BIOCELL
2006, 30(1): 125-130

ISSN 0327 - 9545
PRINTED IN ARGENTINA

**Symposium: BIOLOGY AND CULTURE OF SILVERSIDES (PEJERREYES)**

# The recreational fishery in cabra corral reservoir (Argentina): A first comprehensive analysis

C. Baigún[1], R. Bernal[2], D. Barrientos[2], L. Muñoz[2], E. Barros[2], and J. Sauad[2]

[1] IIB-INTECH, Camino de Circunvalación Laguna, Km 6, 7120 Chascomús, Argentina,
[2] Universidad Nacional de Salta, Salta.

**Key words:** pejerrey, Cabra Corral reservoir, catamarans, recreational fishery

Cabra Corral reservoir is located in Salta Province and is the largest man-made lake in northern Argentina. As other reservoirs located in this area, it was stocked with pejerrey (*Odontesthes bonariensis*) with excellent results. The pejerrey is the most important and valuable recreational fish in Argentinean warmwater lakes and at present most of these reservoirs exhibit well developed populations being inhabited also by other non game fish species. Cabra Corral was considered as the most important recreational fishery in Salta Province concentrating 86% of fishing activity (Volante *et al*., 1997).

Pejerrey fishery in this reservoir poses management challenges. Fisheries information is still sparse and previous studies focused only on pejerrey biological features (Barros and Regidor, 2002; Barros *et al*., 2004). There is a lack of reliable data related to number of anglers using the reservoir, annual harvest and potential yeld. Socio-economic analysis in the reservoir was initiated by Volante *et al*. (1997), but did not consider fishery economic value. In the last years managers have been confronted with the possibility of developing a commercial fishery, without having assessed the current status of the recreational fishery and reservoir fish production to support both activities. The aim of this study is to present a general perspective of the pejerrey recreational fishery in Cabra Corral reservoir acquiring relevant data as a first step for developing a sustainable management framework.

## Study Area and fishery characteristics

Cabra Corral reservoir is located in Salta Province and was formed on the Juramento River (Fig. 1). The reservoir is 1,037 m above mean sea level about 80 km from Salta city. It has a surface of 11,360 ha, with a maximum and mean depth of 90 m and 28 m respectively. Trophic status is rather mesotrophic with 360 µS/cm of conductivity, 16 µg/l of total phosphorous, 71 µg/ l of chlorophyll and 2.10 m of transparency (Quirós *et al*., 1988).

Cabra Corral fishery is mainly based on rented and private catamarans and boats but anglers fish also from a long bridge that cross on the reservoir at its narrowest point. Fishing activity takes place mostly at night using light attractors. Such modality is almost unique from this site and is not allowed for other pejerrey fisheries across the country. Tournaments take place only during day

Address correspondence to: Claudio Baigún. IIB-INTECH, Camino de Circunvalación Laguna, Km 6, (7120) Chascomús, ARGENTINA. E-mail: claudiobaigun@intech.gov.ar
*Received on March 15, 2005. Accepted on April 21, 2005.*

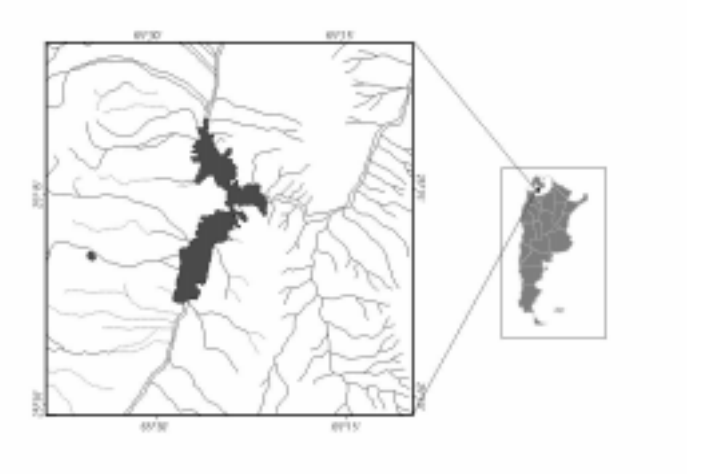

**FIGURE 1.** Geographic location of Cabra Corral reservoir in Salta province.

**TABLE 1.**

**Estimated potential yield for pejerrey in Cabra Corral reservoir based on empirical models and biomasss estimation.MEI: morphoedphic index; TEMP: Mean air temperature.**

