



1.5. Distribution and conservation status of the Bolivian river dolphin *Inia boliviensis* (d'Orbigny 1832)

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Abstract

The present paper reviews available information on the Bolivian river dolphin (*Inia boliviensis*), formerly considered a subspecies of *I. geoffrensis*, but which recently was recognized as a different species, based on genetic and morphometric studies. The two species within the genus *Inia* are separated by the Madera rapids, situated downstream and along the

Bolivian-Brazilian border. Within Bolivia, its distribution range is limited by three additional geographical barriers: rapids in the Beni river, close to the town of Cachuela Esperanza, the Chiquitano mountains of the Precambrian Shield in the northeast and the elevation in the piedemonte and subandean region in the southwest. The paper presents a summary of

available distribution and abundance data. *Inia boliviensis* is considered to be more vulnerable than *I. geoffrensis*, due to low genetic variability, low total population size and low genetic interaction between local populations, among other factors. However, at present the species is still well conserved, main current threats being mercury contamination, commercial fisheries nets, boat traffic and general habitat degradation. Planned hydroelectric dam construction in the Madera and Beni rivers may impose the main threat on the species in the future.

Resumen

El presente documento sistematiza la información disponible sobre el delfín de río boliviano (*Inia boliviensis*), la cual hasta hace poco era considerada como una subespecie de *I. geoffrensis*, ha sido reconocida recientemente como especie diferente, basada en estudios genéticos y morfométricos. Las dos especies dentro del género *Inia* se encuentran separadas por las cachuelas del río Madera, cuyos tramos altos representan el límite entre Bolivia y Brazil. Dentro de Bolivia, su distribución es limitada por barreras geográficas adicionales, como son las cachuelas del río Beni, cerca a la localidad de Cachuela Esperanza, las primeras estribaciones montañosas del Andes en el suroeste de la cuenca amazónica y las serranías chiquitanas del Escudo Precámbrico en el sureste de la misma cuenca. Se presenta la información disponible sobre la distribución de la especie y se discuten los factores que influyen en su abundancia. El relativamente bajo número de individuos, baja variabilidad genética y baja tasa de intercambio genético entre poblaciones locales aumentan su vulnerabilidad. La especie se encuentra relativamente bien conservada, y las principales amenazas identificadas para

la misma son contaminación con mercurio, mortandad en redes de pesca, navegación y degradación general del hábitat acuático. La construcción de represas hidroeléctricas en el río Madera y en el río Beni podría representar la principal amenaza en el futuro próximo.

Resumo

O presente documento sistematiza a informação disponível do golfinho de rio Boliviano *Inia boliviensis*. Este golfinho foi considerado uma subespécie de *Inia geoffrensis* e só até 2008 foi reconhecida como uma espécie diferente baseada nos estudos genéticos e morfométricos da mesma. As duas espécies dentro do gênero *Inia* ficam separadas pelos caudais do Rio Madeira cujas partes altas ficam na fronteira Bolívia- Brazil. Dentro da Bolívia sua distribuição é limitada pelas barreiras geográficas adicionais como os caudais do Rio Beni perto da localidade de Cachuela Esperanza, as primeiras derivações montanhosas dos Andes no sudeste da bacia amazônica e as serranias do escudo precambriaco no sudeste da mesma. O baixo número relativo de indivíduos, a baixa variabilidade genética e a baixa taxa de intercambio genético entre as populações locais incrementam sua vulnerabilidade. A espécie fica bem conservada e as principais ameaças identificadas são a contaminação com mercúrio, morte nas redes pesqueiras, navegação e degradação do habitat aquático. A construção de represas hidroeléctricas no Rio Madeira e no Rio Beni podem representar a principal ameaça no futuro próximo.

Introduction

Inia is the only dolphin genus that is strictly restricted to continental waters of South

America. *Inia geoffrensis*, which is present in the Amazon River and its main tributaries, is considered Data Deficient by IUCN (2010), a decision that was motivated by the absence of adequate information on its distribution and/or population status to make an assessment of its risk of extinction.

During several years, the differences between the central Amazon populations and the dolphins that inhabit the Bolivian rivers have been in discussion (see Pilleri & Gihl 1977, Aliaga-Rossel *et al.* 2006). However, after having been officially considered for more than 140 years as a subspecies of *I. geoffrensis*, the Bolivian river dolphin was recently proposed as a separate species (*Inia boliviensis*) (Hamilton *et al.* 2001, Banguera-Hinestroza *et al.* 2002, Martínez-Agüero *et al.* 2006, Ruiz-García *et al.* 2008). This recognition by the scientific community of course adds new conservation value to the species. Moreover, the fact that this species is confined mostly to Bolivian territory makes conservation actions at the national level more relevant. However, relatively little information on the species is available, limiting the development of a conservation strategy.

In Bolivia, the local common name for *I. boliviensis* is “buefo”. The indigenous people Guarayos used the name “Inia” for buefos (and this name was adopted for the genus by d’Orbigny (1834), but this name is not commonly used in Bolivia.

The present paper is a revision of the available information on the species in Bolivia and presents some new data on distribution patterns and abundance. Most information on *I. boliviensis* is of a descriptive nature (Pilleri 1969, Pilleri & Gihl 1977), knowledge of its biology being mostly based on research of *I. geoffrensis* in the Brazilian Amazon (for

example, Best & da Silva 1993, Martin & da Silva 2004a, 2004b).

Taxonomic status

The genus *Inia* belongs to the order Cetacea, suborder Odontoceti, superfamily Platanistoidea, and family Iniidae. The genus was described in 1834 by the naturalist Alcide D’Orbigny, who observed freshwater dolphins in the Bolivian Amazon. In 1855, Gervais transferred the species at that time known as *Delphinus geoffrensis* (de Blainville 1817) to the genus *Inia*. From then on, all river dolphins from South America were considered to belong to one and the same species, *Inia geoffrensis*, with three subspecies, *I. geoffrensis humboldtiana*, present in the Orinoco River Basin, *I. g. geoffrensis*, in the Amazon River Basin, and *I. g. boliviensis*, in the Bolivian Amazon (Best & da Silva 1993).

During the last century, the number of species within this genus has been in discussion (see review by Aliaga-Rossel & McGuire 2010). Pilleri & Gihl (1977) were the first to propose the distinction of two species within the genus *Inia*: they considered the river dolphins encountered in the central Amazon as *Inia geoffrensis* and the ones observed in Bolivian territory as *Inia boliviensis*. This distinction was based on morphological and morphometric differences based on few individuals deposited in museum collections. According to these authors, the Bolivian dolphins had a longer rostrum, higher number of teeth, and a braincase with a smaller volume.

The evidence presented by Pilleri & Gihl (1977) was met with skepticism by the scientific community due to the small sample size used. The Bolivian river dolphin continued to be considered by most as a subspecies of *I.*

geoffrensis (*I. g. boliviensis*); however, between 1969 and 2007, the possible validity of *Inia boliviensis* kept on being discussed in many publications (Van Bree & Rabineau 1973, Best & Da Silva 1993, Banguera- Hinestroza *et al.* 2002).

The hypothesis of two valid species within the genus *Inia* was resolved with molecular and genetic studies. Analysis of the mitochondrial DNA, the mitochondrial cytochrome *b* gene, and nuclear intron sequences showed a wide range of differences between the Bolivian dolphins and the dolphins of the central Amazon. Hamilton *et al.* (2001) and Banguera-Hinestroza *et al.* (2002) presented the first molecular evidence, and additional morphometric (Ruiz-García *et al.* 2006) and genetic (Ruiz-García *et al.* 2007, Ruiz-García *et al.* 2008) analyses confirmed the presence of the two different species within the genus.

According to Ruiz-García *et al.* (2007), the *Inia boliviensis* population is the result of a founder effect that occurred between 5 and 6 million years ago, at the time when the rapids along a 400 km stretch in the high Madera and the lower Mamoré and Beni rivers were formed. This geographic barrier triggered off speciation of the *Inia* genus into the two different species *I. geoffrensis* and *I. boliviensis*. However, using microsatellite and mitochondrial markers, Ruiz-García *et al.* (2008) and Ruiz-García (2010) suggested that speciation of *I. boliviensis* is of a more recent date, between 50 000 and 500 000 years ago.

Morphology

The morphological characteristics of *I. boliviensis* are similar to those of other river dolphins of South America. The body is

corpulent and heavy, but extremely flexible, capable of bending and twisting (Best & da Silva 1993, Aliaga-Rossel & McGuire, 2010). Morphological adaptations, such as free cervical vertebrae, the very motile pectoral fins and an echolocation system allow the dolphins to enter the floodplains to catch fish. They present a pronounced melon, have a long snout with short bristles on the top, the eyes are small; the teeth are heterodontous (different types of teeth). The pectoral and caudal flippers are big and the dorsal fin is very low; they have an internal ear that it is localized behind the inferior jaw (Best & da Silva 1993).

