The fishery and fishery yield of *Hypophthalmus edentatus* (Spix,1829), (Siluriformes, Hypophthalmidae), in the Itaipu reservoir, Paraná state, Brazil

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RESUMO: A pesca e o rendimento pesqueiro de *Hypophthalmus edentatus* (Spix, 1829), (Siluriformes, Hypophthalmidae) do Reservatório de Itaipu – PR, Brasil. Os dados sobre rendimento anual e esforço de pesca aplicado na captura de *Hypophthalmus edentatus*, utilizados neste estudo, são oriundos da pesca artesanal do Reservatório de Itaipu, no período de 1987-1993 e de 1995-1998. Os aspectos histórico, estrutural e funcional da pesca, foram descritos em trabalhos anteriores. Os dados registraram uma queda sensível no rendimento de *H. edentatus* a partir do ano de 1995, com os menores valores encontrados em 1998 (154 tons) e os maiores em 1991 (515,3 tons), sendo que o mesmo ocorreu para os valores de CPUE (Kg/pescador.dias de pesca). O esforço aplicado na pesca (dias de pesca), foi maior no ano de 1993 (75890), mantendo-se constante a partir deste. O menor valor foi registrado em 1987 (42000). O ajuste do modelo de Schaeffer, utilizando procedimento não linear, mostrou um rendimento máximo sustentável (RMS) de cerca de 395 tons/ano, para um esforço ótimo de 66500 pescador.dias^{-1} de pesca. Problemas na reprodução, diminuição na disponibilidade de alimento, predação e a sobrepesca, parecem estar relacionados com o decréscimo do rendimento de *H. edentatus*. Entretanto, fatores tais como "blooms" de algas (*Mycrocistis sp*) e utilização de redes com malhas de menor tamanho (70mm) na pesca, talvez tenham também contribuído para a queda do rendimento. Uma avaliação mais profunda se faz necessária pois, os fatores que afetaram o rendimento de *H. edentatus* podem ter efeito multiplicativos com interações relevantes.

Palavras-chaves: rendimento, CPUE, esforço de pesca, rendimento máximo sustentável.

ABSTRACT: The fishery and fishery yield of *Hypophthalmus edentatus* (Spix, 1829), (Siluriformes, Hypophthalmidae) in the Itaipu Reservoir, Paraná state, Brazil. Artisanal fisheries conducted in the Itaipu Reservoir were surveyed from 1987-1993 and 1995-1998 to obtain information on landings (yield) and fishing effort used to catch *Hypophthalmus edentatus*. Historical, structural and functional aspects of the *H. edentatus* fishery were obtained previoushy. Yield and CPUE (kg/fish.day) of *H. edentatus* decreased after 1995. The lowest yield value was observed in 1998 (154 tons) and the highest in 1991 (515.3 tons). The effort applied (fishing days) was highest in 1993 (75,890). The lowest vale was registered in 1987 (42,000). The Schaeffer model, adjusted by nonlinear procedure, estimated the maximum sustainable yield (MSY) near 395 tons/year and optimum effort of 66,500 fisherman x fishing days^{-1}. Factors like failures in spawning, decline in food supply, predation and overfishing seem to related to the decrease in yield of *H. edentatus*. Nevertheless, factors such as algae blooms (*Mycrocistis sp.*) and use of small gillnet meshes (70mm) in the fishery may also have contributed to the decrease in yield. Another complete evaluation may be necessary because the factors that affect the yield of *H. edentatus* may have multiplicative effects with possible interactions.

Key words: yield, CPUE, fishery effort,maximum sustainable yield.

Introduction

The distribution of *Hypophthalmus edentatus* (spix, 1989) involves the Amazonas, Orinoco and Plata basins. Before the construction of the Itaipu Reservoir in the Paraná River, it was restricted to the lower stretch of the former Saltos de Sete Quedas. It currently occupies the upper segment.

The available data about fish landings before the formation of the Itaipu Reservoir does not record this species in commercial exploitation, possibly because of its low abundance in the lotic waters of the Paraná River, as demonstrated by the experimental fishery previously carried out, when only three individuals were caught during two years of sampling (Agostinho et al., 1994a). One year after the formation of the reservoir, it became the main species in the commercial fishery (Cecílio & Agostinho, 1999). Its economic exploitation began in 1986, four years after the formation of the reservoir, when artisanal fishery restrictions in the reservoir were lifted. It was the species with the highest contribution in landings from 1987 to 1993, falling to third place in 1998 (Petrere et al., in press). Thus, for almost 10 years, it had an important role in the economy of a social segment composed of essentially families excluded from other economic activities, both by the new agrarian model that was implanted with the wheat-soy culture and by reductions in the size of the rural establishments resulting from the Itaipu flooding (Agostinho et al., 1999).

The proliferation of the *H. edentatus* in the new environment reflected the conditions of food availability caused by the damming and the best adaptation of the species in using the pelagic zone, little exploited by the other species. Among the intrinsic characteristics of the species, which favors a pelagic life, high concentration of lipids in the musculature (Oliveira, 2000), low head with large lateral eyes (Freire & Agostinho 2000 a,b), pelagic eggs and larvae (Nakatani et al., 1999) and multiple spawns, which can be separated by more or less long periods (Suzuki, 1992 and Benedito-Cecilio et al., 1997), stand out. In addition, they present daily vertical migrations associate with feeding and flight from predators. Their concentration at the surface is high at night (Agostinho et al., 1994a).

However, the results of the experimental fishery carried out more recently in the Itaipu Reservoir (Itaipu Binacional, 1999) point key to depletion in the stocks of this species, with disastrous consequences for the subsistence of a large number of people.

The annual variations in the yield of this species in artisanal fisheries and possible factors related to them, with emphasis on those connected to recruitment and fishing effort, were evaluated in this study.

Material and Methods

Study area

The Itaipu Reservoir (24005'-25033'S, 54000'-54037'W), closed in 1982, has an area of about 1,350 km² and is intended for the production of electricity. Located in the Paraná River on the Brazil-Paraguay border, it presents an average depth of 21m and a maximum depth of 170m. Water renewal time is 40 days and the flow about 8,200 m^3s^{-1}. It has a maximum length of 170km and presents a well-defined longitudinal gradient, in which fluvial, transition and lacustrine zones characterized by Thorton (1990) and Agostinho et al. (1995a,b) can be identified.