| Source | Geographic area and environments | Input variables | Total yield (kg/ha) | Pejerrey yield (kg/ha)[a] | RYI (%) |
|---|---|---|---|---|---|
| Jenkins and Morais (1971) | 103 reservoirs from USA | Area | 20 | 12 | 56 |
| Jenkins (1982) | 294 sport fish reservoirs from USA | MEI | 25.7 | 15.4 | 43 |
| Ryder (1965) corrected by latitude | 23 north temperate lakes | MEI | 16.8 | 10.1 | 66 |
| Shlesinger and Regier (1982) | 43 commercial lakes between 62º N and 15º S | TEMP, MEI | 24.5 | 14.7 | 46 |
| Mosa and Regidor (2003) | Cabra Corral estimation | Biomasss | 14 | 8.4 | 80 |

hours. The fishery is partially regulated and no lures and baits restrictions are imposed. Creel limit comprises 40 fish per angler/day and no size limits. The southern area of the reservoir (Zapallar Bay) is considered as a closed area during spawning season in spring (Barros, 1999).

## The recreational fishery performance

Proposing management measures implies first knowing the recreational fishery performance in terms of catch and efforts. We assessed fishing activity between November 2003 and October 2004 by developing monthly samplings of boat anglers (catamarans) and on boat tournament anglers, considering potential differences between weekend and weekdays strata and between seasons (Malvestuto, 1994). Only 25% of available weekends per month could be sampled thus a correction factor to estimate angler number on weekdays was applied. Catamaran samplings were considered as complete fishing trips since catch and effort data were obtained from complete surveys at the end of each sampling night (Pollock *et al*., 1994).

In Cabra Corral we found that summer season comprised 40% of fishing effort and 43% of total catch. Twenty three rented catamarans operated regularly in the reservoir during weekends carrying 84% of anglers, whereas 16% of them fish on private (and smaller) catamarans and boats. Mean party size in catamarans was estimated as 22 anglers per trip. CPUE was higher for regular fishing trips than for tournaments. Since mean fishing effort was almost 8 hours per angler, and mean CPUE was 4 fish/angler/hour, this indicated that anglers did not surpass the creel limit (40 fish), except during spring when CPUE increased up to 8 fish/angler/hour, probably due to pejerrey spawning behavior. In turn CPUE for tournaments was rather small (1.06 fish/angler/hour ) which may reflect differences in day and night catchability.

Length structure showed only small differences between tournaments, catamaran anglers and experimental gillnet captures from this and a previous survey (Fig. 2). Most of caught fish were above 13 cm SL (15.6 cm TL) which corresponds to length at first maturity (Barros *et al*., 2004), but a large proportion of fish were well below to $Lm_{50}$. For example, catch mean length by regular catamaran anglers, bridge tournament anglers and catamaran tournament anglers were 21.4, 19.6 and 22.8 cm respectively. Catamaran and bridge tournament anglers captured 47% and 75% of fish below such size,

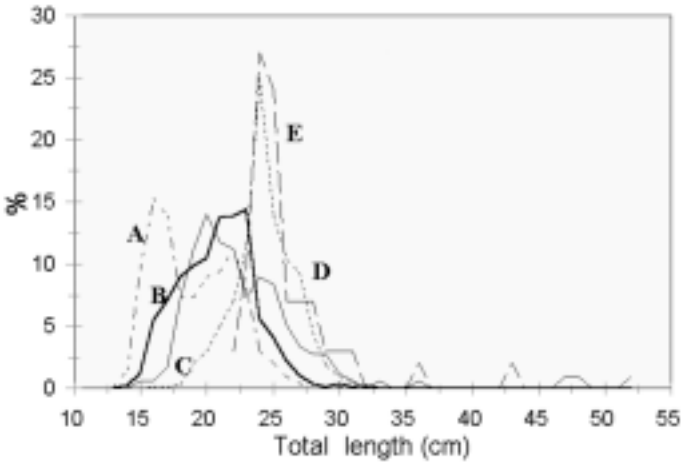


**FIGURE 2.** Length frequency distribution of pejerrey sampled from A:bridge tournaments; B: catamarans; C: catamaran torunaments; D: 2003-2004 experimental gillnets; E: 1986 experimantal gillnes at Cabra Corral reservoir

whereas 57% captured fish were bellow $Lm_{50}$. Total estimated harvest by catamaran fishing for the sample period was 47.7 tons, representing 4.2 kg/ha, but additional 22.7 tons (2 kg/ha) can be estimated from recreational bridge anglers.

**Is the fishery overexploited?**

Determining the exploitation level is an important step in Cabra Corral reservoir. We estimated first potential yield by using morphoedaphic index models and other variables and then compared with angler harvest (Cryer, 1996). However, direct application of such models in subtropical environments such as Cabra Corral would underestimate fish yield. Thus following Baigún (2001) approach, Ryder's (1965) original model was used but corrected by a climatic constant (k=3) derived from Henderson *et al*. (1973, Fig. 6). We also applied Schlesinger and Regier (1982) equation that incorporates mean air temperature, Jenkins' (1982) model for reservoir sport fish harvest and Jenkins and Morais approach (1971) based on middle latitude reservoirs area. We considered the MEI value as an aggregate yield estimates for all species, being analogous to the maximum sustainable yield (MSY) (Matuszek, 1978).

