (Gualeguaychú, 48) and middle (Colón, 50) Uruguay River do not present a defined relationship with temperature.

Catch and Fish Movements

The results of fish tagging in the lower Plata Basin were analyzed in terms of the principal axis of the river, without attention to fish movements to and from the floodplain. Patterns of recaptures (Bonetto et al. 1971; Bonetto and Pignalberi 1964; Espinach Ros et al. 1982) of *Prochilodus* specimens tagged on the floodplain suggest that *Prochilodus*

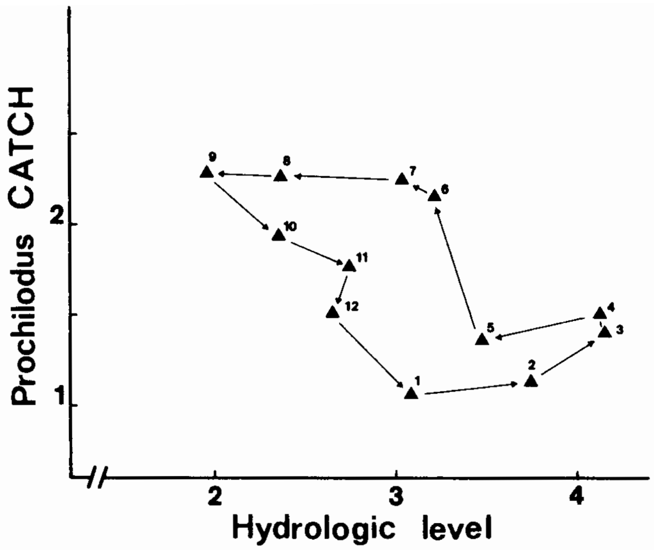

FIG. 7. Paraná River at Puerto Gaboto (16). *Prochilodus* catch ($t \cdot 10^{-1}$) against monthly mean hydrological level at Santa Fe (19). Numbers indicate month of the year.

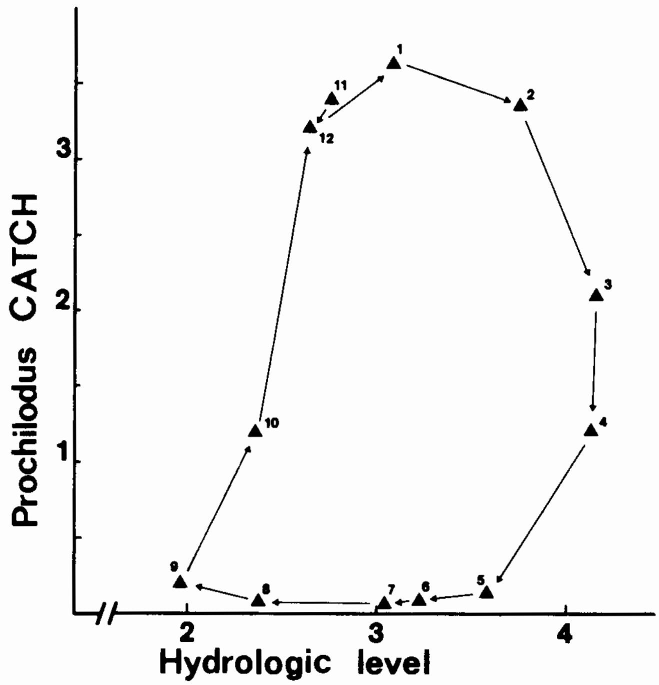

FIG. 8. Plata River at Quilmes (2). *Prochilodus* catch ($t \cdot 10^{-2}$) against monthly mean hydrological level at Santa Fe (1). Numbers indicate month of the year.

migrates downstream along the main channel only at falling water or low rising water, south of the Santa Fe–Parana (18–19) axis (Table 8) (Poddubnyi et al. 1981). Movements reported as upstream migrations for fish initially caught on the floodplain in lagoons or secondary channels are short movements either along the channel with reentries to the floodplain or along tributaries and secondary channels of the floodplain. A great proportion of tagged *Prochilodus* showed no movement and were recaptured near the tagging site at all stages of the hydrological cycle (Table 8). Recaptures in the channel downstream were made in months of