Data collection and analysis

Data referring to the annual catches and the effort applied in the *H. edentatus* (Spix, 1829) (Siluriformes, Hypophthalmidae) fishery were obtained by accompanying the commercial catches carried out in the Itaipu Reservoir from 1987 to 1998, with an interruption in 1994. The sampling plan includes a network of daily collection information on forms designed by the fishermen-samplers themselves, who were distributed along the reservoir. The samplers had the task of revising the forms for the other fishermen, directing their completion and carrying out their collection. They contained information about the fishing yield of each fisherman per day. The catch per unit of effort (CPUE) used was biomass caught (kg)/fisherman x fishing day. CPUE was used because it be estimated from representative sample of the fisherman, and it's obtained by the division of the total catch (C, portion of the population that is removed from the system), and effort employed in the fishing (f) (Ney, 1993). In addition, a random sampling of some fishermen, whose fish were measured (standard length in cm) and maturation stage determined, was carried out.

Yield values were plotted graphically, together with effort, in an attempt to obtain a model that describes the relationship between the two variables. This relationship is know as yield curve, very important to stock exploitation (Santos, 1978). The most adequate was Schaefer model, described by the equation $C = af - bf^2$ (Ricker, 1975), where a and b are the coefficients of the relation. Schaeffer's model allows attainment of maximum sustainable yield ($MSY = a^2/4b$) and optimum effort ($OE = a/2b$).These parameters can be estimated directy from the relation of equilibrium yield to equilibrium effort without knowing the catchability of fish. When the size of stock is under equilibrium conditions, the instantaneous rate of surplus production (recruitment plus growth less natural mortality) of a stock is directly proportional to its biomass and also to the difference betweem the actual biomass and maximum biomass the area will support. In this case equilibrium conditions surplus production is a parabolic function (Ricker, 1975). So maximum sustainable yield (MSY) and optimum effort (OE), can be used as a reference in evaluating stock exploitation status (Ricker, 1975). A nonlinear procedure (PROC NLIN, SAS Institute Inc., 1996) was used to adjust the Schaeffer's model. Data up to 1995 not were used for this analysis because after this year there was an alteration in the net mesh used in catching H. edentatus.

The temporal variations in the factors that could lead to the depletion of the species stocks in the Itaipu Reservoir were investigated.

Among the biotic factors evaluated were:

(i) species diet (1983-88=Lansac-Tôha et al., 1991; 1994-97=Abujanra, in preparation) and density of the zooplankton, which serves as food (1987=SUREHMA-ITAIPU BINACIONAL, 1988; 1997=SEMA-ITAIPU BINACIONAL, 1998).

(ii)annual frequency of stages indicative of reproductive activity (reproduction = mature + semi-spent), based on the analysis of females caught in artisanal fisheries along the reservoir from January to April and from August to December of each year.

(iii) Larval density of the species in areas of high occurrence, in the transition zone of the reservoir, in the vicinity of the São Francisco Falso River (1988-90=Nakatani, 1994; 1997-98=Cavichiolli, 2000).

(iv) The variations in the catch per unit of effort of the *H. edentatus* and its main predator, the "curvina", *Plagioscion squamosissimus* (Hahn et al., 1998; Cavicchiolli, 2000) were analyzed from the landing data of artisanal fisheries.

The Schaeffer's model (King, 1995) was used too, in an attempt to determine if overfishing had caused depletion in the catch per unit of effort for *H. edentatus* in Itaipu Reservoir during the period analyzed. Only yield and effort data until 1995 were used for this model because of alterations in the minimum allowed mesh in 1996. Additionally, variations in the average catch size and the catch of juveniles were evaluated as indicators of overfishing.

Results

The fishery

The fishery of *Hypophthalmus edentatus* in the Itaipu Reservoir was begun soon after the lifting of the artisanal fishery there (1986). It was carried out with gillnets, initially with the minimum allowed mesh, that is to say, 8.0cm stretch. With the observation that the stock is concentrated on the subsurface (Agostinho et al., 1994a) and that the use of 7.0cm-mesh nets was more efficient, this strategy was used starting from 1988. The legalization of this procedure, however, came only in 1993 (Brasil, 1993). However, with the decrease in yield and under the allegation that the use of gillnets on the surface brought about thefts, the fishermen began to conduct this type of fishing on the bottom and on the banks, leading to massive mortality of juveniles of other species. This fact caused the Fishing Colonies to establish a Protocol of Intentions prohibiting the use of 7.0cm meshes starting from 1996. Starting from 1998, in addition to the minimum mesh size change, the fishery in the Itaipu Reservoir started to be regulated by limitations in the issue of licenses and fishery bans during the reproduction period (October to February). (Agostinho et al., 1999).

In 1987, a year after the beginning of the exploitation of the "perna-de-moça" stocks, the catches of this species were relatively low considering the recent character of this exploitation. On the other hand, in 1988 and in subsequent years, it was verified as the main species caught, with landings always above 350 tons (Fig. 1). Starting from 1995, the yield of this species fell, reaching only 154 tons in 1998. Since the fishing had not been monitored the year before, the fall in yield may have begun in 1994.

The effort applied to catch the species during the period was low in the first year of monitoring (42,000 fishing days), rising gradually until 1993, when it reached its highest