As a measure of exploitation level the relative yield index (RYI) defined by Adams and Olver (1977) was used. The RYI is the ratio between the observed catch and the estimated potential yield ($RYI=Y_{obs}/Y_{est}$). Since MSY cannot be considered as an advisable target level, $Y_{est}$ was corrected by a factor of 0.75 for safety margin (Ontario Ministry of Natural Resources, 1983), thus being $RYI= (Y_{obs}/Y_{est}) \times 0.75$.

Estimated yield ranged from 16.8 and 25.7 kg/ha, averaging 20.8 kg/ha (Table 1). Since pejerrey comprises 60% of community structure mean potential yield represented 12.5 kg/ha or 142 annual tons. On the other hand, total fish biomasss was estimated in Cabra Corral as 35 kg/ha (Mosa and Regidor, 2003), which corrected by pejerrey relative abundance represents 21 kg/ha. Assuming that yield is 0.6 of fish production (Gulland, 1970) a MSY of 13.86 kg/ha may be achieved. However, since MSY has been questioned as a management concept (Caddy and Mahon, 1996), a more conservative approach was derived by using a 2/3 correction factor for MSY. Such approach yield 80% of MSY without overexploitation risks (Doubleday, 1976) and represented 9.2 kg/ha. Since total estimated harvest by the recreational fishery for the 2003-2004 period was calculated as 6.7 kg/ha, RYI derived from empirical models ranged from 45 to 66% but was 73% from biomasss estimation (Table 1). Although pejerrey population cannot be considered as overexploited ($RYI \geq 1$), CPUE values have strongly fluctuated during last years (Mosa and Regidor, 2003; Fig. 16) and abundance variation coefficients over 50% represents an indicator of heavy fishing (Ontario Ministry of Natural Resources,

**TABLE 2.**

**Pejerrey main fisheries and economic characteristics estimated for Cabra Corral reservoir (11/03 to 10/04). Data corresponds to catamaran anglers.**

| | |
|---|---|
| Number of anglers during January and February | 10, 500 |
| Number of anglers from March to December | 14,900 |
| Number of caught fish | 793,960 |
| Harvest (tons) | 47.6 |
| Angling effort (anglers/ha/hour) | 0.28 |
| Angler CPUE (fish/angler/hour) | 4.0 |
| Angler BPUE (grams/angler/hour) | 241 |
| Tournament CPUE (fish/angler/hour) | 1.7 |
| Economic impact per hectare/year (US $) | 131 |
| Economic value per hectare/year (US $) | 33,8 |

1983). At present recreational fishery would exerting a fishing effort that removes between 50% of potential yield (based on empirical models) and 80% (from biomass estimation)

## How valuable is the fishery?

Information on fishery economic value was obtained using the contingent valuation method (Azqueta Oyarzun, 1994). Pejerrey anglers were willing to pay US $16 per day more than their current expenses (US $62) to continue fishing in the reservoir. Total estimated expenditures derived from a fishing trip represented US $1,490,000 per year exceeding in some cases the economic impact for well known pejerrey in Pampean lakes. Because average consumer surplus increased 26% over current expenditures a total of US $384,000 can be estimated as net economic value on annual basis.

Expenditures estimated from recreational fishery is very important if compared with the US $3,600,000 value determined for all the Salta province fisheries (Volante *et al*., 1997). The economic yield per hectare is in between the estimated value for several pampean lakes (e.g. Grosman and Peluso, 1998; Baigún and Delfino, 2003). In Table 2 we summarize key estimated parameters of the pejerrey fishery. Effort and catch data per unit area should be considered with caution since some lake areas are strongly preferred by anglers.

## Management perspectives

Comparing these results with length-frequency data from a past survey (1986) with similar experimental gillnets (Baigún, unpublished), length structure appears as have been shifted to smaller sizes. Lack of large fish size could be considered as indicator of exploited fisheries (Tripped, 1995).

However, Cabra Corral is a mesotrophic reservoir with low proportion of macrozooplankton (Quirós *et al*., 1988). Such feature may limit fish grow and accounted for observed low condition as was reflected by the relative weight index and the length-weight relationship slope (2.78). Based on observed results we conclude that pejerrey population structure appears as being shifted to small and medium fish size of poor condition, thus lowering fishery quality due to lack of trophy sizes. High socioeconomic values challenge managers to mantain sustainable management actions. Such scenario may limit the development of a commercial fishery due to fish size and catch pressure exerted by the recreational fishery. Future research should be directed to elucidate how limnological conditions (water quality and plankton composition), biological features (trophic niche, mortality rate, reproduction size, etc) and fishery impact are interacting and regulating pejerrey population in this reservoir.

