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Application of extinction risk and conservation criteria for assessing fish species in the lower La Plata River basin, South America

C. R. M. BAIGÚN[a,*], D. COLAUTTI[a], H. L. LÓPEZ[b], P. A. VAN DAMME[c] and R. E. REIS[d]
[a]*Instituto Tecnológico de Chascomús (IIB-INTECH), Universidad Nacional de General San Martín, Camino de Circunvalación Laguna Km 6, C.C. 164, (7130) Chascomús, Argentina*
[b]*División Zoología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina*
[c]*Asociación FAUNAGUA, Instituto de Investigaciones de los Recursos del Agua, Arocagua Norte, Sacaba-Cochabamba, Bolivia*
[d]*Laboratório de Sistemática de Vertebrados, Pontifícia Universidade Católica do Rio Grande do Sul, Av. Ipiranga, 6681, 90619-900 Porto Alegre, Brazil*

ABSTRACT

1. The Lower La Plata River basin contains between 160 and 260 native species depending on the river segment, with a few stretches containing locally endemic species.

2. Extinction risk analysis for 185 freshwater fish in the lower La Plata River basin is presented for the first time on the basis of regionally standardized International Union for Conservation of Nature (IUCN) Red List criteria and is compared with alternative methods within the region.

3. There were 11 threatened species (6%), of which three were considered as Endangered and eight as Vulnerable. A further three were rated as Near Threatened; while 121 (66%) were assessed as being of Least Concern, and 49 (26%) remained Data Deficient. The application of regional guidelines after using the global criteria did not change the categories established.

4. The application of the IUCN criteria A and B presented considerable challenges because of insufficient information, with criterion C being inapplicable; whereas criterion D proved valid in five instances where endemic species were found highly restricted in geographical range and only inhabiting small streams.

5. The use of other approaches, such as the Sum of Index (SUMIN) method and the Assessment Method of Threat Degree (MEGA), resulted in only an 11% agreement with the IUCN results for the main commercial and recreational target species.

6. The discrepancies between the IUCN and the other methods may be explained in that the former measures the extinction risk by population decline as the main criterion, whereas the latter two put more emphasis on the assessment of intrinsic vulnerability and the threat status, with these additional criteria being incorporated in order to define conservation priorities.

7. Further research is strongly recommended for the application and improvement of the IUCN regional criteria based on better ecological information, particularly data on non-target species inhabiting small tributaries, wetlands, and headwaters across the basin.
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KEY WORDS: La Plata River basin; extinction risk; conservation priorities; IUCN criteria; MEGA; SUMIN

*Correspondence to: C. R. M. Baigún, Instituto Tecnológico de Chascomús (IIB-INTECH), Universidad Nacional de General San Martín, Camino de Circunvalación Laguna Km 6, C.C. 164, (7130) Chascomús, Argentina. E-mail: cbaigun@yahoo.com

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INTRODUCTION

The International Union for Conservation of Nature (IUCN) in 1994 developed quantitative Red List criteria for systematically and objectively determining the conservation threat status for species of animals and plants and for highlighting those considered to be at the greatest risk of extinction. These criteria are revised and updated on a regular basis and constitute the grounds for developing the Red List of Threatened Species for all major taxonomic groups (IUCN, 2010). Red-listing exercises are now considered by professional conservationists to be a key step in the process of assigning species to a category of threat dependent on the risk of extinction (Lamoreaux *et al*., 2003; Rodrigues *et al*., 2006; Hoffmann *et al*., 2008). The IUCN system represents a powerful and comprehensive conservation assessment and management tool. The criteria provide an accurate evaluation of the status of biodiversity at a global scale (IUCN, 2001) as well as regional levels (Gärdenfors *et al*., 1999, 2001; IUCN, 2003; Miller *et al*., 2007) and allow for the mapping of changes in biodiversity, the assessment of threats, and identification of sites for conservation action. This system also constitutes a scientific framework for determining management policies (Miller *et al*., 2007). Although the application of global criteria is appropriate as a first attempt at establishing extinction risk, the application of IUCN regional criteria for non-endemic species should also be considered as the required information becomes available.

Although mammals, birds, and amphibians have been comprehensively assessed, fish have not (Darwall *et al*., 2008). This circumstance certainly applies to South American freshwater and estuarine species, where comparatively few have been scientifically assessed by the IUCN or by other criteria. Major discrepancies, for instance, concern the development and application of national or state versus the international tools and criteria, resulting in the development of non-standard lists in each country with only limited comparability. In Brazil, for example, red lists comprising freshwater and marine fish have been developed by different states through the use of diverse criteria, but the IUCN norms have been used at a national level (Rosa and Lima, 2008). Colombia adopted the IUCN categories to modify their criteria for the quantitative assessment of fish (Mojica *et al*., 2002), while Bolivia developed its own method called the Assessment Method of Threat Degree (MEGA) for fish and other vertebrates (Aguirre *et al*., 2009), arguing that the IUCN criteria were not fully applicable because of a lack of data. Conversely, Argentina, Paraguay, and Uruguay have so far not assessed extinction risks of their fish species at a national level although some creditable efforts have been made to define conservation priorities for some specific local geographical areas (Bertonatti and González, 1993; Orlandini *et al*., 2001; López *et al*., 2003; Zayas and Cordiviola, 2007; Chebez *et al*., 2009; Cordiviola *et al*., 2009).

The assessment of fish population status is becoming an important issue for most large South American rivers. Dam construction, flow regulation, mining, deforestation, and industrial and agricultural pollution are some of the main threats that are increasingly affecting major river basins by modifying fish habitats and altering fish life-cycles (Barletta *et al*., 2010). A notable feature of this basin in particular is the large number of dams that have been constructed mainly in the upper Paraná River basin (Baigún *et al*., 2011), in contrast to other basins that are still dominated by large wetlands and natural floodplains.