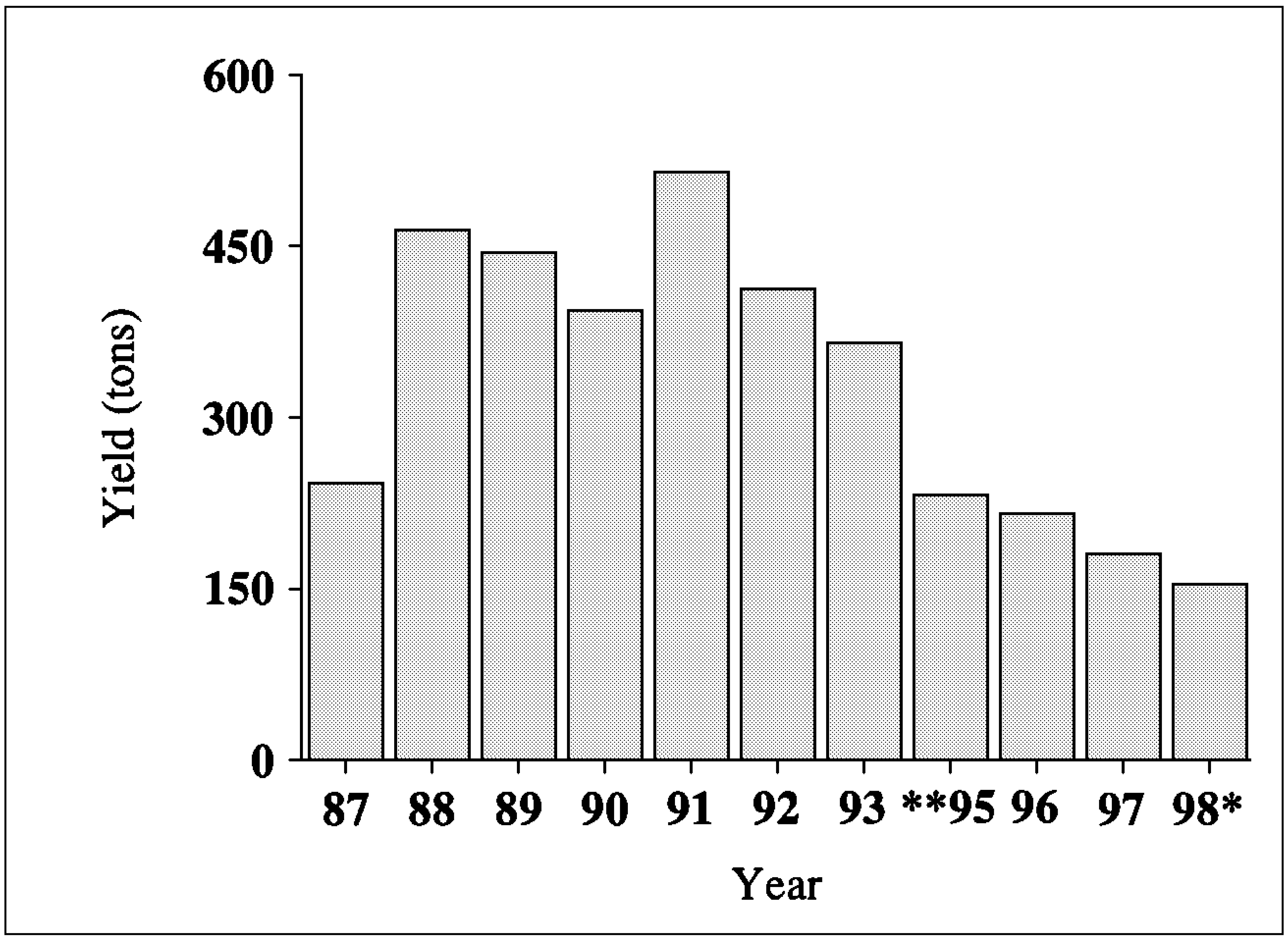

Figure 1: Variation in annual commercial fishery catch of the *H. edentatus* in the Itaipu Reservoir.
* The fishery ban during spawning (October-December 1997 and January-February 1998).
** Samplers interruption in 1994.

value (75,890 fishing days) (Fig. 2). In the years that followed, the effort used showed a slight decrease, with minimum values in the last (1998), when the regulations prohibiting the fishery in october to february were introduced.

Catch per unit of effort was shown high in 1988, when it reached 8.5 kg/fisherman.day (Fig. 2). The values rose until 1992 (>6.0), presenting a sharp fall between 1993 and 1995 (4.8 and 3.2, respectively) and stayed low in the subsequent years (3.2 to 2.6).

Fishing effort also showed marked spatial variation, being high in intermediary areas (transition zone) during the entire period (Fig. 3). Catch per unit of effort, which also was high in the transition zone in the first years, fell sharply starting from 1993, equaling the others.

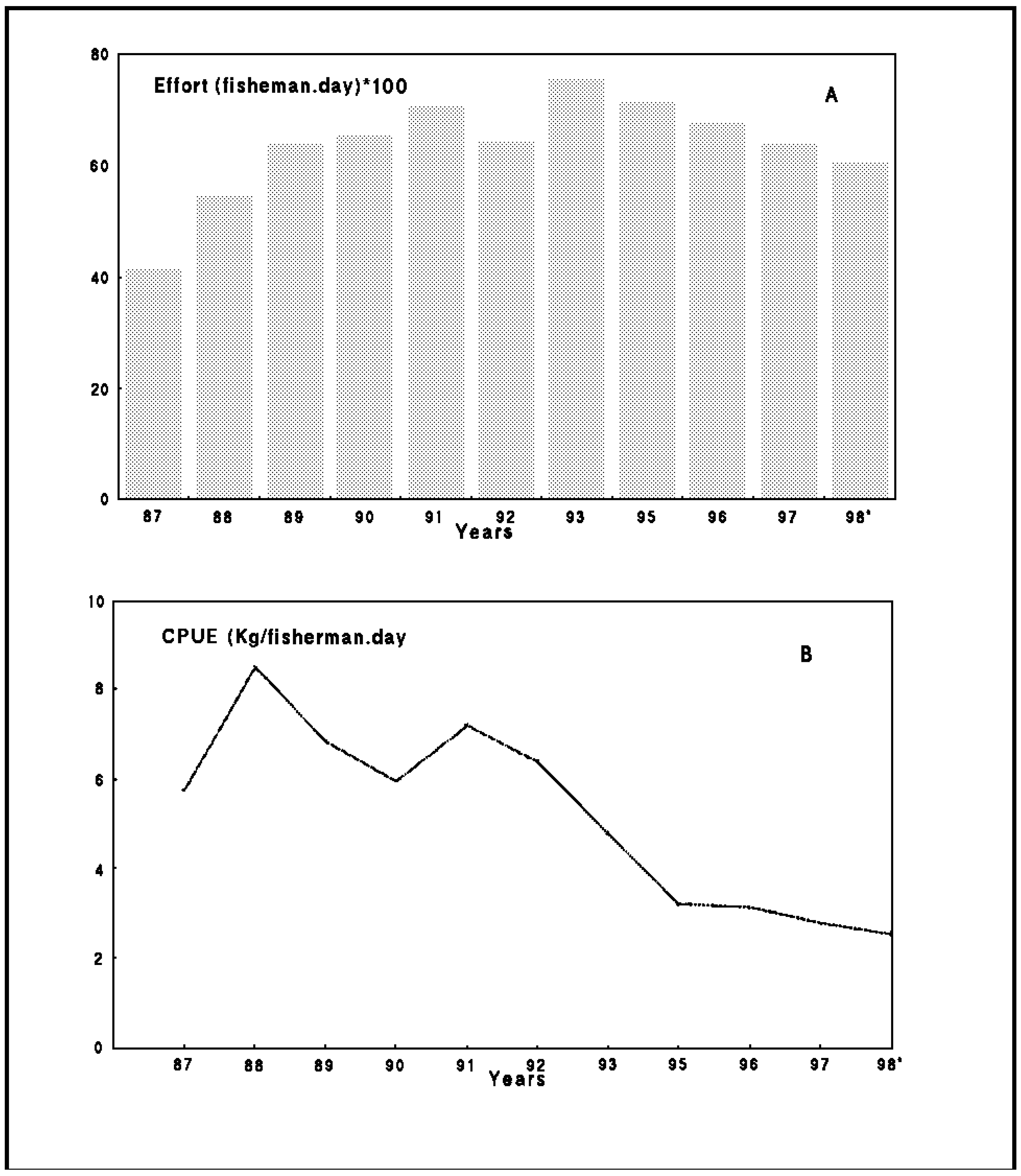

Figure 2: Annual variations in effort (fisherman.day) (A) and in the catch of the *H. edentatus* per unit of effort (kg/fisherman.day) (B) in the artisanal fishery in the Itaipu Reservoir from 1987-1998. * The fishery ban during spawning (October-December 1997 and January-February 1998). ** Samplers interruption in 1994.