## Acknowledments

We want to acknowledge Lorena Bonavia, Lourdes Casasola, Simón Chihan and Fernando Franqui for assistance in the field. We are indebted to catamaran owners and anglers for their help and participation.

## References

Adams GG, Olver CR (1977). Yield properties and structure of boreal percid communities in Ontario. J Fish Res Bd Can, 34: 1613-1625.

Azqueta Oyarzun D (1994). Valoración económica de la calidad ambiental. McGraw-Hill/Interamericana de España, Madrid.

Baigún C (2001). Ecología pesquera de lagos y embalses patagónicos (Argentina). Tesis doctoral, Fac. Cs. Exactas y Nat., Univ. de Buenos Aires.

Baigún C, Delfino R (2003). Assessment of social and economic issues as management tools for summer pejerrey recreational fisheries in pampean lakes (Argentina). J Lakes Reserv Manage, 19: 242-250.

Barros SE (1994). Temporada reproductiva y fecundidad del pejerrey (*Odontesthes bonariensis*) en el embalse Cabra Corral (Salta). Tesis profesional para la Licenciatura en Recursos Naturales, UNSA.

Barros SE, Regidor H (2002). Reproduction in *Odontesthes bonariensis* (Atherinidae: Pisces) from north-western Argentina. J Appl Ichthyol, 18(1): 27-28.

Barros SE, Regidor H, Iwaszkiw J (2004). Biología pesquera del pejerrey *Odontesthes bonariensis* (Cuvier y Valenciennes 1835) en el embalse Cabra Corral en el subtrópico de Argetntina. Revista Aquatic 20: 32-37. http://revistaaquatic.com/aquatic/art.asp?t=p&c=159

Caddy JF, Mahon R (1996). Puntos de referencia para la ordenación pesquera. FAO Doc. Téc. Pesca 347, Roma, 109 pp.

Cryer M (1996). Trout yield in Lake Taupo, New Zealand: angler's eldorado or just another fishery? In: Stock assessment in inland fisheries. I. G. Cowx, Ed. Fishing News Books, pp. 378-386.

Doubleday WG (1976), Environmental fluctuations and fisheries management. ICNAF Selec Pap, 1: 141-150.

Grosman F, Peluso F (1998). La pesca deportiva en lagunas de la Pampasia. Realidad Económica 133: 74-99.

Gulland JA (1970). The fish resources of the ocean. FAO Fish. Tech Rep 97.

Henderson HF, Ryder RA, Kudhongania (1973). Assessing fishery potentials of lakes and reservoirs. J Fish Res Board Can, 30: 2000-2009.

Jenkins RM (1982).The morphoedaphic index and reservoirs fish production. Trans Amer Fish Soc, 111: 133-140.

Jenkins RM, Morais DI (1971). Reservoir sport fishing effort and harvest in relation to environmental variables. Amer Fish Soc Spec Publ, 8: 371-384.

Malvestuto S (1994). Sampling the recreational creel. In: Fisheries Techniques, Murphy B and Willis DW, Eds. American Fisheries Society, 2nd edition, Bethesda, Maryland.

Matuszek JE (1978). Empirical predictions of fish yields of large North Amercian lakes. Trans Amer Fish Soc, 107: 385-396.

Mosa S, Regidor H (2003). AES Juramento S.A. Programa de Monitoreo Cabra Corral-Peñas Blancas-El Tunal. Informe Anual 2003.

Ontario Ministry of Natural Resources (1983). The identification of overexploitation.Report of SPOF Working Group Number 15, 83 pp.

Pollock, KH, Jones C, Brown T (1994). Angler survey methods and their application in fisheries management. Am Fish Soc Spec Publ, 25.

Quirós R, Baigún C, Cuch S, Delfino R, De Nichilo A, Guerrero C, Marinone M, Menu Marque S, Scapini M (1988). Evaluación del rendimiento pesquero potencial de la República Argentna. I. Datos. Informe Técnico Nro 7, Dpto. Aguas Continentales, INIDEP.

Ryder RA (1965). A method for estimating the potential fish production of north-temperate laes. Trans Amer Fish Soc, 94: 214-218.

Schlesinger D, Regier HA (1982). Climatic and morphoedaphic indices of fish yields from antural lakes. Trans Amer Fish Soc, 111: 141-150.

Tripped EA (1995). Age at maturity as a stress indicator in fisheries. Bioscience 45(11): 759-770.

Volante JH, Garrido J, Sauad J, Picón Matorras M (1997). Análisis de la pesca deportivo-recreacional en la Provincia de Salta. Manejo de Fauna, Publ. Téc 8: 1-11.