The rostrum is long and is covered both dorsally and ventrally with numerous bristles, especially in the juveniles. Behind the head the body becomes rapidly thicker and passes without any sign of neck into the powerful trunk. The cranium appears long and narrow, the nares are longitudinally oval. The single nasal opening is about 1 to 1 ½ times as long as it is wide (Pilleri & Gihl, 1977).

Pilleri & Gihl (1977) described the morphological characteristics which distinguish *Inia boliviensis* from *I. geoffrensis*. According to these authors, the average number of teeth on each side of the upper and the lower jaw is 33. The average cranium length is 476.6 ± 15.1 mm, and the average volume of the neurocranial cavity is 558 ± 14.3 cm³. The color pattern of *I. boliviensis* is variable, varying from dark grey, white to pink, whereas claves are grey (Pilleri & Gihl 1977, Aliaga-Rossel & McGuire, 2010), the color being related to physical activity and probably being dependent on age, water clarity and temperature (Best & Da Silva 1993).

Ruiz-García *et al.* (2006) presented detailed morphological and morphometric data on *I. boliviensis*, based on the measurement of 27

individuals (16 males and 11 females) captured in the Bolivian Amazon. Mean total male length was 193.8 (± 9.2) cm, whereas females were generally larger (total length of 202.2 ± 14.8 cm). However, it is supposed that these size differences are an artifact of inefficient

sampling of adult males. Probably, *I. boliviensis* males are larger and heavier than the females, the same as was reported for *Inia geoffrensis* (Martin & Da Silva 2006). Further differences between the two species are provided in Table 20.

Table 20. Sexual dimorphism and morphometric differences between *I. geoffrensis* and *I. boliviensis*. Measurements of *I. geoffrensis* from the Orinoco River Basin are not included.

	<i>Inia geoffrensis</i>	<i>Inia boliviensis</i>	Source
Sexual dimorphism	_>_	_>_	Da Silva 1994
	>	_>_	Ruiz-García <i>et al.</i> 2006
Total length (mm)†	_2740	-	Layne 1958
	-	_2160	Pilleri & Gihl 1977
	_1927 (1830–2050) _2160 (1865–2550)	_2071.6 (2000 – 2150)	Best & Da Silva (1993) Da Silva 1994
	_2550	_1800 (1600 – 1980)	Best & Da Silva 1993
	_ 2146 ± 130.6	_2022 ± 148.2	Ruiz-García <i>et al.</i> 2006
	_2030 ± 249.3 *	_1937.7 ± 91.5 *	Ruiz-García <i>et al.</i> 2006
	_1998 ± 12.2 _ 2315 ± 15.3		Martín & Da Silva 2006
Length from the tip of the jaw to melon (mm)		_330 (310 – 350)	Best & Da Silva 1993
	_230 (205 – 260) _290 (230 – 350)		Da Silva 1994
	_ 252.9 ± 38.8 *	_248.2 ± 27.1*	Ruiz-García <i>et al.</i> 2006
	_219.2 ± 61.5	_ 209.7 ± 43	Ruiz-García <i>et al.</i> 2006
Length from the tip of the jaw to mouth basis (LTJMO) (mm) †	_ (305.7 ± 29.5 *	_330.9 ± 37.5 *	Ruiz-García <i>et al.</i> 2006
	_ 280.8 ± 63.9 *	_ 290 ± 44.7 *	Ruiz-García <i>et al.</i> 2006
Length from the tip of the jaw to spiracle (LTJS) (mm) †	_ 397.9 ± 41.4 *	_389.1 ± 35.6 *	Ruiz-García <i>et al.</i> 2006
	_ 351.5 ± 92.6	_ 351.3 ± 54.7	Ruiz-García <i>et al.</i> 2006

	<i>Inia geoffrensis</i>	<i>Inia boliviensis</i>	Source
Length from the tip of the jaw to genital aperture (mm) (LTJGA) †	$_{-} 921.5 \pm 194.2 *$	$_{-} 890 \pm 92 *$	Ruiz-García <i>et al.</i> 2006
Width of the dorsal fin (mm) (WPF) †	$_{-} 200.7 \pm 30.4 *$	$_{-} 180.9 \pm 20.2 *$	Ruiz-García <i>et al.</i> 2006
	$_{-} 186.5 \pm 30.4 *$	$_{-} 166.1 \pm 18.3 *$	Ruiz-García <i>et al.</i> 2006
Length of dorsal fin (LDF) (mm) †	$_{-} 82.1 \pm 11.3$	$_{-} 66.4 \pm 9.7$	Ruiz-García <i>et al.</i> 2006
	$_{-} 83.1 \pm 23.8 *$	$_{-} 58.5 \pm 8.8 *$	Ruiz-García <i>et al.</i> 2006
Width of fluke (WF) (mm) †	$_{-} 170 \pm 17 *$	$_{-} 153.6 \pm 25 *$	Ruiz-García <i>et al.</i> 2006
	$_{-} 164 \pm 30.4$	$_{-} 145.3 \pm 13.9$	Ruiz-García <i>et al.</i> 2006
Flukes tip to tip (FIT) †	$_{-} 453.6 \pm 66.7$	$_{-} 446.4 \pm 33.8$	Ruiz-García <i>et al.</i> 2006
	$_{-} 483.1 \pm 107.6 *$	$_{-} 408.8 \pm 44.8 *$	Ruiz-García <i>et al.</i> 2006
Weight (kg)		$_{-} 49.5$ $_{-} 75.4$	Aliaga-Rossel 2002
		$_{-} 79.5$ (67.4 – 96.5) $_{-} 108$ (63 - 159)	Da Silva 1994
		$_{-} 160$	Best & Da Silva 1993
		$_{-} 99.6 \pm 2.1$ (72 – 141) $_{-} 154.2 \pm 2.0$ (113.5 - 207)	Martin & Da Silva 2006

* Measures significantly different between species (*I. geoffrensis* e *I. boliviensis*).

† Measures that are represented in Figure 9.

Biology

Ruiz-García *et al.* (2007) provided genetic evidence that *Inia boliviensis* is strongly filopatric, showing a strong preference for specific lakes. Martin & da Silva (2004a, 2004b), who observed similar patterns for river dolphins (*I. geoffrensis*) in the central Amazon, distinguished “permanent residents” (mainly

occurring in lake systems) and river-dwelling individuals; these authors assumed that genetic exchange between lakes is accomplished during high water, when the lakes interconnect. According to Ruiz-García *et al.* (2007), the spatial structure of *I. boliviensis* populations is probably based on lake systems. These authors only collected lake samples, and the role of rivers for genetic exchange is not yet clear. They

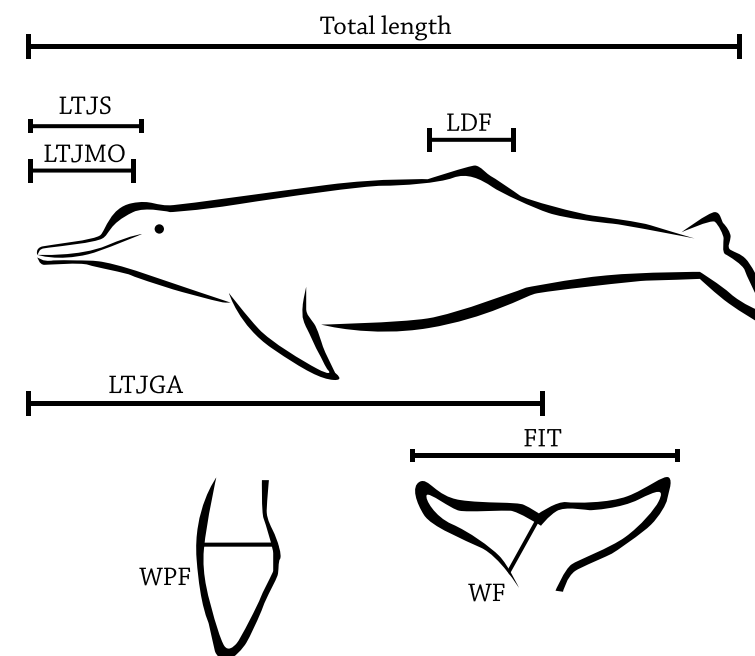


Figure 9. Abbreviations of measures of *Inia* spp. used in Table 20 (Ruiz-García *et al.* 2006).

argued that in the lower Bolivian Amazon, lake populations may be more isolated than in the upper part, due to the presence of river rapids, which make exchange of genetic material by river more difficult. On the other hand, lake populations in the upper Bolivian Amazon can become isolated from river populations as a consequence of lower frequency and duration of river-lake interconnections. The same can occur in remote tectonic lakes with little connection to the river.