The lower La Plata River basin contains fish from the Alto Paraguay and Parano Platense zoogeographical provinces (López *et al*., 2002; López and Miquelarena, 2005). According to López *et al*. (2008), this portion of the basin belongs to the Large Rivers Province comprising the Paraguay, Upper Paraná, and Lower Paraná freshwater ecoregions of Abell *et al*. (2008). The native fish species richness varies between 160 and 260 depending on the river segment, with a few stretches containing locally endemic species (López *et al*., 2002; Barletta *et al*., 2010). The number of species discovered in recent years in the basin is, however, constantly increasing (Liotta, 2010). The profile of fish present is dominated by small to medium-sized species (Bonetto *et al*., 1965; Cordiviola de Yuan and Pignalberi, 1981; Oldani, 1990). Like other extensive river basins in South America, the La Plata River basin supports large migratory species with dominant potadromous and interoparous life-history strategies that sustain most of the artisanal and recreational fishing activities. In addition, several small-sized species constitute the target for unregulated activities in ornamental fishing or are collected and thereafter used as bait (Gómez *et al*., 1994; Chebez *et al*., 2009). Despite the species richness and identified impacts, including different

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types of fishing activities, a comprehensive assessment of the conservation status of the species on a broad geographical scale is still lacking in this extensive and diverse basin. This situation is particularly necessary since the lower basin comprises two main Ramsar sites (Jaukanigas and Humedales Chaco).

This study has analysed for the first time the extinction risk for a large number of fish species inhabiting the lower La Plata River basin on the basis of the regional IUCN criteria, and compared these results with previous non-standard assessments obtained for the lower and upper basin areas. Some of these evaluations were also applied at a regional scale and an assessment was made of the advantages and the limitations of using alternative approaches for the determination of fish conservation status.

MATERIALS AND METHODS

The La Plata River basin, covering some $3.2 \times 10^6\,km^2$, is the second largest drainage system in South America; its rivers flow through Brazil, Bolivia, Paraguay, Argentina, and Uruguay. In this basin the Paraguay, Paraná, Uruguay, and La Plata rivers represent the major courses, with the headwaters located on the Brazilian shield and Mato Grosso plateau in Brazil and in the Andes Mountains of Argentina and Bolivia. Although there is no formal definition of what constitutes the lower La Plata River basin, we considered this region to be formed by the lower and middle Paraná, the lower Paraguay, the middle and lower Uruguay, and the La Plata rivers (Figure 1).

The raw data were generated at an international workshop conducted in Asunción, Paraguay (August 2008; http://www.proteger.org.ar/peces-cuenca-plata/at). The workshop was attended by fish experts (including the authors), government representatives, IUCN officials, fishermen, and members of non-governmental organizations, who together assessed the extinction risk for a large number of fish species inhabiting the lower La Plata River basin. The procedure for defining species extinction risks was based on the opinions of the experts present, while the status of the various species was obtained from available publications and references on fish distribution and abundance in addition to fishing activity. In some instances this

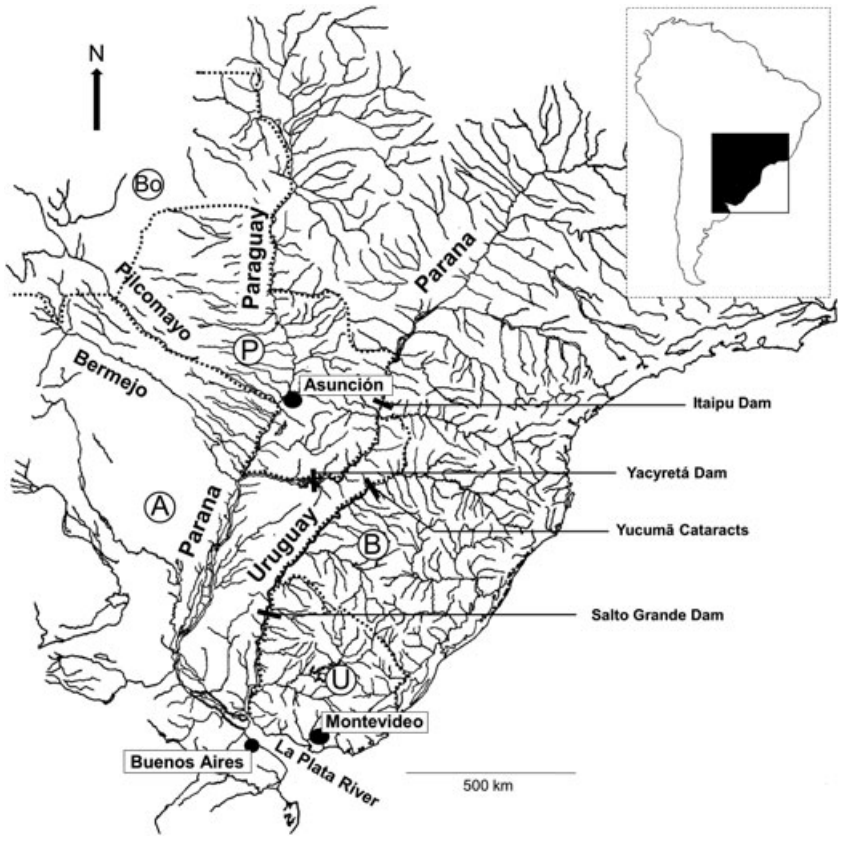

Figure 1. Areas of the lower La Plata River basin included in this study. A: Argentina; B: Brazil; Bo: Bolivia; P: Paraguay; U: Uruguay.

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information was supplemented by considering traditional ecological knowledge provided by fishermen.

The IUCN Red List criteria (IUCN, 2001) were initially applied, but to the regional populations among the fish species inhabiting the lower La Plata basin during this workshop, thus achieving a preliminary regional categorization. The criteria for assessing the risk of extinction followed the IUCN 3.1 version protocols (IUCN, 2001) and took into account the five categories fully described in IUCN (2003, 2006). A species was evaluated on the basis of adequate data availability, but otherwise was considered under the Data Deficient (DD) category. Species were categorized as Extinct (EX), Extinct in the Wild (EW), of Least Concern (LC), Near Threatened (NT), or Threatened. A Threatened species, in turn, can be classified as Critically Endangered (CR), Endangered (EN), or Vulnerable (VU). Five quantitative criteria are used to determine whether a taxon is threatened or not, and, if threatened, which category of threat it belongs in. Criterion A is related to population reduction and can be divided into subcriteria (A1–A4) according to the percentage decrease measured over 10 years or three generations on the basis of (a) direct observation; (b) an index of abundance pertaining to the taxon; or (c) a decline in the extent of occurrence, the area of occupancy, and/or the habitat quality; (d) the actual or potential levels of exploitation; and (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors, or parasites present. Criterion B considers geographic range in the form of B1 (the extent of occurrence) or B2 (the area of occupancy), and at least two of the following additional features: (a) severe fragmentation of populations or decrease in the number of locations by 1–5 or 6–10; (b) a progressive decline in (i) the extent of occurrence (ii) the area of occupancy, (iii) the area, extent, and/or quality of the habitat, (iv) the number of locations or subpopulations, and (v) the number of mature individuals; (c) extreme fluctuations in any of the following characteristics: (i) the extent of occurrence, (ii) the area of occupancy, (iii) the number of locations or subpopulations, and (iv) the number of mature individuals. Criterion C is concerned with small population size and/or population decline and is based on estimating the number of remaining mature individuals and the rate of their diminution. Criterion D focuses on very small or restricted populations, based on the number of mature individuals or the area of occupancy. Finally, Criterion E applies a quantitative analysis to indicate the probability of a taxon's extinction in the wild.