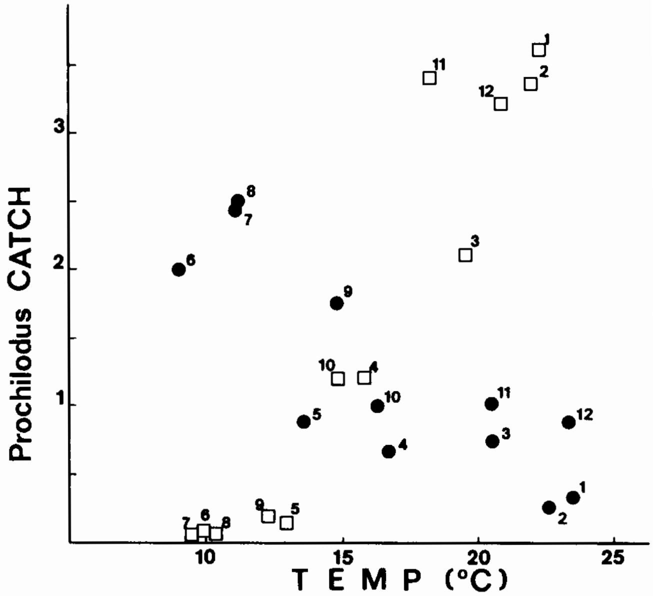

FIG. 9. *Prochilodus* catch against monthly mean air temperature. (□, $t \cdot 10^{-2}$) Plata River at Quilmes (2). (●, $t \cdot 10^{-1}$) Paraná River Delta at Tigre (5). Numbers indicate month of the year.

low rising water when fishermen reported fish entering the trammel nets "from above", that is in the direction of the current; at the same time catches increased in the Plata River (Fig. 8).

General Conclusions

The exploitation level of fish in the whole system is low with the lower Plata River Basin fishery fundamentally based on the capture of large specimens of *Prochilodus* and other big migrators. As in other rivers with extensive floodplains (Welcomme 1979, 1985, 1986), catches depend on flooding intensity and on the amount of water remaining in the system during the low water season in the years in which the age classes taken by the fishery were born. As noted earlier, the magnitude of the high water phase affects the size of stocks through improved reproduction, survival and growth of the fish; the minimum water level affects natural survival and ease of capture during the low water phase (Welcomme 1975, 1986; Welcomme and Hagborg 1977). In the middle Parana floodplain, total catches are related both to high and low water phases, but the relationships appear stronger with the latter. Of fish taken by the fishery, *Prochilodus* appears to be the species most directly dependent on the floodplain. *Prochilodus* catches seem to be more directly related to the amount of water remaining in the floodplain in the years immediately preceding the catch and to the strength of low and high water phases 4 or 5 yr previously. A direct effect might be massive mortalities of fish being trapped in drying floodplain pools in the low water season (Bonetto 1975). The remaining species appear to be affected most by flood levels 5–7 yr previous to the catch. Others are affected by the low water phase and at least one does not show any difference in relation to the low and high water phases. For the system as a whole, catch is related to the amount of water both in high and low water phases in years fish were hatched. Moreover catch could also be related to the magnitude of the high water phase in the two preceding years.

Both the catch-per-unit-effort and the proportion of *Prochilodus* in the catch increase towards the Plata River. The relative abundance of *Prochilodus* along the principal axis of the river appears to be inversely related to the proportion of backswamp in the floodplain. In floodplain lagoons and swamps, the proportion of *Prochilodus* is very high and is practically the only migratory species present, with the exception of some young specimens of other species (Bonetto et al. 1969a; Bonetto et al. 1971; Cordiviola de Yuan and Pignalberi 1981).

The temporal structure of the system is fundamentally linked to the flood regime. The influence of the climatic regime seems to be far less important. Phytoplankton production and biomass in the main channel are maximal at low water. In lagoons phytoplankton production and biomass are maximal during the summer but abruptly decrease with the inflow of the sediment laden flood water towards the end of the season (Perotti de Jorda 1977). Macrophyte production in floodplain lagoons starts to increase towards the end of the spring and reaches a maximum in autumn with high waters and then begins its decay (Lallana 1980). In lagoons and shallow marshes towards the end of the spring and beginning of the summer part of the aquatic and interphase vegetation dies producing an enrichment of organic matter. When water starts falling it washes dissolved and particulate organic matter and vegetation debris at different stages of decay towards certain secondary channels, streams and the main channel (Neiff 1978). Floating plant masses can reach the Plata River (Bonetto 1975).

The whole system appears to be spatially structured according to the main axis of the river and follows a second physical axis perpendicular to the first. There appears to be an increase of nutrients, zooplankton, benthos, fish and organic matter (both in the water column and bottom sediments) in the main channel from the upper Parana towards the Plata River. Phytoplankton primary production increases in the same direction in the main channel. From the main channel towards the secondary channels and streams, the mouths of the tributaries and the floodplain lagoons there is an increase in phytoplankton, zooplankton, benthos and fish biomasses as well as in total nutrients and organic matter in the water column and in bottom sediments. Fish biomass in floodplain lagoons appears to increase moving from those most influenced by the main channel to those located in the distal margin of the floodplain. Phytoplankton primary production increases from the main channel toward floodplain lagoons, although net primary production seems to be of little importance compared to that of macrophytes, the importance of which appears to increase towards the distal margin of the floodplain (Bayo et al. 1981). Macrophyte production is the main energy source of the system and its production and decay cycles control the whole secondary production of the system and those of fish in particular (Bonetto 1975; Welcomme 1979; FAO 1980; Bayley 1981; Chapman 1981; Quirós and Baigún 1985).