Aliaga-Rossel (2002) in the Tijamuchi River found that 42% of observations were of solitary dolphins, and 32% were pairs, but occasionally large groups were observed (maximum group size of 19 individuals). The largest group observed by Aliaga-Rossel *et al.* (2006) in the same river consisted of 14 individuals. Large groups were generally found in confluences, where fish prey is abundant, whereas pairs were

more often found during the reproduction period.

The reproduction in freshwater dolphins ranges from highly seasonal to year-round. In many species, reproductive seasonality varies geographically (McGuire & Aliaga-Rossel 2007). *Inia geoffrensis* males generally reach reproductive maturity at total lengths of 198 to 200 cm, and the females mature at 170-183 cm (McGuire & Winemiller, 1998). Best & da Silva (1993) reported slightly smaller sizes at first maturity, resp. 195 and 160-175. The gestation period for this species is estimated between 10.5 and 10 months, having in each one calve that is nursed until month 8-9 (Emmons 1998). There are no data available on reproductive parameters of *I. boliviensis*. However, neonates and juvenile individuals have been observed all year long in Bolivian territory, suggesting that reproduction takes place within the species both during high

and low water seasons (Pilleri & Gühr 1977, Mc Guire & Aliaga-Rossel 2007). Aliaga-Rossel (2002), however, found that both mating and birth have a peak during the low water season.

There is a lack of information about natural predators of river dolphins, but Best & da Silva (1993) report that black caiman (*Melanosuchus niger*) and the jaguar (*Panthera onca*) might be occasionally preying on *I. geoffrensis*. In Bolivia there is a record of a female dolphin that died after intraspecific sexual assault; such attacks have been also observed in the Colombian Orinoco dolphin *I. geoffrensis humboldtiana* (Aliaga-Rossel 2002). There are anecdotic reports of caimans killing newborns, however, these were not confirmed (Aliaga-Rossel, in press).

There is little information available on the diet of *I. boliviensis*. It is likely that the diet is similar to *I. geoffrensis*. For the latter species, da Silva (1983, 1994), da Silva & Best (1982) and Best (1984) registered more than 50 prey species, most of them of intermediate size, with prey items ranging in size from 5 to 80 cm (average 20 cm). The same authors found that solitary fish are taken in similar quantities to schooling species and that pelagic fish are more preyed upon than benthic or littoral fish. They apparently prefer fish from the families Sciaenidae, Cichlidae, Characidae and Serrasalmididae, which are also present in the Bolivian Amazon. The daily food intake of an adult *I. geoffrensis* is between 2.7 and 4.5 kg, whereas Best & da Silva (1993) reported daily food consumption rates in captivity of 3.1 % of body weight daily. Aliaga-Rossel *et al.* (in prep.) found in the stomach content of a juvenile dolphin at least 12 fish belonging to four families (Characidae, Auchenipteridae, Heptapteridae and Doradidae). Aliaga-Rossel (unpubl. data) reported the presence of two fish of the Gasteropelecidae family in the stomach

of a necropsied adult dolphin in the Mamoré River Basin.

Distribution

Most of the distribution range of *I. boliviensis* overlaps with the north and northeast of the Bolivian Amazon, coinciding with approximately 50% of the upper Basin of the Madera River. It is present in the rivers that represent international limits between Brazil and Bolivia: the Iténez-Guaporé river in the north east (Tavera, unpublished data), the Abuná river in the north-west of Bolivia (Aliaga-Rossel 2003) and the Madera and Mamoré rivers between Guayaramerín and Manao (Salinas, pers. comm.). The specimens in the Abuná river might belong to either of the two species (Van Bree & Rabineau 1973; Tavera *et al.* 2010) (see also below).

Between the communities of Guayaramerín (Bolivia) in the Mamoré River and Porto Velho (Brazil) on the Madera river a sequence of 18 rapids seems to represent geographical barriers for *Inia boliviensis* (Fig. 11), contradicting the earlier hypothesis of Best & da Silva (1993) who suggested that at high water season *Inia* may be able to pass these barriers, as do migratory catfish. These rapids and waterfalls can be found over a distance of 400 km downstream along the Madera River and produce a total change in altitude of approximately 60m (Molina, in press). The last one of these rapids is located 6 km upstream of Porto Velho in Brazilian territory. This series of waterfalls represents the main barrier limiting the distribution of several species, including *I. boliviensis* in the north of Bolivia (Figure 10).

Best & da Silva (1993) reported on the existence of freshwater dolphins between Porto Velho and Guayaramerín, but there are no

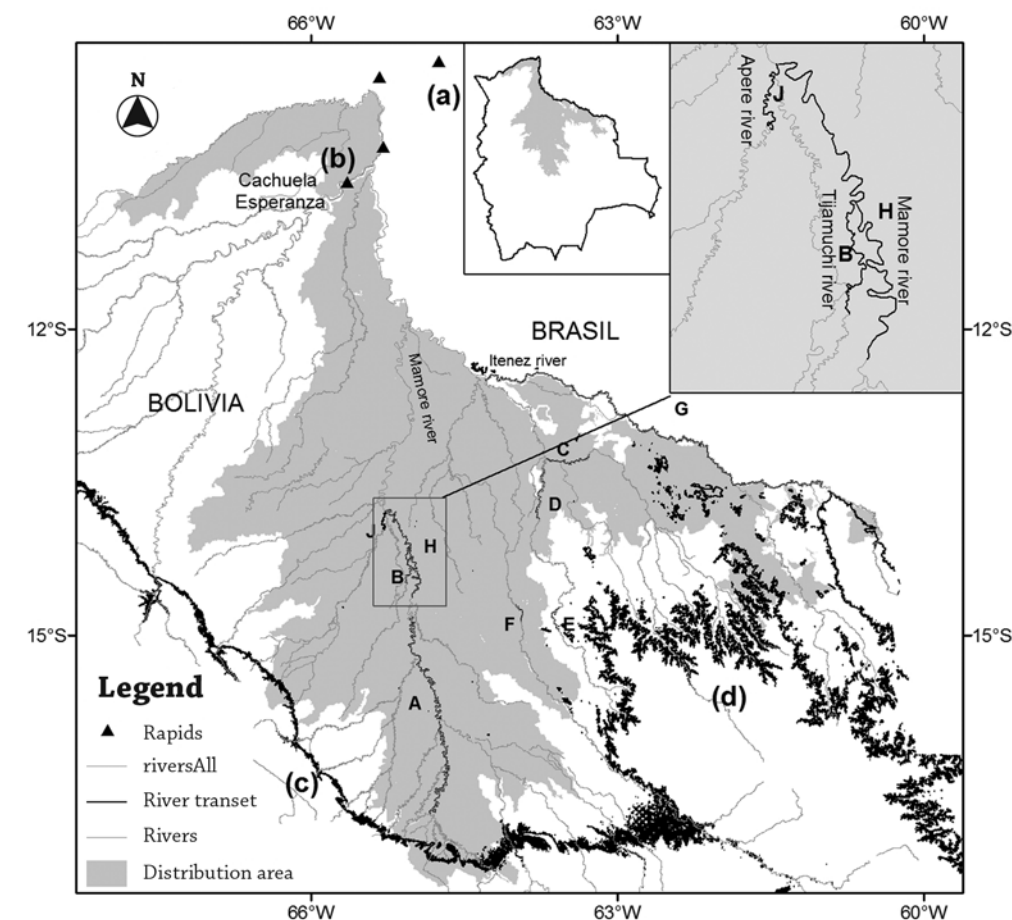


Figure 10. Estimated Extent of occurrence and river surveys of *Inia boliviensis* in the Bolivian Amazon. Only main rivers are shown. Physical barriers for the species are indicated as follows: (a) rapids in the Madera river downstream of its distribution range; (b) rapids in the Beni river which impede dispersion to the Beni and Madre de Dios watersheds; (c) Elevation in piedmontone zone of subandean region (altitude limit of 240 m above sea level); (d) Chiquitano mountains (altitude limit of 240 m above sea level). A = Study area in the Ichilo-Mamoré River (Tavera, in press); B = Study area in the Tijamuchi River (Aliaga-Rossel, 2002); C = Study area in the San Martín River (Salinas, 2007); D = Study area in the Blanco River (Salinas 2007); E = Study area in the Negro de Caimanes River (Arias *et al.* 1994); F = Study area in the Blanco River (Arias *et al.* 1994); G = Study area in the Iténez River (Tavera *et al.* unpublished data). Abundance data are provided in Table 3.

detailed data on their distribution in relation with the presence of waterfalls, neither do we know to which of the two species the dolphins in these stretches belong to. The main rapids are Teutónia waterfalls, close to Porto Velho and Jirau waterfalls, halfway between Porto Velho and the Brazilian-Bolivian border (Figure 2) According to Molina (in press), the difference in height of the largest of these

(Teutónia) changes in function of increasing water discharges (from 5 000 to 40 000 m³/s) between, respectively, 9 m and 4 m. Jirau, on the other hand, has a minimum difference in height of 4m all year round (Molina, in press). These two waterfalls probably represent the main actual barriers for *I. geoffrensis* (Figure 11) and *I. boliviensis*. Ribereia and Pederneira, both waterfalls of intermediate size, as well as

other smaller waterfalls, are probably easier to be passed by dolphins.