The second step in the regional assessment was conducted by the authors during preparation of the present study. After a preliminary categorization had been achieved during the workshop the regional guidelines were followed as described by IUCN (2003). This procedure is used to decide if the preliminary categorization of the species should be modified (through upgrading or downgrading) – a decision that depends mainly on the population's breeding status, the immigration of propagules, and the environmental conditions outside the region (Figure 2).

The present study extended the original assessment by comparing the results with similar analyses previously performed in the lower and upper La Plata basin through the application of the IUCN or other criteria such as: (a) a set of standardized IUCN criteria applied either for species inhabiting the upper basin in Brazil (Rosa and Lima, 2008) or at a continental level (i.e. South America; IUCN, 2010); (b) species categorized by the Sum of Indices (SUMIN) method for a part of the lower Paraná basin (Zayas and Cordiviola, 2007; Cordiviola *et al.*, 2009); (c) species inhabiting the upper La Plata basin in Bolivia as categorized by MEGA (Van Damme *et al.*, 2009); and (d) categorization of Argentine species based on expert opinion (Chebez *et al.*, 2009).

The SUMIN approach, proposed by Reca *et al.* (1994) and adapted for fish by Bello and Úbeda (1998), is based on summing the score of 12 criteria to display a final conservation index for defining categories such as Vulnerable of Maximum Priority, Vulnerable of Special Attention, and Not of Priority. Those species that exhibit scores between the mean score and one standard deviation are categorized as Vulnerable of Special Attention; if the score surpasses this limit, the species are considered as Vulnerable of Maximum Priority.

The MEGA approach was used for those common species found and categorized in the upper La Plata basin (Bolivia), most of them belonging to the Paraguay River and headwaters of the Bermejo and Pilcomayo rivers (Van Damme *et al.*, 2009). The MEGA approach considers the same categories as the IUCN but uses the five main criteria of taxon distribution, habitat conservation, population status, intrinsic biological vulnerability of taxa, and principal threats. Within each criterion

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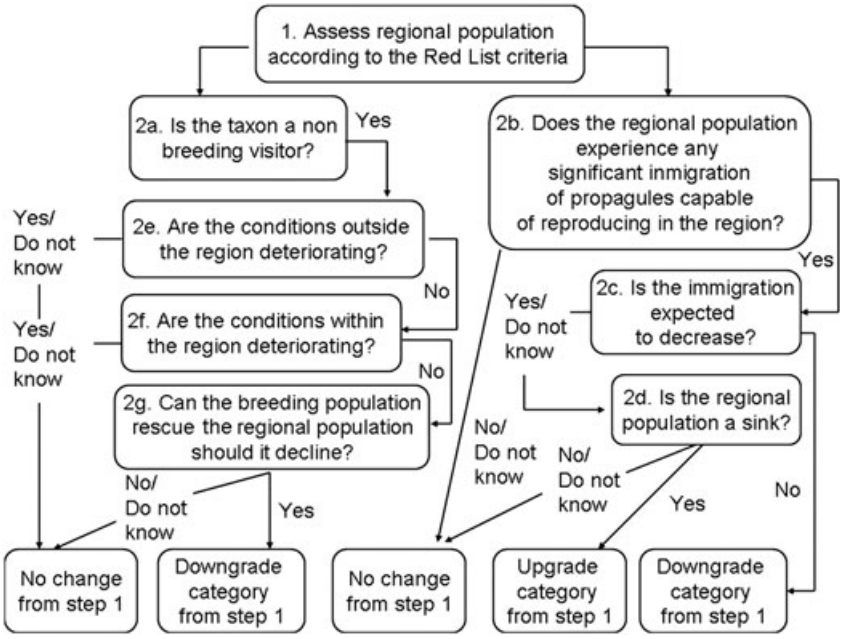

Figure 2. Guidelines for applying regional criteria to assess species extinction risk (adapted from IUCN, 2003).

a point system of scoring is applied, with the species classified according to the final summed score. Expert opinion can be taken into account to move species upor down from one category to another. In Table 1 the criteria and subcriteria of IUCN, SUMIN, and MEGA methods are summarized and compared.

Finally, we used the results of Chebez *et al*. (2009) who developed their own criteria based on categorizing species as Rare, Undetermined, and Vulnerable for Argentinean fish taxa, including those inhabiting the study area. We considered Undetermined as equivalent to DD as proposed by the IUCN (IUCN, 2010).

RESULTS

A total of 185 species belonging to 11 orders and 33 families were analysed in the Asunción workshop, which focused on following only the IUCN criteria (Appendix 1). Most species corresponded to the orders Characiformes and Siluriformes within which the families Characidae, Loricariidae, and Pimelodidae contained the largest number of species.

A total of 66% of the assessed species in this study were classified as LC, and 26% as DD, with both categories together totalling 92%. Only 11 species (6%) were found to be Threatened, three of which were considered EN and eight VU, whereas three species were rated as NT (Table 2). Five (45%) of the threatened species exhibited migratory habits, but those included only the true anadromous species (*Genidens barbus*), which enter the lower La Plata River basin during the late spring for spawning.

Of all the species analysed, only 6% had previously been assessed under the IUCN criteria (IUCN, 2010), thus resulting in a 64% agreement when categories DD and LC were treated separately and a 91% agreement when those categories were combined. The only major discrepancy occurred with *Ancistrus piriformis*, a species that had been categorized as LC by the IUCN (2010), but was assessed as VU in the present study. Four of the categorized species that also inhabit the upper basin (in Brazil) were considered either as EN or VU in the Red Book of Brazil (Rosa and Lima, 2008), in partial concordance with results obtained here for the lower basin. The only exception was *Myleus tiete*, categorized as VU in Brazil but regarded as DD in the lower La Plata basin. Furthermore, the application of the regional categorization protocol through step 2 did not yield different results since we had accepted that all the species considered as Threatened by using the global procedure can reproduce within the lower basin area.