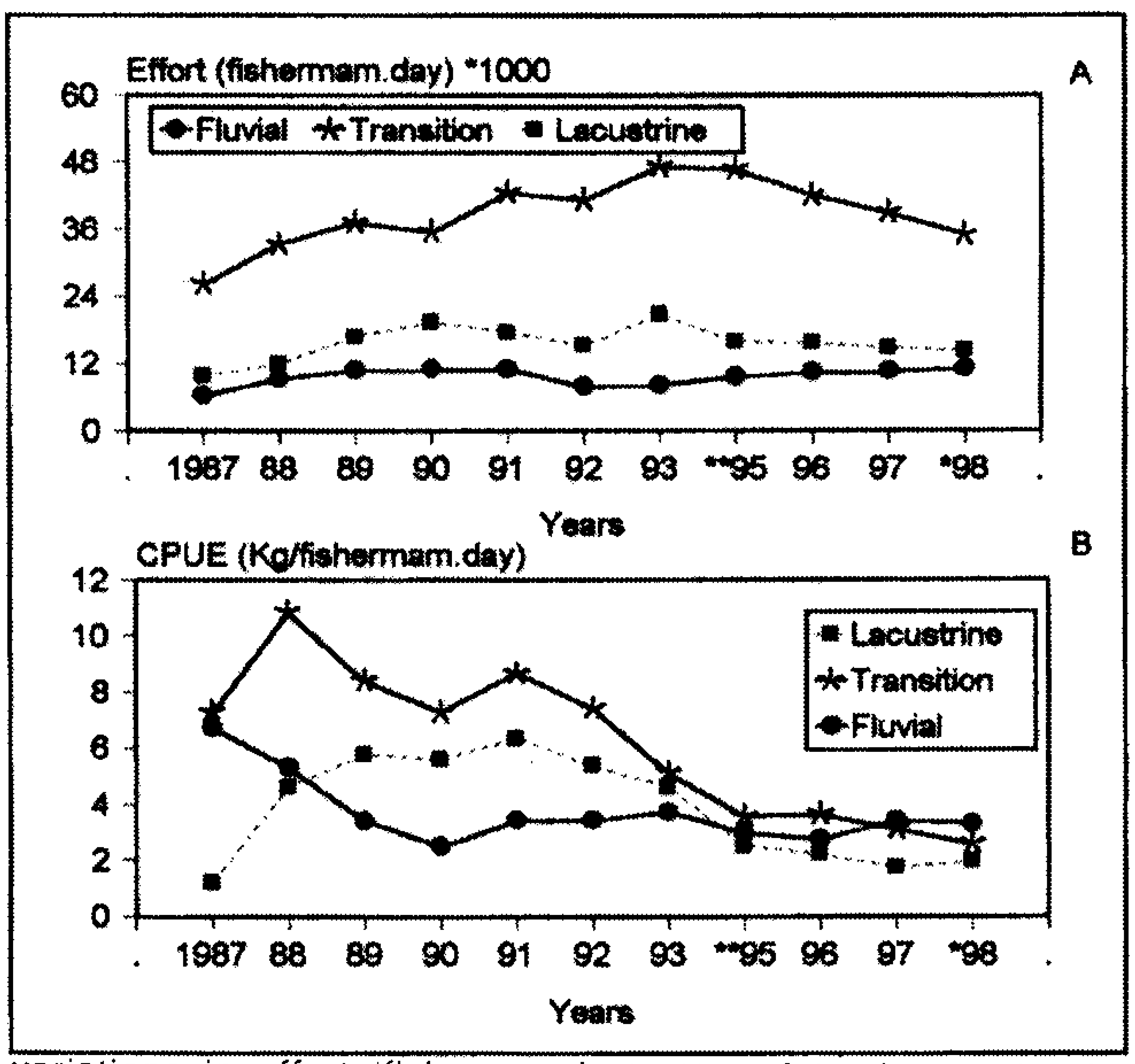

Figure 3: Annual variations in effort (fisherman.day) (A) and in the catch of the per unit of effort (kg/fisherman.day) (B) of *the H. edentatus* in the artisanal fisheries carried out in the different zones of the Itaipu Reservoir from 1987-1998. * The fishery ban during spawning (October-December 1997 and January-February 1998). ** Samplers interruption in 1994.

Biotic factors related to fishing yield

Diet and food availability

The gastric content data of the "perna-de-moça" specimens obtained in two periods (1984-88 and 1995-97) show that the diet of this species is predominantly composed of cladocerans. This predominance is more conspicuous in the last period (Tab. I). The most consumed species in this group were, in the first period, *Bosmina hagmani* and *Bosminopsis deitersi*, being surpassed by *Daphnia gessneri* (58%), a large-sized species, in the second. The most obvious alteration in the diet of the "perna-de-moça" was, however, the fall in the participation of Cyanophyceae, not enterily assimilate.

Zooplankton density in the lower half of the reservoir was high in every group considered (Tab. II). Tab. II shows a reduction in the concentration of chlorophyll in 1997 when compared with that of ten years before.

Table I: Values of the Alimentary Index of the *H. edentatus* in the Itaipu Reservoir from 1984-88 and 1995-97

INDEX	1984-88	1995-97
CLADOCERANS	33.90	73.07
CALANOIDS	11.50	21.30
CYCLOPOIDS	17.20	5.59
CYANOPHYCEAE	25.90	0.01
OTHERS	11.50	0.03
SOURCE	Lansac-Tôha et al., (1991)	Abujanra (in prep.)

Table II: Average density of zooplanktonic organisms (org./m³) and average concentration of chlorophyll registered in the lower half of the Itaipu Reservoir in 1987 and 1998.

	1987		1998	
	Density	%	Density	%
ROTÍFERA	6,471	25.3	8,046	18.8
CLADOCERA	7,423	29.0	11,856	27.6
COPEPODA	11,677	45.7	22,989	53.6
TOTAL	25,571		42,891	
Chlorophyll *a* (mg/m³)	3,75		1,77	
SOURCE	Surehma-Itaipu Binacional (1988)		Sema-Itaipu Binacional (1998)	

Reproductive activity

Analysis of 22,600 *H. edentatus* individuals from 1988 to 1998 showed that the annual frequency of females in reproduction (mature and semi-spent) were high starting from 1993, when fishing yield declined, reaching the maximum in 1998. Participation of females at this stage was particularly low in 1990 and 1992 (Fig. 4).

Larval density

Comparison between the larval densities of *H. edentatus* from September/89 to April/90 and October/96 to March/97 at four sampling sites located in the transition zone were showed in Tab. III. The total average density was, however, high in the last period.