Due to the Madera rapids the distribution of *Inia boliviensis* is likely to be largely restricted to the Bolivian Amazon (Figure 10), where it can be found both in clear and white water floodplains in the departments of Santa Cruz, Cochabamba, Beni and Pando (Aliaga-Rossel 2004). The mapped distribution range of *I. boliviensis* (Fig. 10) took into account geographical barriers as well as dolphin sightings. Within Bolivia, about 55% of the geographical range of *Inia boliviensis* overlaps with the Iténez River Basin, 43% with the Mamoré River Basin and 2% with the Beni River Basin (Figure 11).

The species is present in the Mamoré River channel (Anderson 1997) and most of its tributaries (see reviews in Anderson 1997, Aliaga-Rossel 2003). In the western part of the

Mamoré River Basin, there are records in the Rapulo, Maniqui and Curiraba Rivers (FAN-SERNAP-FAUNAGUA 2007), and the most southern records are known for the Isiboro Rivers (Van Damme, unpubl. data) and the Ichilo river (Pillieri & Gihl 1977, Van Damme, unpubl. data). Further to the southwest and south, the elevation represents a geographical barrier for the species. The altitudinal limit for *I. boliviensis* in the Mamoré River Basin was set on 250 meter above sea level, considering that in this region there is one sighting at 243 meter above sea level, in the Maniqui river (FAN-SERNAP-FAUNAGUA 2006). However, the distribution limit may change in different smaller Basins as a consequence of local differences in slope and presence of waterfalls that cannot be passed by bufeos (Figure 11).

Aliaga-Rossel (2003) reported the presence of bufeos during the high water season at an altitude of 500 m above sea level, but this record

was based on not confirmed local anecdotal information. Pillieri & Gihl (1977) established 380m as the upper distribution limit for the species; however, their reference location (Puerto Villaruel) is located at an altitude of 240 m above sea level. Best & da Silva (1993) suggested that the temperature of the water in the headwaters can pose an additional limit on dolphin distribution. Extremely high water turbidity, as for example in the Grande River, a headwater in the Mamoré River Basin, can pose an additional limit (Van Damme, unpubl. data).

The species is also common in the Iténez River channel (Anderson 1997, Tavera unpubl. data) and in most of its Bolivian tributaries (Painter 1994, Yañez 1999, Salinas 2007) (Figure 10). In the Iténez River Basin, the Chiquitano Mountains of the Precambrian Shield are likely to limit the distribution of *I. boliviensis* in the south-eastern part of its distribution range. Based on the sighting maps, the distribution limit of the species in the Bolivian section of the River Basin was set at 240 m above sea level. Probably, the distribution of bufeo in the upper parts of this watershed is also limited by the presence of dense floating macrophytes that are common in this area.

In the northwest of Bolivia, the rapids of “Cachuela Esperanza” (Figure 10) seem to represent a geographical barrier that has impeded the upstream passing of the species from the Mamoré River to the Madre de Dios and Beni River sub-Basins, since there is no evidence of the presence of the species in these Basins (Aliaga-Rossel, in press; Escobar Wilson-White, pers. comm.). There exist no hydraulic data on this rapid within Bolivian territory, but the difference in height seems to be at least two meters throughout the year (Carvajal, pers. comm.).

Habitat use

The distribution range of *Inia boliviensis* overlaps with seven Aquatic Ecological Systems (SEAs), delimited in the sense of Crespo *et al.* (2007). In the Beni River Basin, the only overlapping SEA is the lower part of the alluvial floodplain; in the Mamoré River Basin, the overlapping SEAs are the Mamoré alluvial floodplain, the pluvial alluvial floodplain and the inundation floodplain; in the Iténez River Basin, the three overlapping SEAs are the Iténez alluvial floodplain, the Precambrian floodplain and flooded zone. The two latter SEAs coincide with the Hydroecoregion “Precambrian Shield”, as defined by Navarro y Maldonado (2002) whereas the first five SEAs mentioned coincide with the Hydroecoregion “lowland floodplains” (see Table 21). As a rough estimate we can distinguish eight aquatic habitat types in these two hydro-ecoregions.

The habitats used by *Inia boliviensis* in the Hydro-ecoregion “lowland floodplains” are the flooded white water and clear water floodplains, white water rivers, clear water rivers and streams, floodplain lakes (both oxbow and várzea lakes), and tectonic lakes (Navarro & Maldonado 2002) (Figure 11).

Within this region we can recognize two main river types. The large rivers generally are “white water” rivers that drain the Andes and therefore contain high amounts of dissolved and suspended solids resulting in high turbidity (Pouilly 2006), moreover they are characterized by a polymodal flood pulse. The “clear water” rivers and streams, on the other hand, originate in the same plain and have low solid content. Aliaga-Rossel (2002) describe a range of other types of river types (mixed waters, black waters), but this tipification is not validated limnologically (Navarro & Maldonado 2002). Typical ‘black waters’ in the sense of Sioli (1975)

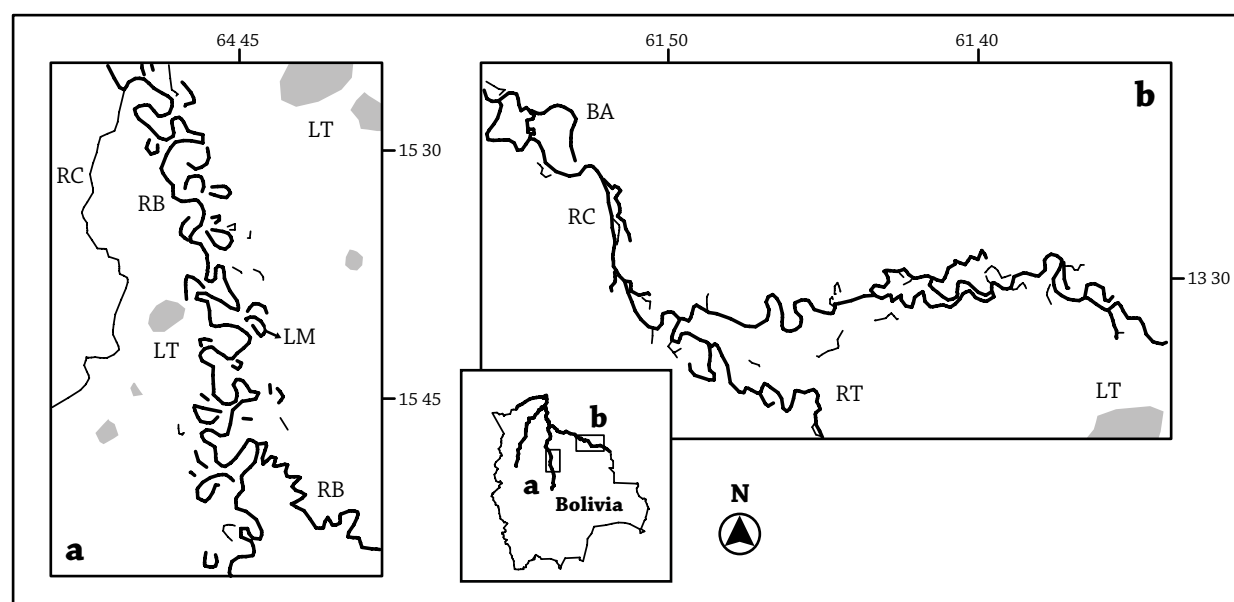


Figure 11. Main habitat types in the Hydro-ecoregions (a) “Lowland Floodplains” (Mamore River) and (b) “Precambrian Shield” (Iténez River), used by *Inia boliviensis*; RC = Clear water river; RB = White water river channel; LT = Tectonic lake; LM = Floodplain lake; BA= Old river arms.