Twenty-one per cent of the species analysed had also been assessed previously by Zayas and Cordiviola (2007) and Cordiviola *et al*. (2009) in the lower Paraná area through the application of the SUMIN method (Bello and Úbeda, 1998). A comparison of those studies with the present analysis indicated a 64% agreement among the cases when LC and NP were chosen as equivalent

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Table 1. Comparison between IUCN, SUMIN and MEGA criteria and sub-criteria related to main attributes influencing species conservation (modified from Liotta, 2010). NI: not included

Factor	IUCN	SUMIN	MEGA
1. Taxon distribution	B1: Extent of occurrence B2: Area of occupancy D2: Restricted area of occupancy	Continental National	a) Scale Continental National Ecological aquatic system b) Type Continuous vs discontinuous
2. Habitat conservation status	NI	NI	Good vs bad
3. Population status	A1, A2, A3, A4: Population reduction levels B (b): Geographic range with continuous decline B (c): Geographic ranges with extreme fluctuations C: Small population size and decline D: Very small or restricted populations	Abundance	Local abundance Population trend
4- Intrinsic biological vulnerability of the taxon	NI	Amplitude in the habitat use Width in the vertical space use Reproductive potential Trophic amplitude Body size Singularity Taxonomic singularity	Amplitude of life areas Reproductive mode and potential Trophic amplitude Taxonomic stability Displacement capacity
5. Main threats	E: Quantitative analysis	Extractive actions Protection degree	Use intensity Habitat modification Presence in conservation units

categories. The VU category (11 cases) exhibited only a 9% agreement between the two assessments since *Brycon orbygnianus* was the sole species categorized as VU by both methods. Species such as *Luciopimelodus pati*, *Pseudoplatystoma corruscans*, *P. reticulatus*, *Salminus brasiliensis*, and *Serrasalmus marginatus* were classified as LC by the IUCN but as Vulnerable of Maximum Priority by the SUMIN criteria; whereas species such as *Oxydoras kneri*, *Piaractus mesopotamicus*, *Platydoras costatus*, *Sorubim lima*, and *Pimelodella gracilis* were categorized as LC and as Vulnerable of Special Attention by both methods. By contrast, 42% of the species analysed by the IUCN criteria were likewise evaluated by Chebez *et al.* (2009). The single species that those authors categorized as Vulnerable (*Lepidosiren paradoxa*) was rated as LC by the IUCN (2010) method. Moreover, whereas 32% were assessed as Undetermined and 57% as Rare by Chebez *et al.* (2009) criteria, almost 90% of those same latter species were categorized as LC and DD by the IUCN.

The MEGA approach applied to the migratory species present in the upper La Plata basin in Bolivia (Paraguay, Bermejo, and Pilcomayo rivers) deviated slightly from the IUCN categorization applied to the same species in the lower La Plata basin. When LC and DD were combined, 72% of the species were classified in the same category, with *Zungaro jahu* being rated as VU by both methods. In contrast, *Prochilodus lineatus*, *Pseudoplatystoma corruscans*, and *Piaractus mesopotamicus* were considered as NT by the MEGA assessment but as LC by the IUCN criteria.

DISCUSSION

The present study represents the first attempt to categorize a large number of fish species according to their risk of extinction through the use of the regional IUCN criteria on a broad scale in the lower La Plata River basin. Although the Asunción meeting used the standardized global IUCN criteria, we consider here the applicability of this approach based on an extension of these results to a regional framework, and a comparison of these findings to previous assessments for several basin areas by applying alternative approaches. Even though the lower La Plata basin comprises transborder rivers that are shared by countries with a large number of common species and similar environmental characteristics, few species have been assessed for their risk of extinction. Moreover, the information

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Table 2. Threatened species of lower La Plata basin according to IUCN criteria and main biological and ecological characteristics and identified impacts

Species	Status	Criteria and sub-criteria	Previous IUCN classification	Geographic distribution	Migratory	Niche features	Main impacts
Brycon orbignyanus	VU	A2ac	None	Lower Paraná and lower Uruguay Rivers[9]	Yes	By trophic habits: seeds and fruits	Recreational fishing; habitat degradation
Gymnogeophagus setequedas	EN	B1b(i)	None	Endemic. Restricted to Paraná tributaries in Brazil and Paraguay[1]	No	By habitats: small streams and sandy/muddy bottoms	Ornamental fishing
Hypostomus dlouhy	EN	B2ab(i)	None	Iguazu River[10]	No	By habitat: small creeks, turbid lagoons and sandy bottoms	?
Ancistrus piriformis	VU	A2d,D2	LC[10]	Endemic. Acaray stream, Paraná basin (Paraguay)[2], Urugua-i stream (Argentina)[3]	No	By habitat: small streams, rocky bottoms	Ornamental fishing
Corydoras carlae	VU	A1c,D2	None	Endemic. Urugua-i stream[3], Iguazu tributary (Argentina)[4]	No	By habitat: small creeks with rocky bottoms	Ornamental fishing
Genidens barbus	VU	D2	None	Lower Paraná River, Paraná Delta and lower Uruguay River [9]	Yes	By reproductive habits	Recreational fishing
Rhamdella aymarae	VU	D2	None	Endemic. Itiyuro River[5] and Urueña River[6] (Argentina)	No	By habitats: sandy/muddy bottoms	?
Rhamdella cainguae	VU	D2	None	Endemic. Cuña Piru stream, Paraná basin (Argentina)[7]	No	By habitat: rocky bottoms in shaded areas	?
Salminus hillari	VU	A1ac	None	Endemic Iguazu River (Argentina)[8]	Yes		Artisanal fishing
Steindachneridion scriptum	VU	A2ac, D2	None	Lower Paraná and lower Uruguay[9]	Yes	By habitat: deep pools in main channels	Artisanal fishing
Zungaro jahu	VU	A2acd	None	Lower Paraná River, Bermejo River[9]	Yes	By habitat: deep pools in main channels	Artisanal and recreational overfishing

[1]Reis *et al*. (1992);
[2]Fisch-Muller (2003);
[3]Miquelarena *et al*. (1997);
[4]Reis (2003);
[5]Miquelarena and Menni (1999);
[6]Monasterio de Gonzo and Barros (2006);
[7]Bockmann and Miquelarena (2008);
[8]Vittar *et al*. (2006);
[9]Liotta (2010);
[10]Weber (2003).

required to develop red lists is still meagre or in many instances unavailable. These gaps are critical within the data necessary for fish species conservation in South American basins as a result of the increased damming of rivers, water diversion, floodplain disappearance, inappropriate land-use, waterway construction, and contamination.