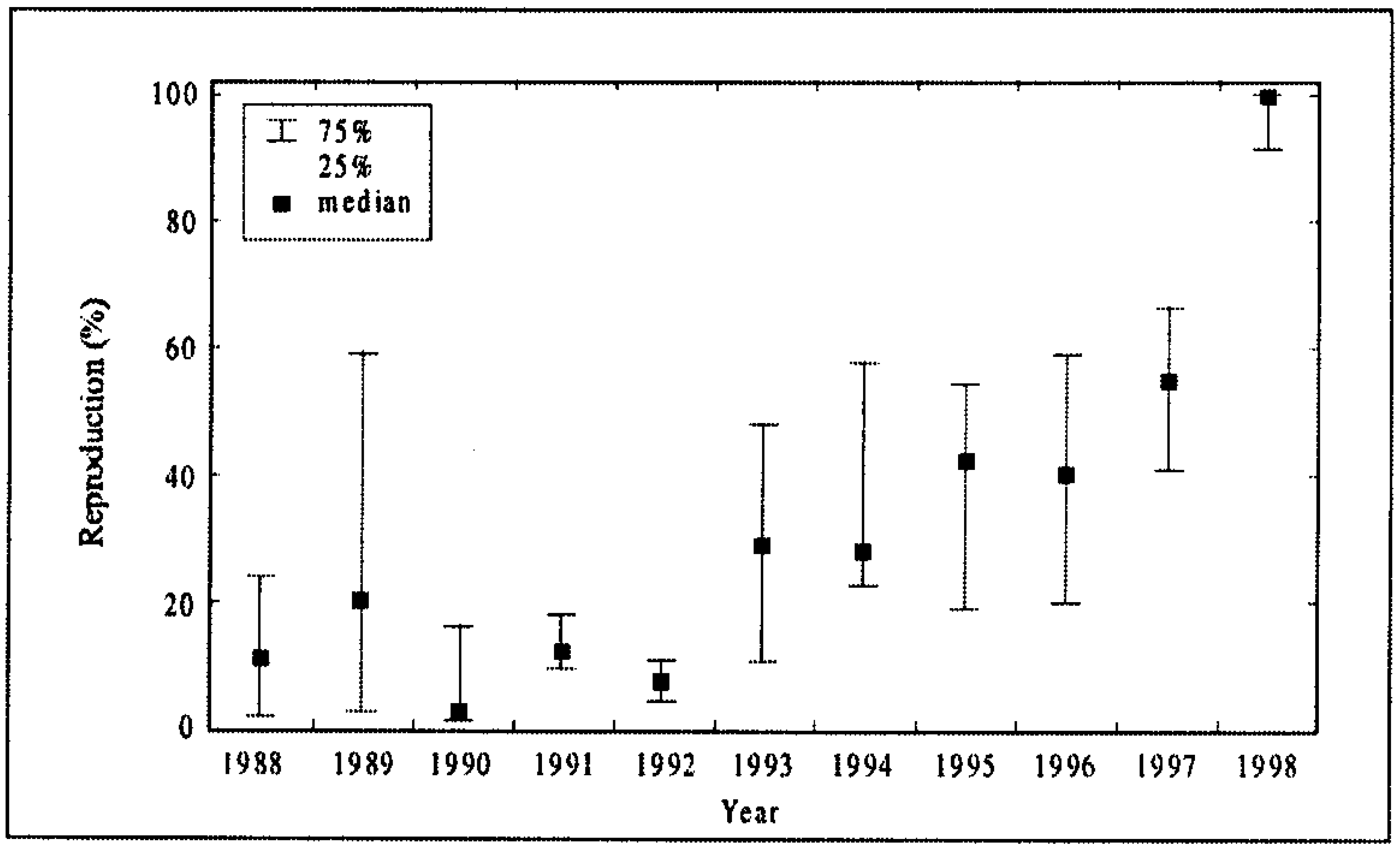

Figure 4: Annual frequency of females in reproduction in artisanal fisheries in the Itaipu Reservoir.

Table III: Larval density of *H. edentatus* in the Itaipu Reservoir, vicinity of the São Francisco Falso River (larvae/10³) in two periods

Sites sampling	**September/89 a April/90**	**October/96 a March/97**
Main body 1	9,7	20,0
Main body 2	29,4	5,0
Arm of the River S. Fco.Falso	5,5	80,0
Backwater in the River S. Fco. Falso	10,2	60,0
Density avarege	13,7	41,25
SOURCE	Nakatani (1994)	Cavicchiolli (2000)

Predation

Variation in the abundance of the *H. edentatus* and *Plagioscion squamosissimus* "curvina" your main predator, was compared 1988 to 1998 in the Fig. 5. A rise in predator abundance from 1991 to 1993 may have affected the most caught age classes (3 to 5-year old) of the "perna-de-moça" in subsequent years. Both species, however, presented low abundance in the last four years when compared with the first.