Table 21. Hydro-ecoregions (Navarro & Maldonado 2002) and Aquatic Ecological Systems (Crespo *et al.* 2007) overlapping with the distribution range of *Inia boliviensis*.

Hydro-ecoregions	Aquatic Ecological Systems		Habitat types within the hydro-ecoregions
Lowland floodplains	Beni River Basin	Alluvial floodplain of the Beni River Basin	*White water rivers *Clear water rivers and streams *Floodplain lakes (Both oxbow lakes and várzea lakes) *Tectonic lakes
	Mamoré River Basin	Alluvial floodplain of the Mamoré River Basin	
		Pluvial alluvial floodplain of the Mamoré River Basin	
		Flooded, floodplain of the Mamoré River Basin	
Iténez River Basin	Alluvial floodplain in the Iténez River Basin		
Precambrian Shield	Iténez River Basin	Precambrian floodplain	* Clear water rivers * Tectonic lakes * Old river arms (“Bahías”) * Floodplain lakes
		floodplain of the Precambrian Shield	

are absent in the Bolivian Amazon (Pilleri & Gihl 1977, Navarro & Maldonado 2002). Within the main river channels, the dolphins seem to prefer river confluences (Aliaga-Rossel 2002, Aliaga-Rossel *et al.* 2006).

A confluence was defined as the place where a tributary discharges its water in the main river stem (Aliaga-Rossel 2002). McGuire (2002) & Aliaga-Rossel *et al.* (2006) speculate that these confluences have a high productivity, as well as greater abundance of fish. Furthermore, Aliaga-Rossel (2002) observed high numbers of dolphin in old river arms connected with the Tijamuchi River, considered to be a clear water tributary (Navarro & Maldonado 2003) of the Mamoré river. However, during the dry season the connection channel between these old river arms and the river stem was reduced to very low depths and bufeos migrates to the main river.

A very typical lentic habitat in this hydro-ecoregion is represented by the floodplain lakes, which are used intensively by freshwater dolphins, however there are no detailed abundance data for this habitat. Ruiz-García *et al.* (pers. comm.) collected 70 individuals from floodplain lakes in the Mamoré River Basin (a white water floodplain), without indicating how many were present in total in each lake. However, the fragmentary data indicate that the densities in floodplain lakes are high, and in fact the larger part of the population may occupy these habitats throughout the year. It is expected that floodplain lakes in more productive white water floodplains have higher fish productivity (see for a discussion Navarro & Maldonado, 2002, and Pouilly *et al.* 2006) and, consequently, higher dolphin abundances, however, there exist no data to test this hypothesis.

Whereas many of the aquatic habitats have a patchy distribution during the dry water season, lakes and rivers interconnect during the raining season (Navarro & Maldonado 2002), and dolphins disperse along the floodplain (Martin & Da Silva 2004a). The flooded riparian vegetation in this region is a very important habitat for the dolphins, chasing and catching small fish that enter the floodplain. The same as was described for *I. geoffrensis* (Martin & Da Silva 2004b), the hydrological cycle likely has a dominating influence on bufeo habitat use through the year. Additionally, during the flooding season, movements within the floodplain and between the floodplain and the river and lakes will be determined mostly by prey availability, which is related to migration patterns of fish, as well as to water level and oxygen concentration of the floodplain (Martin & Da Silva 2004b; Aliaga-Rossel & Quevedo in prep.).

Within the Brazilian Shield Hydroecoregion, on the other hand, aquatic environments are very different and are mainly characterized on the basis of their geomorphology and hydrochemistry. Pilleri (1969), Pilleri & Gihl (1977), Yañez (1999), Tavera *et al.* (unpublished data) and Salinas (2007) confirmed that the Bolivian river dolphin is present in most of the aquatic habitats within this aquatic mosaic.

The rivers in this hydroecoregion are ‘clear water rivers’ draining old geological formations, and are characterized by nearly neutral pH and low solids content. The main river stem has many side channels, and represents a very heterogeneous habitat for dolphins. The flood pulse in these rivers is unimodal. The river-floodplain system also has a complex structure. Most of the old river arms stay connected with the river all year round, which is a consequence of low sedimentation rates

(Navarro & Maldonado 2002). Altogether the rivers which intersect the inundated floodplains present relatively deep channels and have steep banks. Aquatic vegetation is present mostly in the form of floating plants such as the “tarope” (Navarro & Maldonado 2002). Salinas (2007) also observed that the Bolivian dolphins seem to prefer confluences of the main river and, respectively, tributaries and old river arms connected with the main river. During the dry season, when small canals and lakes are not deep, dolphins are often seen feeding at river confluences, probably because it is in these places where currents disorient the fish and facilitate their capture (Best & Da Silva 1993, McGuire 2002, Aliaga-Rossel 2002).

While the available habitat for the dolphins in the Iténez River Basin is the main channel and side channels of the rivers, they also appear to use lakes, floodplains and smaller tributaries (Tavera, unpublished data). Most of the tectonic lakes in the Iténez River Basin are not used during the dry season, probably because they are too shallow (Salinas 2007).

Abundance

The available information on the abundance of river dolphins in Bolivia is increasing in volume. The works published by Pilleri (1969), Pilleri & Gihl (1977), and Tapia (1995) mentioned the presence of the species in their study areas, without providing detailed data on distribution and not applying standard methods that allowed for comparison of results. Most authors do not provide details on survey methodology or surveyed very short stretches, tending to overestimate or subestimate dolphin abundance. Moreover, it is difficult to standardize survey methods among very different habitats, which also explains why methods in small and large

ivers differ considerably. Most recent authors used strip transects (Aliaga-Rossel 2002, Aliaga-Rossel *et al.* 2006) or line transects to estimate dolphin relative abundances.

We reviewed published literature in order to estimate river distance sampled within the distributional range of bufeos in Bolivia. Overall, white water rivers in the Mamoré River Basin have been sampled quite intensively, whereas other river types are not very well studied. There is hardly any information on the use of floodplain lakes by dolphins (an exception is Aliaga-Rossel 2002).

Pillari & Gihl (1977) found 0.25 ind./km in a stretch of 130 km of the Ichilo River and 1.17 ind./km along a short transect of 12 km in the Upurupuru river. Aliaga-Rossel *et al.* (2006) reported abundance indexes and encounter rates for dolphin populations in four tributaries of the Mamoré River. The encounter rates presented for the rivers Tijamuchi, Yacuma, Apere, Rapulo and Mamoré were between 1.2 and 5.8 ind./km. Aliaga-Rossel *et al.* (2006) found encounter rates in the Mamoré river channel of 1.6 ind./km. At the start of the dry season of 2007, 550km were navigated on the Mamoré River, from Puerto Villarroel to Trinidad, a major white water river draining the Andes, and 598 km on the Iténez River, from Pimenteiras in Brazil to Buena Vista, the main clear water river draining the Precambrian shield. Using a standardized methodology, encounter rates of, respectively, 1.3 ind./km and 1.6 ind./km were recorded (Tavera *et al.* in prep.). Finally, Salinas (2007) found higher abundance of river dolphins in a white water river (Blanco) (1.62 ind./km) than in a clear water river (0.74 ind./km) draining the Precambrian Shield (San Martín River) of the Iténez River Basin (Table 22).

Data are still too poor to detect abundance patterns; however, some hypothesis can be put forward. Observed differences in dolphin abundance may be a result of differences in river size, surface area of the adjacent floodplain, or food availability.

The river type is important in the sense that it affects the total primary and secondary production in the drainage Basins and in this matter may have a strong influence on freshwater dolphin abundance (Best & Da Silva 1993). Moreover, river and floodplain size differences may be superimposed on differences in productivity. Generally, the white water floodplains are considered to be very productive, whereas the floodplains that drain the Precambrian Shield are nutrient poor (Navarro & Maldonado 2002). We assume that the main factors influencing abundance of the dolphins are those related to the productivity of the aquatic systems. Productivity is related to food availability which in turn might influence the abundance of the dolphins in the different River Basins.

Threats

Freshwater dolphin populations in South America seem to be in a better health than the Asian river dolphins, mainly because both fisheries and dam construction are less developed in the Orinoco and Amazon than in Asia. In particular, this applies for *Inia boliviensis*, a species which dwells in an area with low fisheries pressure and without any dam so far constructed in the lowlands. However, this situation might change in the near future.

The Conservation Action Plan for the World's Cetaceans 2002- 2010 (Reeves *et al.* 2003) considered several threats for the river dolphin

Table 22. Encounter rates of *Inia boliviensis* in different water systems in the Bolivian Amazon.