The application of the IUCN criteria for fish inhabiting such basins, however, has encountered some conceptual difficulties when compared with terrestrial vertebrate groups. For example, the application of Criterion A requires knowledge of the percentage population reduction – information that is still either unknown or poorly documented for almost all fish species. For this criterion, most of the threatened species were considered under sub-criterion A2, an assessment signifying that the causes of a species reduction either may not have ceased, may not be understood, or may not be reversible. In this circumstance, items (a) and (c) were mostly selected to account for such a decline. Almost all threatened species were considered at risk because of some sort of fishing activity and habitat use. The few exceptions are mainly commercial species for which the catch record statistics have been collected by the National Direction of Continental Fisheries of Argentina between 1935 and 1978 (Quirós and Cuch, 1989) that provided a rough picture of the general catch historical trends. Unfortunately, all this information and other data necessary for reliable assessment of commercial fisheries in the lower Paraná (Bechara *et al*., 2007) did not include values for catch per unit effort, a parameter that represents a suitable index for displaying trends in abundance (Maunder *et al*., 2006) and can be considered as a proxy statistic for population changes.

The assessment of risk of extinction for commercial and recreational target species, however, should be done with caution (Baigún, 2010). Criterion A has been criticized for not reflecting the management goals for most fisheries, where a reduction of 50% in the commercial viable populations represents a principal objective to achieve the maximum sustainable yield (Matsuda *et al*., 1998; FAO, 2000; Powles *et al*., 2000; Mace, 2004). Another problem in considering Criterion A in regional studies (i.e. non-endemic species) is that under certain circumstances its use results in a taxon qualifying for placement in a higher category at the global level than at the regional. This feature may occur when a regional population is more or less stable but constitutes only a small percentage of a global population that is experiencing a net decline.

The use of Criterion B was possible for only two species, as this criterion is recognized to be of complex application to species inhabiting longitudinal systems (Mace *et al*., 2008). A correct assessment of the extent of occurrence or the area of occupancy of a given species appears to be problematic in rivers with floodplains since certain species exhibit a gradient in their distribution with respect to connectivity with the main channel and with the dynamics of flooded areas (Miranda, 2005; Martelo *et al*., 2008; Gonzalez *et al*., 2009). Moreover, the available area could critically change at differences in flow intensities and particularly during El Niño Southern Oscillation events. Clearly, in those rivers without large floodplains or with narrow channels Criterion B may well overestimate the risk of extinction (Helfman, 2007).

Criterion C was found to be not applicable because of lack of information, but Criterion D proved to be appropriate for five taxa corresponding to highly endemic species inhabiting small streams. Such examples are probably representative of others that could be expected in isolated wetlands or in headwaters distributed across the basin. Liotta (2010), for example, mentioned that 71 species so far have been recognized as endemic for the Argentine sector of the La Plata basin. This feature suggests that the percentage of endemic species is probably higher than indicated by previous studies (López *et al*., 2003) because these species are extremely vulnerable as a result of their strong dependence on habitat quality. In contrast, most of the non-target species and small target species that are captured for bait or ornamental purposes were categorized as DD or LC. These species lack appropriate controls and regulations and reliable quantitative assessment (Gómez *et al*., 1994; Chebez *et al*., 2009) and their conservation status is therefore difficult to assess.

The application of specific regional guidelines did not produce changes to categories with respect to the global criteria applied to regional populations. Based on available knowledge and the riverscape characteristics of the lower basin, we concluded that the best known species can be considered as breeding populations and are not dependent on propagule immigration (*cf*. step 2, regional guidelines). Unlike most of the upper basin, the lower basin still maintains almost all of its floodplains and secondary channels connected by regular flood pulses that are critical for sedentary

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species based on their reproductive, trophic, and rearing habits. Moreover, for certain large migratory species such floodplain characteristics are also necessary to increase their survival, since after reproduction their larvae drift and enter the alluvial valley. Nevertheless, even if some species could not be self-sustaining because they may depend on conspecific populations inhabiting the upper basin, we agree that environmental conditions in this region are deteriorating. Industrial pollution, urban sewage, mining, water diversion, deforestation, and flow regulation by dams and other devices constitute the main impacts on fish and fisheries, either directly or indirectly (Bonetto, 1998). For instance, the upper Paraná basin has lost 80–90% of its forest coverage in the last 50 years (Tucci and Clarke, 1998), whereas the change in land use from natural forests to soybean production has increased the inputs of sediment and pollutants and changed water quality drastically. In addition, river damming in the upper La Plata River basin is considered to be one of the primary influences reducing fish diversity (Agostinho and Gomes, 1997), while the change from lotic to lentic conditions as a result of impoundment has promoted significant changes to fish communities (Agostinho *et al.* 2007). Such features indicate that results derived from using global criteria on regional populations (i.e. step 1) in the lower La Plata basin should not be modified.

The constraints imposed by the IUCN protocols have prompted alternative approaches in other South American countries (Helfman, 2007). For example, the SUMIN criteria, when applied in the lower La Plata basin (although for fewer species and more restricted geographical areas), resulted in significant differences in certain instances (Zayas and Cordiviola, 2007; Cordiviola *et al.*, 2009). This approach differs from that of the IUCN in being based on different multimetric summed criteria and directed at assessing conservation priorities. López *et al.* (2003) and Chebez *et al.* (2009) claimed that the IUCN criteria were not fully applicable because they relied only on the assessor's experience and knowledge and lacked the information necessary for enabling the correct assessment of conservation status. In addition, the application of different categorization criteria produced very different results for commercial target species. For example, most of these species were considered as LC by the IUCN, Vulnerable by the SUMIN, and Undetermined by Chebez *et al.* (2009). A possible explanation for such discrepancies can be found in the more diverse criteria that SUMIN takes into account. Likewise, the MEGA approach (Aguirre *et al.*, 2009), as adapted for fish categorization (Van Damme *et al.*, 2009), was developed to define the vulnerability of fish found in the Bolivian sector of the upper basin through consideration of the biological, ecological, and zoogeographical criteria.