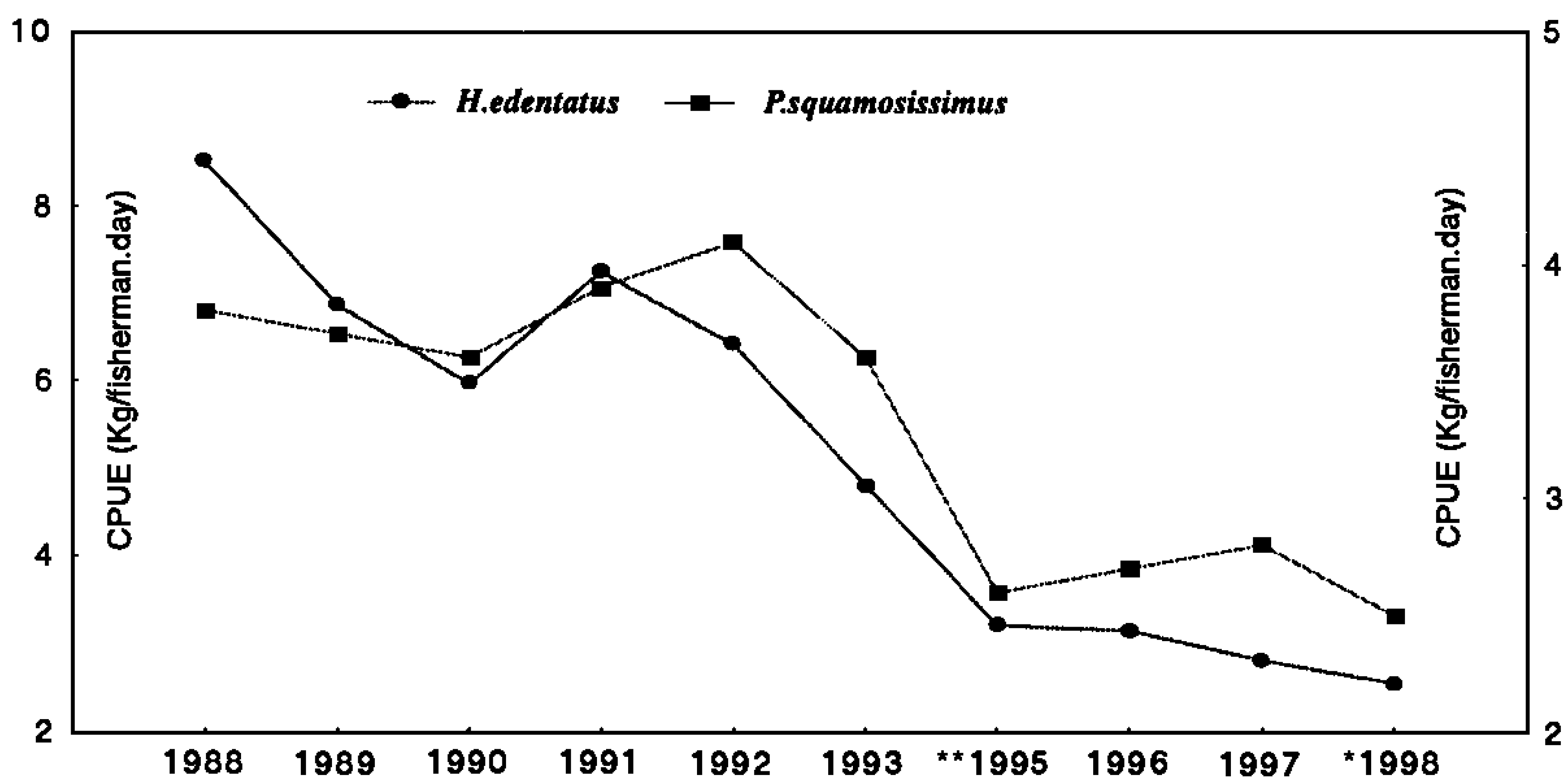

Figure 5: Catch per unit of effort of the *H. edentatus* and the *P. squamosissimus* from 1988 to 1998 in the Itaipu Reservoir. * The fishery ban during spawning (October-December 1997 and January-February 1998). ** Samplers interruption in 1994.

Overfishing

Having in view the evaluation of the state of exploitation of the stocks of the species in the Itaipu Reservoir, the relationship between yield and fishing effort used during the period was established, that was significative (F= 62,12); P<0,0001). The adjustment of Schaeffer's model, using a nonlinear procedure, is presented in Fig. 6, considering the period 1987 to 1995, when the minimum mesh size for capturing *H. edentatus* was the same. From 1996 to 1998, regulations change the minimum mesh size. Thus, the inclusion of the three years violate assumptions of the Schaeffer's model (see Ricker, 1975). Maximum sustainable yield (MSY) was estimated at 395 tons/year, for an optimum effort of 66,500 fisherman x days. The yield values verified from 1988 to 1992 (Fig. 1) were greater than the sustainable estimate. Optimum effort, associated with this value, was surpassed beginning in 1991 (Fig. 2). In the search for evidence of growth in overfishing, the variation in the average size of the specimens caught during the period was analyzed (Fig. 7). Decreases were not noted. On the contrary, a tendency to increase in the mean standard length was verified starting from 1991.

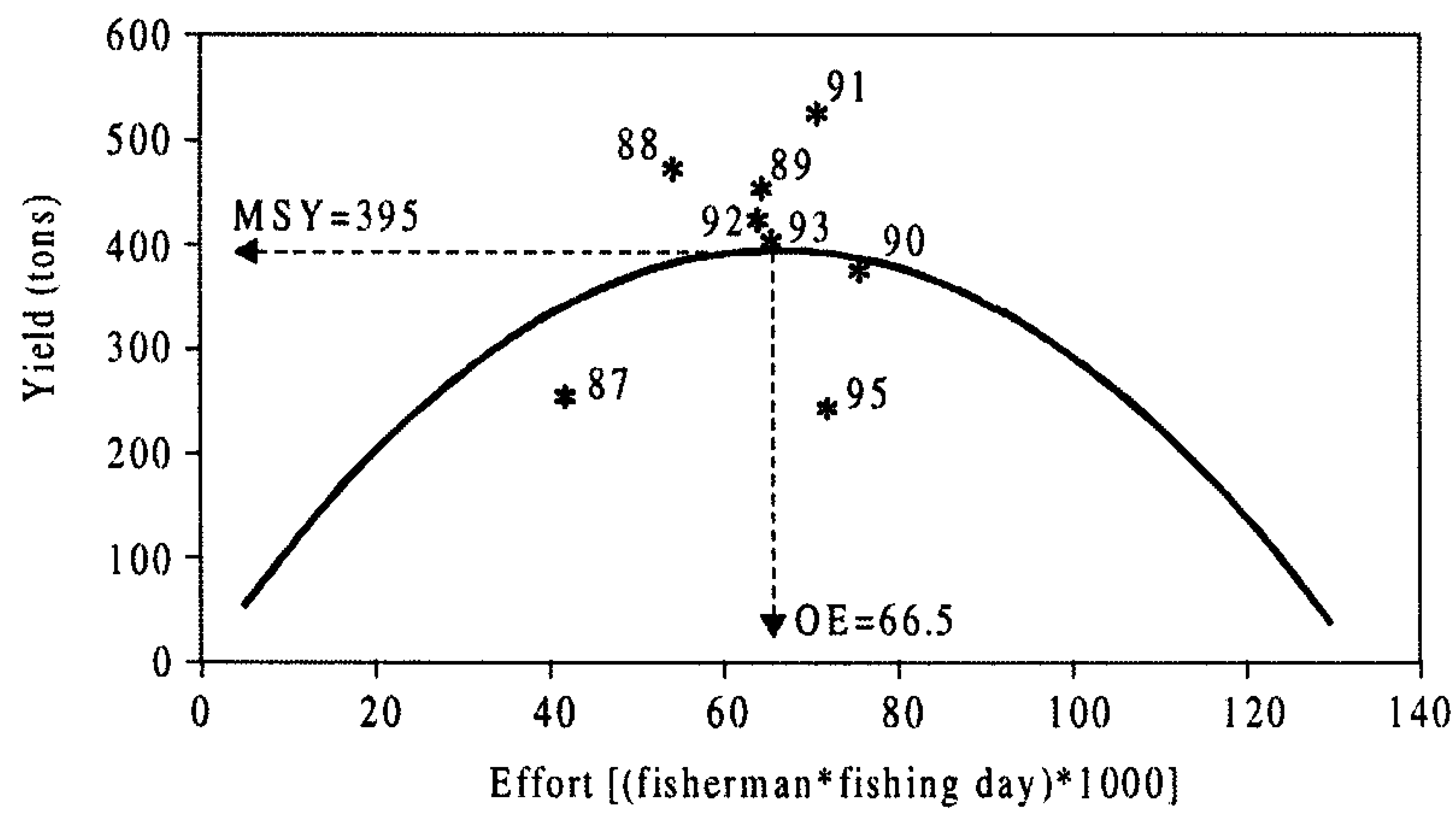

Figure 6: Relationship between the annual yield values (tons.) and effort (f) in the catch of the *H. edentatus* in the Itaipu Reservoir from 1987-1993 and 1995-1998.