Autor	River	Type of water	Transect length (km)	Encounter rate (ind/ km)
Pillari & Gihl 1977	Ichilo	White	130	0.25
Pillari & Gihl 1977	Upurupuru	White*	12	1.17
Painter 1994	Blanco	Clear	***	0.16
Painter 1994	Negro de Caimanes	Clear	***	0.22
Aliaga-Rossel 2002	Tijamuchi	Clear**	185	1,2
Aliaga-Rossel <i>et al.</i> 2006	Mamoré	White	222,2	1,6
Aliaga-Rossel & Quevedo in prep.	Ibare	Clear	175	0,2
Salinas 2007	San Martín	Clear	56	0,74
Salinas 2007	Blanco	White*	66	1,62
Tavera <i>et al.</i> unpublished data	Ichilo-Mamoré	White	550	1,30
Tavera <i>et al.</i> unpublished data	Iténez	Clear	598	1,60

* The Blanco river is considered to be a white water river though it does not drain the Andes Mountains. It should be considered different from "typical" white water rivers.

** Aliaga-Rossel (2002) refers to this river as a "black-water" river or a "mixed water river". However, following the recommendations of Navarro & Maldonado (2002) we classify it as a clear water river.

*** Without information.

populations around the world. In South America the effects of these threats for *Inia* are difficult to quantify due to the lack of information. This makes it difficult to evaluate whether there are significant conservation problems for the populations of dolphins or whether the mortality caused by humans is incidental or intentional.

In many parts of the world, aquatic ecosystems receive more human pressure than their terrestrial equivalents (Dudgeon *et al.* 2006), though for Bolivia there exist no detailed evaluations. In the Bolivian Amazon, the erosion caused by the inadequate use of land and the deforestation of riparian zones might have changed dolphin habitat occurring

downstream, however this impact has not been quantified. Contamination with mercury (Maurice-Bourgoin 2001), the spill of domestic and industrial waste, and petroleum contamination (Van Damme *et al.* 2000) may have severe impacts downstream, often at a large distance from the contamination points (Van Damme 2002), but the effect on dolphins is not known.

In the next paragraphs we indicate some mayor threats for *I. boliviensis* populations in Bolivia, giving emphasis to the possible impact of mercury, dam development, boat traffic and commercial fishing. Figure 12 summarizes some of the important threats.

Hunting and fishing

The fish consumption in Bolivia is one of the lowest of all Latin American countries (1.4 Kg/person/year, significantly lower than the rate recommended by the FAO which is 12 Kg/person/year). This coincides with low fisheries pressure. In general, the fish resource is considered to be underexploited (Alisson, 1998, Reinert & Winter 2002). Some species as the 'pacu' (*Colossoma macropomum*) are showing local signs of overexploitation, mainly in the Mamoré River Basin, but healthy populations are present in some tributaries (Reinert & Winter 2002, Van Damme & Carvajal 2005).

As a consequence, fish depletion is not considered as a direct threat for the dolphin populations at the moment. Furthermore, Amazon fisheries in Bolivia are focused on the larger carnivorous and omnivorous fish species and not on the smaller omnivorous and detritivorous fish species and thus are not likely to provoke a depletion of the food resource of dolphins, neither at River Basin level nor at local level (Van Damme, in prep.). The estimated number of 80 000 dolphins (see below) would consume a yearly average of 43 800 tons of fish (assuming that daily fish consumption is 2 kg, based on Best & Da Silva), which is far above the 3 400 ton estimate for fisheries exploitation (Van Damme *et al.* in prep.). Even if the estimates of bufeo densities are too optimistic, there is no reason to be concerned with direct resource competition between fishermen and bufeos.

In many places, fishermen consider the *Inia* as harmless, but in some areas (for example, the Mamoré River Basin) there are seen as competitors. Mortality may occur when dolphins are accidentally entangled and die of asphyxiation in fishing nets as they are prevented from reaching the surface of the water to breathe (Tavera pers. obs. 2007); in other cases, the fishermen prefer to kill the dolphins rather than suffer net damage (Aliaga-Rossel 2002, 2003). In 2002, Muñoz and Tavera (pers. comm.) recorded the death of a dolphin in the fishing nets of commercial fishermen in the Ichilo River. In 2007, an infant young female of 1.30 m length and 30 kg weight was found dead in the San Martín River (Iténez River Basin) nearby the community of Bella Vista. Aliaga-Rossel (2002), based on interviews, described cases of dolphin mortality in fishing nets in old river arms and in the Tijamuchi River. Recently, during the rising water season, in the Apere and Niquisi rivers, a newborn and a juvenile were found dead, the necropsy

showing that both died drowned after being trapped by fishing nets. The juvenile had the caudal fin removed (Aliaga-Rossel *et al.* In prep.) Some illegal fishing methods are considered threats to *Inia boliviensis* populations such as the use of dynamite (Aliaga-Rossel, 2003; in press), occurring mainly in the headwater Basins. However, we consider these deaths to be accidental. Though there are only anecdotal records so far, intensified commercial fishing might pose the species some risk in the future, especially in the lower Mamoré river.

There is increasing evidence or records of intentional killing of river dolphins in Bolivia. Anecdotal reports indicate that in the last year more than 10 adult bufeos in the area of the Tijamuchi river were intentionally killed, leaving them in the shore where they were left grief-stricken, or using the fat as bait. Despite being forbidden by law, sporadic hunting of freshwater dolphins still occurs in Bolivia. Occasionally dolphins become targets during practice of shooting techniques by hunters (Aliaga-Rossel 2003, Tavera pers. obs. 2008). In the town of Riberalta, dolphin teeth are sold as amulets to protect against bad luck or as sexual attraction (Aliaga-Rossel 2003).

Aliaga-Rossel (2003) mentioned old traditions and myths that may still influence local actual perception of bufeos. In the Iténez River Basin, Itonama and Baures indigenous tribes thought that bufeos once were people that received a divine punishment and were transformed (Ribera 2000). Other extinct tribes thought that dolphins could transform themselves in to men seducing village girls (Yañez 1999). Most local people adopt the idea that the bufeo meat is not consumible, however, they are still consumed by some indigenous groups. There are indications that traditional beliefs are changing and bufeo might become a main target in the

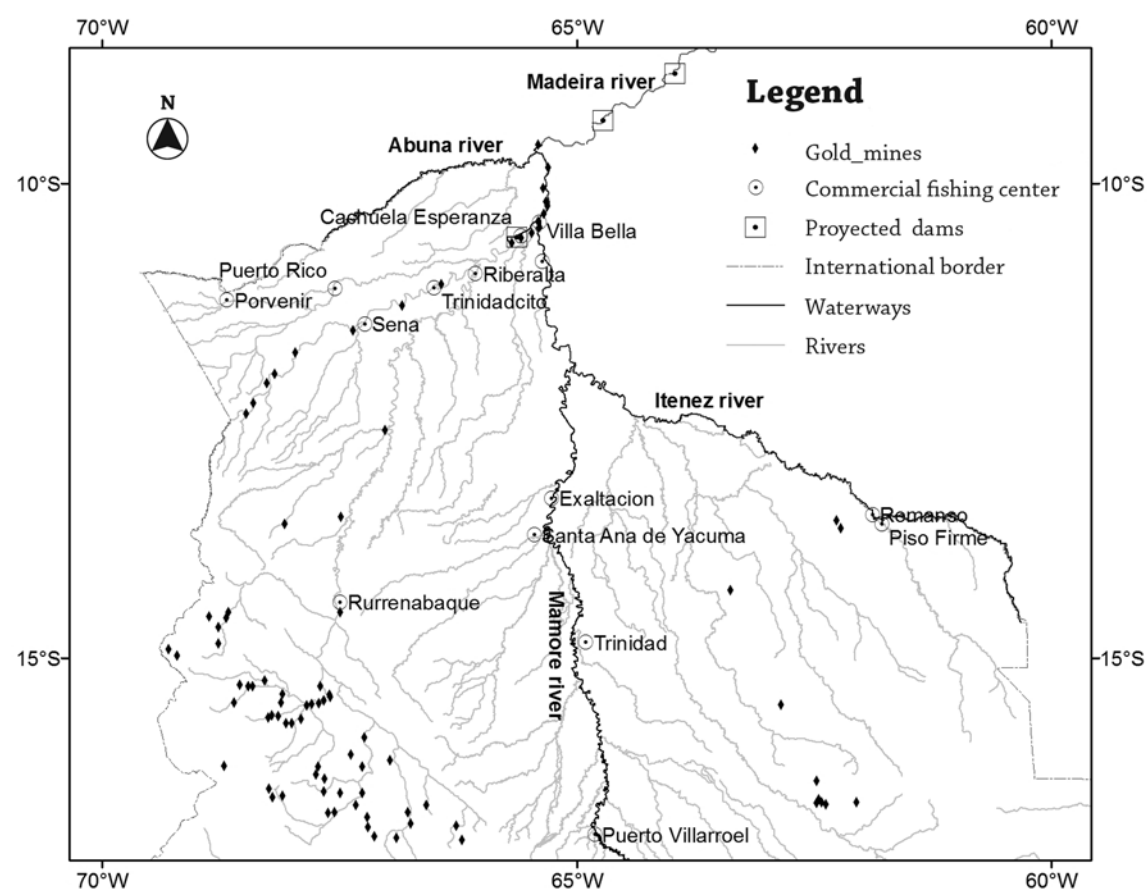


Figure 12. Map of threats that put on risk the future of *Inia boliviensis* in Bolivia: gold mining, dam construction, planned waterways and main commercial fisheries.

future. There also exists information that bufeo is used as bait in the central and lower Mamoré river.