Both the MEGA and the SUMIN methods are directed at assessing the conservation status of species based on a regional perspective. Although the MEGA approach follows the SUMIN general criteria, some major differences are nevertheless apparent (Figure 3). SUMIN puts a greater emphasis than MEGA on the relevance of population decrease (IUCN Criterion A), whereas MEGA gives greater weight to the geographical aspects (IUCN Criterion B). With respect to those features not considered by IUCN, threats were regarded as of major significance by MEGA, whereas SUMIN puts equal emphasis on threats and the intrinsic vulnerability characteristics. When MEGA and SUMIN are compared through quantitative scores and the criteria related to the IUCN approach, 38% and 39% of the respective criteria used by SUMIN and MEGA are similar to those of IUCN, and both of the former approaches share similar features not considered by IUCN. The greater emphasis placed on threats and intrinsic vulnerability by SUMIN and MEGA systems resulted in certain migratory and commercial species becoming categorized as Vulnerable that were classified as LC by IUCN. Such differences are of paramount significance and could promote very different management responses either by applying unnecessary protective measures or by ignoring genuine threats for the species involved.

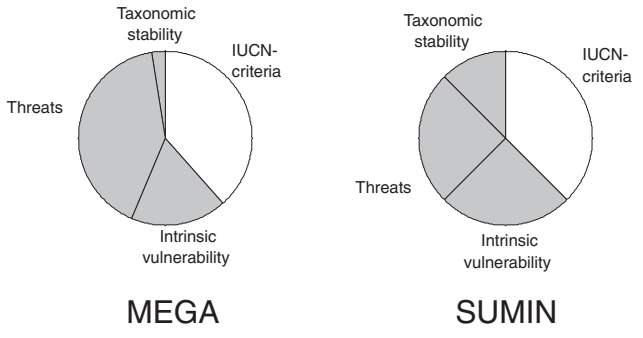

Figure 3. Relative importance given to typical IUCN criteria (IUCN, 2001), such as geographical distribution and population status, and to non-IUCN criteria (intrinsic vulnerability, threats and taxonomic stability) by MEGA (Van Damme *et al.*, 2009) and SUMIN (Bello and Úbeda, 1998).

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Direct comparisons between the IUCN method and the others, however, are probably not fully appropriate since the IUCN criteria primarily assess risks of extinction, whereas the alternative methods are aimed at evaluating conservation priorities, threat levels, or vulnerabilities through the use of additional criteria (Table 3). Whereas the risk of extinction is one of the suite of considerations that determine priorities for management actions, conservation priority is a concept that emerged after the incorporation of additional influences such as social and economic values (Miller *et al*., 2006; Miller *et al*., 2007), particularly in the example of target species. Differences among the approaches under comparison here also arise from their respective means of assessing species status because IUCN uses rules while SUMIN and MEGA employ point scores (Regan *et al*., 2004). Point scoring may pose some severe limitations since that method is not necessarily linked to the risk of extinction, the scores are arbitrary and depend on their method of combination and/or calculation (i.e. whether they are additive or multiplicative), and the numerical results can lead to very different conclusions (Mace *et al*., 2007).

As noted above, the La Plata River basin is highly heterogeneous, exhibiting major differences between sectors with respect to geological history, ecological attributes, riverscape characteristics, and the availability of appropriate species information. For target species, the fishing characteristics may strongly differ according to regional demands, local regulations, and management policies, thus promoting different assessments of species status. That the lower La Plata basin represents the southernmost distribution sector for several Brazilian species (Ringuelet, 1975) may constitute a critical element determining differences in species abundance and the perception of conservation status throughout the basin. Thus, the marked disagreement in the characterization of the same species by the IUCN criteria on the basis of the judgement of experts from different geographical areas, as occurred in the example of *Ancistrus piriformis*, is understandable.

An essential lesson derived from these attempts to categorize species in the lower La Plata River basin is the need to define clearly the gaps in information that need to be filled in order to start developing an operative and reliable threatened species list (Possingham *et al*., 2002). For instance, the application of the IUCN criteria for red lists at the regional level, followed by action plans directed at defining conservation priorities in those portions of the basin supporting either current or predicted

Table 3. Comparative analysis among different methods used for freshwater fish categorization in South America

Criteria	IUCN	SUMIN	MEGA	Chebez *et al*. (2009)
Main objective	Assess extinction risks	Assess conservation priorities	Assess vulnerability to threats	Assess conservation status
Categories used	Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, Data Deficient	Vulnerable of Maximum Priority, Vulnerable of Special Attention, Not Priority	Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, Data Deficient	Rare, Undetermined, Vulnerable
Species distribution range	Global and regional (quantitative)	National and continental (quantitative)	By macrobasins and number of ecological aquatic systems (qualitative)	National (qualitative)
Habitat conservation status	Not considered	Not considered	Considered	Not considered
Knowledge of the extent of decline	Required	Required	Required	Not considered
Reduction thresholds	Specified	Not specified	Not specified	Not specified
Explicit biological characteristics	None	Trophic amplitude, reproductive potential, body size, taxonomic singularity	Trophic amplitude, reproductive potential, body size	None
Basin environmental features	Not included	Not included	Included	Not included
Abundance measures	Yes, quantitative	Yes, qualitative	Yes, qualitative	No
Population trends	Yes, quantitative	No	Yes, qualitative	No
Threats	Not considered	Not considered	Habitat modifications, contamination	Not considered
Use or exploitation	Not Considered	Considered (qualitative)	Considered (qualitative)	Not considered
Degree of protection	Not considered	By number of conservation units	By management plans, protected areas, specific regulations	Not considered

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heavy impacts, may be advisable. At the scale of the entire La Plata basin, however, only Bolivia (using the MEGA criteria) and Brazil (using the IUCN criteria) have developed their own national red lists; Argentina, Uruguay, and Paraguay, the countries occupying most of the lower basin area, still need to start this process. The use of the IUCN criteria offers the advantage of credibility, international recognition, and theoretical support; but the application of these criteria for freshwater fish inhabiting large and heterogeneous basins has emerged as a difficult task because of a lack of suitable quantitative information and the particular technical limitations discussed above. Similar constraints have also been noted, for example, for Colombian and Bolivian fish, where the IUCN categories were maintained but the criteria were adapted or modified (Mojica *et al*., 2002; Van Damme *et al*., 2009).