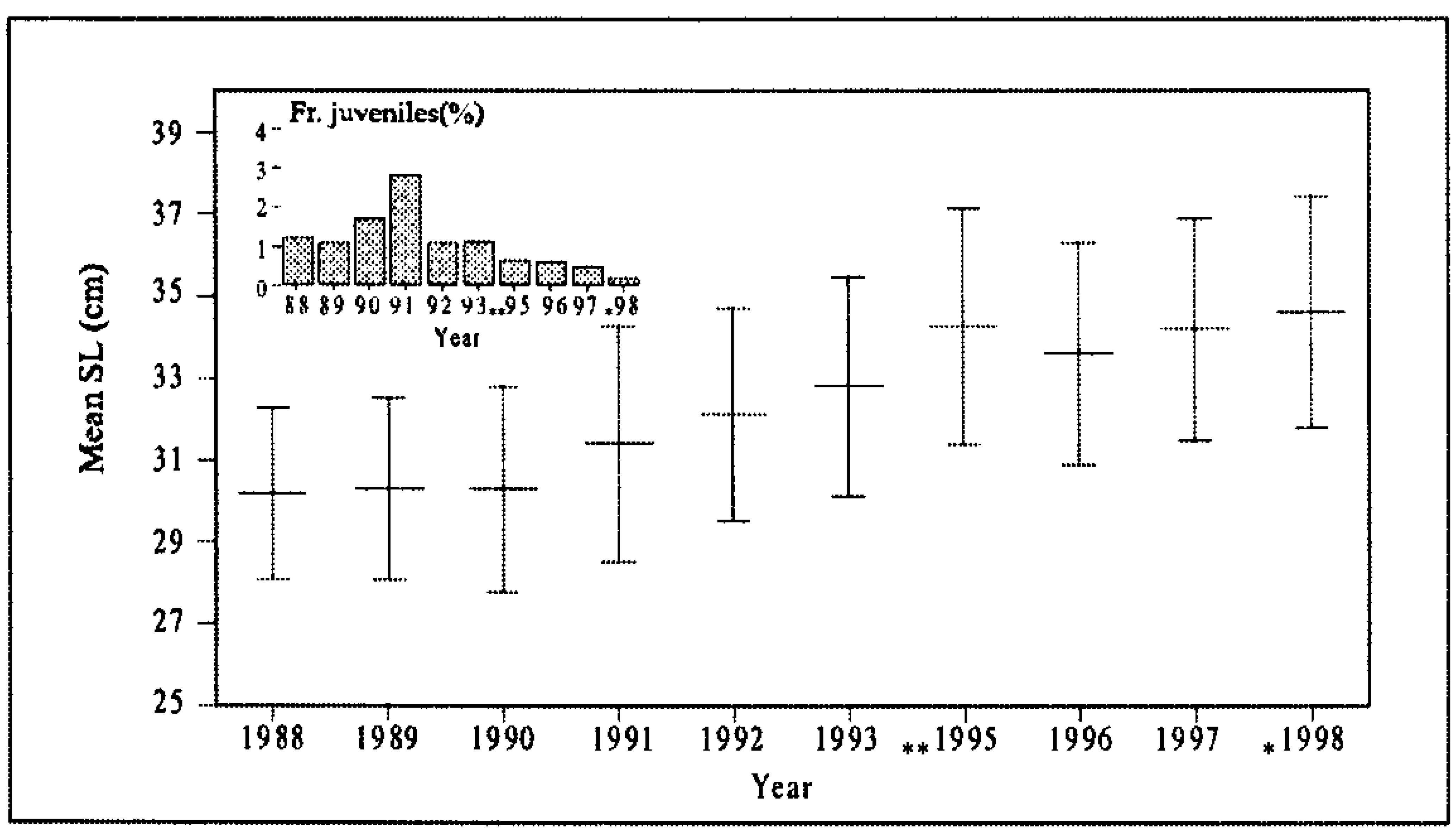

Figure 7: Annual variation in mean standard lengths (cm) of *H. edentatus* obtained in artisanal fisheries in the Itaipu Reservoir from 1988-1993 and 1995-1998. * The fishery ban during spawning (October-December 1997 and January-February 1998). ** Samplers interruption in 1994.

Discussion

In the occupation of new environments formed by large dammings, very successful species are those with pre-adaptations to lacustrine conditions (Fernando & Holcik, 1982 and Kubecka, 1993). The open and deep areas, the most conspicuous in reservoirs, are precariously occupied and according to data from Agostinho et al. (1999), contribute to less than 10% of the biomass caught in Itaipu Reservoir. According to these authors, this can be attributed to the lack of natural lakes in the basin that could allow the appearance of species with morphological and behavioral adaptations for feeding, locomotion, spawning and protection from predators. In the Itaipu Reservoir, the few species that occupy the pelagic zones possess the body shape, eyes and mouth position appropriate for an existence on the surface, with the H. edentatus, the "surumanha", *Auchenipterus nuchalis* and the "dourado cachorro", *Rhaphiodon vulpinus* predominating. All, however, are more abundant in the littoral areas or in the reservoir arms (Agostinho et al., 1999).

The incorporation of high biomass and a high concentration of nutrients in the period that followed the damming should have allowed *H. edentatus*, with adaptations to planktonic feeding, to proliferate in this environment (Kimmel & Groeger, 1986; O'Brien, 1990). In this sense, it should have also contributed to the fact that the species present at least two spawning peaks during the year (Benedito-Cecílio, 1989), small eggs and, like the larvae, are pelagic (Agostinho et al., 1999). High species density, already registered in the first years, and probably originating from a reduced number of individuals present in the river and the multiple spawns initially observed, suggested an "opportunist" strategy in the sense presented by Winemiller (1989).

Although abundant from the second year of the formation of the reservoir, the stock of this species continued being underexploited even after the lifting of the fishery restrictions (Agostinho et al., 1999). This was due to: (i) the resource being unfamiliar to fisheries previously carried out in the region, (ii) the low acceptance by the consumer market of the region and (iii) the prohibition of a mesh size more favorable to its exploitation (70mm stretch).