The spatial structure of the system reinforces previously established relationships between organic matter levels in the water column and fish abundance in the lower Plata Basin (Quirós and Baigún 1985). Both in the main channel and in the floodplain the total biomass of heterotrophs (Table 3) increases in the same direction as total nutrient levels in the water and organic matter in the water and bottom sediments.

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Appendix. Catch frequencies by species and landing sites in the lower Plata Basin.

		ARM	ANCH	BGTO	BOGA	BAMAR	DOR	MAND	MANG	MONCH	PAT	PEJ	PIRA	PACU	SAB	SUR	TAR	TOTAL
1.	Cambaceres	–	–	0.03	0.00	–	0.58	–	–	0.00	1.67	0.64	–	–	97.07	0.00	–	733.27
2.	Quilmes	–	–	0.01	0.02	–	0.44	–	–	–	0.94	0.59	–	–	97.95	0.05	0.00	1707.47
3.	Boca – Riachuelo	–	0.01	0.65	5.87	–	3.00	–	–	–	18.29	15.81	–	–	56.38	0.00	–	261.58
4.	San Fernando	0.15	5.87	5.49	7.20	0.11	7.42	–	–	–	10.42	3.84	–	–	57.31	0.37	1.82	149.63
5.	Tigre	0.01	6.86	1.01	8.57	–	3.83	–	–	–	11.11	5.01	–	–	58.52	1.55	3.36	136.82
6.	Campana	19.64	–	29.15	5.26	–	0.81	2.83	–	–	26.32	2.23	–	–	–	12.75	1.01	4.94
7.	Zarate	6.56	10.71	36.38	2.24	1.10	1.33	–	–	0.16	14.15	5.91	–	0.03	13.27	7.79	0.36	30.81
8.	Baradero	0.52	0.05	20.71	0.26	–	4.63	0.01	–	–	13.47	1.20	–	–	39.59	18.78	0.78	19.22
9.	San Pedro	0.34	10.14	15.08	7.60	–	7.86	0.27	–	–	19.96	2.64	–	–	20.92	8.44	6.75	99.68
10.	Ramallo	6.05	0.03	3.28	5.31	10.80	0.61	1.41	–	13.38	16.90	1.23	–	–	23.49	12.09	5.41	97.81
11.	San Nicolás	9.67	–	1.01	11.71	2.70	2.52	–	–	13.55	14.64	3.93	–	–	24.70	11.65	3.93	72.60
12.	Vá. Constitución	3.47	0.15	2.30	8.51	9.19	0.80	0.52	–	1.49	22.12	0.40	–	0.05	26.46	17.77	6.76	261.67
13.	Rosario	9.97	0.65	1.62	10.37	1.33	4.22	0.18	–	2.69	11.31	0.06	–	0.10	42.75	14.64	0.10	478.18
14.	San Lorenzo	1.72	–	14.44	10.98	–	–	–	–	0.64	12.89	0.02	–	0.08	39.72	18.06	1.45	542.46
15.	Victoria	–	–	1.36	–	0.03	0.35	–	–	–	0.37	0.12	–	0.00	95.27	2.50	–	508.19
16.	Gaboto	2.03	–	8.30	7.21	1.04	3.01	0.01	–	2.56	12.81	0.39	–	0.10	43.07	18.22	1.35	488.92
17.	Diamante	3.43	–	–	2.44	3.15	0.01	1.87	0.04	3.31	5.95	0.67	–	1.43	61.73	15.97	–	163.88
18.	Paraná	15.82	–	2.37	6.62	11.68	0.25	3.35	–	12.02	11.24	–	–	0.97	21.62	14.06	–	166.77
19.	Santa Fé Coronda	0.09	–	0.01	0.47	2.75	0.05	1.09	–	10.46	16.43	–	–	11.44	25.62	31.59	–	161.12
20.	Hernandarias	–	–	–	–	–	–	–	–	1.79	23.49	–	–	12.75	29.08	32.89	–	4.47
21.	Helvecia	2.51	–	–	6.17	1.16	4.60	–	–	7.57	15.24	0.08	–	4.88	37.21	20.33	0.15	296.47
22.	Santa Elena	–	–	–	–	0.33	4.91	–	–	4.17	41.46	–	0.16	1.14	24.78	22.73	–	12.23