Mercury contamination

According to Aliaga-Rossel (2010), gold mining in Bolivia is a major threat for *Inia boliviensis*. In the western Bolivian Amazon River Basin, gold mining is associated with mercury disposal in aquatic systems. Between 1979 and 1997, Maurice-Bourgoin (2001) estimated that in the northwest of the Bolivian Amazon (Pando) alone, 300 tons of mercury was flushed into the river each year. Up until 2000, in the upper Iténez River Basin, 500 small miners were emitting approximately 15 tons of mercury per year (Hentschel *et al.* 2000). Pouilly (unpubl. data) confirm that mercury disposal is still very high both in the upper Iténez river and in the Beni River Basin.

Mercury particles in solution in the rivers can become trapped in water droplets and travel far in the atmospheric water vapor. Precipitation can then lead to contamination of rivers in other drainages (Maurice-Bourgoin 2001). In addition, it can travel very long distances through accumulation in migratory fish. These two factors suggest that mercury contamination is not an isolated and localized event, but a global problem that can affect all the Bolivian Amazonian River Basin, including zones where there has never been gold exploitation. Thus, the mercury contamination in the Beni River, which is not overlapping with the distribution range of bufeo, can easily affect individuals occurring in the eastern parts of the Bolivian Amazon.

Under favorable conditions, mercury can be incorporated into the sediments and enter the aquatic trophic chain by aquatic

plants, ultimately becoming biomagnified in carnivorous fish. Top predators, whether human, river dolphins *I. boliviensis* or giant otter *Pteronura brasiliensis* (Aliaga-Rossel 2003, Ibisch & Merida 2003) are supposed to accumulate significant quantities of mercury (Pouilly, pers. comm.). So far, there are no data of mercury accumulation in freshwater dolphins, though their position in the food web renders them extremely vulnerable (Maurice-Bourgoin *et al.* 1999, Maurice-Bourgoin 2001, Aliaga-Rossel in press, Ibisch & Merida 2003).

Maurice-Bourgoin *et al.* (1999) and Maurice-Bourgoin (2001) determined the mercury concentrations in sediments and fish, and evaluated the impact on the riparian human populations. According to these authors, the contamination by mercury of streams and rivers located close to the gold mines at the base of the Andes is very high. The mercury concentrations analyzed in this superficial water surpasses more than 500 times the worldwide average value. Moreover, the sediments of the rivers from the high Andes are very contaminated. The concentrations exceed up to 44 times the permissible limit in Bolivia. 72% of collected piscivorous and carnivorous fish in the tributaries of the Beni River were highly contaminated, since they exceeded up to five times the limit value of the OMS (1976) of 0,5 µg Hg/g. The contaminated species were the surubi (*Pseudoplatystoma spp.*), palometa (*Pygocentrus nattereri*), muturo (*Zungaro zungaro*) and the plateado (*Brachyplatystoma rousseauxii*), all species of commercial value both in the Beni and the Mamoré watersheds.

Boat traffic

Major navigable rivers in Bolivia such as the Mamoré and the Iténez are used for commercial transport while tributaries of these rivers are

used for local transport, and increasingly for tourism. Boat engines can cause mortality of the dolphins (Van Damme, pers. obs.). Aliaga-Rossel (2002), in the Tijamuchi River (Mamoré River Basin), found a dead specimen with cuts in the head area and the lower jaw broken, with obvious signs of having been injured by a propeller. Further studies are needed to confirm the magnitude of this threat for the Bolivian river dolphin populations.

Boat traffic may become a major problem once proposed waterways in the Madera, Mamoré and Iténez River Basin are constructed. The building of the Madera waterway is foreseen in the framework of planned dam construction. Brazil foresees the creation of sluices that can facilitate navigation between Porto Velho and Guayaramerín. The Mamoré (planned between Puerto Villarroel and Guayaramerín) and the Iténez waterways (planned between Pimenteiras and Guayaramerín) will be constructed by dredging, allowing boat traffic all year around, affecting fish and Bolivian dolphin populations.

Dam development

Since 1971 the Ministry of Mines and Energy of Brazil and the National Company of Electricity (ENDE) of Bolivia have been identifying four locations for the construction of hydroelectric power stations in the upper Madera River Basin, with the main aim to supply energy for the Brazilian and Bolivian economy. The two dams for which admission procedures are in an advanced stage are Santo Antonio and Jirau on the Madeira River in Brazilian territory (Molina 2006).

The dams of Jirau and Santo Antonio in Brazil are expected to generate 6.450 megawatts, equivalent to 8% of the energetic demand in Brazil. The reservoirs created by the dams

will flood hundreds of square kilometers of Amazonian forest. Experts of the National Institute of Amazonian Investigations (INPA) argue in addition that the Jirau dam might flood a surface twice the planned 204 km² and could eventually flood Bolivian territory. This would exacerbate the problem of mercury pollution, spreading the impact over a wider area (Pouilly, pers. comm.).

The construction of the hydroelectric dams in the Madera River in addition will likely result in the decrease and potential economical extinction of fish species of commercial value, disabling the migration paths of these to their spawning habitats in the headwaters (Van Damme & Carvajal, in prep.). Besides the large carnivorous catfish and characid species, the dam may affect smaller migrating detritivorous and omnivorous species, such as *Potamorhina*, *Triporthus* and *Prochilodus* which are favorite preys of *Inia*.

The construction of the San Antonio and Jirau dams will create reservoirs which will flood the rapids in the river. The reservoirs created by the dams will be probably used by Bolivian river dolphin, considering that the reservoir will harbor a huge amount of planktivorous and carnivorous fish species of intermediate size. However, fish diversity in these reservoirs will be drastically reduced, and this is likely to affect *Inia*, which has a wide feeding spectrum (Best & Da Silva 1993). The construction of dams in sequence will aggravate the problem.

Erroneous construction of the fish bypass or of the dam's doors could allow passage of dolphins upstream, and *Inia geoffrensis* coming from Brazil, could possible invade the Bolivian Amazon, affecting the *Inia boliviensis* populations, which is genetically vulnerable. Dam development represents a potential threat for the Bolivian dolphins. A similar situation

was described for the river dolphin of the Ganges, which is considered near extinction due to population fragmentation caused by dam development. However, whereas in Asia populations are threatened by fragmentation, the Bolivian river dolphin may be threatened by a rupture of its isolation in the Bolivian Amazon. Compared to other freshwater dolphin populations in South America and in the world, *Inia boliviensis* is considered to have a better conservation status, however, it is a species very vulnerable to large-scale hydrological river changes.

Conservation status and legal protection

According to the IUCN (2010), *I. geoffrensis* is categorized as “Data Deficient”, due to the absence of reliable distribution and population data. It is included in the Appendix II of CITES (2008). In the 2002-2010 Conservation Action Plan for the World’s Cetaceans (Randall *et al.* 2003) this species was considered as “not evaluated species”. This uncertainty on the conservation status of *I. geoffrensis* also applies for *Inia boliviensis* (though at the time of classification it was considered as a subspecies of *I. geoffrensis*). In Bolivia, the bufeo was considered within the Red Book of Threatened Vertebrates (Ergueta & De Morales 1996) as a species of “Low Risk”. However, in the revised version of the Red List of Bolivian vertebrates, *Inia boliviensis* was considered “Vulnerable”, a decision based on aquatic habitat degradation and decrease of population size, but also on low genetic variability (Aliaga-Rossel 2009).

The population of *Inia boliviensis* is more vulnerable than the population of *Inia geoffrensis*. Ruiz-García *et al.* (2007), using macrosatellite markers (STRP) and Random

Amplification Polymorphism DNA markers (RAPD), indicated that at the macrogeographic level the genetic variability of *I. boliviensis* is considerably lower. Moreover, the same authors using RAPD showed that at the microgeographic level (Mamoré floodplain) there is high genetic heterogeneity amongst floodplain lakes within one and the same River Basin but very low genetic interchange between the lake populations, giving rise to a significant spatial structure. Therefore, genetic isolation was related to the distance between lakes, which according to these authors is explained by the existence of geographical barriers, mainly rapids, in the Bolivian Amazon.