High yield in catches carried out in the intermediary stretches of the reservoir (transition zone) is an expected phenomenon in fisheries of large reservoirs, in as much as transport and sedimentation processes in these areas are balanced, resulting in high penetration of light and even higher concentrations of nutrients (Thorton, 1990; Agostinho et al., 1999). It is natural, therefore, that high fishing effort had been applied in this zone. However, the fact that the catches per unit of effort had equaled those of areas traditionally not very productive, like the fluvial, is a solid indication of reduction in the stocks. After some years, variable among reservoirs, sedimentation and export processes via unloading or with drawal of fish through exploitation, a depletion is verified in the concentrations of nutrients and in biological production (Agostinho et al., 1999). This process could have affected the stocks of the "perna-de-moça" via restrictions in the availability of zooplankton. However, analysis of the zooplankton densities, especially cladocerans (its basic food), shows increases in 1997 in relation to that of ten years before. Its diet, except for a slight use of Cyanophyceae algae, was not altered in any relevant way. Among the cladocerans, there was an change in the predominance of smaller-sized Bosminidae to Daphnidae (Abujanra, in preparation). Cyanophyceae algae, previously abundant in the diet of the species, does not seem relevant, in as much as its digestibility is low or non-existent, passing unharmed through the digestive tract (Abujanra, in preparation).

The development of the alga *Microcystis sp* in the Itaipu Reservoir and its liberation of a powerful toxin (Itaipu Binacional, 1999) may have had some impact on the species and on the fishery, due to its planktophagous habit. Although the slaughter of larvae could have gone unnoticed in the monitorings of the fisheries in the reservoir, it would have beén notable if large-sized specimens had been involved. Nothing of this nature was registered in the reservoir during the period. However, no specific study was carried out.

Successive gaps in reproduction, motivated by various environmental factors, may lead to notable depletions in stocks and its commercial extinction. A problem of this type has been described by Agostinho et al. (2001) and Gomes & Agostinho (1997). These problems can be detected satisfactorily based on the frequency of individuals with mature and semi-spent gonads and by the densities of eggs and larvae. From 1993 to 1998, however, when yield decreased, *H. edentatus* was marked by an increase in the proportion of individuals in reproduction. Also, larval density was higher than that of high yield periods (1989-90). Thus, spawning and development of eggs and larvae, at least until the end of the absorption of the vitellinic sac, did not explain the fall in recruitment.

The main predator of *H. edentatus* juveniles is the *P. squamosissimus* (Hahn et al., 1997). This predation was considered by Agostinho & Julio Jr. (1996) as probably responsible for the yield fluctuations in the catches of the former from 1988 to 1993. Catch per unit of effort analysis carried out on both species shows relationships between the abundance of the "curvina" in one year and the "perna-de-moça" two or three years later. However, the fall in the CPUE of the predator in 1995 did not increase the abundance of the prey. The relationships between these two species are, however, complex. The studies developed by Cavicchiolli (2000) about the diet of both species show that zooplankton is predominant, with a predominance of cladocerans in the stomachs of *H. edentatus* and copepods in those of *P. squamosissimus*. The specific overlap of food items is, however, relevant. In addition, the latter, with a high index of cannibalism, had already started its predation on the former in this phase. Although the mechanisms by which predation is imposed by the "curvina" on the "perna-de-moça" larvae and juveniles are unclear, it is reasonable to suppose that they had contributed to the reductions in the stocks of this species. The increase in the mean size of the landed specimens in the artisanal fisheries of 1991 to 1995, a period in which alterations in the fishery strategy were not registered, seems to indicate gaps in recruitment. Information given by the species growth curve (Ambrósio et al., submitted) shows that the catches, initially based on individuals in the 3 to 4-year-old age class, changed to the 4 to 6-year-old age class in subsequent years, a fact that demonstrates problems in recruitment. Competition by the same diet with "surumanha" *Auchenipterus nuchalis*, may also comtributed to the reductions in the stocks of *H. edentatus*.

Overfishing, as a factor responsible for the depletion in the stock of H. edentatus, is also raised. According to Miranda et al. (2000), yield is not sustainable when fish are caught before they can spawn at least once or when the fishery causes a high reduction in population size. In the first case, called recruitment overfishing, the fishery may enter into collapse, leading to its extinction (Cushing, 1996). This tendency is shown in the reduction in the lengths of individuals in the fisheries, with a high incidence of juveniles. In the second, growth overfishing (Gulland, 1988), the stock may also be extinguished as a result of a disproportionately high effort. The fact that the mean sizes of the specimens caught had risen in the period indicates that the first case is improbable or unverifiable, in as much as it may result from recruitment gaps, as discussed above. On the other hand, the second possibility is considered probable, in as much as the catch effort seems to have supplanted what was considered optimum in the applied sustainable yield model, starting from 1991. Fishing effort disproportionate to the exploited stock has been described by Okada et al. (1996), applying the same model and based on the yields up to 1993. Although this model should not be used as an objective to be followed rigidly in the decisions of fishery management, it is recommended by Gulland (1983) in the description of the facts that occurred in the life of the stocks in relation to exploitation in the clear definition of the monitoring objective of a stock and in the measurement of the success with which a stock is being monitored. An additional indication of the exaggerated character of the applied effort is the similarity verified in the catch per unit of effort between the traditional fishing areas of the species and those in which it never was the object of a relevant fishery, such as the fluvial, where effort was always low.

The suspension of the use of gillnets with a 7.0cm mesh stretch and the establishment of a fishing prohibition period in the Itaipu Reservoir (measures implemented in 1998) should be able to reduce the fishing effort on the species in the medium term and raise the yield per recruit, with a favorable impact on future profitability in the fisheries (Miranda et al., 2000). However, it is possible that this measure will increase the stocks of the "curvina", in as much as this equipment catches large quantities of juveniles of the species. In this case, considering the control that the "curvina" exerts over the "perna-de-moça", the result of this measure on the fishery of the latter may be harmless.

The factors that determine reduction in yield of the "perna-de-moça", probably multiple and with relevant interactions, need a more detailed evaluation. In addition to monitoring the stock in relation to the latest management measures, it is necessary to understand the interspecific relationship in every phase of development of this species. It is also necessary that the social and economic implications of the measures on the fishing community are part of the analysis, given the precarious conditions of this community and the attraction exerted by profits in illicit activities in a frontier region such as the Itaipu reservoir.

Acknowledgements

The authors are most greateful to the researchers and students belonging to the "Núpelia (Núcleo de Pesquisa em Ictiologia, Limnologia e Aqüicultura)" and "PEA (Curso de Pós-graduação em Ciências Ambientais" for their help and assistence in all phases of this research. We would like to thank the Itaipu Binacional for their help with samplings in Itaipu Reservoir.

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Recebido em: 10 / 04 / 2001
Aprovado em: 22 / 06 / 2001