Although our attempt to categorize species at the regional level was acceptable, we conclude that these results should be considered with caution. More appropriate biological knowledge is still required to improve species assignment to the IUCN Red List categories at the regional level. We suggest that future efforts be directed at expanding assessments in two directions. First, we recommend the incorporation of local ecological information as a routine complementary tool for assessing the likelihood of species extinction, particularly in those areas where habitat deterioration by river damming, dredging, water diversion, pollution, and fishing exploitation practices for the purpose of ornament or bait are greatly increasing. The views of fishermen are useful for detecting past species trends even before data become available (Saenz-Arroyo *et al*., 2005), and traditional ecological knowledge has proved to be useful for assessing population status (Silvano and Bergossi, 2010) as well as being applicable for marine systems having a paucity of biological and demographic information (Castellanos-Galindo *et al*., 2011). Such an approach would be particularly useful to detect changes in abundance. However, as local ecological knowledge is generally limited to specific commercial or sport fish, we also encourage basic ecological and demographic research in order to gain a more complete understanding of fish population abundances, distributions, and bionomic characteristics, particularly for the unknown or unexploited species.

Finally, we recognize the need to bring under consideration different tributaries, headwaters, and valuable ecological areas containing important wetlands, particularly those that can be easily damaged by land and water use and where more endemic species might be detected or scarce species could become threatened. These elements are key considerations for setting species conservation priorities in the face of the projected developments and environmental changes that will soon spread across the La Plata basin.

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APPENDIX

Species categorization according to different criteria for the lower La Plata River basin and border areas. LC: Least Concern; DD: Data Deficient; EN: Endangered; VU: Vulnerable; NT Near Threatened; NP: Not Priority; VSA: Vulnerable Species of Special Attention; VMP: Vulnerable Species of Maximum Priority; nE: not Endemic to the lower La Plata River basin, cosmopolitan; E: endemic. Distribution status according to expert opinion and literature based on the Asunción Workshop

	Method used and source Geographic area	IUCN[1] South America	Expert opinión[2] Argentina	IUCN[3,4] Lower La Plata Basin	SUMIN[5,6] Lower Parana	MEGA[7] Bolivia, Upper La Plata basin	IUCN[8] Brazil Upper La Plata basin	Distribution status
Order	Species							
Rajiformes	*Potamotrygon brachyura*	DD		DD				nE
	Potamotrygon hystrix	DD	Undetermined	DD		DD		nE
	Potamotrygon motoro	DD		LC		DD		nE
Characiformes	*Apareiodon affinis*		Undetermined	LC				nE
	Aphyocharax anisitsi		Rare	LC	NP			nE
	Aphyocharax dentatus			LC				nE
	Aphyocharax nattereri		Rare	DD				nE
	Aphyocharax rathbuni			DD	NP			nE
	Astyanax abramis			LC	NP			nE
	Astyanax bimaculatus			LC	NP			nE
	Astyanax fasciatus			LC	NP			nE
	Astyanax paraguayensis		Rare	DD				nE
	Astyanax pellegrini			DD				nE
	Brycon hilarii		Undetermined	DD		LC		nE
	Brycon orbignyanus			EN-A2ac	VSA		EN-A2ace; B2b (iii)	nE
	Bryconamericus stramineus			LC	NP			nE
	Characidium fasciatum		Rare	LC				nE
	Cheirodon ibicuhiensis		Undetermined	DD				nE
	Cheirodon interruptus			LC	NP			nE
	Cyphocharax platanus			LC				nE
	Cyphocharax voga	LC	Rare	LC				nE
	Erythtrinus erythinus		Rare	DD				nE
	Gymnocorymbus ternetzi			DD	VSA			nE
	Hemigrammus tridens		Rare	DD				E
	Heterocheirodon yatai			DD				nE
	Hoplerythrinus unitaeniatus			LC				nE
	Hoplias malabaricus		Rare	LC				nE
	Hyphessobrycon elachys			DD				nE
	Hyphessobrycon eques		Undetermined	LC	NP			nE
	Hyphessobrycon luetkenii		Rare	DD				nE
	Leporinus lacustris		Undetermined	LC				nE
	Leporinus obtusidens	LC	Rare	LC				nE
	Macropsobrycon uruguayanae			DD				nE
	Moenkhausia dichroura		Undetermined	LC	NP			nE
	Moenkhausia intermedia			LC				nE
	Moenkhausia sanctaefilomenae		Rare	LC	NP			nE
	Myleus tiete		Undetermined	DD			VU-A2ace	nE
	Mylossoma duriventre			LC				nE
	Odontostilbe microcephala	LC		DD	NP			nE
	Odontostilbe paraguayensis			LC				nE
	Odontostilbe pequita			LC	NP			nE
	Oligosarcus jenynsii		Rare	LC	NP			nE
	Piabucus melanostomus		Undetermined	DD				nE

(*Continues*)

	Piaractus mesopotamicus			LC	VSA	NT	nE
	Potamorhina squamoralevis			LC			nE
	Prochilodus lineatus			LC		NT	nE
	Psectrogaster curviventris			LC			nE
	Pygocentrus nattereri			LC			nE
	Pyrrhulina australis		Undetermined	DD			nE
	Raphiodon vulpinus		Undeterminad	DD			nE
	Salminus brasiliensis		Rare	LC	VMP	LC	nE
	Salminus hillari			VU-A1ac		DD	nE
	Schizodon borelli			LC			nE
	Schizodon dissimilis			DD			nE
	Schizodon platae			LC			E
	Serrapinnus calliurus			DD			nE
	Serrapinnus kriegi			DD			nE
	Serrapinnus microdon			DD			nE
	Serrapinus piaba			LC			nE
	Serrasalmus maculatus			LC			nE
	Serrasalmus marginatus		Undetermined	LC	VMP		nE
	Steindachnerina brevipinna		Undetermined	LC			nE
	Thoracocharax stellatus			LC			nE
Siluriformes	*Ageneiosus inermes*			LC			nE
	Ageneiosus militaris			LC			E
	Ancistrus pirareta		Rare	DD			E
	Ancistrus piriformis	LC		VU-A2dD2			E
	Ancistrus cirrhosus		Rare	LC			E
	Auchenipterus nigripinnis			LC			E
	Auchenipterus osteomystax			LC	NP		nE
	Bergiaria platana		Rare	LC			E
	Brochiloricaria chauliodon		Undetermined	DD			E
	Bunocephalus iheringii			DD			nE
	Bunocephalus rugosus		Undetermined	DD			nE
	Callichthys callichthys		Rare	LC			nE
	Corydoras aeneus			LC			nE
	Corydoras aureofrenatus			LC			nE
	Corydoras carlae		Rare	VU-A1cD2			E
	Corydoras ellisae		Undetermined	LC			E
	Corydoras hastatus		Rare	LC			E
	Corydoras micracanthus			LC			E
	Corydoras paleatus			LC	NP		nE
	Farlowella paraguayensis		Rare	DD			nE
	Genidens barbus			VU-D2			E
	Hemiloricaria lanceolata			LC			nE
	Hemiloricaria parva		Undetermined	LC			E
	Hemisorubim plathyrhynchos		Undetermined	NT	MPV		nE
	Hoplosternum littorale		Rare	LC	NP		nE
	Hypophthalmus oremaculatus			DD			nE
	Hypoptoma inexspectatum			LC			nE
	Hypostomus boulengeri		Undetermined	LC			nE
	Hypostomus commersoni			LC	NP		nE
	Hypostomus dlouhyi			EN-B2ab(i)			nE
	Hypostomus laplatae			LC			nE
	Hypostomus latifrons		Rare	LC			nE