23.	La Paz	–	–	–	–	–	1.55	–	–	0.90	20.53	–	–	11.58	8.68	56.76	–	28.93
24.	Esquina	1.90	–	0.22	0.02	–	–	0.28	–	0.67	18.11	–	0.02	21.08	8.55	49.14	–	17.89
25.	Reconquista	–	–	–	–	–	3.94	0.06	–	3.88	15.75	–	–	4.05	10.74	61.58	–	34.80
26.	Goya	0.60	–	–	–	–	–	0.01	0.02	0.36	13.60	–	–	8.87	4.13	72.40	–	8.23
27.	Bella Vista	2.14	0.34	0.17	0.28	0.20	0.21	–	1.95	0.08	11.46	0.28	–	7.60	4.59	70.70	–	107.04
28.	Empedrado	–	–	–	4.24	–	–	–	14.05	–	7.12	–	–	7.29	13.52	53.77	–	63.47
29.	Barranqueras	0.01	–	–	0.27	–	–	0.01	3.88	0.52	14.23	–	–	5.89	1.51	73.69	0.51	153.23
30.	Corrientes	6.90	–	1.31	0.65	–	0.00	0.21	5.95	1.35	10.10	–	0.08	6.99	3.70	62.75	–	156.05
31.	Po. de la Patria	–	–	–	–	–	–	–	23.82	–	12.43	–	–	16.59	–	47.15	–	36.52
32.	Itatí	–	–	–	–	–	–	–	0.39	–	11.63	–	–	11.24	3.49	73.26	–	2.58
33.	Yahapé	–	–	4.07	0.45	–	0.23	–	3.39	–	8.60	–	–	7.92	69.46	5.88	–	4.42
34.	Ita Ibaté	1.20	–	–	–	–	–	–	–	–	3.41	–	–	7.13	45.22	43.05	–	4.24
35.	Ituzaingó	5.22	–	–	–	–	–	2.17	–	–	9.13	–	–	37.83	24.35	21.30	–	2.30
36.	Posadas	8.44	–	8.44	–	–	–	0.41	1.93	–	5.62	–	3.34	9.14	53.66	9.02	–	17.07
37.	Santa Ana	6.03	–	3.90	4.45	1.02	1.07	2.91	3.83	–	3.16	–	17.22	5.78	33.57	19.28	–	20.51
38.	Pto. Maní	14.88	–	1.78	2.05	1.25	0.04	1.06	29.27	–	5.67	–	3.71	9.50	22.44	8.76	–	2.16
39.	Pto. Mineral	13.64	–	2.65	–	–	–	–	–	–	1.14	–	4.55	26.14	31.82	20.08	–	2.64
40.	L.G. San Martín	6.69	–	4.67	3.59	0.78	1.32	0.90	9.50	0.22	1.98	–	7.42	22.81	30.38	9.93	–	14.89
41.	El Dorado	5.02	–	2.51	–	0.04	–	0.04	14.48	–	1.66	–	4.39	17.97	4.75	49.13	–	22.31
42.	Pto. Libertad	–	–	–	–	–	–	–	10.34	–	–	–	10.34	37.93	–	41.38	–	0.58
43.	Pto. Iguazú	1.85	–	4.32	–	–	–	0.12	12.95	–	3.08	–	17.26	14.80	4.93	40.69	0.25	1.62
44.	Bermejo	0.04	–	–	–	–	–	–	11.33	–	31.54	–	–	7.11	–	49.98	–	4.50
45.	Formoso	5.05	–	0.07	1.16	–	–	–	0.75	0.27	15.77	–	0.34	4.57	0.27	71.74	–	14.65
46.	Pilcomayo-Bouvier	–	–	–	–	–	–	–	4.36	–	13.43	–	–	6.79	–	75.42	–	44.02
47.	Río Bermejo	–	–	–	–	–	–	–	20.65	–	6.40	–	–	7.35	28.40	37.19	–	214.38
48.	Gualeguaychú	–	–	5.91	0.00	–	0.02	–	–	–	0.14	0.04	–	–	99.69	0.06	0.00	2249.71
49.	Concep. del Uruguay	–	–	34.70	0.68	–	7.53	1.37	–	–	27.17	2.28	–	–	4.57	4.57	16.44	4.38
50.	Colón	–	–	33.07	5.47	–	2.02	–	–	–	20.60	3.85	2.25	–	8.45	22.89	1.40	101.43
51.	Concordia	5.10	–	56.86	6.27	–	0.39	3.14	0.39	0.39	21.57	1.96	0.39	–	–	3.53	–	2.55
52.	Santo Tomé	13.51	–	27.56	16.21	–	2.16	5.94	1.62	–	16.75	–	0.54	–	0.03	15.67	–	1.85
53.	San Javier	–	–	12.75	11.41	–	2.01	17.45	2.01	–	–	–	12.08	–	34.90	6.71	0.67	1.49
54.	El Soberbio	3.09	–	3.09	17.53	–	8.25	12.37	1.03	–	–	–	4.12	–	37.11	13.40	–	0.97