Total population size of *Inia boliviensis* is also lower, coinciding with its smaller distribution range. Martin & da Silva (2004a) estimated that 13 000 *I. geoffrensis* occur in the 11 240 km² Mamirauá Sustainable Development Reserve in Brazil, which covers an estimated 11%-18% of várzea habitat. This data probably is a subestimate, and da Silva (pers. com.) recently estimated total population size of *I. geoffrensis* (in all its distribution range) between 3 000 000 and 5 000 000 specimens. On the other hand, total population size of *I. boliviensis* is probably lower than 80 000. This latter figure was derived from an extrapolation of relative abundance data for rivers to the entire distribution range within Bolivia (Crespo, unpublished data). The higher vulnerability of *I. boliviensis*, resulting from low total population size, the low genetic variability and the low genetic interaction between its populations, implies that floodplain habitat protection should receive top priority amongst possible conservation strategies (Ruiz-García *et al.* 2007).

In Bolivia, the protection of this species is contemplated indirectly in the Political Constitution of the State and the following

laws: (a) Decree 22641: General Prohibition of Hunting in the country, modified in July 1999 according to Supreme Decree 25458; (b) Decree of Law 12301 of Wildlife, National Parks, Hunting and Fishing, and c) The Supreme Decree 24781 which establishes the general management strategies for protected areas. A Departmental Law of March 2008 decrees the Bolivian River Dolphin as a Natural Patrimony of the Department of Beni.

This regional legal instrument is an important achievement contributing to the conservation of the dolphins within Bolivian territory, and reflects political concern for its preservation and its use as an emblematic flagship species.

About 15,6 % of the Bolivian Amazon is protected within protected areas and 19% overlaps with Indigenous Territories. The delimitation of National Parks was carried out following terrestrial criteria and political concerns, and generally did not take into account the limits of River Basins. Less than 4% of the extent of occurrence of *I. boliviensis* overlaps with Indigenous Territories (TCO) (where hunting and fishing is allowed) and less than 2% with protected areas (Figure 13). The main protected areas where the bufeo is effectively protected are the National Park Noel Kempff Mercado and the Iténez Protected Area, both in the north east, and the Isiboro-Sécure National Park, in the upper Mamoré River Basin.

Conservation initiatives

With the recognition of *I. boliviensis* being a unique species, the interest in its conservation has been increasing in the last few years. In the next paragraphs we present some lessons learned and indicate conservation priorities.

Local and regional action plans

Action plans include a proposal of conservation actions that are based on a baseline study and an identification of main threats. So far, in Bolivia, the conservation of *I. boliviensis* only has been considered in the framework of the development of management plans of protected areas, such as Noel Kempff National Park, Iténez protected area, and Reserva de ríos Blanco y Negro. However, it is necessary to develop action plans that cover larger parts of the distribution range. Equally, it is important to include other aquatic species (such as giant otter *Pteronura brasiliensis* and black caiman *Melanosuchus niger*) within these action plans.

Evaluation of environmental impact of megaprojects

One of the most important limitations for conservation action in Bolivia is the lack of information and concern about the value of its natural resources. In the framework of environmental studies on the impact of dam construction on aquatic fauna in the Madera River Basin, the possible impact on *I. boliviensis* is being evaluated.

Public relationships

Recently the media have been given attention to the Bolivian dolphin. Press and other media attention can trigger public support for conservation. It is important to maintain a fluid communication with the press such that they can inform the general public and contribute indirectly to the conservation of the species. A communication strategy is required to streamline information on the species.

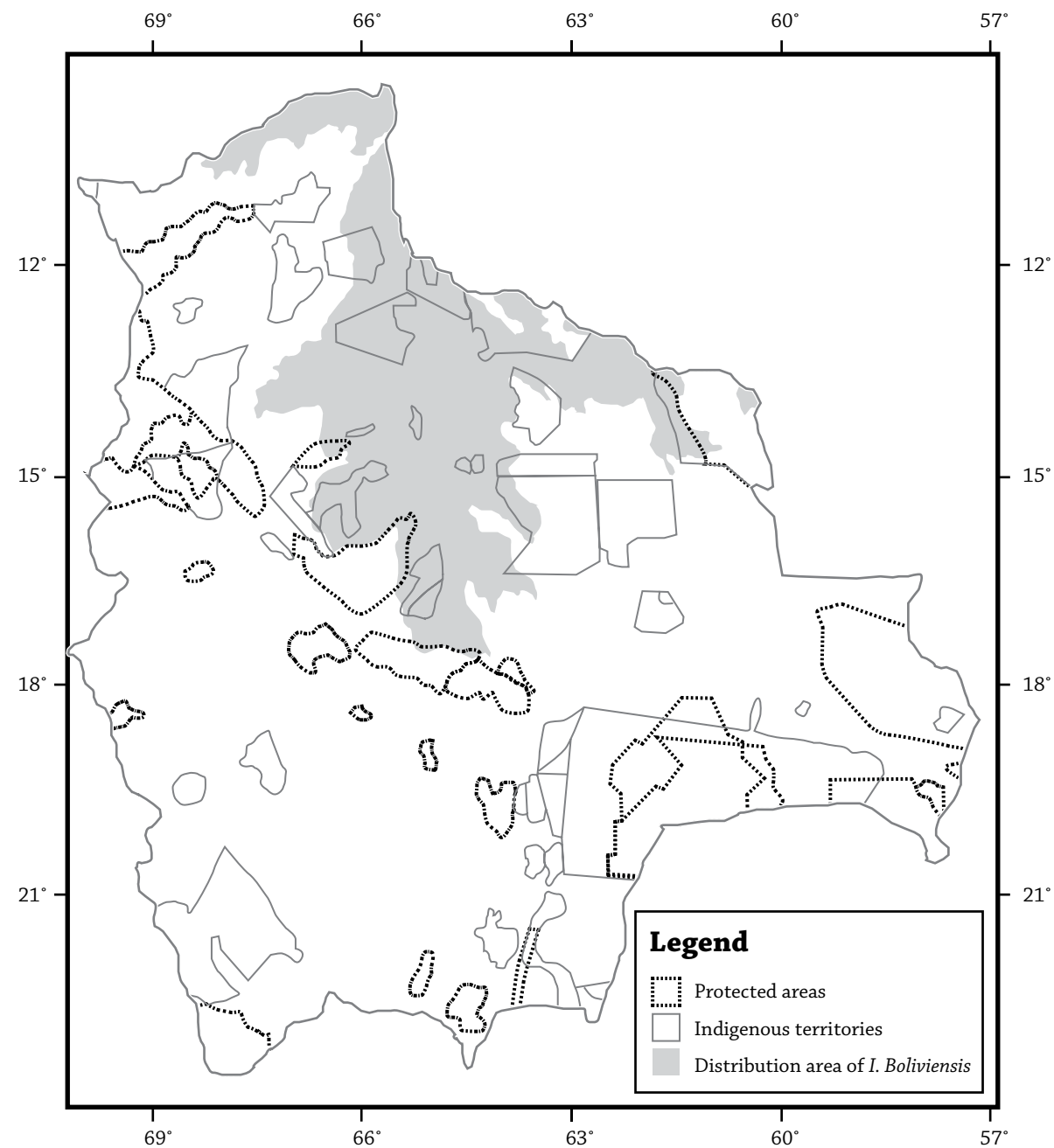


Figure 13. Overlap of the Extent of Occurrence of *I. boliviensis* with protected areas and indigenous territories in the Bolivian Amazon.

Diffusion and environmental education

A clear strategy of environmental education is important for conservation planning. It is a priority in the conservation strategy to facilitate the information to local people who can later undertake conservation actions or develop management strategies, for example in the framework of responsible tourism. This type of activity should be based on the best technical information available and should be accompanied with a monitoring program. So far, no specific environmental education programs on Bolivian dolphins were developed, although some projects are underway, especially in the Iténez River Basin. The Bolivian river dolphin may be used as flagship species for aquatic habitat conservation.

National laws

The promulgation of the departmental law that considers the Bolivian River Dolphin as a Natural Patrimony of the Department of Beni is perhaps one of the most important steps towards effective conservation of the species, and might open the road for the design of a National Law that regulates the protection of *I. boliviensis* within Bolivian territory. In the future, it will become important to provide assessment and technical information both to national and local authorities.