(*Continues*)

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Hypostomus microstomus			LC			nE
Hypostomus paranensis			LC			E
Hypostomus piratatu		Rare	LC			nE
Hypostomus regani			LC			nE
Iheringichthys labrosus			LC			nE
Ixinandria steinbachi			LC		DD	E
Lepthoplosternum pectorale		Rare	LC			nE
Loricaria tucumanensis			NT			E
Loricariichthys anus		Rare	LC	NP		nE
Loricariichthys edentatus	LC	Rare	DD			E
Loricariichthys labialis			LC			nE
Loricariichthys platymetopon			LC	NP		nE
Luciopimelodus pati			LC	VMP		nE
Megalancistrus parananus			LC			nE
Megalonema argentina		Undetermined	DD			E
Microglanis cottoides		Undetermined	LC			nE
Otocinclus arnoldi			LC			nE
Otocinclus vestitus			LC			nE
Otocinclus vittatus			LC	NP		nE
Oxydoras kneri			LC	VSA		nE
Paraloricaria vetula			LC			E
Parapimelodus valenciennis	LC	Undetermined	LC	NP		E
Parastegophilus maculatus			LC	NP		nE
Pimelodella gracilis			LC			nE
Pimelodella laticeps			LC	NP		nE
Pimelodus absconditus			LC			nE
Pimelodus albicans		Rare	LC	NP		E
Pimelodus brevis			LC	NP		E
Pimelodus maculatus		Rare	LC	NP		nE
Pimelodus mysteriosus		Rare	LC			nE
Pimelodus ornatos			LC	NP		nE
Pinirampus pinirampu		Rare	LC			nE
Platydoras armatulus		Rare	LC			nE
Platydoras costatus		Undetermined	LC	VSA		nE
Pseudoplatystoma corruscans		Undetermined	LC	VMP	NT	nE
Pseudoplatystoma reticulatus			LC	VMP	LC	nE
Pterygoplichthys anisitsi		Rare	LC			nE
Rhamdella aymarae			VU-D2			E
Rhamdella cainguae		Undetermined	VuD2			E
Rhamdia quelen			LC			nE
Rhinelepis strigosa			LC			E
Rhinodoras dorbignyi			LC			nE
Ricola macrops			LC			E
Rineloricaria cacerensis		Undetermined	LC			E
Rineloricaria catamarcensis		Undetermined	LC			E
Sorubim lima			LC	VSA		nE
Steindachneridion scriptum		Rare	VU-A2ac,D2		EN-A2ace; B2ab(iii)	nE
Trachelyopterus albicrux	LC	Rare	LC			E
Tridentopsis cahuali		Rare	DD			E
Tridentopsis personi			LC			nE
Xyliphius barbatus			DD			E
Xyliphius lombarderoi		Undetermined	DD			E
Zungaro jahu		Rare	VU-A2acd		VU	E

(*Continues*)

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Gymnotiformes	*Apteronotus albifrons*			DD		nE
	Apteronotus ellisi		Undetermined	LC		nE
	Brachyhypopomus brevirostris			DD		nE
	Brachyhypopomus pinnicaudatus		Rare	DD		nE
	Eigenmannia trilineata		Undetermined	LC		nE
	Eigenmannia virescens		Rare	LC		nE
	Rhamphichthys hahni			DD		E
Atheriniformes	*Odontesthes bonariensis*		Undetermined	LC		nE
Cyprinodontiformes	*Austrolebias bellottii*		Rare	DD		nE
	Austrolebias patriciae		Rare	LC		E
	Austrolebias vandenbergi			DD		nE
	Jenynsia multidentata			LC		nE
	Megalebias monstrosus		Rare	DD		nE
	Neofundulus ornatipinnis			DD		nE
	Papiliolebias bitteri			DD		nE
	Simpsonichthys chacoensis		Undetermined	NT		E
	Trigonectes aplocheiloides		Rare	DD		nE
Beloniformes	*Potamorraphis eigenmanni*		Rare	LC		nE
	Pseudotylosurus angusticeps			LC		nE
Synbranchiformes	*Synbranchus marmoratus*			LC		nE
Perciformes	*Aequidens tetramerus*			LC		nE
	Apistogramma borelli			LC		nE
	Apistogramma commbrae		Rare	LC		nE
	Apistogramma trifasciata			LC		nE
	Australoheros guarani			DD		nE
	Australoheros fascetum			LC		nE
	Bujurquina vitatta			DD		nE
	Cichlasoma pusillum			DD		E
	Crenicichla lepidota	LC		LC		nE
	Gymnogeophagus balzanii			LC		nE
	Gymnogeophagus setequedas			EN-A2ace; B1b(i)	VU-A2ace;B2ab(iii)	nE
	Pachyurus bonariensis			LC		nE
	Plagioscion ternetzi			LC		nE
Pleuronectiformes	*Catathyridium jenynsii*			LC		nE
	Catathyridium lorentzii			DD		nE
Lepidosireniformes	*Lepidosiren paradoxa*		Vulnerable	LC	LC	nE

[1]IUCN (2010); [2] Chebez *et al* (2009); [3]IUCN (2010); [4]IUCN (2003); [5]Zayas and Cordiviola (2007); [6]Cordiviola *et al.* (2009); [7]Van Damme *et al*. (2009); [8]Rosa and Lima (2008).

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